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0 Executive Summary

The economic policy instrument (EPI) discussed in this case study involves nutrient credit trading between point source wastewater treatment plants (WWTPs) and nonpoint sources (agriculture) in the Great Miami River Watershed of Ohio (U.S.). Commonly referred to as water quality trading (WQT) in the U.S., this EPI is a market-based approach to pollution control in which pollutant reductions are treated as commodities.

0.1 Definition of the analysed EPI and purpose

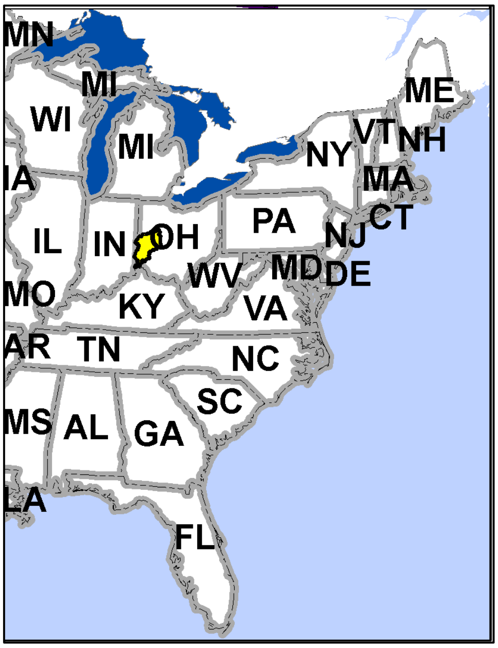
In a WQT market, dischargers that reduce their pollutant loads below required levels can sell surplus reductions, called credits, to other dischargers that need to make reductions to meet compliance requirements but face much higher costs to achieve required reductions. Credit price can be determined via negotiations between the buyer and seller, derived from credit auctions, or can be set by the government or other agency.

The purpose of this case study is to describe how a watershed-based flood control agency in southern Ohio developed a plan for WQT to provide a cost-effective alternative for WWTP compliance. WWTPs will soon face more stringetn effluent limits as a result of impending numeric nutrient standards being assigned to rivers and streams receiving treated wastewater. Lessons learned from this case study have substantial merit as an EPI because this program provides an economic framework for applying and using WQT in a regulatory setting. This case study example is also one of the largest and most successful WQT programs in the U.S. to negotiate nutrient credit trades between mulitple point source buyers and nonpoint source sellers. Of note is the use of a reverse auction for securing lowest-cost credit contracts. This program was the first of its kind in the State of Ohio. An ex post evaluation of the program was conducted on the first six rounds of reverse auction bidding (out of a total of ten completed to date) for nonpoint source projects (Newburn and Woodward, 2011).

0.2 Introduction

In 2004, ahead of statewide policy or rules for WQT, the Miami Conservancy District (MCD) (a watershed-based flood district with taxing authority) examined opportunities for a point source/nonpoint source WQT pilot program in the Great Miami River watershed (see Map 0.1). The program was designed to improve locally impaired waterways and to provide a cost-effective alternative for WWTP compliance under forthcoming nitrogen and phosphorus standards. Once nutrient standards are in place, municipal, industrial and other permitted point sources will be required to meet more stringent effluent requirements. Such limits will require significant capital investments and increase annual operation and maintenance costs for these permitted WWTPs.

The intent of the trading program is for agriculture to supply cost-effective nutrient reduction credits in lieu of anticipated point source reductions associated with expensive wastewater treatment plant upgrades. As agriculture is the predominant land use in the watershed, it was originally envisioned that trading opportunities in a water quality market with significant demand will motivate agricultural producers to participate. Robust participation by agriculture in a trading program can overcome common challenges in traditional programs that lack the authority or incentives to engage producers in water quality initiatives. The goal of the program was to establish a unit of credit for nitrogen and phosphorus reductions generated by agricultural best management practices (BMPs) that reduced nutrient loading to local surface bodies. Cost-effective credits would be sold to downstream wastewater treatment plants looking to offset effluent discharges. The program was developed with pre-compliance incentives to encouage early participation prior to issuance of more stringent WWTP effluent limits. Seven point source buyers representing a total of nine permitted outfalls have participated in the pre-compliance version of this early WQT market. (More than 300 permitted dischargers exist in this watershed.)



As of the case study report, nutrient standards have not been promulgated. Despite this setback, the MCD WQT program has been successful in conducting reverse auctions and funding agricultural producers to implement BMPs that improve water quality. The program has also been successful in getting financial support from point sources even though a regulatory driver for demand has been lagging.

Map 0.1 – Location of the Great Miami River Watershed in southern Ohio, U.S.

0.3 Legislative setting and economic background

The MCD WQT framework was approved by the Ohio Environmental Protection Agency (OEPA) prior to the promulgation of statewide trading rules in 2007. The statewide trading rules contain a grandfather clause that authorizes the MCD WQT program to continue using their existing trading framework for a limited time period of ten years. Each of the wastewater treatment plants (WWTPs) purchasing credits through MCD's WQT program have modified National Pollution Discharge

Elimination System (NPDES) permits that allow them to purchase credits to meet their effluent limit (or future limit). The WWTPs were given an additional financial incentive because of their early pre-compliance participation in the WQT pilot program. The incentive is in the form of a more favorable trading ratio in the future after the pre-compliance period.

As part of MCD's effort in developing a pilot point source/nonpoint source WQT program in the watershed, an economic analysis was conducted to examine two requisite conditions for WQT in the watershed. The analysis found that there was an adequate supply of agricultural nonpoint source reductions in phosphorus to meet all of the demand (and most of the nitrogen demand) through application of no-till management practices on 50% of the row crops in the watershed (K&A, 2004). The cost differentials between point source upgrades (approximately $422.5 million) and trading credits from agriculture (approximately $37.8 million) were sufficient to support a trading program (K&A, 2004).

MCD's WQT program focuses on those practices which achieve the highest and most cost-effective loading reductions of total phosphorus (TP) and total nitrogen (TN) in relation to the buyer's location in a watershed and point of water quality concern. For the MCD WQT program, these locations are upstream of WWTP buyers. Other federal conservation programs focus more on producers interested in implementing conservation plans and consider numerous conservation benefits of all environmental resources regardless of watershed location of load reduction. These resources include water quality issues in a ranking system that makes awards based on cumulative benefits. While both programs fund BMPs that may result in water quality benefits, trading programs using reverse auctions focus on those BMPs that deliver the greatest water quality benefits per dollar expended.

0.4 Brief description of results and impacts of the proposed EPI

In the pre-compliance phase, the main goal for the MCD WQT program to date has been testing and adapting a framework for WQT that will provide WWTPs and other permitted point sources with reliable nutrient credits to comply with future more strict effluent limits in NPDES permits. An economic assessment of the potential cost efficiencies of WQT in the Great Miami River Watershed revealed that the MCD WQT program will provide substantial cost savings in the future when stricter numeric nutrient standards are enforced.

In terms of environmental outcomes, the MCD WQT program has implemented ten rounds of agricultural BMP reverse auction bids. As part of the bidding process, local county Soil and Water Conservation Districts (SWCDs) must calculate the anticipated TP and TN load reduction from proposed BMPs. SWCDs must use state-approved spreadsheet tools to estimate the load reduction. This system provides more consistent load reduction estimates and assurance that the WQT program is environmentally sustainable. Contracted BMPs represent reductions of 339 tons of TN and 130 tons of TP reductions or credits through the first six rounds of reverse auctions. Additionally, the MCD conducts annual water quality monitoring throughout the watershed.

The geographic and social equity of credit distribution throughout the Great Miami River Watershed is affected by the program framework. The MCD WQT program requires point source buyers to purchase credits from upstream sources. This influences the distribution of eligible producers that can implement BMPs and sell nutrient credits based on the point source buyers in the market. In addition, because cost-effectiveness is one of the main project goals, as opposed to social equity, producers working with more experienced SWCDs tended to have more BMP proposals submitted and accepted than producers working with less experienced SWCDs. Newburn and Woodward (2011) determined that over time, SWCDs that participated in bidding each year could better inform their producers on what cost range to submit in their bids. This lead to an uneven distribution of BMP projects selected among the eligible counties in the watershed.

In addition to funding the lowest cost nutrient reductions in the watershed, there were several other benefits of the WQT program that were not directly targeted. Ancillary environmental benefits were realized through nonpoint source nutrient reductions, including: habitat improvement, stream shading/temperature benefits, streambank stabilization, flow velocity stabilization, and floodplain preservation. The MCD WQT program also fostered collaboration and cooperation between many disparate stakeholder groups beyond the pollutant reduction transaction. For example, several cities in the watershed have been working collaboratively with landowners and producers to develop recreational trails in what has been coined "Ohio's Great Corridor". In general, WQT has allowed MCD to leverage additional funds and resources for general water quality management that would otherwise be invested in traditional WWTP technology upgrades. In this way, WQT has achieved the intended water quality benefits and additional ancillary environmental, community quality of life, and watershed management benefits.

0.5 Conclusions and lessons learned

Overall the EPI has been relatively successful in meeting the goals of cost-effectively generating nutrient reductions in the watershed. Throughout the process of developing and testing a WQT framework, several enabling and disabling factors were identified. Necessary factors for successfully developing and implementing WQT include the commitment and leadership of a watershed "champion". This champion must engage a multitude of stakeholders and work through a public process to gain the support and buy-in from different stakeholder groups. It is important to take advantage of existing, well-established relationships within the watershed, especially when it comes to getting buy-in and participation from the agricultural community.

Disabling factors for WQT were also identified. The Great Miami River Watershed, like many watersheds in the U.S., lacks a definitive regulatory driver for water quality improvements, especially for point source dischargers. This is due in part to the lagging development of state numeric nutrient criteria. This lack of criteria has lead to a great deal of uncertainty in WQT markets and has limited demand.

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1 EPI Background

The Miami Conservancy District (MCD) initiated collaborative efforts with municipal wastewater treatment plants (WWTPs) and agriculture in 2003 to consider development of a point source/nonpoint source water quality trading (WQT) pilot program in the Great Miami River. This innovative EPI was developed prior to statewide rules for WQT and as such, MCD program elements followed the Federal Final Water Quality Trading Policy (USEPA, 2003). Starting in 2004, the MCD developed a policy framework for post-compliance WQT and began testing this framework in 2006 by implementing agricultulral BMPs through pilot trading. Elements of the framework are briefly described in this section.

1.1 Baseline characterization

WQT is a market-based approach to pollution control in which pollutant removal is traded as a commodity. With WQT, dischargers that reduce their pollutant loading below required levels can sell surplus reductions, called credits, to other dischargers that need to make reductions to meet compliance requirements. The WQT program in the GMR watershed was driven by the potential cost savings that nutrient credits could provide over treatment technology upgrades at WWTPs. The credits take on a monetary value, and it is the buying and selling of pollutant credits among dischargers to achieve an overall net reduction in loading in a watershed that is the essence of WQT. Credit price can be determined via negotiations between the credit buyer and seller, or it can be set by the government or other agencies. Usually the credit price cannot be lower than the cost to reduce pollutant loadings incurred by the seller (i.e., BMP implementation cost), and it cannot be higher than the cost of an abatement alternative for the buyer (i.e., treatment technology upgrade).

In 2004, MCD examined opportunities for a WQT pilot program in the GMR to improve locally impaired waterways and to provide WWTPs with flexible alternatives to address forthcoming nitrogen and phosphorus standards. As agriculture is the predominant land use in the watershed, it was envisioned that trading opportunities in a water quality market with significant demand would motivate agricultural producers to participate. Robust participation by agriculture in the program may help overcome common challenges in traditional conservation programs that lack the authority or incentives to engage agricultural producers in water quality initiatives. As such, an economic analysis was conducted to examine if two requisite conditions for WQT existed in the watershed. The analysis indicated that there was an adequate supply of agricultural nonpoint source reductions in phosphorus to meet all of the WWTP demand (and most of the nitrogen demand) through application of no-till management practices on 50% of the row crops in the watershed (K&A, 2004). The analysis also found cost differentials between WWTP upgrades (approximately $422.5 million) and trading credits from agriculture (approximately $37.8 million) were sufficient to support a trading program (K&A, 2004).

During this pre-compliance pilot period where nutrient limitations have not yet been included in WWTP permits, the MCD collects funds from WWTPs in the watershed that are used to purchase nutrient credits and fund administrative and water quality monitoring costs. The program has also been supported through numerous federal grants. In the post-compliance period, all revenue used to purchase credits will come from permitted point sources.

1.2 Key program features

Several conditions existed or were developed in order for the MCD pilot program to be operational. The first necessary condition was a driver for nutrient reductions. WWTPs in the watershed anticipate stricter effluent limits in their discharge permits and water quality impairments in the watershed continue to trigger TMDLs that will allocate nutrient load restrictions for both point and nonpoint sources. Second, a feasibility study for WQT in the watershed indicated that future WWTP demand for nutrient credits would result from stricter effluent limits. The study also reported the capacity for ample agricultural credit supply throughout the watershed. Political conditions in the watershed were also ripe for WQT. OEPA, the state permitting authority, modified WWTP discharge permits as part of the pilot program to allow nutrient credits to offset effluent limits. Lastly, the MCD has been a watershed champion for WQT and gained stakeholder buy-in through a robust public participation process.

The *Great Miami River Watershed Water Quality Credit Trading Program Operations Manual* developed by the Water Conservation Subdistrict of the MCD (MCD, 2005) outlines the WQT program framework. Key features of the program are briefly described here:

Policy Objectives The manual points to the following environmental, social, and economic objectives (MCD, 2005): 1) improved surface water quality in the watershed (primarily measured by nutrient concentrations, biological indicators, and beneficial use attainment); 2) increased implementation of agricultural BMPs (tracked and quantified through pounds of nutrients not discharged; and, 3) lower costs for WWTP rate payers (eventually quantified through the savings WQT offers when compared to treatment technology upgrades at plants).

Program Design and Delivery Mechanisms The program involves voluntary point source/nonpoint source trading of phosphorus and nitrogen credits, where a credit represents one pound of phopshorus or nitrogen prevented from discharing into surface water in the watershed (MCD, 2005). Landowners work with truested agricultural agents from County Soil and Water Conservation Districts (SWCDs) to develop BMP proposals for credits. The MCD, acting as a third party credit clearinghouse, selects proposals using a reverse auction process where contracts are awarded to proposals with the lowest cost credits first. Contracts are then awarded to proposals with the next highest credit costs until the target number of credits are obtained. Figure 1.1 demonstrates the flow of nutrient credits from agriculture to WWTPs (see compound arrows). Dashed lines between SWCDs and the Ohio Department of Natural Resources (ODNR) represent credit calculation and BMP inspection oversight. ODNR and MCD interact through adaptive management of credit calculations.

Safeguarding Mechanisms to Avoid Negative Effects During the pilot trading period, the program uses two safeguarding mechanims to ensure environmental protection and validity of nutrient credits: 1) WWTPs are limited to buying only upstream nutrient credits to avoid nutrient hotspots at or below the plant and ensure environmental benefits throughout the watershed, and 2) annual site inspections are conducted to ensure BMPs are maintained and operated to agreed upon standards. A third mechanism is described in the manual and will be used once post-compliance trading begins. This mechanism involves MCD managing an insurance pool of credits that can be used to address credit failure.

Imact Assessments The manual outlines two different ways in which the WQT program will be evaluated and how improvements will be made once post-compliance trading begins: 1) the performance of agricultural BMPs will be validated through site-specific water quality monitoring and results will be used to periodically evaluate the credit estimation methods, and 2) the overall program performance will be validated through continuous water quality monitoring at several points throughout the watershed and results will be used to evaluate the entire WQT program to ensure environmental protection.

Political and Legal Process The structure of the program is such that MCD has taken on the role of credit clearinghouse and facilitator of trading. The program relies on existing legal framework between WWTPs and the OEPA. Figure 1.1 represents OEPA's role in the program in terms of reviewing water quality monitoring data and working with WWTPs to incorporate trading into discharge permits (solid line arrows). WWTPs then enter puchases of credits through the MCD.

Public Participation The manual describes the initial interaction of stakeholders in developing the WQT program. Over 100 meetings have been held between MCD and SWCD boards, joint boards, WWTPs, and community-based watershed organization to solicit input. Numerous meetings where also held with state (OEPA, ODNR) and federal agencies (US EPA, USDA), Ohio Environmental Council and Ohio Farm Bureau.

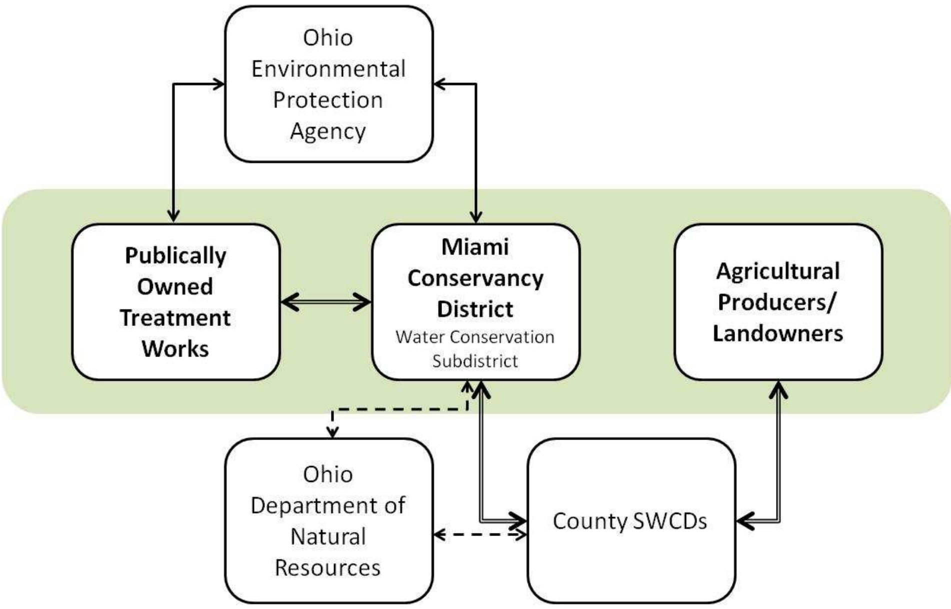


Figure 1.1 – Organizational flowchart of WQT in the Great Miami River Watershed (green box indicates trading between nonpoint sources and point sources, such as agriculture and WWTPs, which occurs through third party interactions; compound lines represent credit flow; dashed lines represent the relationship between ODNR and agriculture; solid lines represent regulatory oversight of OEPA).

Source: Adapted from MCD, 2005

2 Characterisation of the case study area

The EPI piloted by the MCD beginning in 2006 targeted the development of a water quality (pollutant) trading program in the Great Miami River (GMR) watershed of southwest Ohio, USA. The watershed is primarily agricultural resulting in water quality impairments related to nutrient and sediment loading. Over 300 WWTPs are also scattered through the basin in both small and large communities. Pending nutrient standards in Ohio to address eutrophication concerns will result in lower permit limits for phosphorus and nitrogen in wastewater discharges. Required treatment technology to meet new limits is expensive, requiring substantial capital upgrade costs. Nutrient losses from agricultural practices are largely unregulated and corrections relatively inexpensive. As such, potential cost savings with nutrient trading between permitted dischargers and agriculture were evaluated as a cost-effective compliance alternative to WWTP upgrades. This section further describes the Great Miami River Watershed setting.

2.1 Land use in the Great Miami River Watershed

The GMR watershed is approximately 1M hectares in area and covers portions of fourteen counties. It drains to the Ohio River which eventually discharges to the Gulf of Mexico after joining with the Mississippi River. Map 2.1 depicts the location and land cover of the watershed in southwestern Ohio. Upper and lower watersheds (outlined in blue) are dominated by agricultural land cover comprising nearly 70% of the land use (USDA, 2010). Western portions of these areas cross into the state of Indiana in Darke, Preble and Bulter Counties. According to the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service, cultivated crops are the main agricultural land use covering over 50% of the land area (USDA, 2010). The USDA's 2010 cropland GIS data layer provides a breakdown of cultivated crops by crop type. These recent land use data show cultivated crops in the watershed are comprised of approximately 45% corn, 50% soybeans, 4% winter wheat and less than 1% in other crops (refer to Table 2.1).

The major urban areas are located in the southeast portions of the watershed (Map 2.1) comprising over 15% of the land use in the watershed (USDA, 2010). The majority of forested lands in the watershed are located near the southern terminus of the Great Miami River. Forests constitute less than 13% of the land use in the watershed (USDA, 2010).

Table 2.1 – Land use in 2010 in the Great Miami River Watershed

Land Use	Hectares
Urban areas	168,523
Forest	130,453
Grassland/shrub	9,093
Pasture/hay	160,574
Cultivated crops	528,774
Wetlands	791
Other (barren/fallow)	789

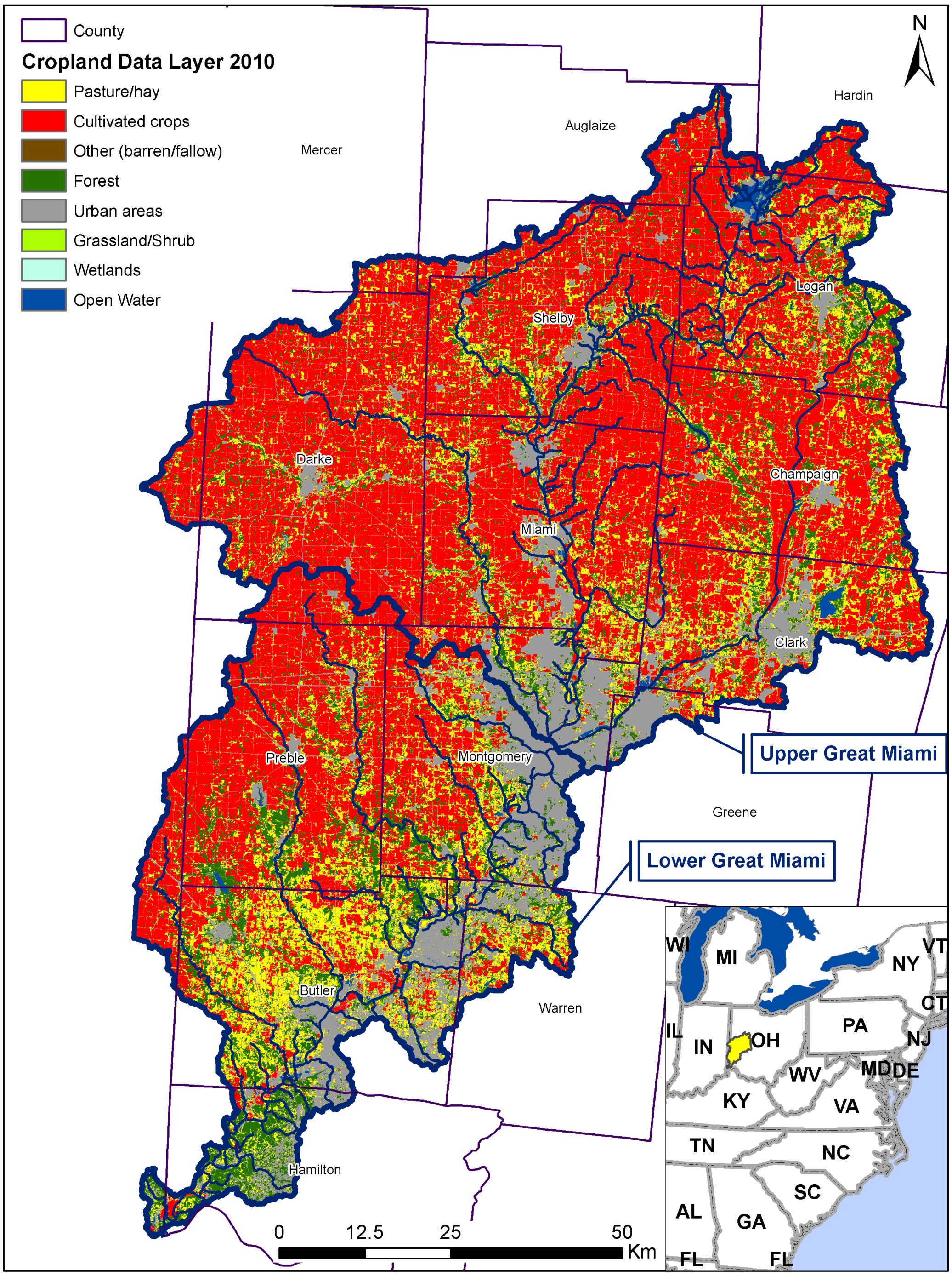
Source: USDA, 2010

2.2 Water quality and economic drivers in the Great Miami River Watershed

The Great Miami River Watershed is home to approximately 1.5 million people (US Bureau of the Census, 2010). The population density in urban centers (shown in Map 2.2) and the high percentage of agricultural land use in the watershed both contribute runoff to surface waters. According to the Ohio Department of Development (2010), Ohio has the eighth largest economy in the United States with a GDP of $471.5 billion, or 3.33% of the United State's GDP. Manufacturing is the largest industry in Ohio. While agriculture (crop and animal production) is only 2.22% of Ohio's GDP, the net growth in agricultural has out-paced Ohio's overall growth (ODD, 2010). In 2007, Ohio was the fifth ranked source for soybeans and the seventh ranked source for corn with 7.5 and 4.1 percent, respectively, of national production (US Bureau of the Census, 2008). Rowcrop production such as corn and soybeans can put pressure on water resources and water quality if Best Mangement Practices (BMPs) to conserve soil and reduce agricultural and urban runoff are not in place. Nonpoint source (diffuse) pollution in general has been identified as the main source of impairment throughout the Great Miami River Watershed resulting in over enrichment of streams, excess sediment loading, and habitat alterations (OEPA, 2000).

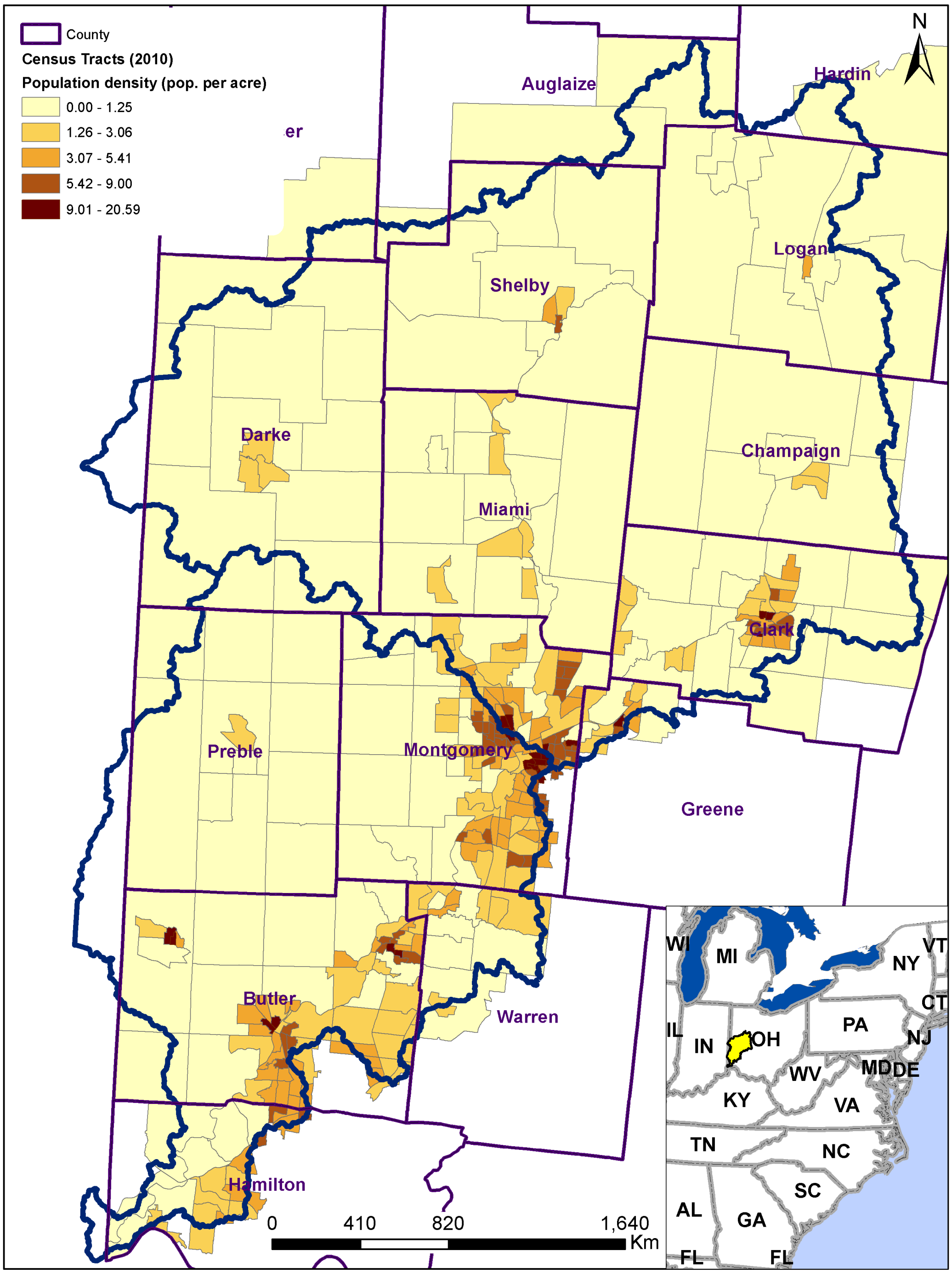
In the U.S., states are required to assess surface waterbodies and report water quality impairments to the U.S. Environmental Protection Agency (USEPA). To address impaired waterbodies, states must analyze the sources of impairment and set a Total Maximum Daily Load (TMDL) for pollutants of concern that the waterbody can receive in order to meet an acceptable level of water quality. To date, the USEPA (2011) identifies that in the Upper Great Miami River Watershed there are 25 TMDLs for phosphorus, eight TMDLs for sediment and four TMDLs for nitrogen and two sediment TMDLs in the Lower Great Miami River Watershed. Watersheds with TMDLs must address the sources of pollution by setting allowable discharge limits by sector (e.g., industrial, urban and agricultural). Water quality impairments and TMDLs are one driver for the Great Miami River EPI pilot project to cost-effectively meet the loading limits in TMDLs and address pollutant sources contributing to water quality impairments.

Another water quality-related driver for this EPI has been developing in the watershed for several years. Section 304(a) of the Federal Water Pollution Control Act of 1972 (refered to herein as the Clean Water Act) identifies that USEPA and/or delegated authorities shall develop numeric water quality criteria for all surface waters (as seen in USEPA, 2000). In Ohio, the Ohio Enviromental Protection Agency (OEPA) has been working on such standards since 2004. Permited point source discharges in the Great Miami River anticipate that numeric standards for nutrients will result in lower effluent limits of phosphorus and nitrogen in future permits. A study completed by Kieser & Associates, LLC in 2004 found that a majority of the WWTPs in the watershed would need to upgrade their treatment technology to Biological Nutrient Removal (BNR) in order to meet the anticipated and more stringent nutrient effluent limits (K&A, 2004). This study identified how both small and large WWTPs may face high technology upgrade costs in the face of new effluent limitations on nutrients.



Map 2.1 – Land use in the Great Miami River Watershed from USDA 2010 Cropland Data Layer

Source: USDA Cropland Data, 2010



Map 2.2 – Census Tract Population Density in 2010 for Counties in the Great Miami River Watershed

Source: U.S. Census Tract, 2010

3 Assessment Criteria

A number of indicators can be used to measure the success of an EPI. This summary of assessment criteria discussed in Section 3 aims to answer the question of what environmental outcomes this case study has produced and at what cost. Economic efficiency and transaction costs are also explored in more detail.

3.1 Environmental outcomes

An ex-post evaluation of the MCD WQT program was published by Newburn and Woodward (2011) that summarizes the nutrient load reductions (combined pounds of total phosphorus and total nitrogen) from reverse auction rounds one through six. Table 3.1 provides a breakdown of the types of BMPs implemented by the pilot program and the estimated load reductions (as calculated by SWCDs using ODNR approved spreadsheet tools).

Table 3.1 – BMP proposal applications and load reductions by practice type

BMP Type	Proposals Submitted	Proposals Funded	Funded Proposals	
			Total Nutrients Reduced (lbs)	Minimum and Maximum Bid (USD/lb)
Bank stabilization	7	5	39,466	1.69-1.75
Cover crops	55	47	67,342	0.36-2.00
Filter strips	2	0	NA	NA
Grass waterways	14	9	36,224	1.24-2.00
Fertilizer management	10	0	NA	NA
Hayfield establishment	11	9	26,357	1.12-1.60
Livestock management	12	12	467,768	1.20-1.99
Conservation tillage	49	18	171,689	0.58-2.00
Total	160	100	808,845	0.36-2.00

Source: Adapted from Newburn and Woodward, 2011

There is an implicit understanding that these BMPs produce environmental benefits in the form of nutrient reductions, especially in the pre-compliance period when WWTPs are not yet required to reduce effluent discharges of nutrients. Yet it is important to note that the nutrient reductions in Table 3.1 are estimates using a spreadsheet calculator based on empirical load reduction formulae. These formulae determine a nutrient reduction from a BMP assuming average conditions. The calculator does not take into account delivery to the surface water body or fate and transport through the watershed in the MCD program.

To better confirm water quality benefits, MCD does annual water quality sampling throughout the watershed.

In addition to quantitative water quality benefits, the MCD WQT program has identified several ancillary benefits trading can produce when compared to technology upgrades at WWTPs alone. Many agricultural BMPs reduce sediment loading to local streams and rivers that would otherwise not be contributed by or regulated at a WWTP. Riparian BMPs and other upland BMPs result in improved riparian and in-stream habitat. Riparian BMPs can also provide canopy that shades streams and rivers and helps control in-stream temperature. Streambank stabilization and velocity are also improved through select agricultural BMPs. WQT also has the potential of increasing the geographic extent of many water quality benefits when upstream trading in headwater streams is utilized. Instead of implementing an improvement in water quality at the WWTP effluent discharge location, this pilot program requires an equivalent or greater reduction in pollution to occur upstream of the discharge point. In many cases this results in improved stream conditions and water quality in sensitive headwater tributaries.

3.2 Economic Assessment Criteria

The MCD authorized an economic analysis of WQT in the Great Miami River watershed in order to make an informed decision on the economic benefits of WQT before developing a pilot program. K&A (2004) completed this preliminary economic analysis and reported a substantial cost savings for WWTPs if they were to purchase nutrient credits rather than upgrade plants to biological nutrient removal (BNR) technology. Using the best available information at the time of the study and reasonable assumptions, it was determined that treatment plant upgrades to BNR for a majority of the WWTPs in the Great Miami River watershed would cost approximately $422.5 million dollars (based on a 20 year investment and 5% interest rate using 2003 US$). Assuming the WWTPs would have to meet a 1 mg/L phosphorus and 10mg/L nitrogen limit, an equivalent amount of nonpoint source nutrient credits would cost WWTPs approximately $37.8 million (based on no-till practice costs) (K&A, 2004). This resulted in a projected cost-savings of approximately $384.7 million.

One way in which the MCD and program decision-makers worked to make WQT cost-effective was by selecting a reverse auction method for soliciting proposed BMPs projects. This method has been employed in selecting projects in all ten rounds of Request for Proposals (RFPs). Once all proposals are submitted, MCD selects the lowest “bids” for BMP projects until all of the funds for that particular round are committed. In an ex-post evaluation of the MCD WQT program, Newburn and Woodward (2011) assessed the cost-efficiency of MCD’s reverse auction method from the supply side of the market. According to their cost savings metric, the average cost-savings for agricultural BMPs in round one was 32%. The cost-savings decreased to 19% when rounds one through six were evaluated (see Table 3.2). Newburn and Woodward (2011) suggest this was due to SWCDs learning the relatively stable threshold of credit prices MCD would fund after multiple rounds. They point out that over time the WQT program has begun to function more like a fixed-priced program versus a reverse auction (Newburn and Woodward, 2011).

Table 3.2 – Cost savings by round of reverse auction

Round Number	Proposals Submitted	% Accepted	CS Metric (% savings)
1	19	63	32
2	62	24	24
3	9	89	28
4	18	78	19
5	2	50	1
6	50	100	14
Average		63	19

Source: Adapted from Newburn and Woodward, 2011

While the reverse auction method advances the goal of cost-efficiency, it does not benefit all stakeholders equally. In theory, the WWTP buyers benefit by getting the lowest cost nutrient credits in the watershed. It is important to note not all SWCDs in the watershed submitted proposals for BMP projects, so lower cost credits may exist throughout the watershed. In this case, producers located in counties where SWCDs did not participate in the WQT program lost out on a potential funding stream for BMPs. WWTPs are also required to pay into the program proportionally, but because of the trading requirement where WWTPs can only apply upstream credits to their permit, plants located higher in the watershed may not be able to access credits in proportion to what they pay for through MCD.

Other stakeholder groups that are at a disadvantage in the MCD WQT program framework include producers already participating in USDA Farm Bill programs (i.e., federal cost-share programs for conservation practices). These producers are ineligible for trading in the MCD program. In general, BMPs with relatively high costs compared to credit potential would not be awarded through the reverse auction. Producers that want to be compensated for full opportunity costs are also less competitive in the reverse auction system. Because the reverse auction method favours lower cost credits, BMP such as vegetative buffers with native plantings are less competitive than those with non-native brome grass, for example. The drawback is that brome grass, which generally comes at a lower cost, has less habitat value than more costly native plantings.

While the WQT program has the potential to increase cost-efficiency of nutrient reductions for WWTPs, it also presents an increase in risk when compared to command-and-control alternatives (i.e., plant upgrade). The MCD WQT trading plan was designed to offset this risk using a number of different approaches. First, decision-makers sought institutional buy-in from regulatory agencies in advance of trading and continue to consult agencies while implementing the trading program. Second, the trading plan describes an insurance pool of credits and a contingency plant that will be operated once WWTPs engage in trading for compliance purposes. The insurance pool of credits will be managed by MCD, in consultation with OEPA and ODNR, to replace credits in the event of BMP failure. The contingency plan, developed by MCD and maintained with input from ODNR, assures a timely, coordinated and consistent response to BMP failure (MCD, 2011). This contingency plan and individual BMP contracts include provisions related to recovery of funds from failed BMPs.

The MCD WQT program provides good incentives to meet two prerequisites of a successful nutrient credit market. In order to develop a market for nutrient credits, there must be sufficient buyer demand for credits and a large enough cost margin between trading and traditional command-and-control alternatives to attract buyers. Since no definitive drivers were in place in the watershed when MCD initially develop the WQT program (e.g., numeric water quality standards or restrictive wasteload allocations), MCD provided buyers with a financial incentive to participate in early, pre-compliance trading. MCD negotiated with OEPA that WWTPs that purchased credits prior to a compliance driver would be guaranteed a better trade ratio when purchasing credits in the future. Early participants are now locked into a 1:1 trade ratio for buyers discharging to fully attaining waters and a 2:1 trade ratio for buyers discharging to impaired waters (MCD, 2011). For WWTPs that purchase credits after the pre-compliance period, trade ratios will be 2:1 and 3:1, respectively. The reverse auction method discussed in this section is the second incentive MCD developed to attract buyers. By purchasing the lowest cost credits, MCD is able to keep cost margins high enough to make trading more attractive to WWTPs than traditional technology upgrades.

Due to the transparency MCD established at the outset of the WQT program, asymmetric information was not an issue during initial rounds of reverse auctions. In later rounds in could be argued that some county SWCDs were less astute at getting the best information to producers on the expected level of payments MCD would select during the reverse auction. This lack of knowledge on behalf of the SWCDs and lack of information provided to producers in these counties could be seen as asymmetric information. Newburn and Woodward (2011) point out that of the fourteen eligible counties in the watershed, 78% of all proposals submitted in rounds one through six came from three counties (Darke, Preble and Shelby). They also note that these counties had a high rate of acceptance of their proposals, which tended to increase in subsequent bidding rounds.

3.3 Distributional Effects and Social Equity

3.4 WQT provides a flexible and innovative means to realizing pollution reductions in a cost-effective manner. Social equity and even distribution of funding are not main tenants of WQT. This case study has already some of the program requirements and features that lead to targeted and uneven distribution of BMP projects. In the MCD WQT program, upstream trading is required of credit buyers (i.e., nonpoint source reductions must be generated upstream of a buyers discharge point). Due to this requirement, producers located below the group of WWTPs participating in the MCD WQT program are ineligible to sell credits in this limited pilot market. The locations of participating WWTPs are shown in Institutions

In terms of water administration and management, interactions between state regulatory agencies, WWTPs and producers are important to understand and respect when developing a WQT program. In the initial phases of developing this WQT program, tension existed between state regulatory agencies and agricultural producers. Producers have traditionally been uneasy about regulators having access to their property. Because the WQT program required some level of inspection of BMPs to ensure they are operated and maintained to acceptable standards, MCD had to be sensitive to producer concerns over regulatory agencies playing a role in BMP inspections. To get producer buy-in, MCD developed a system where SWCDs would perform inspections of BMPs. MCD was able to take advantage of existing and trusted relationship SWCDs had with producers.

Map 3.1. Another factor that limits producer participation on a spatial basis is the requirement that county SWCDs must complete proposals on behalf of the producer and submit them to MCD for the reverse auction. Not all SWCDs participated in the WQT program. Table 3.3 from Newburn and Woodward (2011) provides a breakdown of the proposals submitted to MCD during rounds one through six. As previously mentioned, three of the county SWCDs (Darke, Preble and Shelby) seemed to have higher success in getting proposals accepted and funded.

Table 3.3 – Proposal applications and percent acceptance by county and round number (percent acceptance in parenthesis)

County	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Total
Butler	1 (0)	2 (50)			1 (0)		4 (25)
Clark				5 (40)			5 (40)
Darke	7 (100)	2 (100)	6 (100)	5 (100)	1 (100)	16 (100)	37 (100)
Logan	1 (100)					3 (100)	4 (100)
Mercer		1 (100)				9 (100)	10 (100)
Miami	1 (100)		1 (100)	4 (100)		1 (100)	7 (100)
Montgomery	2 (100)						2 (100)
Preble		54 (15)					54 (15)
Shelby	4 (0)	3 (67)	2 (50)	4 (100)		21 (100)	34 (85)
Warren	3 (33)						3 (33)
Total	19 (63)	62 (24)	9 (89)	18 (78)	2 (50)	50 (100)	160 (63)

Note: Five of the 15 eligible counties (Auglaize, Champaign, Hamilton, Hardin and Greene) did not submit any applications

Source: Newburn and Woodward, 2011

Another factor influencing the sell side of the market (i.e., producers) is whether the producer wants to be compensated for all of their BMP and opportunity costs. The MCD WQT program is voluntary and encourages low cost credits from producers. If a producer wants a particular BMP implemented at their farm because it will increase quality of life or provide an improvement to their operations, the producer can under price their BMP proposal to make it more competitive. Another inequality for individual producers can occur if their local SWCD adds costs to the BMP proposal to cover the cost of SWCD technical services. The MCD WQT program allows SWCDs to decide on a case-by-case basis whether they want to add compensation for technical services to the BMP proposal.

Overall, the EPI has had a very positive effect on the community. In addition to the environmental outcomes and benefits discussed in Section 3.1, the MCD WQT program has provided the following benefits to the watershed:

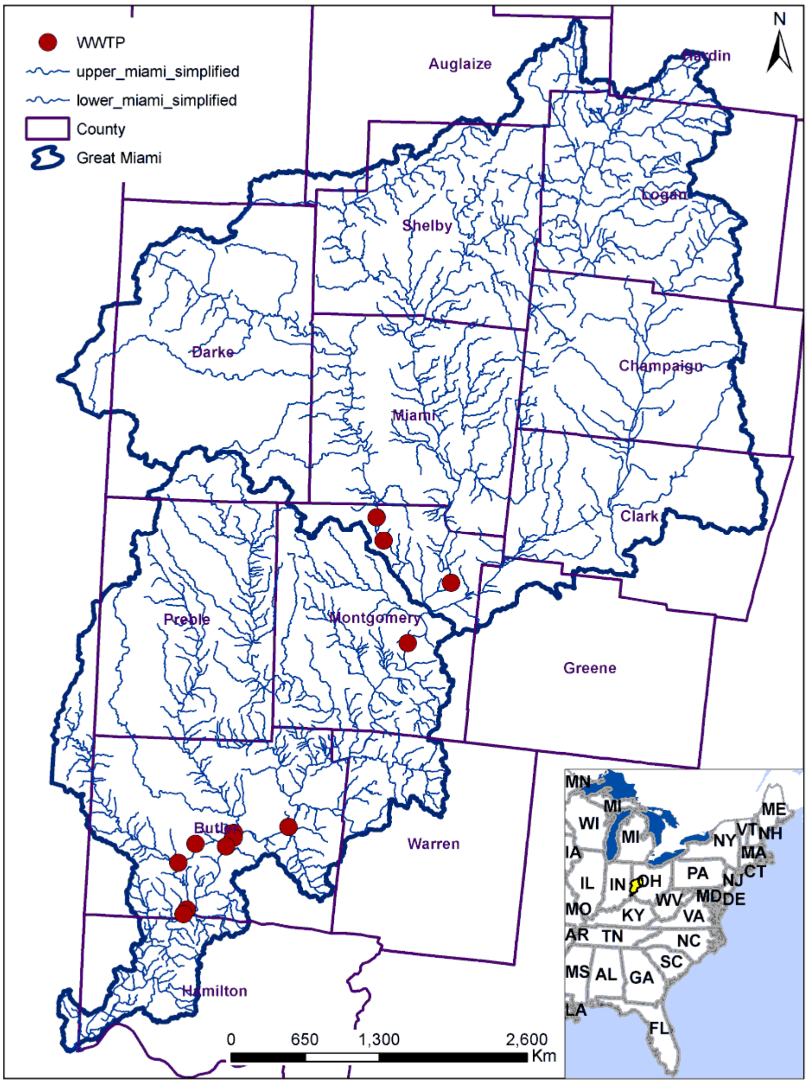
- Provides much needed funding to county SWCDs (which can add administrative fees to producer bids)
- Provides additional funding to further implement agricultural BMPs
- Provides water quality data to state agencies which contributes to more accurate development of water body load reduction needs
- WQT leverages funds to undertake watershed management functions that would not otherwise be spent on nonpoint source nutrient reductions
- Improves stakeholder interactions between the participating cities (with WWTPs) and agricultural producers
- Political acceptance with state legislators supporting the program

- Improves relationship between MCD and the community/landowners (prior to WQT program citizenry was concerned over MCD's eminent domain authority to seize land for flood control)
- Garners support from environmental groups (e.g., Sierra Club issued a press release in support of the program in a 2007 issue of their newsletter; Sierra Club, 2007)

3.5 Institutions

In terms of water administration and management, interactions between state regulatory agencies, WWTPs and producers are important to understand and respect when developing a WQT program. In the initial phases of developing this WQT program, tension existed between state regulatory agencies and agricultural producers. Producers have traditionally been uneasy about regulators having access to their property. Because the WQT program required some level of inspection of BMPs to ensure they are operated and maintained to acceptable standards, MCD had to be sensitive to producer concerns over regulatory agencies playing a role in BMP inspections. To get producer buy-in, MCD developed a system where SWCDs would perform inspections of BMPs. MCD was able to take advantage of existing and trusted relationship SWCDs had with producers.

Map 3.1 – Locations of WWTPs participating in the MCD WQT program



Source: MCD

3.6 Policy Implementability

Implementation of WQT in the state of Ohio has been relatively successful when compared to similar water quality markets throughout the U.S. (USEPA, 2008). Trading success started with the MCD WQT program, which developed and implemented a flexible, yet reliable trading framework for the Great Miami River. In many ways, the MCD WQT program forced OEPA to promulgate statewide trading rules. Although these rules were highly influenced by the MCD WQT program, early drafts of the rules contradicted elements of the MCD framework (D. Hall, personal communication, 2011). This initiated a grandfather clause and adaptation of the rules to allow for the MCD WQT program to continue using the same framework. These statewide trading rules, promulgated in 2007, also provide for a flexible and adaptive approach to WQT which allows each individual trading program in the state to be innovative. They also provided assurances to the public that nutrient reductions are real and surplus (beyond what was already required as applicable to each credit seller).

In addition to influencing statewide trading rules, the MCD WQT program resulted in cooperation and coordination between OEPA and ODNR, which did not happen initially. The two state agencies now work collaboratively in overseeing different aspects of the WQT program. Buy-in and support from OEPA and ODNR did much to advance the WQT program and helped MCD gain broader buy-in from stakeholders and credit buyers (D. Hall, personal communication, 2011). In addition to agency support, MCD held more than 100 stakeholder meetings to engage municipal buyers, agricultural sellers, federal agencies, environmental groups and the general public to design a WQT program that would have wide support of stakeholders. This included groups that might typically be opposed to market-based approaches to nutrient reductions.

While MCD has experienced success with their WQT program, there are barriers that have impeded expansion of the program. For instance, there is currently no definitive driver in the watershed to drive demand for nutrient credits from point source or other buyers. At the state and regional level numeric nutrient standards have been lagging. In addition, a TMDL developed by OEPA for a sub-basin of the Great Miami was determined to be flawed based on early WQT economic modelling (K&A, 2004) and later on WQT program monitoring. OEPA eventually rescinded this TMDL. These actions produce uncertainty in the market and work to lower demand for nutrient credits.

3.7 Transaction Costs

Much of the start-up cost and initial program develop was heavily subsidized through federal grants (D. Hall, personal communication, 2011). Newburn and Woodward (2011) assessed the transaction costs for both search and bargaining and monitoring and enforcement in their ex-post evaluation of the MCD WQT program. Overall, they concluded that transaction costs do not create a considerable barrier to market efficiency.

Newburn and Woodward (2011) go on to explain that the institutional framework of the MCD WQT program is such that MCD acts as a clearinghouse for nutrient trades. This design lowers the bargaining costs for trading since there is no contract between buyer and seller that needs to be negotiated. In addition, the clearinghouse model eliminates the cost to the buyer and seller incurred when searching for trading partners. The reverse auction method also reduced transaction costs on the supply side since BMP proposals are accepted or denied based solely on cost and credits generated (Newburn and Woodward, 2011).

Another aspect of the trading program that Newburn and Woodward (2011) identify as a way in which MCD gains cost-savings is by using the county SWCD offices to recruit producers. They point out that SWCDs already have similar duties to provide technical services to producers under larger federal conservation programs, therefore SWCD duties are not greatly expanded by participating in trading. A breakdown of the costs for producer assistance (including recruitment, design/implementation, credit calculations, and proposal preparation) and monitoring are presented in Table 3.4 after Newburn and Woodward, 2011. The SWCD cost assistance and monitoring represent approximately 3.9% and 1.0% (respectively) of the over $1.3 million total expenditures of the MCD (reported by Newburn and Woodward, 2011 after round six).

Table 3.4 – Total program funds for producer assistance, BMP monitoring and producer BMP payments in participating counties

County	Funded Projects	SWCD Initial Assistance Cost (USD)	SWCD Monitoring Cost (USD)	Farmer Payments (USD)	Number of SWCD Staff[1]
Butler	1	350	0	18,000	3
Clark	2	400	1,000	15,909	4.5
Darke	37	46,475	11,128	790,149	7
Logan	4	1,650	150	20,833	4.5
Mercer	10	0	0	23,927	5.5
Miami	6	1,125	625	57,085	5
Montgomery	2	1,900	100	15,855	6.5
Preble	8	800	1,000	20,329	5
Shelby	29	0	0	262,164	7
Warren	1	0	0	45,260	3
Total	100	52,700	14,003	1,269,511	51

Note: [1]SWCD staff numbers were gathered by Newburn and Woodward, 2011 during in-person interviews in June 2009. All other values are from the bid data provided by the MCD.

Source: Adapted from Newburn and Woodward, 2011

3.8 Uncertainty

In the evaluation of the MCD WQT program there are two forms of uncertainty that exist. First, there is market uncertainty for potential credit buyers (i.e., point sources). Second, there is uncertainty in data and credit calculation methods that must be addressed through programmatic elements.

The regulatory climate in the U.S. is such that permitted point sources do not have adequate knowledge of how future water quality regulations will affect their operations. U.S. EPA and states have been working on developing numeric nutrient criteria for over a decade with little success. This lack of certainty surrounding future regulatory requirements for point sources results in market uncertainty for the demand side of a WQT market.

One of the main objectives of WQT is to ensure real and surplus nutrient reductions are taking place (i.e., water quality benefits). Under the current pilot program setting, quantified nutrient load reductions (from ODNR-approved credit calculation methods) are relatively imprecise. Nutrient load reductions are calculated using simple empirical spreadsheet calculations.

Uncertainty increases substantially when trying to quantitatively estimate or measure precise nutrient load reductions from nonpoint source BMPs when compared to WWTP effluent monitoring. Because the MCD WQT program is still in the pre-compliance phase, no credit discounting or modifications to trade ratios have been employed to address this uncertainty. When WWTPs are under a compliance regime, a 2:1 trade ratio will become the minimum trade ratio used for WWTPs discharging to unimpaired waters and 3:1 for those discharging to impaired water bodies. This will address some of the uncertainty related to estimating nutrient reductions from BMPs, though only by assumption and not by statistical analysis of this uncertainty.

4 Conclusions

MCD WQT program implementation has been successful in completing nutrient credit trading between point sources and nonpoint sources. These trades have taken place in a pre-compliance setting through a pilot program. Moving from pre-compliance to post-compliance and increasing trading at scale may present both benefits and challenges to WQT. The program has succeeded in implementing BMPs that have explicit water quality benefits as well as other ancillary benefits. The program has been shown to be cost-efficient due to BMP funding mechanisms and the program framework. The program has been successful in working with existing institutions and adapting to preferences of different sectors in order to build trust between stakeholders (e.g., ensuring producers that site inspections would not be conducted by regulatory agencies, putting them at higher enforcement risk). In addition, Newburn and Woodward (2011) found the program transaction costs to be relatively low. They attributed this to MCD’s ability to work with existing agricultural technical service providers in the watershed and MCD’s clearinghouse model which lowered search and bargaining costs.

In terms of economic efficiency, MCD has been successful for a number of reasons. In an ex post evaluation of rounds one through six of RFPs, Newburn and Woodward (2011) report that MCD funded BMPs at a substantial cost-savings averaging 19%. This cost-efficiency is due to the reverse auction method used by MCD. A study by K&A (2004) indicated that WWTPs have the potential to realize substantial cost-savings using WQT instead of traditional technology upgrades to meet more stringent effluent limits in permits in the future. While the MCD WQT program has been highly subsidized by federal grants, the transaction costs have been relatively low (Newburn and Woodward, 2011). Program staff anticipate costs to continue to decrease in the future once the market grows with future demand (D. Hall, personal communication, 2011).

4.1 Lessons learned

The MCD WQT program was designed for post-compliance nutrient credit trading and was tested prior to this compliance stage using a pilot approach. The pilot program provided useful insight into the general application of the EPI and its transferability to other settings. A summary of the lessons learned is provided here (from program staff, consultants and researcher observations).

Stakeholder collaboration was critical in the initial stages of program development. This phase was, however, time intensive (D. Hall, personal communication, August 19, 2008). MCD convened more than 100 meetings from 2003-2005 and started a committee for program decision-making. Stakeholder meetings involved cities and counties with WWTPs, SWCDs, agricultural producers, OEPA, U.S. EPA, ODNR, Ohio Farm Bureau, Chamber of Commerce, USDA and the Ohio Environmental Council.

Minimum new bureaucracy was a strength of the program noted by MCD staff (D. Hall, personal communication, August 19, 2008). The WQT program incorporated existing state regulatory agencies and agricultural technical service providers into the administrative process. In addition to these existing institutions, MCD acted as a clearinghouse to negotiate and manage trades between point sources and nonpoint sources. WWTPs typically do not have expertise or staff in these regards.

Partnering with existing agricultural organizations was key to agricultural producer participation and lower transaction costs (D. Hall, personal communication, 2011; Newburn and Woodward, 2011). Agricultural producers already had a level of trust with SWCDs and expressed concerns in the initial program development phase about state regulatory agencies having access to their private property. Using the SWCDs resulted in better producer buy-in and helped lower transactions costs MCD would otherwise incur if their own staff had to recruit producers to implement BMPs.

In addition to "lessons learned", MCD experienced a few unintended consequences that were generally beneficially to the community. First, new relationships have been formed as an outgrowth of the WQT program. These relationships between cities and rural landowners have led to a collaborative branding campaign in the watershed. Ten cities and approximately 100 miles of river are now part of "Ohio's Great Corridor", which has led to rural land preservation and opportunities for new recreational trails (D. Hall, personal communication, April 7, 2011). A copy of the Ohio's Great Corridor brochure is included in Annex I.

A second unintended benefit of WQT in the watershed has been MCD's ability to leverage additional funds and resources for general watershed management. Without WQT it can be argued that many of the BMPs implemented through this program would not have been implemented. The nutrient and sediment reductions, in addition to other ancillary benefits discussed herein, are the direct result of the MCD WQT pilot project. In addition, MCD has been collecting water quality monitoring data throughout the watershed as part of the WQT program. These data has been able to inform state agencies in developing better TMDLs for impaired waters.

Even though the MCD WQT program has seen success in implementing WQT in the Great Miami River Watershed, there are improvements that could be made to the program, especially when transferring the EPI to different watersheds and local markets. These include:

- Adoption and application of discount factors for nutrient credits, including delivery, location and bioavailability factors.
- Independent, third-party oversight/inspection of agricultural BMPs

4.2 Enabling / Disabling Factors

There are a number of factors that helped enable MCD in developing a functioning WQT pilot program. The factors, listed below are important considerations for other watersheds interested in developing a point source/nonpoint source credit trading market:

- MCD acted as a watershed champion to convene stakeholders and a decision-making committee that was committed to developing a program with broad buy-in and support. When WQT involves both point sources and nonpoint sources, broad support is necessary to get participation in the market on both the supply side and demand side. When regulated entities are involved the program can get even more scrutiny and may require broader stakeholder participation.
- WQT that involves agricultural producers has unique challenges in terms of recruitment, establishing trusted relationships, ensuring BMP performance, communication and contract negotiation. Taking advantage of existing relationships between county SWCDs and producers was a key program success for the MCD WQT program.

A number of factors serve as barriers for trading in the MCD WQT program example. These disabling factors are also transferable to other settings and should be considered in other watersheds developing WQT:

- The Great Miami River watershed, like many watersheds in the U.S. lacks definitive drivers for water quality improvements, especially for point sources dischargers. U.S. EPA and state agencies have been working towards numeric nutrient criteria for rivers and lakes for over a decade with little success. States have been slow to develop TMDLs for impaired waters that would require point sources to reduce effluent discharges. It was envisioned that these types of water quality standards would serve as substantial drivers for WQT.

- Lack of numeric water quality criteria have led to a great deal of uncertainty in the market for credit buyers. Until federal and state regulators can provide a clear understanding to point sources on what standards and timeline they will have to meet in the future, point sources will continue to be hesitant to participate in WQT. This uncertainty makes quantifying economic benefits or cost-efficiency of WQT versus traditional command-and-control approaches difficult for point sources.
- For MCD, draft statewide trading rules initially contradicted some elements of the MCD WQT program. This was overcome through a grandfather clause included in the Ohio Trading Rules. In other states, lack of trading rules or rigid, prescriptive rules or policies can serve as a barrier to WQT. WQT often works best when local stakeholders can be innovative and flexible in drafting a program framework that best fits their specific watershed setting. This local flexibility can, however create barriers to broader geographic trading across watersheds for far-field water quality issues. This is being realized particularly for multi-state water bodies such as in the Ohio River Basin where thirteen different states drain to the Ohio River including the Great Miami.

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