

Trading Pollution for Water Quality:
Assessing the Effects of Market-Based Instruments in Three Basins

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**TRADING POLLUTION FOR WATER QUALITY:
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ABSTRACT

Since its passage in 1972, the majority of pollution reduction under the federal Clean Water Act has resulted from technology-based limits imposed on point source dischargers. However, most U.S. water bodies are unmonitored and of those that are, between 40 and 50 percent remain impaired. Given this limited progress, the U.S. Environmental Protection Agency, multiple state agencies, and non-governmental organizations have proposed water quality trading as a cost-effective means to achieve pollution reductions from point and nonpoint sources. To determine whether these programs actually achieve cost-effective pollution reduction in practice that they promise in theory, I evaluate direct and indirect outcomes associated with three water quality trading cases: the Grassland Area Farmers Tradable Loads Program in California's San Joaquin Valley; the Tar-Pamlico River Basin Nutrient Offset Program in North Carolina; and the Long Island Sound Nitrogen Credit Exchange in Connecticut.

Although reallocating reduction efforts through trades to achieve cost-effective solutions is supposedly the major benefit of market-based instruments, only dischargers in the Long Island Sound Nitrogen Credit Exchange actively traded. The Grassland Area Farmers abandoned trading in favor of a more affordable and heavily subsidized management strategy, and members of the Tar-Pamlico Basin Association removed pollution onsite because reductions were less costly than expected and uncertainty over Offset Program parameters impeded planning around trades. Dischargers in the two cases also hesitated to trade because political transaction costs that trading imposed on relationships among entities did not outweigh perceived savings. Connecticut mitigated these costs and uncertainty by administering the Nitrogen Credit Exchange. The major contributions of market-based instruments across cases were facilitating dischargers' willingness to accept more stringent regulations and increasing the institutional capacity for watershed management by encouraging formation of organizations along hydrologic boundaries and information collection and dissemination. These benefits are attributable to the decentralized governance structure in general rather than economic incentives specifically, suggesting that policymakers should consider other decentralized approaches to watershed management. If policymakers want dischargers to actively trade, they should design parameters that mitigate uncertainty, market distortions, and political transaction costs. Even if trades never occur, however, indirect outcomes associated with market-based instruments are significant given the ongoing challenges to water quality improvement under the Clean Water Act.

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CHAPTER 1: FRAMING THE PROBLEM – SUCCESSSES AND ONGOING CHALLENGES OF THE CLEAN WATER ACT

Water has filled an integral role in the development of the United States. Before the advent of railroads and highways, rivers comprised major thoroughfares, and cities located along prominent harbors and confluences. Early settlers and subsequent generations nourished themselves with fish, and farmers used streams and diversions to irrigate crops. Water powered the early stages of the industrial revolution. Water bodies also served as receptacles for human, agricultural, and industrial waste. Over the centuries and particularly since the Industrial Revolution, these uses have degraded water quality to the point that in many places native fish no longer thrive and people cannot safely swim. Ohio's Cuyahoga River infamously ignited due to oil and grease contamination and was declared a fire hazard in 1969 (Plater et al. 1998, 502). In the watershed where I grew up, the Nashua River changed color daily based on dyes released by paper factories. Worsening conditions and the groundswell of concern for the environment led to governmental action to restore the nation's water resources.

In response to these conditions, Congress passed the 1972 Clean Water Act, which requires states to adopt ambient water quality standards for surface water with the goal of restoring all waters to fishable and swimmable conditions. In its early years, the Act primarily imposed technology-based standards on pollutant dischargers, meaning that effluent limits are derived from "Best Available Technology Economically Achievable." The National Pollutant Discharge Elimination System (NPDES), the major Clean Water Act program, requires the U.S. Environmental Protection Agency (EPA) or approved states to issue permits to point source dischargers based on "technology-based effluent limitations."¹ Congress did not initially call for regulation of nonpoint sources because point sources were considered the primary cause of impaired waters; nonpoint source regulation typically involves land-use controls, which traditionally fall under local jurisdiction; and it is far more difficult to hold diffuse nonpoint source dischargers accountable when the exact location and impact of pollution is unknown (Plater et al. 1998, 501-2, 514).

Compliance with technology-based limits within NPDES permits was sufficient to restore some water bodies to conditions safe for fishing and swimming; estimates suggest that 90 percent of point source pollution has been removed since Clean Water Act passage (Plater et al. 1998, 501-2). The Cuyahoga River is now an amenity in Cleveland's downtown. However, in areas with concentrated point sources, incidence of previous contamination remaining in sediments and the water column, or excess nonpoint source pollution from agriculture or stormwater runoff, waters

¹ A point source is "any discernible, confined and discrete conveyance... from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture" (33 U.S.C.A. § 502(14)). A nonpoint source is "any man-made source, discharging to surface waters, that is not a point source. In general, a nonpoint source is a diffuse, intermittent source of pollutants that does not discharge at a single location but whose pollutants are carried over or through the soil by way of stormflow processes" (Plater et al. 1998, 513). States may administer NPDES programs if they receive approval from EPA, although state programs remain subject to EPA review (33 U.S.C.A. § 510).

remain impaired even after point sources complied with technology-based limits (Plater et al. 1998, 501-2; Vergura et al. 2003, 51). Furthermore, NPDES does not impose limitations on nonpoint sources lacking one discharger or location on which agencies can impose permits. NPDES also exempts agricultural dischargers by designating them a category of nonpoint source pollution despite agriculture being the most widespread source of water pollution in the U.S. (Austin 2001, 340; Plater et al. 1998, 506-7).

EPA acknowledges that efforts under the Clean Water Act to restore the nation's waters have been incomplete. First, most water bodies are not monitored for many chemical, physical, and biological parameters (EPA 2003b). Second, of those that are monitored, 40 percent of rivers, 45 percent of streams, and 50 percent of lakes failed to meet water quality-based standards suitable for their designated uses such as fishing and swimming as of 2003 (EPA 2004, 1). To address these ongoing challenges, EPA began incorporating water-quality based standards in the late 1980s rather than relying primarily on technology-based limits. In addition, the agency transitioned from point source-by-point source management to a more holistic, watershed-based approach that considered the impact of all sources, including nonpoint sources, on water bodies (EPA 2003b; Viessman and Hammer 2005, 14; Interview G-7).

The first step in pursuing this more holistic approach is to determine whether water bodies meet quality-based standards. If so, states implement anti-degradation policies to maintain water quality. If not, states place them on the 303(d) list for impaired waters. Next, states should identify pollution sources and the amount of reductions necessary to achieve restoration goals (EPA 2003b). Section 303 of the Clean Water Act establishes a Total Maximum Daily Load (TMDL) as the maximum pollutant loading that a water body can assimilate without impairing water quality beyond what is allowable under its designated use. Based on the TMDL analysis, states distribute that load among point sources of pollution (known as the wasteload allocation), nonpoint sources (known as the load allocation), and an additional margin of safety that ensures discharges do not exceed the total pollution a water body can assimilate (Furtak 2006). Together, the wasteload allocation, load allocation, and margin of safety essentially create a pollution "cap."

EPA encourages states to implement a plan to achieve loading reductions necessary to meet TMDL allocations. However, the Clean Water Act only requires the Agency to approve TMDL analyses; EPA does not enforce against states that fail to implement plans and achieve TMDL allocations (Plater et al. 1998, 534; Interview O-2).² Further, EPA requires states to incorporate more stringent water quality-based limits consistent with the wasteload allocation into NPDES permits if a TMDL analysis is complete (EPA 2003b; Interview O-2).³ Given the cost of such limits, point sources are likely to delay or resist these changes. States have their choice of additional policies and tools to achieve discharge reductions in compliance with the TMDL

² TMDLs and water quality-based standards were largely ignored for the first couple decades after Clean Water Act passage until many lawsuits against states and EPA forced agencies to define a TMDL completion schedule (Feldman and Heinrich 2003, 256; Interviews L-5, O-2).

³ Because allowable discharges depend on water quality rather than available technology, discharge targets under TMDL plans are known as water quality-based standards, compared to the initially more prevalent technology-based standards. This distinction means that even though a point source might use the Best Available Technology Economically Achievable to reduce pollution, a NPDES permit can assign a stricter discharge limit to maintain consistency with a completed TMDL analysis wasteload allocation.

analysis, and many have implemented voluntary programs that educate and provide incentives for point and nonpoint sources to implement best management practices that reduce discharges. In addition, some states have approved water quality trading programs in which point and nonpoint dischargers in the same watershed voluntarily buy, sell, or offset the ability to discharge pollution. In fact, TMDL analyses and the incorporation of more stringent, water quality-based limits into NPDES permits are the driving force behind many water quality trading programs nationwide since point sources often find it more affordable to pay others to reduce pollution than to comply onsite (EPA 2004, 2).

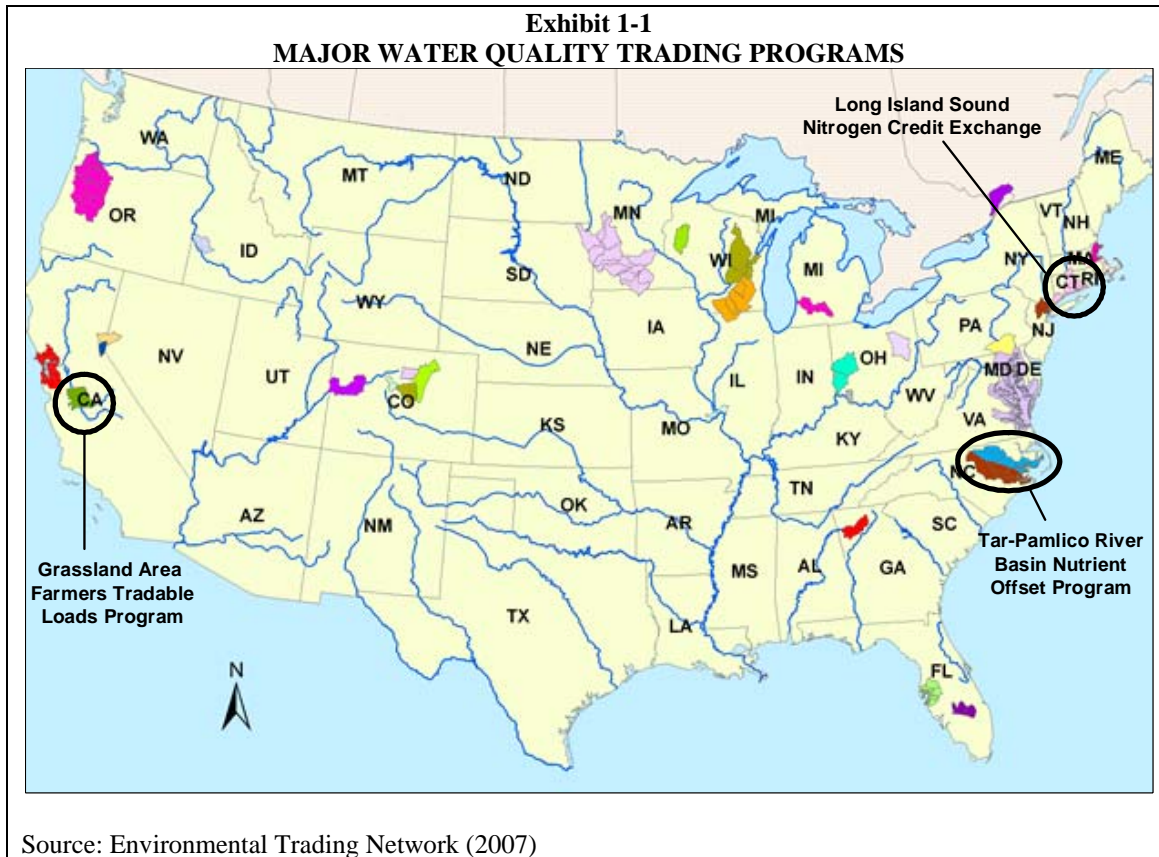
To be effective, any management strategy that states adopt to achieve their TMDL goals must incorporate political viewpoints, environmental concerns, economic realities, legal authority, and technical and physical parameters within an area that often does not coincide with political boundaries (Viessman and Hammer 2005, 6). However, because of point sources' resistance to more stringent water quality-based standards, agricultural exemptions, financial barriers to pollution reduction upgrades, difficulties making nonpoint sources accountable for meeting their load allocation, lack of information on the sources and impacts of pollution, and challenges coordinating management strategies on a watershed scale, much pollution continues to enter and impair waterways despite increasing reliance on water quality-based standards. In this regulatory environment, water quality trading presents a way to engage sources and persuade them to reduce discharges by allowing them to profit from credits that others pay to offset their own discharges. In theory, water quality improvements that would not otherwise occur become feasible due to gains in cost-effectiveness which allow sources to maximize the amount of pollution reduction possible with available resources. This ability is particularly relevant for publicly-owned sewage treatment plants that face an ongoing struggle to secure public funds to upgrade aging infrastructure. EPA recognizes that trading might not be the most effective or appropriate tool in all watersheds or for all pollutants, however (EPA 2004, 2-3; Interview O-2).

Because of the theoretical benefits of market-based instruments, multiple states and local governments have established water quality trading programs as part of broader watershed strategies to more cost-effectively reduce pollution loads entering and impairing waterways. To determine whether this tool has effectively advanced its objectives and yield lessons for policymakers considering various implementation plans in other watersheds, my thesis asks:

“How and to what extent do market-based instruments in practice achieve the outcomes that they promise in theory?”

I analyze three cases that adopted water quality trading at least five years ago and claim to have reached their pollution reduction goals in the majority of years: the Grassland Area Farmers Tradable Loads Program in California's San Joaquin Valley; the Tar-Pamlico River Basin Nutrient Offset Program in North Carolina; and the Long Island Sound Nitrogen Credit Exchange in Connecticut (see Exhibit 1-1). I selected cases in existence for at least five years so that I could assess direct and indirect outcomes including whether trades occurred, changes in pollution discharges, and any unexpected results. Although one source suggests that as many as 70 market-based instruments have been implemented, piloted, or proposed (Kieser and Fang 2005), I identified just 14 major programs that began in the U.S. before early 2002 (EPA 1999;

Fang and Easter, 2003; Breetz et al., 2004; Hahn, 1989; Kieser and Fang, 2005).⁴ Therefore, my analysis provides an in-depth examination of more than 20 percent of these older programs.



I argue that market-based instruments can only achieve their goal of improving cost-effectiveness if dischargers actually trade to reallocate pollution reduction efforts. This intended outcome does not consistently occur, but the implementation of trading programs can yield additional benefits. To support this argument, I assess factors that preceded the programs, either encouraged or deterred trading, and contributed to other outcomes that could indirectly advance water quality improvement goals. By analyzing three cases, I identify similarities in the tool's benefits and limitations.

Compared to research on the use of market-based instruments to manage air emissions, relatively little exists on water quality trading. Further, much of the literature covering multiple programs are surveys rather than case study analyses and tend to focus on program design and trading activity. This thesis contributes an in-depth analysis across three cases that explores the unexpected outcomes associated with market-based instruments in addition to trading activity and cost-effectiveness, including dischargers' willingness to comply with more stringent

⁴ In addition to the three cases evaluated in this thesis, the programs are: Boulder Creek, Cherry Creek, and Dillon Reservoir in Colorado; Piasa Creek Watershed in Illinois; Kalamazoo River in Michigan; Rahr Malting Company and Southern Minnesota Beet Sugar Cooperative in Minnesota; Passaic Valley Sewerage Commission Pretreatment Program in New Jersey; New York City Watershed Pilot Offset Program; and Fox River and Red Cedar River in Wisconsin (EPA 1999; Fang and Easter 2003; Breetz et al. 2004; Hahn 1989; Kieser and Fang 2005).

regulations, improved dynamics among stakeholders, formation of organizations along watershed boundaries, and greater collection, dissemination, and use of information.

This contribution is important because the ongoing challenges to continued water quality improvements under the Clean Water Act are not only the result of limited resources for pollution upgrades. On the contrary, progress has also been impeded by difficulties getting point and nonpoint sources to accept more stringent, water quality-based standards, incomplete information on pollution sources and impacts, and lack of institutional capacity to manage resources on a watershed scale. I argue throughout this thesis that the primary contribution of market-based instruments is not the ability to redistribute abatement efforts in order to achieve more cost-effective pollution reduction with finite resources. Rather, the major benefit of water quality trading is its ability to facilitate more stringent and unprecedented regulations and increase the institutional capacity for watershed management.

I develop and evaluate this argument as follows. Chapter 2 summarizes how water quality trading should achieve cost-effective outcomes in theory and outlines the accepted, necessary conditions for market-based instruments to function. I also present my methods for conducting this case study analysis. Chapter 3 places the background and design of the three programs in context in order to understand the significance of the findings in the remaining chapters. Chapter 4 analyzes why dischargers did not actively trade and thus reallocate pollution reduction efforts to achieve cost-effective outcomes in two of the cases but did in the third. In Chapter 5, I provide evidence that trading activity is not necessary to meet pollution reduction objectives. I also evaluate the unexpected contributions of trading to increasing the capacity to regulate and manage pollution on a watershed scale. In addition, I discuss whether program adaptability increased with the option to trade. Finally, Chapter 6 concludes with the major lessons from these cases and the broader implications for water quality planning.

CHAPTER 2: THE PROMISE AND PRACTICE OF POLLUTION TRADING

Although they have existed for decades, market-based instruments in general and pollution trading specifically are receiving growing interest as an efficient, effective, and affordable regulatory tool (Tietenberg 2007, 63; Ellerman 2007, 48; Rothenberg 2005, 220). Public attention has become particularly high in recent months as politicians debate ways to combat climate change; almost daily, newspaper editorials call for economic incentives to reduce carbon emissions (Leonhardt 2007).⁵ The U.S. Environmental Protection Agency (EPA) also recognizes the potential for leveraging market forces to improve and protect the nation's water resources; it issued a *Water Quality Trading Policy* in 2003, a *Water Quality Trading Assessment Handbook* in 2004, and is in the final stages of preparing a water quality trading guide for permit writers (EPA 2003a, 2004; Interviews L, O-1, O-2).

Before assessing how trading programs function in practice, I review why they should create cost-effective outcomes in theory. I note prominent trading "successes" that inspired policymakers in the three cases to explore market-based instruments. I next identify necessary conditions for a trading system to function and conclude by describing how I conducted this case study analysis.

The Mechanics of Trading

The foundational principle of environmental economics is that some pollution is efficient, but too much causes excess damage while too little unnecessarily precludes other beneficial activities (Kolstad 2000, 101). As a simple example, emissions from power plants incrementally harm human health, but the ability to pollute reduces production costs. If power plants operated at full capacity without abating emissions, the damage to health would exceed savings that plants derive from the ability to pollute. However, if power plants ceased emitting to prevent any human harm from emissions, production costs would be prohibitive, resulting in too little electricity. A balance exists where the marginal savings that plants gain from the ability to pollute equals the marginal damage imposed on others; this is the *efficient* level of pollution (Kolstad 2000, 148).

Often plants have different abatement costs and increasing marginal reduction costs, meaning it costs plants more per ton of pollution reduction the more that they reduce. If the government wants to limit the amount of pollution that plants emit to the efficient level, it could require all plants to reduce by the same amount (hypothetically, 10 tons) and impose costs on all plants. However, plants with higher abatement costs could save money by paying a plant with lower abatement costs to pollute less; thus the higher cost plant could reduce 8 tons while the lower cost plant reduces 12 tons. The plants can continue to decrease total abatement costs by paying the lower cost plant to reduce more until eventually marginal reduction costs at the two plants are

⁵ In a March 28 *New York Times* column entitled "Earth's Climate Needs the Help of Incentives," David Leonhardt argued that a cap and trade system for carbon could generate similar successes as it had in restoring fisheries and reducing acid rain-causing sulfur dioxide emissions (Leonhardt 2007).

equal. This *cost-effective* point occurs where no discharger can save money by paying another to reduce for less; the least-cost solution has been achieved (Kolstad 2000, 148).⁶

Adding another level of complexity to pollution management, identical amounts of emissions from plants in two different locations often do not have the same impact on ambient pollution levels or a particularly sensitive receptor. For example, if two identical power plants in different locations emit sulfur dioxide that creates acid rain damaging to forests, the plant closer to the forest could create twice the amount of acid deposition in the forest per unit of emissions as the plant that is further away; its equivalency factor is twice as high.⁷ If the agency knows the fate and transport of emissions and their effect on ambient pollution levels at the receptor, it can assign an ambient pollution limit rather than an emissions limit. After normalizing emissions by their equivalency factor, the cost-effective solution occurs where plants equalize the amount that they spend to decrease the marginal damage to the forest (Kolstad 2000, 157).

These increasing complexities illustrate the tradeoffs that regulators face between efficiency and simplicity, particularly when they lack complete information. One compromise is a zonal fee system that incorporates the impact of location more simply than an ambient system but more accurately than an emissions system. Rather than assigning each discharger a unique equivalency factor, the regulator divides the jurisdiction into zones and assigns each zone a factor (Kolstad 2000, 163).

Given that polluters typically have better knowledge of their operations and costs than regulators, agencies should more easily achieve least-cost solutions by implementing regulatory tools that grant polluters flexibility to decide how to reduce (Kolstad 2000, 180). The agency can employ market-based instruments to achieve this goal; I describe the three used in my case studies. First, it can institute a *cap and trade system* in which polluters are left on their own to identify each other, bargain, and trade pollution loads until they equalize marginal reduction costs. The cap provides certainty regarding the quantity of pollution reduced, but the price is less certain and depends on polluters' marginal reduction costs (Kolstad 2000, 184).

Second, if the agency knows the marginal cost of reducing from another source, such as the cost of reducing one pound of carbon by generating electricity from a wind turbine rather than a coal-fired power plant, it can offer polluters the option to offset their emissions at this rate. Under the *offset system*, a polluter chooses to either reduce its emissions by a specified amount or purchase credits, usually from a clearinghouse. This system increases certainty regarding pollution abatement costs; marginal abatement costs should not exceed the offset rate because the rational polluter will purchase credits if its costs are greater than the credit price. The agency must ensure that offsets actually fund reductions additional to any reductions that would have otherwise occurred in order for the offset system to reduce a specific quantity of pollution. Otherwise, the offset functions as a tax that somewhat deters emissions. In summary, offsets

⁶ For the purpose of this thesis, I do not evaluate the efficiency of trading programs. Other than mentioning any concerns about pollution reduction targets that stakeholders voiced, I do not question the cap imposed by the regulatory agency. Rather, I evaluate whether trading programs enable dischargers to pursue the most cost-effective solution to achieving pollution reductions by engaging in trades to redistribute reduction efforts. I also discuss non-market costs and benefits that address other challenges to continued water quality improvements.

⁷ Equivalency factors are also known as transfer coefficients.

have medium quantity certainty but high price certainty (Kolstad 2000, 184). Further, the clearinghouse lowers transaction costs associated with uncertainty, search, and bargaining.

The third tool is a hybrid of the cap and trade and offset systems. Known as a *credit exchange*, the agency sets a cap on all polluters and assigns them individual reduction targets. The agency also establishes a clearinghouse and sets a credit value. If the discharger does not reduce enough, it can purchase credits similar to the offset system. If the polluter reduces more than necessary, it can sell credits to the exchange. Thus the polluter has more incentive to reduce pollution than under the offset system because reducing more than necessary avoids costs *and* generates revenue. However, unlike the offset system, payments that the clearinghouse receives for credit purchases do not necessarily induce similar reductions elsewhere; the credit exchange does not guarantee that it is revenue neutral, meaning that credit sales equal purchases. As a result, the credit exchange only has medium certainty regarding the quantity of reduction but high certainty regarding the price. Again, the clearinghouse lowers transaction costs associated with uncertainty, search, and bargaining. Table 2-1 summarizes these tools.

THREE MARKET-BASED INSTRUMENTS TO ENCOURAGE COST-EFFECTIVENESS			
	Certainty of Reduction		Transaction Costs: Search and Bargaining ^a
	Quantity	Price	
Cap and Trade	High Certainty	Low Certainty	Potentially High
Offset Program	Medium Certainty	High Certainty	Low
Credit Exchange	Medium Certainty	High Certainty	Low
^a Transaction costs associated with search and bargaining are likely to vary by choice of market-based instruments. I discuss other types of transaction costs later in this chapter.			

Theoretical Advantages of Market-Based Instruments Over Prescriptive Regulations

Ellerman (2007, 49) explains that both traditional regulations and market-based instruments involve “command” by an agency; the distinction is the level at which the command occurs. Prescriptive regulations specify particular limits at each source of pollution, whereas market-based regulations only specify the aggregate limit among a group of sources in a particular region. Under the decentralized, market-based approach, dischargers maintain autonomy to decide how they want to meet production limits.

The sulfur dioxide cap and trade system established under the 1990 Clean Air Act amendments was one of this country’s first major experiments with market-based instruments and demonstrates several advantages that market-based instruments might yield over prescriptive regulations. Known more commonly as the Acid Rain Program, Congress established and distributed tradable emissions rights as a way to achieve 50 percent reductions in sulfur dioxide emissions (Ellerman 2007, 52; Kolstad 2000, 21). Many stakeholders that I interviewed cited it as one of the reasons they chose to explore pollution trading in their watershed.

Market-based instruments are touted as having many advantages over traditional prescriptive regulations. First, they should save money by allowing dischargers to identify the least-cost method to achieve necessary reductions. Under the Acid Rain Program, the price per ton of sulfur dioxide dropped from over \$500 to \$65, suggesting major decreases in abatement costs

(Kolstad 2000, 21).⁸ Second, economic incentives can be designed to achieve objectives faster by encouraging early over-compliance (Leonhardt 2007). Cap and trade and credit exchange systems encourage more rapid reductions by providing polluters the opportunity to earn revenue for their efforts. Along with offset programs, they also induce early compliance by allowing dischargers to avoid the costs of purchasing the right to pollute. The Acid Rain Program realized almost fifty percent decreases in just the fifth year of implementation because it allowed polluters to voluntarily bank credits (Ellerman 2007, 50). The final major benefit that proponents tout is the ability of market-based instruments to encourage innovation in compliance mechanisms by creating value in the ability to reduce pollution more than necessary. Advances in scrubber technology and increased availability of low sulfur coal could arguably be attributable to the Acid Rain Program (Tietenberg 2007, 67).

EPA notes that trading may yield additional improvements in water quality, such as engaging less-regulated nonpoint sources in improving water quality through offset programs and generating ancillary benefits by reducing other threats to water quality as well as the pollutant being traded (EPA 2004, 1). The Clean Water Services Model Trade in Oregon's Tualatin Watershed illustrates these benefits. In 2001, the Oregon Department of Environmental Quality completed a temperature TMDL for the Tualatin River that required Clean Water Services, a sewer agency, to reduce its effluent's temperature by 95 percent in order to protect endangered salmon (ODEQ 2006, 12). Clean Water Services estimated that refrigeration would require an upfront investment of \$60 to \$150 million and annual operating costs of \$2.5 to \$6 million. Recognizing that the majority of temperature increases resulted from degraded riparian buffers upstream, the sewer agency proposed offsetting its temperature impact by paying farmers through the U.S. Department of Agriculture's Conservation Reserve Enhancement Program to restore vegetation and shade riparian corridors. This restoration should yield ancillary erosion and habitat benefits (Biorn-Hansen 2004; ODEQ 2006, 12; Interviews G, I). Although too early to evaluate outcomes since its 2005 implementation, the program demonstrates the additional benefits that water quality trading could achieve. Finally, EPA notes that trading can facilitate watershed management by increasing communication among stakeholders within a basin (EPA 2004, 1).

Necessary Conditions for Trading to Occur

Rothenberg (2005, 220) explains that while market-based instruments provide many opportunities, they also require careful design to function properly and avoid unintended consequences. In its *Water Quality Trading Policy* and *Water Quality Trading Assessment Handbook*, EPA outlines the following conditions that should exist to support a viable market-based instrument:

- **Regulatory Driver:** Without regulation, pollution abatement has little value to dischargers. The value comes from avoiding compliance costs or penalties imposed by a regulatory agency. For a trading system to function, explicit compliance and enforcement mechanisms must back up these regulations;

⁸ An alternative interpretation is that industry overstated compliance costs.

- **Suitable Pollutant with Reliable Units of Trade:** The exchange of pollution loads between two parties should not harm a third party (Easter et al. 1997, 604). Therefore, EPA prefers trades of nutrients (nitrogen and phosphorous) and sediments that are not sensitive to short-term loadings or prone to creating localized problems known as “hotspots.” EPA prefers prescriptive regulations with tighter controls for persistent bioaccumulative toxics that pose a greater risk to human health and have impacts more sensitive to temporary load fluxes. Suitable pollutants should be traded as distinct units, and any credits purchased should generate pollution reductions before or during the period in which they serve as a compliance mechanism;
- **Difference in Marginal Costs That Exceeds Transaction Costs:** Savings associated with trading must surpass the resources that dischargers expend in order for trades to be worthwhile. Conditions that increase transaction costs are described below;
- **Willingness to Participate and Provide Input:** A variety of watershed stakeholders should participate in the design of the program and the public should have access to information to increase the program’s credibility; and
- **Adaptability:** Agencies should conduct periodic evaluations accessible to the public that review whether trades advance water quality objectives, incorporate new or changing information, assess and if necessary adjust pricing mechanisms, and address any other concerns (EPA 2003a, 8-11; EPA 2004, 2; Easter et al. 1997, 604; Scholz and Stiftel 2005, 234).

In addition, Kolstad (2000) adds that a functional market requires:

- **Dischargers Responsive to Price Signals:** In order for a market to yield cost-effective outcomes, dischargers must realize the full costs and benefits of their management decisions. Incentives and penalties must affect those with the ability to change pollution levels. Trading is less effective in sectors that are heavily subsidized or have softer budget constraints (Kolstad 2000, 150).

Stavins (1995) identifies three sources of transaction costs that can prohibit trades: search and information costs; bargaining and decision-making costs; and monitoring and enforcement costs. These costs can be exacerbated by:

- **Insufficient Information:** Adequate information is a critical component of any market (Israel 2002, 245). Dischargers must know their marginal abatement costs in order to determine at what price it becomes advantageous to trade allocations or offset loads rather than reduce pollution onsite. They must also have enough information to estimate present and future credit or load prices. Finally, entities must be able to ascertain that purchased credits are legitimate in order to trust trading as a compliance mechanism that can be incorporated into their planning process; the government can play an important role in establishing this credibility (Israel 2002, 245). If these conditions do not exist, transaction costs will become excessively high; and
- **Market Thinness:** A small number of trading partners creates a condition of market thinness in which participants cannot easily identify advantageous trades.

Fewer transactions make it harder for dischargers to equalize marginal abatement costs and achieve cost-effective outcomes (Kolstad 2000, 170).

Method

To evaluate whether market-based instruments actually achieved theorized gains in cost-effectiveness, observe how programs dealt with obstacles to trading, and identify any common unexpected outcomes, I conducted a qualitative assessment of market effectiveness for three cases: the Grassland Area Farmers Tradable Loads Program; the Tar-Pamlico Basin Nutrient Offset Program; and the Long Island Sound Nitrogen Credit Exchange. As Tietenberg explains, a market-effectiveness evaluation assesses whether the programs' structure allowed a market to emerge that resulted in cost-effective reallocations of pollution or if transaction costs and other limitations prevented exchanges from even occurring. Similar to Wossink (2004) and Young (2004), I relied on interview responses and documented evidence rather than quantitatively modeling transaction costs and exchanges (Tietenberg 2007, 65, 89).

For each case, I examined publicly available and internal documents from regulatory agencies and regulated entities, including enabling legislation, agreements, and bylaws; annual reports; monitoring information; and budget data. I also reviewed third party sources such as journals, reports, and newspaper articles that described conditions in the watershed or the trading program specifically. Finally, I interviewed state and federal agency staff, regulated dischargers and their consultants, and environmental groups. I also spoke with a range of individuals involved in some aspect of watershed management who could broadly assess water quality-based regulations and trading programs. Table 2-2 summarizes the interviews that I conducted both in person and over the phone between November 2006 and March 2007, and Appendix 1 lists these individuals and describes my interview protocol.

	Federal Agency	State Agency	Regulated Entity	Environmental Organization	Total
Grassland Area Farmers Tradable Loads Program	4	4	7	1	16
Tar-Pamlico River Basin Nutrient Offset Program	0	4	2	4	10
Long Island Sound Nitrogen Credit Exchange	4	2	2	0	8
Other	10	1	0	2	13
Total	18	11	11	7	47

Summary

Water quality trading offers many potential benefits because of its theoretical ability to maximize a regulation's cost-effectiveness. However, multiple conditions are necessary for the tool to succeed, and some factors inherent to water quality management such as pollution fate and transport and market thinness may limit this promising tool's practical benefits. To determine

whether water quality trading contributes to pollution reduction by reallocating loads to increase the impact of abatement efforts or by realizing other indirect, ancillary benefits, I evaluate different market-based instruments in California, North Carolina, and Connecticut.

CHAPTER 3: PLACING TRADING PROGRAMS IN CONTEXT

Tietenberg (2007, 64, 66) explains that no program evaluation is complete without considering context and relationship to existing regulations and complementary policies. Therefore, I present the environmental problems, political dynamics, and existing institutions that precipitated each trading program and describe the program design process. I include details relevant to discussions in Chapters 4 through 6 on why active trades only occurred in one out of three programs and the significance of the tool's unintended contributions to increased pollution regulation and management on a watershed scale.

Controlling Selenium in the San Joaquin Valley

The potent and deadly effects of selenium grabbed national attention in 1983 when U.S. Fish and Wildlife Service biologists discovered abnormal numbers of severely deformed and dead baby birds in the San Luis National Wildlife Refuge's Kesterson Reservoir (Harris 1991; Fisher-Vanden et al. 2004). The "Kesterson Disaster," as it was called, resulted when irrigation water leached the naturally occurring trace element selenium from soils into subsurface drains designed to prevent water-logging and salinization in farms along the western flank of California's San Joaquin Valley.⁹ The U.S. Bureau of Reclamation (the Bureau) began the San Luis Drain in 1968 to transport drainage water from Westlands Water District in Fresno County northwest to the San Francisco Bay Delta. Funding, political complications, and environmental concerns halted Drain construction in 1975, and water stopped abruptly in Kesterson after 85 miles (San Joaquin River Exchange Contractors Water Authority et al. 2003, 9; Young and Congdon 1994; Interview G-5).

Kesterson constituted a 1,200 acre reservoir in the midst of 60,000 acres of existing duck clubs and state and federal wildlife refuges (Interviews G-5, G-8). At first clubs welcomed the drainage water to supply the various wetlands and reservoir; the effects of selenium were not well-known or publicized. Lacking an outlet, however, selenium concentrated and bioaccumulated up the food chain until 1983 when 20 percent of nests contained deformed birds and over 40 percent had at least one dead embryo. Only one fish species remained (Young and Congdon 1994, 9).

Kesterson's consequences were drastic and long-lasting. The Bureau closed the San Luis Drain in 1986, converted the reservoir to upland habitat, and ripped subsurface drains out of lands within Westlands Water District (California Regional Water Quality Control Board 2001, 3; Interview G-5). Yet the same level of agriculture was not possible since salinization and water-logging threatened productivity.

⁹ This portion of the Valley is highly dependent on irrigation as it receives less than ten inches of precipitation annually (Austin 2001, 344).

Located between the massive Westlands Water District, Kesterson, and other wetland refuges, seven districts totaling approximately 97,000 acres in the Grassland Basin also relied on drains. They ranged from 840 to 42,300 acres, and land within them produced primarily cotton, melons, vegetables, alfalfa, grains, grapes, and orchard fruit (San Luis and Delta-Mendota Water Authority 1996; Austin 2001, 344).¹⁰ Their drainage flowed into channels that initially delivered a mix of “hot” and “fresh” water to other wetland refuges before the Kesterson Disaster.¹¹ After the discovery of wildlife mortalities, channels flipped between conduits of fresh water for the wetlands and drainage water that passed en route to the San Joaquin River. The 1992 Central Valley Project Improvement Act increased fresh water allocations to the refuges, and the “flip-flop” system restricted delivery of this preferable supply (Austin 2001; Interviews G-1, G-5).

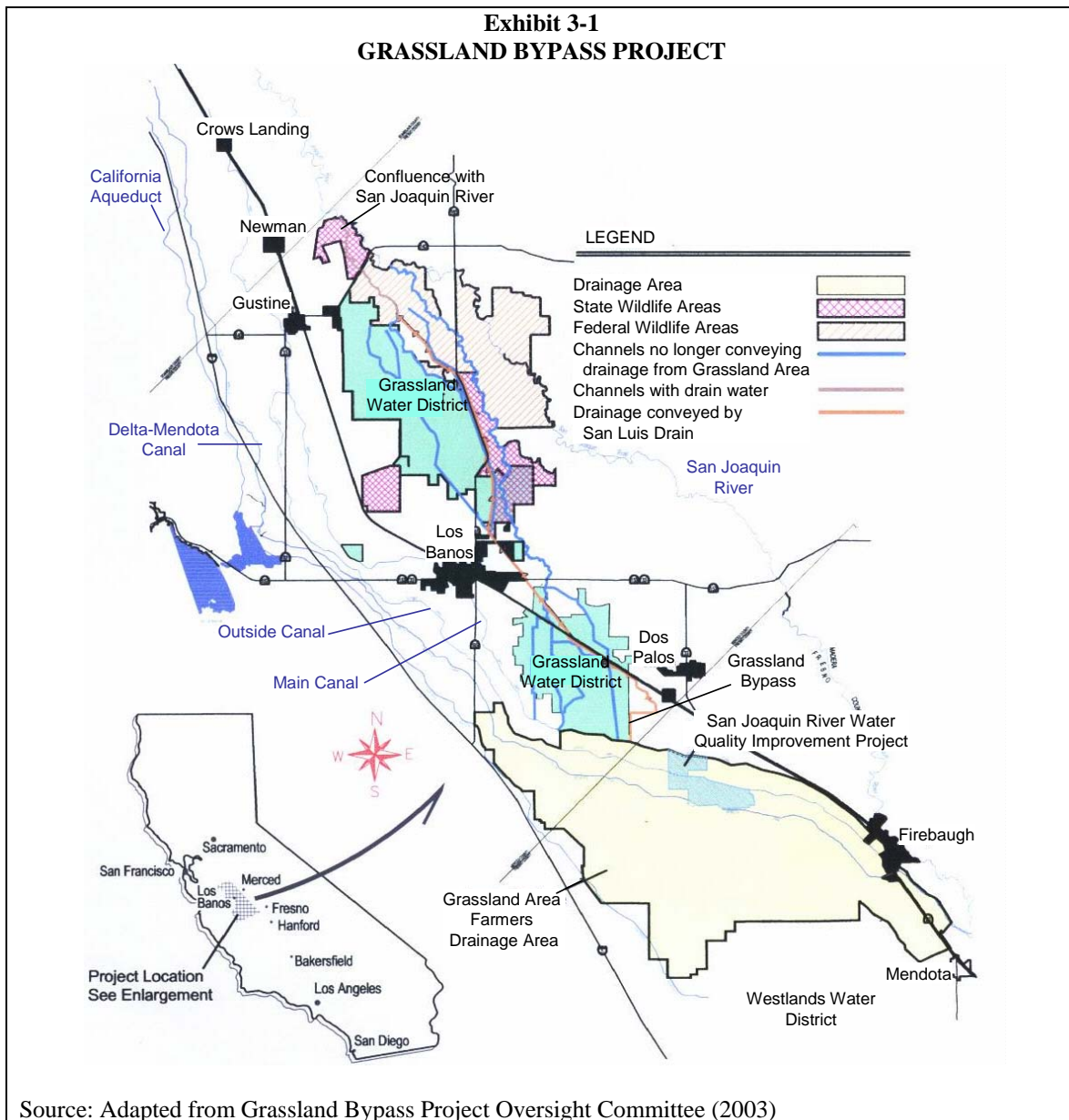
Given the outcry over selenium’s deadly effects on wildlife and the increased availability of fresh water, district managers and farmers in the Grassland Area saw mounting pressure to prohibit selenium-laden drain water from passing through channels and reduce selenium loads by regulating drainage. Realizing that productivity would decrease without drainage, the seven districts began negotiations in 1988 with San Luis and Delta-Mendota Water Authority (the Water Authority),¹² the Bureau, U.S. Fish and Wildlife Service, EPA, Environmental Defense, and downstream Contra Costa County and Contra Costa Water District over use of 28 miles of the San Luis Drain to bypass water around the wetland channels into Mud Slough eight miles upstream of its confluence with the San Joaquin River (San Joaquin River Exchange Contractors Water Authority 2003, 9; Grasslands Area Farmers 2006; Interviews G-1, G-4, G-8, G-12). The proposition was controversial, with many concerned that it was reviving Kesterson’s “killer drain” (Interviews G-1, G-8). The seven districts formed the Grassland Area Farmers in 1995 as a regional drainage entity within the Water Authority in order to enter into an agreement with the Bureau (see Exhibit 3-1) (Interview G-4, Fisher-Vanden et al. 2004; USBR 2005).¹³ The Bureau and Water Authority on behalf of the Grassland Area Farmers signed the Agreement for the Use of the San Luis Drain (known as the Use Agreement) in November 1995, commencing the Grassland Bypass Project. The Use Agreement contained two components critical for a tradable loads program: 1) the Bureau’s condition that selenium discharges from the region to the San Joaquin River stay below monthly and annual limits; and 2) granting the Grassland Area Farmers the right to design their own management system to achieve these regional limits. The Bureau monitors selenium loads coming from the Grassland Area at Site B in the San Luis Drain just upstream of its confluence with Mud Slough.

¹⁰ In 2003, the crop market value from the area’s agricultural production approximately equaled \$113 million, which generated an additional \$126 million for the local and regional economies. Together, the area has an economic value of roughly \$239 million (San Joaquin River Exchange Contractors Water Authority et al. 2003, 6).

¹¹ No drainage from the seven districts was ever delivered to Kesterson Reservoir.

¹² The San Luis and Delta-Mendota Water Authority is a Joint Powers Agreement comprised of 32 water districts with federal contracts to receive water from the Central Valley Project. Under California law, two or more governmental agencies (in this case, water and drainage districts) with a common interest may form a Joint Powers Agreement. Districts formed the Water Authority in order to assume operations and maintenance responsibilities from the Bureau for the federal infrastructure that conveyed water to them. The Grassland Area Farmers formed as an Activity Agreement within the Water Authority (Interview G-4).

¹³ The seven districts are: Broadview Water District; Firebaugh Canal Water District; Pacheco Water District; Panoche Drainage District; Charleston Drainage District; Widren Water District; and Camp 13 Drainage District.



Administered by an Oversight Committee composed of senior staff from the Bureau, U.S. Fish and Wildlife Service, California Department of Fish and Game, Central Valley Regional Water Quality Control Board, and EPA, the Use Agreement set clear enforcement and accountability conditions. It could terminate drain access if discharges exceeded 120 percent of the regional selenium load limit or created “unacceptable adverse environmental effects” (Young and Karkoski 2000, 157; Austin 2001, 350). The Grassland Area Farmers, governed by the Grassland Basin Drainage Steering Committee composed of representatives from each district, paid incentive fees for lesser exceedances (Austin 2001, 351).^{14, 15}

¹⁴ Under “unforeseeable or uncontrollable conditions,” the Use Agreement grants the Oversight Committee the authority to waive incentive fees or termination of the Grassland Bypass Project (Young and Karkoski 2000, 157).

The selenium limits took effect in 1997, and in the first two years the goal was for discharges to remain constant compared to historical average of 6,660 pounds per year. The load limit has since decreased until reaching its wet year limit of 3,087 pounds in 2005. The critical dry year limit will continue to decrease until it reaches 1,001 pounds in 2010 (Young and Karkoski 2000, 157; San Francisco Estuary Institute 2007; Interviews G-1 and G-2).^{16, 17} These final limits are consistent with the Total Maximum Monthly Load that the Central Valley Regional Water Quality Control Board completed in 2001.

Unlike elsewhere in the U.S., California Regional Water Quality Control Boards have the authority to regulate and issue waste discharge requirements to both point *and* nonpoint sources, including agriculture. The Central Valley Regional Water Quality Control Board issued a Phase I waste discharge requirement to the Grassland Bypass Project in 1997, and the effluent limits in the Phase II requirement in 2001 were based on the Total Maximum Monthly Load (California Regional Water Quality Control Board 2001; Austin 2001, 340-341; Interview G-6).

Incorporation of Water Quality Trading

The selenium reductions outlined in the Use Agreement and waste discharge requirement became the regulatory driver for the Grasslands Area Farmers Tradable Loads Program. Terry Young and Chelsea Congdon of Environmental Defense first proposed a cap-and-trade system in their 1994 report *Plowing New Ground*, which provided the framework for the Use Agreement (Young and Congdon 1994; Interviews G-1 and G-12).¹⁸ Young and Congdon (1994) envisioned a two-tiered system in which the Bureau set a regional reduction limit, provided monitoring, and imposed penalties for exceedances while the Grassland Area Farmers administered the Tradable Loads Program among the seven districts internally. After allocating the regional load among districts, each member district could either meet its share or purchase load allocation from other districts (Austin 2001, 338). Young felt that trading would be the optimal regulatory system because it would meet the pollution cap;¹⁹ promote cost-effectiveness; offer a flexible, decentralized strategy that districts could tailor to best meet their needs; promote equity through initial permit allocation; utilize existing monitoring systems to verify compliance; and minimize districts' and agencies' administrative costs (Young and Congdon 1994, ES-12).

¹⁵ The Second Use Agreement, granted in 2001 and extending the contract through 2009, allowed the region to earn incentive credits to offset future annual fees if discharges are less than 90 percent of the annual limit (USBR 2001, 5, 44; Young and Karkoski 2000, 157).

¹⁶ Remaining constant at Site B still required discharge reductions because of lower attenuation rates in the San Luis Drain than in the wetlands channels (Interviews G-1).

¹⁷ Load limits vary by type of water year (extending from October through September) because wet years lead to increased river flows, which subsequently allows more selenium to enter the San Joaquin River without violating water quality concentration standards (Young and Karkoski 2000, 157; Interviews G-1 and G-2).

¹⁸ Environmental Defense, a U.S. nongovernmental organization that had been involved in implementing trading to reduce sulfur dioxide under the 1990 Clean Air Act, is known for proposing free-market instruments.

¹⁹ As Chapter 2 explains, tradable permits should result in more definite pollution levels than offset fees but at the expense of some uncertainty in abatement costs (Kolstad 2000, 144). Although the Grassland Area Farmers could opt to pay incentive fees for mild exceedances, the threat of Use Agreement termination provided a strong impetus for the region to meet selenium load limits.

Unlike many other nonpoint sources, trading among the districts was feasible because they could record or estimate selenium loads by monitoring drains and sumps. The Grassland Area Farmers funded a Regional Drainage Coordinator and a Field Coordinator to collect and prepare the seven districts' loading data (Interview G-3).²⁰ Consequently, the program became one of the first water quality trading programs exclusively among nonpoint sources. However, this degree of accountability was not viable at the farm level because costs associated with increased monitoring and reporting would likely exceed efficiency gains (Interviews G-1, G-2, G-6, G-8).

Based on interest garnered by *Plowing New Ground* (Young and Congdon 1994), the Water Authority received a federal grant to hire environmental lawyer Susan Austin. The Grassland Basin Drainage Steering Committee convened an Economic Incentives Advisory Committee composed of Austin as project director, a district farmer, an EPA regulator, Young of Environmental Defense, and a professor in University of California at Davis's Department of Environmental Science and Policy to design the program. After iterations in June 1998 and January 1999, the Steering Committee passed the final Grassland Basin Drainage Steering Committee Rule Enforcing Selenium Load Allocation and Establishing a Tradable Loads Program for Water Year 2000 in October 1999 (Austin 2001, 353, 392; Interviews G-1, G-8).

The Advisory Committee devised rules for trading but left prices up to individual districts to negotiate. Assigning a penalty fee structure and allocating selenium among districts were the two greatest challenges that the Advisory Committee had to define, revise, and compromise on over the course of the deliberations (see Table 3-1).^{21, 22} Because districts could monitor their total discharges at a single point before these loads entered the San Joaquin River, the Tradable Loads Program did not have to safeguard against hotspots or assign trading ratios to compensate for uncertainty or disparate downstream impacts (Austin 2001, 372).

²⁰ In addition to the Grassland Area Farmers' water quality monitoring efforts at Site B and throughout the drainage area, the Central Valley Regional Water Quality Control Board monitors wetland water quality and the Bureau funds monitoring throughout the region. The Bureau pays the U.S. Geological Survey to collect water quality data at Site B (from which load levels are based) and U.S. Fish and Wildlife Service and California Department of Fish and Game to collect and monitor selenium levels in invertebrate and fish samples throughout the drainage area and wetlands. The San Francisco Estuary Institute, considered independent and neutral, compiles and publishes data from these sources. These data are considered reliable and accurate (Interviews G-2, G-5).

²¹ The final Tradable Loads Rule required districts that exceeded their allocation to pay their proportional share of the Bureau's incentive fee had the whole region exceeded limits by the same percentage. Districts discharging less than their allocation also received rebates equal to the lowest possible price per pound incentive fee that the Bureau would issue. Penalties and rebates were issued annually rather than monthly to allow districts greater flexibility, ease program administration, and decrease uncertainty by allowing trading after the year's monitoring data were available (Austin 2001, 354-5, 359-61; Interviews G-6, G-8). Rebates and fees somewhat decreased the need to trade because districts could simply earn or pay them rather than seek trading partners (Austin 2001, 361-63).

²² District allocations equally weight three factors contributing to selenium loads: area drained, area irrigated, and selenium concentrations (Austin 2001, 354-5, 359-361; Interviews G-1, G-2, G-6, G-8).

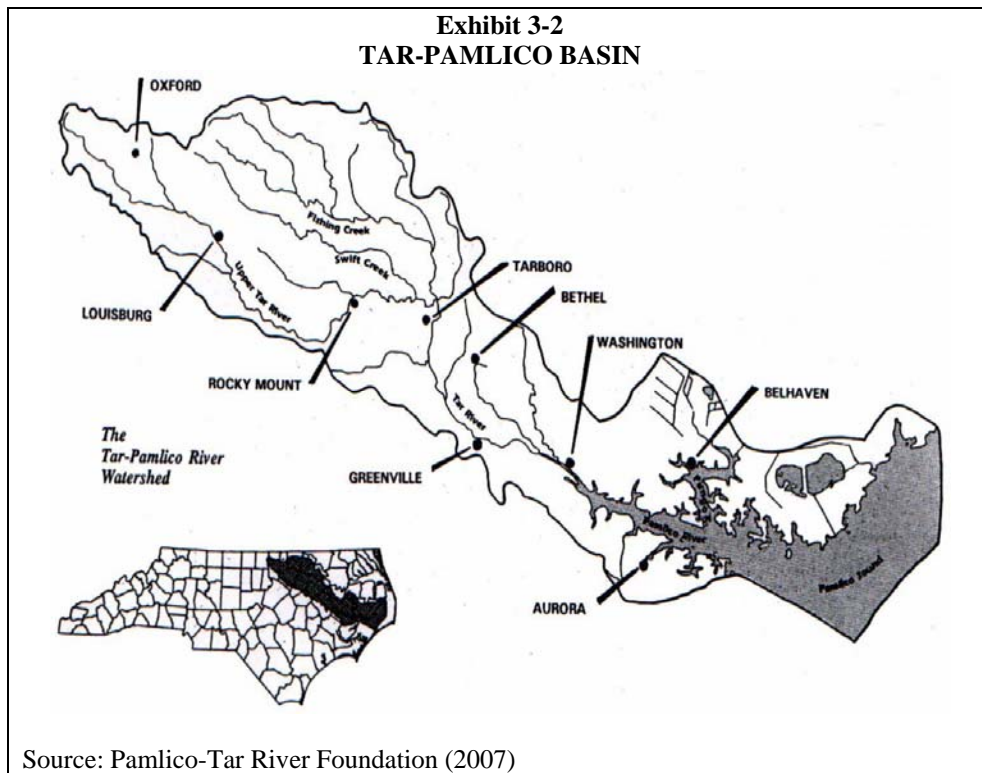
Table 3-1 GRASSLAND AREA FARMERS ANNUAL SELENIUM ALLOCATION, BY DISTRICT		
District	Acreage ^d	Selenium Load Limit (lbs) (Above Normal) ^{a, c}
Broadview Water District ^b	9,520	395
Camp 13 Drainage District	5,490	108
Charleston Drainage District	4,310	145
Firebaugh Canal Water District	22,300	593
Pacheco Water District	5,180	238
Panoche Drainage District	42,300	1,485
Widren Water District	840	15
Other	7,490	0
Total	97,430^c	3,088^f
Notes:		
^a Selenium load limits vary by type of water year, ranging from wet to critical.		
^b Broadview Water District sold its water allocation and no longer irrigates.		
^c Totals may not sum due to rounding.		
Sources:		
^d Derived from San Luis and Delta-Mendota Water Authority (1996).		
^e Derived based on selenium load allocation provided by Panoche Drainage District (2007) and annual load limit data from San Francisco Estuary Institute (2007).		
^f San Francisco Estuary Institute (2007)		

In summary, the Grassland Area Farmers Tradable Loads Program was born out of a nationally-publicized crisis that threatened a region’s primary industry. In a compromise to sustain agriculture and protect wildlife, districts, agencies, and environmentalists came together and adopted a cap and trade system as a decentralized mechanism to achieve unprecedented and stringent selenium reductions.

Saving the Pamlico River

Encompassing 30,000 square miles, the Albemarle-Pamlico watershed is the second largest estuarine system in the United States after Chesapeake Bay (Albemarle-Pamlico National Estuary Program undated). The Tar-Pamlico basin comprises almost 20 percent, or 5,570 square miles, of this system and is located completely within North Carolina (see Exhibit 1). From its source near the Virginia border, the Tar River flows approximately 140 miles through the rural Piedmont, past hog, cattle, and crop operations in the Coastal Plain, widens at Washington to become the Pamlico River, a tidal estuary, and travels another 35 miles before entering the Pamlico Sound (DENR 2004, Pamlico-Tar River Foundation 2007). The basin has traditionally supported valuable fisheries. However, anoxic zones known as “dead water” seriously threatened this economic base, recreational opportunities, and the estuarine ecosystem in the mid-1980s. The commercial fishery in the Pamlico River and Sound at the time totaled approximately \$20 million, or one-third of the state’s catch (Tursi 1987, 1). Fishermen and environmentalists voiced alarm over declining yields that they posited could be linked to

multiple causes including anoxia or hypoxia (Tursi 1987, 1, 10-11; Interview T-8).²³ Although some uncertainty existed, the North Carolina Department of Environment and Natural Resources (DENR) reported that approximately 78 percent of the nitrogen responsible for the hypoxic conditions entered the estuary from nonpoint sources including agricultural, rural, and urban runoff; 19 percent came from point sources including sewage treatment plants; and two percent from the country's largest phosphate mining and fertilizer plant located on the Pamlico's southern bank (Tursi 1987, 6).²⁴



The North Carolina Environmental Management Commission designated the basin as Nutrient Sensitive Waters in 1989 due to eutrophication in the upper Pamlico. Unique to North Carolina, the designation means that a water body is subject to excessive algal growth and thus requires additional management to control nutrients (typically nitrogen, the limiting resource in estuaries, and phosphorous, the limiting resource in freshwater) (DENR 2006a).²⁵ The Commission required the Department of Environment and Natural Resources to develop a basin-wide, site-specific nutrient management strategy.²⁶ Although they only attributed about 20 percent of

²³ Hypoxia refers to oxygen deficiency, and anoxia is more severe oxygen deprivation. Nutrient discharges cause these conditions because estuarine waters are typically nitrogen-limited, meaning that more algae can grow when additional nitrogen enters the system. The subsequent algal blooms die as they sink and receive less light. Bacteria consume oxygen as they decompose the dead algae, creating the low-oxygen conditions known as hypoxia or anoxia. This process is known as eutrophication.

²⁴ The agency was called the Division of Environmental Management (DEM) at that time.

²⁵ Unlike a 303(d) listing specified in the federal Clean Water Act, the Nutrient Sensitive Waters designation does not necessarily mean that a water body is *currently* impaired; rather, it means that water is *prone to* impairment (Interview T-8).

²⁶ The Environmental Management Commission exercises discretion as to whether it requires the Department to develop a nutrient management strategy and rules for water bodies designated as nutrient sensitive. The high-profile

nitrogen loads in the basin, the Department's nutrient strategy initially focused on point sources, in part because they were the only regulated nutrient dischargers in the watershed at the time (DENR 2004, 62; Fisher-Vanden et al. 2004, 227; Interview T-7). Primarily sewage treatment plants, these point sources possessed individual NPDES permits issued by the Department's Division of Water Quality for other pollutants. However, effluent limits for nitrogen and phosphorous did not exist in the state.

The Department of Environment and Natural Resources initially proposed reducing nitrogen and phosphorous loads from point sources by imposing uniform concentration limits on all effluent from sources discharging more than 0.5 million gallons of wastewater per day (mgd) (Interview T-3). Sewage treatment plants objected that such regulations would unduly burden them; back-of-the-envelope calculations suggested the proposed concentration limits would reduce nutrient loads from point sources by approximately 30 percent but would cost roughly \$50 to \$100 million (Fisher-Vanden et al. 2004, 227; Interviews T-3, T-6, T-7, T-8). With these concerns in mind, one municipality approached John Hall, a lawyer and former EPA policy analyst and engineer now working with Washington D.C.-based Hall & Associates. Hall suggested that the plants cooperatively identify an alternative nutrient reduction strategy that would achieve similar outcomes at less cost. The Tar-Pamlico Basin Association (the Basin Association, or the Association) formed in 1989 with the proposal that its 12 municipal members aggregate their nitrogen and phosphorous loads and meet reductions under a group cap instead of accepting nutrient effluent limits as part of their individual NPDES permits (Interviews T-3, T-6).

The Association went about selling the Division of Water Quality, the Pamlico-Tar River Foundation (the Foundation), a small grassroots organization founded in 1981 to protect the watershed, and Environmental Defense, the national non-governmental organization that also featured prominently in the Grassland Area Farmers Tradable Loads Program, on their idea.^{27, 28} Meanwhile, members also commenced reducing nutrient discharges in anticipation of future limits (Interviews T-6).

Incorporation of Water Quality Trading: Program Design

The structure of the Tar-Pamlico River Basin Nutrient Offset Program differs significantly from the Grassland Area Farmer Tradable Loads Program's cap and trade system. The Basin Association may purchase credits from the North Carolina's Agriculture Cost Share Program, administered by Department of Environment and Natural Resource's Division of Soil and Water Conservation, to fund the implementation of best management practices on farms in the basin if sewage treatment plant nutrient loads exceed the group cap. Unlike the Grassland

fish kills in the 1980s prompted the Commission to require that the Department develop a strategy for the Tar-Pamlico basin (Interview T-3).

²⁷ The Department of Environment and Natural Resources sought buy-in from the Foundation and Environmental Defense since they were instrumental in pressuring the Commission to make the Nutrient Sensitive Waters designation and were lobbying the Department to develop a nutrient strategy plan (Interview T-6).

²⁸ Sources interviewed disagree over whether John Hall or staff at Environmental Defense initially proposed water quality trading (Interviews T-6, T-7, T-8). Hall was familiar with water quality trading from his work at EPA, whereas Environmental Defense was a well-known proponent of market-based instruments, most notably sulfur dioxide trading under the acid rain title of the 1990 Clean Air Act Amendments.

program in which drainage districts are the primary pollution source, offsetting is possible in the Tar-Pamlico Basin because point sources are not the major nutrient source. In addition, offsetting appealed to treatment plants because they believed that agricultural nonpoint sources could achieve the same nitrogen reductions more cost-effectively.²⁹ The specifics of the Nutrient Offset Program evolved over the course of three phased agreements among sewage treatment plants, state agencies, and environmental organizations.

Phase I Agreement

The North Carolina Divisions of Water Quality and Soil and Water Conservation, the Tar-Pamlico Basin Association, Environmental Defense, and the Pamlico-Tar River Foundation jointly developed and signed the Phase I Agreement of the nutrient strategy. Although the Environmental Management Commission did not formally approve Phase I until February 13, 1992, it covered 1990 to 1994 and included:

- **Group cap** on combined nitrogen and phosphorous loads from Basin Association members that decreased by almost 20 percent from 525,000 kg/year in 1991 to 425,000 kg/year in 1994;^{30, 31}
- **Ability of Association to offset** loads that exceeded the group cap by buying credits from the Agriculture Cost Share Program (Nutrient Offset Program);
- **Upfront payments from Basin Association into Agriculture Cost Share Program** totaling \$850,000. Approximately \$150,000 came from the Association directly, and federal grants from EPA funded the remaining \$700,000; and
- **Development of estuary model** funded by a federal grant to the Association to estimate the level of nutrient reductions that would minimize chlorophyll a (an indicator of eutrophication) standard violations in the Pamlico River.

The Agreement is not a formal state rule; rather, it falls under contract law (Interviews T-3). In lieu of nutrient effluent limits, the 12 initial Association members' NPDES permits refer to the Agreement and group cap. However, it is not a group NPDES permit (Interview T-1), and members lack individual allocations. Instead, the group cap is internally managed as a "gentleman's agreement" among members that all will do their best to reduce nutrient loads (Interviews T-1, T-3, T-6). If the Basin Association fails to meet its load reductions, EPA has no jurisdiction to intervene and enforce (Interview T-2). Table 3-2 lists Association members.

²⁹ The offset system evolved from the Association's initial proposal to pay the North Carolina Agriculture Cost Share Program the costs of installing enough best management practices to reduce an equivalent amount of nutrient loads; they estimated this cost to be approximately \$11.8 million. The Association shifted tactics after a few initial payments (Interview T-3). Offset rates and credits were based upon the cost and estimated nutrient removal capacity of best management practices that the Agriculture Cost Share Program installed in North Carolina's Chowan Basin (Interview T-3).

³⁰ Although Phase I covered 1990-1994, signatory parties agreed that 1991 was the first year that Association members had to monitor nutrient discharges and track reductions (EMC 1994, 5).

³¹ The cap was derived from expected reductions resulting from proposed concentration limits rather than the estuary's need (Interview T-3).

	Date Joined	2005 Average Flow (MGD)	Percent Flow	2005 Nutrient Load	Percent Load
Rocky Mount	1991	11.019	37.73%	74,159	26.93%
Greenville	1991	9.165	31.38%	108,076	39.25%
Tarboro	1994	2.106	7.21%	38,073	13.83%
Washington	1991	1.942	6.65%	4,685	1.70%
Oxford	1991	1.111	3.80%	8,873	3.22%
Robersonville	1999	0.653	2.24%	5,761	2.09%
Louisburg	1991	0.620	2.12%	1,953	0.71%
Belhaven	1991	0.397	1.36%	4,370	1.59%
Enfield	1991	0.454	1.55%	2,003	0.73%
Warrenton	1991	0.433	1.48%	6,108	2.22%
FWASA	1991	0.494	1.69%	4,585	1.67%
Scotland Neck	2002	0.340	1.16%	7,532	2.74%
Pinetops	1992	0.210	0.72%	3,427	1.24%
Spring Hope	1991	0.157	0.54%	4,436	1.61%
Bunn	1991	0.105	0.36%	1,291	0.47%
National Spinning (closed 2005)	1994	0.258 (2003)	0.70% (2003)	2,913 (2003)	0.85% (2003)
Total		29.206	100.00%	275,331	100.00%
Note: Total does not include National Spinning, which closed in 2005. Source: Tar-Pamlico Basin Association (2007b)					

EPA was not involved in the Phase I nutrient strategy agreement, in part because no TMDL had been developed for the basin (Interview T-9). At the time, few TMDLs existed and the Phase I Agreement was one of the first cases where a form of water quality trading was a compliance option. Several sources noted that if the program were developed today when TMDLs are more common and EPA has issued water quality trading guidance, the program would incorporate more stringent accountability mechanisms such as a group NPDES permit (Interviews L, T-2, T-3, T-6).

The Basin Association surpassed its Phase I nutrient reductions by hiring a consultant to perform optimization studies at member plants to identify low-cost operational improvements that would reduce nutrient loads.³² These relatively simple modifications which members began to implement in 1989 allowed the Association to collectively achieve 80 percent of its Phase I reduction target (Interviews T-6, T-7). Second, the Association agreed that each member would install biological nutrient removal when conducting other plant modifications (DENR 2004, 62). Implementing nutrient removal simultaneously with other plant construction saved substantial capital.³³ The Association can expel members that do not install nutrient removal at the time of other plant renovations, but it has not been necessary to date (Interview T-6).

Under the Nutrient Offset Program, the basin's Agriculture Cost Share Coordinator uses revenue generated from offsets and upfront payments to locate lands where best management practices

³² For example, one plant significantly reduced its nitrogen by decreasing the amount of time that sludge was stored on site (Interviews T-6, T-7).

³³ One stakeholder estimated that adding biological nutrient removal on its own at a plant would cost \$1 million, but it would only add \$200,000 to other project costs (Interview T-6).

would have the greatest impact on estuary water quality, identify willing farmers, and cover 75 percent of installation costs.³⁴ The process typically takes three years from first contact with a farmer to a fully-functioning best management practice (Interviews T-4, T-5, T-6).

The upfront funds generated nitrogen credits at a rate of \$56/kg based on the estimated cost-effectiveness of best management practices multiplied by a 2.1:1 trading ratio. The 2:1 is for uncertainty and the additional 0.1 accounts for administrative costs (EPA 1999, 26; Fisher-Vanden et al. 2004, 226).^{35, 36} Through the upfront payments, the Association accrued 22,660 kg of nitrogen credits intended to expire at the end of Phase II on December 31, 2004. However, Association funds were just a fraction of the money coming into the basin to support agricultural best management practices, and many other sources had strict expiration dates. Therefore, the Coordinator prioritized spending other funds, and approximately \$30,000 of Phase I money remains unused (Interviews T-1, T-4, T-5). The Association argued and other Agreement partners granted that it should continue to receive credit for these initial payments since they will produce future nutrient reductions. Consequently, a nitrogen credit balance of 12,604 kg remains from Phase I (DENR 2006b; Interviews T-1, T-3).

In addition to being a type of water quality trading between point and nonpoint sources, offsets resemble a pollution tax to point sources because they maintain the option to discharge more than their allocation by paying a fee (Fisher-Vanden et al. 2004, 227). The certainty of total nutrient discharges depends on the reliability of offset reductions. If best management practices are implemented promptly and maintained properly, fewer nutrients enter the estuary. However, Phase I delays and questions of practice efficacy created uncertainty regarding discharge levels (Kolstad 2000, 144). Given that nutrients are less toxic than selenium and do not bioaccumulate, greater uncertainty in discharge levels in the Tar-Pamlico Basin yielded less acute environmental or public health risks than similar fluctuations in the Grassland Area.

For the final component of Phase I, Association members agreed to comply with reductions from a 1991 baseline that the estuary model calculated would reduce chlorophyll a water quality standard violations in the estuary (EMC 1994). It reported that no increase in total phosphorous and 30 percent total nitrogen reductions would address the majority of violations and substantially improve dissolved oxygen levels, while 45 percent total nitrogen reductions would eliminate violations (EMC 1994, 7). The estuarine model became the basis of the water body's TMDL, which EPA approved in 1995 although it is less rigorous than models used in more recent TMDL analyses (Fisher-Vanden et al. 2004, 227-8; DENR 2004, 63, Interview T-2).

³⁴ After the nonpoint source rule adoption, only counties that complied with agricultural nonpoint source targets could receive best management practices funded by Basin Association credits (Interview T-6).

³⁵ This ratio does not attempt to estimate the effect of source location on nutrient deliveries to the estuary, also known as a transfer coefficient. Rather, it treats a pound of nitrogen the same whether it occurs in the upper reaches of the watershed and partly denitrifies before reaching the estuary or is discharged directly into the estuary.

³⁶ Although free-market proponents argue that trading partners should set prices through negotiation, one stakeholder noted that the state needed to set the offset rate in order to avoid potential price volatility associated with a thin market (Interview T-2).

Phase II Agreement

Given lingering uncertainty and concerns regarding the feasibility and costs of a 45 percent nitrogen reduction, the Phase II Agreement called for a 30 percent reduction across all sources and no increase in phosphorous loads from 1991 levels. It recognized that further reductions might be necessary in the future (EMC 1994, 7-10). The Basin Association could still offset any nutrient exceedances and maintained credits accrued in Phase I. The Association also agreed to pay \$44,400 per year on average to fund a portion of the Tar-Pamlico Agriculture Cost Share Coordinator's position and support a U.S. Geological Survey monitoring gage on the Tar River. At a revised offset rate of \$29/kg, the Association annually earned approximately 1,520 nitrogen credits for future exceedances, or less than 0.4 percent of its annual nitrogen cap (DENR 2006b, 2007).

Point sources discharging more than 0.5 mgd that were not Association members were subject to individual concentration limits within five years. Facilities also had to offset any increased nitrogen and phosphorous loads from construction or expansion (EMC 1994, 13; DENR 2004, 62). No facilities had to comply with these limits because they discharged less than 0.5 mgd, joined the Basin Association, or connected their flows to an Association member, and no expansions or new plants occurred. By the end of Phase II, the Association had expanded from 12 to 16 members and accounted for 93 percent of the basin's point source discharges (DENR 2004, 66).

The Phase II Agreement also called for nonpoint sources to reduce nitrogen by 30 percent and not increase phosphorous over 1991 levels. Initially the Environmental Management Commission planned to meet these objectives by increasing efforts, targeting, and coordination among existing voluntary programs, but it determined that these programs were insufficient and initiated a NPS rulemaking process in 1998. Of the rules for riparian buffers, stormwater, nutrient management, and agriculture which became effective in 2000 and 2001, only the agriculture rule addressed existing runoff without a land use change trigger (DENR 2004, 63).³⁷

Notably, Environmental Defense and the Pamlico-Tar River Foundation did not sign on to Phase II because of concerns that: 1) the group cap should be a 45 percent nitrogen reduction and discrepancies in the baseline needed to be addressed; and 2) voluntary nonpoint source programs were inadequate (Interviews T-1, T-4, T-5, T-6, T-8).³⁸ Despite opposition from the environmental community, the Division of Water Quality moved forward with Phase II, which spanned from 1995 to 2004.

³⁷ The riparian buffer rule protected existing buffers, the nutrient management rule required fertilizer applicators (not including residential landowners) to take state-sponsored nutrient training or develop nutrient management plans for fertilized land, and the stormwater management rule required new development to reduce nitrogen runoff 30 percent below pre-development levels and hold phosphorous discharges constant. The agriculture rule required 30 percent nitrogen reductions and no phosphorous increases from existing land (DENR 2004, 63).

³⁸ The Division of Water Quality had to specify what portion of the reduced load should come from point and nonpoint sources. Earlier estimates suggested that point sources accounted for 15 to 20 percent of nitrogen entering the estuary (Tursi 1987, 6; Interviews T-6, T-7, T-8). To give credit to upgrades that the Association had made as part of the optimization studies prior to 1991 without resetting the model baseline, the Division agreed to only apportion 8 percent of necessary reductions to point sources (EMC 1994, 11; Hall 2004; Interviews T-6, T-8).

Phase III Agreement

Environmental Defense and the Pamlico-Tar River Foundation returned to the table for Phase III negotiations. The recent rulemaking addressed their nonpoint source pollution concerns, and they felt they could contribute rather than just react to the nutrient strategy as signatories (Interview T-1, T-5, T-8).³⁹ The Divisions of Water Quality and Soil and Water Conservation, the Basin Association, Environmental Defense, and the Foundation signed and the Environmental Management Commission approved an initial Phase III Agreement in April 2005, but some outstanding issues remained in early 2007:

- **Offset rate:** A North Carolina State University team is re-evaluating the average offset rate weighted by best management practice cost-effectiveness and feasibility within the basin (Interviews T-6, T-7);
- **Credit-earning activities:** Environmental groups objected to the Association's credit accrual for funding part of the Agriculture Cost Share Program Coordinator's position and U.S. Geological Survey gage since these activities do not directly reduce nitrogen loads. The Association holds that the Division of Water Quality requested the funding and it would not have agreed without credit (Interviews T-1, T-4, T-5, T-6). Environmentalists are also concerned that larger programs already fund agricultural best management practices.⁴⁰ To ensure that offsets actually induce additional change, they suggest funding stormwater retrofits not currently covered by nonpoint source rules. However, the Association resists paying substantially more for credits out of fairness to wastewater rate payers (Interviews T-1, T-3, T-4, T-5, T-7, T-8); and
- **Appropriateness of cap:** Environmental groups advocate a 45 percent nitrogen reduction. The Division of Water Quality agreed to reopen the TMDL and consider other nutrient management options if any portion of the estuary remains impaired in 2013 (EMC 2005, 19; Interviews T-3, T-5, T-6, T-8).

Parties will submit a revised Agreement to the Environmental Management Commission in 2007. Consensus exists that the Association will hit its cap in approximately ten years due to population growth, so parties view resolving issues as important before the Nutrient Offset Program really comes into use (Interviews T-1, T-3, T-5, T-8).

Monitoring

Basin Association members submit weekly discharge, upstream, and downstream water quality data to the Division of Water Quality.⁴¹ The Association also compiles and compares its members' annual load data to the group cap and submits these data to the Division (EMC 1995; Interviews T-1, T-7). The Division bases official nutrient numbers on the monthly point source

³⁹ The Association was also pleased that the state adopted NPS rules since these sources contribute the majority of nutrient loads to the estuary (Interview T-6).

⁴⁰ When the Nutrient Offset Program was first developed, the Agriculture Cost Share Program faced budget shortfalls and needed additional funds to complete projects (Interviews T-1, T-6).

⁴¹ The Division maintains the discretion to allow less frequent monitoring (EMC 2005).

submissions, but they are typically very similar to the Association's reports (Interviews T-1, T-5).⁴²

No one appears to doubt the reliability of regular point source monitoring data, but concerns exist regarding lack of data. For instance, the state manages ambient water quality monitoring but does not collect data along tributaries; conditions within whole portions of the watershed are unknown. In addition, agriculture nonpoint source pollution is estimated based on modeling rather than monitoring, and only approximately ten percent of best management practices are inspected annually (Interviews T-4, T-5). Farmers found in noncompliance pay back just the Cost Share money (Interview T-4).⁴³ Although stakeholders did not report problems with noncompliance (they did express uncertainty over best management practice effectiveness), this system suggests that monitoring and enforcement mechanisms do not ensure functional best management practices. Given concerns regarding lack of data, the Association and Division of Water Quality entered into a Memorandum of Agreement in October 2006 allowing Association members to form a monitoring coalition and gather ambient water quality data in lieu of reporting up- and downstream water quality data at specific distances from plants (DENR 2006c). This strategy would coordinate efforts and methods, reduce redundancy, and provide a better understanding of conditions throughout the watershed (Interviews T-1, T-4, T-5, T-6, T-7, T-8).

In summary, the Tar-Pamlico Basin faces three major challenges: nutrient loading that causes eutrophication, lack of data, and insufficient nonpoint source accountability. The Basin Association accepted a group cap on nutrients and the option to both offset and trade loads internally in exchange for avoiding costly, individual effluent limits. It has also provided funding to increase knowledge of the basin. Agencies, the Association, and environmental interests continue to negotiate the exact terms of this program since point sources will likely rely on it more in the coming years.

Enacting a Plan to Restore Long Island Sound

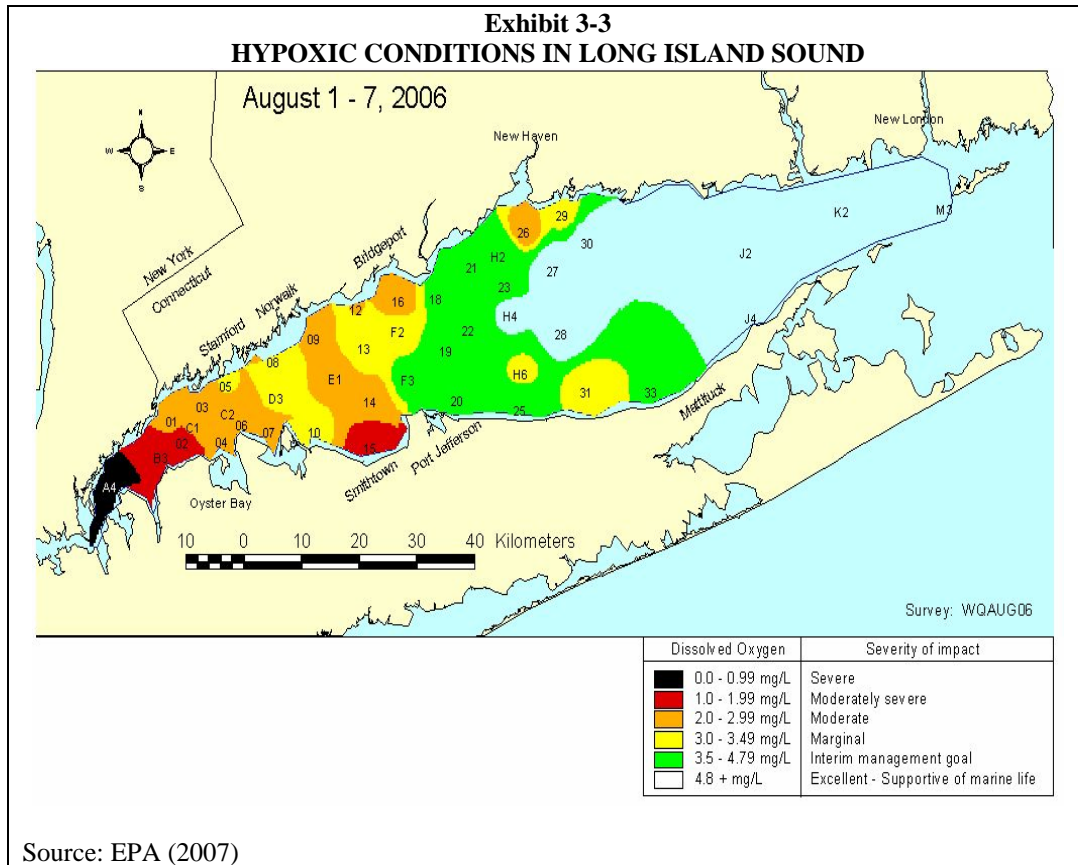
The Long Island Sound case bears similarities to both the Tar-Pamlico Basin Nutrient Offset Program and the Grassland Area Farmers Tradable Loads Program. The Sound is the nation's third largest estuary after Chesapeake Bay and the Albemarle-Pamlico Sound. It stretches 110 miles from east to west between Long Island and Connecticut, with only two outflows at either end. The Sound reaches 21 miles at its widest point. Its 16,000 square-mile watershed receives drainage from five states: Connecticut, New York, Massachusetts, Vermont, and New Hampshire (EPA 1994, 2-3). It is the only watershed I evaluate that is not completely contained within one state.

Similar to the Pamlico River, the Sound suffered highly publicized fish kills due to hypoxic conditions caused by nutrient loads in the 1980s (see Exhibit 3-3). Particularly severe fish kills

⁴² Some concerns exist over whether nutrient discharges during spills are fully counted (Interviews T-1 and T-5).

⁴³ Kolstad (2000, 205) explains that the optimal fine equals the marginal damage of the action divided by the probability of being caught. If the marginal damage equaled the amount that the Agriculture Cost Share Program paid the farmer to install the best management practice, then the fine should theoretically be ten times that amount to deter farmers from gaming the system and not maintaining their best management practices.

in 1987 and 1988 led to proclamations that the Sound was dying. Other events such as medical waste washing ashore also increased the salience of water quality problems (Interview L-1).



In 1985, Connecticut, New York, and EPA formed the Long Island Sound Study (EPA 1998). Again similar to the Albemarle-Pamlico Sound, Long Island Sound joined the National Estuary Program in 1987 (EPA 2007). Unlike the North Carolina estuary, however, Connecticut's Nitrogen Credit Exchange Program did not become effective until 2002, after years of planning and analysis (CTDEP 2006). In the interim, the Study developed a Comprehensive Conservation and Management Plan, released in 1994.

The Plan identified six problem areas: hypoxia; toxic contamination; pathogen contamination; floatable debris; impact of water quality problems and habitat loss on living resources; and detrimental effects of development on water quality and habitat. It prioritized addressing the hypoxic dead-zone that appeared in late summer in the western portion of the Sound (EPA 1994, 2). The Study also adopted a phased approach to reducing nitrogen: Phase I, which started in 1990, froze nitrogen loads at current levels; Phase II, beginning in 1994, called for low-cost nitrogen reductions throughout Connecticut and New York similar to the optimization modifications by Tar-Pamlico Basin Association members in the late 1980s and early 1990s; and Phase III, adopted in 1998, required the two states to develop watershed plans, incorporate nitrogen limits into point source permits, and conduct nonpoint source management and habitat restoration with the goal of reducing nitrogen loads by 58.5 percent within 15 years from 1999

levels. The states would have to meet 40 percent of this target in 2004 and 75 percent in 2009 (EPA 1998, 6, 13, 22-23).⁴⁴

Phase III of the Long Island Sound Study also called for the Connecticut Department of Environmental Protection (the Department, or CTDEP) and the New York State Department of Environmental Conservation (NYSDEC) to jointly develop a TMDL that would allocate nitrogen load reductions from point and nonpoint sources within the two states to achieve dissolved oxygen standards (EPA 1998, 22). Interestingly, one source familiar with the process noted that the Department of Environmental Protection actively pushed for TMDL development in order to lend authority and enforcement mechanisms to the policies that it would adopt to meet Phase III objectives. Policymakers recognized that a strong regulatory driver was necessary to induce dischargers and the state to financially commit to the nitrogen reduction strategies identified in the comprehensive planning process (Interview L-5).

The TMDL formalized and specified many of the findings that had already been agreed upon in Phase III of the Study (Interview L-1). Unlike the previous two cases, the majority of the 53,270 tons of nitrogen (73 percent) delivered to Long Island Sound from Connecticut and New York came from point sources.⁴⁵ Of this in-basin load, approximately 15,760 tons, or 30 percent of nitrogen reaching the Sound after natural attenuation, comes from Connecticut wastewater treatment plants (CTDEP and NYSDEC 2000, 15). Consistent with Phase III of the Long Island Sound Study, the TMDL called for a 58.5 percent annual reduction of in-basin nitrogen loads by 2014 in order to substantially reduce the incidence of hypoxia in Long Island Sound and its detrimental impact on marine life.⁴⁶ Taking into account feasibility and cost-effectiveness, the TMDL assigned a wasteload allocation requiring point sources to decrease loads by 64 percent in Connecticut and 59 percent in New York and a load allocation requiring nonpoint sources to reduce nitrogen discharges by ten percent in both states (CTDEP and NYSDEC 2000, 25; EPA 2007; Interview L-1).

Incorporation of Water Quality Trading: Program Design

Although water quality trading was a known tool that EPA was interested in pursuing in the late 1990s, the Long Island Sound Nitrogen Credit Exchange was largely the brainchild of Robert Moore, former Deputy Commissioner of the Department of Environmental Protection (Interviews L-1, L-2, L-4). Moore recognized that sewage treatment plants faced different nitrogen reduction costs. Further, the hydrodynamic model developed as part of the Long Island Sound Study and TMDL process demonstrated the varied effects of nitrogen discharges on dissolved oxygen conditions; loads from the northeastern portion of the state had far less impact

⁴⁴ The two primary reasons for the 15-year compliance schedule were: 1) it allowed facilities to save money by combining denitrification components with other plant modifications as they became necessary; and 2) there were insufficient public funds to support all upgrades at once (Interviews L-1, L-2, L-5).

⁴⁵ The remaining nitrogen comes from runoff, tributaries upstream of Connecticut, and boundary fluxes at the Sound's eastern and western outlets. Also, nitrogen delivered is less than total nitrogen discharged; portions of discharges natural attenuate before reaching the Sound (CTDEP and NYSDEC 2000, 12, 18).

⁴⁶ To meet water quality standards, the TMDL noted that in-basin reductions would be coupled with reductions of nitrogen and carbon from out-basin sources, non-treatment actions, and a margin of safety. Similar to the Tar-Pamlico basin, an annual limit was selected because nitrogen levels throughout the year contribute to hypoxic conditions, and hypoxia is not sensitive to daily or short-term loadings (CTDEP and NYSDEC 2000, 25).

on hypoxia in the western reaches of the Sound due to natural attenuation than discharges from the southwestern corner (CTDEP and NYSDEC 2000, 12; EPA 1998, 10-11; Moore et al. 2000, ES-1-3; Interviews L-1, L-2, L-4). Phase III of the Study also reported differences in sewage treatment plant capital costs per unit of oxygen improvement and set point source nitrogen limits at this “knee of the curve” to maximize oxygen improvements per dollar spent.⁴⁷ The Study opted not to assign stricter concentration limits to more cost-effective plants given uncertainties regarding actual costs and other considerations. Rather, it imposed uniform reduction targets but left effluent trading as an option to redistribute abatement efforts more cost-effectively (EPA 1998, 11-12, 15; Interviews L-1, L-2). The Department of Environmental Protection held public hearings to discuss point sources’ wasteload allocation and potential nitrogen trading as part of the TMDL process (CTDEP and NYSDEC 2000, 3).

New York chose not to pursue interstate trading, so Connecticut began designing its own program (Fisher-Vanden et al. 2004). Moore, who had left the Department, secured a grant that enabled a working group to develop a nitrogen trading program. Moore’s group proposed the following components to the Department and the Connecticut General Assembly:

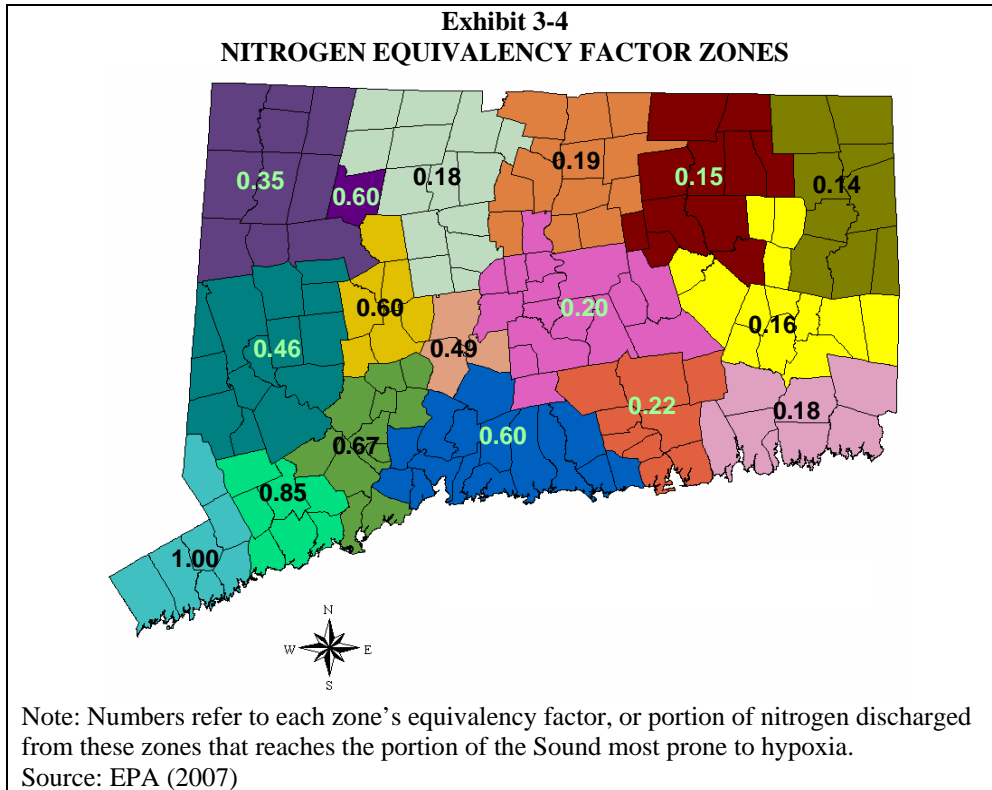
- **Equalized nitrogen credits:** All sewage treatment plant nitrogen discharges are normalized by their equivalency factor so that discharges equal the amount of nitrogen reaching portions of the Sound most prone to hypoxia.⁴⁸ These equivalency factors are derived from the TMDL’s hydrodynamic model (see Exhibit 3-4);⁴⁹
- **General Permit:** One General Permit covers nitrogen discharges from all sewage treatment plants in the state. The permit gradually decreases so that by 2014 it achieves a 64 percent nitrogen load reduction consistent with the TMDL wasteload allocation. The permit allows plants to comply by either reducing nitrogen discharges onsite or purchasing equalized nitrogen credits;
- **Nitrogen Credit Exchange:** Administered by the state, the Nitrogen Credit Exchange is a clearinghouse for plants that have not met their individual reduction targets to buy equalized nitrogen credits and plants that have reduced loads more than necessary to sell credits and generate revenue; and
- **Clean Water Fund support:** Municipalities may finance necessary plant upgrades through the Connecticut Clean Water Fund. The Fund provides grants for 30 percent of nutrient removal costs and offers two percent, 20 year loans for the remainder. It also covers the Nitrogen Credit Exchange’s administrative

⁴⁷ Using Department of Environmental Protection data, the Long Island Sound Study plotted estimated capital expenditures against modeled improvements in the Sound’s oxygen levels for each treatment plant. The “knee” occurred where the slope of oxygen improvement per dollar began to level, indicating that less improvement was occurring for each additional dollar. The Study calculated that upgrades only at plants with above-average cost-effectiveness would reduce nitrogen delivery by 62 percent (EPA 1998, 10; Interviews L-1, L-2).

⁴⁸ For example, the hydrodynamic model estimates that if Hartford discharges ten pounds of nitrogen, only two pounds will reach the portions of Long Island Sound prone to hypoxia and eight pounds will naturally attenuate en route. Therefore, Hartford has an equivalency factor of 0.20 (CTDEP 2006, 9).

⁴⁹ Another term for equivalency factor that appears in the pollution trading literature is “transfer coefficient” (Kolstad 2000, 156). The use of equivalency factors assigned based on the region in which a sewage treatment plant is located makes it a zonal fee system. This system is a compromise between the efficiency of an ambient fee system, which considers the impact of space on overall pollution levels at the receptor, and the simplicity of an emissions fee system, which considers only the amount discharged (Kolstad 2000, 163-164).

costs and any discrepancies between credit purchases and sales.⁵⁰ Sewage treatment plants may still participate in the Nitrogen Credit Exchange if they do not use the Fund to finance nutrient reduction (Moore et al. 2000; CTDEP 2007, 5, 7; Interviews L-1, L-2, L-3, L-4).



Moore's group estimated that the Nitrogen Credit Exchange would save over \$200 million in capital costs and reduce the total number of necessary upgrades compared to requiring all plants to meet the same standard. The program could also hasten water quality improvements by prioritizing nutrient removal efforts in the areas with the greatest impact on dissolved oxygen levels (Moore et al. 2000, 1-4; 3-4 - 5). Finally, it would reward facilities that upgraded sooner and more than necessary by allowing them to generate revenue from their investments (EPA 2007; Interviews L-1, L-6).

With support from EPA, Connecticut's Governor, and the Department of Environmental Protection, the Connecticut General Assembly passed Public Act 01-180, An Act Concerning Nitrogen Reduction in Long Island Sound, that established the Nitrogen Credit Exchange in June 2001; it took effect in 2002 (CTDEP 2006; Interview F). The Department issued a General Permit for the state's 79 sewage treatment plants, giving them a choice to join with the option to trade or receive an independent nitrogen effluent limit. All sources opted to join and have since remained in the program (CTDEP 2003, 2004, 2006, 2007; Interviews L-1, L-2).

⁵⁰ The Clean Water Fund derives its resources from federal grants and state revenue and general obligation bonds (CWF Advisory Work Group 2007, 9-11).

The Act also created the Nitrogen Credit Advisory Board to assist and advise the Department of Environmental Protection in the administration of the Long Island Sound Nitrogen Credit Exchange. The Board comprises 12 members representing agency interests and a variety of sewage treatment plant sizes and locations in order to get an equal distribution of buyers and sellers; it is appointed by the Governor and General Assembly (Connecticut General Statutes Sections 22a-521 – 527). The Board recommends the price of an equivalent nitrogen credit to the Department based on that year's capital and operating costs of per-pound equivalent nitrogen reduction at all facilities receiving Clean Water Fund grants and loans.⁵¹ The equalized nitrogen credit value has more than doubled from \$1.65 in 2002 to \$3.34 in 2006 (CTDEP 2003, 7-8; CTDEP 2007, Att. B). By March 31 of each year, the Department completes its audit of plant discharges, sends them a statement declaring whether they must purchase credits or receive payment, and specifies the annual equivalent nitrogen price. Plants must purchase credits by July 31, and the Department will buy excess credits from plants by August 14 (Connecticut General Statutes Sections 22a-521 – 527; Interviews L-2, L-4).

The Nitrogen Credit Exchange is a compromise between a quantity-based instrument like the Grassland Area Farmers Tradable Loads Program and a price-based instrument. Despite its revenue-neutral design, the exact amount of load reduction in any given year is somewhat uncertain since credit purchases do not have to equal sales. Like the Nutrient Offset Program, sewage treatment plants could potentially opt not to reduce and instead buy credits. However, the ability to earn revenue from upgrades by selling credits creates a greater incentive to reduce than just the avoided cost of an offset (Interview L-1).⁵² Furthermore, EPA could require individual permits instead of the General Permit or withhold federal support for the Clean Water Fund if the program causes plant discharges to exceed the TMDL's wasteload allocation; EPA lacks this enforcement mechanism in the Tar-Pamlico basin (Interviews L-2, L-3, L-4, L-5, T-2, T-3, T-6).⁵³ Given that nitrogen is less toxic than selenium and does not bioaccumulate, greater uncertainty in exact discharge levels in any given year yields less risk than it would in the Grassland Area (Interview L-5).

Of the three cases, Long Island Sound had the most data, greatest accountability among sources, largest market, and longest planning process pre-dating the trading program. The Long Island Sound Nitrogen Credit Exchange applied to all sewage treatment plants in Connecticut and encouraged them to reduce nitrogen in a way that could save money, generate revenue, and prioritize change where it would have greatest impact on water quality.

Summary

The catalyst and design of the Grassland Area Farmers Tradable Loads Program, the Tar-Pamlico River Basin Nutrient Offset Program, and the Long Island Sound Nitrogen Credit Exchange bear multiple similarities (see Table 3-3). They all formed as alternatives to prescriptive regulations that seemed likely in response to a highly-publicized environmental

⁵¹ The equalized nitrogen credit values represent subsidized rates because the capital costs do not include expenses covered by Fund grants and assume a two percent interest rate (CTDEP 2003, 7-8).

⁵² The state pays the difference if more sewage treatment plants sell credits than buy, and it deposits excess revenues into the Clean Water Fund if the opposite occurs (Interviews L-1, L-2, L-4).

⁵³ A few sources felt that such intervention by EPA would be unlikely (Interviews L-4, L-5, O-2).

problem. All dischargers accepted group limits on previously unregulated pollution, and program design and implementation led to the establishment of institutions aligning with watershed boundaries. Further, each program emerged from phased negotiations involving a variety of state, discharger, and environmental interests. Chapter 5 assesses the indirect and unexpected outcomes associated with these conditions and how they might contribute to future pollution reductions.

Despite these similarities, three different market-based instruments emerged with varying levels of quantity and price certainty. The Grassland Area Farmers Tradable Loads Program involved the strictest limit on discharges, in large part because selenium is an acute toxic with impacts more sensitive to short-term fluxes (EPA 2004, 5; Interviews O-2, L-5). The number of market participants and degree of state involvement also varied across cases. The following chapter discusses how these variations led to differences in dischargers' decision to trade.

		Grassland Area Farmers Tradable Loads Program	Tar-Pamlico River Basin Nutrient Offset Program	Long Island Sound Nitrogen Credit Exchange
Pollutant		Selenium (acute)	Nitrogen and Phosphorous (chronic)	Nitrogen (chronic)
Regulatory Driver		San Luis Drain Use Agreement ^a	Nutrient Sensitive Waters Designation	Long Island Sound TMDL
Design		Cap and Trade	External: Offset; ^b Internal: Potential Cap and Trade ^c	Credit Exchange
Buyer		7 Drainage Districts (NPS ^d)	External: 1 TPBA ^f (PS ^e) Internal: 15 TPBA ^f members (PS ^e)	79 sewage treatment plants (PS ^e)
Seller		7 Drainage Districts (NPS ^d)	External: Farmers (NPS ^d) Internal: 15 TPBA ^f members (PS ^e)	79 sewage treatment plants (PS ^e)
Clearinghouse		No	External: State-run Agriculture Cost Share Program; Internal: No	State-run Nitrogen Credit Exchange
Reduction Certainty ^g	Quantity	High	External: Medium; ^h Internal: High	Medium
	Price	Low	External: High; Internal: Low	Medium

Notes:

^a The Central Valley Regional Water Quality Control Board has since issued a waste discharge requirement to the Grassland Area Farmers; the Use Agreement and waste discharge requirement limits are identical.

^b The Tar-Pamlico Basin Association retains the ability to purchase offset credits if nitrogen discharges exceed the group cap. These offsets fund nitrogen reductions from agricultural land in the basin.

^c The Basin Association may meet its group cap however it chooses. Although outside sources have posited that an internal cap and trade exists and members have discussed the possibility, members report that they have not established such a system to date.

^d Nonpoint source

^e Point source

^f Tar-Pamlico Basin Association

^g High quantity certain means that the total amount of pollution discharged is definite; low means that total discharges may vary or exceed the cap. High price certainty means that definite limits on compliance costs exist, whereas low certainty means that costs are largely unknown.

^h The level of certainty regarding nitrogen discharges ranges from low to high, depending on whether it is assumed that agricultural best management practices are implemented on schedule and achieve their estimated reductions.

CHAPTER 4: EXPLAINING VARIATIONS IN TRADING ACTIVITY

In Chapters 1 and 2, I explain that three major challenges to water quality improvements are 1) difficulties getting point and nonpoint sources to comply with more stringent water quality-based regulations; 2) incomplete information on the sources and impacts of pollution on water bodies; and 3) funding pollution reductions, particularly at publicly-owned sewage treatment plants. As Chapter 2 explains, much of the pollution trading literature cites its ability to maximize the benefits of limited resources by achieving cost-effective solutions as the major benefit of trading. This chapter discusses whether the three programs realize this goal. I argue that market-based instruments can achieve cost-effective outcomes only if dischargers use them. Despite the deliberations that went into the three programs' formation, however, only the Long Island Sound Nitrogen Credit Exchange demonstrates active trading (see Table 4-1), indicating that market-based instruments for the most part did not perform their primary function of redistributing pollution reduction efforts cost-effectively.

	Grassland Area Farmers Tradable Loads Program^f	Tar-Pamlico River Basin Nutrient Offset Program^g	Long Island Sound Nitrogen Credit Exchange^h
Market Activity	None; some trading in past	External and Internal: None to date; expect future trades	Active
Years with Activity	2 out of 9	0 out of 16 ^a	5 out of 5
Peak Year Trading Activity	605 of 5,124 discharged lbs; ^b 12% (1999)	-- Never offset or traded	3,197 of 14,182 equalized lbs discharged/day; 23% (2004)
Price	Avg \$40/lb monthly allocation or \$100/lb annual allocation ^c	\$13.18/lb ^d	\$3.34/equalized lb ^e
^a Does not include credits accrued from upfront payments in Phase I or annual payments in Phase II. ^b This figure overstates monthly allocations exchanged in 1999 because it includes quantities for one trade in 1998. This figure also does not include the 128 pounds of annual allocation (2 percent of limit) that were exchanged in 1999 to prevent double-counting. ^c Based on average value of trades in water year 1999, which was the last time districts reported trades. ^d Based on offset rate of \$29/kg, which has been rate since 1994. ^e 2006 equalized nitrogen credit value. Sources: ^f Austin (2001); ^g North Carolina Department of Environment and Natural Resources (2006b); ^h Connecticut Department of Environmental Protection (2003; 2004; 2006; 2007).			

I attribute differences in activity to varying levels of conditions necessary to support trading that are either cited in the literature and described in Chapter 2 or identified in my assessment of the three cases. The additional conditions that I identified are whether trading was the most affordable strategy for dischargers and the ability of dischargers to incorporate trading into their long-term plans.⁵⁴ Table 4-2 compares whether these components existed in each case, and I argue that the variation in trading activity results from whether trading was the most affordable

⁵⁴ I distinguish cost-effectiveness as the solution that minimizes expenditures from *all* sources. In contrast, affordability only refers to the costs incurred by dischargers.

strategy available to dischargers, the ability to incorporate trading into long-term planning, and the magnitude of transaction costs compared to savings. The key difference in transaction costs is the presence of political transaction costs among dischargers in the California and North Carolina cases and the mitigation of these costs through state involvement in Connecticut. To support this argument, I describe the differences in trading activity among programs and then explain how the conditions necessary to support trading varied and why they enabled or deterred program use.

Table 4-2 COMPARISON OF ACTIVITY AND NECESSARY TRADING CONDITIONS			
	Grassland Area Farmers Tradable Loads Program	Tar-Pamlico River Basin Nutrient Offset Program	Long Island Sound Nitrogen Credit Exchange
Activity			
Dischargers Actively Trade	No	No	Yes
Necessary Trading Conditions^a			
Regulatory Driver ^b	Yes	Yes	Yes
Suitable Pollutant ^b	Questionable	Yes	Yes
Most Affordable Strategy ^c	No	No	Yes
Ability to Plan Around Trades ^c	Questionable	Questionable	Yes
Difference in Marginal Costs Exceeded Transaction Costs ^d	No	No	Yes
Responsive to Price Signals	Questionable	Questionable	Questionable
Increased Adaptability ^e	Questionable	Yes	Questionable
^a I describe necessary trading conditions identified by EPA (2003a, 2004), Easter et al. (1997), Kolstad (2000), and Scholz and Stiftel (2005) in Chapter 2. Additional necessary conditions that I identified are denoted (°). I argue that conditions shaded in yellow explain variation in trading activity. ^b I discuss the role of these conditions in Chapter 3. ^c The literature that I reviewed did not identify these components, but their role was apparent in the three cases. ^d I discuss three types of transaction costs: 1) insufficient information and 2) market thinness are discussed in the literature and Chapter 2; I define and identify 3) political transaction costs as another impediment to trading. ^e I discuss whether trading better prepared policymakers and stakeholders to adapt water quality strategies in Chapter 5.			

Summary of Trading Activity

Very few or no trades occurred in the California and North Carolina cases, demonstrating that market-based instruments did not directly lead to pollution reductions by enabling a more cost-effective allocation of abatement across individual dischargers in the two watersheds. The Grassland Area Farmers Tradable Loads Program featured some trading in its early years. An initial exchange between Charleston and Panoche drainage districts in 1998 made the internal allocation distribution acceptable to all districts (Austin 2001, 354). As of February 2000, nine trading agreements consisting of 39 separate component trades occurred between districts. Besides the initial Charleston-Panoche arrangement, these trades covered loads in water year 1999. The transactions resulted in 605 pounds of monthly load allocations, 128 pounds of annual load allocations, and \$14,320 changing hands, compared to an annual load limit of 6,327 pounds and annual discharges of 5,124 pounds in 1999 (see Table 4-1). Loads typically traded for \$40 per pound for monthly loads and \$100 per pound for annual loads based on the 1999 monthly and annual rebates of \$50 and \$120 per pound, respectively (Austin 2001, 380-381).

Individuals familiar with the Tradable Loads Program report that few trades occurred between 2000 and 2006.⁵⁵ They claim that trading alone would not allow the region to meet its increasingly restrictive limits and rising marginal abatement prices (Interviews G-1, G-2, G-3, G-5, G-6, G-11).

The Nutrient Offset Program comprised two types of market-based instruments. First and most discussed in Chapter 3, the Tar-Pamlico Basin Association (the Basin Association) had the ability to offset any nutrient discharges that exceeded its group cap by purchasing nitrogen credits from the North Carolina Agriculture Cost Share Program. Second, more informal and almost identical to the Tradable Loads Program, the Association maintained authority to induce members to meet the group cap however it chose, including with an internal cap and trade system in which some members who reduced nutrient discharges more than required could sell their excess allocation to others.⁵⁶ However, neither type of trading has occurred in the Tar-Pamlico Basin to date outside of initial Phase I payments and annual support of the Agriculture Cost Share Program Coordinator and U.S. Geological Survey gage. The Association has banked 28,960 kg of nitrogen credits through these payments, or approximately seven percent of its current annual nitrogen cap (DENR 2006b; 2007). Although some compared the annual credit accruals to an insurance policy, the small amount of credits substantiates others' claims that if and when the Association exceeds its cap, it will spend the banked credits rapidly and need to offset (Interview T-7).

Districts and Basin Association members would have found the Tradable Loads and internal nutrient trading programs more useful if they preferred reducing loads independently and exchanging among those over or under their allocation. According to a 1990 federal-state interagency study, decreasing agricultural water use, or source control, represented one way that growers and districts could reduce selenium loads in the Grassland Area (San Joaquin Valley Drainage Program 1990; Environmental Defense undated a). Onsite reductions were the districts' primary strategy in the early years when the few trades did occur (Austin 2001, 378-9; Grassland Area Farmers 2006, 2-4; Interviews G-2, G-3, G-4, G-8, G-9, G-10, G-12).⁵⁷

One striking similarity between the cases is that cooperation mitigated the need for trading. In the Grassland Area after 1999, districts transitioned away from trading onsite reductions to a less expensive regional strategy by combining their resources and attracting grant support, described in the Most Affordable Strategy section. Likewise, the Basin Association did not need to use offsets or internal trading because pooling members' resources to hire a consultant allowed them

⁵⁵ Internal documents suggest that some selenium was traded among districts in 2005 and 2006, although no stakeholders acknowledged these trades.

⁵⁶ An internal cap and trade or nutrient fee system would require the Basin Association to assign members individual nutrient allocations. Such assignment was possible with data gathered by the Association, but it was not a component of the group cap system as of early 2007 (Interviews T-6, T-7).

⁵⁷ Source control efforts included tiered water prices, irrigation improvements, canal lining to reduce seepage, workshops, and low-interest loans for efficient irrigation equipment. Some crop transitions also reduced irrigation in the Grassland Area. Finally, districts used state and district funds to construct recirculation systems that conveyed drainage water back into irrigation distribution systems. Selenium load reductions were not the only reason districts and growers implemented these strategies. They also sought to reduce water use because of severe drought in the late 1980s and early 1990s that led to improved water management and decreased discharges. Further, transitions to crops requiring less irrigation were driven by broader economic forces than the need to reduce selenium loads alone (Austin 2001, 378-9; Grassland Area Farmers 2006, 2-4; Interviews G-2, G-3, G-4, G-8, G-10, G-12).

to achieve significant reductions through low-cost modifications. Implementing nutrient removal at a few facilities kept the Association well below its group cap despite increasing discharge flows by seven percent from 1991 to 2004 (DENR 2004). It is also noteworthy that trading still *could* have accompanied these solutions; though unnecessary, it remained an option. Therefore, subsequent sections explore what deterred dischargers in both cases from generating revenue off of variations in onsite reductions or purchasing offsets.

Unlike the other two cases, all sewage treatment plants have actively and consistently participated in the Long Island Sound Nitrogen Credit Exchange since the program's inception (see Tables 4-1 and 4-3). In 2004, the year with the highest percentage of credits traded, the average of total credits bought and sold on the Exchange was \$2,223,270, or 1,170,142 equalized pounds of nitrogen.⁵⁸ This figure represents 3,197 equalized credits per day, or 21 percent of the permitted amount (15,444 equalized nitrogen pounds per day) and 23 percent of the daily average discharges (14,182 equalized nitrogen pounds per day) (CTDEP 2007, Att. E).

	2002 ^d	2003 ^e	2004 ^g	2005 ^h	2006 ^h
Facilities Selling Credits	39	40	35	29	32
Facilities Buying Credits	38	37	44	50	47
Participation Rate ^b [(Sellers + Buyers) / 79] * 100%	97%	97% ^f	100%	100%	100%
Maximum Sold	\$624,400	\$600,400 ^f	\$517,600	\$279,100	\$357,500
Minimum Sold	\$0	\$900 ^f	\$200	\$0	\$400
Maximum Bought	\$272,600	\$378,700 ^f	\$347,900	\$513,400	\$996,000
Minimum Bought	\$200	\$3,000 ^f	\$100	\$100	\$500
Total Sales	\$2,757,300	\$2,428,600	\$2,659,800	\$1,315,400	\$2,281,400
Total Purchases	\$1,317,200	\$2,116,900	\$1,786,700	\$2,466,700	\$3,949,900
Balance (Sold – Bought) ^c	\$1,440,100	\$311,800	\$873,100	-\$1,151,333	-\$1,668,500
Notes:					
^a Figures rounded to the nearest hundred.					
^b Sewage treatment plants did not participate in the Nitrogen Credit Exchange if their discharges exactly equaled their permit limit. They still were part of the General Permit, however.					
^c Numbers may not add due to rounding. Negative values indicate that facilities exceeded the General Permit limit in that year.					
Sources:					
^d Connecticut Department of Environmental Protection (2003), 8-9, unless otherwise noted					
^e Connecticut Department of Environmental Protection (2004), 2, unless otherwise noted					
^f Connecticut Department of Environmental Protection (2004), App. F					
^g Connecticut Department of Environmental Protection (2006), Att. H, unless otherwise noted					
^h Connecticut Department of Environmental Protection (2007), Att. E, unless otherwise noted					

Trading activity enables the redistribution of pollution reduction efforts for more cost-effective outcomes. However, opinions differ as to how well the Nitrogen Credit Exchange and Clean Water Fund actually prioritized upgrades at least-cost facilities. Some claimed that the program's design inherently facilitated upgrades at plants with the most impact on dissolved

⁵⁸ Conversion based on 2004 equalized nitrogen credit value of \$1.90 (CTDEP 2006, Att. H). I take the average rather than the sum of equalized credits bought and sold to prevent double-counting. Likewise, I would not count 20 for ten pounds bought and ten pounds sold for a ten-pound trade.

oxygen conditions and that the Fund increasingly prioritized projects with greater denitrification benefits. Others cited examples of Fund projects that did not generate substantial credit sales as evidence that the system was not achieving its cost-effectiveness goal (Interviews L-1, L-2, L-3, L-4). Despite debates over whether the program maximized cost-effectiveness, plants' willingness to participate and the fair portion of equalized nitrogen loads passing through the Exchange indicate that dischargers were at least willing to redistribute reduction efforts, the first step to achieving lower cost outcomes. Therefore, this chapter analyzes what variations in design and conditions made benefits large enough and sufficiently minimized transaction costs in just one case so that trading became a worthwhile compliance mechanism.

Chapter 3 describes the regulatory driver that prompted trading and pollutant suitability for market-based instruments in each case; Chapter 5 discusses whether trading contributed to pollution reduction efforts beyond increasing cost-effectiveness. The remaining sections of this chapter explain whether the necessary conditions to support trading outlined in Table 4-2 existed in each case and why these conditions create variations in trading activity. I demonstrate that the presence of a more affordable strategy, ability to plan, and magnitude of transaction costs relative to savings accounted for the variation in trading among these cases. Within the transaction cost discussion, I argue that political transaction costs, a previously overlooked obstacle, had the greatest impact on dischargers' decision to utilize market-based instruments.

Most Affordable Strategy

Chapter 2 explains that dischargers should theoretically want to trade in order to reallocate pollution reduction so that abatement occurs for less. However, dischargers have no incentive to trade if a more affordable alternative exists. I distinguish cost-effectiveness as the solution that minimizes expenditures from *all* sources. In contrast, affordability only refers to the costs incurred by dischargers. The level of trading activity in the Long Island Sound Nitrogen Credit Exchange suggests that it was the most affordable solution available. If sewage treatment plants could secure Clean Water Fund support, upgrading and selling credits generated revenue. Purchasing credits in the interim was cheaper than immediate upgrades (Interviews L-3, L-4).⁵⁹ In the remaining two cases, dischargers did not exercise their option to trade in part because more affordable strategies emerged.

Low-cost operational changes among all members enabled by pooling resources to hire a consultant and nutrient removal implementation at a few facilities kept the Tar-Pamlico Basin Association well below its group cap (Interview T-4). Insufficient data make it impossible to determine whether the Association could have achieved the same reductions for less by purchasing more nitrogen credits. Members had not calculated the portion of plant upgrades for nutrient removal specifically to determine the per-kilogram cost, although this analysis was feasible (Interview T-6, T-8). Furthermore, facilities with nutrient removal did not seek compensation from others. These two findings suggest some factor other than affordability drove the decision not to trade.

⁵⁹ Credit sales do not generate enough revenue to cover debt repayments; sewage treatment plants would not perform upgrades solely to sell credits. However, if they are performing upgrades, they will estimate revenue that they can generate from sales upon project completion (Interview L-3).

In contrast, Grassland Area districts ceased relying on onsite selenium reductions and trading whatever loads were over or under district allocations in favor of a more affordable regional solution known as the San Joaquin River Water Quality Improvement Project (SJRIP). In response to a 1995 lawsuit brought by Westlands Water District, the district that delivered selenium-laden drainage to Kesterson, a federal appeals court ruled in 2000 that the U.S. Bureau of Reclamation was responsible for solving the San Joaquin Valley's drainage challenges (Martin 2007). Consequently, the Bureau engaged in a Re-Evaluation Study to explore alternative drainage management solutions, including reuse (Interview G-12). SJRIP was a demonstration project that, if successful, could be replicated on a larger scale elsewhere in the Area or in Westlands.

Initiated and managed by Panoche Drainage District, the regional goal was to completely eliminate discharges into the San Joaquin River (Interview G-3).⁶⁰ Under SJRIP, the Grassland Area Farmers purchased land and converted it to a Regional Reuse Area. Instead of discharging into the San Luis Drain and San Joaquin River, SJRIP irrigated a range of salt tolerant crops with a mix of fresh and drainage water. Subsurface drains collected this water. As it evapotranspired, the drainage volume decreased and salt and selenium concentrations increased. Reuse did not reduce selenium; rather, the objective was to decrease drainage volume, store it in the ground, and eventually treat it with reverse osmosis or another strategy to remove and dispose of selenium elsewhere or perhaps incorporate it into a marketable product. Reuse reduced drainage volume by approximately 73 percent (San Joaquin River Exchange Contractors Water Authority et al. 2003, 8, 17; Interviews G-1, G-2, G-3, G-8, G-12). Until the Grassland Area Farmers identify an affordable treatment process, however, SJRIP will require more money to continue expanding the Regional Reuse Area for selenium storage purposes (Interviews G-3, G-8, G-11, G-12).

The regional solution was more affordable to districts than individual actions because the Panoche Drainage District Manager and Grassland Area Farmers Regional Drainage Coordinator solicited federal and state funds to implement SJRIP. However, when including government dollars, it was not the most cost-effective solution. In total, the U.S. Bureau of Reclamation, a state bond, California Division of Water Resources, and CalFed financed \$23.5 million, or 97 percent of total project costs as of 2006. In contrast, districts contributed only \$766,000, or three percent of costs (Grassland Area Farmers 2006).^{61, 62}

To illustrate the subsidy's effect, the Regional Reuse Area did not support profitable crops such as melons and tomatoes (Interview G-2). Instead, the influx of government money sustained less

⁶⁰ Panoche Drainage District is the largest of the Grassland Area Farmers districts, commands the most resources, and has some of the worst drainage problems due to above-average selenium concentrations. These factors may explain why Panoche Drainage District took the initiative and contributed a disproportionate amount of resources to a regional approach; it has the most to gain or lose from the Use Agreement (Interviews G-4, G-10, G-11).

⁶¹ Unpublished data from Panoche Drainage District (2007) indicate that districts paid almost \$1.9 million in participation fees to SJRIP between 2002 and 2007. If these fees were instead of the district contributions cited in Grassland Area Farmers (2006), total SJRIP project costs were \$25.4 million, and districts contributed over seven percent of costs. If these fees were in addition to contributions cited in Grassland Area Farmers (2006), then total SJRIP project costs were \$26.1 million, and districts contributed approximately ten percent of costs. In any case, government subsidies cover at least 90 percent of selenium management costs in SJRIP.

⁶² Some stakeholders suggest that individual district load reductions became cost-prohibitive as selenium limits decreased and marginal, per pound reduction costs rose (Interviews G-1, G-2, G-6, G-11).

valuable, more salt-tolerant crops. As long as these wealth transfers continued, a market distortion would deter districts from pursuing in-district source control and trading (Interviews G-11, G-12).

SJRIP also induced cultivation on land that might otherwise be retired. Per-acre SJRIP fees decrease if more land remained in production since the majority of the Reuse Area's costs such as purchasing land, planting crops, and monitoring were fixed and few costs such as pumping water were variable. Therefore, the marginal cost of sending an additional pound of selenium to the Regional Reuse Area was relatively low. This condition would likely remain until the Grassland Area Farmers identify a treatment process that removed selenium from drainage water. Consequently, more district land sending water to the Area as of 2006 increased the distribution of fixed costs and decreased average costs (Interview G-1).

Stakeholders seemed to agree that the small number, proximity, and good working relationships among districts allowed them to pursue a regional solution. However, they disagreed as to whether trading was a necessary or useful step in the evolution of a regional strategy to reduce selenium loads. Some claimed that the Tradable Loads Program eased the transition between forming the Grassland Area Farmers, meeting the initial Use Agreement limits, and pursuing a regional drainage solution; it represented one of many useful tools to achieve reductions in the early years until other options emerged (Interviews G-1, G-3, G-4, G-5, G-12). Others familiar with the program felt that the Grassland Area Farmers could have transitioned into a regional approach without attempting the Tradable Loads Program; one doubted that trading made any contributions (Interviews G-2, G-8, G-10).

Districts might have continued to utilize Tradable Loads Program for longer if they had not received government funds to initiate SJRIP. However, trading ceased because the wealth transfer prevented districts and farms within the region from fully internalizing the costs of selenium loads, driving down what they were willing to pay for selenium management (Interviews G-11, G-12).⁶³ Because of the 2000 court ruling, however, these funds were not debatable (Interview G-12). Yet concerns exist over the Reuse Area's long-term sustainability. Without treatment, the toxic element becomes increasingly concentrated. I present evidence supporting these concerns in Chapter 5, but it is important to note here that the Grassland Area Farmers abandoned depending solely on onsite treatment and trading loads amongst each other because a more affordable alternative emerged. Compared to historic loads of 12,700 pounds, the Grassland Area Farmers managed selenium in 2003 by sending 5,100 pounds (40 percent) to the Regional Reuse Area, discharging 4,000 pounds (32 percent) to the San Joaquin River via the Grassland Bypass and San Luis Drain, and reducing 3,600 pounds (28 percent) through onsite conservation activities, of which tradable loads was just one component (Grassland Area Farmers 2006, 2).

⁶³ The districts may not have remained under their limits without the Reuse Area and could have lost access to the San Luis Drain as a result (Interview G-1). If the Regional Reuse Area cannot accept all drainage water to meet increasingly stringent load reductions, districts may have to trade amongst each other again (Interview G-12).

Ability to Plan around Trades

The ability to trade or offset loads is most useful to dischargers if they can accurately foresee future market parameters and rates in order to reliably incorporate trading into their long-term plans. If the option or cost of trading is uncertain, dischargers may prefer alternative management strategies to avoid being caught unable to trade and thus penalized for noncompliance. Although no Tar-Pamlico Basin Association members voiced this concern specifically, they might have optimized and implemented onsite treatment as the opportunity arose rather than purchasing credits given some uncertainties surrounding the Nutrient Offset Program. In recent years, Agreement signatories questioned when credits started and expired; who should be liable for best management practice implementation; the offset rate; and valid use of offset credits. If Association members must purchase credits for stormwater rather than agriculture reductions, the offset rate would increase dramatically (Interview T-4, T-6, T-8). These uncertainties might have encouraged sewage treatment plants to make onsite reductions so that they could better comply if individual permits were issued or an unfavorable agreement were reached.

The state-run Nitrogen Credit Exchange overcame this instability and allowed treatment plant operators to plan by providing a guaranteed buyer and seller of credits and setting the credit value (Interview L-1, L-3, L-4, L-6).⁶⁴ Connecticut Department of Environmental Protection (CTDEP) filled the role that Israel (2002, 245) envisions for the government in trading programs: improving information regarding exchanges; reducing transaction costs associated with search, bargaining, and implementation; increasing the probability that successful exchanges occur; and reducing the risks to parties involved in transactions.

The most unreliable component of the Nitrogen Credit Exchange was Clean Water Fund solvency. The Nitrogen Credit Advisory Board determined equalized nitrogen credit value by dividing capital and operating costs of facilities receiving Clean Water funds by pound of equalized nitrogen credit removed. However, the Fund kept capital costs artificially low by providing a 30 percent grant and two percent loan. Although not obligated to use the Fund, facilities preferred its favorable terms and the program became dependent on state funds (Interviews L-1, L-3, L-4); consequently, more sewage treatment plants chose to purchase artificially low credits in order to comply with the General Permit than to self-finance, upgrade, and sell when the program was under-funded in 2005 and 2006.⁶⁵ The pollution reduction outcomes of this subsidy are discussed in Chapter 5.

In response to this criticism, it is important to note that the Clean Water Fund predated the Exchange and most municipalities would have relied on it for facility upgrades regardless of the Exchange. State revolving funds support sewage treatment plant upgrades throughout the U.S.

⁶⁴ Although the equalized credit price more than doubled in the Exchange's first five years of operation, stakeholders reported the ability to predict future credit prices (Interviews L-1, L-4). Some plant operators also calculated the level at which it became more cost-effective to reduce nitrogen onsite than purchase credits. By estimating the rate of price increase, they could determine when it was most effective to begin planning a facility upgrade (Interview L-4). Others state that potential revenues were not enough to induce upgrades; they were a benefit, but not a basis for decisionmaking (Interview L-3).

⁶⁵ One stakeholder suggested that if the Fund ceased and credit prices substantially increased, municipalities would resist paying so much for credits and the Nitrogen Credit Exchange might dissolve (Interview L-3).

Furthermore, those familiar with the process note that funding shortfalls often delay sewage treatment plant upgrades. Finally, excess revenues generated by the Exchange through credit sales repay the Fund and help finance future projects. Therefore, they see the Nitrogen Credit Exchange as an improvement over the status quo because it prioritized spending on projects yielding the greatest water quality improvements (Interview L-1, L-2, L-3, L-4). These findings support the argument that trading can improve water quality by maximizing available resources.

Finally, municipalities incorporated the Nitrogen Credit Exchange into their planning process because of its credibility. Since the program was created and administered by the state, sewage treatment plants were assured that purchasing credits was a legitimate compliance mechanism (Interview L-1). None of the lingering debates over offset rates and valid credit actions that possibly deterred facilities in the Tar-Pamlico from relying on the Nutrient Offset Program existed in Connecticut. In summary, although state administration meant that the Nitrogen Credit Exchange lost some free-market flexibility and efficiency, government involvement legitimized the program and made municipalities more willing to participate.

Difference in Marginal Costs Exceeds Transaction Costs

Trading will not occur if transaction costs exceed gains in cost-effectiveness; a discharger must save more money by paying another entity to reduce pollution than it expends in time and resources to make the trade happen (Stavins 1995). Differences in water contracts, crops, necessary irrigation levels, and selenium concentrations suggest that marginal reduction costs vary among Grassland Area districts (Interviews G-5, G-12).⁶⁶ Stakeholders familiar with the Tar-Pamlico Basin Association also indicated that some sewage treatment plants could more readily reduce nutrients than others (Interviews T-6, T-7). Given the apparent differences in marginal reduction costs, even larger transaction costs must have existed within the Tradable Loads and Nutrient Offset programs to explain the lack of trading. This section explains which costs deterred trading in California and North Carolina and how Connecticut overcame these obstacles in the Long Island Sound Nitrogen Credit Exchange.

Insufficient Information

Dischargers must know their marginal abatement costs in order to determine at what price it becomes advantageous to trade allocation or offset loads. District managers in the Grassland Area may have lacked enough information about their own districts to evaluate potential trades. Austin surveyed district managers to determine their understanding of selenium reduction activities' costs and benefits. While most knew the total amount of selenium discharged and costs of load reduction efforts, they were unsure how much these actions reduced loads or water

⁶⁶ Districts with federal contracts in the Grasslands Basin charge approximately \$75 per acre-foot of water, compared to average costs of \$20 per acre-foot among the exchange contractors (Interview G-5). Furthermore, the Central Valley Project Improvement Act (1992) provided water to the wetlands north of the Grasslands Area by "allocating off the top" of federal contracts for environmental purposes, thus reducing the amount of water available to these districts (Interviews G-1, G-5). Differences in water prices do not affect all selenium reduction strategies, however (Interview G-8).

use. Without quantifying the benefits of their actions, district managers could not accurately identify prices at which they should buy or sell (Austin 2001, 379-380).

Similarly, the Basin Association has not calculated total capital investments for nutrient removal within the basin. The analysis was possible, but without it the Association could not compare average nutrient reduction costs across members to determine whether offsetting was more cost-effective (Interview T-6). However, the fact that they had not calculated these costs and benefits again indicates that minimizing costs was not the primary driver of nutrient management decisions.

Information costs also most likely did not preclude a cap and trade system among Basin Association members. If insights from participants in the Long Island Sound Nitrogen Credit Exchange provide an indication, sewage treatment plants knew how much it cost to reduce specific amounts of nutrient discharges. Again, the fact that facilities were not using this information to increase the cost-effectiveness of their efforts suggests that other types of transaction costs deterred Basin Association members from trading.

Market Thinness

A small number of trading partners creates a condition of market thinness in which participants cannot easily identify advantageous trades. Fewer transactions make it harder for dischargers to equalize marginal abatement costs and achieve economic efficiencies that markets should provide (Kolstad 2000, 170). Market thinness seems the obvious reason why trades did not occur in California (seven districts) and North Carolina (12 to 16 point sources) but were active in Connecticut (79 sewage treatment plants) (Austin 2001, 365; Interview G-8).⁶⁷ The Long Island Sound Nitrogen Credit Exchange had few transaction costs from information or market thinness. State involvement eliminated costs associated with search and bargaining. Watershed size, density of facilities, incentives to join, and authority under the General Permit resulted in 79 plants participating in the Exchange. As a result, 34 percent of facilities buying and selling credits in 2006 exchanged less than \$10,000 (CTDEP 2007). If transaction costs had been higher, perhaps requiring additional staff to seek trades, these smaller exchanges would not have been worthwhile (Interviews L-1, L-4).

Market thinness did not pose a direct obstacle to the Tar-Pamlico Basin Association's participation in the external Nutrient Offset Program. The Association had a guaranteed price at which it could purchase credits, thus reducing search, bargaining, and decisionmaking costs.⁶⁸ Lack of buyers did hinder the Agriculture Cost Share Program's ability to spend credit revenues on best management practices, however, motivating the Division of Water Quality and

⁶⁷ The Grassland Area Farmers did not increase the number of participants in the market by extending the Tradable Loads Program to growers because it would have required substantial increases in the level and frequency of monitoring, making transaction costs prohibitively high. Furthermore, activities on one field may influence selenium levels underlying neighboring fields. In summary, it would be too difficult to create enough accountability to support trading among growers (Interviews G-1, G-2, G-6, G-8).

⁶⁸ The fixed price precluded any bargaining opportunities, including the possibility that the Association would have opted to offset if it could have negotiated a lower nitrogen credit price. No stakeholders expressed the desire to pursue bargaining, however.

environmental groups to suggest that the Nutrient Offset Program fund urban stormwater retrofits as well (Interviews T-1, T-5, T-6, T-8). Nevertheless, market thinness did not limit the Association's ability to participate in the Nutrient Offset Program.

On closer inspection, thin markets also did not explain the lack of activity within the Grassland Area and internal Association cap and trade programs. Few partners would have limited exchanges by increasing search and bargaining costs, but participants reported low transaction costs because the small number and proximity of dischargers increased the frequency of interactions. For example, monthly Steering Committee meetings provided an opportunity for districts to exchange information on who was willing to trade. It was easy for them to find partners and negotiate; districts reported that trades in 1999 on average took less than one hour to negotiate (Austin 2001, 382; Interviews G-1, G-8, G-12).

Tar-Pamlico Basin Association members also could have overcome transaction costs of internal trades through their familiarity and frequent contact at Association meetings. In fact, it appears that no attempt was even made to bargain; facilities that upgraded and invested in nutrient removal did not try to recover costs from other facilities that benefited from remaining under the group cap without capital investment (Interviews T-6, T-7). Finally, Association membership dues were distributed based on percentage of permitted wastewater flow rather than percentage of total nutrient loads, although the latter was possible with available data (TPBA 2007a; Interview T-7). In summary, no financial incentive existed among members to reduce loads other than avoided individual permit costs. Despite the belief of free-market proponents that economic rationale drove Basin Association members to reduce nutrients (Interview T-8), these findings suggest that another type of transaction cost existed which deterred members from offsetting and internal trading.

Political Transaction Costs

The two previous sections suggest that insufficient information and market thinness alone did not prohibit offsets and trades. Therefore, I suggest that another force was at play which I call *political transaction costs* and define as the costs that trades impose on relationships among entities.

The incentive driving the Tar-Pamlico Basin Association and the Grassland Area Farmers to keep discharges within the group limit was the desire to avoid individual permits and maintain drain access to collectively sustain agriculture. Both organizations naturally gravitated toward a team mentality to achieve these goals; they preferred collaboration for a regional solution over competition with each other to minimize individual costs (Interviews G-1, G-4, G-5, G-10, G-12). I attribute this preference to the political transaction costs that trading imposed on districts and sewage treatment plants.

Stone (2002, 267) notes that individuals are not economically rational actors and social welfare does not equal the aggregate of individual welfare. She also highlights that policymakers must consider the effects of collective processes on individuals, adopting a "polis" rather than a "market" view of society. More specific to this thesis, Breetz et al. (2005, 172) report that socio-cultural goals and concerns as well as the financial bottom line shape farmers' decisions whether

to participate in water quality trading programs. Stone's distinction and Breetz et al.'s observation might explain why Panoche Drainage District took the initiative with SJRIP, a project that benefits the whole Grassland Basin. Providing further evidence that the Grassland Area Farmers were not driven by short-term economic signals alone, one farmer and district representative commented that districts' desire to stay below selenium limits was motivated more by concern over bad press than by incentive fees (Young and Karkoski 2000, 158; Interview G-1). Furthermore, when the seven districts exceeded their monthly load limits in early 2005 and 2006, they opted to discharge less in later months so that the region still met its annual limit. This action did not save the Grassland Area Farmers money; they could have used accrued incentive credits to cover annual incentive fees. However, the Grassland Area Farmers felt that it would better serve their long-term interests to prove that they could remain under the annual cap in order to maintain trust with regulatory agencies and environmental groups (Interview G-1). Likewise, Stone (2002, 74-75) points out that most exchanges are part of long-term relationships, and loyalty, politics, and alliances preclude perfect competition. Supporting this observation, one informant reported that districts did not drive hard bargains when trading did occur. They preferred maintaining a "neighborly" relationship rather than appearing to profit from each other (Interview G-12).

Likewise, the peer pressure of achieving the Basin Association's goal was enough for members to make operational modifications and install nutrient removal when upgrading their plants; no one wanted to seem like they were taking advantage of the system and others' reductions by not doing their part (Interview T-1, T-6, T-7, T-8). They neither needed nor *wanted* financial incentives for their efforts, again indicating that asking sewage treatment plants to compensate each other would impose a political transaction cost. To confirm that lack of compensation was not just a matter of convenience, Association dues reveal that payments into the program to retain Hall & Associates as a consultant, support the U.S. Geological Survey gage and the Agriculture Cost Share Program Coordinator, develop a monitoring coalition, and other miscellaneous expenditures did not impose undue costs on members (TPBA 2007a, Interview T-7). However, political transaction costs would emerge if members tried to buy or sell nutrient load allocations from each other. One stakeholder explained that it would be politically unfeasible for a city or town council to approve payments to another municipality (Interview T-7). Just as Grassland Area districts did not traditionally compete (Interview G-12), municipalities did not want to seem like they were profiting from one another, overly reliant on each other, or paying another town for its infrastructure. Instead, a perception existed that members cooperatively met the cap by doing their share as opportunities arose (Interview T-6, T-7).

Transaction costs do not prohibit market activity from ever occurring. Instead, costs must either be minimized or benefits increased so that partners have enough to gain from trades or offsets that they overcome these costs. Stakeholders explained that as population growth in the Tar-Pamlico basin causes wastewater flows to increase, it will be harder for the Basin Association to meet its group cap (Interviews T-1, T-3, T-6, T-7, T-8). At that point, they will appreciate the opportunity to offset as a way to mitigate the risks of exceedances and might consider an internal cap and trade or nutrient fee system to further induce nutrient reductions and distribute any offset costs fairly (Interview T-6, T-7). Similarly, the Grassland Area Farmers traded until a regional strategy emerged. As long as reduction goals are relatively easy, however, political transaction

costs deter Association and Grassland Area members from cost-effectively distributing the financial burden of reductions.

The fact that sewage treatment plants actively participated in the Long Island Sound Nitrogen Credit Exchange suggests that political transactions costs did not outweigh trading gains. I argue that state involvement minimized these costs and allowed participants to demonstrate more rational economic behavior.

Designers of the Nitrogen Credit Exchange considered alternatives in which municipalities bargained directly with each other. Although more free-market, they abandoned this idea because of concerns that wealthier southwestern municipalities with higher equivalency factors would take advantage of northeastern towns. Not wanting to create a massive wealth transfer among municipalities and knowing that towns would hesitate to pay and depend on one another in order to comply with regulations, the state designed a system in which it acted as a middleman. This solution seemed more acceptable to the public utilities who valued staying out of trouble over generating revenue (Interview L-1, L-2, L-3, L-4). As a result, the Nitrogen Credit Exchange and Nitrogen Credit Advisory Board overcame political transaction costs by eliminating payments among municipalities. It made trading part of a compliance mechanism rather than an opportunity to profit from other entities (Interview L-1).

Response to Price Signals: Disconnect Between Incentives and Dischargers

In addition to ease of transactions, a market-based instrument only functions if participants receive clear price signals and internalize the external damages caused by pollution. Otherwise, they have no incentive to reallocate pollution reduction responsibility in order to maximize savings. The Long Island Sound Nitrogen Credit Exchange and Tar-Pamlico Basin Association were composed almost exclusively of sewage treatment plants.⁶⁹ Although they face limited budgets and must pass costs on to rate payers, wastewater treatment facilities do not compete for customers and will most likely not cease operating for financial reasons. Kolstad (2000, 150) questions how well governmental or quasi-governmental agencies with softer budget constraints respond to economic signals since they do not have the same incentive to maximize cost-effectiveness.

Connecticut sewage treatment plants may have participated in the Long Island Sound Nitrogen Credit Exchange despite their softer budget constraints because of the Clean Water Fund-subsidized equalized nitrogen credit values. The subsidy made participation more affordable than self-financed, individual upgrades. The grant and low-interest loans also explain why the Exchange was not revenue-neutral and loads exceeded permitted levels in 2005 and 2006 (see Ability to Plan around Trades section and Chapter 5).

Misaligned incentives and market distortions explain why price signals were not strong enough to induce onsite management and trading in the Grassland Area. First, the Tradable Loads Program functioned at the district level, but growers substantially influenced selenium loads

⁶⁹ The Basin Association included one industrial member, National Spinning, from 1995 until its closure in 2004, and the Nitrogen Credit Exchange was tentatively beginning to incorporate industrial point sources in 2007 (TPBA 2007b; Interviews L-2, L-4).

because they made irrigation decisions. The incentives that districts received from the market-based instrument were only indirectly passed on to growers through pricing, policy, information sharing, and peer pressure; districts lacked the authority to directly control drainage from growers. Yet insufficient monitoring and accountability prohibited viable trading among growers (Interview G-1, G-6). Therefore, costs and benefits of behavior may have been too dispersed to affect any real change. Second, government funding for drainage management described in the Most Affordable Strategy section distorted the value of reducing selenium and prevented districts from internalizing the full costs of selenium loads.

Summary

Compared to open, private sector markets for normal goods or trading among other types of pollution, these three cases demonstrate that market-based instruments face many challenges when applied to water quality. One of the purported benefits of trading is that it maximizes the amount of pollution reduction possible with finite resources. Yet trades only achieve this objective if 1) dischargers have sufficient incentive to identify the most cost-effective way to meet load allocations; and 2) the most cost-effective and reliable option is paying another discharger for a portion of their allocation and the ability to pollute after factoring in transaction costs. Despite years of negotiation and planning, dischargers completed only a few initial trades in the Grassland Area and no trades or offsets in the Tar-Pamlico basin between program creation and the end of 2006, indicating that trading failed to improve cost-effectiveness.

The Grassland Area Farmers leveraged millions of dollars in government subsidies to manage drainage, making the Regional Reuse Area more affordable than managing selenium through individual efforts and relying on trades to redistribute these efforts. Consequently, a market distortion prevented trading from becoming the most affordable solution. The Tar-Pamlico Basin Association avoided having to pay for equivalent offsite reductions through the Nutrient Offset Program by reducing loads onsite much less expensively than initially expected. Further, programmatic uncertainties prevented Association members from reliably incorporating the Nutrient Offset Program into their long-term plans. Finally, political transaction costs in both cases strongly deterred partners from trading. Not wanting to compete and appear to take advantage of one another, they pursued regional solutions instead.

The Long Island Sound Nitrogen Credit Exchange demonstrates that state involvement can provide legitimacy, neutrality, and credibility to create a market in which public utilities actively participate. Although the Exchange's state control sacrificed some free-market components, it minimized uncertainty and political transaction costs. As structured, however, the Exchange depended on public funds and induced sewage treatment plants to exceed their group cap when the state and federal government under-financed the Clean Water Fund. Beyond variations in trading activity, the next chapter assesses the direct and indirect outcomes of program design, utilization, and existence.

CHAPTER 5: UNEXPECTED CONTRIBUTIONS OF WATER QUALITY TRADING

This thesis asks how and to what extent water quality trading in practice contributes to the outcomes that it promises in theory. Chapter 4 explains why the primary theoretical benefit of trading, improving the cost-effectiveness of pollution reduction efforts, did not occur in two out of three cases. This chapter examines whether dischargers in each program actually reduced pollution loads regardless of trading activity and thus contributed to water quality improvements. I also evaluate the unexpected outcomes of the three programs and consider how they could benefit watershed planning efforts.

Although much of the economic literature focuses on gains in cost-effectiveness as the major benefit of trading, surprisingly the most consistent contributions of market-based instruments across the three programs were 1) increased willingness to comply with more stringent, water quality-based standards; and 2) increased capacity for watershed management. Outcomes contributing to the latter benefit were 1) better dynamics among diverse stakeholders; 2) formation of organizations that align with watershed boundaries; and 3) increased information collection, dissemination, and use. In this chapter, I discuss why these changes occurred and how they could contribute to further water quality improvements. I also assess whether trading improved the ability to adapt management strategies to new information and conditions (see Table 5-1). Given the challenges to further progress under the Clean Water Act, these largely overlooked contributions are significant.

	Grassland Area Farmers Tradable Loads Program	Tar-Pamlico River Basin Nutrient Offset Program	Long Island Sound Nitrogen Credit Exchange
Intended Outcomes			
Achieved Pollution Reduction Goals	Yes – 80% of years and 84% of months	Yes – 100% of years	General Permit: Yes – 60% of years; TMDL: Yes – 100% of years
Improved Water Quality ^a	No – Less selenium in river, but increasing egg-selenium concentrations	Yes – N and P down; less impaired estuary	Yes – N down; DO up
Unintended Outcomes ^b			
Willingness to Accept Regulation	Yes	Yes	Yes
Information Collection, Sharing, and Use	Inconclusive ^b	Yes	Inconclusive ^b
Formed Group Along Watershed Boundaries	Yes	Yes	Yes
Increased Ability to Adapt to Changing Conditions and Information			
More Adaptable	Inconclusive ^b	Yes	Inconclusive ^b
^a Changes in water quality cannot be attributed exclusively to the existence of market-based instruments. ^b Trading programs were part of broader pollution reduction strategies, so unintended outcomes are not only the result of dischargers' option to trade. Information collection and phased review also resulted from the Use Agreement and San Joaquin River Water Quality Improvement Project in the Grassland Area and the Long Island Sound Study in Connecticut.			

Direct Outcomes: Changes in Water Quality

The objective of market-based instruments is to achieve a more cost-effective distribution of abatement efforts than would occur under a traditional, prescriptive regulation, therefore lowering total compliance costs. Measures of program effectiveness should also address whether pollution reduction occurred and the capacity for further water quality improvements increased.

An environmental outcome is easiest to measure if it can be compared to a specific target. The ideal measure is whether the problem caused by the pollution (e.g., wildlife deformities, hypoxia, or fish kills) has decreased. However, many of these effects have lags between changes in pollution loads and observable effects. For instance, nutrients persist in the water column and sediment, and changes in discharges may not affect dissolved oxygen levels for two to five years (Interviews L-4, L-5). Selenium, an acute toxic, has a much shorter lag time; experts estimate that eggs could contain measurable selenium concentrations and deformed embryos within weeks of bird exposure (Boxall 2006; Interview G-13). These effects are also difficult to measure because they are influenced by multiple variables. For instance, precipitation and temperature affect the extent and duration of hypoxic zones. Finally, baseline and monitoring data may not exist to document changes in water quality.

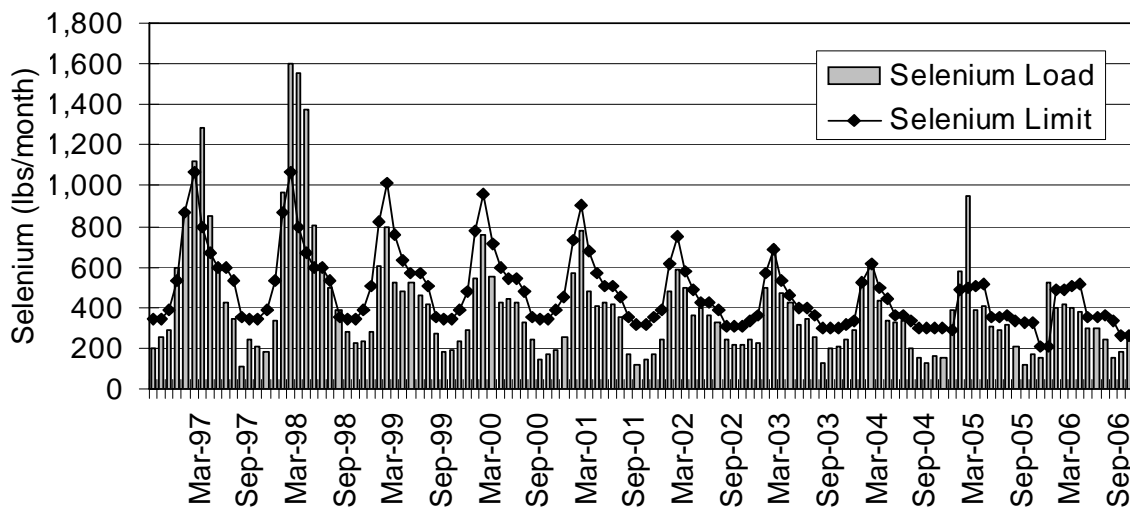
Given these complexities and the relatively short time since program implementation, I discuss changes in second-best measures such as chlorophyll a and nutrient concentrations in the Pamlico River and Long Island Sound. Again, however, these levels are subject to lags and influence by factors beyond the trading programs' control. Therefore, I compare pollution loads from regulated dischargers to reduction targets as another measure of environmental outcomes.

Comparison of Actual to Targeted Pollution Reductions

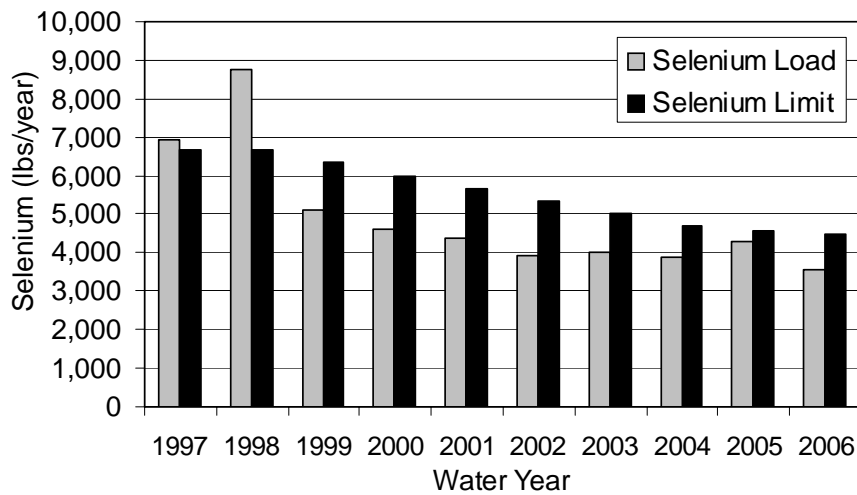
Table 5-1 and Exhibits 5-1 through 5-3 demonstrate that dischargers in all three watersheds succeeded in keeping loads below the regulatory cap in the majority of months and years. The Grassland Area Farmers have consistently discharged less than their selenium load limits with the exception of the program's first two years and a few monthly exceedances in early 2005 and 2006. Members halved their total annual discharges between water years 1997 and 2006, from approximately 7,100 to 3,560 pounds (see Exhibit 5-1) (San Francisco Estuary Institute 2007).⁷⁰ Since April 1998, no subsurface drainage discharges from the Grassland Drainage Basin have entered wetlands channels (San Joaquin River Exchange Contractors Water Authority et al. 2003, 7). The Tradable Loads Program only explains a small portion of the region's success in meeting selenium limits, however, in part because multiple incentives and subsidies existed to reduce selenium loads by other means.

⁷⁰ The 1997 exceedance predated the first Tradable Loads Rule, and incentive fees totaled \$60,500. The Oversight Committee deemed exceedances between February and June 1998 to be "unforeseeable and uncontrollable events" caused by El Niño. The Grassland Area Farmers still paid \$3,400 in fees for exceedances between July and September 1998 (Austin 2001, 374). The Grassland Area Farmers have not exceeded annual limits since, but they accrued approximately \$250,000 in incentive fees for monthly exceedances in early 2005 and 2006 (Interview G-2). However, the Oversight Committee allowed the fees to fund selenium reduction efforts that would not otherwise occur (Interviews G-1, G-3, G-5).

**Exhibit 5-1
GRASSLAND BYPASS PROJECT MONTHLY SELENIUM LOADS
(1997 – 2006)**

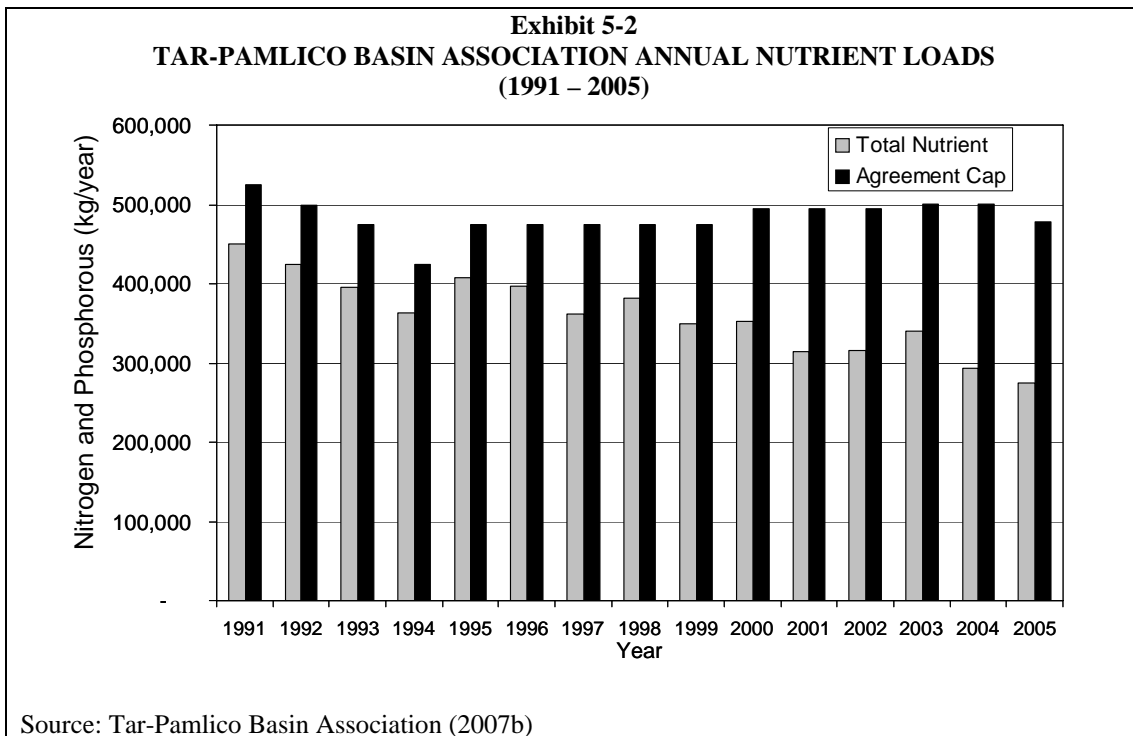


GRASSLAND BYPASS PROJECT ANNUAL SELENIUM LOADS



Source: San Francisco Estuary Institute (2007)

Without offsetting or internal trading, the Tar-Pamlico Basin Association (the Basin Association, or the Association) has consistently remained well under its group caps of 30 percent nitrogen reductions and no phosphorous increases even though wastewater flows rose by seven percent since the start of the nutrient strategy’s Phase I Agreement (see Exhibit 5-2) (DENR 2004, 63; TPBA 2007b). Modeled estimations of nutrient reductions from agricultural lands suggest that the majority of counties are meeting their nutrient limits for agriculture reductions as well (Interviews T-4). The stormwater and buffer rules do not address existing nutrient runoff; they only place restrictions on new development, raising concerns that these sources will not decrease nitrogen by 30 percent (DENR 2004, 67; Interviews T-1, T-3, T-5).



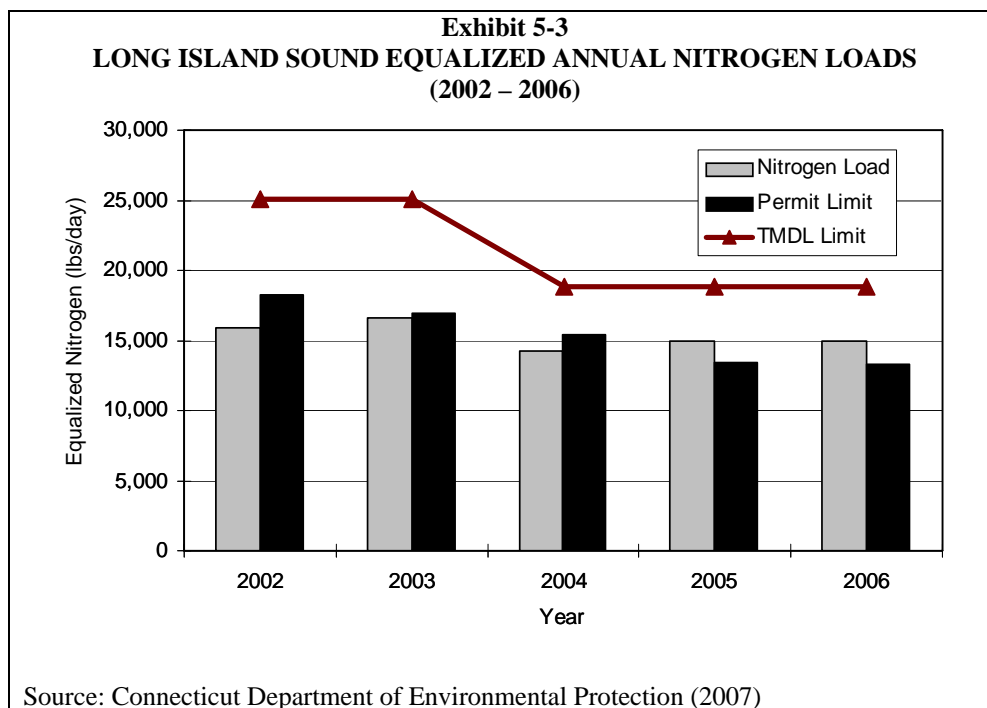
Connecticut sewage treatment plants reduced nitrogen loads by 41 percent from 25,008 equalized pounds per day when the Nitrogen Credit Exchange started in 2002 to 14,637 equalized pounds per day in 2006 (CWF Advisory Work Group 2007, 5). Plants collectively kept equalized nitrogen discharges below General Permit levels in 2002 through 2004 but exceeded the limit in 2005 and 2006 (see Exhibit 5-3). Loads remained below the TMDL allocation for all years, however (CTDEP 2003, 2004, 2006, 2007; Interview L-2). Further, stakeholders believe that enough projects are in design and scheduled for completion that the state will not violate its final TMDL wasteload allocation in 2014 (Interviews L-2, L-4). Nevertheless, by staying below General Permit discharge requirements in only 60 percent of years, the Credit Exchange had the lowest rate of meeting its reduction targets.⁷¹ This finding indicates the need to differentiate between *trading* and *pollution reduction*. It is possible to design a program that facilitates active trades, but that does not mean that water quality improvements will necessarily occur.

The Nitrogen Credit Advisory Board, Connecticut Department of Environmental Protection, and individuals familiar with the program explained that Clean Water Fund shortfalls caused credit purchases to exceed sales in 2005 and 2006 (CTDEP 2006, 14-16; CTDEP 2007, 4; Interviews L-1, L-2). As of early 2007, the Fund could not finance five projects that applied for support because of general obligation bond rescissions in 2003 and 2004, no bond authorization in 2005, and only \$20 million in 2006 and 2007, compared to the average annual bond authorization of \$47.9 million from 1987 to 2002 (CTDEP 2007, 6).⁷² Recognizing the backlog in facilities

⁷¹ Reduction targets across the three cases do not represent equivalent efforts.

⁷² Federal grants and state bonds also finance the Fund is also (CTDEP 2007, 5). Federal funds can only be used for the low-interest loans. However, the Connecticut General Statutes requires the Clean Water Fund to provide a state

requesting Fund support, the Department amended the General Permit to increase allowable nitrogen loads for 2006. The General Permit still follows a reduction schedule so that permitted levels in 2014 meet the TMDL wasteload allocation (CTDEP 2006, Att. B; Interview L-2).



Measuring Changes in Water Quality

Conditions in the Pamlico River and Long Island Sound have shown some improvement since program implementation, but it is impossible to attribute changes to specific strategies or occurrences (Interviews T-3, T-5, T-6). North Carolina Department of Environment and Natural Resources (DENR) Division of Water Quality determined that both total nitrogen and total phosphorous concentrations demonstrated statistically significant reductions between 1991 and 2002 (DENR 2003, 2004, 64).⁷³ Further, the percent of estuary classified as impaired decreased by 90 percent between the 1994 and 2004 (DENR 1994, 57; Interview T-3). Trends in the incidence of algal blooms and fish kills were harder to verify given the multiple contributing factors and lags (Interviews T-3, T-4, T-5, T-9). Despite favorable trends in the estuary, some stakeholders expressed concern that conditions in large portions of the watershed were unknown due to insufficient monitoring. Further, some felt that the nitrogen reduction target should be 45 rather than 30 percent to adequately protect the estuary (Interviews T-5, T-8).

match of 30 percent for denitrification projects (state match levels vary by project type). Therefore, the bottleneck in Fund availability is the state money available for grants, not the federally and state-funded low-interest loans (CWF Advisory Work Group 2007, 9; Interview L-2). To address the backlog, CTDEP commissioner Gina McCarthy convened a Clean Water Fund Advisory Group per the request of Governor Jodi Rell to evaluate options that would allow the Fund to support wastewater facility upgrades for the purpose of improving water quality (CWF Advisory Work Group 2007, 1).

⁷³ Nitrogen concentrations at the Grimesland gage just upstream of where the Tar River widens into the Pamlico decreased by approximately 18 percent between 1991 and 2002 (DENR 2003, 2004, 64)

Similarly, it is difficult to detect short-term changes in hypoxia in Long Island Sound. Ambient water quality monitoring indicated decreased total nitrogen and chlorophyll a concentrations and increased dissolved oxygen levels (U.S. EPA 2007; Interview L-1). However, it is impossible to isolate effects of the Nitrogen Credit Exchange from other actions adopted as part of the Long Island Sound Study.

The various strategies to manage selenium in the Grasslands Area, of which storage in the Regional Reuse Area predominated and the Tradable Loads Program was relatively minor, successfully reduced selenium discharges into the San Joaquin River. However, wildlife continued to be exposed to the toxic element, raising questions about the Regional Reuse Area’s long-term sustainability. Without treatment, the toxic element became increasingly concentrated. A private firm contracted by the Grassland Area Farmers to monitor selenium found that drainage used to irrigate crops in the Reuse Area between 2003 and 2005 had selenium concentrations ranging from 43 to 761 parts per billion (ppb), well above the 32 ppb standard associated with a high probability of reduced avian hatchability and an increased probability of embryo deformities (H.T. Harvey & Associates 2006, 23).

Although managers actively deterred wildlife from the Reuse Area, eggs gathered along drainage ditches in 2005 registered selenium levels as high or higher than those recorded in Kesterson in the 1980s (Boxall 2006; Interviews G-5, G-13). The firm reported that egg-selenium concentrations were significantly greater in the Reuse Area than in a nearby reference area, but that even eggs in the reference area demonstrated elevated levels (see Table 5-2) (H.T. Harvey & Associates 2006, 23).⁷⁴ Experts found the elevated reference levels most disturbing because they indicated that alternative pathways to selenium exposure could exist and efforts to prevent harmful wildlife exposures were failing (Interview G-13). The firm also reported that egg-selenium concentrations were significantly higher in 2005 than in 2004 (P<0.05) (H.T. Harvey & Associates 2006, 17). Table 5-3 demonstrates that higher proportions of eggs collected in the Reuse Area had an increased probability of impaired reproduction (H.T. Harvey & Associates 2006, 23).

Species Group	Killdeer		Recurvirostrid ^a	
	Reuse Area	Reference Area	Reuse Area	Reference Area
Mean Selenium (ppm dry wt)	15.9	5.5	35.3	12.4
Significant difference between sites	Yes; t= 7.3764; P<0.0001		Yes; t=6.6239; P<0.0001	
Notes: ^a Recurvirostrids include American Avocets and black-necked stilts. Source: H.T. Harvey & Associates (2006), 17				

⁷⁴ Studies have indicated that “eggs are the best indicator for selenium transfer and toxic biological effects to avian species” (H.T. Harvey & Associates 2006, 20).

Table 5-3 DISTRIBUTION OF EGG-SELENIUM CONCENTRATIONS BY PROBABILITY OF REPRODUCTIVE IMPACT (2005)				
Species Group	Killdeer		Recurvirostrid ^a	
	Reuse Area	Reference Area	Reuse Area	Reference Area
Background level: ^b <3 ppm dry wt	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Increased probability of avian reproduction effects: 3-7.9 ppm dry wt	1 (7%)	15 (100%)	0 (0%)	4 (24%)
Increased probability of reduced hatchability: 8-18 ppm dry wt	7 (47%)	0 (0%)	0 (0%)	10 (59%)
High probability of reduced hatchability: >18 ppm dry wt	7 (47%)	0 (0%)	12 (100%)	3 (18%)
Total	15	15	12	17
Notes:				
^a Recurvirostrids include American Avocets and black-necked stilts.				
^b Experts reported being most concerned that all eggs from the reference area exceeded background selenium levels, indicating broad contamination in the San Joaquin Valley that could threaten wildlife reproduction (Interview G-13).				
Source: H.T. Harvey & Associates (2006), 21				

The number of exposed birds was far less in the Regional Reuse Area than in Kesterson Reservoir because the area of drains was smaller than the former Reservoir and the San Joaquin River Water Quality Improvement Project (SJRIP) prevented selenium from reaching wetland habitat (Interview G-8). Also notable, Panoche Drainage District prepared a Negative Declaration for SJRIP under the California Environmental Quality Act in 2000. The Declaration included monitoring protocols developed in conjunction with the U.S. Fish and Wildlife Service and mitigation provisions if monitoring detected negative impacts to wildlife. Under Panoche Drainage District's lead, SJRIP complied with these provisions by making the area less attractive to birds and avoiding drainage ponding. After reviewing the 2005 monitoring data, SJRIP funded the creation of 50 acres of wetland habitat supplied by freshwater to mitigate any harm to wildlife (H.T. Harvey & Associates 2006, 1, 23, 24; Boxall 2006; Interview G-3).

However, others responded that any strategy which increased wildlife exposure to selenium was not sustainable (Interviews G-11, G-12, G-13). Some informants also expressed concern that too few variables were monitored; they felt that the broader ecosystem effects, including impacts on terrestrial species, should be examined in order to fully understand and, if necessary, adapt SJRIP (Interview G-11). In summary, other strategies which more actively limited selenium leaching in the first place might have yielded greater benefits to wildlife, had fewer externalities shouldered by federal and state funds, and thus have been more cost-effective. If the regulation's objective was to reduce selenium loads in general rather than in the San Joaquin River specifically, the Grassland Bypass Project failed because until a viable treatment process exists, Grassland Area Farmers only store rather than reduce selenium leaching.

In summary, dischargers in each case succeeded in meeting pollution reduction targets in the majority of months and years even if they did not trade amongst each other. In fact, the Long Island Sound Nitrogen Credit Exchange, the only program which supported trading activity, had

the lowest rate of meeting its General Permit target whereas the Tar-Pamlico Basin Association, which neither offset nor internally traded, remained well below pollution limits in all years. Water quality results were less clear. While conditions in the Pamlico River and Long Island Sound showed some initial improvements, it is not possible to attribute these changes to specific programs. In contrast, preliminary water quality results in the Grassland Area are less promising. Despite keeping selenium discharges to the San Joaquin River below limits in most months and years, egg-selenium data suggest that wildlife are at risk of reduced reproductive success due to selenium exposure, and these risks are greatest in the Regional Reuse Area.

Some stakeholders in each program have concerns over long-term water quality improvements. As long as equalized nitrogen credits remain subsidized, continued upgrades and nitrogen reductions depend on the availability of the Clean Water Fund. A few stakeholders in North Carolina question whether the nutrient reduction target is sufficient and if nonpoint sources will achieve mandated nutrient reductions to restore the estuary. Finally, monitoring data in the Grassland Area suggest that current management strategies are failing to protect wildlife from harmful selenium exposure. Despite an apparent disconnect between pollution reduction and trading activity, lingering concerns over management strategies, and inconclusive evidence on whether water quality is improving due to market-based instruments, I now consider what unexpected outcomes emerged that could indirectly benefit water quality.

Indirect Outcomes: Accepting Regulations and Improving Watershed Management

I argue that the contributions of market-based instruments to pollution reduction are not limited to whether trades redistribute abatement efforts to maximize cost-effectiveness. I now discuss the indirect benefits of these programs that were most consistent across cases, including increasing sources' willingness to accept more stringent regulations; facilitating the collection, sharing, and use of information; and increasing capacity to manage resources along hydrologic boundaries. This section compares how each trading program facilitated regulations; changed dynamics among dischargers, agencies, and environmental groups; and altered the transfer and value of information and the means to implement strategies on a watershed scale – all of which could indirectly contribute to water quality improvement.

Increased Willingness to Comply with Pollution Regulations

As Chapter 1 explains, one obstacle to continued water quality improvements under the Clean Water Act has been point sources' resistance to more stringent water quality-based regulations and difficulties engaging nonpoint sources in pollution reduction efforts. Therefore, it is a significant finding that each case involved dischargers accepting a more stringent and unprecedented regulation. In North Carolina and Connecticut, point sources were accustomed to effluent limits within NPDES permits, but nutrients specifically had not been controlled.⁷⁵ The California case represented an even greater change; although authority existed under state law, Regional Water Quality Control Boards had not previously issued waste discharge requirements

⁷⁵ The group cap on nutrient discharges from Tar-Pamlico Basin Association members is an agreement rather than a formal state regulation (Interview T-3).

for nonpoint sources.⁷⁶ The Use Agreement conditions imposed by U.S. Bureau of Reclamation and the Phase I and Phase II waste discharge requirements issued by the Central Valley Regional Water Quality Control Board in 1997 and 2001 were the first load limits on agricultural sources in California (Austin 2001, 341; Interview G-6).

Why did dischargers in each case accept these new controls? In the Grassland Area, districts formed a regional entity and agreed to reductions to secure access to the San Luis Drain and sustain agriculture (Interviews G-1, G-2, G-4, G-10). In all cases there was also a realization of impending regulations.⁷⁷ Each watershed had a well-publicized problem creating a sense of crisis, and agencies had both the authority and will to act. Sources familiar with the Long Island Sound Nitrogen Credit Exchange noted that sewage treatment plants were also willing to accept nutrient limits in part because the Long Island Sound Study and Comprehensive Conservation and Management Plan built consensus around the need to address hypoxia; TMDL limits were no surprise after years of deliberative study (Interviews L-1, L-3, L-5).

Recognizing impending regulations, sources faced three options: 1) comply with the individual regulations and bear financial burdens; 2) resist, thus avoiding immediate expenditures but risking legal and administrative fees while increasing agency costs (Tar-Pamlico and Long Island Sound basins) or access to the San Luis Drain (Grassland Area); or 3) pursue an alternative such as trading. Oldham and Castille (2003, 42) report that the threat of regulation plays an important role in encouraging nonpoint sources to participate in new management strategies.⁷⁸ I argue the inverse as well: the option to trade eased the implementation of an unprecedented regulation. North Carolina's Division of Water Quality and Connecticut's Department of Environmental Protection recognized that point sources would likely resist prescriptive limits, creating a lengthy and costly process. To the extent that they did prevent dischargers from opposing and delaying new requirements, market-based instruments allowed pollution reductions to happen faster. The General Permit and group cap also eased the Department's and Division's administrative burden significantly by eliminating many individual permits (Interviews T-7, L-1, L-2, L-4, L-5, L-6).⁷⁹

⁸⁰

Dischargers in all cases preferred the flexibility and autonomy of a decentralized regulatory approach that trading offered over individual, prescriptive limits, and many claimed it played a role in dischargers' compliance with the more stringent limits. One stakeholder claimed that a critical component of the Grassland Area Farmers' willingness to accept selenium load limits was the assurance that agencies and environmentalists would stay out of internal activities if the region remained below load limits at Site B; they were willing to cooperate as long as their autonomy was respected (Interview G-12). The decentralized regulatory framework of the Tradable Loads Program better meshed with this dynamic than prescriptive, individual permits.

⁷⁶ The state had previously relied on voluntary implementation of best management practices.

⁷⁷ Two stakeholders believed that the districts would have been more likely to resist the load limits were it not for the state's authority to regulate nonpoint source pollution (Interviews G-1, G-5).

⁷⁸ Oldham and Castille (2003, 42) were discussing voluntary implementation of agricultural best management practices in the southeastern U.S.

⁷⁹ One stakeholder estimated that a facility could delay a permit up to five years (Interview L-2).

⁸⁰ Staff approximated that writing a nitrogen effluent limit into each NPDES permit would take staff at the two months of uninterrupted effort (Interview L-6).

Stakeholders also recognized that trading under a group limit provided risk pooling or “safety in numbers” that prevented smaller dischargers in particular from being unduly burdened and gave them time to upgrade (Interviews G-1, G-4, G-12, T-1, T-3, T-5, T-6, T-7). The option to voluntarily participate in the market mitigated risks. Dischargers in the Tar-Pamlico and Long Island Sound basins appreciated knowing that they could simply purchase credits if nutrient limits were not achievable. Similarly, the Grassland and Long Island Sound programs reduced exposure to over-compliance by allowing dischargers to generate revenue if they reduced loads more than necessary, providing an incentive to go “above and beyond” (Interviews G-4, T-1, T-3, T-5, T-6, L-1, L-2, L-4, L-5, L-6).

Factors in addition to the option to trade also contributed to sources’ acceptance of regulations and participation in management programs. For instance, greater accountability among point sources in Connecticut compared to North Carolina might explain why municipalities in the Long Island Sound watershed were willing to reduce wastewater loads. Oldham and Castille (2003) have observed that refusal to accept responsibility can impede actions to improve water quality. Even when stakeholders agree that a watershed faces water quality problems, they will often not accept responsibility and instead derail results by blaming others. There was far less finger-pointing among Connecticut sources than in the Tar-Pamlico basin, probably because both wastewater discharges and urban stormwater runoff (the two primary sources of nitrogen loads from Connecticut to Long Island Sound) fell under municipal jurisdiction. Municipalities had to reduce nitrogen loads either way, and increasing sewage treatment was more straightforward. Consequently, dischargers did not resist when point sources were tasked to reduce a disproportionate share of the nitrogen entering the watershed (Interview L-4). In contrast, Tar-Pamlico Basin Association members emphasized that the majority of hypoxia-causing nutrients came from agriculture, not their facilities, so they should not be the only sources to reduce loads.

In addition to easing point source acceptance of a new regulation, the Tar-Pamlico Nutrient Offset Program attempted to engage nonpoint sources, a previously unregulated sector, by having point sources fund the Agriculture Cost Share Program Coordinator (Interviews T-1, T-4, T-5, T-6). This support indirectly contributed to best management practice modification so that practices better met nutrient reduction goals (Interviews T-4, T-5, T-6).⁸¹ This connection was valuable given that the majority of nutrient loads was attributable to agriculture, but at the outset of Phase I only point sources were regulated.

Given the potential savings, autonomy, and risk reduction, both dischargers and regulators stood to benefit from trading. As Hahn (1989, 111) suggests, the decision to adopt market-based instruments was based on political as well as economic realities; policymakers were not just trying to maximize cost-effectiveness. In summary, the flexibility of a regional limit with the option to trade encouraged point sources to cooperate with the state and environmental interests; accept more stringent, unprecedented limits; and attempt to engage previously unregulated nonpoint sources in pollution reduction efforts.

⁸¹ Farmers are unaware of the source of Agriculture Cost Share funds that they receive in order to ease administration and prevent competition among funding sources. Consequently, most farmers are probably unaware of the Nutrient Offset Program (Interviews T-4, T-5).

Increased Capacity for Watershed Management

The other indirect outcomes associated with market-based instruments that could increase the capacity for watershed management relate to changes in dynamics among stakeholders. The trading programs made relationships between agencies and dischargers less adversarial than they would have been under the prescriptive alternative (Interviews L-2, L-3, T-6); the flexibility and decentralization of decisionmaking appeared to diffuse tensions. Program design also brought diverse interests including public utilities, drainage districts, regulators, and environmentalists to the table to discuss load management. Particularly in the San Joaquin Valley in the aftermath of the Kesterson disaster, dischargers and environmentalists were wary of each other. When Terry Young approached the districts with the tradable loads proposal, they initially dismissed her ideas and agreed to test the strategy only after receiving a federal grant to fund Susan Austin, effectively making it a free experiment (Interview G-4). However, districts came to recognize some value in the decentralized regulatory strategy; the program made the two interests partners in a common problem, and they both gained. Environmental Defense had the opportunity to test a market-based instrument for water quality protection, and the Grassland Area Farmers had another tool that could help them meet their regional limit (Interview G-4).

The development and approval of the Tradable Loads Program became a coalescing process for the Economic Incentives Advisory Committee composed of a farmer, regulator, environmentalist, and academic, as well as for the Grassland Area Farmers as a whole. Every Grassland Basin Drainage Steering Committee member had to approve the program (Austin 2001, 353, 392; Interviews G-1, G-8). Dividing the regional selenium allocation among the seven districts, monitoring, and issuing internal, performance-based penalties and rebates, all necessary for a cap and trade system, increased accountability by dividing responsibility among members (Austin 2001, 382-3; Interview G-12).⁸² These discussions were valuable because they forced diverse interests to establish how they would interact, define guiding principles, and assign responsibility (Interviews G-1, G-4, G-8, G-10, G-12).

Accounts vary, but most people interviewed across cases indicated that relationships among groups improved as a result of the negotiations and agreements had greater value and legitimacy because they received broad buy-in (Interviews G-1, G-4, G-8, G-12, T-1, T-5, T-6). At the same time, stakeholders readily admit that differences in viewpoints and priorities among parties still exist (Interviews G-11, T-7). Most notably, one stakeholder felt that the adoption of Phase II of the Tar-Pamlico Basin nutrient strategy without environmental groups' approval demonstrated that collaboration was not really necessary (Interview T-7). However, they also hope that the legitimacy created by broad participation would shelter aspects of the agreement from Legislative interference (Interviews T-6, T-7). Similarly, the Grassland Area Farmers continue to try to garner approval from environmental groups as they pursue other regional non-trading strategies to manage selenium (Interviews G-3, G-12). In summary, trading program

⁸² Opinions differ as to whether the Grassland Area Farmers would have divided the region's allocation among districts anyway. Some feel that distribution would not have occurred without the Tradable Loads Program (Interviews G-4, G-12), while others felt that distributing the allocation was necessary with any reduction strategy (Interview G-1). Either way, the allocations have contributed to other aspects of selenium reduction efforts. For instance, distribution of incentive fee and SJRIP payments rely on this allocation (Interviews G-4, G-12).

design brought diverse stakeholders together, built trust and credibility, and increased the likelihood that these groups would work together in the future despite lingering differences.

Finally, closer relationships may have increased sources' ability to reduce pollution. Dischargers in each case benefited from staying under a regional cap by avoiding permits or gaining access to the San Luis Drain. Therefore, they took a collective interest in wanting each other to reduce loads (Interviews G-1, G-3, G-4, G-8, G-10, T-1, T-3, T-6, T-7, L-1, L-2, L-3).⁸³ Developing an interest in helping others to collectively achieve group reduction targets and better relations and increased communication among stakeholders facilitated the sharing and use of information that could improve watershed management. This finding is relevant given that incomplete information poses a major challenge to watershed management. Regulators in particular often do not fully understand pollution sources, how substances travel through and affect the environment, and how easily these damages could be mitigated. Resource constraints limit agencies' monitoring and modeling efforts to shed light on these questions and thus better protect water resources. Trading can contribute to water quality improvements if it makes better use of existing data and induces the collection and sharing of additional information by changing the incentives facing dischargers.

In theory, pollution trading should take advantage of the fact that dischargers often have a better understanding of how to reduce pollution than regulators. Rather than prescribing uniform controls for each source, trading allows dischargers to leverage their knowledge and select the most cost-effective way to meet targets (Kolstad 2000, 145; Interview G-12). These cases demonstrate that trading also creates a demand for information. Most notably in the Tar-Pamlico basin, the programs had the indirect benefit of increasing data and understanding by transforming information from a liability to an asset.

The Tar-Pamlico Basin Association seized data as a means to demonstrate its good-faith efforts, thus maintaining its right to a group cap in lieu of individual permits. Members also wanted substantive data and analysis to prove that nonpoint sources contributed most nutrient loads and point sources should not be responsible for the majority of reductions. The Association therefore secured resources for the estuary model in Phase I and signed a Memorandum of Agreement in 2006 with the Division of Water Quality to start a monitoring coalition so that water quality data could yield more useful information. The Association hoped that greater information would improve accountability among nonpoint sources (DENR 2006c; Interviews T-1, T-4, T-5, T-7). The estuary model was particularly important because of the scientific uncertainty surrounding the causes of eutrophication in the Pamlico River. Unlike other trading programs such as the Long Island Sound Nitrogen Credit Exchange, a TMDL specifying a final cap on allowable loads did not exist when the state decided to move forward with the nutrient strategy. Therefore, better understanding and nutrient reductions were concurrent goals. Securing resources to adequately monitor and develop TMDL analyses is a common challenge among states, and the estuary model and monitoring coalition reduced the Division's burden and provided more information than would otherwise exist (Interviews T-1, T-3, T-4, T-6, T-8). The Basin Association made these contributions in part to maintain the decentralized alternative to prescriptive, individual permits and the option to offset loads.

⁸³ One Tar-Pamlico stakeholder believed that the Basin Association would not be as close-knit if the group cap assigned individual allocations (Interviews T-7).

The Long Island Sound Nitrogen Credit Exchange appears to have somewhat increased the degree of information dissemination among facilities and the Department, although not as dramatically as the Tar-Pamlico program. The desire to minimize credit purchases, generate revenue through sales, and meet the General Permit and TMDL limits so that the Nitrogen Credit Exchange could remain intact may have increased demand for optimization trainings and plant modifications and prompted research on methods to further reduce nitrogen loads (Interviews L-1, L-2, L-3, L-6). In addition, the collective interest generated by sewage treatment plants' desire to maintain the aggregate nutrient limit and Exchange option most likely enabled the Department to audit and standardize data reporting processes, a step which gave the state better control and knowledge over pollution entering the watershed (Interviews L-1, L-2, L-3). However, the role of the Exchange is hard to isolate from other outreach efforts occurring as part of the Long Island Sound Study.

More notably, the Nitrogen Credit Exchange increased the salience of water quality issues and support for restoring the Clean Water Fund more than its developers had envisioned. The need for facilities that had not reduced loads to purchase credits created a tangible expense on city budgets and gained mayors' attention. These politicians then lobbied the state to authorize more general obligation bonds to fund facility upgrades (Interview L-4).

Another critical challenge of watershed management is that political and hydrologic boundaries often do not align. EPA highlights that one benefit of trading is its ability to facilitate communication among discharges within a watershed. All three cases took this benefit a step further by creating institutions organized along basins. It is difficult to separate the role of trading from other factors contributing to the formation of the Grassland Area Farmers. The entity was created prior to the implementation of the Tradable Loads Program so that the districts could enter into the Use Agreement; some insisted that it would have existed even without trading (Interview G-1). However, Young, who proposed the cap and trade system and was involved in the Use Agreement negotiations from the start, determined over the course of her research on economic incentives that a regional approach was necessary. She therefore insisted that a regional entity be created and the selenium load limits be set at this level (Interview G-12).

A group of dischargers organized by watershed did not exist in North Carolina prior to the Tar-Pamlico Basin Association. The benefits of the group cap and the option to trade under the Nutrient Offset Program over traditional, individual effluent limits created demand for the Association and attracted members (Interviews T-5, T-6, T-7, T-8). The Association facilitated communication and planning among otherwise independent municipal dischargers (Interviews T-4, T-5, T-6). Quarterly meetings became a forum for exchange; each meeting concluded with a roundtable to share thoughts on issues not just related to nutrient management (Interviews T-5, T-6). Finally, one stakeholder believed that the Basin Association and subsequent discharger organizations in North Carolina forced the state to look at basinwide approaches (Interview T-7). In summary, dischargers were drawn to both the Basin Association and the Grasslands Area Farmers because of the ability to trade, avoid individual permits and, in the Grasslands' case, gain access to the drain. These groups then increased understanding and facilitated further regional initiatives because of the communication they initiated on a watershed scale (Interviews T-5, G-1, G-4, G-8, G-10, G-12).

In summary, the appeal of trading as a more flexible, decentralized alternative to prescriptive limits increased dischargers' willingness to accept unprecedented regulations and facilitated a collective interest in remaining within their regional limit in order to maintain trading as an option. This common goal encouraged the formation of groups along watershed boundaries and better use of information, both changes that could facilitate further water quality improvements in the future. Given the uncertainty in environmental planning, these results are significant contributions.

Ability to Adapt

Another challenge of water quality management is adapting to new or changing information. No strategy will be perfect, leading one stakeholder to note that any program must be able to adjust to some trial and error (Interview T-5). At the same time, flexible and fluctuating regulations can be more costly to the regulated community because they discourage dischargers from making long-term capital-investments (Kolstad 2000, 206). I found that the option to trade in the Tar-Pamlico basin helped the state to attempt adaptive management by inducing point sources to fund and provide necessary information.

The negotiations and agreements leading to the development of all three programs had definite phases that provided an opportunity for re-evaluation: the Grassland Bypass Project's Use Agreement with U.S. Bureau of Reclamation and state waste discharge requirement permits; Long Island Sound's General Permit and TMDL with a mandated five-year review;⁸⁴ and the phases of the Tar-Pamlico nutrient strategy. Although some improvement in the estuary was apparent, the Division of Water Quality committed to develop a new TMDL if studies for the 2014 Basin Plan identify any remaining impairment in the Pamlico River (DENR 1994; Interview T-3, T-5, T-6, T-8).⁸⁵ Each program also required monitoring data that were analyzed annually.

The finite phases and range of signatories provided Tar-Pamlico, Grassland Area, and Long Island Sound stakeholders with a regular opportunity to evaluate new and emerging issues, uncertainty, and the tradeoffs between adaptability and consistency. The proposal to have a group cap and trading option was one of the primary reasons that North Carolina adopted the negotiated and phased approach to Tar-Pamlico basin's nutrient strategy development. Parties could opt not to participate, such as Environmental Defense's and Pamlico-Tar River

⁸⁴ Both Phase III of the Long Island Sound Study and the TMDL specified that the TMDL would be revisited every five years to ensure that the plan is reducing hypoxia (CTDEP and NYSDEC 2000, 8; EPA 1998 22). Any revisions to the TMDL would trigger adjustments to the General Permit to ensure that the reduction schedule remained consistent with the interim and final wasteload allocation. Although the General Permit has been revised, Connecticut and New York have not revisited the TMDL since its initial passage. The Connecticut Department of Environmental Protection recognizes that it is necessary, particularly given new information suggesting equivalency factors in one of the basins must be revised (Interviews L-2). However, such revisions would expend agency staff effort, particularly because of the requisite public hearings that must accompany any changes in the TMDL or General Permit (Interviews L-2, L-6).

⁸⁵ Some stakeholders voiced concern that the Division will not expend the resources to develop a TMDL for the estuary since it backed away from developing a fate and transport model for the basin at the end of Phase II. The Division's response is that many far less studied watersheds exist in North Carolina, so it cannot spend resources on watersheds that already have nutrient strategies with demonstrated progress (Interviews T-1, T-3, T-5, T-8).

Foundation's decision to abstain from Phase II given concerns over nutrient reduction targets and insufficient nonpoint source requirements. Phase II continued without them; only the state had veto power over an unfavorable agreement (Interviews T-6). The environmental groups returned to the table for Phase III because they felt that they could better influence the process as participants rather than commenters (Interview T-5). Signatories reported better understanding and respect for other parties' viewpoints even if they did disagree (Interviews T-5, T-6).

Phase III negotiations in 2007 provided the opportunity to revisit the Nutrient Offset Program's unsettled details. Many agree that maintaining loads below limits will be increasingly difficult as population increases, and the Basin Association may need to offset a portion of its loads in the future (Interviews T-1, T-3, T-6, T-7, T-8). Therefore, addressing differences over offset rates, actions, and credit lives is important in 2007 before offsets become critical to the point sources' compliance strategy (Interviews T-1, T-5, T-8).⁸⁶

Evaluating progress requires data, and one stakeholder noted that insufficient monitoring to capture constantly changing information is the greatest challenge of adaptive management; models only provide static estimations of current conditions (Interview T-8). In exchange for the granting point sources greater flexibility by allowing a group cap and offset option and in an attempt to prove that nonpoint sources account for the majority of nutrient loads, the Basin Association willingly filled some of these knowledge gaps that the Division noted were the greatest obstacles to nutrient strategy development (Interviews T-1, T-4, T-5, T-6). This data collection and analysis has augmented the state's basinwide planning process.

In summary, scheduled permit renewals, often with opportunities for public comment, are common in water quality management. However, these programs appeared to go a step further. Broader stakeholder interests were actively involved in program formation and evaluation as well. Of course, greater attention and review are not surprising given the salience of the water quality problems in each watershed. The Tar-Pamlico case demonstrates the clearest connection between a market-based instrument and adaptability; the existence of the trading option can leverage additional information necessary for any type of adaptive management.

Summary

Dischargers in the Grassland Area, Tar-Pamlico, and Long Island Sound basins have demonstrated pollution reductions that have met objectives in most years. In addition, initial evaluations suggest water quality is improving in the Pamlico and Long Island estuaries. Participation in the Nitrogen Credit Exchange suggests that plants have hastened and prioritized nitrogen removal where it is most beneficial, but the direct role of trading in the other two cases is limited. The cases also demonstrate that trading activity is not synonymous with pollution reduction; Connecticut sewage treatment plants have the lowest rate of meeting state pollution reduction targets. Even without active trading, market-based instruments made unexpected

⁸⁶ The environmental groups and the Division would like to see at least a portion of nitrogen credits fund stormwater retrofits, the nonpoint source with the greatest unaddressed need. Consequently, the offset rate should be adjusted accordingly (Interviews T-1, T-8). In the absence of rigorous or frequent auditing programs, environmental groups would also prefer the implementation of best management practices with minimal maintenance requirements to increase the certainty that nutrient reductions actually occur (Interviews T-5, T-8).

contributions that could indirectly improve environmental outcomes. In all three cases, trading facilitated the adoption of new and more stringent regulations and improved use of information and communication among dischargers, regulators, and environmental groups on a watershed scale.

On the other hand, the documented impacts of selenium on wildlife in the Grassland Area's Regional Reuse Area also reveal the disadvantage of foregoing the control of prescriptive, command and control management strategies. Harmful as well as beneficial unintended outcomes become more likely. This tradeoff is especially risky for toxic substances like selenium. Although trading was not the primary driver of the San Joaquin River Water Quality Improvement Project, concerns over the long-term feasibility and safety of the Reuse Area highlight the need to reframe questions and adjust strategies as new information or conditions emerge. Increased communication and information sharing, most notably demonstrated in the Tar-Pamlico basin, indicate that market-based incentives can encourage behavior that supports review and adaptation.

CHAPTER 6: LESSONS FOR OTHER WATERSHEDS

Since the Clean Water Act's passage in 1972, the issuance of technology-based limits on point sources has removed much pollution from U.S. waterways. In water quality-limited areas that remain impaired even after point sources complied with technology standards, some states have developed Total Maximum Daily Load (TMDL) analyses to determine how much pollution water bodies can assimilate while still meeting quality-based standards and apportioned these loads among sources, encouraging pollution management on a watershed scale. Despite these efforts, states and the U.S. Environmental Protection Agency (EPA) have not achieved the Clean Water Act's goal of restoring all waters to fishable and swimmable conditions. The majority of water bodies are not even monitored for chemical, physical, and biological parameters, and 40 to 50 percent of rivers, streams, and lakes that are monitored failed to meet standards supporting their designated uses as of 2003 (EPA 2003b, 2004, 1). Given the limited resources available to fund pollution reductions and the success of some market-based instruments in addressing other environmental problems such as sulfur dioxide, many economists, states, dischargers, and non-governmental organizations have proposed trading as a means to increase the cost-effectiveness of reduction efforts and thus achieve greater water quality improvements.

To determine whether trading achieved these expected benefits, I analyzed three market-based instruments: the Grassland Area Farmers Tradable Loads Program in California's San Joaquin Valley; the Tar-Pamlico River Basin Nutrient Offset Program in North Carolina; and the Long Island Sound Nitrogen Credit Exchange in Connecticut (see Table 6-1).⁸⁷ Each program was just one component of broader strategies to improve water quality. Despite cases' unique context, similarities yield lessons on the feasibility and utility of market-based instruments as regulatory tools to improve water resources. In this final chapter, I discuss how policymakers and environmental advocates could apply findings from these cases to other watersheds in need of pollution reductions to meet water quality standards.

⁸⁷ I refer to all of these programs under the broad term of water quality trading because they involve some type of agreement in which one discharger agrees to pollute less so that another can pollute more.

Table 6-1 SUMMARY CHARACTERISTICS OF TRADING PROGRAMS			
	Grassland Area Farmers Tradable Loads Program	Tar-Pamlico River Basin Nutrient Offset Program	Long Island Sound Nitrogen Credit Exchange
Pollutant	Selenium (acute)	Nitrogen and Phosphorous (chronic)	Nitrogen (chronic)
Regulatory Driver	San Luis Drain Use Agreement ^a	Nutrient Sensitive Waters Designation	Long Island Sound TMDL
Design	Cap and Trade	External: Offset; ^b Internal: Potential Cap and Trade ^c	Credit Exchange
Buyer	7 Drainage Districts (NPS ^d)	External: 1 TPBA ^f (PS ^e) Internal: 15 TPBA members (PS ^e)	79 sewage treatment plants (PS ^e)
Seller	7 Drainage Districts (NPS ^d)	External: Farmers (NPS ^d); Internal: 15 TPBA members (PS ^e)	79 sewage treatment plants (PS ^e)
Clearinghouse	No	External: Yes; Internal: No	Yes
Reduction Certainty ^g	Quantity	High	External: Medium; ^h Internal: High
	Price	Low	External: High; Internal: Low
Market Activity	None – Some in past	External and Internal: No – Expect in future	Active
<p>Notes:</p> <p>^a The Central Valley Regional Water Quality Control Board has since issued a waste discharge requirement to the Grassland Area Farmers; the Use Agreement and waste discharge requirement limits are identical.</p> <p>^b The Tar-Pamlico Basin Association retains the ability to purchase offset credits if nitrogen discharges exceed the group cap. These offsets fund nitrogen reductions from agricultural land in the basin.</p> <p>^c The Tar-Pamlico Basin Association may meet its group cap however it chooses. Although outside sources have posited that an internal cap and trade exists and members have discussed the possibility, members report that they have not established such a system to date.</p> <p>^d Nonpoint source</p> <p>^e Point source</p> <p>^f Tar-Pamlico Basin Association</p> <p>^g High quantity certainty means that the total amount of pollution discharged is definite; low certainty means that total discharges may vary or exceed the cap. High price certainty means that definite limits on how much regulated entities will pay to comply exist, whereas low certainty means that abatement costs are largely unknown.</p> <p>^h The level of certainty regarding nitrogen discharges ranges from low to high, depending on whether it is assumed that agricultural best management practices are implemented on schedule and achieve their estimated reductions.</p>			

Findings Across Cases

Table 6-2 shows that dischargers in each program met their pollution reduction targets in most years. However, the means by which they achieved these goals varied significantly. Some Connecticut sewage treatment plants used the state Clean Water Fund to upgrade plants and sold credits on the Nitrogen Credit Exchange; others purchased credits in order to comply with the General Permit. All participated in the Exchange. In contrast, Tar-Pamlico Basin Association (the Basin Association) members met their group cap by optimizing plant operations and agreeing to implement nitrogen removal when performing other upgrades; they did not seek compensation for these actions. Finally, the Grassland Area Farmers abandoned trading in favor of storing selenium in the government-subsidized Regional Reuse Area.

Table 6-2 OUTCOMES OF WATER QUALITY TRADING PROGRAMS			
	Grassland Area Farmers Tradable Loads Program	Tar-Pamlico River Basin Nutrient Offset Program^a	Long Island Sound Nitrogen Credit Exchange
Changes in Water Quality			
Achieved Pollution Reduction Goals	Yes – 80% of years, 84% of months	Yes – 100% of years	General Permit: Yes – 60% of years; TMDL: Yes – 100% of years
Improved Water Quality ^b	No – Less selenium in river, but increasing egg-selenium concentrations	Yes – N and P down; less impaired estuary	Yes – N down; DO up
Primary Means to Reduce Pollution	Selenium storage in Regional Reuse Area	Onsite optimization; nutrient removal when other upgrades	Participate in Nitrogen Credit Exchange
Remaining Concerns	Wildlife exposure to selenium in Reuse Area	Adequacy of nitrogen cap; need to reduce urban and rural runoff	Future availability of Clean Water Fund
Intended Outcomes			
Increased Cost-Effectiveness	No – Trading not used	No – Offsets and internal trading not used	Yes – Reduction efforts redistributed through Exchange ^c
Unintended Outcomes^b			
Willingness to Accept Regulation	Yes	Yes	Yes
Immediate Benefit	Flexibility in meeting Use Agreement limits	Avoided individual effluent limits	Avoided individual effluent limits
Improved Relations among Stakeholders	Most agree yes	Most agree yes	Most agree yes
Created Institution Consistent with Watershed Boundaries	Yes – Grassland Area Farmers	Yes – Tar-Pamlico Basin Association	Yes – General Permit includes equivalency factor zones; whole state within watershed
Promoted Information Collection, Sharing, and Use	Yes – Increased monitoring; share strategies to reduce selenium, protect wildlife	Yes – Basin Association funded estuary model, gage, Cost Share Coordinator, and monitoring coalition	Somewhat – May have increased interest in trainings and encouraged standardized monitoring and analysis
Notes:			
^a External trading refers to the Nutrient Offset Program, whereas internal trading refers to the Tar-Pamlico Basin Association’s option to create an internal cap and trade system, although it has not to date.			
^b Trading programs were all part of broader pollution reduction strategies, so changes in water quality and unintended outcomes are not only the result of dischargers’ option to trade.			
^c Some stakeholders disagree over whether the Clean Water Fund and Nitrogen Credit Exchange actually prioritized upgrades at facilities where they would be most cost-effective.			

Water quality outcomes also varied across cases and are not attributable exclusively to the market-based tools. Preliminary analysis suggests that Long Island and Pamlico sounds are improving, although some uncertainty remains. In contrast, egg-selenium concentrations indicate that wildlife is exposed to the toxic element and at risk of reduced reproductive success.

While much of the literature focuses on the ability of market-based instruments to maximize cost-effectiveness, only dischargers in Connecticut utilized trading to reallocate pollution reduction. These exchanges may not have induced the most cost-effective upgrades. Rather, the most consistent contribution of trading programs to better water quality management was increasing dischargers’ willingness to accept more stringent and unprecedented regulations in all three cases. In addition, and most notably in the Tar-Pamlico basin, the option to trade increased the capacity for watershed management by encouraging institutions to form along watershed

boundaries, involving diverse stakeholders in management decisions, and inducing dischargers to collect and share information with each other, regulators, and environmental organizations.

Lessons for Other Watersheds

What lessons from these three cases can be applied to other areas developing pollution management strategies? How can policymakers know if a market-based instrument is an appropriate management tool and what benefits they might expect from trading? Compared to open, private sector markets or trading among other types of pollution, market-based instruments face many challenges when applied to water quality such as market thinness, lack of information, and impact of discharge location on ambient water quality. Table 6-3 displays the major obstacles to trading in the Tar-Pamlico and Grassland Area basins.

Table 6-3 MAJOR OBSERVED OBSTACLES TO WATER QUALITY TRADING				
		Grassland Area Farmers Tradable Loads Program	Tar-Pamlico River Basin Nutrient Offset Program^a	Long Island Sound Nitrogen Credit Exchange
Market Distortion	Level	High – Government funded 90-97 percent of Regional Reuse Area	Medium – Government funds for Agriculture Cost Share Program created offset backlog	Medium – Equalized credit value based on Clean Water Fund projects
	Effect	Deters – Subsidizes alternative strategy	External: Deters – Creates uncertainty over reductions credit effectiveness	Encourages – But if Clean Water Fund insufficient, loads exceed General Permit limit
Uncertainty	Level	Questionable	Medium – 1) Debates over legitimate credit use; and 2) overestimate of onsite compliance costs	Low - Due to state administration
	Effect	Minor	External: Deters – Impedes planning around future trades; makes onsite treatment relatively more certain	Encourages – Creates stability and credibility
Political Transaction Costs	Level	High	High	Low
	Effect	Deters – Districts do not want to pay each other	Internal: Deters – Plants do not want to pay each other	Encourages – Removes plants’ need to pay each other
Note: ^a External trading refers to the Nutrient Offset Program, whereas internal trading refers to Tar-Pamlico Basin Association’s option to create an internal cap and trade system, which it has not to date.				

Even if dischargers never trade, policymakers should still consider allowing a group cap when sources are likely to oppose individual limits if it is possible to accurately measure total pollution loads. Given dischargers’ ability to delay and resist, it is very difficult for agencies to control pollution without some level of trust and willingness with the regulated community. This thesis suggests that trading can help policymakers achieve a balance between regulation and flexibility while increasing control over water quality. Of course, factors other than the ability to trade also contributed to these dischargers’ acceptance of regulations, most notably the salience of each water quality problem. Increasing the visibility of water quality problems is an effective way to get regulation on the policy agenda. Nevertheless, the consistent willingness to comply among dischargers is notable given the ongoing challenges of mandating pollution reductions.

Policymakers should use dischargers' preference for trading to leverage cooperation on other aspects of watershed management such as forming basin organizations, collecting and disseminating information, and collaborating with diverse stakeholders. For example, the dischargers in the cases that I studied did not want to lose the major benefit that compliance offered, including access to the San Luis Drain and avoided individual effluent limits requiring immediate, costly upgrades. As a result, they willingly communicated methods to decrease discharges. Information became valuable because it allowed the group as a whole to stay below its load limit, prove its success, and thus maintain the decentralized autonomy and flexibility afforded by the trading program.⁸⁸

This ability of trading to induce behavior that could increase capacity for watershed management derives largely from its decentralized regulatory structure, not just the economic incentives that trading specifically offers. Therefore, policymakers should remain open to other decentralized models that could achieve similar outcomes instead of expending time and resources only to develop pollution markets. A decentralized regulatory approach does not mean weakening federal and state standards, however; the three cases demonstrate that trading only works with a strong regulatory driver.

When considering whether to develop a trading program, policymakers should also note the types of dischargers most suited to market-based instruments. Trading works best among sources that are sensitive to price signals and have a clear incentive to minimize overall costs. These signals are typically weaker or skewed among quasi-public or highly subsidized industries (Kolstad 2000, 150). Furthermore, policymakers must recognize political transaction costs, or the costs that trades impose on relationships between entities, that market-based instruments might impose on sources which do not traditionally compete and would hesitate to be perceived as profiting from one another. The transaction cost illustrates that dischargers are not driven by economic rationale alone. These entities might still benefit from the increased flexibility of a decentralized regulatory approach, but solutions are more likely to involve regional cooperation than minimizing individual financial costs.

Alternatively, policymakers can learn from Connecticut's ability to neutralize transaction costs by appointing a representative board to set credit values and passing money through a state-administered exchange. Having the state as a middleman eased concerns that some entities might take advantage of or overly depend on others. State involvement can also reduce transaction costs associated with uncertainty and market thinness by guaranteeing a buyer and seller, setting prices to guard against volatility, and legitimizing credits as a compliance mechanism. Although a less free-market approach, state intervention allowed facilities to participate in the Exchange for little cost and incorporate trading into their long-term planning process. In contrast, the Tar-Pamlico case demonstrates that lingering uncertainty can induce dischargers to pursue alternative, more reliable, but potentially less cost-effective solutions.

Whether or not trading is the primary strategy, policies should frame objectives carefully and institutionalize ways to evaluate progress, incorporate new information, and adapt as necessary

⁸⁸ In addition to proving that it was below the group cap, the Tar-Pamlico Basin Association also wanted to provide evidence that point source pollution did not cause eutrophication. Consequently, it funded an estuary model, water quality gage, Agriculture Cost Share Coordinator, and monitoring coalition to redistribute the burden to reduce back on to those responsible for the majority of pollution: agriculture.

to address uncertainty and guard against unintended consequences. As the Tar-Pamlico Basin Nutrient Offset Program in particular demonstrated, trading can facilitate this adaptive management process by bringing diverse stakeholders to the table, increasing the value of information, generating levels of cooperation among stakeholders, and creating discharger associations that align with watershed boundaries. Environmental organizations can use their place at the table to influence this adaptive process. They fulfill a role by continuing to review results and raise concerns.

States must also be prepared to maintain their political will and support for water quality improvements regardless of what watershed management strategy they adopt. Agencies and legislatures need to commit resources to fund facility upgrades such as continued investment in Connecticut's Clean Water Fund if the Nitrogen Credit Exchange is to induce plants to upgrade and comply with General Permit and TMDL nitrogen limits. Similarly, government entities must commit to monitoring and modeling efforts that highlight necessary changes and enforce management strategies. Otherwise, unintended consequences of more flexible regional solutions such as wildlife exposure to selenium through the Regional Reuse Area might proceed unchecked. Similarly, the North Carolina Division of Water Quality cannot determine whether a 30 percent nutrient reduction is sufficient to restore the Pamlico River without ongoing monitoring. The Long Island Sound Nitrogen Credit Exchange demonstrates that trading can increase support for state and federal funding by making pollution a financial cost as well as an environmental concern. Nevertheless, ultimate results depend on government commitment and the public's willingness to devote taxes or rates to these problems. Again, environmental organizations can help strengthen political will and investment in solutions by maintaining the salience and public awareness of water quality problems.

Conclusions

Did water quality trading perform in practice as it promised in theory? Market-based instruments only facilitated cost-effective pollution reduction when programs were carefully designed to be credible, reliable, and minimize transaction costs among dischargers that might not be accustomed to exchanging with one another. The Long Island Sound Nitrogen Credit Exchange demonstrates that when these conditions are met, trading can become one useful component of broader watershed management strategies. Just as notable, however, the Connecticut program did not meet its General Permit discharge limits in two out of five years. It is impossible to compare Connecticut's results to the counter-factual scenario of discharge levels without the Exchange, but this finding demonstrates that designing policies to promote trading alone will not always achieve pollution reduction objectives. It is necessary to decouple trading from water quality improvements, and agencies and environmental organizations must maintain the political and financial will to support source control efforts, enforcement, and regular evaluation of objectives and strategies.

What were the major contributions of market-based instruments? Despite no trades in the majority of cases, these programs had other unexpected outcomes that could enable further water quality improvements. Because of their appeal as a flexible, decentralized alternative to prescriptive regulations, the market-based instruments enabled increased regulation, transfer and use of information, and formation of organizations along watershed boundaries. Given the

existing barriers to continued water quality improvement under the Clean Water Act, these findings are significant.

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APPENDIX 1: INTERVIEWS AND INTERVIEW PROTOCOL

Name	Office
Iliana Ayala	Bureau of Water Protection and Land Reuse, CT Department of Environmental Protection
Sonja Biorn-Hansen	Oregon Department of Environmental Quality
Paul Blount	Rocky Mount Water Resources and Member, Tar-Pamlico Basin Association
Kate Bowditch	Charles River Watershed Association
Francoise Brasier	U.S. EPA Office of Wetlands, Oceans, and Watersheds
Gail Cismowski	Central Valley Regional Water Quality Control Board
Steve Coffey	Division of Soil and Water Conservation, NC Department of Environment and Natural Resources
David Cory	Des Jardins Ranch and Camp 13 Representative
Melville Peter Coté, Jr.	U.S. EPA Ocean and Coastal Protection Unit
Debra Denton	Central Valley Regional Liaison, U.S. EPA Monitoring and Assessment Office
Chris Eacock	U.S. Bureau of Reclamation, South-Central California Area Office
Atomic Falaschi	Panoche Drainage District
Manny Furtado	Branford Water Pollution Control Department
Rich Gannon	Division of Water Quality, NC Department of Environment and Natural Resources
Mike Gardner	Grasslands Area Farmers
Marcos Hedrick	Panoche District
Bryan Horsburgh	U.S. Bureau of Reclamation
John Huisman	Division of Water Quality, North Carolina Department of Environment and Natural Resources
Heather Jacobs	Riverkeeper, Pamlico-Tar River Foundation
Gary Johnson	Bureau of Water Protection and Land Reuse, CT Department of Environmental Protection
Joe Karkoski	Central Valley Regional Water Quality Control Board
Kavya Kasturi	U.S. EPA Office of Wastewater Management
Virginia Kibler	U.S. EPA Office of Water, Headquarters
Barrett Lasater	Greenville Utilities and President, Tar-Pamlico Basin Association
Chris Lewicki	U.S. EPA Office of Water, Headquarters
Professor Lynn Maguire	Duke University Nicholas School of the Environment and Earth Sciences
Laurie Mann	U.S. EPA Region 10, Watershed Restoration Unit
Matthew McCarthy	Central Valley Regional Water Quality Control Board
Joseph McGahan	Grasslands Area Drainage Coordinator, Summers Engineering
Eugenia McNaughton	EPA Region 9 Quality Assurance Office
Robert Moore	Hartford Metropolitan District
Dan Nelson	San Luis and Delta-Mendota Water Authority
Doug Norton	U.S. EPA Office of Water, Headquarters
Theresa Presser	USGS Water Resources Division
Douglas Rader	Environmental Defense
Diane Rathmann	General Counsel for San Luis Delta-Mendota Water Authority
Carol Lee Rawn	Conservation Law Foundation
Bob Rose	U.S. EPA Office of Water, Headquarters
Joseph Rudek	Environmental Defense
Claire Schary	U.S. EPA Region 10, Watershed Restoration Unit
Rudy Schnagl	Central Valley Regional Water Quality Control Board
Alison Simcox	U.S. EPA Region 1
Mark Tedesco	U.S. EPA Long Island Sound Office
Mike Templeton	Division of Water Quality, NC Department of Environment and Natural Resources
Steve Winnett	U.S. EPA Region 1
Terry Young	Consultant

I conducted interviews in person and over the phone between November 2006 and March 2007. I used a semi-structured protocol and sent individuals whom I interviewed in person my questions prior to our meeting. In addition, I sent my notes to the people whom I spoke with so that they had the opportunity to retain a copy and edit, add, or remove any portions of the interview.

I promised individuals that I would not quote or attribute any material to them directly. Therefore, I assign each interview a unique code known only to myself when referencing these interviews. This approach protects the confidence of those whom I spoke with while providing a sense of the number of people who stated the findings presented in this thesis.