Abstract

Assessing best management practice (BMP) effectiveness in large basins is complicated by hydrologic variability, ecosystem complexity, and issues of scaling. A traditional approach to assessing BMP effectiveness in large watersheds is to forecast several BMP scenarios and compare their performance relative to a baseline scenario. While this approach may provide insight into the effectiveness of future BMP scenarios, it does not quantify the impact of BMPs that have already been implemented. The authors propose that a continuous water quality model may be used as a pseudo-control watershed in order to determine BMP effectiveness in large catchments. Preliminary results using this approach suggest that agricultural BMPs have reduced dissolved phosphorus loads to the Cannonsville Reservoir in Upstate New York. Future work will involve the implementation of sophisticated analyses to confirm the statistical significance of reductions in dissolved phosphorus loads to the reservoir.

Introduction

According to the Environmental Protection Agency (EPA), eutrophication caused by excessive inputs of nitrogen and phosphorus is the most common impairment of
surface waters in the country (EPA 1990). Eutrophication has a wide variety of negative consequences, the most noticeable of which is the increased growth of algae and aquatic weeds that interfere with the use of water for fisheries, recreation, industry, agriculture, and drinking (Carpenter et al. 1998). Studies have shown that the primary source of nitrogen and phosphorus inputs to freshwater bodies is non point source pollution from urban and agricultural activities (Havens and Steinman 1995, Gianessi et al. 1986). In rural watersheds where agriculture is the dominant industry, excessive fertilization and manure application cause a phosphorus surplus to accumulate in the soil, some of which is transported to surface waters (Carpenter et al. 1998, Tolson 2005). While current practices will lead to increases in non point source pollution, there is a wide variety of Best Management Practices (BMPs) that, when implemented on a watershed scale, have been shown to reduce sediment yield and nutrient concentration by altering watershed hydrology (Sharpley et al. 2006).

The Cannonsville Basin is a 1200 km² rural watershed located in the Catskills region of Upstate New York and is part of the New York City reservoir system. Water quality in the basin has for decades been plagued by excessive phosphorus losses from agricultural land, resulting in the assessment of a total maximum daily load (TMDL) for phosphorus. In order to avoid building costly filtration plants to filter drinking water from the basin, the New York City Department of Environmental Protection has instituted an extensive water quality management program, which emphasizes the use of best management practices (BMPs). Widespread BMP implementation has been taking place in the basin since the mid 1990s. A recent study showed that a farm in the basin reduced event loads by 43% for dissolved phosphorus and 29% for particulate phosphorus by implementing BMPs (Bishop et al. 2005). The purpose of this study is to discuss the use of a SWAT2000 model of the Cannonsville watershed to determine if BMPs have affected water quality at the basin scale.

Analysis of BMP Effectiveness at the Large-Basin Scale

Assessing BMP effectiveness at the large-basin scale presents several difficulties. First, with regard to phosphorus, it may take many years for management practices to have a measurable impact due to years of phosphorus building up in the soils and streambed sediments and a to variety of other factors (Nagle et al. 2006, Tolson 2005, Sharpley et al. 2006, McDowell et al. 2002). Another potential contributor to the time lag is that in field-level studies, farms make up a large percentage of the land area in the treatment watershed, while the overwhelming majority of land in the Cannonsville is forested. This difference in land use make up could make BMP effects more difficult to detect as farm level BMPs may be drowned out at the large watershed scale. Second, water quality trends are heavily influenced by hydrologic variability, particularly by peak storm events (Pionke et al. 1997). While it is clear, however, that BMP effectiveness is much more straightforward at the scale of small catchments, environmental policy tends to be defined and implemented at much larger geographical scales. Therefore, there is a clear need to develop methods for
assessing BMP effectiveness in large-watersheds in order to measure the success of water quality management programs.

**Using SWAT2000 to Assess BMP Effectiveness**

Traditionally, water quality models such as SWAT have been used to analyze BMP effectiveness by creating forecasts of potential BMP scenarios and comparing them to a baseline management scenario. Such an approach is useful for estimating the future impact of BMPs, but does not provide any insight into the impact of BMPs that have been implemented in the past. Another approach to assessing BMP effectiveness is to use a calibrated continuous water quality model, such as SWAT, as a pseudo control watershed. Using this approach, it is possible to compare the relationship between measured water quality data and model predictions before and after BMP implementation.

A recent study by Tolson and Shoemaker on the Cannonsville basin involved the development, calibration, and validation of a SWAT model for the prediction of flow, sediment, and phosphorus at the watershed outlet (Tolson and Shoemaker 2006, 2004). The model was calibrated and validated using flow and water quality data from 1994-2000 and 1991-1993, respectively. The authors of this study used the same model to generate predictions for flow and water quality from October of 1991 through September of 2004. Model predictions as well as measured water quality data were separated into three time periods: Pre-BMP (1991-1994), BMP-Implementation (1995 -1998), and Post-BMP (1999-2004). In general, model performance for flow, sediment, total phosphorus, and particulate phosphorus remained the same during all three periods. The same was not true, however, for dissolved phosphorus. Despite the fact that the model simulated the same management practices in each year of simulation, the model exhibited a greater tendency to overpredict dissolved phosphorus in the post-BMP period than during the pre-BMP period, particularly during events, as seen in Figures 1 and 2 on the following page. This finding suggests that the implementation of BMPs may have reduced dissolved phosphorus losses. Further analysis is needed, however, to determine the statistical significance of the change in the relationship between measured loads and those predicted by the SWAT model and whether or not the change can be attributed to BMPs.
Biweekly Average TDP Loads

Figure 1 - Plot of Biweekly Average Total Dissolved Phosphorus

Biweekly Average TDP Prediction Error

Figure 2 - Plot of Biweekly Average Total Dissolved Phosphorus Prediction Errors

Conclusion

Assessing the effectiveness of BMP implementation in large watersheds is a process complicated by hydrologic variability, ecosystem complexity, and differences in land use distribution between large watersheds and the small farms and fields that are typically used for BMP studies. The authors propose that a continuous water quality model, such as SWAT, may be used as a pseudo control watershed to assess BMP effectiveness in large basins. Preliminary results show that the relationship between measured and predicted dissolved phosphorus loads is different in pre and post BMP periods, suggesting that BMP implementation may have improved water quality in the basin. Future research will address the implementation of sophisticated analyses to determine the statistical significance of the change in the relationship between measured and predicted dissolved phosphorus loads in the pre and post-BMP periods.
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**References**


