Chapter 16
Nitrogen Reduction in North Carolina

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Abstract This EPI case study analyzes Nitrogen trading in North Carolina's Neuse River. Under the United States' Clean Water Act, the Neuse River is a section 303(d) impaired water. Typical 303(d) regulation is command-and-control: wastewater treatment plants that emit Nitrogen are required to meet their own emission limits. In the EPI, however, a cap-and-trade program was put in place under which plants are given a permit to emit Nitrogen, and this permit may be sold or temporarily leased to another plant. The EPI met the environmental goal in that emissions were significantly reduced below baseline levels. But the EPI did not meet the economics goal of reducing emissions in the least cost way, because few permits were traded. The design could be improved by restricting trading to occur within zones, rather than having only one single zone. The practice could be improved by encouraging plants to make trades. This case study informs the regulation of water quality in the USA under the Clean Water Act. Moving from the traditional regulation of these point sources to a properly designed EPI with active trading could potentially generate hundreds of millions of dollars in benefits to society.

Keywords Permit trading • Nitrogen • Clean Water Act

16.1 Introduction

The widely acknowledged success of the United States Environmental Protection Agencies cap-and-trade programs for the reduction in emissions of S02 from electric power plants (Stavins 1998), has generated considerable interest in applying cap-and-trade programs to other pollution control problems. In particular, the Environmental Protection Agency (EPA) has encouraged the use of water quality trading to lower the cost of meeting the standards set by the Clean Water Act (USEPA 2003; Stephenson and Shabman 2011). An EPI based on a cap-and-trade

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program has many theoretical advantages relative to other types of regulation. Perhaps most importantly, it offers the promise of reaching a given water quality goal in the least cost manner. In this case study, we critically evaluate a cap-and-trade EPI that was applied to Nitrogen emissions into North Carolina's Neuse River Basin.

The impetus for implementing an EPI for nitrogen trading in the Neuse River Basin has its origin in the major fish kills that occurred in 1995 (NCEE 2011). In response, the State of NC government developed a regulatory structure to reduce the flow of Nitrogen into the river. Rulemaking for the reduction of nitrogen was developed by the Environmental Management Commission and administered by the Division of Water Quality (Hamstead 2008). Reduction was targeted from both point and non-point sources, but the rules for point sources contained an interesting provision that generated the EPI. Rather than require that each point source meet an individual emission requirement, the rules allowed polluters to jointly meet an aggregate group emission requirement by forming an association. The members of the association would not be fined by the State of NC as long as the total aggregate emissions of pollution were below the required level (Hamstead 2008). This case study focuses group emissions from 22 point sources known collectively as the Neuse River Compliance Association (NRCA). These are almost entirely wastewater treatment plants (WWTP). This association was formed in 2002 in response to the Nitrogen emission rules described above.

16.2 Setting the Scene: Challenges, Opportunities and EPIs

The Neuse River Basin covers approximately 9 % of the state of North Carolina, or 15,959 km^2. This region has experienced significant growth over the last 10 years with a decrease in forest land and an increase in development. This trend is expected to continue over the next 10 years (UNRBA 2011). All members of the NRCA discharge nitrogen into the Basin. Many of these sources are expected to experience 50–100 % increase in discharges by 2030, due primarily to increases population (all data from NCDWR 2010). In addition to these point sources, emissions from non-point sources also lead to decreases in water quality. The main non-point source emissions are from storm water and agricultural runoff. In particular, there has been a large increase in agricultural runoff from concentrated animal feed operations over the last decade (NCDWQ 2009).

In the USA, emissions of water pollution from point sources are governed by the Clean Water Act. Under the Clean Water Act, an emitter must obtain a National Pollutant Discharge Elimination System (NPDES) permit from the EPA (USEPA 2011). The actual administration of the NPDES permit is usually undertaken by individual states, as is the case in North Carolina. In North Carolina, the Division of Water Quality is the responsible state agency (NCDENR 2011).

Under the Clean Water Act, the Neuse River Estuary in North Carolina has been declared a section 303(d) impaired water. The typical regulation of 303(d) impaired waters can be characterized as command-and-control regulation. The NPDES permit specifies a maximum Nitrogen emission level from that plant. In contrast, for the Neuse, the state of North Carolina, in conjunction with the EPA, has crafted an innovative EPI that gives the WWTP more flexibility. Rather than require that each point source meet an individual emission requirement, the rules allowed polluters to jointly meet an aggregate group emission requirement by forming an association. The members of the association would not be fined by the State of NC as long as the total aggregate emissions of pollution were below the required level (Hamstead 2008). If a WWTP wants to emit more pollution than its individual requirement, it can do so provided that it secures a corresponding decrease in emissions from another plant. In this way the WWTP are effectively trading emissions. Through this process of trade, an individual WWTP may no longer meet its individual requirement, but the aggregate requirement is still met. The intention of the EPI is to lower the costs of compliance with the Clean Water Act by allowing NRCA members to trade emissions.

The trade process is formalized by giving each WWTP a quantity of emissions permits equal to their individual Nitrogen emission requirement. These permits implicitly define a property right, which the plant may permanently sell or temporarily lease. Trading of these rights is approved by a North Carolina statute. The WWTP are often owned by local municipalities, so they are not necessarily profit maximizing firms. Even so, it is not unreasonable to assume that their goal is to trade permits in such a way as to minimize their total costs of abatement activities and permit purchases.

There are two levels of enforcement of the EPI. At the external level, the State of NC imposes fines if the aggregate emissions of pollution of the association exceed the aggregate nitrogen emission requirement. At the internal level, the NRCA has a complicated system for allocating fines to its own members. The internal fine structure reveals that the NRCA has not fully endorsed the emission trading concept. If actual emissions from a WWTP exceed their individual emission requirement, it must pay an internal fine, even if it purchases permits from another WWTP to cover actual emissions. This is at odds with the typical pollution permit trading scheme in which firms are fined only if they do not have enough permits to cover their actual emissions. The goal of these internal fines seems to be to induce the individual members to upgrade their facilities so as to be able to meet their individual requirement in the future, as much of the fine is returned once such improvements are made (Hamstead 2008).

16.3 The Nitrogen Trading Program in Action

The EPI was put in place to lower the aggregate costs of meeting the overall goal in reduction of Nitrogen emissions. The EPI was quite successful in reducing emissions of Nitrogen, but significant cost savings were not realized because the WWTP did not engage in very many trades. In addition, the design of the market could have been improved by breaking the market up into sub-markets and allowing trade to take place between firms in the same sub-market, but not between firms in different sub-markets. A design of this type allows the optimal trade-off between costs to WWTP of reducing emissions and costs to society from damages from these emissions.

16.3.1 The Nitrogen Trading Program Contribution

16.3.1.1 Environmental Outcomes

The fundamental environmental outcome in this case study is the pounds of Nitrogen emitted by the members of the NRCA. This information is given in Table 16.1 (data provided by the NRCA). The EPI was conducted in a setting in which total Nitrogen emitted into the river from all sources is decreasing over time (Lebo et al. 2012). The NRCA was formed in 2002, and using this year as a baseline yields a 35 % reduction in emissions. At face value, this suggests that the EPI has been dramatically successful in reducing emissions. But the aggregate Nitrogen emission requirement assigned to the NRCA is 1,137,171 lb. Thus the members are emitting 52 % less Nitrogen than they are allowed to emit. This indicates significant over

Table 16.1 Yearly emissions of nitrogen by members of NRCA

Year	Total flow (MGD)	Total estimate pounds N to the estuary
1995	83.808	1,784,130
1996	85.675	1,741,492
1997	81.444	1,653,262
1998	93.442	1,387,717
1999	94.659	1,123,169
2000	92.582	1,056,202
2001	86.818	907,381
2002	89.926	797,991
2003	107.463	711,398
2004	101.203	558,553
2005	101.757	566,627
2006	102.970	542,205
2007	92.994	461,322
2008	90.563	489,789
2009	98.570	497,002
2010	101.852	584,192
2011	93.384	513,269
2012	97.248	540,892
2013	102.847	514,847

Source: Data from the Neuse River Compliance Association compliance, and suggests that there are other reasons for the marked decline in emissions rather than just the EPI.

In particular, it appears that the WWTP are motivated by the dynamic between future population growth and increasingly strict future regulations (Hamstead 2008). Many of the municipalities anticipate significant population growth in the next 20 years. They also anticipate significantly stricter emissions controls over the same time period. In response to this dynamic, they perceive their optimal strategy is to take steps to install abatement capacity now to be ready to meet these future challenges. Hamstead (2008) suggests that this unusually forward-looking behavior on the part of the WWTP is due to a combination of risk aversion, public image incentives, and altruism.

Evidence for this over compliance behavior comes from analyzing capital expenditures by WWTP to reduce Nitrogen emissions over the last two decades. Members of the NRCA spent US$16 million from 1995 to 1998 and they spent US$31 million from 1998 to 2003 (LNBA 2012). More recently, from 2003 to 2006 the City of Raleigh spent US$40 million on upgrades to their WWTP (Yadkin Riverkeeper 2012).

An ex-post assessment of the environmental outcomes of the EPI itself is difficult to perform because, as discussed below, there was very little actual trading of emissions between the WWTP. As Table 16.1 shows, however, there has been a dramatic decline in Nitrogen emissions since the 1995 fish kill. So we can perform a counterfactual of the overall Nitrogen emissions using the 1995 baseline. The baseline level of emissions for members of the NRCA in 1995 was 1.78 million pounds of Nitrogen per year. This Nitrogen was contained in an outflow of 83,000 MGD from the treatment plants. By 2006, the emissions had been reduced to 0.54 million pounds from an outflow of 102,000. Although some of the increase in the flow was due to an increase in membership of the NRCA, we can use this data to approximate the counterfactual level of emissions by simply assuming the pound/gal rate would have remained constant over time. This implies that if "business as usual" had continued from 1995, there would have been 2.19 million pounds of Nitrogen emitted in 2006. This implies there is actually a 75 % reduction in emissions from the counterfactual.

16.3.1.2 Economic Outcomes

The EPI is centered around an aggregate emissions requirement. This specifies the total emissions across all members in the NRCA. As long as the total emissions are below this requirement, the group is considered to be in compliance with the regulation. An important feature, however, is that each member is still given an individual emissions requirement, and, as discussed above, the internal system of fines within the NRCA is based on this individual requirement (Hamstead 2008).

Regulation with an aggregate emissions requirement has the potential to generate significant cost savings for the members of the NRCA relative to the command-and-control alternative. If one WWTP faces high costs of abating pollution, then it can simply buy emission reductions from another WWTP, which presumably has lower costs. This generates abatement costs savings relative to the alternative in which each WWTP has to meet their own individual emission requirement. A simple aggregate emissions requirement, however, is not the least cost EPI available. Yates et al. (2013) describe a system in which the aggregate emissions requirement is further subdivided into zones. WWTP within a zone may trade emissions with one another, but WWTP in different zones may not. The zonal system strikes a balance between reduced abatement costs and increases in "hot spots". (One can think of the actual EPI, with a simple aggregate emission requirement, as a special case of the zone system in which there is only a single zone.) Allowing WWTP to trade within a zone reduces abatement costs in the manner described above: high cost WWTP can trade with low cost WWTP to the benefit of both. Using zones rather than a single aggregate emission requirement allows a greater control over the spatial distribution of emissions. This reduces the likelihood of a large concentration of emissions in a specific part of the river.

In theory, the ability to trade means that some WWTP would not have to undertake costly abatement. In actual practice, there has been very little trading in the EPI. Apparently the WWTP do not view trading as a method for reducing aggregate abatement costs. The only time that permanent trades took place was when a WWTP went out of business. This occurred twice. The WWTP view trading as a short-term measure. If a WWTP is emitting more than their individual emissions requirement, they can use trading as a temporary fix until they can reduce their emissions (Hamstead 2008). There were six of these temporary trades (leases). As a result of the limited trading, the cost savings of the EPI seem to be minimal.

In the absence of abatement cost savings, the primary benefit of the EPI seems to be related to risk reduction for the WWTP, both in the short term and the long term. In the short term, despite the provisions for trading, the WWTP seem to view it as their responsibility to meet their own individual emission requirement. (This is reinforced by the internal fine structure described above.) The few temporary trades that took place appear to have been motivated as "insurance" against the possibility that they might be temporarily out of compliance with their individual requirement. In the long term, due to the increases in population and the stringency of anticipated future regulation, the WWTP like having the option of trading in case they have trouble meeting future emission requirements (Hamstead 2008).

The EPI did not generate any revenues for the local or national government. The two permanent trades and six temporary trades simply transferred money from one WWTP to another (Hamstead 2008). Alternatively, the individual emissions requirements could have been sold to the WWTP at the start of the program to generate revenue for the State of NC.

The EPI seems to have provided the correct incentives in theory, but not in practice. In the case of this EPI, the correct incentives would have led the WWTP to meet the group emission requirement in the least cost way. All of the theoretical requirements for this to happen are found in the EPI. In fact, the EPI seems to be a classic example of a cap and trade permit market. The actual experience, however, shows that there is a subtle requirement needed to insure that the EPI is successful. In particular, the WWTP have to fully accept the group emission concept. It appears that they did not, as they still felt bound to meet their individual requirement. It will be interesting to see if this changes over time. At the current time, in light of the data in Table 16.1, it appears that it is rather easy for the WWTP to meet their individual emission requirements. Thus the WWTP were not really forced to consider how abatement costs could be reduced by moving from individual to group compliance. From Table 16.1, we see that the total allocation of Nitrogen would have to fall well below 500,000 lb before the WWTP will have strong incentives to consider group compliance. This may occur in the future, as the regulations become increasingly stringent. Thus one would expect there to be an increase in trading activity as emission constraints become more binding and WWTP come to realize that trading will enable them to reduce abatement costs.

16.3.1.3 Distributional Effects and Social Equity

This EPI is tightly focused on the WWTP in the NRCA. The distributional effects and social equity are therefore defined with respect to the WWTP. As discussed above, the WWTP made significant capital expenditures to decrease the emissions of Nitrogen. As most of the WWTP are owned by cities or municipalities, these expenditures were typically paid for by a combination of bond issues and tax dollars. As much or all of these expenditures are likely to have taken place without the EPI, we do not provide estimates of the resulting distributional effects.

Based on qualitative interviews with participants in the EPI summarized by Hamstead (2008), we can, however, identify four components of distributional effects and social equity that are directly attributable to the EPI. A more detailed explanation for these assessments is as follows:

1. Public Image. Participants recognized that public image associated with the EPI could be positive or negative, depending on the emissions outcomes. In practice, the emissions have decreased significantly, so the effect is considered to be positive.
2. Information Sharing. The EPI has provided a forum for both formal and informal information sharing between WWTP. The information includes specific abatement practices and technology as well as insight into the regulatory process.
3. Political Representation. The EPI has created a unified group that represents the interests of the WWTP. This group has more political influence than the individual members would have if they acted alone.
4. Social Benefit. Before the EPI, the WWTP had isolated individual relationships with each other. After the implementation of the EPI, the WWTP began to feel united in working toward a common goal. Interestingly, this common goal seems have been viewed as helping each other meet their individual emission requirements.

16.3.2 The EPI Setting Up

16.3.2.1 Institutions

In 2003, the EPA officially issued a new water quality policy to encourage trading between point sources in watersheds with an approved aggregate emission requirement (known as the Total Maximal Daily Load, or TMDL) (USEPA 2003). This policy can be viewed within the context of wider use of pollution permits by the EPA after the successful implementation of S02 permit trading in the previous decade (Boyd et al. 2003). In formulating the 2003 policy, the EPA also cited promising results from a trial water quality trading program in Connecticut and a study that suggested that water quality trading could save almost a billion dollars if implemented nationwide (USEPA 2003).

Although concern about water quality in the Neuse started in the 1970s, the real impetus for stricter regulation of Nitrogen emissions was the 1995 fish kill. The TMDL for the Neuse was approved by the EPA in 2002. In that same year, the General Assembly for the state of North Carolina approved a Wastewater Discharge Rule. This rule enabled the formation of the NRCA and allowed it to jointly meet the TMDL rather than comply with the individual NPDES permit (USEPA 2007). Thus the NRCA can be viewed as a new institution that developed from the change in water quality policy. Although these developments pre-date the official EPA policy that supported trading, it is likely that the EPA was already encouraging trading in advance of the official policy statement.

The failure of the EPI to reach the economic goal does not seem to be related to a failure of institutions. Indeed, all the proper institutions to support trading seemed to be in place. This implies that institutions are necessary, but not sufficient for a successful EPI.

The interactions between the EPI and the institutional setting are summarized as follows. The interactions between the EPI and level 2 institutions are positive. The agreement between the EPA and the legislative and executive branches of the NC state government greatly supported the design and implementation of the EPI. As documented above, there were very few trades that took place. But, for the few trades that did take place, prices played their accustomed role in trade. So we rate this a positive interaction for level 4 institutions at the operation phase.

16.3.2.2 Transaction Costs and Design

Unfortunately, little direct information is available about transactions costs of the EPI, so we must rely on indirect evidence. In the absence of the EPI, the DWQ and the NRCA would still have to monitor, report, and enforce emission levels in the Neuse. (A crude estimate of these costs is US$88,000 per year based on expenditures in 1995 (USEPA 1997).) So this analysis focuses on just the incremental transactions costs associated with actual trading of emissions. Miller and Wolverton (2005) qualitatively classify transactions costs (as being either "low", "medium", or "high") in a variety of water quality trading programs. Trading in the Neuse River is classified as having a "low" level of transactions costs. The authors further note that most of the transactions costs are assumed by the State of North Carolina, presumably by the DWQ. Additionally, Breetz et al. (2004) state that the actual transaction costs for point source to point source trading in the Neuse should be small because of the NRCA. Other indirect evidence comes from a study of point/non-point source trading of water quality permits in Minnesota (Fang et al. 2005.) Here the total transactions cost of a single trade across both the permitting and implementing phase is determined to be US$105,000. Of this total, approximately US$19,000 was incurred by the point source and the vast majority of the rest was incurred by the state agency. Given the qualitative estimates above, it is reasonable to interpret the figure from Fang et al. (2005) as a very crude estimate for the upper bound of the costs per trade. As of 2007, there appears to have been only eight total trades in the history of the EPI (Hamstead 2008), giving an upper bound of US$152,000 of total transactions costs incurred by the members of the NRCA. This compares to a price of US$1.7 million for one of the permanent trades.

The EPI design, implementation, and monitoring involved primarily North Carolina's DWQ, although the EPA played an advisory role and supported the development of trading through its policy. The total time for the development of the EPI was 7 years, from the 1995 fish kill to the formation of the NRCA and approval of permit trading by the General Assembly in 2002. The EPI was applied as a particular implementation of the Clean Water Act.

16.3.2.3 Implementation

The EPI is very flexible, and can easily be adopted widely in other river systems. In these other systems, each large point source is typically allocated a fixed level of Nitrogen emissions (a NPDES permit) by the EPA. To implement the EPI, these individual amounts can be aggregated to determine the total cap on Nitrogen among all the point sources. From this a permit trading system can be set up. As discussed above, the EPA has experience with a similar water quality trading program in Connecticut. And there are similar small regional permit markets for other pollution problems, such as the RECLAIM air pollution trading program in California (SCAQMD 2012).

The experience from the Neuse EPI, however, suggests that one must be concerned that the problem of limited actual trading might also appear when the EPI is applied to these other river systems. It may help to move from the internal fine system found in the Neuse to a more typical external fine system. Here each firm must hold enough permits to cover their own emissions after trading or face external fines. Such a system explicitly moves the emphasis from meeting requirements on Nitrogen before trading takes place to meeting requirements on Nitrogen after trading takes place. Perhaps this will lead the WWTP to more fully embrace the group compliance concept.

The EPI can easily be adjusted following a review of its performance or in response to new information about the damages from Nitrogen emissions. For example, if new information reveals that damages are more severe than previously thought, then the size of the aggregate emission requirement can be reduced.

The major stakeholders in the EPI are the WWTP. They were quite successful in influencing the development of the EPI. In particular, the members of the NRCA were instrumental in convincing the EPA and the Division of Water Quality in NC to set up the group permit system rather than using the traditional individual permit system (Hamstead 2008). Their influence seems to stem from the fact that they had cultivated a long relationship with state regulators. Before the NRCA was formed, many of the WWTP belonged to another group called the Lower Neuse Basin Association (LNBA). This group formed in 1994 to collectively monitor emissions of Nitrogen in the Neuse and worked with the state of NC in this capacity (Hamstead 2008). So the step from the LNBA to the NRCA can be seen as the natural extension of group monitoring of emissions to group compliance of emissions.

The EPI would not have been possible without the cooperation of the North Carolina Division of Water Quality (NC DWQ) and the EPA. The EPA provided support for trading through their water quality trading policy statement (USEPA 2003). But the actual administration of the program is conducted by the NC DWQ. Thus these groups had to be in agreement about the usefulness of implementing the group compliance strategy. This strategy allows for more flexibility in meeting the requirements of the Clean Water Act.

16.4 Conclusions

The results of this EPI are decidedly mixed. On one hand, compared with the typical 303(b) regulation, the aggregate emission requirement and attendant trading system is a big improvement. It offers WWTP the opportunity to greatly reduce the total cost of meeting the Clean Water Act regulation. On the other hand, there was not much actual trading. The WWTP never fully endorsed the group compliance concept, and remained focused on meeting their individual emission requirements. Thus there was very little cost savings associated with the EPI.

Moreover, even in theory, the EPI was not the most efficient type of regulation. In the EPI, there is essentially a single market for the entire Neuse River. Any WWTP may trade permits with any other WWTP. A system of trading zones would perform better. In such a system, groups of WWTP are placed into various zones. WWTP within a zone are allowed to trade with each other, but there is no trade across zones. The zones are designed to account for both the abatement costs and the damages from emissions of pollution. Yates et al. 2013 show that a zone system would lead to several million dollars of overall cost savings per year relative to the current design of the EPI, provided of course that the WWTP actually exploited the opportunities for trade.

In theory, pollution permit trading allows a group of emitters to reach an aggregate emission goal in the least cost way. The individual endowment of emissions is merely the starting point. Firms may increase or decrease emissions from this point through trade. In practice, the cost savings from trading will not be realized if the emitters do not actively participate in the market. In this EPI, the WWTP seemed to view the individual endowment of emissions as the desired outcome. Thus the only trades that occurred were temporary transactions when a WWTP found itself out of compliance with their permit endowment.

The support of the EPA for more flexible trading based regulation was a significant enabling factor for the EPI. In addition, the long established relationship between the stakeholders and regulators at the state level was strong positive influence on the EPI design. The stakeholders had already been successfully applying a group monitoring system, so it was not a large step to move to a group compliance system.

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