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Laura McCann and K. William Easter

DEPARTMENT OF APPLIED ECONOMICS
COLLEGE OF AGRICULTURAL, FOOD, AND ENVIRONMENTAL SCIENCES
UNIVERSITY OF MINNESOTA

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Laura McCann and K. William Easter*

*Laura McCann is lecturer in agricultural and resource economics at the University of Western Australia and K. William Easter is professor of applied economics at the University of Minnesota. McCann was a graduate student at the University of Minnesota when this research was completed. Partial funding for this project was provided by the University of Minnesota Experiment Station and an NSF/EPA research grant.

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Abstract

As point sources of pollution reduce their emissions due to water quality control efforts, nonpoint sources have become relatively more important. In the case of agricultural nonpoint source pollution, the policy instruments recommended by economists are not observed in practice. This study was designed to measure the magnitude of transaction costs associated with policies to reduce agricultural nonpoint source pollution and to determine whether transaction costs help explain the prevalence of the policies actually observed.

Interviews with staff from governmental agencies were conducted to estimate transaction costs associated with four policies to reduce agricultural phosphorous pollution in the Minnesota River. The tax on phosphate fertilizers had the lowest transaction costs (U.S. $0.94 million), followed by educational programs on best management practices ($3.11 million), the requirement for conservation tillage on all cropped land ($7.85 million), and expansion of a permanent conservation easement program ($9.37 million). Taxes thus may have advantages with respect to transaction costs as well as abatement costs.

Evaluating Transaction Costs of Alternative Policies to Reduce Agricultural Phosphorous Pollution in the Minnesota River

A. Introduction and objectives

Severe water quality problems exist in the Minnesota River that make it unswimmable, unfishable, and even uncanoeable in the Twin Cities metropolitan area (MPCA 1994). It is a major source of pollution for the Mississippi River. Water quality problems in the Minnesota River include phosphorus (P) and nitrogen (N) enrichment, bacteria, suspended solids, and ammonia. The Environmental Protection Agency (EPA) asked for a 40 percent reduction in biochemical oxygen demand (BOD) and phosphorous between Shakopee and the mouth of the Minnesota River by 1996.[1] Models indicate that this would sustain aquatic life in the Metro area. It is estimated that it would cost the waste treatment plants $400 million to comply with these regulations (MPCA 1994).

In the Minnesota River, P has been identified as the limiting nutrient for the algal growth which causes eutrophication (MPCA 1994). Phosphorous pollution comes from point sources such as industry and waste treatment plants, as well as nonpoint sources such as private septic systems, pastures, erosion of farmland, and urban runoff. The amount of P loading from agricultural runoff is affected by a variety of factors including the P content of the soil and the amount of soil erosion. Estimated contribution of agricultural nonpoint source (NPS) has varied from 35% of P loading in a low rainfall year (1988) to 90% in a high rainfall year (1991) (MPCA 1994).

Various policies have been proposed to solve NPS water quality problems in the Minnesota River Basin. There have already been some educational efforts to reduce agricultural pollution of the Minnesota River and an expanded initiative has been proposed. Conservation tillage is being promoted to reduce erosion and is being adopted by a number of farmers. Also, there has been a proposal to expand Reinvest in Minnesota (RIM), a state program that obtains permanent easements on land to limit its use.

[1] This reduction has yet to be achieved.

Nonpoint source pollution control is a difficult problem in theory and in practice. The inability to observe emissions at reasonable cost means that emission taxes and standards are difficult if not impossible to implement. In the case of NPS pollution we observe programs or policies based on education, cost sharing/technical assistance, land retirement, and conservation compliance while economic theory indicates that incentives such as input taxes are generally more efficient. Yet this conclusion is based on cost estimates that exclude transaction costs.

Inclusion of transaction costs in policy evaluation is important for three reasons: 1) they may affect which policy alternative attains an environmental goal at least cost, 2) they will reduce the amount of abatement that is optimal from the point of view of society, and 3) their inclusion may lead to the design of policies and institutional arrangements which lower transaction costs. Transaction costs (including administrative costs) might be particularly high for nonpoint source pollution due to the high cost of monitoring emissions and the large number of polluters. These higher costs may be one reason why point sources (PS) have been emphasized in water quality legislation.

The primary objectives of this study were: 1) to estimate the magnitude of transaction costs of policies to reduce phosphorus pollution in the Minnesota River; 2) to determine whether the observed choice of policy instruments for correcting nonpoint source pollution could be explained by differences in transaction costs; and 3) to identify the underlying factors affecting transaction costs in the case of environmental policies. Estimation of the magnitudes of transaction costs would indicate to what extent it is important to include them in policy analysis since this would affect the optimal amount of abatement. If the ranking of cost effectiveness of policies changes when transaction costs are included in the analysis it could alter policy recommendations. Federal budget deficits, aversion to new programs that would result in increased bureaucracy, and requirements for cost benefit analysis make this a particularly relevant policy question.

B. Literature review

Environmental policy evaluation studies usually implicitly or explicitly assume that transaction costs are negligible or that they differ little between policies. In actual practice, transaction costs are usually important and the best policy or combination of policies for a given situation will depend on the size of transaction costs as well as abatement costs. Transaction costs as a determinant of firm organization have been stressed by Coase (1960) and Williamson (1985). The concept of transaction costs was related to environmental policy in Coase's 1960 article "The Problem of Social Cost". However, little effort has been made to measure the magnitude of transaction costs in either context.

1. Definition and determinants of transaction costs

There are several definitions of transaction costs. According to Arrow (1969), transaction costs are costs of running the economic system. Gordon (1994) defines transaction costs as the expenses of organizing and participating in a market or implementing a government policy. In his article on externalities, Coase (1960) uses the phrase "the cost of carrying out market transactions" to refer to interactions between firms or between individuals and firms. Coase refers to administrative costs when the resolution of the externality comes about within a firm or by government regulation. Some authors treat transaction costs and administrative costs as essentially interchangeable concepts (Stiglitz 1986). When evaluating alternative policies to reduce pollution, making a distinction between transaction costs and administrative costs can confuse the issue, particularly if both market and non-market policies are being evaluated (Stavins 1995b). Therefore, in this paper, the definition of transaction costs includes administrative costs.

Examples of types of transaction costs relevant to externalities include: search and information costs, bargaining and decision costs, and monitoring and enforcement costs (Dahlman 1979). Information generation costs are incurred even when there are no transactions (Griffin 1991). Conlisk (1996) stresses the importance of deliberation costs if agents are boundedly rational. Stavins (1995b), discussing tradable emissions permits, mentions an alternative taxonomy developed by Foster and Hahn (1993). It consists of direct financial costs of engaging in trade, costs of regulatory delay, and indirect costs associated with the

uncertainty of completing a trade. Some costly tasks associated with administering public laws and programs are: design of detailed regulations, development of application procedures, review of applications, and sending out of checks (Stiglitz 1986). Griffin and Bromley (1982) discussed some of the transaction costs involved with nonpoint water pollution. "Policy transaction costs include the costs of initial information for a specific instance of market failure and of deciding whether or not to invoke a nonmarket allocation mechanism, the costs of policy design, the structural costs of the administering agency, variable enforcement costs (for monitoring, assessment, and litigation), and the costs of periodic policy reevaluation." (p. 550). Thompson (1996) developed an Institutional Transaction Cost (ITC) framework to compare the cost effectiveness of various policies in meeting a specified environmental policy outcome. The ITC categories include: enactment, compliance, implementation, prosecution, inducement, and detection. Fixed and variable costs are related to the set-up and continuing costs in each category.

2. Transaction costs and environmental policy evaluation

The magnitude of transaction costs involved with eliminating externalities is affected by the number and diversity of agents, available technology, policy under consideration and amount of abatement or the size of the transaction. According to Oates (1986), and Williamson (1985) transaction costs increase as the diversity and number of parties involved increase which would indicate that transaction costs in the case of NPS pollution would be greater than in the case of point sources. Transaction costs will likely lower the efficiency gains of having policies that differentiate among agents according to their cost, damage, or utility functions (Milgrom and Roberts 1992, Kozloff et al. 1992). North (1990) says that transaction costs also depend on technology. For example, improvements in monitoring equipment could drastically decrease monitoring costs.

In the case of agricultural pollution, monitoring compliance with a large number of relatively small farm firms will be more costly than monitoring a small number of larger firms. Farmers' aversion to government intervention in their affairs also increases the transaction costs of regulations designed to reduce

pollution. In this situation an integrated approach of regulations, taxes, and education may be most effective (Easter 1993).

The magnitude and type of transaction costs depend on the institutional environment (Coase 1960, North 1990, Griffin 1991, Vatn and Bromley 1994) as do externalities themselves (Vatn and Bromley 1994). Coase's 1960 article "The Problem of Social Cost" addresses the influence of the law on the economic system and the importance of institutions with respect to externalities. The presence of transaction costs may inhibit voluntarily negotiated agreements and Coase has stressed their importance both in the original article and in his later writings. In the presence of transaction costs the optimal amount of the externality depends on the initial allocation of rights (Coase 1960). If the polluter has the property right, the optimal amount of abatement will be less than in the case of zero transaction costs, while the opposite is true if the recipient of the externality has the property right. The burden of proof for environmental improvement usually falls on those wanting the change so they pay the transaction costs involved in making changes in regulations or incentives (Boggess 1995). While transaction costs are usually modeled as being paid by either the seller (Stavins 1995b) or the buyer (Colby 1990), both parties incur information and decision costs.

Gordon (1994), drawing on Coase's 1960 article, maintains that market failure exists to a large extent because transaction costs, involved in assigning property rights for example, are prohibitively expensive. He argues that the presence of transaction costs implies less governmental reform of the market is appropriate than in the case without transaction costs. Stavins (1995a) suggests that considering transaction costs will make marketable pollution permits less appealing than currently thought.

Coase (1960) argues that court decisions or direct government intervention may be alternatives to bargaining depending on the costs involved in moving to the new arrangement as well as operating it. Recent literature on transaction costs and environmental policy indicates that since it is difficult to know *a priori* whether the transaction costs of market solutions will be greater or less than non-market solutions, options need to be evaluated on a case by case basis (Griffin 1991, Easter 1993, Stavins 1995a, 1995b). It is

important to take account of not only the administrative costs borne by various levels of government but also the time and informational costs borne by firms or individuals (Stiglitz 1986, Friedman and Waldfogel 1995).

3. Transaction cost measurement

If transaction costs are to be incorporated in policy evaluation, they must be measured. Williamson (1993) suggests that researchers may be able to measure a lower bound of TC indirectly. The difference between buying and selling price for SO_2 permits can be used as a measure of transaction costs although it does not include time spent within the firm nor monitoring and enforcement costs borne by the government (Stavins 1995b). Wallis and North (1986) tried to estimate the transaction "sector" for the U.S. They classified certain jobs in firms (shipping clerk) and certain industries (real estate) as being primarily associated with transactions. They estimated that public and private sector TC increased from ¼ to ½ of GNP in this century. Transaction costs are sometimes estimated based on the difference between supply and demand curves that are themselves estimated (Hearne and Easter 1995, Archibald and Renwick 1997). Colby (1990) looked at policy induced transaction costs in western water markets. Colby compared actual transaction costs among various western states and related that to differences in state laws, the value of the water right, and the size of the transfer. Transaction costs averaged 6% of the price paid by the applicant to transfer water, with Colorado having higher costs than the other states involved in the study. Howitt (1994) reported that the overhead costs incurred by the State Department of Water Resources for the California Water Bank were about 8% of the water purchase cost. Hearne and Easter (1995) found that the transaction costs involved with water transfers in Chile represented 7-23% of the transaction price. McCann (1997) analyzing Natural Resource Conservation Service cost share and technical assistance data found that transaction costs represented 38% of the total conservation cost. Boggess (1995) cites a 1992 Rand study which estimated that 88% of Superfund payments were for transaction costs, not clean up.

The literature suggests that transaction costs of environmental policies are likely to be significant, especially in the case of NPS pollution, so they should be included in policy evaluation. Most studies of transaction costs and environmental policy to date have either compared transaction costs qualitatively

(Easter 1993), used the cost savings as an upper bound on transaction costs (O'Neil 1980), arbitrarily plugged a range of transaction costs into their model (Netusil and Braden 1995), or assumed transaction costs to be some constant proportion of taxes raised (Smith and Tomasi 1995). Another approach would be to directly obtain estimates of transaction costs by means of surveys of government agency personnel similar to that of Thompson (1996) or the examination of past governmental costs for similar policies.

C. Analytical framework for transaction costs

1. Components of transaction costs related to environmental policy

The classification scheme used here is based on Thompson's (1996) institutional transaction cost (ITC) framework. While Thompson includes compliance or abatement costs in his definition of institutional transaction costs, they are not included in the definition of transaction costs used in this analysis since abatement costs are what is typically measured in the evaluation of alternative policies. Also, other costs that Thompson did not include separately, such as research and information costs, are explicitly incorporated in this model. Transaction costs (TC) thus include: research, information gathering and analysis (R), enactment of enabling legislation including lobbying costs (E), design and implementation of the policy (D), support and administration of the on-going program (S), prosecution/inducement (P), and monitoring/detection costs (M). The magnitude of transaction costs involved with an environmental policy is thus represented by the sum of these costs. The primary input is labor as represented by staff and farmer time.

$$TC_1 = \sum_{t=0}^{T} \beta_t (R_{it} + E_{it} + D_{it} + S_{it} + P_{it} + M_{it}) \qquad (1)$$

where:
β = *discount factor*
i = *policy*
t = *time period*

2. Determinants of transaction costs

Transaction cost theory maintains that bounded rationality and opportunism are behavioral assumptions that imply increased transaction costs. A transaction can have attributes that also affect the transaction costs such as asset specificity, frequency of transaction, and uncertainty. What are the analogues in the case of agricultural nonpoint source pollution or do totally different factors affect these costs? There is little existing empirical work to suggest what the determinants of transaction costs are in the case of environmental policies. The literature review suggests that existing institutions, the policy under consideration, and the abatement level would all have an effect on transaction costs.

If there is already a program that is similar to that needed to implement a nonpoint source reduction policy, transaction costs would be lower. For example, if a conservation compliance program already exists, adding a particular best management practice to the requirements for being in compliance will be less costly than if a new program were to be developed from the ground up. Not only would a new program not have to be implemented but there is already expertise in the agency. There are also larger institutional issues involved such as whether farmers have the right to pollute. Some policies imply a change in property rights from the status quo and that would be expected to encounter resistance and thus increase transaction costs.

In this model, instead of transaction costs depending on the form of organization of a firm, they depend on a policy and the various aspects of that policy such as the amount of monitoring it requires, how difficult it is to design and implement, and the information requirements. If farmers perform a particular practice only once per year, a policy that addresses that practice will probably have lower monitoring costs than a policy related to a practice that is performed year round. For example, planting is done annually but manure applications occur year round on many operations.

3. Implications of transaction costs

Although it can be argued that property rights for nonpoint source pollution have not been clearly specified, in the figures below, transaction costs are shown for the case where polluters (e.g. farmers) have the property rights and also pay the transaction costs involved. Figure 1 is a market equilibrium diagram

adapted to the market for abatement of externalities (Randall 1981). Abatement is the commodity and the demand curve (MB) represents the marginal benefit from a unit of abatement and the supply curve (MC) is the marginal cost of abatement. The optimal amount of abatement in the absence of transaction costs is where the two curves intersect. Changes in the benefit from abatement (changes in preferences or incomes) or in the cost of abatement (changes in technology) will change the optimal level of abatement. Diagrams such as this have also been used to examine the effect of transaction costs on the optimal amount of abatement but have not considered multiple policies. Figure 1 illustrates the case where there are different transaction costs depending on which environmental policy is implemented and where marginal abatement costs are assumed not to vary with the policy. The policy with the lowest marginal transaction costs (TC1) would result in the greatest amount of abatement (Q1), although it would still be less than the amount of abatement under the scenario with no transaction costs (Q*). Is policy 1 superior to the other policies? If there are no fixed costs or set-up costs associated with the policies, it is. If, however, there are fixed costs associated with the various policies, the one that minimizes total costs for a particular level of abatement may not be the policy that has the lowest marginal costs.

While the above example had constant marginal transaction costs, Figure 2 illustrates the case where alternative policies have increasing, constant, and decreasing marginal transaction costs. We again assume no fixed costs and the same abatement costs (MC) for all policies. Policy 1 exhibits increasing marginal transaction costs. Policy 3 exhibits decreasing marginal transaction costs while Policy 2 represents constant marginal transaction costs. In the absence of information on a benefit function, the optimal policy will differ depending on the target level of abatement. If the target is set at A, the optimal policy is 1. This may represent the case where cajoling, education, or perceived threat of further restrictions can achieve a small amount of abatement, but where the costs of achieving additional abatement become significantly higher. If the target level of abatement is B, implementation of Policy 1 and then 2 will be optimal. If the target is C, the most cost effective policy seems to be a sequence including all three policies. However, this is only the case if the transaction costs involved with Policy 3 depend on the total abatement obtained so far. If the

lower transaction costs obtainable with Policy 3 at abatement level C is dependent on its use for preceding units of abatement, it will never be optimal to include this policy since marginal transaction costs for Policy 2 are a constant x dollars per unit of abatement while the transaction costs for Policy 3 start at y dollars, where $y > x$ (Figure 2).

Figure 1. Transaction Costs With Alternative Policies

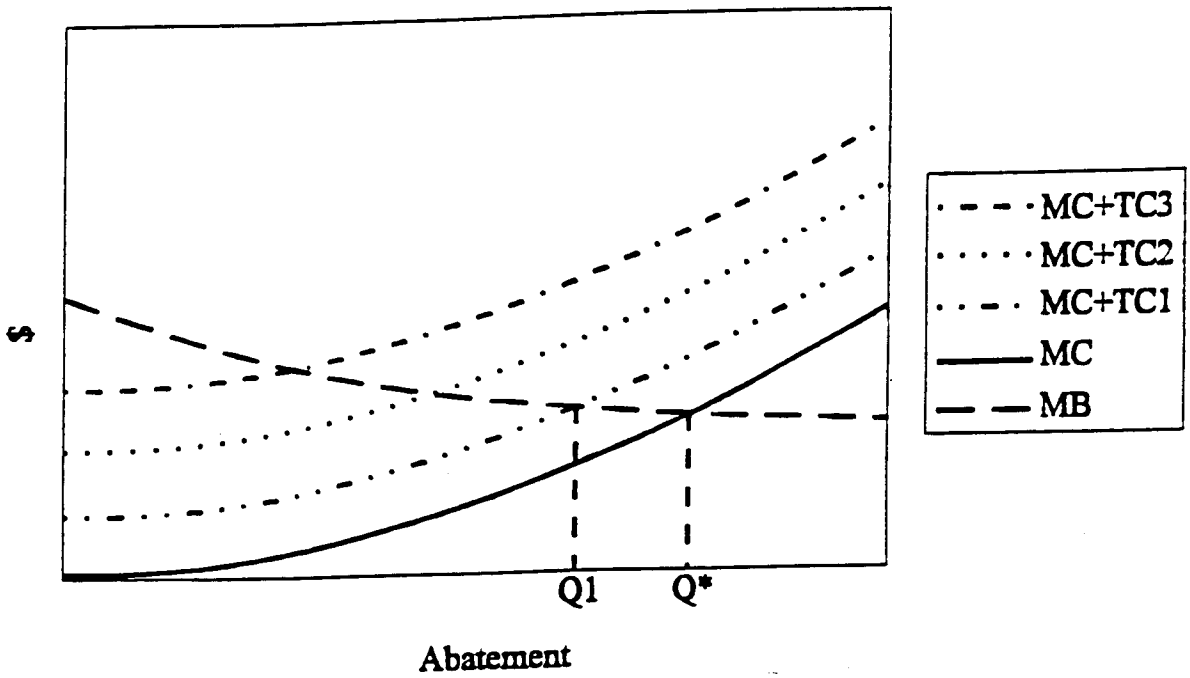
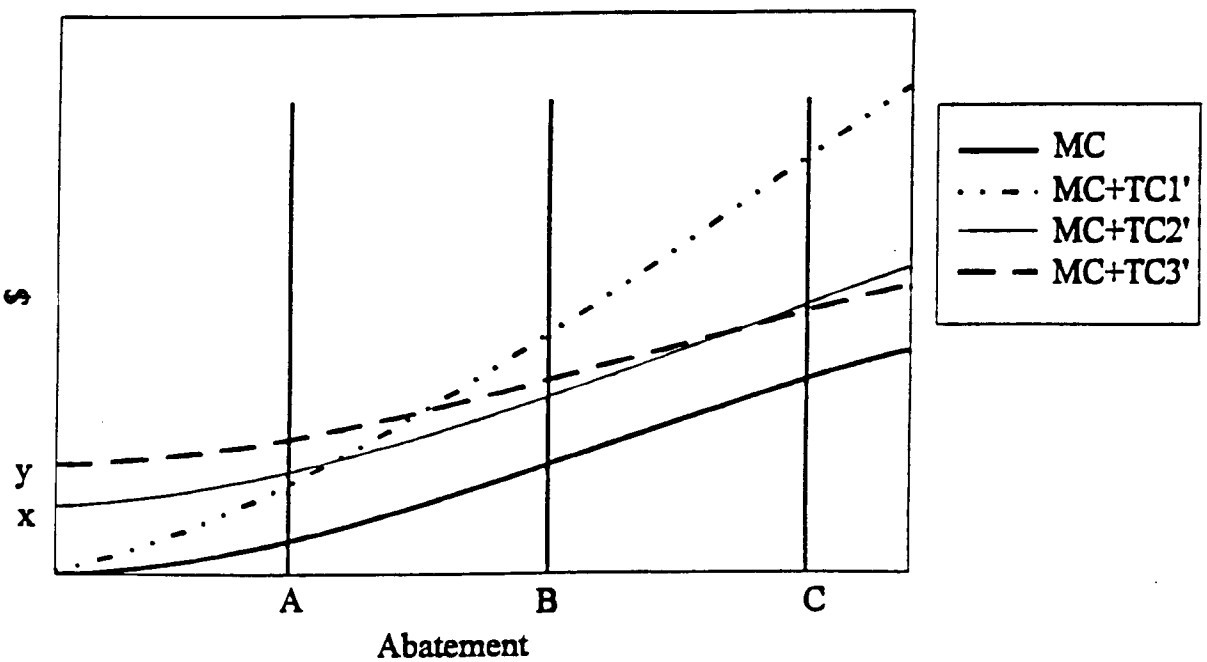


Figure 2. Increasing, Constant, and Decreasing Marginal Transaction Costs



4. Model of transaction costs

The decision maker is assumed to minimize the costs related to attaining an environmental goal or pollution reduction target (A) by choosing the policy or combination of policies that minimizes total costs. A particular policy may appear to be the most cost effective when only abatement costs are evaluated but it is the sum of abatement costs plus transaction costs that needs to be minimized. The total cost of policy (c_i) thus consists of some fixed cost (k_i) plus a variable cost related to abatement costs (m_i) and a variable cost related to transaction costs (t_i). The amount of abatement obtained using a particular policy is denoted a_i . Abatement costs can include those that are financed publicly as well as private costs borne by the polluters. Private costs can include non-cash expenses such as family labor as well as out of pocket expenses. Policies are assumed to be separable in that the cost of abatement using policy 1 does not depend on whether policy 2 is in effect.

$$Min(a_1^*, a_2^*, a_3^*): c_1(a_1) + c_2(a_2) + c_3(a_3) \qquad (2)$$
$$s.t.\ a_1 + a_2 + a_3 \geq A$$

where:

$$c_i = k_i + \int_{a_i=0}^{a_i^*} [m_i(a_i) + t_i(a_i)]\, d\, a_i, \qquad i = 1,2,3$$

The optimal policy or policies will depend on the abatement level. This is a normative model in that it shows how policy makers should decide which policy or policies to implement given a target.

D. Methodology to estimate transaction costs of alternative policies

Four policies designed to reduce agricultural sources of phosphorous pollution are considered: expanded educational efforts, a requirement for conservation tillage on all cropped land, expansion of the Reinvest in Minnesota program which obtains permanent cropping and development rights, and a tax on phosphorous fertilizers. The corresponding four agencies or organizations that would be involved include the Minnesota Extension Service, Minnesota Pollution Control Agency (MPCA), Board of Soil and Water Resources (BWSR), and Minnesota Department of Agriculture (MDA). In addition, the Natural Resource

Conservation Service (NRCS) and Soil and Water Conservation Districts (SWCD's) were also contacted since they would be involved in implementing of some of these policies.

In order to compare the total costs of the various policies under consideration for reducing agricultural phosphorus pollution of the Minnesota River, a quantitative measure of transaction costs is needed. If the estimation were being made *ex-post*, or after a policy were implemented, an examination of the actual costs incurred would be possible. If the objective is to chose the least costly policy overall to achieve an environmental goal, *ex-ante* measurements must be used. One possibility for obtaining *ex ante* estimates would be to try to find similar programs that have actually been implemented elsewhere and estimate the administrative costs by examining the budgets. This method would not incorporate the effect of institutions that are particular to Minnesota and the Minnesota River Basin. Another problem with this method is that it would necessarily be piecemeal if costs from a variety of situations nationwide were pulled together. It might also be the case that a similar program has not been implemented previously. For these reasons, in-depth interviews with governmental agency personnel were conducted to obtain *ex ante* estimates of transaction costs that would be borne by the implementing agencies. It is not possible to know what the actual costs are *ex ante*, so interview results represent perceived costs. The questions regarding the transaction costs of alternative policies are hypothetical and thus hard to answer. The estimates do not include those transaction costs borne by farmers.

Key individuals were selected to represent different levels of organization in the various agencies. These people were chosen because of their knowledge of Minnesota River pollution problems as well as their ability to provide informed opinions on the costs involved with the policy under consideration. It is similar to choosing individuals for the Delphi method of subjective forecasting (Parenté and Anderson-Parenté 1987). Thompson (1996) relied on estimates of programs that were somewhat similar and on the estimates of a single informed individual. In this study, a wider group of people was contacted regarding their estimates of the costs of alternative policy options.

The study incorporates aspects of the Delphi technique and the contingent valuation (CV) method. The interviews differ from the Delphi technique in that respondents were not given the opportunity to revise their answers in response to information about others' answers. The interviews differ from the typical CV study in several ways. Agency personnel were asked for their opinion on the costs of a program, not on the benefits. Also, the cost estimate already represents the cost to society so there is no extrapolation to non-sampled individuals and then a summation to obtain a final estimate. While the potential policies are hypothetical to a greater or lesser degree, the individuals interviewed may well be called upon to make budget estimates for proposed programs, whereas individuals surveyed about their valuation of an environmental benefit do not typically encounter the hypothetical situation. On the other hand, it may be more difficult to estimate the costs of a program, many aspects of which agency staff will have no control over, than to indicate what value they themselves would assign to a benefit. Another problem is that there is some incentive for strategic behavior since agency staff may think that their answers will have an impact on public policy relating to the Minnesota River. As in the case of CV studies one needs to specify the scenario so that all surveyed individuals understand the proposed policy options in the same way.

A letter was sent to potential participants outlining the objectives of the study, the policy being considered in the case of that agency, and a request for an interview. Potential participants were then contacted to arrange a 1 to 1 ½ hour interview. In some cases, they suggested other people in the agency that would be more knowledgeable about the subject and those individuals were interviewed. Each person was asked the set of questions that pertained to the policy with which their agency would potentially be involved so not all questions were asked of all participants. Other than having the participants read the scenario relating to their agency, the same interviewer asked the questions orally. Questions were repeated if necessary and clarification provided if requested. While a detailed analysis of the abatement effects of the various policies was not attempted, the scenarios were developed to obtain approximately a 40 percent P loading reduction goal. The scenarios for the extension and RIM policies were based on proposed programs, but the conservation tillage requirement and phosphorous tax are not currently under consideration and the

scenario text for those policies was developed independently of any government agency. The text of the four scenarios is presented in the appendix.

E. Estimating transaction costs and policy implementation

1. Extension/Educational Program

According to staff that were interviewed, steps that would be involved in designing and implementing an expanded extension program to reduce phosphorus include: creating awareness of the problem, obtaining input from farmers and citizens regarding needs, goals, and solutions, developing educational materials in conjunction with other agencies, creating teams of technical resource people, identifying delivery methods, developing demonstration plots, working individually with farmers on land use planning, and evaluating progress. Administering the program once it was set up would involve continuing coordination efforts, developing updated information, distributing information, and monitoring progress. Extension would not be involved in prosecution/enforcement or litigation but educational programs might address current regulations and the implications of non-compliance.

As expected, cost of the policies was seen as affecting adoption rates. Adoption rates and program costs are seen to be highly correlated with uncertainty about the P problem in the Minnesota River. Staff were asked whether costs would change if the required reduction were 20 percent or 60 percent instead of 40 percent. Two staff members indicated that costs would change, one indicated that the time frame would change, and another that the structure of agriculture in the basin would need to change to achieve very high levels of abatement.

2. Conservation tillage

A requirement for conservation tillage on all land in the Minnesota River Basin was not a program that was suggested by MPCA or anyone in state government but it was selected for comparison purposes. In fact, the MPCA staff did not favor such a proposal even though they provided cost estimates.

The staff indicated that if a requirement for conservation tillage were legislated, there would be less effort required on the part of MPCA to design and implement the program so their costs would be lower.

If it were not legislated, designing and implementing the policy would involve discussions with citizens and affected parties to obtain their input and cooperation. The development of a document called a Statement of Needs and Reasonableness (SONAR) is required by law and presents the rationale and effects of the rule. Language for the rules would then need to be drafted. Hearings would be conducted by an administrative law judge with a period for comment afterwards. The judge would prepare a report and staff would respond and present the SONAR and rules to the MPCA Board. The adopted rules would then be registered with the Secretary of State. An educational effort to sell the program and development of alliances with other agencies would also be required. In the case of feedlot rules, authority is delegated to counties which are given funding for administration and enforcement. They would foresee a similar process for a conservation tillage requirement. Monitoring of compliance would be accomplished by a transect survey while water quality monitoring would continue as before. An audit/complaint referral system would need to be developed. Violations would result in several visits to try to achieve compliance. Only if noncompliance continued after the visits would a notice of violation be sent and a fine imposed. The effect of uncertainty regarding the problem of water quality in the Minnesota River was thought to be significant with respect to the rule's ability to withstand challenges. There is also less tolerance for uncertainty with a command and control approach as compared to a voluntary approach which would substantially increase enforcement costs. When asked whether costs would vary if the requirement were for a 20 percent reduction instead of a 40 percent reduction, one person indicated that it would not differ and another that the time frame would change. They thought that costs would double if the requirement were for a 60 percent reduction.

3. Reinvest in Minnesota

Agency staff indicated that steps involved with designing and implementing this permanent easement program include developing a memorandum of agreement between USDA and BWSR to clarify the responsibilities of each agency. Subsequent steps would be to develop an educational program through SWCD's, conduct the actual sign-up, evaluate applications, accept parcels that Minnesota and USDA agree are priorities, acquire easements, and design and implement conservation plans on the land. Since it is a real

estate transaction, a clear title is needed and this can be expensive and time consuming. More staff would need to be hired to implement the program, but the RIM design is already in place. Once parcels are in the program, there are few administrative costs since most farmers take the lump sum payment. If payments are to be made yearly, like CRP, there will be higher costs. Monitoring consists of yearly inspections for the first five years and then once every three years. If a violation is noted there is a discovery phase. If it is determined that a landowner is in violation, a penalty can be invoked but this has not yet happened, since BWSR tries to resolve the problem with the farmer. One easement per year out of 2,500 is a problem and fewer than 10 cases have gone beyond an initial meeting.

Uncertainty about problems with water quality in the Minnesota River is not seen as an issue for the RIM program for several reasons. Water quality is not the primary motivation for program participation. Agency staff indicated that CRP and RIM were not sold as a means to obtain cleaner water, although there is a recognition that it helps protect the land and the environment as well as providing wildlife habitat. All staff indicated that costs would not vary with the amount of P abatement required since it is only one of the benefits of the program.

4. Tax on phosphorus fertilizer

The MDA would implement the proposed tax on phosphate fertilizers. The department already has authority for nitrogen restrictions and a minimal tax on fertilizer to cover inspection fees and the cost of cleaning up spills. Staff indicated that the steps involved with actually implementing a tax would be fairly minor because of the existence of the current program. The numbers on the forms, which are updated on a regular basis, would need to be changed. The tax is currently collected at the first point of sale. Controversy would be the major cost. MDA staff would need to deal with angry people, respond to complaints, communicate with fee payers and farmers to explain the rationale for the program, and hold public meetings. Designing programs that would effectively use the funds to improve water quality would be another aspect of the policy. The administration of the current program includes collecting information and fees from input suppliers, processing licenses, and the associated paperwork. Monitoring would consist of requiring tonnage

reports similar to the current system and probably also auditing sales of fertilizers. Non-compliance would be expected to increase under this program compared to the current program of a $0.35 tax per ton of fertilizer.

Two staff felt that scientific uncertainty of P pollution would not have an effect on the administrative costs of setting up the program while another staff member felt that uncertainty might increase costs. A policy such as this would be easier to implement and less prone to litigation if it could be proven that P fertilizers were the problem. The alternative of removing the income tax deduction for fertilizers would be even less costly to implement and might be more acceptable to farmers. However, it would result in a smaller reduction in P loadings so it would not bring about the required improvements in water quality.

5. Time requirements for implementation

In addition to the qualitative interview results summarized above, information on the time required for various aspects of each policy was elicited. The averages, expressed as full time equivalents (FTE's) for each category of transaction cost were calculated and are presented in Table 1. If the individual response was a range, the midpoint was used in the calculation. The information that was given at a substate level was multiplied by either 7 (for cluster level data from Extension since there are 7 clusters in the basin) or 37 (for county level data since there are parts of 37 counties in the basin). Because many people included time spent in meetings in the category of research and information gathering, those two categories were added together.

The SWCD's and BWSR spent about 22 FTE's in meetings, information gathering activities and research related to water quality issues in the Minnesota River over the two year period preceding the interviews. The Extension Service and MPCA spent half that amount of time on these activities while MDA spent the least amount of time. Since P is only one of the water quality problems in the River, they were asked to estimate how much less time would have been spent if sediment and bacterial contamination were not problems. Since water quality is only one goal of RIM, staff indicated that time spent in meetings would not have changed. MPCA and MDA would have cut the time by a third, which indicates that P is an

important concern. Extension would have halved their efforts, perhaps since many of their activities relate to erosion control. Time expected to be spent on meetings, information gathering and research in the next two years was similar to the previous two years for Extension, MPCA, or MDA but organizations associated with the RIM program indicated that they would reduce the time spent on these activities.

The next questions related to the hypothetical policy scenarios. Designing and implementing the policy was assumed to occur at the beginning of the time period except for the RIM program for which sign-ups were expected to occur over a ten year period. The RIM program had the highest design and implementation costs followed by education, conservation tillage, and the P tax. Administration, monitoring, and enforcement costs are assumed to occur each year over the life of the policy. Administration and enforcement costs were highest for the conservation tillage program while monitoring costs were highest for RIM. Lobbying costs were expected to be high for both the conservation tillage requirement and the P tax.

Table 1. Average Policy Costs (in FTE's unless otherwise noted)

Sources of Transaction Costs	Education (Extension Service)	Conservation Tillage (MPCA)	RIM (BWSR, SWCD's)	P fertilizer tax (MDA)
# Person years spent on information gathering, research and meetings in last two years	11.13	10	21.64	5.15
If P were the only water quality problem would less time have been spent? How much less?	Yes, -47%	Yes, -32%	No	Yes, -35%
How much more time will be spent in next 2 years on information gathering?	11.0	9	0.447	7.125
Time to design and implement the program	14.33	3.42 + $9,020	16.28 per year for 10 years	0.895
Time to administer program once set up (per year)	5.25	16	0.048	1
Time in monitoring (per year)	0.475	0.0305 + $10	6.45	0.5
Time with prosecution-enforcement-litigation (per year)	0	2	0.095	0.15
Would costs vary with P loading goal?	Yes	Yes	No	Yes
Lobbying overall	0.12	5.5	0.21	4

6. Transaction cost calculations

The time requirements are translated into monetary terms in Table 2. Recurring costs for administration, monitoring, and enforcement were discounted at a rate of 5% over a 10 year period. In the case of RIM, the implementation costs were discounted over the 10 year period since parcels would be enrolled over this period. The 1996 Minnesota Salary Survey was used to obtain salary information. Salaries for a range of positions including compliance officers, public administration chief executives, and agricultural scientists were quite consistent and did not vary greatly between the Twin Cities and the

Southwest region so a per hour salary of $20 was used. The annual cost was calculated assuming 40 hour weeks and 52 weeks per year. Fringe benefits were added at a rate of 28% for a total cost per FTE of $53,000.

The fertilizer tax was the least expensive policy in terms of total transaction costs at less than a million dollars (Table 2). The next least costly policy was the extension program at over 3 million dollars followed by the conservation tillage requirement at almost 8 million dollars. The most costly policy was the permanent easement program at over 9 million dollars. The RIM program had the highest design and implementation costs while the conservation tillage requirement had the highest administration, monitoring and prosecution costs. When the time horizon assumption was increased to 20 years, the conservation tillage requirement became the most expensive of the four policies. Changing the discount rate to 10% had no effect on the ordering of the policies.

Table 2. Transaction Costs of Alternative Policies to Reduce Phosphorus Pollution in the Minnesota River (in $1000)

Type of Cost	Extension	C. Till.	RIM	P Tax
Research/Info/Meeting	1,173	1,007	1,171	651
Lobbying	6	292	11	212
Design/Implementation	759	181	6,663	47
Adm/Monitoring/Pros.	2,343	7,379	2,697	675
Sum (except research)	3,109	7,851	9,371	935

E. An Assessment

Interviews with government agency personnel regarding transaction costs of the various policies highlighted the types of costs incurred under the four alternative scenarios as well as the issues faced by these agencies. The process of conducting in-person interviews rather than relying solely on mail surveys or on published information resulted in a much fuller understanding of the importance of these issues. It was difficult for the interviewees to answer some of the questions both because the policies were at least partially hypothetical and because they generally do not think about costs in these terms. In the future, the personal

interview instrument could be improved to more closely reflect the cost categories with which agency staff are familiar. Because the policies examined were heterogeneous, it is difficult to compare types of costs across policies. Research may have one meaning in the context of a University sponsored extension program and quite another in the case of an agency's regulatory program. Similarly, implementing a program such as RIM is quite different from implementing a tax. Categorizing costs may provide insight into differences between policies and also serve to elicit more information, but if the categories seem artificial to interviewees, it may distort the results. Because some costs may be categorized differently than intended in the research, the totals are probably more valid than individual categories.

Taking account of transaction costs does not change the efficiency ranking of taxes compared to other policies, however taxes are very unpopular. Eliminating the income tax deductibility of fertilizers was seen as both more palatable and less effective in changing behavior.[2] The relatively low cost of educational programs coupled with their popularity among both farmers and agency personnel helps to explain their prevalence with respect to nonpoint source pollution. The RIM program is popular but it is not targeted. The current form of the RIM program may economize on transaction costs compared to its original, more targeted form (Steve Taff, personal communication). Obtaining permanent easements is a cumbersome and expensive process due to the requirement for a clear title, although the costs of monitoring and enforcement are quite low. The RIM program could be modified to have long term easements, e.g. 30 years, rather than permanent ones. This might reduce the transaction costs of putting the program in place and also increase interest by those farmers who are hesitant to become involved in a permanent easement program. While agency staff see one-on-one interaction as necessary to get farmers to implement best management practices, this is costly. High transaction costs for agricultural nonpoint source pollution policies may be partly due to these policies being perceived by land owners as a change in property rights.

[2] The price elasticity of demand for phosphate fertilizers is -0.25 to -0.29 (Denbaly and Vroomen 1993, Roberts 1986).

Many administrators see taxes as a form of punishment or a way to raise funds rather than a way to change behavior. This may be because the effects of a tax on behavior are more indirect than a regulation. Even those individuals who are familiar with the concept of using taxes to alter behavior question their effectiveness. Taxes were thus seen as both ineffective and unpopular and it is not surprising that we do not see this type of policy implemented in the case of nonpoint source pollution where a large number of voters would be affected. Agency staff are not immune from popular opinion since legislators can reduce funding to the agencies.

There are a number of limitations to this study. The costs to other agencies that might be affected by a policy were not included. For example, if a conservation tillage policy were implemented, extension educators would be expected to develop programs in this area. The education, conservation tillage, and RIM programs have a wider range of benefits than just P loading reductions. They would also tend to reduce bacteria, sediment and nitrate loading. In addition, the RIM program has wildlife and aesthetic benefits. The costs listed do not take account of the support or overhead costs for the programs such as buildings, secretarial support, and supplies, nor do they include equipment or travel costs. These figures also do not include all the costs of imposing a highly unpopular policy. The jobs of people in the implementing agency would become less pleasant and in some cases there might be the possibility of physical danger. Agency staff did include time spent overcoming resistance to policies. If a phosphorous tax of the magnitude indicated here were implemented, it is likely that some legislators would be voted out of office. While a small fertilizer tax exists in Minnesota, the magnitude of the change in tax rate means that it may be difficult to extrapolate from that program. On the other hand, all the polices relate to existing organizations. Since only parts of some of the 37 counties are actually in the basin, the figures obtained by multiplying county responses by 37 may overstate the cost. While it is assumed that transaction costs are primarily borne by agencies rather than farmers, this needs to be studied in future research. Considering these limitation, it appear that the estimates of transaction costs from the agency interviews probably underestimate the total transaction costs associated with the policies. Nevertheless, this research provides an order of magnitude estimate of

transaction costs associated with reducing nonpoint source pollution. The fact that a separate mail survey gave the same ranking for these four policies as the interviews lends support to the validity of the estimates obtained from the interviews (McCann 1997).

F. Conclusions and recommendations

The estimated transaction costs for policies to reduce agricultural nonpoint source phosphorous pollution in the Minnesota River provided several surprises. A tax on phosphorous fertilizers had by far the lowest transaction costs followed by an expanded educational program, a conservation tillage requirement and an expanded RIM program. Transaction costs thus reinforce the efficiency advantages of an input tax relative to a practice standard. It also suggests that expanding the nontargeted RIM program to reduce P pollution in the Minnesota River Basin is probably not advisable.

It may be the case that policies should be sequential. For example, there would be more support for regulations if it was proved that education and other voluntary programs did not solve the problem. It may also be the case that for small amounts of abatement, educational programs may be cost effective. If farmers are only boundedly rational, there is potential for programs that improve environmental quality while increasing or at least not decreasing profits. As an example, soil testing has the potential to reduce farmer costs and also lower nutrient runoff and leaching. It may also be the case that farmers gain utility from being good stewards of the land and that educational programs could reinforce this behavior. Nevertheless, educational programs have limited ability to increase adoption of practices that are costly to the farmer.

Transaction costs in the case of agricultural nonpoint source pollution are affected by a variety of factors. Factors highlighted by this analysis are the number of agents affected, resistance to the policy, amount of cleanup required, the time frame involved, whether the policy is voluntary or not, the technology for best management practices as well as monitoring, and the existing institutional arrangements. A more careful examination of the determinants of transaction costs is needed and the interviews provided information that will be useful in directing such research.

A benefit of an emphasis on transaction costs involved with various policies is that it could promote competition between agencies to accomplish a particular goal at lower cost. This would tend to reduce the tendency towards government inefficiency. Currently, competition among agencies for state funding provides an incentive to inflate the amount of money that is actually needed.

Transaction costs are important and should be taken into account when determining the optimal level of abatement and when evaluating alternative policies. The high transaction costs associated with reducing nonpoint source pollution may explain the early emphasis on point sources. They do not however, explain the policy choices observed in the case of nonpoint source pollution since taxes have efficiency advantages with respect to transaction costs as well as abatement costs. When Coase wrote "The Problem of Social Cost" procedures for measuring non-market values of resources had not been developed. Now they are extensively used in cost-benefit analyses. Perhaps in the future, it will be common to estimate transaction costs.

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Appendix

The following are the four policy scenarios used during the interviews with the agency personnel.

Extension/Education Program

"Suppose an extension/educational program were going to be implemented to reduce phosphorus loadings in the Minnesota River Basin. This would be through the University of Minnesota and the Minnesota Extension Service in cooperation with NRCS, SWCD, and MDA. This would be a voluntary program designed to increase the adoption of best management practices (BMP's). In some cases, it may be that farmers do not have complete information about the BMPs so education could improve the environment as well as profitability. The educational programs would also address the linkages between the individual action and the environment. No legislation would be involved except for appropriation of the additional funding that would be required to hire six additional educational specialists. The BMP's to be promoted would be conservation tillage, banding of phosphorus, soil testing, appropriate manure management, and grass buffers near drainage ditches and surface inlets. Extension activities would include personal visits with farmers in the flood plain about land management planning, publication of fact sheets, county level meetings, demonstration farms, field day demonstrations, and press releases. The goal would be 75% adoption."

Conservation Tillage

"Suppose conservation tillage (30% residue after corn) were required on all agricultural land in the Minnesota River Basin whether or not the farmers participated in the farm program. This policy would be implemented by MPCA. This would result in decreased loadings of sediment of 40% according to an AGNPS simulation and a decrease of P loadings of 20% according to an HSPF simulation. It would require involvement of the Legislature to enact a law and appropriate money for implementation/enforcement of the program. While current statutes would permit MPCA to develop such a regulation, it would be so controversial that it would probably not occur without specific legislation requiring it. An appropriate fine that would generate compliance would be part of the regulation. Cost of compliance for farmers may be

negligible in many cases since about a quarter of farmers are already switching to conservation tillage and in fact there are several counties in the Basin with conservation tillage adoption rates of over 50%. On some soils there may be a yield loss with continuous corn."

Reinvest in Minnesota

"Suppose a Conservation Reserve Enhancement Program were to be implemented where Federal Conservation Reserve Program (CRP) funds would be used to help enroll vulnerable Minnesota River Basin acres in the Reinvest in Minnesota (RIM) Reserve Program. This program is voluntary and would be administered by Board of Water and Soil Resources (BWSR) with some involvement of MDA, DNR, and MPCA. The program would be implemented at the local level by the Soil and Water Conservation Districts. The program would obtain voluntary perpetual conservation easements on 190,000 acres of floodplains, edges of fields, and wetlands. Farmers would submit bids for enrollment of vulnerable acres similar to the CRP program. The development of conservation plans and installation of conservation measures such as seeding native grasses would be required. Currently the RIM program gives farmers the option of either annual payments or a one-time payment. At the federal level, the legislation to allow this type of collaboration exists but the Secretary would have to decide whether to authorize it and there would be costs involved with coordinating it between the State and Federal levels. It does not seem like additional state legislation would be needed for the 190,000 acres although additional appropriations would be needed if the program were expanded. This represents 1.7% of the acreage in the basin. This is more than enough to provide 60 foot buffers along the Minnesota River and its major tributaries, however the location of the acres enrolled in the program depends on the interest of the farmers. The reductions in sediment and P that would result from the program have not been determined."

Tax on Phosphorous Fertilizer

"Suppose a tax on phosphate fertilizers were implemented, although we would ideally tax P emissions. The Minnesota Department of Agriculture would be involved in implementation of this policy. They already administer a fertilizer tax of $0.10 per ton which is collected at the point of sale. The current

tax rate is thus on the order of 0.05% for phosphate containing fertilizers. The legislature would have to pass a law authorizing the tax. This would only have an effect on P loadings over the long term. It is necessary to determine the length of time for this policy to reach the 40% reduction goal. There are two questions: what effect would the tax have on soil P levels and what effect would that have on P loading. If no P is added to soils with 100 ppm P, the content will go down by 2 ppm per year. If the soil P goal is 60 ppm, this would take 20 years. If farmers respond to price changes as they have in the past, a 100% tax would only decrease phosphate purchases by 30%, so the goal would be reached only after 67 years. A 40% reduction in soil P levels may result in more or less than a 40% reduction in P loading depending on other management practices. We will assume for our purposes that it would decrease by 40%. The taxes would go into a fund to improve the quality of the Minnesota River."