Reverse Auctions: Are they a Cost-Effective Alternative to Traditional Agricultural Conservation Spending?

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Abstract
Agricultural practices continue to degrade water quality and ecosystems worldwide. In the United States, programs like the Department of Agriculture's (USDA) Environmental Quality Incentive Program (EQIP) target the voluntary adoption of agricultural best management practices (BMPs). Demand for these programs has historically exceeded available funding, so allocating funding to achieve the greatest environmental outcome is essential. In recent years, economists have argued that market mechanisms should be incorporated within government programs to improve their cost-effectiveness. This article presents the results of a reverse auction to allocate funding to reduce phosphorus losses from farms, and compares the results with EQIP funded contracts in the same watershed.

Key words: market-based incentives, reverse auctions, EQIP, conservation funding, performance based strategies.

Agricultural Conservation Funding

Traditional U.S. conservation programs like the USDA's Natural Resources Conservation Service (NRCS) EQIP use a practice-based funding allocation strategy, meaning they allocate funding based primarily on the best management practice (BMP) a producer implements; not on the BMPs environmental performance. The BMPs cost-effectiveness is not a determining factor for deciding which projects are ultimately funded. Consequently, the allocation of funding for BMPs within government programs has been criticized for not being a cost-effective use of public funds (Searchinger and Friedman 2003; SWCS and ED 2007).

In contrast, performance-based funding allocation strategies emphasize maximizing environmental outcomes. They prioritize funding based on a BMPs environmental performance, relative to other BMPs, not the BMP itself. This is important because BMP performance varies depending on farm location, level of implementation, and existing on-farm resource concerns. Because performance-based programs prioritize those BMPs that will yield the greatest environmental outcomes, they are able to maximize the conservation goals of the program, and in theory, promise to achieve greater environmental outcomes per dollar spent (Greenhalgh et al. 2006).

Performance-based strategies can be implemented in several ways. One option is for a program to establish a fixed price for every unit of environmental outcome, awarding payments to those applicants who demonstrate the greatest environmental outcome. Another option is to incorporate bidding. This involves soliciting bids from producers that include a suite of practices to be undertaken and the price they are willing to accept in order to implement those practices. Bids are then accepted or rejected based on cost and the environmental outcomes achieved (Cattaneo et al. 2005).

Performance-based funding allocation strategies are increasingly being tested around the world as ways to improve the cost-effectiveness of conservation spending. In Australia, the Victorian EcoTender auction in 2005 allocated conservation funding based of water quality, climate and biodiversity outcomes (Eigenraam et al. 2006). There have also been a number of biodiversity and water quality auctions or tenders conducted throughout Australia (Australian Government: Department of the Environment, Water, Heritage and the Arts; Australian Government: National

Action Plan for Salinity and Water Quality). In the United States, the USDA's Wetland Reserve Program piloted the use of auctions to reduce the acquisition costs of wetland easements in 2006 and 2007. In the 2006 auction, enrollment applications were prioritized according to an environmental benefits index determined by dividing the landowner bid by an environmental self-assessment score. The 2006 auction enrolled 3,500 acres into the program and reduced acquisition costs by around 14 percent or $820,000 (NRCS 2006).

This article takes a closer look at reverse auctions as a performance-based conservation funding allocation strategy, and compares them with the more traditional EQIP practice-based funding allocation process. Our comparison includes the results of a reverse auction held in the Conestoga Watershed in Pennsylvania in February 2006 and EQIP allocations within the same watershed in December of 2005.

Allocating Agricultural Conservation Funding in EQIP

The USDA's EQIP program promotes agricultural conservation measures that, among other things, reduce soil erosion and improve water quality. The program is designed to provide eligible producers with financial and technical assistance to install or implement structural and management practices on their operation. Each state develops a ranking system to allocate the federal EQIP funds at a local level and is developed in accordance with National, state and local priorities (USDA/NRCS 2008; Greenhalgh et al. 2006)

In Pennsylvania, there are a number of EQIP ranking forms[1]. Applicants are ranked using one or more forms depending on the types of resource concerns that they are addressing—livestock, grazing, cropland, nutrient management, no-till or odor control. Points are awarded to applicants based on the nature of their resource concerns, current conservation efforts, and their willingness to adopt or install certain BMPs. The contracts are scored and ranked as 'low,' 'medium,' or 'high' priority, with some ranking forms incorporating farm specific characteristics such as slope and distance to the stream. However, the expected environmental outcomes associated with the proposed BMPs on each farm are not calculated, and project costs are not included in any of the ranking forms and therefore, are not considered in funding prioritization.

For example, Pennsylvania's nutrient management ranking form awards points to producers based on their level of compliance in adopting a number of prescribed practices, e.g., adopting a nutrient management plan, performing phosphorus and nitrogen soil tests, establishing cover crops, and adopting a conservation plan. Producers who propose to undertake more prescribed practices receive more points. Contracts are awarded to the producers with the highest rankings (i.e., the most points) within each category, until the funds are exhausted. Outlined in Appendix 1 are the rankings for the funded contracts in the December 2005 EQIP round.

After approving a contract, EQIP provides cost-share payments to producers; covering between 50 and 75 percent of estimated projects costs (up to 90 percent for low-income producers). Project costs are generally estimated using a standard EQIP price list developed by each state, though for some structural practices professional estimates are the basis for the project cost. The

[1] http://www.pa.nrcs.usda.gov/programs/eqip/ranking.html

final payment is based on the structural costs of implementing the proposed BMPs and not on the environmental outcomes provided by these practices.

In total, EQIP received 19 applications in the Conestoga watershed; of these, 13 were funded (Table 1). The total 2005 program expenditure in the Conestoga watershed was $275,552; with an expected 10,520 pound reduction in phosphorus losses over the lifespan of the funded projects.

Reverse Auctions

Reverse auctions, one type of performance-based funding allocation strategy, are competitive bidding systems with a single buyer and multiple sellers. Unlike standard auctions in which multiple buyers compete to buy goods from a single seller, in reverse auctions multiple sellers compete to sell goods to a single buyer. Reverse auctions are also sometimes referred to as procurement auctions.

The bidding process is key to a reverse auction, with the theoretical benefit of a bidding system being it gives participants the incentive to reveal the minimum compensation they are willing to accept to adopt the BMP. Willingness to accept, which only the participant knows, is important information for an administrator of a reverse auction as they want to minimize the costs of adoption. By making selection competitive, the producer has an incentive not to inflate his bid price much beyond the minimum price they are willing to accept, as this may lead to not being selected into the program at all.

In this way, reverse auctions can be an effective tool for allocating agricultural conservation funding in programs with a limited budget. Applicants are awarded funding based on the cost-effectiveness of addressing a specific environmental concern (e.g., water quality), relative to all other bidders. Funding is allocated to the most cost-effective applicants until either the program has reached their funding allocation limit, or a break point in the cost-effectiveness of bids is reached (Greenhalgh et al. 2007).

Table 1. Funded EQIP and Reverse Auction Contracts in the Conestoga Watershed

EQIP (December 2005)				Reverse Auction (February 2006)			
Project Type	**Payments† (cumulative)**	**Reductions in P Losses (lbs)* (cumulative)**	**Cost effectiveness† ($/lb) (cumulative)**	**Project Type**	**Bids† (cumulative)**	**Reductions in P Losses (lbs)* (cumulative)**	**Cost effectiveness† ($/lb) (cumulative)**
Livestock Mgt[a]	$4,500	2,219	$2.03	Livestock Mgt[a,p]	$84,000	35,576	$2.36
Field Mgt[b]	$1,829 ($6,329)	462 (2,681)	$3.96 ($2.36)	Livestock Mgt[a,p]	$59,000 ($143,000)	24,350 (59,926)	$2.42 ($2.39)
Field Mgt[c,d,e,f]	$19,099 ($25,428)	2,729 (5,410)	$7.00 ($4.70)	Field Mgt[e]	$1,678 ($144,678)	590 (60,516)	$2.84 ($2.39)
Livestock Mgt[a]	$4,200 ($29,628)	466 (5,876)	$9.01 ($5.04)	Livestock Mgt[g]	$36,722 ($181,450)	12,886 (61,106)	$2.85 ($2.47)
Livestock Mgt[a]	$9,000 ($38,628)	914 (6,790)	$9.85 ($5.69)	Livestock Mgt[n,j]	$3,185 ($184,635)	428 (73,992)	$7.44 ($2.50)
Livestock Mgt[a]	$9,000 ($47,628)	914 (7,704)	$9.85 ($6.18)	Field Mgt[m,o]	$2,000 ($186,635)	215 (74,420)	$9.30 ($2.52)
Livestock Mgt[a]	$6,249 ($53,877)	188 (7,892)	$33.24 ($6.83)	Livestock Mgt[a,p]	$106,000 ($292,635)	6,742 (80,787)	$15.72 ($3.62)
Livestock Mgt[a]	$1,320 ($55,197)	29 (7,921)	$45.52 ($6.97)	Livestock Mgt[p,q]	$104,140 ($396,775)	6,198 (86,985)	$16.80 ($4.56)
Livestock/ Field Mgt[e,a,g,h,c,f]	$56,190 ($111,387)	1201 (9,122)	$46.79 ($12.21)	Livestock Mgt[f]	$1,500 ($398,275)	78 (87,063)	$19.23 ($4.57)
Livestock/ Field Mgt[h,e,i,j,a,g,k]	$29,056 ($140,443)	382 (9,504)	$76.06 ($14.78)	Field Mgt[d,n]	$9,464 ($407,739)	282 (87,345)	$33.56 ($4.67)
Livestock/ Field Mgt[l,e,f,a,g,j,c,h]	$64,747 ($205,190)	628 (10,132)	$103.10 ($20.25)	Field Mgt[d,n]	$4,500 ($412,239)	129 (87,474)	$34.88 ($4.71)
Field Mgt[h,e,d,a,m,n]	$61,573 ($266,763)	346 (10,478)	$177.96 ($25.46)	Livestock Mgt[p,q]	$31,051 ($443,290)	785 (88,259)	$39.56 ($5.02)
Field Mgt[l,e,o,n]	$8,789 ($275,552)	42 (10,520)	$209.26 ($26.19)	Field Mgt[e]	$3,700 ($446,990)	68 (88,327)	$54.41 ($5.06)
Cumulative Total	$275,552	10,520	$26.19	Cumulative Total	$446,990	88,327	$5.06

† Some values are rounded.

*All phosphorus reductions are adjusted for delivery to the mouth of the Conestoga River. Where project includes livestock and field management, the phosphorus losses were estimated separately for each category and then added.

[a] nutrient management plan, [b] no till, [c] fence, [d] terraces, [e] grassed waterway, [f] stream crossing, [g] waste storage, [h] conservation cover, [i] pasture and hay planting, [j] heavy use protection, [k] roof runoff, [l] diversion, [m] contour farming, [n] subsurface drain, [o] strip cropping, [p] stacking pad, [q] animal composting

The Conestoga Reverse Auction

With a USDA Conservation Innovation Grant, the World Resources Institute[2] (WRI) and its project partners[3] conducted two reverse auctions in Pennsylvania's Conestoga Watershed. The Conestoga Watershed is located primarily within the heavily agricultural community of Lancaster County. In 1996, the Conestoga watershed was listed as a phosphorous-impaired waterbody; and agriculture was identified as the largest contributor of phosphorus loads in the watershed. The purpose of these auctions was to pay producers to improve water quality within the watershed, by compensating producers for reducing phosphorous losses through the implementation of BMPs. A trial auction was conducted in June 2005, and administrative modifications were made to streamline the reverse auction mechanism. The final reverse auction was conducted between October 2005 and February 2006.

Technicians from the Lancaster County Conservation District (LCCD) worked closely with producers within the watershed to estimate the phosphorus reductions that could potentially be achieved by BMPs the producers were interested in implementing. A version of WRI's NutrientNet tool[4] was used to estimate phosphorus reductions using a series of online calculations (Guiling and St John 2007).

In the first auction, producers entered their bids to implement specific BMPs based on standard EQIP BMP costs and cost-share amounts, while in the second auction producers faced no restrictions on their bid price, and bids were allowed to exceed the fixed EQIP BMP

[2] The World Resources Institute is an environmental think-tank based in Washington DC and has been working on U.S. agricultural policy for over 15 years.
[3] Other project partners included the Pennsylvania Environmental Council, Lancaster County Conservation District, NatSource LLC, and The Conservation Fund.
[4] A version of the reverse auction on-line tool can be found at http://conestoga.nutrientnet.org.

implementation costs. The bids were then ranked based the unit cost of reducing phosphorus losses (i.e., dollars per pound of phosphorus reduced). Projects were funded in order of most cost-effective until the auction budget of $486,000 was exhausted.

While producers in the reverse auction were given no restrictions on the total price they could bid, they were cautioned that the auction was ranked using cost-effectiveness (dollar per pound of phosphorus reduced) and that their bid price would determine their competitiveness in the auction.

In total, the second reverse auction received 23 bids; of these, 13 were accepted and funded (table 1). In aggregate, the funded projects are expected to reduce phosphorous losses by over 88,000 pounds over the lifespan of the projects. The total program expenditures were $446,990.

Comparing the Conestoga Reverse Auction to the EQIP Allocation

Our analysis compares the performance of these two programs in terms of the reduction in phosphorous losses achieved and the cost-effectiveness of achieving those reductions. We estimated the reduction in phosphorus losses from the EQIP contracts using NutrientNet—the same estimation tool used to calculate phosphorus reductions in the reverse auction.

The comparison uses contracts funded through EQIP in December 2005 and those funded through the second reverse auction in February 2006. Because the total program expenditures under the reverse auction were approximately 60 percent more than the EQIP expenditures (table

1), we created an artificial budget constraint of $293,000[5] for the reverse auction. Constraining the budget in this manner allows us to make a more valid comparison with the $275,552 spent in the 2005 EQIP round in the Conestoga watershed. In table 1, the shaded area represents the contracts funded in the reverse auction but not included in this comparison as they fall outside of our artificial budget constraint of $293,000. The comparison, therefore, was between the 13 EQIP funded contracts and the first seven of the reverse auction funded contracts.

Funding Allocation Process

Unlike the ranking process in EQIP, the reverse auction used a purely quantitative approach to 'scoring' applications, i.e., applicants were scored based on the pounds of phosphorus they reduced and their bid price. Producers were allowed to choose from a list of BMPs that are acceptable for use under EQIP. Bids received from producers included both the practice(s) they were interested in implementing and the price they were willing to accept to implement those practices. Bids were funded based on how cost-effectively they reduced phosphorus losses, and bids were funded until the budget was exhausted.

The EQIP process, on the other hand, scores applicants by allocating points based on National, state and local resource priorities. Some of the key differences are:

[5] We could also have constrained the reverse auction budget at $187,635 (including only the first six contracts), resulting in an overall cost-effectiveness of $2.52/lb. However, it was felt that this budget constraint would be perceived as biased towards maximizing the cost-effectiveness of the reverse auction, so the decision was made to include the seventh contract.

a) EQIP considers more resource concerns than just the ability to reduce phosphorus losses when scoring each application. However, as the Conestoga River is listed as a phosphorus-impaired waterway, BMPs that reduce phosphorus losses and improve water quality are awarded more points.
b) EQIP considers various social aspects that were not represented in the reverse auction, such as being a limited resource farmer.
c) EQIP uses a mixture of qualitative and quantitative approaches for awarding points.
d) The cost of implementing a BMP is not typically considered when awarding points in EQIP.

Funded Practices

To determine if the reverse auction and EQIP funded different types of BMPs, we sorted the BMPs into two categories—"Livestock Management" and "Field Management." The livestock management category included those practices that fell into the EQIP nutrient management and livestock categories, while field management where those that covered the EQIP cropland and no-till practices.

Both EQIP and the Conestoga reverse auction funded a similar mix of BMPs (table 2). This is not too surprising, given the relatively small size of the Conestoga watershed and the uniform nature of land uses. As shown in Table 2, roughly two-thirds of the funded projects are livestock management and the remaining one-third is field management in both programs. However, with the reverse auction, almost all of the funding went to livestock management practices that generated nearly all the reduction in phosphorus losses.

Table 2. Categories of BMP Funded through both Programs*

	Livestock Management		Field Management	
	EQIP	**Reverse Auction**	**EQIP**	**Reverse Auction**
Number of Funded Projects *(% of Funded Projects)*	9 *(69%)*	5 *(71%)*	4 *(31%)*	2 *(29%)*
Program Costs for Projects *(% of Program Budget)*	$184,262 *(67%)*	$288,957 *(99%)*	$91,290 *(33%)*	$3,679 *(1%)*
Reduction in Phosphorus Losses† *(% of Total P Reduction)*	6,941 *(66%)*	79,982 *(99%)*	3,579 *(34%)*	805 *(1%)*

* Represents only the subset of reverse auction contracts that would have been funded given the artificial budget constraint.

† Phosphorous reductions were estimated using NutrientNet and are in pounds of phosphorus losses reduced over the entire useful life of the BMP. They are also adjusted for delivery to the mouth of the Conestoga River.

Expenditure and Reduction in Phosphorus Losses per Contract

Individual contract expenditures generally tended to be higher in the reverse auction compared with those in EQIP (Figure 1 and table 1). This is largely due to participants in the reverse auction not being limited to standard cost-share rates, therefore attracting producers with a higher 'willingness to accept' (i.e., those that would not have participated in EQIP because they were unwilling or unable to pay the producer's share of the project costs as stipulated by EQIP).

Producers in the reverse auction often placed bids equal to the full price of the project. No bids received in the reverse auction were below the standard price producers would have received in EQIP for the same practice. This indicated that the presence of a "competing" conservation program created an artificial price floor. Producers were unwilling to go below the standard EQIP practice costs, reasoning that if they were unsuccessful in the reverse auction they could then enroll in EQIP the following year. Therefore, the cost-effectiveness realized in the reverse

auction are likely to be conservative; if *all* conservation funds were distributed competitively, it is likely bid prices would be lower.

As with the individual contract payments, the reduction in phosphorus losses also tended to be higher in the reverse auction on a per contract basis (Figure 2).

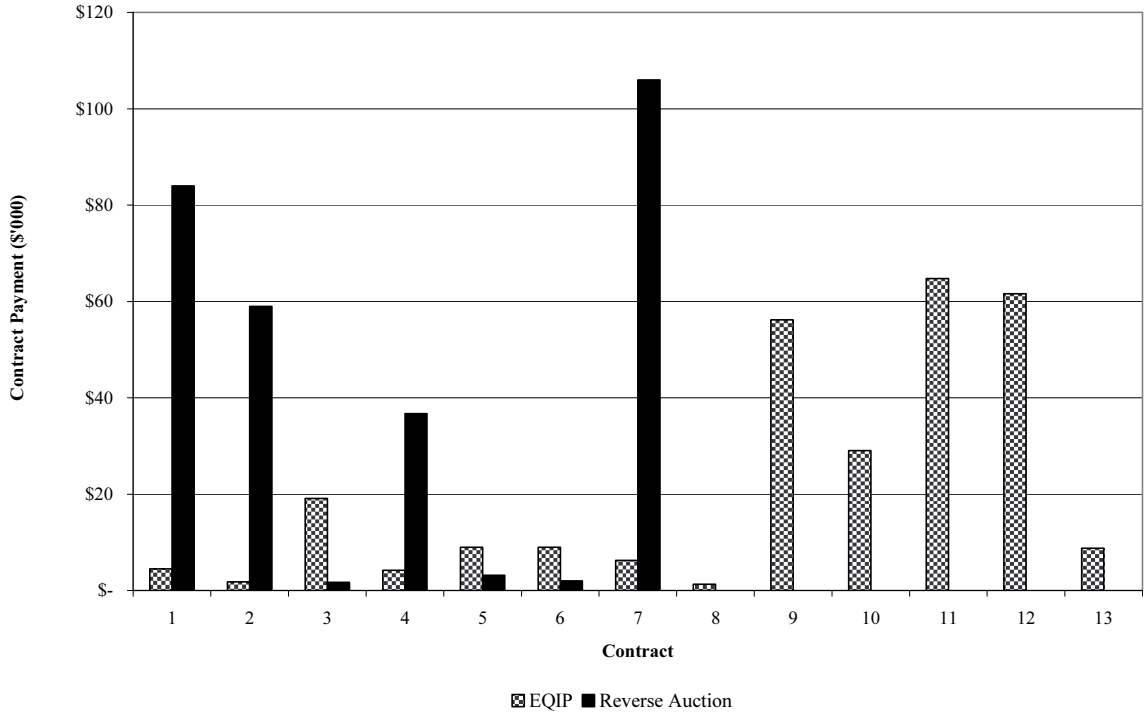

Figure 1. Individual Reverse Auction and EQIP Contract Payments (Contracts Ordered by Cost-Effectiveness)

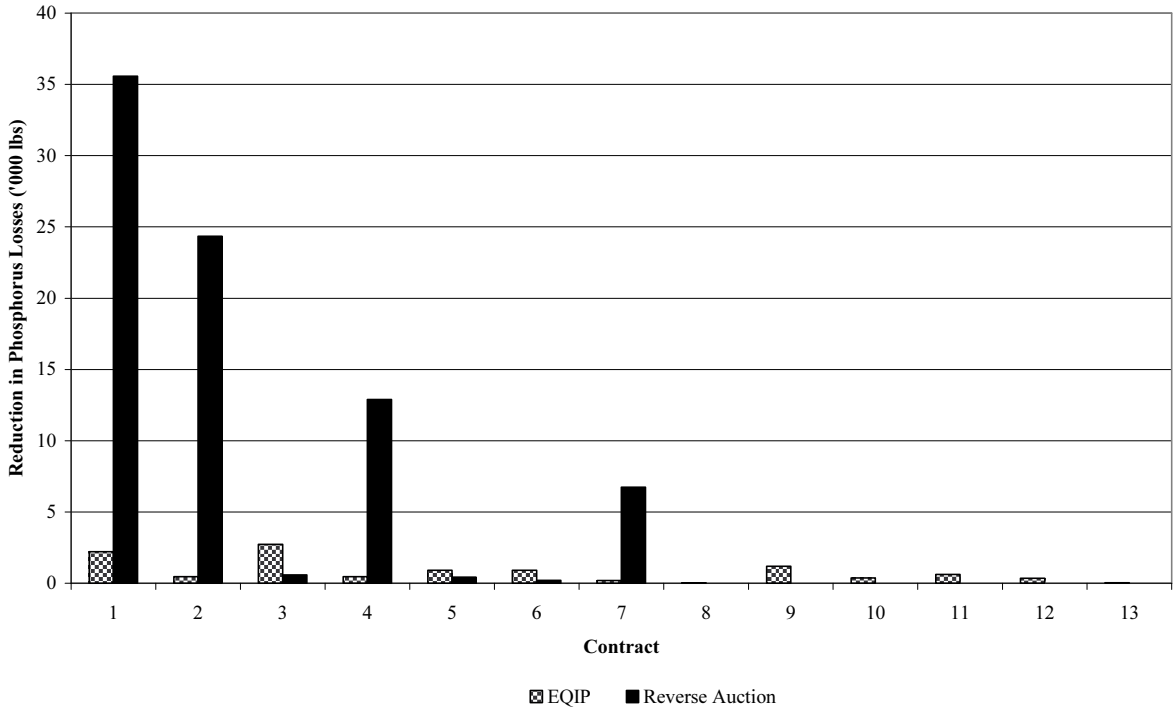

Figure 2. Estimated Reduction in Phosphorous Losses (Contracts Ordered by Cost-Effectiveness)

Cost-effectiveness

In comparing the cost-effectiveness of the contracts funded through EQIP and the reverse auction, we compare the average cost of reducing a pound of phosphorus losses. The 13 contracts funded through EQIP had total cost-share expenses of $275,552, and the first seven contracts of the reverse auction had a total bid payment of $292,635 (Table 3).

Table 3. Comparison of the Average Cost-Effectiveness between Programs

Program	Number of Projects Funded	Total Cost ($)	Total Estimated Phosphorous Reduction† (pounds of P)	Cost-Effectiveness ($/lb P reduced)
EQIP	13	$275,552	10,520	$26.19
Reverse Auction	7	$292,635	80,787	$3.62

† Phosphorous reductions are estimated over the entire useful life of the BMP using NutrientNet.

There are marked improvements in cost-effectiveness between the reverse auction and EQIP. The average cost of reducing phosphorus losses was $3.62/lb P reduced in the reverse auction, and $26.19/lb P reduced in the 2005 EQIP round. This equates to approximately a seven-fold increase in cost savings in the reverse auction. The least cost-effective winning bid in the reverse auction was $15.72/lb P reduced[6], while in the 2005 EQIP round the highest per unit cost was $209.26/lb P reduced—further illustrating the magnitude of price differences between the two programs.

When ranking the projects funded by EQIP according to cost-effectiveness (i.e., cost per pound of phosphorus reduced), we find that many of the projects that ranked 'medium' on the EQIP ranking forms are some of the most cost-effective for reducing phosphorus losses (Appendix 1). In fact, three of the top four most cost-effective contracts were ranked medium in EQIP, and one of these was the most cost-effective contract overall, coming in at $2.03/lb of P reduced.

This discrepancy may be because EQIP forms rank a contract according to a number of environmental parameters, not just water quality. Although these medium-ranking contracts prove to be very effective at reducing phosphorus losses[7], they may not have ranked high on other environmental factors such as air quality or at-risk species habitat. However, the reduction in phosphorus losses was selected as the focus for the reverse auction because phosphorus is both the primary environmental threat to the Conestoga watershed, and the primary focus of EQIP. EQIP also tends to focus on the adoption of BMPs and reward farmers who agree to implement

[6] Without the artificial budget constraint in the reverse auction, the highest price paid was $54.41 per pound of phosphorus reduced.
[7] On closer inspection, the types of BMPs funded by EQIP and the reverse auction were comparable and would not be expected to produce dissimilar environmental outcomes.

more practices. This possibly dilutes the cost-effectiveness of the contract even though the contract overall ranks more highly. Therefore, it should be remembered that the true benefits of most of the BMPs adopted in these programs may extend beyond this single phosphorus loss measurement.

The cost paid by EQIP to implement a practice is also pre-determined and the producer is paid between 50 and 75 percent of this cost. On the other hand, producers in the reverse auction were allowed to bid what they were 'willing to accept' to implement the practice, which may have been the full cost of implementing the practice. Because of the scale of reductions in phosphorus loss estimates for many of the projects, we believe that some producers felt comfortable bidding the full cost of the project.

Another way to think about comparing these two programs is to estimate the cost-effectiveness of the reverse auction bids based on their cost-share rates if they had been submitted to the EQIP round. The LCCD technicians during the process of entering data for the reverse auction also determined what the EQIP cost-share rate (and therefore the EQIP payment) would have been for each of the reverse auction bids (Appendix 2). Based on EQIP cost-share rates, the reverse auction would give a total bid payment of $289,547, reducing approximately 89,001 pounds of phosphorus losses with an average cost-effectiveness of $3.25/lb of P reduced.[8] The relative cost-effectiveness of the projects also changed as the bid payment had changed to reflect EQIP cost-share rates. Once again, for comparative purposes we imposed an artificial budget constraint of $275,552 (which was the EQIP expenditure for the 2005 round). This meant that 14 reverse

[8] The average cost-effectiveness of the bids is lower as the cost-share funding by the producers means that the program pays out less per project.

auction bids were used in the comparison (instead of 7 in the earlier analysis). Basing the reverse auction bid payments on EQIP cost-share rates further demonstrated the cost-effectiveness of a reverse auction approach.[9]

Willingness to Accept

In many instances it was the flexibility in bid pricing that attracted participants to the reverse auction. Because the reverse auction did not place a limit on bid pricing, it was able to attract a larger group of producers—particularly those produces who did not wish to participate in EQIP where only a percentage of total implementation costs were covered.

In Pennsylvania, the EQIP program typically limits cost-share rates of structural practices to 50 percent of the cost of the structural practice, as their goal is to fund as many projects as possible. Because manure storage systems are costly—often as much as $100,000 per system—many producers are not willing, or cannot afford, to implement these practices for the EQIP cost-share price. The reverse auction, which had no bid price limit, was attractive to producers that could not afford to pay the EQIP producer match. This was the situation for at least one reverse auction participant, who had refused previous offers by LCCD technicians to submit applications for EQIP funding. In another instance, a producer who needed a manure management system on his recently purchased farm had been approached by LCCD technicians to enroll in earlier EQIP rounds. He always refused, based on his own financial constraints. He was, however, willing to participate in the reverse auction because the auction provided enough flexibility to cover all of his project costs.

[9] This is only a small sample size and the disparity in cost-effectiveness may diminish if compared using a larger sample size.

The reverse auction is able to maximize cost effectiveness because it bases its payments on the applicant's willingness to accept, and not a fixed cost-share payment rate. As a result, the reverse auction is able to capture those participants who provide cost-effective phosphorus reductions, but whose 'willingness to accept' price is above the EQIP fixed-rate price. While we cannot verify this, we also expect that if there was no competing funding source (i.e., EQIP) the reverse auction would also be able to capture discounts from those producers willing to accept less than the standard EQIP rate.

In Summary

A reverse auction combines performance-based strategies with competitive bidding. In a reverse auction, producers compete for funding based on the compensation they demand to implement a BMP. All other things being equal, lower priced bids are preferred to higher priced bids.

In contrast to traditional fixed-payment approaches such as those within EQIP, competitive bidding has incentive compatibility features, which encourage producers to reveal the minimum price they are willing to accept to implement a specific BMP. Because stewardship values and expected returns differ among producers, the price producers are willing to accept to undertake various conservation measures will also vary. In some cases, this may be below the price they would receive in a fixed-payment program. In competitive bidding schemes, winning bids may be selected as a function of price, estimated project outcomes, or both. When coupled with performance-based strategies, competitive bidding can be a powerful tool for efficiently

allocating conservation dollars in a manner that maximizes total environmental outcomes while minimizing public expenditures.

The results of the Conestoga reverse auction clearly convey the effectiveness of performance-based strategies coupled with bidding at identifying and funding those practices which generate the greatest environmental outcomes at the least cost. The EQIP program, which uses fixed-rate payments, only generated a fraction of the environmental outcomes given similar budget constraints. In the 2002 Farm Bill, Congress eliminated the requirement to "maximize net environmental benefits per dollar expended", and as a result the practice of bidding and selecting successful applications based on cost effectiveness was eliminated from the program.

Clearly, however, measures of cost-effectiveness and bidding are important elements for maximizing environmental outcomes. Funding allocation strategies within EQIP should be revisited with an eye towards maximizing taxpayer benefit by maximizing environmental outcomes and minimizing costs. At a minimum, allocation strategies should require a more quantitative approach to measuring environmental outcomes, as well as a measure of cost-effectiveness. Ideally, the funding allocation strategy would also include bidding and operate in a manner similar to a reverse auction, providing greater monetary benefits by paying producers according to their willingness to accept, not according to a fixed-cost rate.

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Appendix 1. Details of the contracts funded in the 2005 EQIP funding round for the Conestoga Watershed.

Project	Score (total points possible)	Cost Effectiveness	EQIP Rank
Nutrient Management: 590 Nutrient Management Plan (NMP), Pre-Side Dressed Nitrogen Test (PSNT), Corn Stock Nitrogen Test (CSNT)	70/100	$2.03	Medium
No-Till: Conservation Cover, Conservation Crop Rotation, Residue Management, Contour Farming, 590 NMP, Pest Management, Deep Tillage	60/105	$3.96	High
Cropland: Fence, 2 Terraces, Grassed Waterway, Stream Crossing,	75/110	$7.00	Medium
Nutrient Management: 590 NMP, Pre-Side Dressed Nitrogen Test, Corn Stock Nitrogen Test	65/100	$9.01	Medium
Nutrient Management: 590 NMP, Pre-Side Dressed Nitrogen Test, Corn Stock Nitrogen Test	100/100	$9.85	High
Nutrient Management: 590 NMP, Pre-Side Dressed Nitrogen Test, Corn Stock Nitrogen Test	100/100	$9.85	High
Nutrient Management: 590 NMP, Cover Crop, Residue Management, Deep Tillage, Residue Management	100/100	$33.24	High
Nutrient Management: 590 NMP, Pre-Side Dressed Nitrogen Test, Corn Stock Nitrogen Test	65/100	$45.52	Medium
Livestock: Grassed Waterway, 590 NMP, Waste Storage, Conservation Cover, Fence, Stream Crossing	113/191	$46.79	Medium
Livestock: Conservation Cover, Grassed Waterway, Pasture and Hay Planting, Heavy Use Protection, 590 NMP, Waste Storage, Roof Runoff	96/191	$76.06	Medium
Livestock: Diversion, Grassed Waterway, StreamCrossing, 590 NMP, Waste Storage, Heavy Use Protection, Fence, Conservation Cover	96/191	$103.10	Medium
Cropland: Conservation Cover, Grassed Waterway, Terraces, 590 NMP, Contour Farming, Subsurface Drain	55/110	$177.96	Medium
Cropland: 300ft Diversion, Grassed Waterway, Stripcropping, Subsurface Drain	85/110	$209.26	Medium

Appendix 2. Comparison between EQIP contracts and the reverse auction bids if they used EQIP cost-share rates to determine the bid payment

EQIP contracts				Reverse Auction Bids but with EQIP cost-share			
Project Type	**Payments† (cumulative)**	**Reductions in P Losses (lbs)* (cumulative)**	**Cost effectiveness† ($/lb) (cumulative)**	**Project Type**	**Bid† (cumulative)**	**Reductions in P Losses (lbs)* (cumulative)**	**Cost effectiveness† ($/lb) (cumulative)**
Livestock Mgt[a]	$4,500	2,219	$2.03	Livestock Mgt[a,p]	$27,720	24,350	$1.14
Field Mgt[b]	$1,829 ($6,329)	462 (2,681)	$3.96 ($2.36)	Field Mgt[e]	$8,39 ($28,559)	590 (24,940)	$1.42 ($1.15)
Field Mgt[c,d,e,f]	$19,099 ($25,428)	2,729 (5,410)	$7.00 ($4.70)	Livestock Mgt[a,p]	$55,738 ($84,297)	35,576 (60,516)	$1.57 ($1.39)
Livestock Mgt[a]	$4,200 ($29,628)	466 (5,876)	$9.01 ($5.04)	Livestock Mgt[g]	$24,515 ($108,812)	12,886 (73,402)	$1.90 ($1.48)
Livestock Mgt[a]	$9,000 ($38,628)	914 (6,790)	$9.85 ($5.69)	Field Mgt[m,o]	$1,275 ($110,087)	215 (73,617)	$5.93 ($1.50)
Livestock Mgt[a]	$9,000 ($47,628)	914 (7,704)	$9.85 ($6.18)	Livestock Mgt[a,p]	$47,990 ($158,077)	6742 (80,359)	$7.12 ($1.97)
Livestock Mgt[a]	$6,249 ($53,877)	188 (7,892)	$33.24 ($6.83)	Livestock Mgt[n,j]	$3,185 ($161,262)	428 (80,787)	$7.44 ($2.00)
Livestock Mgt[a]	$1,320 ($55,197)	29 (7,921)	$45.52 ($6.97)	Livestock Mgt[p,q]	$52,070 ($213,332)	6,198 (86,985)	$8.40 ($2.45)
Livestock/ Field Mgt[e,a,g,h,c,f]	$56,190 ($111,387)	1201 (9,122)	$46.79 ($12.21)	Livestock Mgt[f]	$1,500 ($214,832)	78 (87,063)	$19.23 ($2.47)
Livestock/ Field Mgt[h,e,i,j,a,g,k]	$29,056 ($140,443)	382 (9,504)	$76.06 ($14.78)	Field Mgt[d,n]	$2,488 ($217,319)	129 (87,192)	$19.28 ($2.49)
Livestock/ Field Mgt[l,e,f,a,g,j,c,h]	$64,747 ($205,190)	628 (10,132)	$103.10 ($20.25)	Field Mgt[d,n]	$9,464 ($226,783)	282 (87,474)	$33.56 ($2.59)
Field Mgt[h,e,d,a,m,n]	$61,573 ($266,763)	346 (10,478)	$177.96 ($25.46)	Livestock Mgt[p,q]	$31,051 ($257,834)	785 (88,259)	$39.56 ($2.92)
Field Mgt[l,e,o,n]	$8,789 ($275,552)	42 (10,520)	$209.26 ($26.19)	Field Mgt[e]	$10,038 ($267,872)	245 (88,504)	$40.97 ($3.03)
				Field Mgt[e]	$21,675 ($289,547)	497 (89,001)	$43.61 ($3.25)
Cumulative Total	$275,552	10,520	$26.19	Cumulative Total	$289,547	89,001	$3.25

† Some values are rounded.

*All phosphorus reductions are adjusted for delivery to the mouth of the Conestoga River. Where project includes livestock and field management, the phosphorus losses were estimated separately for each category and then added.

[a] nutrient management plan, [b] no till, [c] fence, [d] terraces, [e] grassed waterway, [f] stream crossing, [g] waste storage, [h] conservation cover, [i] pasture and hay planting, [j] heavy use protection, [k] roof runoff, [l] diversion, [m] contour farming, [n] subsurface drain, [o] strip cropping, [p] stacking pad, [q] animal composting