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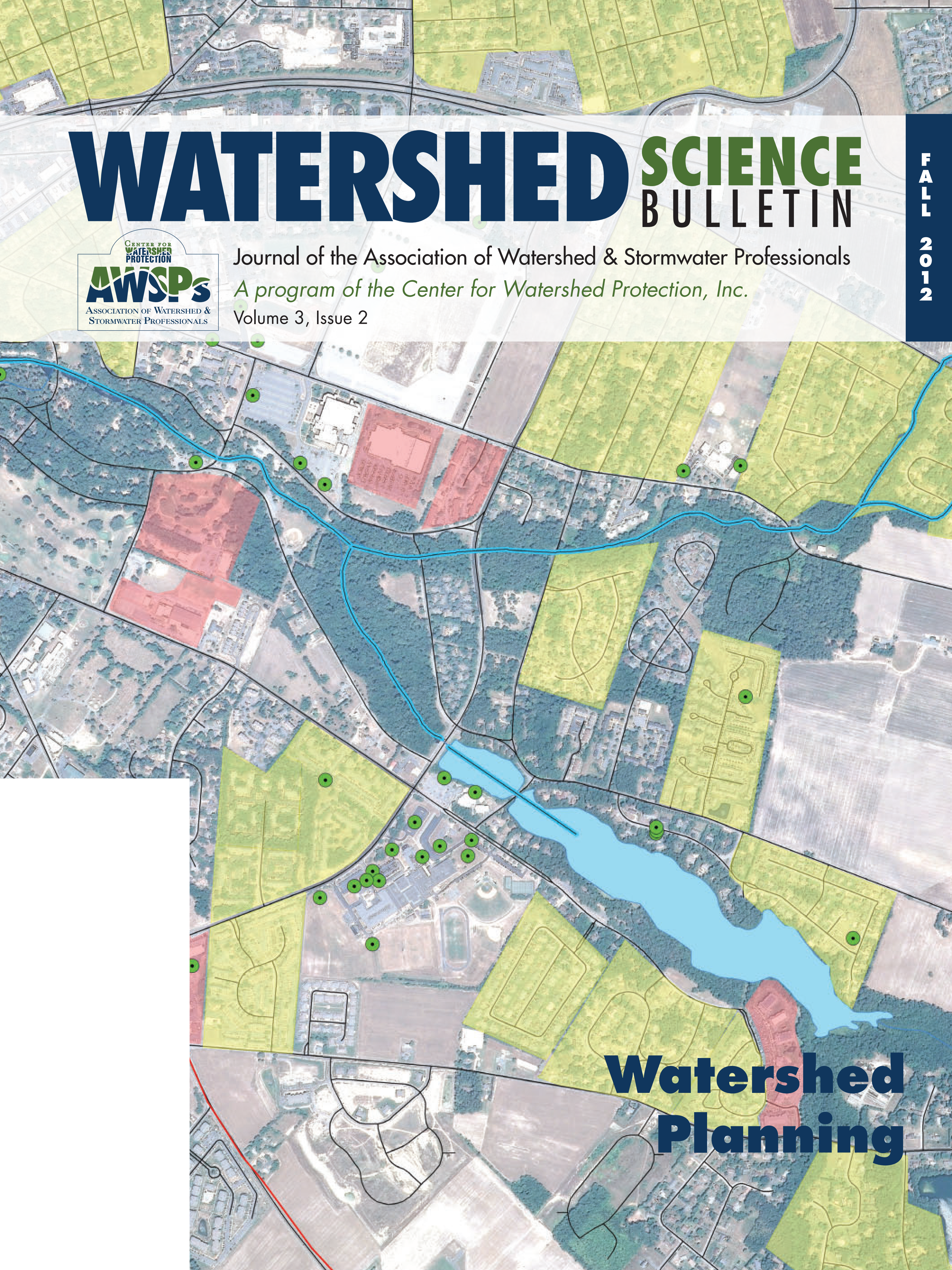

Watershed Planning

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BULLETINDEPARTMENTS

Challenges of Achieving Watershed Goals in a Changing Agricultural Environment

Roger T. Bannerman[a]

Abstract

A comprehensive watershed plan, prepared more than 20 years ago for Wisconsin's East River Priority Watershed Project, contained all the key elements for the successful control of nonpoint sources of pollution. These elements included descriptions of the pollutant sources, water quality goals, the identification of best management practices (BMPs) eligible for cost sharing, an implementation plan, and a monitoring plan to evaluate project effectiveness. The Wisconsin Department of Natural Resources selected the Bower Creek subwatershed for implementing the monitoring plan. The watershed project was expected to reduce the phosphorus load in this primarily agricultural drainage area by 70% and the sediment delivery by 50%. After years of monitoring during the pre- and post-BMP periods, the results indicate that implementation of the watershed plan did not achieve any significant reductions in storm loads for phosphorus, sediment, or ammonia nitrogen.

It appears that more or different types of BMPs are needed to achieve storm load reduction goals for the existing agricultural activities. Although many BMPs, such as various barnyard runoff controls and nutrient management plans, were implemented in the subwatershed, they were not enough to compensate for the change in farming practices during the project period. The most important changes in farming practices were a shift toward much larger dairy herds on fewer farms and increased milk production for each animal. These changes led to less conservation-oriented cropping practices and increased manure production. Future efforts at nonpoint source control in this subwatershed should focus on management of the robust network of drain tiles, protection of areas of concentrated flow, and better implementation of nutrient management plans.

Introduction

Nonpoint source contamination is a major contributor to water resource quality problems in Wisconsin. In recognition of the importance of nonpoint sources, the Wisconsin Nonpoint Source Water Pollution Abatement Program (Nonpoint Program) was established in 1978. When first introduced, the Nonpoint Program identified problems in 130 of Wisconsin's 330 watersheds. The 130 watersheds identified as part of the WI Nonpoint Program were called priority watersheds projects. For each watershed, the Nonpoint Program offered funding support for various voluntary best management practices (BMPs). The sizes of the drainage areas generally ranged from 259 to 518 km^2. To help support the appropriate use of the funds, comprehensive watershed plans were prepared by the Wisconsin Department of Natural Resources (WDNR); Wisconsin Department of Agriculture, Trade, and Consumer Protection; and local agencies, such as counties and planning commissions. These plans contained all the key elements to successfully select and implement BMPs for each watershed. With a special focus on the needs of the receiving waters, the key elements included descriptions of the pollutant sources, water quality goals, the identification of BMPs eligible for cost sharing, an implementation plan, and a monitoring plan to evaluate project effectiveness.

The purpose of the Nonpoint Program was to achieve water quality benefits in the receiving waters, rather than to demonstrate BMP effectiveness. To demonstrate the effectiveness of BMPs for improving water quality in Wisconsin's priority watersheds, WDNR and the US Geological Survey (USGS) developed and began a comprehensive, multidisciplinary evaluation monitoring program in water year 1989 (Wierl et al. 1996). This monitoring program, called Whole-Stream Monitoring, included biological and stream habitat monitoring by WDNR and water quality monitoring by USGS. For this extra-intensive evaluation monitoring program, WDNR and USGS chose six subwatersheds from four of the priority watersheds. These subwatersheds were chosen because they had the potential for significant improvement, according to WDNR and County Land Conservation District personnel, and because BMPs were scheduled to be installed within the project time frame. Results from five of these subwatersheds—Brewery and Garfoot creeks in the Black Earth Creek priority watershed (Graczyk et al. 2003), Otter Creek in the Sheboygan River priority watershed (Corsi et al. 2005), and Joos Valley and Eagle creeks

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in the Waumundee River priority watershed (Graczyk et al. 2012)—were published previously.

The sixth subwatershed is within the 383–km2 East River priority watershed (WDNR 1993), which drains directly into the Fox River near the city of Green Bay, Wisconsin. WDNR (1993) classifies Bower Creek, a 110–km2 subwatershed near DePere, Wisconsin, as a warm-water forage stream that has the potential to maintain a forage fish population. WDNR and USGS selected the Bower Creek subwatershed as a whole-stream monitoring site because the fisheries habitat is degraded by sedimentation, and water quality sampling conducted in 1988 found relatively high concentrations of pollutants (phosphorus, biochemical oxygen demand–5, and bacteria; Hughes 1988). The high phosphorus levels are a concern not only to Bower Creek, but to the receiving waters of the East River and Green Bay. Based on calculations done during the preparation of the watershed plan, the Bower Creek subwatershed is the largest contributor of phosphorus and the second-largest contributor of sediment in the East River watershed (WDNR 1993). The BMPs recommended in the East River priority watershed plan were designed to reduce the phosphorus load to Bower Creek by 70% and the sediment load by 50%.

To document the level of phosphorus and sediment reduction achieved in the Bower Creek subwatershed during the East River Priority Watershed Project, WDNR and USGS collected stream flow and water quality data in the pre- and post-BMP period, including both baseflow and storm event samples. Although changes in ammonia nitrogen concentrations and flow were not targeted as goals for the project, we needed the flow data for load calculations and any changes in the ammonia nitrogen concentration might reflect benefits of better manure management. The pre-BMP implementation period was between 1990 and 1994, and the post-BMP implementation period was between 2006 and 2009. Given the high cost of monitoring and the relatively small chance of observing small changes from year to year, we did not sustain the monitoring on an annual basis between the pre- and post-BMP periods. We compared and contrasted pre- and post-BMP concentrations of total suspended solids, total phosphorus, and dissolved ammonia nitrogen in samples collected at baseflow and during storm events.

Physical Setting and Land Use

Bower Creek drains 38.3 km^2 upstream of the stream gaging station; the total length of the stream channel, which is all intermittent channel, is 59.7 km from the station to the stream headwaters. Total land use and land cover for Bower Creek at the beginning of the study is shown in Figure 1. In the Bower Creek subwatershed, cropland (83.1%) dominated the land use and land cover, and woodlots (6%) were the next-greatest land use and land cover. In all, 115 farms were included or partially included in the Bower Creek subwatershed. The average farm size was 48.6 ha, with an average of 33.6 ha in crop production. The subwatershed included 41 barnyards, with an average herd size of 118 animals, of which 97% were dairy cows (Rappold et al. 1997). According to the Brown County Land and Water Conservation Department, the numbers of livestock in the subwatershed and the cropland percentage have not changed substantially throughout the monitoring period, but exact numbers were not available. The soil types in the Bower Creek subwatershed vary spatially and consist mainly of silt loams to silty clay loams. These soils are poorly drained unless a tile system, a network of below-ground pipes that removes excess water from the soil subsurface, is used (Link et al. 1974).

Targeted and Implemented BMPs

Table 1 summarizes targeted and implemented BMPs for the Bower Creek subwatershed. Brown County determined the initial BMP targets based on an assessment of potential water quality influences in Bower Creek (WDNR 1993). The county used inventory data collected between 1988 and 1989 in the Wisconsin Barnyard Runoff model (Baun 1992) and the Wisconsin Nonpoint Source model (Baun and Snowden 1987) to determine the sources of phosphorus and sediment, respectively. The data also included the locations and degrees of streambank erosion. Figure 2 shows the status of animal waste management and streambank protection practices as of 2009.

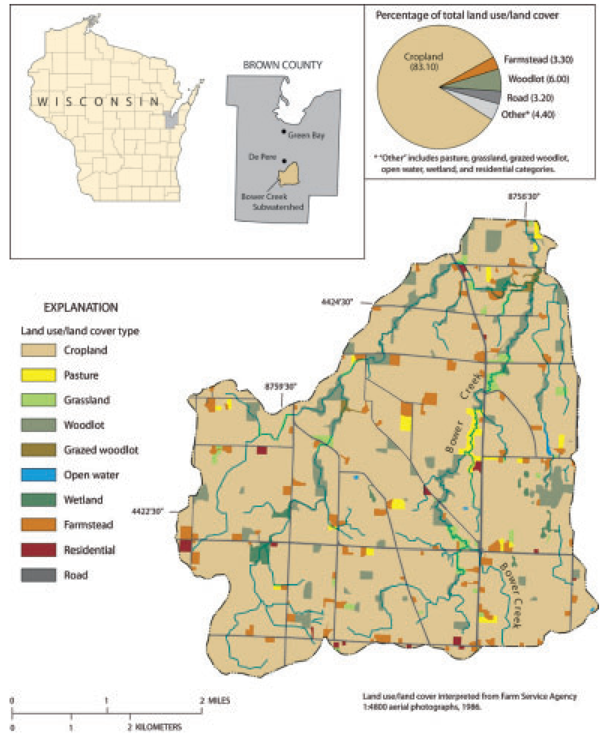

Figure 1. Land use and land cover in the Bower Creek subwatershed, Brown County, Wisconsin.

Table 1. Summary of targeted and implemented rural BMPs in the Bower Creek subwatershed, Brown County, Wisconsin.

Management Practice	Targeted	Implemented
Animal Waste Management		
Manure storage (no. facilities)	9	7 [a]
Barnyard runoff control systems (no. facilities)	32	16
Milkhouse wastewater treatment (no. facilities)	2	2
Streambank Protection		
Stream shaping, seeding, and riprap (m)	707.1	613.6
Fencing (m)	190.5	190.5
Stream crossing (no. crossings)	1	1
Grade stabilization (structures)	0	1
Buffer strips (ha)	0	6.6
Upland Management[b]		
Nutrient management (ha)	1,626.8	784.7
Upland BMPs (ha)	1,813.0	632.9

[a] Seventeen other manure storage facilities were implemented by previous farm programs.
[b] Upland BMPs include a change in crop rotation, reduced tillage, critical area stabilization, grass waterways, and pasture management.

Water Quality before and after Installation of BMPs

The primary objective of this study was to evaluate overall BMP effectiveness at the subwatershed scale. We evaluated changes in water chemistry before and after BMP installation using data from baseflow sampling as well as from storm loads (Corsi et al. 2012). We used land use data to interpret the results of these analyses and to help understand the effects of individual types of BMPs.

Pre- and Post-BMP Implementation Baseflow Concentrations

Baseflow in Bower Creek consists of groundwater contributions, including those from drain tiles. The water quality sample results for baseflow concentrations therefore reflect groundwater discharges, direct surface influences, and instream processes. WDNR and USGS collected fixed-interval water quality samples throughout the pre- and post-BMP implementation periods. We collected a total of 44 samples during baseflow conditions for total suspended solids, 44 for total phosphorus, and 41 for dissolved ammonia nitrogen during the study (Figure 3).

We used statistical analyses (Wilcoxon rank-sum tests) to test for differences between baseflow samples collected during the pre- and post-BMP implementation periods (Helsel and Hirsch 1992). Results indicate a significant reduction at the 95% confidence level between pre- and post-BMP baseflow concentrations for total phosphorus, but not for total suspended solids or dissolved ammonia nitrogen (Table 2). The lack of a significant change in ammonia nitrogen concentrations during baseflow in Bower Creek is similar to results from all but one (Garfoot Creek) of the other whole-stream monitoring sites.

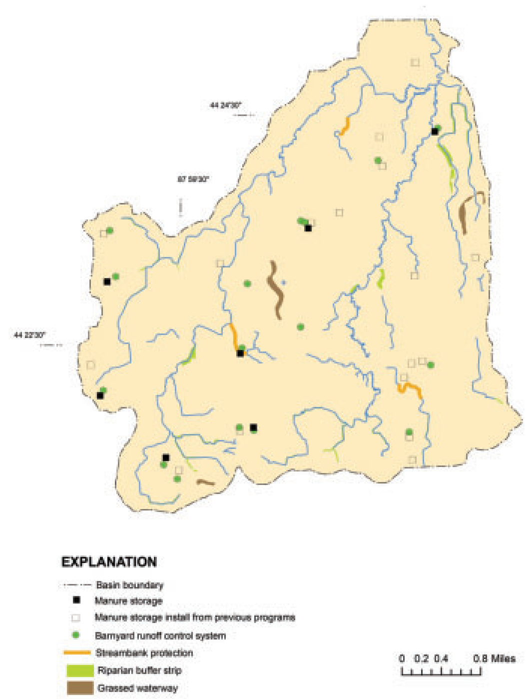

Figure 2. Animal waste management and streambank protection BMPs implemented during the study period in the Bower Creek subwatershed, Brown County, Wisconsin. 1 mile ≈ 1.6 km.

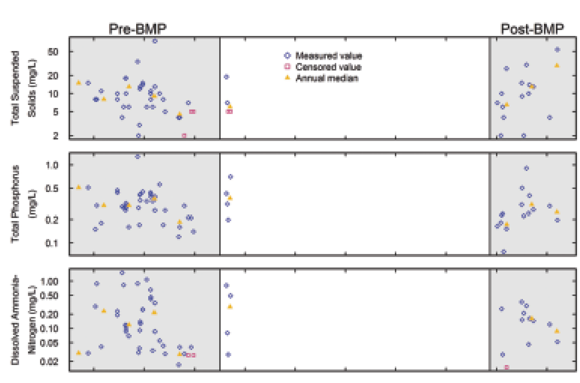

Figure 3. Concentrations and water–year medians of total suspended solids, total phosphorus, and dissolved ammonia nitrogen in baseflow samples throughout the study period at Bower Creek, Brown County, Wisconsin.

Pre- and Post-BMP Implementation Storm Loads

Because much of the annual transport of total suspended solids and nutrients occurs during storms, fixed-interval sampling—particularly at a monthly interval—may not show changes resulting from BMP implementation (Walker 1993). The percentages of the annual total suspended solids, total phosphorus, and ammonia nitrogen loads occurring during storms were about 92%, 79%, and 64%, respectively, for Bower Creek (Corsi et al. 2012). Consequently, we computed mass transport resulting from individual storms and used this in the final storm load analysis. The storm loads also became the basis for judging how well the watershed project achieved the pollutant reduction goals.

For total suspended solids and total phosphorus, median storm loads from rainfall periods decreased. For dissolved ammonia nitrogen, median storm loads increased. Testing the storm load residuals demonstrates that these changes were not statistically significant for any of the constituents at the 95% confidence level (Table 3). Therefore, the differences in pre- and post-BMP conditions are probably not due to the BMPs installed; they are more likely due to natural variability from variable hydrologic or seasonal conditions. The watershed goals of a 70% reduction in phosphorus loads and a 50% reduction in

Table 2. Results of Wilcoxon rank-sum tests for differences between constituent concentrations in baseflow samples from pre- and post-BMP implementation periods at Bower Creek, Brown County, Wisconsin.

Response Variable	No. Samples for pre-/post-BMP Periods	Median Concentration (mg/L)		
		Pre-BMP	Post-BMP	Significance Level
Total suspended solids	29/15	10.0	10.0	0.691
Total phosphorus	29/15	0.340	0.235	0.0258
Dissolved ammonia nitrogen	29/12	0.139	0.149	0.398

Table 3. Median and mean rainfall period storm loads and results of the Wilcoxon rank-sum test comparing storm load residuals for pre- and post-BMP periods at Bower Creek, Wisconsin.

Variable	Median Storm Loads		Mean Storm Loads		Storm Load Residuals
	Pre-BMP	Post-BMP	Pre-BMP	Post-BMP	Significance Level
Total suspended solids (metric tons)	17.2	8.6	137	95.3	0.5508
Total phosphorus (kg)	103.4	83.9	358.3	241.8	0.91
Dissolved ammonia nitrogen (kg)	26.8	65.8	118.4	73.9	0.61

sediment loads were not achieved with the BMPs installed during the course of this study. This unexpected conclusion may be explained by the changing agricultural environment for the Bower Creek subwatershed because changes in agricultural practices may mask the benefits of these BMPs.

Effects of Management Practices on Bower Creek

Landowners implemented many BMPs in the three major categories targeted in the Bower Creek subwatershed (Table 1). In the animal waste category, about 70% of the targeted manure storage and 50% of the barnyard runoff control systems were implemented. Installation of the barnyard runoff control systems provided the extra benefit of controlling most of the animal access to the stream channels since livestock in or adjacent to feedlots previously accessed the Bower Creek stream channel. All targeted streambank fencing, shaping, and seeding listed under the streambank protection category was completed during the project period. A new county ordinance requiring 6.1- to 10.7-m riparian buffer strips resulted in over 6.5 ha of riparian buffer strips. In the upland management category, most of the farms prepared nutrient management plans and they implemented almost 50% of the upland BMPs. A description of the individual BMPs and their potential effects on water quality has previously been published (Graczyk et al. 2003).

Influence of BMPs on Water Quality

Despite the implementation of many BMPs in the Bower Creek subwatershed, the sampling results provide no evidence of substantial improvement in most measures of water quality. Baseflow concentrations were significantly reduced after BMP implementation for total phosphorus, but not for total suspended solids or ammonia nitrogen. Storm loads after the implementation of BMPs did not differ significantly from those observed before implementation began. With such unexpected results, one should always question the sampling approach, but this cost-effective sampling of concentrations pre- and post-BMP implementation has demonstrated improvements for other sites. At the five other streams included as whole-stream monitoring projects, pollutant concentrations during baseflow and storms declined significantly after BMP implementation (Graczyk et al. 2003.; Corsi et al. 2005.; Graczyk et al. 2012). Although not as robust as a paired site design (Clausen and Spooner 1993), the higher cost and difficulty of maintaining a control site over 20 years precludes the use of such an approach in Bower Creek.

Understanding the influences of specific pollutant sources in a watershed is a complex task. Important factors to consider include the land use, topography, condition of the land, proximity to the stream, the likelihood that runoff from a given area will reach the stream under different conditions, the BMPs installed, the effectiveness of the BMPs, human actions that impact drainage, and other factors. Typically, support for watershed managers is not sufficient to enable a detailed inventory of all of these factors, so a substantial amount of uncertainty exists in the evaluation of source influences on water quality. Given these uncertainties, it is difficult to explain why this level of BMP implementation did not do more to improve water quality in Bower Creek. For the purpose of improving BMP implementation efforts in the future, we explore below the potential reasons why we did not observe improvements in baseflow concentrations and storm loads for the Bower Creek subwatershed.

Influence on Baseflow Concentrations

Results from other monitoring projects in Wisconsin agricultural watersheds might help explain the lack of response in the baseflow concentrations of ammonia nitrogen and total suspended solids. Total suspended solid concentrations measured during baseflow conditions dropped significantly during the post-BMP period for three of the other five whole-stream monitoring sites. Those three sites are characterized by pre-BMP concentrations in the baseflow of about 40 mg/L compared to 10 mg/L in Bower Creek (Graczyk et al. 2003; Corsi et al. 2005; Graczyk et al. 2012). Targeted BMPs in those other subwatersheds also included much more streambank fencing and protection than were targeted for Bower Creek. The implementation of streambank protection and fencing in Bower Creek might be expected to have less of an impact on baseflow total suspended solid concentrations because cows in the stream were not a problem in the first place.

All but one of the other whole-stream monitoring sites showed no significant change in ammonia nitrogen concentration during baseflow. It is not clear why the commonly used BMPs, such as nutrient management, do not control this dissolved pollutant during baseflow. In contrast to total suspended solids, the main source of ammonia nitrogen is most likely groundwater during baseflow. A large number of drain tiles have been installed in the Bower Creek subwatershed; this could be an important system for delivering total phosphorus and ammonia nitrogen to Bower Creek during nonevent periods. Results from drain tile monitoring for the Discovery Farms program in Wisconsin indicated that drain tiles can flow all year long and contribute substantial amounts of total phosphorus and ammonia nitrogen to receiving streams (Cooley et al. 2010). BMP implementation in the Bower Creek subwatershed did not focus on the reduction of nonevent flows from drain tiles.

The results from the other whole-stream monitoring sites do not help explain why a significant reduction in total phosphorus baseflow concentrations was observed for Bower Creek. Out of the other five sites, only Joos Valley and Eagle Creek subwatersheds had significant reductions in baseflow total phosphorus concentrations (Corsi et al. 2012). One factor might have been the unusually high total phosphorus concentrations during baseflow. Results from the five other whole-stream monitoring sites indicate that median total phosphorus baseflow concentrations during the pre-BMP period at those sites ranged from 0.07 to 0.15 mg/L, compared with a much higher median of 0.34 mg/L at Bower Creek (Graczyk et al. 2003; Corsi et al. 2005; Graczyk et al. 2012). Another possible factor needing more evaluation is that the nutrient management practices, such as proper manure application rates, may have a greater impact on the amount of total phosphorus reaching the groundwater or drain tiles than on the amount of ammonia nitrogen. The post-BMP median baseflow concentration of 0.235 mg/L at Bower Creek is still much higher than the 0.075 mg/L targeted for streams of this size (Robertson et al. 2006).

Influence on Storm Loads

Unlike baseflow concentrations, storm loads are more a consequence of sources activated by runoff events. These sources include upland areas, barnyards, woodlots, eroding streambanks, and drain tiles. Results from monitoring small watersheds in the Southeastern Wisconsin Till Plains ecoregion indicate that Bower Creek had the second-largest annual median total suspended solids (out of 14 sites) and total phosphorus (out of 12 sites) unit area loads at 48.9 ton/km^2 and 120 kg/km^2, respectively (Corsi et al. 1997). As mentioned above, storm loads accounted for 92% of total suspended solid loads in Bower Creek, 79% of total phosphorus loads, and 64% of ammonia nitrogen loads throughout the study period (Corsi et al. 2012). Such high storm loads would seem to make it easier to observe some reduction as a result of BMPs, but it also means that targeting the sources with the largest storm loads is more important. All of the above sources must be considered when evaluating the potential reasons why the management practices did not significantly reduce the storm loads in the Bower Creek subwatershed.

Two main factors may explain why storm loads were not reduced: (1) milk production has become more intensive in the watershed and (2) the existing BMPs did not address all of the sources. In the approximate time frame of the monitoring activities (1981 to 2008), the number of cows in Brown County increased only slightly, but average milk production grew from 5,987.4 to 10,115.1 kg/cow/year. Because milk production increased so substantially, manure production also increased (US Department of Agriculture, Natural Resources Conservation Service 2009); therefore, field applications of manure must have increased through the study period. In the same time frame, the number of herds in Brown County declined from 1,348 to 239, indicating that manure was concentrated on fewer farms. According to Brown County records, these county-wide trends also apply specifically to Bower Creek. Dairy farming in Brown County is following the national trend of creating ever-larger dairy herds, with thousands of dairy cows potentially concentrated on one farm. In addition, changes in cropping practices have resulted in less erosion protection and less ground cover over the winter. The altered cropping practices include (1) more land in soybeans, corn, and wheat; (2) less land in hay and other cover crops; (3) less conservation tillage; (4) oats eliminated as a crop; and (5) more land in corn silage. Between 1981 and 2008, the land used for growing soybeans in Brown County increased from 80.9 to 9,665 ha, and the land used for growing hay declined from 74,000 to 61,000 acres. With these increases in manure production and changes in cropping practices, one may have expected storm loads to increase during the monitoring period; instead, storm loads did not change significantly over the study period. It appears that the potential increase in pollutant storm loads due to the transition to less protective cropping practices and a higher concentration of cows might have been offset by the implementation of BMPs targeted in the watershed plan.

Determining whether the implemented BMPs actually prevented a degradation of water quality as a result of these changes would require additional data. But similar sets of BMPs implemented in other whole-stream monitoring sites have produced measurable reductions in phosphorus and sediment storm loads (Corsi et al. 2005; Graczyk et al. 2012). It is reasonable to speculate that a measurable reduction would have been observed in Bower Creek without the changes in the agricultural environment.

Given the water quality results obtained in this study, it appears that more and different types of BMPs are needed to achieve the storm load reduction goals in the watershed plan. Many of the future BMPs will have to be adjusted to target the existing agricultural activities. Previous management efforts in Bower Creek achieved a relatively high level of implementation of animal waste management BMPs, but 50% of the targeted barnyard runoff control measures were not implemented. In addition, substantial targeted areas remain for future implementation of upland management BMPs (Table 1). Soil test phosphorus values (50 to more than 100 ppm) for a number of fields in the Bower Creek subwatershed pose an increased likelihood for phosphorus loading contributions to Bower Creek from upland erosion (Kelling et al. 2003). Many farms have nutrient management plans in place, but some have not been fully implemented because of concentrated flow areas—such as dead furrows (plowed trenches meant to help drain fields more efficiently) and fields without grassed waterways—that have not yet been addressed (Figure 4). Brown County staff feels that it may be beneficial to review how well these nutrient management plans are being implemented.

Figure 4. Example of a dead furrow in the Bower Creek subwatershed, Brown County, Wisconsin.

An additional upland pollutant source that probably needs more consideration and management is the robust network of drain tiles within the subwatershed. This drainage system enhances the efficiency of runoff and allows farmers to work in fields earlier in the growing season than without the drain tiles; however, their use also results in an efficient system that transports pollutants directly to the stream. Previous monitoring of agricultural drain tiles through Wisconsin's Discovery Farms program in Kewaunee County determined that 34% of the annual total phosphorus load and 25% of the sediment load from the monitored fields was delivered through the drain tiles (Cooley et al. 2010). Ammonia nitrogen loads are significant during periods of frozen ground, because it is too cold in the spring for nitrification to occur (Cooley et al. 2010). This indicates that substantial reductions in storm loads may be possible in Bower Creek with management of drain tile discharges. The other whole-stream monitoring sites might also benefit from better management of drain tile discharges, but information on drain tile coverage and extent is not available for the other sites. Future work at Bower Creek will explore means of reducing the concentrations of ammonia nitrogen and phosphorus in drain tile effluents; the successful reduction of pollutants will probably depend on a combination of better implementation of nutrient management plans and the installation of end-of-the-pipe controls, such as flow control valves, on the drain tiles with larger flows. Flow control valves on the drain tiles would restrict discharges in the spring when flows are high; the valves could be opened to lower the groundwater levels when the growing season begins.

Summary and Conclusions

As part of Wisconsin's Nonpoint Program, state and local agencies prepared a comprehensive watershed plan for the East River priority watershed near the city of Green Bay. Based on inventories and the results of runoff models, pollutant reduction goals were selected for each of the subwatersheds. To evaluate the effectiveness of the targeted BMPs to achieve the pollutant reduction goals, WDNR selected Bower Creek subwatershed for a comprehensive monitoring program. For this subwatershed, the total phosphorus and sediment reduction goals were 70% and 50%, respectively. WDNR and USGS collected flow measurements and water quality samples in the pre-BMP period (1990 to1994) and the post-BMP period (2006 to 2009). Despite the implementation of many of the BMPs targeted in the watershed plan, such as barnyard runoff controls and streambank fencing, the monitoring results did not show any significant reduction in the storm loads of total phosphorus, sediment, or ammonia nitrogen. Since the storm loads represent a large percentage of the annual load of each pollutant, the pollutant reduction goals were not achieved after almost 20 years of BMP implementation. WDNR and USGS evaluated changes in baseflow concentrations, but found a significant reduction only in total phosphorus concentrations. Implementation of all targeted BMPs could have helped achieve a significant reduction; however, the changing agricultural environment in the subwatershed might have played a larger role in the failure to achieve the reduction goals because such changes could require the use of different BMPs.

A concentration of approximately the same number of dairy cows on fewer farms and a large increase in the milk production by each cow has changed the agricultural environment in the Bower Creek subwatershed. Not only is the spreading of manure more concentrated, but the amount of manure each cow produces is greatly increased.

In addition, farms in this subwatershed shifted toward cropping practices that provide less protection from erosion. It is possible that these changes somewhat offset the effects of implementing the targeted BMPs in the original watershed plan.

Reasonable goals were selected in the East River Priority Watershed Project based on agricultural practices in the early 1990s. To meet the challenges of a changing agricultural environment, an updated watershed plan would have to keep some focus on existing targeted BMPs, such as upland practices, but increase the emphasis on nutrient management and recommendations for controlling pollutants in drain tile effluent. Improved implementation of nutrient management plans would have to put special emphasis on controlling unaddressed areas of concentrated flow, such as dead furrows. Reducing the pollutant concentrations discharged from drain tiles would help reduce loads to the stream for storms and baseflow.

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