# Analysis of Phosphorus Control Costs and Effectiveness for Point and Nonpoint Sources in the Fox-Wolf Basin



Prepared for Fox-Wolf Basin 2000 July 1999

**RESOURCE STRATEGIES, INC.** 

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# Abstract

In November 1998, Fox-Wolf Basin 2000, through its contractor Resource Strategies, Inc., began gathering phosphorus control cost information from point and nonpoint sources in the Wolf, Upper Fox and Lower Fox River Basins in central Wisconsin. This information is needed to assess the possibility for watershed-based trading for water quality improvement in the region. Cost estimates for municipal treatment plants to comply with a hypothetical 0.3 mg/l effluent phosphorus standard were obtained from plant managers. Similarly, estimated control costs and efficiencies for implementation of best management practices for phosphorus control at selected agricultural nonpoint sources were obtained from county watershed technicians. This information was used to make general assessments of the potential for beneficial watershedbased trading for each of the three basins. The Lower Fox Basin appears to have the greatest potential for trading due to the large number of point sources with a wide range of control costs, and the availability of low cost agricultural reductions. The Upper Fox Basin is unlikely to benefit from watershed-based trading due to the small number of point sources and their relatively low cost of phosphorus control. The Wolf Basin also appears an unlikely candidate for a trading program due to higher cost agricultural reductions and relatively low cost point source controls. Additional cost information for point sources (including industrial sources) and cost information on a larger number of agricultural operations will provide a better assessment of point-point and point-nonpoint trading potential.

# **Executive Summary**

### **Introduction and Background**

The Fox-Wolf Basin in central Wisconsin is comprised of the Wolf, Upper Fox and Lower Fox River Basins, which ultimately drains into Green Bay and Lake Michigan. Historically, these waters have suffered degradation due to industrial and municipal use, urban development and agricultural activity.

The Fox-Wolf Basin 2000 has initiated a number of projects to gather information needed to assess and implement cost-effective water quality programs in Wisconsin. In November 1998, with funding from the Green Bay Metropolitan Sewerage District, Joyce Foundation, Water Environment Research Foundation, and the Wisconsin Department of Natural Resources, FWB2000 contracted with Resource Strategies, Inc. to gather control cost information for phosphorus (P) sources in the basin and research other associated watershed-based trading issues. Products of this and other studies will be used to direct future research efforts and develop opportunities for pilot trades in the basin.

### Watershed-Based Trading

Watershed-based trading (also known as water quality trading or effluent trading) is a regulatory program option that allows sources to negotiate with each other and make "trades" in control obligations. With this type of flexibility, sources with relatively high control costs can seek out sources with lower costs and fund their over-compliance. Credits generated from this over-compliance can then be used toward the higher-cost source's compliance requirements. In this way, overall costs of water quality improvements to society are lower because the highest cost controls are avoided, and lower cost control opportunities are maximized. This type of program has long been advocated by economists as a means of cost-effectively achieving environmental goals. Other programs involving the trading of pollutant "credits" have shown that they are also effective means for promoting innovation and accelerating environmental improvements.

Knowledge of cost variability is essential to determine what regulatory options are appropriate. Situations in which there are dramatic differences in control costs among sources may have potential for substantial cost savings and/or provide greater water quality improvement per dollar spent if effluent trading is allowed.

### **Source Selection**

This study gathered control cost and effectiveness information for *point* sources (that is, those with one discreet point of entrance into the water body) and *nonpoint* or "diffuse" sources. Point sources in the basin include municipal treatment plants (MTPs) and industrial facilities. Samples of permitted MTPs and industrial sources discharging P to surface waters were selected and contacted for control cost information. Information from responding MTPs was included in this study. However, nearly all industrial sources contacted were unwilling to share cost information for this study, and were therefore excluded from the analyses. Nonpoint sources of P in the basin include:

- agricultural operations,
- other rural land uses,

- urban stormwater facilities and
- construction sites.

Due to time and resource restrictions, this study focused on agricultural nonpoint sources because they are significant P sources, and were most likely to become involved in trading, and more likely to be sources of surplus P reductions needed for acceptable trades.

#### **MTP Cost Estimates**

Thirteen of 17 MTPs contacted provided cost estimates. These facilities accounted for about 84 percent of the P load to surface waters from MTPs in the basin in 1998.<sup>1</sup> Plant managers were asked to estimate the costs and pounds of P controlled if their facility were to control to 0.3 mg/l effluent concentration. This level was chosen because it was identified as a probable next step level of control in the Green Bay Remedial Action Plan in 1988 (WDNR, 1988)<sup>2</sup>. Dollar per pound cost estimates were the incremental costs of moving from their current level of control to 0.3 mg/l divided by the incremental amount of P controlled at the new level.

Cost estimates received were rough estimates that included both costs derived from detailed engineering studies and simple calculations. Also, because cost estimates are based on moving from their current P effluent concentration to a permitted level of 0.3 mg/l, if sources were subject to effluent standards above or below 0.3, these cost estimates could change dramatically. Costs of new equipment and structures were converted to an annual cost over 20 years at a 4.5 percent interest rate.

Based on MTP managers' estimated P control costs, incremental dollar per pound control costs to comply with a 0.3 mg/l effluent standard were calculated. These estimated costs ranged from \$1/lb. to over \$500/lb. Wide variation in control costs is one indicator that effluent trading may be beneficial.

### **Agricultural Nonpoint Sources**

Agricultural operations can create P loading reductions through implementation of *best management practices*. Assessment of P control costs for each of these sources involved estimating current P loads, prescribing appropriate best management practices and estimating the costs and resultant P load reductions. For this, watershed technicians involved with state nonpoint source priority watershed projects were consulted. Because of the large number of agricultural operations in the basin, and the administrative cost associated with developing control cost estimates for each, the operations sampled for this study were limited to nonpoint source priority watershed projects because these projects are already developing these types of estimates. A full characterization of the basin, however, should also involve watersheds not currently involved in the state nonpoint source priority watershed program.

County watershed technicians for all current state nonpoint source priority watershed projects were contacted for information. They were asked to select five to ten agricultural operations they viewed as good candidates for P best management practices, but which had not yet committed to a state cost-sharing plan (i.e., these sources were still available for potential trades).

<sup>&</sup>lt;sup>1</sup> Based on WDNR estimated annual P discharge amounts to surface waters in the Fox-Wolf Basin in 1998 as listed in Wisconsin Pollutant Discharge Elimination System permits.

<sup>&</sup>lt;sup>2</sup> Revisions in effluent standards could include effluent limitations higher or lower than 0.3 mg/l.

Technicians from seven priority watershed projects in eight counties provided cost and control estimates.

For each of the operations they selected, watershed technicians gave a prescription for P best management practices and produced cost and control estimates. These estimates were based on state cost sharing values for each type of structure or practice. Structural best management practices were priced at 100 percent of the state estimate (even if the state only cost-shares 50-70 percent). Structure costs are discounted at 4.5 percent over ten or 20 years based on their estimated useful life.

Cost estimates for per-acre-funded practices such as conservation tillage and nutrient management were based on the funding rate for each county (this was either \$12 per acre or \$18.5/acre for conservation tillage, and \$8/acre for nutrient/pest management). Cost estimates for these types of practices are likely to be higher than actual costs. One reason for this is state funding levels last for three years, but if the farmer continues the practice the reduced P loading will continue beyond those three years. The estimates in this study were produced based on continued annual funding, where, in reality, this may not be necessary. Many studies have suggested that these practices are often profitable for farmers who generally just need some financial help implementing them at the outset. Furthermore, cost estimates in this study do not take into account cost savings associated with these practices. Alternative cost estimation methods could produce much lower dollar per pound prices.

Watershed technicians contributed estimates for 17 operations in the Lower Fox, 21 in the Upper Fox, and nine in the Wolf basins. For the sample operations in this study, agricultural control costs ranged from about \$3/lb. to \$117/lb. The average cost of controlling a pound of P was about \$26.

A more extensive cataloging of agricultural operations including those not in nonpoint source priority watershed programs would provide a much better picture of the potential for point/nonpoint trading.

### **Assessment of Trading Potential**

The information gathered on agricultural source costs and MTP costs can be used to do a preliminary assessment of trading potential. Consideration of trading possibilities must take into account likely restrictions on trading. First and foremost, because the pollutants in question are not uniformly mixed (i.e., the point at which they enter the river matters) the Fox-Wolf Basin will undoubtedly be divided into trading zones. The largest possible trading zone in this situation is probably the basin level (i.e., trading will be restricted to within each basin).

Another likely condition on trading is trades between point and nonpoint sources will probably be subject to a trading ratio to include an environmental margin of safety (for more information on margins of safety see Appendix E of this report). A likely ratio, one approved in similar programs, is requiring two pounds of reduction from nonpoint sources to offset each one pound from a point source. Depending on program design, point to point trades may also be subject to a ratio of greater than one-to-one to insure some environmental improvement with each trade.

## Average Incremental Phosphorus Control Costs by Basin Table A

Source	Lower Fox	<b>Upper Fox</b>	Wolf	Overall
MTP Weighted Average Cost/lb.	\$109	\$7	\$13	\$73
Nonpoint Sources Weighted	\$21	\$21	\$45	\$26
Average Cost/lb.				

Note: The weighted average cost is calculated by dividing the overall cost of reductions by the overall pounds of P reduced. Incremental costs are the costs per pound reduced of controlling effluent P levels to 0.3 mg/l.

Comparison of averages of MTP and agricultural source control costs for these basins (summarized in Table A above) gives a crude indication of trading potential in each basin. Looking at these averages it appears that there is potential for cost savings with point/nonpoint trades in the Lower Fox, but it is less likely in the Upper Fox and Wolf Basins. However, a key factor in whether trading within or between source types are desirable options is the variation in costs *among sources* which is not captured by these averages.

# Agricultural Phosphorus Control Cost Information by Basin

	1001	00	
	Lower Fox	Upper Fox	Wolf Nonpoint
	Nonpoint Sources	Nonpoint Sources	Sources
75th Percentile	\$30	\$20	\$59
Median	\$26	\$15	\$49
25th Percentile	\$11	\$11	\$48

Table B shows more detail on the variation in estimated agricultural control costs including the 75<sup>th</sup> and 25<sup>th</sup> percentiles and medians (i.e., middle value) for the samples from each basin. For example 75 percent of the operations for the Lower Fox basin have control costs of \$30 or less per pound and 25 percent have control costs of \$11 or less. The most notable information here is the Wolf basin cost estimates are about double those of the other two basins. One reason for this is the sandy soil in some of the sampled watersheds requires use of expensive concrete structures to prevent groundwater contamination.

Point sources looking for potential sellers of credits will need to consider both price and volume of credits available from other sources. If faced with large reduction requirements, sources may choose to trade with other point sources to minimize costs associated with negotiating with multiple smaller sources.

## **Trading Assessment by Basin**

The Lower Fox Basin shows the most promise for effluent trading program development due to:

- wide variation in point source control costs
- large number of point sources, and
- availability of low cost nonpoint source reductions.

The numerous industrial sources in the basin could also contribute substantially to the formation of a watershed-based trading program if they choose to participate.

The <u>Upper Fox Basin</u>, although nonpoint source control costs are similar to those in the Lower Fox, does not appear to have much potential for effluent trades since the sampled point sources have relatively low estimated control costs, and are therefore unlikely to be motivated to trade. Because of the relatively low cost of reductions from both MTPs and agricultural sources, trading in this basin may still be a viable option to accommodate new growth.

The <u>Wolf Basin</u> has extremely high control costs for the sample of agricultural operations included in this study, and relatively lower control costs for participating MTPs. At this time it does not appear to be fertile ground for effluent trading. However, if new regulations apply to some of the smaller MTPs, these sources could possibly become very motivated to trade to avoid expensive treatment additions for small volumes of P reductions. Also, examination of other agricultural sources and best management practices might reveal some lower cost P reductions than those found in this study.

The unavailability of industrial source cost information does not bode well for industrial participation in watershed-based trading, and makes estimation of trading potential for the basin speculative. However, these sources may step in to the market and buy or sell credits if their savings potential is great enough.

In order for point-nonpoint trading to be seen as a practical option, many more operations will need to be identified. Most of the point sources in our sample would need to reduce their loadings by thousands of pounds per year if the 0.3 effluent standard were implemented and many industrial sources face similar reduction volumes. Such large reductions would require identification of a much larger number of nonpoint source candidates.

Sources needing to purchase larger volumes of reductions may be motivated to trade with other point sources to avoid the transaction costs of negotiating with several agricultural operations. To better assess the possibilities for point-point trading, control cost estimates should be gathered for control levels above, at and below the expected effluent standard. This will give a clearer picture of whether sources are likely to be buyers or sellers of credits.

# Introduction

In November 1998, Fox-Wolf Basin 2000 (FWB2000), through its contractor, Resource Strategies, Inc. (RSI), and others, began a series of projects to characterize control costs and associated issues for sources of phosphorus (P) to surface waters in the Upper Fox, Lower Fox and Wolf River basins. The purpose of these projects is to gather information needed to help assess the viability of effluent trading for P as an option for achieving water quality goals in the Fox-Wolf Basin.

Effluent trading or watershed-based trading is a regulatory program option that allows sources to negotiate with each other and make "trades" in control obligations giving them more flexibility in their compliance options. Sources with higher control costs can offer to buy reductions from sources with lower costs to avoid making the more costly reductions themselves, resulting in the same or better benefit to the environment as non-trading alternatives. The EPA has identified effluent trading as a means of allowing communities to "grow and prosper" while still achieving water quality goals (EPA, 1996).

This report includes the following:

- specific P control cost estimates (in dollars per pound) for selected municipal treatment plants;
- discharger information for industrial point sources;
- background information on urban nonpoint sources of P to surface waters;
- specific P control cost estimates (in dollars per pound) for selected agricultural operations based on prescribed best management practices; and
- assessment of trading potential in the Fox-Wolf Basin.

Appendix A includes some additional detail on control cost estimates for sources. Other appendices in this report also examine some specific issues regarding watershed-based trading as they apply to the Fox-Wolf Basin. These include: non-monetary trades (Appendix B), transaction costs (Appendix D), and use of an environmental margin of safety (Appendix E). In addition, Appendix C includes copies of the letters and forms sent to sources requesting cost and control information.

# Background

The Fox-Wolf Basin is comprised of the Wolf, Upper Fox and Lower Fox River Basins. Located in central Wisconsin, these basins drain ultimately to Green Bay and Lake Michigan. Figure 1 (on the following page) shows the geographic location of these basins.

As of February 23, 1999, the State of Wisconsin had declared 44 water bodies or river/stream segments in the Fox-Wolf Basin to be impaired waters. These water bodies were included in the state's 303d listings as required under the 1972 Clean Water Act (CWA). This list includes 15 water bodies in the Lower Fox, 14 in the Upper Fox and 14 in the Wolf River basins. Table 1 (on the following page) lists the 303d water bodies by basin.

![](_page_12_Figure_0.jpeg)

# Fox-Wolf Basin Geographic Location *Figure 1*

Lower Fox	Upper Fox	Wolf River
Dutchman Creek	Peppermill Creek	Deep Hole Lake
East River (Mi. 0-13.4)	Un. trib to Mason Lake (T14NR7E S25)	Little Sand Lake
East River (Mi. 13.5-39)	Fond du Lac River	Pine Lake
Fox R Seg. 3 Lower	Silver Creek	Roberts Lake
Fox R. Lower Seg. 2	Wurch Creek	Mayflower Lake
Trout Creek	Buffalo Lake	Cloveleaf Chain of Lakes
Apple Creek (Mi. 0-4)	Fox River at Buffalo Lake	Shawano Lake
Apple Creek (Mi. 5-24)	Fox River (from Portage north to, but not	Wolf River below Shawano
	including Buffalo Lake)	Dam to state Hwy 156
Duck Creek (Mi. 0-10)	Silver Lake (Big)	Columbia Lake
Duck Creek (Mi. 11-32)	Butte des Morts Lake	Big Hills Lake
Fox R. Lower Seg 1	Fox River, Oshkosh	Kusel Lake
Kankapot Creek	Poygan Lake	Rat River (Mi. 0-13)
Mud Creek	Winnebago Lake	Rat River (Mi. 13-18)
Plum Creek		Winneconne Lake (Wolf)
Neenah Slough		

#### Wisconsin 303d Listed Waters Table 1

Note: This list was current as of February 23, 1999. The information was taken from the DNR website at http://www.dnr.state.wi.us/org/water/wm/wqs/303d/tmdl.htm.

Many of these segments are listed as being water quality limited due to excess nutrients (i.e., P and nitrogen compounds) or for low dissolved oxygen (DO). The Wisconsin Department of Natural Resources (DNR) must develop "total maximum daily load" (TMDL) numbers for these bodies including a target water quality standard, and outline implementation plans to achieve that standard. Anticipated tightening of effluent limits for point sources and possible new requirements for nonpoints under TMDLs are expected to stimulate increased interest in low cost compliance alternatives.

The DNR Phosphorus Technical Workgroup examined issues surrounding development of a P standard for surface waters in Wisconsin, and concluded that in-stream P standards should be evaluated on a site-specific basis (DNR, 1997b). The group recommended developing "flag" values that would trigger an evaluation process leading to development of specific standards for each area. Implementation of in-stream standards for P will also likely increase interest in regulatory alternatives.

# **Phosphorus Sources**

Sources covered in this project are divided into **point**, those with discrete points of discharge into the water bodies, and **nonpoint** or "diffuse" sources. Point sources in the basin include municipal wastewater treatment plants (MTPs) and industrial treatment plants. Nonpoint sources (NPS) include urban stormwater systems and rural agricultural operations. Due to limitations of time and resources, sources of P to groundwater as well as non-agricultural NPS are not covered in this document.

Table 2 below lists the number of sources that contributed cost information for each category.

14010 2				
Source Type	Number in Lower Fox	Number in Upper Fox	Number in Wolf	Total Number With Cost Info.
Industrial Point	1	0	0	1
Municipal Point	7	3	3	13
Agricultural NPS	17	21	9	47

# Sources Contributing Cost Information by Category

## Source Selection and Estimates Received

The point sources were selected based on their P discharges to surface waters in the basin.<sup>3</sup> A list of Wisconsin Pollutant Discharge Elimination System (WPDES) permitted dischargers of P to surface waters was obtained from the WDNR and selected sources from the list were asked to contribute cost and control information. Whenever possible, the largest point sources of P were selected since they were the most likely to be targeted for further discharge reductions.

**Municipal Treatment Plants**. MTP managers responded very well to requests for information, providing cost estimates whenever possible. Of the 17 managers contacted, 13 gave cost and control efficiency estimates, and four were unable to provide cost information because of lack of resources. Cost estimates obtained ranged from detailed engineering plans to "back-of-the-envelope" calculations.

**Industrial Sources**. Conversely, industrial sources were largely unwilling or unable to provide cost information. Of the 12 sources contacted, one provided cost information, three were unable to provide numbers, two were unwilling, three had (or were upgrading to) systems with very low or zero P discharges, and three were unresponsive. Therefore, out of necessity, industrial sources are excluded from cost analyses in this report. However, information from WPDES permits is included in sections characterizing the basins.

The reluctance of most industrial sources to divulge control cost information was presumably related to concerns over the possibility that making such information publicly available might reveal production trade secrets and compromise their competitive position. This stance is certainly understandable for the types of competitive industries located in the basin. However, since markets need a free flow of information on costs and item availability in order to function properly, it does not bode well for the possibility of full industrial participation in watershedbased trading.<sup>4</sup>

**Agricultural Nonpoint Sources**. Due to the distribution and number of agricultural operations in this region, and the costs of characterizing individual operations, loadings and cost information tend to be unavailable for individual sources. Fortunately, the State of Wisconsin's

<sup>&</sup>lt;sup>3</sup> Loading estimates for point sources are based on 1998 estimated loadings from WPDES data. Agricultural operations were submitted as a list of eligible candidates for P reduction BMPs by county land conservation departments working in state nonpoint source priority watershed projects.

<sup>&</sup>lt;sup>4</sup> This reluctance would limit most industrial participation to occasional bilateral trades based on their assessment of others' costs and would not allow other sources to assess them as potential trading partners.

Nonpoint Source Priority Watershed Program sponsors projects in the high priority watersheds<sup>5</sup> that include gathering of information on specific operations, and development of recommendations for P control measures and best management practices (BMPs). Information on agricultural NPSs was contributed by watershed technicians from county land conservation districts (LCDs) working on priority watershed projects. Specific operations that were not yet committed to cost-sharing agreements with a state Nonpoint Source Priority Watershed Project, were chosen by the county contacts based on their assessment of whether the operations were good candidates for P reduction.

**Urban Nonpoint Sources**. State government specialists in urban NPS pollution from Wisconsin and Minnesota were consulted on strategies for characterizing the cost-effectiveness of BMPs for these sources. The following factors worked against characterization of costs and effectiveness of urban NPS reduction measures in this study:

- The state of Wisconsin is currently working on stormwater standards for urban areas (Bannerman, 1999a). These standards are expected to go into administrative rules by the end of the summer 1999. In order to be creditable under the EPA's guidelines for watershedbased trading, reductions from urban NPS measures would have to be over and above reductions achieved to meet these standards. The content of these standards will determine what constitutes a creditable practice. In addition, estimation of the removal efficiencies of creditable practices will need to be done with post-standard stormwater loadings.
- 2. Urban NPS control measures can significantly affect the volume of water flows, they must be selected or designed, whenever practical, as part of an overall watershed-wide stormwater management plan that addresses the impacts of both water quality and water quantity (SWRPC, 1991). This characteristic does not preclude possible funding of measures by outside sources (i.e., effluent trading), but suggests the most likely scenario for implementation of urban NPS measures is as part of an overall stormwater management plan.
- 3. Cost-effectiveness estimations for urban nonpoint source BMPs are problematic because costs associated with these measures in Midwestern states have not been well documented, and there is wide variation in other site-specific factors that directly affect control efficiency (SWRPC, 1991).
- 4. Finally, the few projects that have estimated costs of urban BMP P control measures have suggested these costs are quite high. For example, the Minneapolis Chain of Lakes Implementation Plan listed estimated dollar per pound P removal costs ranging from \$177 for constructed wetlands to \$1,314 for street cleaning (Minneapolis Park Board and Minneapolis Department of Public Works, October 1993).

For these reasons, and the sheer volume and diversity of urban nonpoint source control options, cost estimates for urban nonpoint sources were not developed for this report. Following the codification of the stormwater standards for urban areas, revisiting urban NPS BMPs looking for cost-effective additional measures for urban areas may be warranted.

<sup>&</sup>lt;sup>5</sup> A watershed gets a high priority ranking when it meets the following criteria: nonpoint sources of water pollution exist; polluted runoff degrades water quality or is a threat to water quality; and the problem can be controlled and/or corrected through WDNR, Natural Resource Conservation Service (NRCS) and Department of Agriculture Trade and Consumer Protection (DATCP).

### Point Source General Cost Calculation Procedures

Cost estimates for point sources were obtained through telephone conversations with plant managers or other qualified personnel for each facility. Managers were asked to provide their P control costs for the lower of either their current level of control, or controlling to 1.0 mg/l (i.e., the effluent limit required under NR 217, WDNR, August 1997). This dollar amount was then used to calculate their current *average cost* of control using the following formula:

$$AC = TC_{1.0}/P_{1.0}$$

where:

AC is average control cost,

 $TC_{1.0}$  is total annual cost of controlling to 1.0 mg/l discharge concentration or their current level (if lower), and

P<sub>1.0</sub> is the amount of P controlled annually at that level in pounds.<sup>6</sup>

Point sources were also asked to estimate their costs of achieving a 0.3 mg/l effluent P level. This was a level discussed in the Lower Green Bay Remedial Action Plan (WDNR, 1988). These two cost figures were used to calculate the source's *incremental cost* of control using the following formula:

$$IC = (TC_{0.3}-TC_{1.0})/(P_{0.3}-P_{1.0})$$

where:

IC is incremental cost of moving from 1.0 mg/l level of control to 0.3 mg/l level of control,

 $TC_{0.3}$  is the annual total cost of controlling at 0.3 mg/l, and

 $P_{0.3}$  is the total amount of P controlled annually when controlling to 0.3 mg/l.

The incremental cost in this situation is actually the average cost of the incremental reductions (as described in USEPA, 1996) or the change in overall costs divided by the change in overall control in going from 1.0 mg/l to 0.3 mg/l.

Some sources were unable to produce complete estimates for controlling at 1.0 mg/l due to missing information on equipment costs or other technical difficulties. However, for some of these sources, information was available on controlling to 0.3 mg/l when purchase of new equipment was needed. For these sources, whatever cost information was available was gathered and possible biases are noted (see details on cost information from individual facilities in Appendix A).

Costs of control typically included:

• chemicals,

<sup>&</sup>lt;sup>6</sup> For the large majority of sources the current level of control was 1.0 mg/l or lower. However, a few industrial sources had alternative effluent limits allowing them to exceed 1.0 mg/l, and a few of the smaller MTPs also had discharges exceeding 1.0 mg/l. For these MTP sources control cost estimates for achieving 1.0 mg/l were incremental costs rather than average costs. The industrial source information includes incremental amount of P controlled to 1.0 mg/l as well as to 0.3 mg/l effluent concentrations.

- related equipment or facilities (e.g., chemical storage tanks and feed pumps),
- sludge handling and disposal attributable to P controls, and
- operation and maintenance.

Annualized equipment costs were calculated using a discount rate of 4.5 percent<sup>7</sup> and an expected useful life of 20 years. Equipment costs are reported in 1998 dollars.<sup>8</sup> When purchase of new equipment or structures was necessary to achieve 0.3 mg/l discharge level, annualized costs were also calculated assuming a 4.5 percent loan rate and a 20-year useful life.<sup>9</sup>

While some sources provided detailed cost estimates for reaching the 0.3 mg/l level of control, most gave educated guesses. An engineering firm in Wisconsin that serves some of the surveyed MTPs provided some rough cost estimates for three facilities that would need substantial additions to reach 0.3 mg/l (Vik, 1999).

## Municipal Treatment Plants Cost Estimates

MTPs contacted for cost information included the ten facilities with the largest design capacities (i.e., greater than 2.0 million gallons per day [MGD]), five with capacities between 0.5 and 2.0 MGD, and two with capacities below 0.5. These sources represent 89 percent of the estimated load of 156,500 pounds of P discharged into surface waters in the basins from MTPs each year.<sup>10</sup> Of these 17 facilities contacted, 13 provided control and cost information (four were unable to produce estimates). Table 3 on the following page lists the MTPs contacted ranked by estimated annual P load for 1998.

<sup>&</sup>lt;sup>7</sup> A sample of managers from four MTPs were asked what their borrowing rate on capital was and responses ranged from 3.5 to 5.0 percent. The rate of 4.5 percent was chosen for consistency and used for all facilities.

<sup>&</sup>lt;sup>8</sup> Conversions were made using the Bureau of Labor Statistics data on Consumer Price Index for all urban consumers. Series I.D.: CUUR0000AA0.

<sup>&</sup>lt;sup>9</sup> While some MTPs are eligible for lower interest rate loans through state programs, this analysis uses a standard discount rate of 4.5 percent. The price of all equipment, regardless of age, is converted into 1998 dollars and costed out over 20 years.

<sup>&</sup>lt;sup>10</sup> These loadings are based on WDNR estimated loadings for 1998.

Facility Name	1997 Design	1998 Estimated Annual P	1998 Mean Effluent
	Capacity (MGD)	Loading (lbs./yr Rounded	Concentration (mg/l)
		to Nearest Hundred)	
Oshkosh	20.0	24500	0.71
Appleton	16.5	22400	0.49
Green Bay MSD	52.5	16100	0.17
Neenah - Menasha	12.8	15800	0.53
Grand Chute - Menasha West	3.6	13300	0.8
Fond du Lac	11.5	13200	0.73
Heart of the Valley MSD (Kaukauna)	5.5	11100	0.64
De Pere	14.2	6100	0.27
Shawano Lake SD (Wolf)	3.0	3200	0.6
New London	2.5	2900	0.8
Ripon	2.0	2900	0.68
Waupaca	1.25	2100	0.66
Clintonville	1.04	1600	0.94
Wild Rose	0.12	1500	5.92
Town of Holland SD #1	0.2	1200	1.53
Weyauwega	0.51	700	0.67
Seymour	0.58	600	0.29
Total		139200	

# Municipal Treatment Plants Surveyed

Source: WDNR estimated annual phosphorus discharge (1998) to surface waters in the Fox-Wolf Basin derived from WPDES records.

According to WDNR WPDES records, overall P loadings from MTPs in the Fox-Wolf Basin dropped by five percent from 1997 to 1998 (from 165,500 pounds to 156,500 pounds).

### **Chemical Costs**

Chemicals used by surveyed facilities to control P levels in discharge include: ferric chloride, ferrous chloride, ferrous sulfate, ferric sulfate, and alum. Some MTPs have established relationships with metal manufacturing industries to obtain a waste product from metal finishing operations (e.g., ferrous sulfate, referred to as "pickle liquor" for use as a P removal chemical. This arrangement results in very low chemical costs for MTPs (usually just cost of transportation and storage).

Contacts for the De Pere and Green Bay facilities which use biological treatment of biological oxygen demanding substances (BOD) indicated that they had no reportable costs for P control at the 1.0 mg/l level, and the De Pere facility manager predicted they would have no reportable costs for P control even at the 0.3 mg/l level. In these systems, P is a nutrient needed by the bacteria in digesting the BOD. Following BOD treatment, very little P remains in the waste stream. In fact, depending on the composition of the influent, facilities using biological BOD treatment may occasionally need to add P to feed the BOD removal process.

### **Sludge Costs**

Facilities also need to pay for proper sludge handling and disposal. Use of P control chemicals results in generation of additional sludge (over the volume generated from other processes) due to the chemicals binding with dissolved P and other competing reactions (i.e., the chemicals bind

with other substances as well). Therefore, the volume of sludge generated will vary depending on the composition of the influent and the level of control attempted. Facility managers estimated that sludge generated due to P control was anywhere from 3 to 50 percent of their overall sludge production.

#### **Equipment and Facilities**

Most facilities opting to use the chemical addition method of P removal need to purchase chemical storage tanks and feed pumps for chemical delivery into their treatment stream.

Table 4 lists the cost information gathered for MTPs, including average cost of control in dollars per pound for the lower of either the current level or 1.0 mg/l, the incremental cost of controlling to 0.3 mg/l, and the pounds of P controlled at both levels.

# Sample of Municipal Treatment Plants Control Costs and P Controlled by Basin

Table 4

		Average Cost	Total lb. of	Incremental	Additional	<b>Total Annual Cost</b>
Basin	Facility Name	Per lb. at	P Controlled	Cost per lb.	(Incremental)	for RAP (0.3mg/l)
		Lower of 1.0	in 1998	at 0.3 mg/l	lb. of P	Effluent Level
		mg/l or Current		_	Controlled	Recommendations
		Level				
LF	Appleton	\$0.16	232,750	\$0.51	9,802	\$5,000
LF	De Pere	None	115,494	None	0	
LF	Grand Chute - Menasha West	\$2.98	70,482	\$50.94	8,300	\$422,819
LF	Green Bay MSD	None	311,299	\$562.96	5,600	\$3,152,575
LF	Heart of the Valley MSD (Kaukauna)	\$0.45	120,000	\$45.66	5,893	\$269,067
LF	Neenah - Menasha	\$0.82	109,500	\$13.08	6,880	\$90,020
LF	Town of Holland SD #1	\$2.62	38,075	\$201.98	533	\$107,657
UF	Fond du Lac	\$0.92	113,838	\$13.45	7,806	\$105,000
UF	Oshkosh	\$0.25	171,185	\$1.20	8,030	\$9,600
UF	Ripon	\$4.78	17,484	\$5.86	1,706	\$10,000
WR	Clintonville	\$7.03	8,000	\$10.69	1,253	\$13,400
WR	New London	\$2.45	30,021	\$19.83	958	\$19,000
WR	Seymour	Unavailable	11,252	Unavailable	0	Unavailable
WR	Shawano Lake SD (Wolf)	Unavailable	17,324	Unavailable	1,599	Unavailable
WR	Waupaca	Unavailable	30,157	Unavailable	1,162	Unavailable
WR	Weyauwega	\$8.25	3,934	\$6.38	488	\$3,115
WR	Wild Rose	Unavailable	1,229	Unavailable	175	Unavailable
	Total		1,402,024		60,185	\$4,207,252
	Weighted Average	\$0.66		\$73.49		

Notes: The sources listed above are those that were contacted for this project and responded. Some sources were unable to provide cost estimates. The weighted average cost for reduction to 1.0 mg/l is extremely low due in part to two large sources with no identifiable P control costs at that level of control. Another factor in this low per-pound cost is the reduction is measured as the difference between influent P and effluent P reflecting all P removal rather than only that associated with P-specific controls (i.e., some other processes also result in P removal although that is not their primary function). Costs, on the other hand are those related to P controls only. Sources with zero in the "Additional (Incremental) P Controlled" column are already operating below 0.3 mg/l. Some sources such as Green Bay MSD are already below 0.3 mg/l but indicated they would need to control to lower levels to include a margin of safety to insure consistent compliance. For additional notes on these estimates see Table A1 in Appendix A.

Costs of controlling P to 0.3 mg/l ranged from about \$0.51/lb. to \$562.96/lb of P controlled. Figure 2 on the following page shows the costs per pound (rounded to the nearest dollar) and volumes of incremental P reductions that would be required to move from 1.0 mg/l to 0.3 mg/l mean effluent concentrations for surveyed MTPs in the basin.

This range of costs is somewhat lower than the costs estimated in an earlier study conducted by Northeast Wisconsin Waters for Tomorrow (NEWWT) (White et al., 1993-4). That study predicted an incremental cost of P control (in that case moving from 3.0 mg/l to 1.0 mg/l level of control) to be an average of about \$146/lb (1990 dollars – or about \$182 in 1998 dollars), whereas this survey found the average cost (of moving from 1.0 to 0.3 mg/l level of control) to be about \$73/lb.<sup>11</sup> Some of these differences in costs are likely related to the NEWWT study inclusion of many small facilities not included in the sample examined for this study. Also, the NEWWT study assumed across-the-board upgrades for facilities from one treatment level to the next higher level, whereas this study gathered specific cost estimates from contacted facilities. The latter strategy, while it does not cover the volume of facilities covered by NEWWT estimates, allows for some variability in control strategies and gathers more facility-specific cost and control information. The cost range found in this study is, however, consistent with the range estimated by a study in Minnesota (Senjem, 1997). The Minnesota study estimated a range of P control costs from about \$3 to about \$151 per pound.<sup>12</sup>

### Note on MTP Control Cost Variability

Perhaps the most important determinant of the dollar per pound cost of P reduction for MTPs is the concentration of P in their influent (Senjem, 1997). For lower influent concentrations of P, the total annualized costs of P control are divided by fewer pounds of P removed, thus increasing the unit (\$/lb.) cost of P control. Similarly, smaller sources that are unable to meet new effluent standards with their current configuration of controls may face very large costs to add treatment resulting in only small reductions in P loadings.

## Industrial Sources Discharge Information

Although industrial source control cost and effectiveness data were not available, some publicly available WPDES data is summarized in this section.

Industrial source loadings for the Fox-Wolf Basin are listed in Table 5 (on the following page) including volume of P reductions that would be required to reach 1.0 mg/l and 0.3 mg/l.

<sup>&</sup>lt;sup>11</sup> This is a weighted average calculated using the estimated overall costs for the surveyed sources divided by the estimated incremental pounds of P controlled if 0.3 mg/l level of control is achieved (\$4,207,226/57,249 lbs.).

<sup>&</sup>lt;sup>12</sup> These estimates were for small to mid-sized facilities using ferric chloride chemical addition.

		1998 Mean	1998 Est. Ann.	Loading When	Incremental
Basin	Industry Name	Effluent	Loading	All Meeting 1.0	Reduction to 0.3
		Concentration	(lbs./yr.)	mg/l (in lbs./yr.)	mg/l (in lbs./yr.)
LF	American National Can Company Neenah	0.265	435	435	0
LF	Appleton Papers Inc Locks Mill	0.89	26,378	26,378	17,486
LF	Fort James Operating Co Green Bay	1.09	27,790	25,495	17,847
	(Broadway)				
LF	Inter Lake Papers	1.27	44,874	35,334	24,734
LF	Kerwin Paper Co Div Riverside Paper	0.73	632	632	372
LF	Kimberly Clark Neenah	0.32	2,924	2,924	183
LF	Nicolet Paper	0.29	1,855	1,855	0
LF	P H Glatfelter Co Bergstrom Paper Div	1.36	18,145	13,342	9,339
LF	Thilmany Div International Paper	0.63	33,583	33,583	17,591
LF	White Clover Dairy Co Kaukauna	0.43	131	131	40
LF	WI Tissue Mills 1	0.55	4,356	4,356	1,980
LF	WI Tissue Mills 2	0.46	4,484	4,484	1,560
UF	Friday Canning	0.39	33	33	8
UF	National By Products Berlin	0.057	6	6	0
UF	Tuscarora, Inc.	0.695	445	445	253
WR	Dean Foods Veg Co Hortonville 1	6.7	2,868	2,868	300
WR	Dean Foods Veg Co Hortonville 2	0.6	114	114	57
WR	Hillshire Farm & Kahns	0.69	1,808	1,808	1,022
WR	Little Rapids Corp Shawano Mill	0.28	1,731	1,731	0
WR	Wisconsin Veneer And Plywood	0.44	318	318	101
	Total		172,909	156,271	92,871

# Industrial Sources Contacted and Loadings by Basin

Source: Wisconsin Department of Natural Resources WPDES permit records for 1998.

Notes: Mean effluent concentrations are reported as listed in WPDES records. Incremental reduction amounts are calculated from 1998 loadings for sources without alternative effluent limits for 1998, and from estimated loadings at 1.0 mg/l for sources with alternate effluent limits.

Industrial sources will reduce annual P loadings by about 17,000 pounds (from 1998 levels) when all are in compliance with the 1.0 mg/l effluent limit. Compliance with a limit of 0.3 mg/l would require an additional annual reduction of nearly 93,000 pounds.

### Note on Alternative Limit Permit Holders

Some industrial facilities were granted alternative phosphorus effluent limitations in their WPDES permits, and therefore, have temporary limits above the 1.0 mg/l effluent limit (including Fort James [formerly Fort Howard] Broadway Plant, Interlake Papers, P.H. Glatfelter, and Dean Foods – Hortonville). For these operations, it may not be technically feasible or economically practicable to reach the 1.0 mg/l level much less 0.3 mg/l. In some instances, addition of a higher volume of chemicals needed to achieve these lower levels may interfere with other abatement processes they are using or may alter the characteristics of their sludge limiting disposal options such as land application or recycling.

# **Non-Point Sources**

Data on loadings from non-point sources tend to be less precise than those for point sources. Because loadings from these sources, by definition, do not have any single point of entrance into surface waters, and because these sources are numerous and geographically dispersed, loadings are usually calculated through some means other than direct monitoring. NPS loads are often estimated using models,<sup>13</sup> or through use of information on land characteristics and application of formulas based on known relationships.<sup>14</sup>

### Urban Non-Point Source Overview

Although cost-effectiveness information for urban NPS BMPs was not gathered in this report, this section contains some background information on these sources and associated BMPs.

Urban stormwater is a nonpoint source of P loading to surface waters. Urban stormwater loadings occur when rain encounters impervious surfaces such as roofs or pavement, or semi-impervious surfaces such as lawns or landscaped areas, and is either channeled through the municipal stormwater system or moves overland reaching surface waters. Urban nonpoint sources are typically divided into two categories, established, which refers to existing urban areas, and developing or areas in which new construction is occurring.

Established urban areas can reduce their nutrient loadings by, treating stormwater that flows into their system (wet detention practices), reducing the volume of stormwater that makes it to their system (infiltration practices), or limiting the amount of nutrients available for stormwater runoff (source reduction practices). Practices range from construction of stormwater detention ponds and underground grit chambers, to educational programs or ordinances regarding yard and animal waste and fertilizer application. One more innovative practice involves fitting houses with special gutters that channel rainwater into a specially constructed "rain garden," where the water is contained until it seeps into the ground, eventually recharging the groundwater (Bannerman, 1999b).

Urban NPS BMPs for developing areas include incorporation of design strategies that promote greater groundwater recharge and minimize surface water runoff. Most developing areas can incorporate conservation design strategies to minimize the development's impact on the stormwater production without significant cost increases. (For more information on conservation design strategies for urban stormwater management see DDNREC, 1997 or Caraco et. al., 1998.)

Also, depending on the rate of development in a watershed, construction sites can be extremely large contributors to sediment and nutrient loadings. For example, the East River Priority Watershed Project identified construction site erosion as contributing 25 percent of the sediment loadings to that watershed (WDNR et al., 1993). Construction site erosion is regulated through several different programs based on the location and size of the site.

## Agricultural Nonpoint Source Overview

Agricultural nonpoint sources have been identified as major contributors of P to surface waters in the Fox-Wolf Basin. One study estimated that about 74 percent of the total phosphorus (TP)

<sup>&</sup>lt;sup>13</sup> Watershed models are used to estimate pollutant loadings to water bodies and water quality models are used to simulate pollutant behavior in water bodies.

<sup>&</sup>lt;sup>14</sup> Examples include the relationships between total suspended solids (TSS) loadings and P loadings, slope and soil loss, particle size and suspension velocities.

loads to Lower Green Bay in 1990 were from agricultural NPSs (White, 1993-94). Since then, revised modeling efforts based on more representative rainfall amounts have suggested a much smaller, but still significant load from nonpoint sources.<sup>15</sup>

There are two main categories of conservation measures or BMPs used for reducing agricultural P loadings to surface waters, upland sediment measures and barnyard practices. Upland sediment measures include conservation tillage (a.k.a. residue management), crop rotation measures, and vegetated buffer or filter strips. Barnyard measures include clean water diversions (including roof gutters, filter walls, concrete walls, picket dams, earthen diversions and sediment detention basins), concrete barnyards, and manure storage pits. Some practices transcend these two categories such as nutrient management, which involves proper storage and handling of animal wastes and application to crop lands at agronomic rates (i.e., rates at which the vegetation and soil can absorb the nutrients, minimizing nutrient runoff).

Some BMPs such as conservation tillage and nutrient management tend to involve fairly small investments to implement and usually create cost savings for farmers. One study estimated that switching to higher residue tillage systems (e.g., either going from zero residue to 30 percent residue, or switching from a 30 percent to higher percentage residue) generally provides cost savings for the farmer (Olson and Senjem, 1988).

# Agricultural Nonpoint Source Cost Information

Numerous site-specific factors influence the cost and/or effectiveness of agricultural BMPs. In recognition of the extreme variability in unit cost of reductions among agricultural nonpoint sources, and the need for specific, accurate numbers for operations in the basin, RSI and FWB2000 elected to obtain control and cost estimates from a sample of individual operations rather than attempt to characterize overall costs for the region. Gathering information on individual operations also produced a roster of candidates for pilot trades.

RSI contacted county land conservation departments involved with state nonpoint source priority watershed projects for cost information on agricultural BMPs. These county contacts were each asked to supply a list of 5 to 10 agricultural operations they chose as good candidates for P control measures, but which had not yet signed up for state cost-share funds. The information they provided for each operation included estimated P loadings, prescribed P control measures, costs of those measures, and estimated amount of P that would be controlled if the measures were implemented. Table 6 (on the following page) lists the counties and priority watershed projects that submitted agricultural operation and cost data.

<sup>&</sup>lt;sup>15</sup> The 1990 rainfall data that was used in the model for the Lower Fox Basin included a "100- year event" (i.e., a rainfall event of such volume that it is expected to occur only about once every hundred years), which elevated the NPS load estimates. Paul Baumgart of Fox-Wolf Basin 2000 conducted a subsequent modeling run on the Lower Fox Basin only, using average annual total suspended solids (TSS) loads from 1977 through 1996. Using these new simulated TSS loads, estimated loads for P were calculated using the observed ratio of P/TSS of 3.7 lbs. P/English Ton TSS. With this new modeling run, the estimated percentage of the P load in the Lower Fox Basin coming from all NPSs (including urban and urbanizing loads) was lowered to about 42 percent (i.e., had 1990 been a more typical rainfall year about 42 percent of TP would have come from nonpoint sources) (Baumgart, 1998). The loadings from the other two basins which were affected to a lesser extent by the heavy rainfall event, have yet to be modeled with updated data. Therefore, a direct comparison of estimated loads for the entire Fox-Wolf Basin with 1990 rainfall data to estimated loads using the 20 year average rainfall data is not possible at time of this report writing.

NPS Priority Watershed Project (Code)	<b>County LCDs</b>
Apple and Ashwaubenon Creeks (LF02)	Brown
	Outagamie
Duck Creek (LF05)	Brown
	Outagamie
Fond du Lac River (UF03)	Fond du Lac
Lake Winnebago East (UF02)	Calumet
	Fond du Lac
Neenah Creek (UF14)	Adams
	Columbia
Pine-Willow Rivers (WR02)	Winnebago
Tomorrow Waupaca (WR05)	Portage

# Agricultural Data Sources by Project and County Table 6

Note: The parenthetical four-digit code following the watershed name is the WDNR reference code for each watershed.

This method of data collection took advantage of the expertise of county Land Conservation Departments and their familiarity with the owners and agricultural operations. Looking at agricultural operations that had not yet implemented BMPs also provided a more accurate picture of the current state of the "market" than would information on operations with BMP measures already implemented.<sup>16</sup>

The sample of operations examined in this study is not random, and is not purported to be representative of all candidate sites in the Fox-Wolf Basin. However, given the volume of agricultural activity in these basins, and the number of operations that signed-up as reported by priority watershed projects,<sup>17</sup> it seems likely that there are more operations like these in the sampled basins.

### Administrative Costs for Nonpoint Cost and Control Estimates

A survey of county Land Conservation District watershed technicians was conducted to develop general costs of assessing operations and providing control and cost estimates for prescribed agricultural best management practices for P control. Four technicians surveyed estimated costs ranging from about \$60 per operation to over \$800 per operation.

Despite the efforts to gather site-specific accurate "market" price data, the cost estimates obtained are still quite rough. The fact that accurate dollar per pound estimates of P reductions

<sup>&</sup>lt;sup>16</sup> The main reason for this is current candidate operations may not have the same characteristics as former candidates, especially if the counties had been successful in targeting and signing up the most critical sites for program participation. Obtaining cost information from these critical sites, which tend to have lower costs of P control because of the volume of their loadings, would give cost information that is not representative of the remaining candidate sites.

<sup>&</sup>lt;sup>17</sup> The Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) and DNR produce a report each year summarizing projects they have funded for reduction of loadings from nonpoint sources in Wisconsin (DATCP and DNR, 1998). Their progress report for 1997 indicated that several projects had recruited 50 percent or less of their target level.

from nonpoint sources are not readily available may have important implications in the viability of establishing a market for P trading.

## Agricultural Nonpoint Source Control Cost Estimates

In general, cost estimates in this report may be somewhat higher than actual implementation costs. One reason for this is estimates are based on the estimated full cost used to determine state cost-sharing amounts, which may not promote frugality in implementation.

While state cost-share amounts do not necessarily reflect actual costs associated with implementation of agricultural BMPs, they do represent proven funding levels at which farmers are willing to adopt these practices. Since there is some disagreement over actual costs, and some practices tend to result in net profits for farmers, state cost share levels are reasonable estimates of expenditures required to promote BMP adoption and overcome apprehensions in the agricultural community. More detailed information on the sampled agricultural operations is included in Table A2 in Appendix A so that alternative values can be used in cost estimates if desired.

Most equipment and structures are expensed over 20 years (estimated useful life). While some of the equipment, such as roof gutters for diversion of rainfall away from barnyards, can probably be expected to last only about 10 years without major repair, many estimates had costs of roof gutters and other, more permanent structures combined. Whenever separate cost information was available for roof gutters these were instead expensed over 10 years.

Estimates for nutrient/pest management and conservation tillage practices may be high because they do not include probable cost savings for farmers. Cost estimates for nutrient/pest management and conservation tillage are based on the following rates:

nutrient/pest management	\$8/acre
conservation tillage	\$12.00 or \$18.50/acre (as noted).

Some estimates did not include costs associated with annual operation and maintenance of measures installed. Whenever possible, annual operation and maintenance costs were produced and included in the cost estimates based on DATCP and NRCS recommended rates.

There are other agricultural BMPs that have potential to reduce loadings from upland sediment sources, such as adding alternative crops or meadow into the crop rotation.<sup>18</sup> Some estimates of P load reductions were received for these types of measures but cost information was often unavailable. Costs for alternative crop rotation measures can include planting and marketing the alternative crop, purchase of new equipment or modification of current equipment, and changes in farmer time demands. Based on control estimates received in this study, these types of practices may be among the most cost-effective and should be targets of further study.

Table 7 (on the following page) lists the cost and control information for the sample of agricultural operations.

<sup>&</sup>lt;sup>18</sup> Crops that are not planted in rows tend to have less soil exposure and lower erosion rates.

### Agricultural Operations Control Costs and Effectiveness Estimates By Watershed *Table 7*

<b>ID Reference</b>	Operation	Measure 1	Measure 2	Measure 3	Annual	Total P	\$/# P
	Туре				Costs	Reduction	Removed
LF-AAC-1	Dairy	Roof Gutters	Filter Wall	Filter Strip	\$1,983	76	\$26
LF-AAC-12	Livestock	Manure Storage	Nutrient/Pest Mgmt.	(\$8/acre)	\$2,394	92	\$26
LF-AAC-2	Dairy	Roof Gutters	Filter Wall	Filter Strip	\$1,845	59	\$31
LF-AAC-3	Dairy	Roof Gutters	Filter Wall	Filter Strip	\$1,307	44	\$30
LF-AAC-4	Dairy	Roof Gutters	Filter Strip		\$621	56	\$11
LF-AAC-8	Livestock	Manure Storage Pit	Nutrient/Pest Mgmt.	(\$8/acre)	\$4,018	189	\$21
LF-AAC-9	Crop	Conservation Tillage	(\$12/acre)		\$1,500	148	\$10
LF-DUK-10	Livestock	Manure Storage Pit			\$2,322	189	\$12
LF-DUK-11	Crop	Conservation Tillage	(\$12/acre)		\$636	183	\$3
LF-DUK-13	Livestock	Manure Storage	Nutrient Mgmt.	(\$8/acre)	\$9,279	216	\$43
LF-DUK-5	Dairy	Roof Gutters	Filter Strip		\$353	41	\$9
LF-DUK-6	Beef	Roof Gutters			\$190	49	\$4
LF-DUK-7	Livestock	Manure Storage Pit	Nutrient/Pest Mgmt	(\$8/acre)	\$5,138	339	\$15
LF-PC-45	Dairy	Manure Storage Structure	Nutrient/Pest Mgmt.	(\$8/acre)	\$3,629	75	\$48
LF-PC-46	Dairy	BY Runoff Control Sys			\$2,199	85	\$26
LF-PC-47	Young Stock	BY Runoff Control Sys	Filter Strip		\$2,222	75	\$30
LF-PC-48	Dairy	BY Runoff Control Sys	Filter Strip		\$2,222	60	\$37
UF-FR-21	Dairy	BY Runoff Control Sys	Roof Gutters	Diversion	\$2,651	119	\$20
UF-FR-22	Dairy	BY Runoff Control Sys	Roof Gutters	Earthen Diversion/ Waterway	\$2,651	101	\$23
UF-FR-23	Dairy	2BY Runoff Control Sys	Roof Gutters	Earthen Diversion	\$4,921	251	\$18
UF-FR-24	Dairy	Roof Gutters			\$506	53	\$10
UF-FR-25	Dairy	Roof Gutters			\$308	16	\$20
UF-LWE-26	Crop/Dairy	Roof Gutters	Filter Wall	Manure Storage Pit	\$2,499	87	\$23
UF-LWE-27	Crop/Dairy	Roof Gutters			\$379	25	\$15
UF-LWE-28	Crop/Dairy	Roof Gutters	Sediment Basin		\$923	89	\$10
UF-LWE-29	Dairy	Roof Gutters	Wall		\$484	68	\$6
UF-LWE-30	Crop/Dairy	Manure Pit			\$2,322	132	\$15
UF-NC-14	Dairy, Beef	Settling Basin	Roof Gutters	Diversion	\$2,891	110	\$24
UF-NC-15	Beef, Sheep	Settling Basin	Roof Gutters	Diversion	\$1,353	69	\$17
UF-NC-16	Dairy, Beef	Manure Storage	Sediment Basin		\$2,706	123	\$19
UF-NC-31	Crop	Conservation Tillage	(\$18.50/acre)		\$500	4	\$117
UF-NC-32	Crop	Conservation Tillage	(\$18.50/acre)		\$962	79	\$12
UF-NC-33	Crop	Conservation Tillage	(\$18.50/acre)		\$777	57	\$14
UF-NC-34	Crop	Conservation Tillage	(\$18.50/acre)		\$2,350	283	\$8
UF-NC-35	Crop	Conservation Tillage	(\$18.50/acre)		\$1,203	104	\$12
UF-NC-36	Crop	Conservation Tillage	(\$18.50/acre)		\$2,118	150	\$14
UF-NC-37	Dairy/Crop	Conservation Tillage	(\$18.50/acre)		\$18,565	300	\$62
UF-NC-38	Crop	Conservation Tillage	(\$18.50/acre)		\$2,838	400	\$7
W-PW-18	Dairy	Manure Storage Structure			\$26.031	700	\$37
W-PW-19	Dairy	BY Runoff Control Sys.	Diversion	Roof Gutters	\$4,114	85	\$48
W-PW-20	Dairy	BY Runoff Control Sys.	Roof Gutters	Underground Outlet	\$4,498	75	\$60
W-TW-39	Dairy	Concrete Barnvard	Filter Strip		\$3.538	70	\$51
W-TW-40	Dairy	Concrete Barnvard	Filter Strip		\$3.538	60	\$59
W-TW-41	Dairy	Concrete Barnvard	Filter Strip		\$4.922	100	\$49
W-TW-42	Dairy	Concrete Barnvard	Filter Strip		\$4.038	84	\$48
W-TW-43	Dairy	Concrete Barnvard	Filter Strip		\$4,922	70	\$70
W-TW-44	Dairy	Concrete Barnvard	Filter Strip		\$5,306	120	\$44
Totals					\$157,867	5960	

Notes: The only modification made to cost data contributed by County Land Conservation Departments was to include an estimate of the time required for the farmer to operate and maintain the practice. Practices priced on a per acre basis, such as conservation tillage and nutrient management, used state cost share values provided by county contacts (included in parentheses following the practice type). All structures are expensed over 20 years at

4.5 percent, unless separate cost information is available for roof gutters which are then expensed over 10 years (their expected useful life).

The overall weighted average cost per pound of P controlled for this sample of agricultural sources was roughly \$26. The sampled agricultural operations included 17 from the Lower Fox, 21 from the Upper Fox, and nine from the Wolf Basin.

Additional information on the distributions of cost-effectiveness estimates for these sources is included in Figure 2.

# Distribution of Control Cost Estimates for Agricultural Operations by Basin Figure 2

![](_page_27_Figure_4.jpeg)

This figure shows the middle 50 percent of the values for each basin. For example 50 percent of the sampled operations in the Lower Fox had P control cost estimates between \$11 and \$30 per pound. In addition, 25 percent had cost estimates below \$11 per pound and 25 percent had estimated costs above \$30 per pound.

The operations in the Wolf River Basin are much higher than those estimated for the Upper Fox and Lower Fox basins. This is due in part to the sandy soils in the basin requiring concrete structures (e.g., barnyards and storage pits) to prevent groundwater infiltration. The higher cost may also be related to sign-up rates in priority watershed projects (i.e., high sign-up rates may mean all the most cost-effective opportunities for controlling P have been implemented), or it could be a product of the sample received.

### Notes on Agricultural BMP Cost Estimates

Agricultural nonpoint sources sampled for this project may not be representative of all sources in each basin because samples were only taken from watersheds participating in the Wisconsin Nonpoint Source Priority Watershed Program, and only operations that had not already signed up

for state cost-sharing funds were included. Some possible implications of this sampling method are:

- the operations with the largest loadings<sup>19</sup> may have already been signed-up and so might be excluded from this sample, and
- there may be other agricultural sources with higher loadings and lower per unit control costs in watersheds not involved with the NPS program.

Sampling operations in other watersheds not currently involved with a priority watershed program may produce a group with very different per unit control costs. A more comprehensive cataloging of agricultural BMP control costs and effectiveness throughout the basin would provide a clearer picture of the potential for effluent trading and would help state cost-share programs move programs in the direction of concentrating on the most cost-effective practices.

# Possibilities for Trading in the Fox-Wolf Basin

Examination of possibilities for trading must take into account estimated control costs, but must also consider probable program restrictions on trading. The EPA's Guidelines for Watershed-Based Trading (USEPA, 1996), other trading programs and communication with regulators all suggest some likely restrictions on trading, including:

- trades must occur within the same basin,
- some trading ratio of greater than 1:1 for use of NPS generated credits by point sources will be required, and
- credited reductions in P must be contemporaneous with credit use (i.e., no banking of credits for use in later years) (USEPA, 1998).

Additional distance and/or directional limitations on credit use are also a possibility but are not considered in this section. Based on ratios used under similar programs, point sources are assumed to need to use credits from nonpoint sources at a 2:1 ratio,<sup>20</sup> and from other point sources at a ratio of 1:1. (For more information on trading ratios see Appendix E.)

Estimated control costs for sources examined in this report varied greatly. Obtaining accurate cost information from point sources has proven difficult largely because sources often cannot predict what their control costs will be without research and testing of control options. In addition, most industrial sources were unwilling or unable to provide cost information which could hamper market function. (For reference, a listing of industrial P dischargers, by basin, is included in Table 5 of this report.)

The exact effluent limit that is required of point sources will affect each source's control cost projections. For example, illustrated with our hypothetical effluent limit of 0.3, some sources may be able to modify existing processes and achieve the new limit, while others may need major structural changes. Sampling costs of achieving 0.3 mg/l gave an indication of how these control costs vary across sources. However, costs of achieving 0.3 mg/l may be very different from costs of achieving 0.1 mg/l (if a source wanted to generate credits to sell) or costs of

<sup>&</sup>lt;sup>19</sup> These sources often have lower per pound control costs due to economies of scale in P control (Senjem, 1997).

<sup>&</sup>lt;sup>20</sup> This ratio is based on ratios used under similar programs such as the Tar-Pamlico trading program in North Carolina (Jacobson et al., 1994) and Dillon Reservoir in Colorado (CDPH&E, 1997). It is also the ratio that is proposed in the Red Cedar Basin for a proposed trade with the City of Cumberland, Wisconsin (Prusak, 1999).

achieving 0.5 mg/l (if a source wanted to make a partial reduction and purchase credits for the remainder of its obligation). When new effluent standards, or new in-stream ambient standards are identified, point source cost estimates should be gathered for levels of control at, above, and below the new standard to assess the possibilities for trading among point sources.

In light of the lack of cost information on industrial point sources, assessments of trading possibilities are limited to examination of control cost information for possible trading program participants by basin, and identification of situations in which sources would be motivated to participate in effluent trading.

## Cost Comparisons and Trading Assessment

Comparison of the average costs estimated for each basin gives a rough idea of how the MTP control costs compare with the agricultural NPS costs. Table 8 lists the weighted average costs for sources studied in this project for each basin.

#### Table 8 Lower Fox Upper Fox Wolf Overall Source MTP Weighted Average of \$109 \$13 \$7 \$73 Sources' Incremental Cost/lb. NPS Weighted Average of \$21 \$21 \$45 \$26 Sources' Incremental Cost/lb.

# Average Incremental Control Costs by Basin

Note: The weighted average cost is calculated by dividing the overall cost of incremental reductions by the overall pounds of P reduced. Incremental costs are the costs per pound of controlling effluent P levels to 0.3 mg/l from their current level.

For this data set, on average, MTP incremental control costs varied greatly between basins. On the other hand, agricultural NPS average control costs were virtually identical for the sampled operations in the Lower Fox and Upper Fox basins, and the average for the Wolf Basin sample was more than double that of the other two. On average, MTP control costs in the Lower Fox are much higher than reductions from agricultural NPSs. However, the Upper Fox and Wolf Basins both had lower MTP costs, on average, than NPS costs. These averages suggest that point-nonpoint trading is likely to be beneficial in the Lower Fox, but is less likely to be beneficial in the Upper Fox and Wolf Basins.

More important than the cost averages, however, is the variability in control costs between sources. Dramatic differences in control costs among sources can provide an incentive for trading. The following sections look at control costs of all sampled sources by basin and assess possibilities for trades in each basin.

### Lower Fox Basin

The Lower Fox Basin has the most industrial sources and many of the largest MTPs in the three basins.<sup>21</sup> This basin has seven MTPs that contributed greater than 150 pounds of effluent P per

<sup>&</sup>lt;sup>21</sup> Although no control cost information is available for industrial sources, and cost information is unlikely to become publicly available should a market be established, they could still participate in a market and buy or sell credits if it looked like they would benefit.

month in 1998.<sup>22</sup> Six of these were contacted for cost information. Table 9 lists all the sampled sources for the Lower Fox Basin ranked by their dollar per pound control costs. Potential NPS reductions (that would be created through implementation of agricultural BMPs) are listed on the left side and MTP cost information (assuming compliance with a 0.3 mg/l effluent standard) is on the right side.

Agricultural NPS	\$/lb. P Removed	Potential Total P	Facility Name	Incremental Cost per lb.	Additional Annual (Incremental) lb. of P
Reference		Reduction	•	at 0.3 mg/l	Controlled
			Appleton	\$1	9,802
LF-DUK-11	\$3	183			
LF-DUK-6	\$4	49			
LF-DUK-5	\$9	41			
LF-AAC-9	\$10	148			
LF-AAC-4	\$11	56			
LF-DUK-10	\$12	189			
			Neenah - Menasha	\$13	6,880
LF-DUK-7	\$15	339			
LF-AAC-8	\$21	189			
LF-PC-46	\$26	85			
LF-AAC-1	\$26	76			
LF-AAC-12	\$26	92			
LF-PC-47	\$30	75			
LF-AAC-3	\$30	44			
LF-AAC-2	\$31	59			
LF-PC-48	\$37	60			
LF-DUK-13	\$43	216			
			Heart of the Valley MSD	\$46	5,893
LF-PC-45	\$48	75			
			Grand Chute - Menasha West	\$51	8,300
			Town of Holland SD #1	\$202	533
			Green Bay MSD	\$563	5,600

Lower Fox Source Cost Rankings and Reduction	Volumes
Table 9	

Note: Sources are ranked from lowest to highest control cost per pound. Equivalent trading rate figures may not exactly equal double the cost figures due to rounding. These MTPs accounted for nearly 98 percent of the P loading from MTPs in the Lower Fox Basin in 1998. Watershed codes for this table (the group of letters following LF in the identification codes) are: DUK, Duck Creek; AAC, Apple and Ashwaubenon Creeks; and PC, Plum Creek. The numbers following the watershed codes are for identification purposes only.

MTPs could benefit by funding reductions at sources listed above them in the table. Realistically, there is likely to be some transaction cost associated with each party involved in a trade (for more information on transaction costs see Appendix D). Therefore, sources needing to purchase large volumes of reduction credits might be better off negotiating with other point

<sup>&</sup>lt;sup>22</sup> Publicly-owned treatment works averaging over 150 lbs. of effluent P per month are subject to NR217 which imposed an effluent limit of 1.0 mg/l for P (WDNR, August 1997). Presumably this same group of sources would be subject to any revision in effluent limits under NR217.

sources rather than several nonpoint sources.<sup>23</sup> A more thorough cataloging of the eligible nonpoint sources in the entire Fox-Wolf Basin including many more candidate agricultural operations is necessary to assess whether point-nonpoint trading would be a viable option for sources subject to larger reduction requirements (the total volume of reductions that could be generated from our entire sample for the Lower Fox is 1976 pounds per year). At a minimum, point sources would need a sizable roster of eligible agricultural operations in their watershed, and at least rough estimates of control costs, to consider buying NPS-generated credits.

To better characterize the costs and volumes of P reductions available from agricultural NPS in the Lower Fox Basin, and the relative costs of point source reductions, a scatter plot chart is presented in Figure 3. This chart gives a picture of the reduction "packages" that are available from the sample of agricultural sources in the Lower Fox Basin. To illustrate these packages, the data points representing an operation that could generate reductions of 183 pounds at \$3/pound (least costly reduction package) and one that could generate 75 pounds at \$48/pound (most costly reduction package) are labeled. In addition, control cost estimates for MTPs are plotted on the graph as dashed vertical lines.

## Sample of Available Agricultural NPS Reductions and MTP Costs in the Lower Fox Basin Figure 3

![](_page_31_Figure_3.jpeg)

MTPs looking for alternative compliance options could consult such a plot and assess whether buying NPS credits or purchasing excess reductions at other MTPs are viable compliance options

<sup>&</sup>lt;sup>23</sup> As an example, if the Town of Holland (the MTP that would be subject to the smallest reduction requirement in our sample) wanted to offset its reduction responsibility (533 pounds) it could fund 1066 pounds in reductions from agricultural nonpoint sources. With the sample gathered in this study for the Lower Fox Basin, that would involve negotiating with anywhere from five to 13 operations to generate the needed reductions.

for them. For example, if HOV with incremental P control costs of \$46 per pound, needed to make a reduction of 300 pounds per year, or purchase about 600 pounds of offsetting P reductions (assuming a 2:1 trading ratio), could contact sources represented by the points left of the dotted line for possible trades. The HOV could even expand the list of sources to those with control costs at or above \$46 and still have cost savings as long as the average control cost per pound for the purchased credits is below \$46.

The Lower Fox Basin has at least 22 WPDES permitted point source dischargers (including industrial sources) that could become involved in P trading. The variation in control costs illustrated above suggests trading among point sources, as well as with agricultural nonpoints, might provide substantial cost savings.

## Upper Fox Basin

In the Upper Fox Basin there are four MTPs with average monthly P loadings of 150 pounds or higher. The three largest of these were contacted for cost information. Table 9 lists the sampled MTPs and NPSs and the estimated control costs for each.

Agricultural NPS Reference	\$/lb. P Removed	Potential Total P Reduction	Facility Name	Incremental Cost per lb. at 0.3 mg/l	Additional Annual (Incremental) lbs. of P Controlled
			Oshkosh	\$1	8,030
UF-LWE-29	\$6	68	Ripon	\$6	1,706
UF-NC-38	\$7	400			
UF-NC-34	\$8	283			
UF-FR-24	\$10	53			
UF-LWE-28	\$10	89			
UF-NC-35	\$12	104			
UF-NC-32	\$12	78			
			Fond du Lac	\$13	7,806
UF-NC-33	\$14	57			
UF-NC-36	\$14	150			
UF-LWE-30	\$15	132			
UF-LWE-27	\$15	25			
UF-NC-15	\$17	69			
UF-FR-23	\$18	250			
UF-NC-16	\$19	123			
UF-FR-21	\$20	119			
UF-FR-25	\$20	15			
UF-LWE-26	\$23	86			
UF-FR-22	\$23	101			
UF-NC-14	\$24	110			
UF-NC-37	\$62	300			
UF-NC-31	\$117	4			

# Upper Fox Source Cost Rankings and Reduction Volumes

Note: MTPs listed in this table include only those from whom cost information was sought. These MTPs accounted for nearly 89 percent of the P loading from MTPs in the Upper Fox Basin in 1998. Watershed codes for this table (the group of letters following UF in the identification codes) are: FR, Fond du Lac River;

LWE, Lake Winnebago East; and NC, Neenah Creek. The numbers following the watershed codes are for identification purposes only.

Figure 4 gives another illustration of the relative costs for MTPs and agricultural BMPs for the basin.

# Sample of Available Agricultural NPS Reductions and MTP Costs in the Upper Fox Basin

![](_page_33_Figure_3.jpeg)

The MTPs providing cost information had lower control costs than the many of the agricultural sources, and when a trading ratio is considered, point-NPS trade options dwindle even further. The difference in control costs among the MTPs was also fairly small, suggesting there will be little incentive for trading among point sources.<sup>24</sup> The combination of these factors suggest the Upper Fox Basin is an unlikely place for beneficial P trading to meet a new effluent standard of 0.3 mg/l. However, because of the relatively low costs for point and nonpoint reductions in the basin, trading to accommodate new growth may be a desirable policy option.

### Wolf River

The Wolf River Basin has four MTPs with average monthly P loadings of greater than 150 pounds. Three of these were contacted for cost information. However, it also has many small MTPs for whom compliance with a 0.3 mg/l P limit would probably be very expensive. For this reason, four other smaller MTPs were also contacted. Four out of the seven MTPs contacted could not produce cost estimates for controlling down to 0.3 mg/l.

<sup>&</sup>lt;sup>24</sup> While control cost information is not available for the industrial sources in this basin, WPDES records show that there is only one that would probably be subject to a revised effluent standard.

Table 10 and Figure 5 below show the control costs for these sources.

	<b>A (1) D</b>			<b>.</b>	
Agricultural	\$/lb. P	Potential		Incremental	Additional Annual
NPS	Removed	Total P	Facility Name	Cost per lb.	(Incremental) lbs.
Reference		Reduction		at 0.3 mg/l	of P Controlled
			Weyauwega	\$6.38	488
			Clintonville	\$10.69	1,253
			New London	\$19.83	958
W-PW-18	\$37	700	Seymour	Unavailable	0
W-TW-44	\$44	120	Shawano Lake SD (Wolf)	Unavailable	1,599
W-PW-19	\$48	85	Waupaca	Unavailable	1,162
W-TW-42	\$48	84	Wild Rose	Unavailable	175
W-TW-41	\$49	100			
W-TW-39	\$51	70			
W-TW-40	\$59	60			
W-PW-20	\$60	75			
W-TW-43	\$70	70			

Wolf River Source Cost Rankings and Reduction Volumes Table 10

Note: MTPs listed in this table include only those from whom cost information was sought. These MTPs accounted for about 59 percent of the P loading from MTPs in the Wolf River Basin in 1998, and the cost information actually obtained represents only about 23 percent of the basin P load from MTPs. Watershed codes for this table (the group of letters following the first W in the identification codes) are: PW, Pine Willow; and TW, Tomorrow Waupaca. The numbers following the watershed codes are for identification purposes only.

# Sample of Available Agricultural NPS Reductions and MTP Costs in the Wolf River Basin

![](_page_34_Figure_5.jpeg)

According to the cost data gathered for the Wolf Basin, trading between point and nonpoint sources looks unlikely. However, this may change if either or both of the following situations are true. First, if the cost profile for agricultural nonpoint sources actually looks more like those collected for the other basins, there may be some lower cost agricultural reductions available. Second, some of those facilities unable to provide information were not required to control P in their effluent. If these facilities were required to meet the 0.3 mg/l effluent limit, they would need to set up costly new control systems for fairly small reductions in P loads. Therefore, depending on the applicability of effluent standard revisions, these sources might be interested in trading as a compliance option.

# Notes on Trading

The control cost estimates gathered for agricultural operations suggest some BMPs may be better bargains than others. Table 11 lists four categories of conservation measures implemented among the sampled operations in this study and the weighted average cost and median cost per pound for P reductions.

#### Phosphorus Control Cost Comparisons Among Types of Agricultural BMPs Table 11

BMP Type/Category	Average Cost \$/lb.	Median Cost \$/lb.
Conservation Tillage	\$18	\$12
Clean Water Diversions	\$24	\$21
Manure Storage/Nutrient Management	\$28	\$21
Concrete Barnyard/Filter Strip	\$52	\$49

Note: Clean water diversions include barnyard runoff control systems, roof gutters, filter strips, filter walls, and earthen diversions. A few operation estimates also included either a settling basin or a manure storage structure.

For the operations sampled, conservation tillage had the lowest cost per pound of P controlled with a average of \$18/lb and a median cost of \$12/lb. On the other end, concrete barnyards with filter strips had the highest cost per pound of P controlled with an average of \$54/lb and a median of \$52/lb.<sup>25</sup>

Point sources looking for alternatives to high cost control options should look in their watershed for other point and nonpoint sources with significantly lower estimated control costs.

# **Conclusions and Next Steps**

Findings of this study indicate that the potential exists for beneficial trading of P control obligations between point sources, and between point and agricultural nonpoint sources in the Lower Fox Basin. Favorable conditions include: a wide variation in point source control costs, large number of point sources, and availability of low cost nonpoint source reductions. The Upper Fox Basin appears to be a less favorable area for point-point and point-nonpoint trading but may be a favorable situation for trading to accommodate new growth. Finally, there could be opportunities for beneficial trading in the Wolf Basin if some of the smaller MTPs are required to meet new effluent limits, and if agricultural NPS reductions with a similar cost range to those

<sup>&</sup>lt;sup>25</sup> Concrete barnyards are relatively costly, but depending on soil type, may be needed in some watersheds to protect groundwater resources.

submitted in the other basins are available. For all three basins, additional information is needed on agricultural nonpoint source candidate operations from watersheds that are not nonpoint source priority watershed projects and control cost estimates from industrial point sources.

Trading may also be used to address some ongoing compliance problems in the waters of the Fox-Wolf Basin. For instance, sources needing alternative compliance limits due to technological or economic factors could be required to offset any permitted standard exceedances with purchase of reduction credits from other sources. Another option is to require that combined sewer overflows, which occur during periods of heavy rain or rapid snow melt, be offset with purchase of reduction credits. One possibility is to require that MTPs hold a certain volume of P reduction credits based on their historical average overflows which would provide roughly contemporaneous offsets to those loadings.

Inability to easily access information on availability and prices of P reductions could impede sources interested in trading by increasing the costs associated with trading (i.e., transaction costs). Furthermore, accurate cost estimates for agricultural nonpoint sources are generally unavailable in watersheds other than those in which Nonpoint Source Priority Watershed Projects are in progress. Operations in these other watersheds may also be good candidates for generating P credits, and options for getting this cost information should be explored.

Further information on control costs for point sources should be gathered when in-stream standards, and revised effluent standards for P are identified for each water body. This information should include control costs for facilities to control at the standard, as well as above and below the standard. These figures will provide a better picture of options for point sources regarding compliance, over-compliance and sales of credits, and use of purchased credits for compliance. More detail on point source control costs in these scenarios will be needed because sources needing high volumes of credits may find trading with a few other point sources more attractive than trading with numerous NPSs. These circumstances suggest that there is a great need for service to gather and provide price information for potential traders.

# References

Bannerman, Roger, Nonpoint Specialist, Wisconsin Department of Natural Resources, personal communication, January 1999a.

Bannerman, Roger, Nonpoint Specialist, Wisconsin Department of Natural Resources, personal communication, April 1999b.

Baumgart, Paul, of Fox-Wolf Basin 2000, personal communication, November 1998.

Caraco, Deb, Rich Claytor and Jennifer Zielinski, *Nutrient Loading From Conventional and Innovative Site Development – Final Report*, prepared for Chesapeake Research Consortium, Edgewater, MD, July 1998.

Colorado Department of Public Health and Environment (CDPH&E), *Regulation No. 71: Dillon Reservoir Control Regulation – 5 CCR 1002-71*, amended July 14, 1997.

Delaware Department of Natural Resources and Environmental Control (DE DNREC), "Conservation Design for Stormwater Management," Dover, DE, 1997.

Jacobson, Elaine Mullaly, Leon E. Danielson and Dana L. Hoag, "The Tar-Pamlico River Basin Nutrient Trading Program," Applied Resource Economics and Policy Group, Department of Agricultural and Resource Economics, North Carolina State University, April 1994, http://www.bae.ncsu.edu/programs/extension/publicat/arep/tarpam.html.

Minneapolis Park Board and Minneapolis Department of Public Works, *Minneapolis Chain of Lakes – Implementation Plan*, October 21, 1993.

Olson, Kent D., and Norman Senjem, *Economic Comparison of Incremental Changes in Till Systems in the Minnesota River Basin*, Regents of the University of Minnesota, 1998.

Prusak, Peter, letter to Cumberland Wisconsin Mayor Deborah Lehman, January 22, 1999.

Senjem, Norman, *Pollutant Trading for Water Quality Improvement: A Policy Evaluation*, Minnesota Pollution Control Agency, Water Quality Division, 1997.

Southwestern Wisconsin Regional Planning Commission (SWRPC), *Costs of Urban Nonpoint Source Water Pollution Control Measures*, Technical Report Number 31, June 1, 1991.

United States Environmental Protection Agency, *Draft Framework for Watershed-Based Trading*, EPA 800-R-96-001, May 1996.

United States Environmental Protection Agency, Region 5, letter from Tim Henry (EPA) to Dave Batchelor (Michigan DEQ) commenting on Michigan's Draft Water Quality Trading Rule, October 1998. Vik, Thomas, McMahon Associates, Inc., Neenah, WI, personal communication, March 1999.

White, David, *Toward a Cost-Effective Approach to Water Resource Management in the Fox-Wolf River Basin: A First Cut Analysis*, Northeast Wisconsin Waters for Tomorrow, Green Bay, Wisconsin, 1993, 1994.

Wisconsin Department of Natural Resources, Chapter NR 217.04, "Effluent Standards and Limitations," August 1997a.

Wisconsin Department of Natural Resources, "Lower Green Bay Remedial Action Plan," 1988.

Wisconsin Department of Natural Resources, "Technical Development of Phosphorus Water Quality Standards: A Report of the Phosphorus Technical Workgroup," PUBL-WT-500-97, October 1997.

Wisconsin Department of Natural Resources, Department of Agriculture, Trade and Consumer Protection, Brown and Calumet County Land Conservation Departments, Bay Lake Regional Planning Commission, Brown County Planning Commission, Local Units of Government, and the East River Watershed Advisory Committee, *A Nonpoint Source Control Plan for the East River Priority Watershed Project*, March 1993.

# Appendix A: Cost Calculation Details

# Notes on MTP Cost Estimates

Table A1

Facility Name	Notes on Cost Estimates			
Oshkosh	Low chemical costs because they use pickle liquor from an Illinois steel mill. If the			
	facility had to go below 0.3, control costs would rise dramatically because they would			
	have to add new treatment.			
Appleton	Low chemical costs because they use pickle liquor from local metal industry. Cost			
	estimates do not include administrative expenses.			
Green Bay MSD	High incremental costs are due in part to the high level of control already attained by			
	the facility operators making the incremental P controlled a small amount. Although			
	they averaged 0.17 in 1998, plant manager feels sand filtration would need to be added			
	to insure consistent attainment of 0.3mg/l. Incremental P is from 0.17 to 0.10 mg/l.			
Neenah - Menasha	Manager felt they may need tertiary filtration to achieve 0.3 consistently (have trouble			
	achieving it under normal conditions). Cost estimates do not include tertiary filtration.			
	Current chemical costs are low because they have a very low cost agreement with			
	supplier (costs are negligible).			
Grand Chute - Menasha West	Costs of 1.0 control level are bundled in information received. Could not separate			
	debt/depreciation to make uniform with other estimates. Cost estimates for attaining			
	0.3 mg/l provided by Thomas Vik, of McMahon Associates, Inc. and include capital			
	costs only.			
Fond du Lac	Equipment costs not included. Rough estimate for costs of achieving 0.3 mg/l.			
Heart of the Valley MSD (Kaukauna)	Cost estimates for attaining 0.3 mg/l provided by Thomas Vik, of McMahon			
	Associates, Inc. and include capital costs only. No way to meet 0.3 given site			
	constraints. The 0.3 estimates are for if site constraints could be overcome and			
	occasional peak flows of over 50MGD are not counted. Incremental cost includes			
	capital costs only.			
De Pere	Facility has P control equipment dismantled because it is not needed. Biological			
	control for BOD uses up small amount of influent P.			
Shawano Lake SD (Wolf)	Plant being upgraded to include biological treatment for BOD, and will need to add P.			
New London	Amounts of P removed reflect change in 1999 due to change in influent P from dairy.			
	1998 loads averaged ~100 pounds/day but expect ~87.5 pounds/day in 1999. P			
	removed (for both levels) was calculated based on estimated influent load in 1999 and			
D'	manager's estimated removal efficiencies (94% and 97%).			
Ripon	Plant uses biological BOD removal and does not always need to control for P with			
	chemical addition. Uncertain whether could get to 0.3 with chemical addition alone			
W/	(may need additional treatment).			
waupaca	Costs of achieving 0.5 are not available. Equipment costs at 1.0 unknown, too many			
Clintonville	Uncertainties and exclusions for cost estimates to be used.			
	Uncertain plant can consistently control down to 0.5 with the current configuration.			
Wild Rose	Not currently required to control for P, just test for it.			
Town of Holland SD #1	Cost estimates for attaining 1.0 and 0.3 mg/l provided by Thomas Vik, of McMahon			
	Associates, Inc. and include capital costs only. Estimates for 1.0 assume replacement			
	of existing P control measures with \$1.3 million system (not meeting current permit).			
	Estimates for 0.3 include only capital costs. Costs are based on reduction from 1.0 to			
	0.3 but pounds reduced may be different depending on control level after upgrade.			
	This estimate is conservative (actual costs per pound could be much higher) including			
	the most possible pounds of P reduced. Estimate also does not include cost of pilot			
Wayaywaga	Study on reastonity of meeting 0.5.			
weyauwega	rough			
Seymour	Plant would probably have to add more treatment suspect costs would be high (no			
Scymour	estimates available) Uncertain about equipment and sludge costs at current level			

ID Reference	Type of Operation	Land Size	Herd Size	Measure 1	Measure 2	Measure 3	Total P Reduction	Total Annual Costs	\$/# P Removed
LF-AAC-1	Dairy		117	Roof Gutters	Filter Wall	Filter Strip	76.3	\$1,983.47	\$26.00
LF-AAC-12	Livestock	57	35	Manure Storage	Nutrient/Pest Mgmt (\$8/acre)		92	\$2,393.52	\$26.02
LF-AAC-2	Dairy		120	Roof Gutters	Filter Wall	Filter Strip	59.4	\$1,845.09	\$31.06
LF-AAC-3	Dairy		48	Roof Gutters	Filter Wall	Filter Strip	44.1	\$1,306.96	\$29.64
LF-AAC-4	Dairy		188	Roof Gutters	Filter Strip		55.7	\$621.31	\$11.15
LF-AAC-8	Livestock	212	98	Manure Storage Pit	Nutrient/Pest Mgmt (\$8/acre)		189	\$4,017.90	\$21.26
LF-AAC-9	Crop	125		Conservation Tillage (\$12/acre)			148	\$1,500.00	\$10.14
LF-DUK-10	Livestock		112	Manure Storage Pit			189	\$2,321.90	\$12.29
LF-DUK-11	Crop	53		Conservation Tillage (\$12/acre)			183	\$636.00	\$3.48
LF-DUK-13	Livestock	565	150	Manure Storage	Nutrient Management (\$8/acre)		216	\$9,278.88	\$42.96
LF-DUK-5	Dairy		109	Roof Gutters	Filter Strip		40.9	\$352.76	\$8.62
LF-DUK-6	Beef		9	Roof Gutters			48.7	\$189.57	\$3.89
LF-DUK-7	Livestock	352	340	Manure Storage Pit	Nutrient/Pest Mgmt (\$8/acre)		339	\$5,137.90	\$15.16
LF-PC-45	Dairy	175	100	Manure Storage Structure	Nutrient/Pest Mgmt (\$8/acre)		75	\$3,629.41	\$48.39
LF-PC-46	Dairy	178	50	BY Runoff Control Sys			85	\$2,198.78	\$25.87
LF-PC-47	Young Stock	250	150	BY Runoff Control Sys	Filter Strip		75	\$2,221.90	\$29.63
LF-PC-48	Dairy	151	60	BY Runoff Control Sys	Filter Strip		60	\$2,221.90	\$37.03
UF-FR-21	Dairy	660	311	BY Runoff Control Sys	Roof Gutters	Diversion	119.1	\$2,650.54	\$19.74
UF-FR-22	Dairy	118	138	BY Runoff Control Sys	Roof Gutters	Earthen Div. /Waterway	101.3	\$2,650.54	\$23.20
UF-FR-23	Dairy	335	515	BY Runoff Control Sys (X2)	Roof Gutters	Earthen Diversion	250.7	\$4,920.95	\$17.63
UF-FR-24	Dairy	125	148	Roof Gutters			52.6	\$505.52	\$9.61
UF-FR-25	Dairy	138	114	Roof Gutters			15.5	\$307.50	\$19.84
UF-LWE-26	Crop/Dairy	80	145	Roof Gutters	Filter Wall	Manure Storage Pit	86.5	\$2,498.78	\$23.11
UF-LWE-27	Crop/Dairy	158	114	Roof Gutters			25.4	\$379.14	\$14.93
UF-LWE-28	Crop/Dairy	300	220	Roof Gutters	Sediment Basin		89.4	\$922.51	\$10.32
UF-LWE-29	Dairy		111	Roof Gutters	Wall		68.2	\$484.38	\$5.64
UF-LWE-30	Crop/Dairy		70	Manure Pit			132.2	\$2.321.90	\$14.54

# Agricultural Operation Details

# Agricultural Operation Details Table A2 (continued)

<b>ID Reference</b>	Type of	Land	Herd	Measure 1	Measure 2	Measure 3	Total P	<b>Total Annual</b>	\$/# P
	Operation	Size	Size				Reduction	Costs	Removed
UF-NC-14	Dairy, Beef		86	Settling Basin	Roof Gutters	Diversion	110	\$2,890.67	\$24.46
UF-NC-15	Beef, Sheep		30	Settling Basin	Roof Gutters	Diversion	69.4	\$1,353.14	\$16.62
UF-NC-16	Dairy, Beef		120	Manure Storage	Sediment Basin		123	\$2,706.28	\$18.75
UF-NC-17	Crop	574		Alfalfa Use in Rotation			742	Unknown	Unknown
UF-NC-31	Crop	27		Conservation Tillage (\$18.5/acre)			4.26	\$499.50	\$117.25
UF-NC-32	Crop	52		Conservation Tillage (\$18.5/acre)			78.65	\$962.00	\$12.23
UF-NC-33	Crop	42		Conservation Tillage (\$18.5/acre)			56.87	\$777.00	\$13.66
UF-NC-34	Crop	127		Conservation Tillage (\$18.5/acre)			282.95	\$2,349.50	\$8.30
UF-NC-35	Crop	65		Conservation Tillage (\$18.5/acre)			104.14	\$1,202.50	\$11.55
UF-NC-36	Crop	114.5		Conservation Tillage (\$18.5/acre)			150	\$2,118.25	\$14.12
UF-NC-37	Dairy/Crop	1003.5		Conservation Tillage (\$18.5/acre)			300	\$18,564.75	\$61.88
UF-NC-38	Crop	153.4		Conservation Tillage (\$18.5/acre)			400	\$2,837.90	\$7.09
W-PW-18	Dairy	208	428	Manure Storage Structure			700	\$26,031.42	\$37.19
W-PW-19	Dairy	400	490	BY Runoff Control Sys	Diversion	Roof Gutters	85	\$4,114.09	\$48.40
W-PW-20	Dairy	100	140	BY Runoff Control Sys	Roof Gutters	Underground	75	\$4,498.47	\$59.98
						Outlet			
W-TW-39	Dairy	200	125	Concrete Barnyard	Filter Strip		70	\$3,537.52	\$50.54
W-TW-40	Dairy	100	125	Concrete Barnyard	Filter Strip		60	\$3,537.52	\$58.96
W-TW-41	Dairy	400	250	Concrete Barnyard	Filter Strip		100	\$4,921.90	\$49.22
W-TW-42	Dairy	200	150	Concrete Barnyard	Filter Strip		84	\$4,037.52	\$48.07
W-TW-43	Dairy	250	175	Concrete Barnyard	Filter Strip		70	\$4,921.90	\$70.31
W-TW-44	Dairy	400	300	Concrete Barnyard	Filter Strip		120	\$5,306.28	\$44.22

# Appendix B: Possibilities for Non-Monetary Trades and Pre-Treatment Trading for Phosphorus in the Fox-Wolf Basin

### Introduction

The term "pollutant trading"<sup>26</sup> conjures images of dollars exchanged for pounds of pollutants, often in the form of pollutant reduction credits. Experiences with pollution trading programs to date, however, have shown that trades in which no money changed hands have also been very important. This appendix examines some types of non-monetary trades and suggests how they may apply as part of a phosphorus (P) trading program for water quality improvement in the Fox-Wolf Basin in Wisconsin. All trading types discussed and use of pollution credits are assumed to either be in the context of a program of scheduled reductions and/or to be subject to a trading ratio<sup>27</sup> providing appropriate environmental safeguards for trading activity.

Although watershed-based trading programs have yet to see widespread use, valuable information can be drawn from other well-established pollutant trading programs such as those for air emissions. As has been experienced with other programs, the creation of incentives for pollution reduction, along with the compliance flexibility provided by a trading program, can promote innovation and technological progress, as well as provide motivation for making marginal low-cost reductions that would not otherwise be attempted. In fact, studies have shown that government pre-implementation estimates of per unit costs of compliance with rules using economic incentives are consistently overestimated, in part due to unanticipated technological innovations and underestimation of the volume of reductions that will be made (Harrington, et al, 1999).<sup>28</sup>

## Types of Non-Monetary Trades

The two predominant types of non-monetary trades that have occurred in air emissions trading programs are:

- intra-plant trading: exchange of credits among sources within the same company, and
- *credit banking (or intertemporal trading)*: keeping of credits generated from present reductions for future use.

A third type of trading, while not necessarily a non-monetary trade, is covered in this section as well: *pre-treatment trading*. Pre-treatment trading refers to agreements that affect the allocation of pollutant loads among facilities discharging wastewater to municipal treatment plants (MTP) (as defined by USEPA, 1996). The "receiving water" into which sources with pre-treatment agreements discharge is the influent to the MTP. Each MTP sets the standards for influent received from sources to avoid problems with their treatment processes and violations of their own discharge

<sup>&</sup>lt;sup>26</sup> In this report, pollutant trading refers to the trading of credits (or pollutant discharge allowances, depending on the program type) generated from overcontrol of pollutants.

<sup>&</sup>lt;sup>27</sup> For more information on trading ratios see Appendix E of this report.

<sup>&</sup>lt;sup>28</sup> In contrast, estimates of per unit costs of compliance with EPA and OSHA rules overall are overestimated about as often as they are underestimated (Harrington et al, 1999). While use of economic incentives cannot guarantee innovation, they can remove disincentives and create a reward for pollution reductions.

permit.<sup>29</sup> An MTP could theoretically choose a policy option that allows trading of P control obligations among pre-treatment client firms to meet its influent standards in a manner that is most cost-effective for the clients.

In addition to these three, there are likely to be other opportunities for non-monetary trades that involve a point source "fixing" some problem that was contributing pollutants to, or in some other way having a detrimental effect on a water body. For example, the EPA has recently approved a National Pollutant Discharge Elimination System (NPDES) permit for a Massachusetts office building complex allowing it to discharge treated sewage into the Sudbury River in exchange for the developer removing a number of failing residential septic systems draining into the river and providing sewage system hookups for those residences (MDEP, 1998). This is one of the first pollutant trading water permits approved by the EPA (The Reinvention Report, October 26, 1998). Other possible non-monetary trades could involve making watercourse improvements or organizing and sponsoring other water quality improvement efforts for credits.<sup>30</sup> The nature of nutrient loadings to surface waters and the diversity of pollutant sources provide fertile ground for creative effluent reduction and trading ideas. The possibilities for these other emerging types of trades are diverse and their full examination is beyond the scope of this appendix.

The three trading types defined above are discussed in greater detail below and, when available, some experiences are outlined. To conclude each section, possibilities for use of these mechanisms in the Fox-Wolf Basin are discussed.

## Intra-Plant Trading

Use of intra-plant pollutant trading to achieve required effluent loading reductions generally has a number of advantages over trades with other companies. These trades tend to involve lower transactions costs (i.e., costs associated with the sale or purchase not directly included in the purchase price)<sup>31</sup> because of a reduction in, or elimination of the need for legal or brokerage services typically associated with transactions between parties (Atkinson and Tietenberg, 1991). If trades involve sources at the same location, requirements for environmental improvement or equivalency testing may also be lower than for trades between distant sources. And finally, costs associated with obtaining information on potential trading partners are also reduced.

The main disadvantage to sources choosing intra-plant trades over inter-plant trades, from an overall market perspective, is the decline in cost-saving potential because of the reduction in trading opportunities. Frequent choice of intra-plant trades can reflect companies' perceptions of uncertainty regarding potential trading partners and trading program stability (i.e., credit price stability and availability), and the existence of other transaction costs.

<sup>&</sup>lt;sup>29</sup> These permits are Wisconsin Pollutant Discharge Elimination System (WPDES) permits. MTPs set standards for influent from clients only if needed. In the Fox-Wolf Basin, some MTPs with pretreatment clients receive insufficient influent P loads to warrant setting P limits for clients.

<sup>&</sup>lt;sup>30</sup> For example, the permit for the Rahr Malting Company in Minnesota, in addition to having groundbreaking point/nonpoint trading provisions, required the company to establish a not-for-profit corporation to sponsor cleanup projects on the Minnesota River (Senjem, 1998). <sup>31</sup> For more information on transaction costs see Appendix D.

### **Program Examples**

One of the earliest U.S. government endorsements of trading was the establishment of a "bubble" policy in 1979 (44 Federal Register 71779, 1979). Bubbling refers to treatment of a group of sources as if they were encased in a dome with a single opening at the top. Emissions from any one source were not important as long as the overall emissions total was within the limit set for the bubble. Although technically applicable to sources under different ownership as well, this compliance strategy was almost exclusively used for intra-plant trades (Dudek and Palmisano, 1988). This policy has allowed plant managers to use emission reduction credits generated by overcontrol of one or more of their own lower-cost sources to offset the need for controls at their higher-cost sources. As of 1989, one study estimated that the potential cost savings from the more than 200 bubbles that were either approved or pending approval exceeded \$800 million, without adverse effects on environmental performance (Hahn and Hester, 1989).

The USEPA Sulfur Dioxide (SO<sub>2</sub>) Trading Program created under Title IV of the 1990 amendments to the Clean Air Act was the first widespread policy experiment with an emissions trading market. While this program created a very large market of potential traders, a large majority of the trades that had taken place as of 1997 had been accounting transfers within firms (Bohi and Burtraw, 1997, also see McLean, 1996). So far, this program has achieved its environmental targets ahead of schedule and has an estimated annual compliance savings of \$1 billion (Stavins, 1998). However, use of the substantial pool of banked credits is expected to temporarily postpone attainment of final reduction goals during the second phase of the program. Banking of credits is discussed further in the next section.

## Applicability to Fox-Wolf Basin

Unlike the air emissions trading programs in the examples above, point sources of phosphorus to surface waters in the Fox-Wolf Basin rarely have more than one outfall (point of discharge), which is the point at which their effluent limit is enforced (through WPDES permits). Therefore, opportunities for intra-plant trading for point sources are very limited.

If agricultural nonpoint sources are subject to categorical source control requirements (i.e., if the TMDL requires specific loading limits or best management practices (BMP) installation for each type of operation), the possibility exists for owners of multiple operations to trade reduction requirements among their operations. These trades would allow implementation of additional measures at sites that contribute the most pollutants in exchange for not implementing measures at sites with lower loadings (i.e., sites with the highest loadings tend to have the lowest per unit abatement costs). An important regulatory approval required for this option to be viable is the approval of use of reduction credits to comply with the TMDL or to comply with technology-based requirements.

# Credit Banking or Intertemporal Trades

Banking of pollution credits for future use may have high appeal because it can help sources manage their compliance risks. In actuality, banking is another form of intra-plant trading; sources are trading with themselves over time.<sup>32</sup> Banking of credits not only has the advantages associated with

<sup>&</sup>lt;sup>32</sup> Of course, banked credits could also be sold to other sources making the transaction a monetary trade.

intra-plant trades, but also gives sources the added assurance of knowing these credits are there for them if they need them in the future.

Allowing banking and future use of credits encourages sources to adopt additional controls early, to help them with compliance in later years. This can be a "win-win" situation for both the environment and industry (Bohi and Burtraw, 1997). Early reductions made to generate bankable credits benefit the environment by reducing pollutant loads earlier than is required. They also provide sources with a form of compliance insurance; sources can elect to sell their banked credits, or use them to postpone making equipment purchases to meet limits when tighter pollutant controls are mandated. This added flexibility gives sources some insurance against compliance uncertainties such as availability or reliability of control equipment, changes in their operations or waste stream, and availability of reduction credits from other sources. This insurance can also help alleviate sources' fears that they might actually be penalized for making early reductions.<sup>33</sup>

Banking of credits can postpone achievement of the ultimate reduction goal (McLean, 1996). Sources may use banked credits, generated from early reductions, to postpone making additional required reductions. However, banked credits are a limited quantity and represent pollutants that were not released into the environment, thus providing an ongoing environmental benefit. In addition, some contend that establishing a pollutant trading market without a banking alternative (e.g., credits have a one year life then expire) may prompt sources to take a "use them or lose them" approach, having detrimental effects on the market (Atkinson and Tietenberg, 1991).

### **Program Examples**

Emission trading programs have dealt with concerns about credit banking in varied ways. Three examples are discussed here.

### One Year Credit Life

The Regional Clean Air Incentives Market, a trading program for  $NO_X$  and  $SO_X$  in the Los Angeles Basin in California, has limited the life of an emission reduction credit (ERC) to one year. However, compliance years are divided into two different cycles for different sources (i.e., some are Cycle 1 – January 1 to December 31, and some are Cycle 2 – July 1 to June 30). The cycles are staggered so they have a six month overlap. A Cycle 1 firm may purchase and use Cycle 2 ERCs and vice-versa. This measure limits the migration of ERCs to 6 months beyond the original expiration date. This limitation has probably reduced the potential control cost savings with the trading program, but designers, faced with extreme air quality problems in the region, chose the more restrictive approach to guarantee regular reductions in air emissions.

<sup>&</sup>lt;sup>33</sup> For example, if new regulations require percentage reductions in emissions and count current emissions (with the early reductions) as their baseline emission level, they would have more restrictive emission limits than firms that did not make early reductions.

#### Unlimited Credit Life

The SO<sub>2</sub> allowance trading program, created under the Acid Rain Program in the 1990 revisions to the Clean Air Act, allows banking and use or sale of unused allowances in future years.<sup>34</sup> Since allowances do not expire, the banking provision has allowed sources to adopt their own timeframes for equipment purchases and implementation of emission controls and has helped them to minimize operational disruptions. The banking provision has also promoted early reductions from sources. In 1995, sources in the allowance trading program emitted 3.4 million tons (39 percent) of SO<sub>2</sub> below their allowable emission level for that year (McLean, 1996). These allowances will likely be used to postpone making the emission cuts required under the second phase of the program and may result in a delay in achieving final program targets.

#### Controls on Banked Credit Use

Use of banked credits (i.e., allowances, in this program) was a contentious issue in the development of the Northeast Ozone Transport Region (OTR) plan for nitrogen oxides reduction.<sup>35</sup> Nichols and Hester (1995) examined numerous policy options for addressing concerns over use of banked allowances through "managed banking."<sup>36</sup> They suggested that there was minimal risk associated with allowing unrestricted banking in the region, but recommended that provisions be made for annual review of how the banked allowances were used. With this plan, costly restrictions are avoided initially, but additional restrictions could be instituted later if deemed necessary. The final Model Rule for OTR states (i.e., the rule is a model after which states can design their own rules) has a progressive flow control feature for banked allowances (Carlson, 1996). If the volume of banked allowances distributed that year, allowances can be used on a 1:1 basis. However, if banked allowances are greater than or equal to 10 percent of the annual distribution, they can only be used at a 2:1 ratio.

#### Applicability to the Fox-Wolf Basin

Allowing banking of P credits for future use appears to have potential for promoting early reductions in the Fox-Wolf Basin. Currently, point sources do not face additional restrictions beyond current control levels until TMDLs are established, which appears to be at least a few years off. Nonpoint sources (NPS) are currently not required to implement best management practices (BMPs) for P control, but may face new requirements following TMDL implementation.<sup>37</sup> Given the current regulatory situation, the offer of future flexibility through use of banked credits may be an effective way to promote voluntary water quality improvements in the near-term.

 $<sup>^{34}</sup>$  The SO<sub>2</sub> allowance trading program is a "cap and trade" program. This type of program sets an overall emissions cap or ceiling, and distributes emissions allowances to registered sources each year.

<sup>&</sup>lt;sup>35</sup> The actual banking of credits was not a big issue, since each banked credit represented a unit of pollution that was not released into the air. However, use of banked credits to offset control obligations was the subject of much debate.

<sup>&</sup>lt;sup>36</sup> This examination of credit banking does not include "borrowing" of credits for current use. For a discussion of program design for credit borrowing and banking see Kling and Rubin, 1997.

<sup>&</sup>lt;sup>37</sup> Credit generation in this situation would be in an "open market." Sources would be granted credits for reductions below their established baseline level of discharge. Michigan Department of Environmental Quality currently has a proposed rule for water quality trading that offers a similar credit generation scheme but sources may be required to demonstrate that water quality standards will not be violated with credit use (MDEQ, 1999). The department chose the term "water quality" trading to communicate the fact that program design elements insure water quality is improved with each credit traded or used.

Some critical regulatory approvals that are needed for this type of banking to take place are: federal approval of credit use for compliance with the TMDL, and federal approval of the use of nutrient credits for compliance in periods other than the one in which they were generated. Requiring the use of more than one credit for each unit of compliance (i.e. a trading ratio of greater than 1:1) would mean that each time a credit is banked or used the pollutant load ultimately released into the environment will be lower than it would have been without banking (assuming other needed safeguards for an effluent trading program are in place). Trading ratios as a tool for addressing uncertainties are discussed in Appendix E.

#### Other Factors Favoring Banking

Uncertainties regarding P residence time in the river and pool systems in the basin, coupled with the little understood relationship between built-up P in sediments and reloading of P into surface waters, will require a long-term focus on water quality goals with emphasis on near-term reductions. These factors fit well with the potential for banking to promote early reductions.

Another factor suggesting the need for an innovative approach for promoting agricultural nonpoint source (NPS) P load reductions is that state funds for cost-sharing of agricultural BMPs have dwindled in recent years. For this reason, finding ways to get NPS reductions funded or promote early voluntary reductions is extremely important. Some practices such as conservation tillage or nutrient management tend to actually reduce costs for farmers once implemented, but require some initial expenditures to get them started. Bankable and salable credits for early reductions may help motivate some agricultural operations to adopt these measures.

Use of banked credits for future compliance can also help sources adopt flexible compliance and expansion schedules allowing more cost-effective addition of control measures. A study in Minnesota found that MTPs had drastically lower marginal costs of P control when they could add P treatment at the same time they were going through a facility expansion (Senjem, 1997).<sup>38</sup> With banked credits, sources could synchronize compliance and expansion schedules to take advantage of these cost savings.

If given an incentive (i.e., the ability to earn credits for future use or sale), plant managers may find ways to reduce pollutant levels leading to the outfall pipe, through process and input changes. This option gives sources the incentive and opportunity to be creative with their control measures and rewards successful efforts.

# Pre-Treatment Trading

Pre-treatment trading<sup>39</sup> is mechanism that could possibly be used in the Fox-Wolf Basin. Depending on availability, the establishment of a pretreatment agreements is another compliance option for point sources to consider. Sources with pre-treatment agreements with an MTP must meet federally proscribed categorical limits for pollutants in their discharge to the MTP. MTPs offering pre-treatment services can set limits on influent pollutant levels that are more restrictive than the

<sup>&</sup>lt;sup>38</sup> In this situation, it is conceivable that state funds set aside for co-funding P reductions could be more beneficially spent on adding P controls to expanding MTPs instead of funding implementation of agricultural BMPs.
<sup>39</sup> Pre-treatment trading is not necessarily a non-monetary type of trade. It could involve an exchange of funds or

<sup>&</sup>lt;sup>39</sup> Pre-treatment trading is not necessarily a non-monetary type of trade. It could involve an exchange of funds or services for control obligations. Pre-treatment trading is one of the types of trades specifically identified by the EPA in their *Draft Framework for Watershed-Based Trading* (USEPA, 1996).

categorical limits. When these more-restrictive limits are set, the ability to trade pollutant reduction responsibilities with other pre-treatment clients to meet the MTP's standards could allow sources to reduce costs while providing equivalent or improved influent concentrations of pollutants. While this type of trading would not directly affect a market for pollution credits for surface water dischargers, the availability of this option would increase the attractiveness of using a pre-treatment agreement as a compliance option. Widespread use of pre-treatment agreements for compliance by point sources could dampen trading activity by giving sources a potentially cheaper compliance alternative.

### **Program Examples**

There are currently no pre-treatment trading program examples. However, the Illinois Environmental Protection Agency has produced a proposal for the establishment of a pre-treatment trading program for pollutants (IEPA, 1996). The proposal was submitted to the EPA but rejected as not workable because pretreatment clients must adhere to categorical limits set by state and federal regulations. This restriction removed most opportunities for trades (Park, 1999).

### Applicability to the Fox-Wolf Basin

A number of MTPs in the Fox-Wolf Basin have pre-treatment agreements with industrial and municipal clients. For Example, the Green Bay Metropolitan Sewerage District (GBMSD) serves, in addition to several industrial pre-treatment clients, the towns of Allouez, Ashwaubenon, Bellevue, Howard, Lawrence, Pulaski and Scott. Increased restrictions on P levels in effluent (to surface waters) might prompt more facilities to seek pre-treatment arrangements with larger facilities such as GBMSD to take advantage of some apparent treatment economies of scale.<sup>40</sup> The magnitude of market effects from point sources moving to pre-treatment agreements are difficult to predict without additional detail on sources for which it is an option, and costs of these agreements. The most likely near-term effect of allowing pre-treatment trading would be a drop in average compliance costs (because of the introduction of a new flexible compliance option) for point sources and decreased interest in trading.

A major regulatory barrier to pre-treatment trading is the EPA's requirement of strict adherence to categorical effluent standards for pre-treatment clients, which eliminates most opportunities for trades.

It is unclear whether sources opting to sign a pre-treatment agreement could be granted credits for the resultant reduction in their pollutant loadings. If they would be eligible for credits, pre-treatment agreements would be more-attractive compliance option.

## **Concluding Remarks**

Of the types of non-monetary trades examined in this appendix, phosphorus credit banking shows the most promise for providing early environmental improvements and compliance cost savings in the Fox-Wolf Basin. If federal restrictions can be lifted regarding banking and future use of reduction credits, a positive incentive for sources to make early reductions in their phosphorus loadings could be established. Properly designed, a credit banking provision could also promote

<sup>&</sup>lt;sup>40</sup> The P treatment costs for GBMSD at their current level of control are negligible because P is used-up in their biological treatment process for biological oxygen demanding compounds (BOD).

"opt-ins" (i.e., sources choosing to participate in credit generation although they are not required to make reductions under the regulation) from unregulated sources such as agricultural operations who would prefer to make operational changes on their own terms rather than wait for government directives.

Required purchase of banked credits could also be used to offset combined sewage overflows from MTPs or unavoidable exceedances from industrial sources such as loadings from alternative effluent limits or seasonal variations in production. Without the granting of credits for early reductions and the assurance of compliance flexibility with future reduction requirements, sources have little incentive to reduce their loadings beyond the permitted level. Program experience with SO<sub>2</sub> allowance trading suggests that this promise of future flexibility can be a strong driver in producing early environmental improvements, and can also promote creativity and technological innovation.

## References for Appendix B

Atkinson, Scott, and Tom Tietenberg, "Market Failure in Incentive-Based Regulation: The Case of Emissions Trading," *Journal of Environmental Economics and Management*, 21, 17-31 (1991), Academic Press Inc.

Bohi, Douglas R. and Dallas Burtraw, "SO<sub>2</sub> Allowance Trading: How Experience and Expectations Measure Up," Resources for the Future, February 1997, Discussion Paper 97-24.

Carlson, Laurel J., *NESCAUM/MARAMA NOx Budget Model Rule*, prepared for the NESCAUM/MARAMA NOx Budget Task Force, NESCAUM/MARAMA NOx Budget Ad Hoc Committee, and the Ozone Transport Commission Stationary and Area Source Committee, May 1, 1996.

Dudek, Daniel J., and John Palmisano, "Emissions Trading: Why is this Thoroughbred Hobbled?", *Columbia Journal of Environmental Law*, Vol 13:217, 1988,

Hahn, Robert W. and Gordon L. Hester, "Where Did All the Markets Go? An Analysis of EPA's Emissions Trading Program," *Yale Journal on Regulation*, Vol. 6, 109, 1989, pp. 109-153.

Harrington, Winston, Richard D. Morganstern and Peter Nelson, "On the Accuracy of Regulatory Cost Estimates," Resources for the Future, January 1999, Discussion Paper 99-18.

Illinois Environmental Protection Agency, "Market-Based Trading of Categorical Pretreatment Limits," a Proposal Prepared by the IEPA, August 1, 1996.

Kling, Catherine, and Jonathan Rubin, "Bankable Permits for the Control of Environmental Pollution," *Journal of Public Economics*, 64 (1997), Elsevier Science S.A., pp. 101-115.

Massachusetts Department of Environmental Protection (MDEP), and Massachusetts Office of Ecosystem Protection, "Authorization to Discharge Under the National Pollutant Discharge Elimination System: Permit No. MA0039853," September 4, 1998.

McLean, Brian, "Evolution of Marketable Permits: The U.S. Experience With Sulfur Dioxide Allowance Trading," U.S. Environmental Protection Agency, Washington, DC, December 1996. (Also printed in the *International Journal of Environment and Pollution*, Vol. 8, Nos. 1/2 (1997), pp. 19-36.)

Michigan Department of Environmental Quality, Surface Water Quality Division, "Water Quality Trading – Draft 13," Water Quality Trading Workgroup Discussion Document, January 1999.

Nichols, Albert L. and Gordon Hester, "Issues in Designing a Banking Program for  $NO_X$  in the OTR," National Economic Research Associates, November 7, 1995.

Park, James, Illinois Environmental Protection Agency, Bureau Chief, Bureau of Water, personal communication, March 1999.

*Reinvention Report*, "EPA Region I Approves First Pollutant Trading Water Permit, October 26, 1998, p. 13.

Senjem, Norman, "Pollutant Trading: Theory and Practice," Minnesota Pollution Control Agency, 1998.

Senjem, Norman, *Pollution Trading for Water Quality Improvement: A Policy Evaluation*, Minnesota Pollution Control Agency, 1997.

Stavins, Robert N., "Market-Based Environmental Policies," Discussion Paper 98-26, Resources for the Future, March 1998.

United States Environmental Protection Agency, *Draft Framework for Watershed-Based Trading*, EPA 800-R-96-001, May 1996.

# Appendix C: Copies of Letters Sent for Cost Information

The documents in this appendix (on the following two pages) were used to request control cost and efficiency information from county land conservation departments and municipal treatment plants (MTP). Some MTP managers did not receive these documents because they contributed information immediately following verbal requests during telephone conversations.

Industrial sources were given similar letters to those sent to MTPs but with reassurances that industrial source information would only be used in aggregate format and no individual sources would be identified with their data.

# **RESOURCE STRATEGIES, INC.**

22 North Carroll Street, Suite 300 Madison, WI 53703

# FAX COVER SHEET

DATE:	March 31, 2003	TIME:	12:28 PM
то:	Watershed Technician Program Manager	PHONE: FAX:	
FROM:	Joseph M. Kramer	PHONE: FAX:	608-251-2260 608-251-5941
RE:	Agricultural Operation P	Reduction	Candidates

#### Message

Dear Sir or Madam:,

Thanks for your help on our project. On behalf of the Fox-Wolf Basin 2000, we are looking for information on the top 5-10 "prime candidate" operations for implementing P controls in your county and watershed. Please select the operations that you estimate to have high P loadings and conditions necessary for effective implementation of P control measures (i.e., no conditions that would preclude implementation or make them excessively costly). These should also be operations that have not yet committed to cost-sharing BMP measures but would be candidates for such measures in the next 1-2 years.

Cost and effectiveness figures will not be treated as "hard and fast" numbers, but as what they are – informed estimates. We recognize that there is substantial variability in cost and effectiveness values not only between operations and watersheds, but over time as well. However, as a county watershed technician you are in the best position to make these estimates due to close contact with the agricultural operations and first-hand experience with BMP implementation.

Following is a sheet with the specific information items we would like to have. Please copy this sheet and fill one out for each operation for which you are sending us information. (If you want to use some other format such as a table for the information, that would be fine also.)

Please feel free to call me if you have any questions or comments. You can also speak with Bruce Johnson of FWB2000 by calling 920-738-7025.

Sincerely,

Joseph M. Kramer

# **RESOURCE STRATEGIES, INC.**

22 North Carroll Street, Suite 300 Madison, WI 53703

# FAX COVER SHEET

DATE:	March 31, 2003	TIME:	12:28 PM
TO:	Plant Manager	PHONE: FAX:	920-725-7031
FROM:	Joseph M. Kramer	PHONE: FAX:	608-251-2260 608-251-5941

**RE:** Phosphorus control cost information

#### Message

Dear Sir or Madam:

We at Resource Strategies, Inc., on behalf of the Fox-Wolf Basin 2000, are seeking cost information from point and nonpoint sources of phosphorus (P) to surface waters in the Fox-Wolf basin.

The information gathered in this project will be used to explore alternative programs for costeffective attainment of water quality goals in the basin. One possible program alternative is allowing point and nonpoint sources to buy and sell effluent control obligations. This type of program would allow P reductions (which are an anticipated outcome of Wisconsin total maximum daily load assessments) to come from those sources with the lowest control costs. To assess whether this or some other program will be appropriate, we need good control costs for sources in the basin.

For the \_\_\_\_\_ facility, we are looking for:

- costs of achieving 1.0 mg/I P discharge level, and lbs./year of P removed; (or current level)
- costs of achieving 0.3 mg/l P discharge level, and lbs./year of P removed.

These cost estimates should be divided into: costs for any structures needed specifically for P control (and approximate year of purchase), chemicals, operation and maintenance, and sludge disposal costs (for sludge generated from P control operations). We would also like information on any other costs associated with consistently achieving each level of control.

This project is partially funded by the Green Bay Metropolitan Sewerage District, the Joyce Foundation, the Water Environment Research Foundation and the Wisconsin Department of Natural Resources. Additional information on Fox-Wolf Basin 2000 can be found on their website at <u>www.fwb2k.org</u>, or you can contact their Executive Director and manager of this project, Bruce Johnson, at 920-738-7025. You can also find out more about Resource Strategies, Inc. on our website <u>www.rs-inc.com</u>.

If you have any questions or would like more information, please call me at 608-251-2260.

Sincerely,

Joseph M. Kramer

# Appendix D: Role of Transactions Costs in Watershed Based Trading for Phosphorus

### Introduction and Background

This appendix takes a brief look at the role of transactions costs in watershed-based trading including sources of costs, who bears them, and some general regulatory approaches to minimizing them.

In the context of watershed-based trading programs, transactions costs are defined as expenses for traders that occur only as a result of trading (EPA, 1996). These may include costs associated with finding potential trading partners, negotiating trades, permit revisions, hiring technical expertise, and carrying out other activities required by the trade such as increased monitoring or other compliance assurance measures.

High transactions costs limit the cost and environmental savings achievable through trading. In their presence, reduced savings are experienced by both buyers and sellers of credits, and there is also a "deadweight loss" to the overall program because of trades that never occurred (Stavins, 1995).

## Sources of Transactions Costs

In any market, buyers and sellers will incur some cost finding and contacting each other. In wellfunctioning markets, with easily accessible information on products and prices, these costs can be negligible, but in some situations transactions costs can entirely obstruct market activity. Some nonnegligible transactions costs are almost certain in any market for complex goods such as effluent reduction credits.

Transactions costs are often directly related to regulatory requirements placed on trading activity. Requirements that increase transactions costs may include: modeling or other demonstrations regarding trade impacts; increased monitoring of credit generating sources or activities; and requirements for trade-based permit modifications. For example, the Minnesota Rahr Malting company permit that incorporates trading includes compliance checking requirements and reporting requirements that impose additional costs on traders including increased reporting requirements for point sources funding nonpoint reductions, and securing of credits through land purchase, easement or other type of contractual obligations (MPCA, 1997). Transactions costs may also accrue to the regulatory authority if trading creates a greater administrative or oversight burden than alternative programs.

Regulatory requirements may also indirectly affect transactions costs by limiting the number of potential trading partners (geographically or categorically), or by placing temporal restrictions on credit generation and use. These types of restrictions reduce the number of trading opportunities making the search for eligible traders more costly.

Regulatory requirements such as those discussed above provide greater certainty that the program will provide equivalent or improved environmental quality compared with non-trading alternatives. Program designers are faced with the difficult task of balancing the often conflicting interests of environmental certainty and cost effectiveness in designing an emissions trading program.

# Program Design

Theory and experience to date have suggested some ways in which program designers can provide opportunities for cost savings without creating unacceptable environmental risk. Some of these options and references to existing or proposed trading programs are outlined below.

One way to reduce transactions costs is by providing centralized control cost and credit availability information for eligible traders. This type of service can help minimize the difference between ask and bid prices making negotiations go more smoothly. The Clean Air Act Acid Rain Program's sulfur dioxide (SO2) trading program established an auction market which generates systematic public information on allowance prices (Tietenberg, 1998). Other emissions trading programs, such as those developed under the nitrogen oxides offsetting provisions of the Clean Air Act, have sometimes included a central banks where credits available for offsetting new emissions are listed. Emission credit banks, if they provide information to traders and the public, can also be valuable sources of information on credit availability.

To reduce the costs associated with finding and negotiating with multiple nonpoint sources, counties or other local units of government could act as the representatives for nonpoint sources in their county or watershed (as suggested by Senjem, 1997). This would give point sources exploring trading options a single point of contact and greatly reduce costs of identifying and negotiating with nonpoint sources.

Clear definition of what constitutes a permissible trade, as identified in clear and concise trading rules, can take some of the risk out of trading and make options easier to evaluate (Senjem, 1997). Providing standard mechanisms or guidelines for participants to evaluate trading opportunities early in the process will help limit the amount of resources wasted on fruitless options. Furthermore, program designs can also minimize transactions costs by streamlining the trading process so traders have an easy means to transact with minimal regulatory oversight.

Program designers can also set program parameters based on expected or likely outcomes rather than worst-case scenarios (Hahn and Hester, 1989). This type of approach was recommended by economists in setting up banking provisions for the NOx trading program in the Northeast Ozone Transport Region (Nichols and Hester, 1995). If more pessimistic scenarios should develop, restrictions could be added as needed during scheduled evaluation and modification periods.

# **Concluding Remarks**

Once favorable conditions for effluent trading are identified, incorporating measures to minimize transactions costs can play a large role in program success. A trading program with high transactions costs can still achieve its environmental goals, but efficiency goals are lost. Knowledge of early program failures and experiences with ongoing programs will allow today's program designers to create more precise policy instruments and have greater success for both the environment and the economy.

# References for Appendix D

Hahn, Robert W., and Gordon L. Hester, "Where Did All the Markets Go? An Analysis of EPA's Emissions Trading Program," *Yale Journal on Regulation*, Vol 6: 109, 1989.

Minnesota Pollution Control Agency (MPCA), "Case Study: Minnesota – Pollutant Trading at Rahr Malting Co.," presented at the Environmental Regulatory Innovations Symposium – November 5-7, 1997.

Nichols, Albert L. and Gordon Hester, "Issues in Designing a Banking Program for NOx in the OTR," National Economic Research Associates, November 7, 1995.

Senjem, Norman, *Pollutant Trading for Water Quality Improvement: A Policy Evaluation*, Minnesota Pollution Control Agency, Water Quality Division, 1997.

Stavins, Robert N., "Transaction Costs and the Performance of Markets for Pollution Control," *Resources*, No. 119, Spring 1995, Resources for the Future, Washington, DC.

Tietenberg, Tom H. "Tradable Permits and the Control of Air Pollution-Lessons from the United States" Zeitschrift für Angewandte Umweltforschung Sonderheft (9,1998):11-31.

United States Environmental Protection Agency, *Draft Framework for Watershed-Based Trading*, EPA 800-R-96-001, May 1996.

# Appendix E: Environmental Margin-of-Safety Use in Watershed-Based Trading Programs and Associated Issues

## Introduction – Dealing with Uncertainty

When considering regulatory options for achieving water quality goals, deciding on an appropriate environmental "margin-of-safety" (MOS) can be a contentious issue for both the regulated community and the general public. Incorporating an MOS is one way of accounting for uncertainties over whether a program, as designed, will meet its environmental goals. The regulated community generally prefers a minimum MOS to minimize costs, whereas the public will generally prefer a larger MOS to provide greater insurance of achieving water quality goals. The US EPA has promoted using an environmental MOS in two distinct areas related to the establishment of total maximum daily loads (TMDL), and watershed-based trading. This appendix discusses the purposes of MOSs and associated issues surrounding use of an environmental MOS in the context of phosphorus (P) TMDLs and watershed-based P trading programs in the Fox-Wolf Basin.

### Uncertainty with Traditional Policies

Traditional "command and control" (CAC) policies regulating point sources of pollutants to surface waters set effluent standards based on effluent pollutant concentrations or treatment technology without determining the ultimate effects of these reductions on overall water quality. Typically, these policies lacked an identifiable MOS for one or more of the following reasons:

- not all sources affecting water quality were accounted for,
- overall loading goals were not identified, and
- plans for achieving water quality goals were not developed.

Furthermore, significant sources of pollutants to surface waters such as urban and agricultural nonpoint sources were essentially unregulated. Reductions from nonpoint sources have generally been voluntary, promoted through state cost-sharing programs.

## Uncertainty with TMDLs

The Clean Water Act (CWA) requires that states identify and prepare TMDL estimates for impaired water bodies. This requirement has forced a change in focus, from individual sources, to the outcome of standards from a watershed perspective. By definition, TMDLs must take into account the water's assimilative capacity and assign permissible load allocations to all sources (point and nonpoint) accordingly. TMDLs must also set out a plan for achieving water quality goals.<sup>41</sup>

Even when a watershed perspective is used, regulations designed to limit effluent (point) and runoff or diffuse (nonpoint) sources of nutrient loadings into surface waters must address certain elements of uncertainty. The behavior of pollutants in a complex aquatic environment requires modeling to assess impacts of nutrient load changes. Also, because of the prohibitive expense of monitoring numerous diffuse sources, loadings from nonpoint sources are almost exclusively derived from

<sup>&</sup>lt;sup>41</sup> Water quality goals are to be set for each water body so that conditions are adequate for its designated use.

models.<sup>42</sup> Because models are approximations of reality, they can only provide estimates of nutrient loads and impacts on water quality.<sup>43</sup>

To account for these uncertainties, the EPA guidelines for TMDL development (40 CFR Part 130.7) include the requirement that TMDLs establish an MOS when allocating pollutant loads to sources. The most straightforward means of factoring in an MOS is to set allowable loads at a level so that water quality violations are rare.<sup>44</sup>

### Watershed-Based Trading

Allowing trading of pollution control responsibilities among sources introduces additional uncertainties over those associated with TMDLs without trading. In recognition of these increased uncertainties, EPA, in its Draft Framework for Watershed-Based Trading (EPA, 1996) recommended that agencies reviewing trade proposals make sure that trades incorporate a "margin of safety that is proportional to the uncertainty associated with load reductions over large spatial scales and is adequate to ensure that the reductions will actually attain water quality standards throughout the trading area." <sup>45</sup>

For this appendix, trading of P reduction responsibilities is examined. Uncertainties added to TMDLs by allowing P trading include those associated with:

- location,
- timing, and
- effluent/runoff composition.

**Location**. The location where P is introduced into the water body is important because different segments of the same stream or river may have different assimilative capacities due to factors such as flow, volume or temperature. Because of this variation, P discharged into one segment may have a different impact on water quality than if it was discharged in another segment. Also, because of the unidirectional flow of most water bodies, whether the credits were generated upstream or downstream of the purchasing source can also affect water quality.

<sup>&</sup>lt;sup>42</sup> Watershed models predict the load contributions to surface waters from surrounding lands based on type of land use, slope, proximity to water bodies, soil type and other factors. Water quality models are used to simulate the effect the loadings will have on overall water quality.

<sup>&</sup>lt;sup>43</sup> Nonpoint source loadings are also dependent on the weather – which we are reminded on a daily basis is tremendously difficult to predict.

<sup>&</sup>lt;sup>44</sup> One method, appropriate if water quality is point source dominated, is to calculate the maximum loadings based on drought flow conditions (i.e., conditions when the water body's assimilative capacity is at its lowest). This provides a margin of safety in that allocations will be below the water body's assimilative capacity at all times, except for the rare occasions when drought conditions exist. An example of this type of MOS is the Chugwater Creek WY, TMDL (Zander, 1999). Alternatively, if water quality is nonpoint source dominated, calculating loads based on infrequent storm events (e.g. based on a ten year storm event) may be more appropriate.

<sup>&</sup>lt;sup>45</sup> MOSs are not the only mechanisms for reducing uncertainty regarding point-nonpoint source trades. Some others include increased regulator or participant monitoring of BMPs (e.g., the Cherry Creek Basin trading program limits use of NPS-generated credits to those from programs run by the regulatory authority – Sandquist and Paulson, 1998), geographic and temporal restrictions on trading, and requirements for modeling of trade impacts on water quality. These provisions also tend to increase transactions costs associated with trading (See Appendix D for more information on transactions costs).

**Timing**. Timing of reductions is important because not all sources have regular daily loadings to the surface waters. Most MTPs have fairly steady P loadings throughout the year. However, industrial sources (and MTPs with industrial pre-treatment clients) may have variations in P loadings based on seasonal activities. Nonpoint sources (runoff sources) tend to have highest P loadings in rainy or snow-melt periods and little or no loadings during dry periods other than atmospheric deposition. P loadings when flow volume is higher may have a different impact on water quality than when volume is lower.

**Composition**. Finally, sources trading P reduction credits must have similar compositions of pollutants in their waste stream or runoff so that reductions at one source are equivalent to reductions at another.<sup>46</sup> For example, P discharged from a municipal treatment plant is usually soluble P whereas P in cropland runoff is usually sediment-attached. These forms of P have different availability for aquatic plant use which may need to be considered in evaluating trades.

### Incorporating an MOS for Trading

An MOS can be worked into trading programs in multiple ways. Since other uncertainties regarding TMDLs, or other cap-based remedial action plans, are appropriately addressed through built-in MOSs, only increased uncertainties associated with trading are what need to be offset. Therefore, it makes sense to have the MOS "activated" by the trading process. Perhaps the most widely-used method is to use a *trading ratio* of greater than 1:1. For example, a program could require sources to purchase two pounds of reduction credits from other sources to offset each pound of pollutant they released. Use of this mechanism, should result in net reductions in pollutants in the water body for each trade transacted.

Trading ratios can be set for an overall program, or used as a means of fine-tuning a trading program. Ratios could be set to promote reductions in problem areas and/or to discourage the use of credits in those areas (i.e., set applicable ratios to make credits generated in problem areas more valuable and make credits generated outside problem areas less valuable when they are used in a problem area). Ratios can also be used to address seasonality issues such as changes in flow volume or loading, or to encourage shorter- rather than longer-distance trades (i.e., seasonally-variable and distance-variable ratios).

Trading ratios can also be set to discourage use of credits from sources for which loading reductions are less certain. For example, a trade between point sources in the same stream segment might be required to meet a ratio of 1.5:1 or lower (i.e., for each 1 credit used one half credit would be permanently retired) reflecting the high level of certainty regarding reductions from these sources. On the other hand, a point source purchasing credits from an agricultural nonpoint source might be required to use them at some higher ratio such as 2:1. In commenting on one proposed water quality trading program, EPA suggested using a ratio as high as 7:1 or 10:1 for NPS/PS trades (USEPA Region 5, 1998).

Additionally, the circumstances under which trading is allowed may also effect how trading ratios are used. For example, trading among sources once TMDL goals are achieved (i.e., to accommodate

<sup>&</sup>lt;sup>46</sup> If relationships can be demonstrated between two different types of pollutants, interpollutant trading may be an option. An example of this is the Rahr Malting Company permit in Minnesota (MPCA,1997). This company negotiated a permit allowing it to release BOD into an impaired stream in exchange for nonpoint source P reductions upstream.

growth or siting of new facilities on the water body) may justifiably be done at a 1:1 ratio if there is good certainty about the effectiveness of the reductions, and source loadings are deemed equivalent. Another way to build an environmental MOS into watershed-based trading programs is to schedule periodic reviews of program performance and steps to be taken for adjusting the program if performance is deemed inadequate. This measure can be beneficial to both regulators and regulated parties as long as the procedures and possible adjustments are outlined in advance so these possibilities can be incorporated into compliance plans. Regulators benefit by having scheduled opportunities to fine-tune programs so that water quality goals are accomplished.

Sources can also benefit from use of scheduled program reviews since this provision allows regulators to design the program based on probable trading scenarios rather than "worst-case" scenarios. In this way, trading designs can avoid unnecessary restrictions and costs.

### **Program Examples**

The following examples illustrate how trading ratios have been used or proposed for use in other trading programs, to provide an MOS.

### Cherry Creek, Colorado

The Cherry Creek trading program<sup>47</sup> established a range of possible P trade ratios from 1.3:1 to 3:1 to be determined on a trade-specific basis. The trade-specific ratio is determined based on an "institutional factor," a "variability factor," and a "Best Professional Judgment" factor (Sandquist and Paulson, 1998). Proposed trades are examined by the basin Water Quality Control Authority and the appropriate ratio is assigned (CDPH&E, 1998).

### Michigan Proposed Water Quality Trading Policy

The Michigan Department of Environmental Quality discussion document titled "Water Quality Trading Rules – Draft 14" proposes applying a discount rate to all reduction credits at the time of generation (MDEQ, 1999). Credits generated by point sources are discounted by 10 percent (i.e., 10 percent of the reduction credits applied for are permanently retired) and those generated by nonpoint sources are discounted by 50 percent. These reductions are to address uncertainty and provide a net water quality benefit. Further discounts (of 10 percent) may apply in the form of equivalence factors applicable when a source uses credits for compliance in a nonattainment area or from a nonpoint source upstream of an impoundment.

### Fox River Transferable Discharge Permits

The TDA program for control of biological oxygen demanding substances (BOD) on the Lower Fox River used "impact coefficients" to address differing impacts of reductions of BOD based on point of entrance into the river (Moore et al, 1980). Using the water quality model QUAL III, impact coefficients would be determined for each source and any volume of credits proposed for trade would be modified to reflect the change in effect on water quality due to location and other effluent characteristics.

### **Tar-Pamlico Trading Program**

<sup>&</sup>lt;sup>47</sup> This program was implemented under the Cherry Creek Basin Water Quality Management Master Plan. This plan covers the measures needed to achieve an in stream standard of 0.035 mg/l of P.

The Tar-Pamlico trading program in North Carolina has set nutrient trading ratios (referred to as "safety factors") for point sources purchasing nonpoint source reduction credits of 3:1 for cropland BMPs and 2:1 for confined animal operations (Jacobson et al, 1994). While these are not explicit trading ratios in this program (i.e., there is no direct trading between sources), required point source funding rates for the state nonpoint source program are based on these ratios.

#### **Rahr Malting Company Permit in Minnesota**

The Rahr Malting Company has been granted a permit allowing offsetting of their discharges of carbonaceous biological oxygen demanding chemicals (CBOD) with P reduction credits obtained from upstream agricultural nonpoint sources (MPCA, 1997). A trading ratio of 1:8 for P reductions to BOD discharged is required reflecting the analysis of the relative effects of these two substances on water quality. The estimated equivalency ratio for P to BOD actually ranges from 1:23 (for the point furthest upstream from Rahr) to 1:8 (for reductions achieved at the same location as Rahr), resulting in a variable MOS based on distance.

#### Wayland Business Center Permit in Massachusetts

The Wayland Business Center complex in Massachusetts obtained a trading clause in its NPDES permit allowing it to implement watershed-based trading to reduce P loadings to the Sudbury River and its tributaries (MDEP, 1998). Discharges from the complex will be offset by assisting a locality (i.e., the Town of Wayland) with connection of several failing septic systems with the sewer system. The estimated trading ratio for this permit is 3:1.

### Applicability to the Fox-Wolf Basin

It is unclear whether the EPA will allow nutrient trading in watersheds to achieve TMDL required limits.<sup>48</sup> This means, trading in impaired water bodies, regardless of whether the trade results in water quality improvements, may not be allowed. For the Fox-Wolf Basin, this may mean that P trading will not be possible until TMDLs are established and water quality goals are achieved.

If trading to comply with the TMDL(s) that will be developed for the Fox-Wolf Basin is allowed, regulators will need to decide whether to put higher ratios into effect until the TMDL goals are accomplished, and then adopt trading ratios as discussed below.

If water quality goals are already achieved, trading would presumably occur only to accommodate new growth, siting of new sources in the watershed, and to cover episodic exceedances of assigned maximum daily loads. Under this scenario, trades between point sources within the same basin could be made with a low or 1:1 ratio. Trades between point and nonpoint sources would probably still require a ratio of greater than 1:1 to account for uncertainty in nonpoint reductions.

## **Concluding Remarks**

Use of trading ratios must be done carefully, since higher ratios translate into higher costs for traders, and lower the overall cost savings achievable through the market. Conversely, ratios that do

<sup>&</sup>lt;sup>48</sup> This is, in fact, one of the key issues on which the Great Lakes Trading Network (a group established in 1998 as the regional component of the Kalamazoo Water Quality Trading Demonstration Project) has requested EPA clarification (Batchelor, 1999).

not adequately cover uncertainties associated with trades might fail to achieve the desired degree of water quality improvement. Setting trading ratios based on likely rather than pessimistic trading scenarios, with well detailed provisions for annual program evaluation and revision, is the most promising strategy for cost-effectively achieving water quality goals.

# References for Appendix E

Batchelor, David J., letter to EPA Assistant Administrator Chuck Fox, on behalf of the Great Lakes Trading Network, February 12, 1999.

Colorado Department of Public Health and Environment, Regulation No. 72, Cherry Creek Reservoir Control Regulation, 5 CCR 1002-72, Amended April 13, 1998.

Jacobson, Elaine Mullaly, Leon E. Danielson and Dana L. Hoag, "The Tar-Pamlico River Basin Nutrient Trading Program," Department of Agricultural and Resource Economics, Applied Resource Economics and Policy Group, North Carolina State University, April 1994, http://www.bae.ncsu.edu/programs/extension/publicat/arep/tarpam.html..

Michigan Department of Environmental Quality (MDEQ), "Water Quality Trading Rules – Draft 14," discussion document, Water Quality Trading Workgroup, March 1999.

Massachusetts Department of Environmental Protection (MDEP), "Authorization to Discharge Under the National Pollutant Discharge Elimination System – Permit No. MA0039853," October 1998.

Minnesota Pollution Control Agency (MPCA), "National Pollutant Discharge Elimination System (NPDES) and State Disposal System (SDS) Permit MN 0031917," Rahr Malting Company, January 8, 1997.

Moore, Christina, Martin David and Erhard Joeres, "Implementation of Transferable Discharge Permits When Permit Levels Vary According to Flow and Temperature: A Study of the Fox River, Wisconsin," University of Wisconsin, October 1980.

Sandquist, Ronda L., and Cynthia Paulson, "The Cherry Creek Watershed: A Case Study of Water Quality Trading," presentation given at the Water Environment Federation 71<sup>st</sup> Annual Conference and Exposition, October 4, 1998.

United States Environmental Protection Agency, *Draft Framework for Watershed-Based Trading*, EPA 800-R-96-001, May 1996.

United States Environmental Protection Agency, letter from Timothy C. Henry to Dave Batchelor of Michigan Department of Environmental Quality commenting on a Draft Water Quality Trading Rule for Michigan, October 23, 1998.

Zander, Bruce, "Critical Issues and the Watershed Management Approach," presented at the conference *Integrating Water Quality Goals Through Total Maximum Daily Loadings*, February 9, 1999, University of Wisconsin, Madison, Wisconsin.