Lake Pittsfield

Illinois National Nonpoint Source Monitoring Program Project

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Introduction

Lake Pittsfield is an 89 ha lake located near the city of Pittsfield in the 10,276 ha Blue Creek watershed within Pike County, western Illinois (Figure 1). Lake Pittsfield was constructed in 1961 as a flood control reservoir. The lake is a highly valued recreational area and serves as the primary water supply for the city of Pittsfield, a community of about 4,600 people.

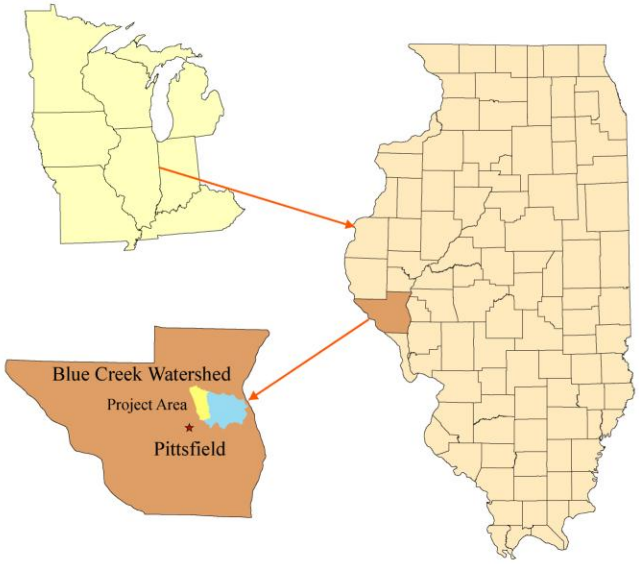

Figure 1. Location of Lake Pittsfield

Sediment deposition into Lake Pittsfield has been the dominant water quality problem facing local residents and recreational users. Lake Pittsfield is located in a region of the state that has the highest in-stream sediment yields (Bonini et al. 1983). The Natural Resources Conservation Service (NRCS) formerly designated the region as part of the critical sediment-producing area of the Upper Mississippi River basin (Crews 1983). Earlier lake sedimentation surveys concluded that the lake lost almost 25% of its original storage capacity between1961 and 1992. This information along with other bathymetry and aerial data indicated that the lake's surface area

decreased by more than 16% from 106 ha in 1961 to 89 ha by 1994. Sediment was believed to be entering Lake Pittsfield from sources that included sheet and rill erosion, gullies, stream channels and the lake's shoreline. Lake Pittsfield was classified as being extremely eutrophic (Benton and Associates, Inc. 1989; Twait and Ramen 1993) because of excess nutrient loads transported both with the high sediment loads and dissolved in the water.

State and federal agencies, the city of Pittsfield and local landowners have been applying erosion control Best Management Practices (BMPs) (USDA 2003), since the 1970s to reduce both damages from high erosion on the land and the effect of high sediment deposition in the lake. These earlier practices included terracing, grassed waterways, filter strips, exclusion of livestock, reduction or other improvements in tillage, landowner education programs and "hard structures" (i.e., drop structures, tiling, dams, etc.). Four lake sedimentation surveys were conducted between 1961 and 1992. The first survey was conducted in 1974 by Benton and Associates, Inc, with advice and equipment provided by the Illinois State Water Survey (ISWS) (Benton and Associates, Inc., 1989). The second survey was conducted in 1979 where the ISWS supervised a field crew from Benton and Associates and prepared all of the calculations (Benton and Associates, Inc., 1989; Bogner 1979). The 1985 and 1992 lake sedimentation surveys were conducted by the ISWS. In 2004 the ISWS conducted a partial sedimentation survey to re-establish baseline conditions in the dredged areas of the lake (Bogner unpublished, 2004). These surveys showed that conservation practices had reduced sediment delivery to Lake Pittsfield (Bogner 1986, Bogner 1979, Allgire 1993). However, significant concern remained because the rate of lake sedimentation was still too high to ensure flood control protection and sustain biological and water-supply functions. While interested groups recognized that erosion is a natural process that can be minimized but not stopped, they remained determined to reduce the rate of erosion in the watershed and the amount of sediment filling Lake Pittsfield. As Lake Pittsfield continued to fill with sediment, these local groups realized there was a need to take a more aggressive approach to address conservation issues.

In 1994, the United States Environmental Protection Agency (USEPA) funded, and the Illinois Environmental Protection Agency (IEPA) administered, the Lake Pittsfield National Monitoring Program (LPNMP) project. The IEPA and USEPA contracted the ISWS to investigate the effectiveness of erosion control practices in reducing sediment transport to Lake Pittsfield. Monitoring the effects of various erosion control land treatment practices proved a challenging task because erosion and sediment reduction efforts were already being implemented in the watershed. Therefore, baseline conditions were already changing and detection of future change would need to be examined carefully to distinguish influencing factors.

Study Area

The study area included 2,815 ha of the Blue Creek watershed above Lake Pittsfield. Land use in the study area is primarily cropland (48%), forest/shrub (21%), pasture (20%), water (4%), developed impervious surface (4%) and parks (3%). Agriculture consists primarily of row crops such as corn and soybeans and includes small livestock operations such as hog production, generally on open lots, and some cattle on pasture. Land use changes have been notable in the Blue Creek watershed above Lake Pittsfield. In fact, between 1979 and 1993 (Figure 2), 12% of

the watershed was converted from row crops to grasslands, roadways, and homesteads (Roseboom et al. unpublished, 1993).

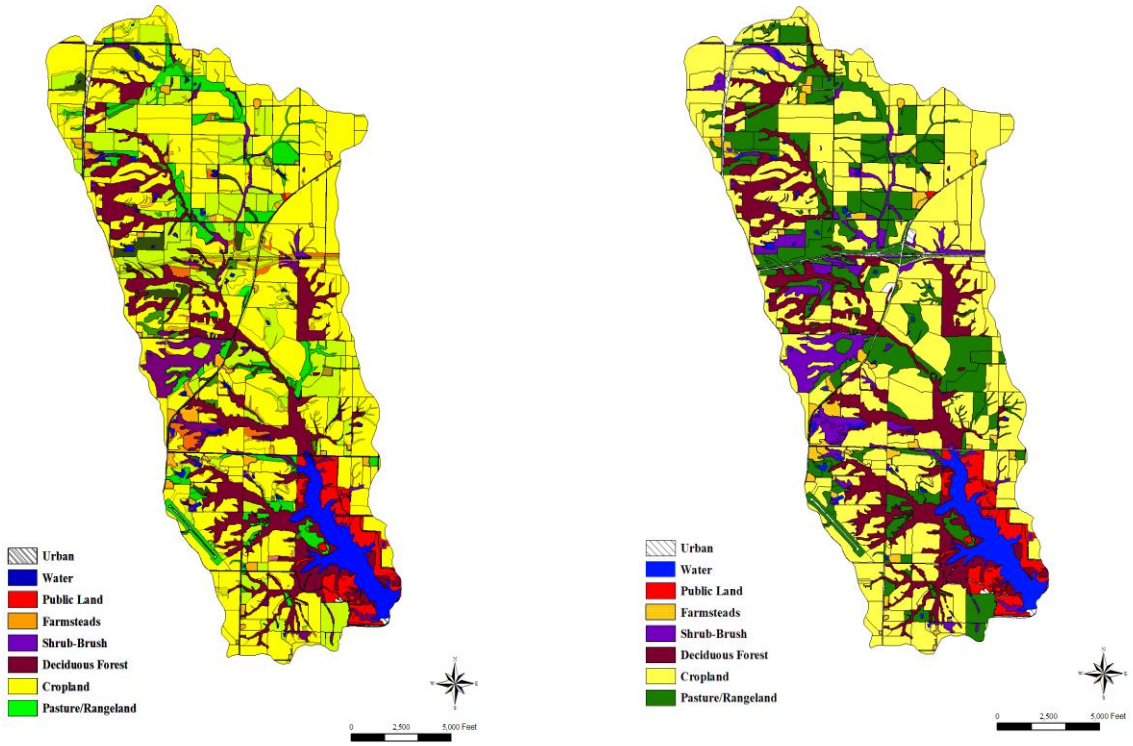

Figure 2. Land use in the Lake Pittsfield watershed, 1979 (left) and 1993 (right).

Lake Pittsfield and its watershed receive approximately1000 mm of precipitation per year, most of which falls in the spring, summer, and early fall. Many of the more intense rainfall events occur in the winter-spring season (January-June). Mean annual temperature in this area over the last 13 years (1995-2008) is 11.7 °C (Midwestern Regional Climate Center 2008).

The Blue Creek watershed above Lake Pittsfield drains an area of Illinoisan-aged glacial deposits that are thousands of years older than the Wisconsinan-aged glacial deposits in northeastern Illinois. The Clinton Keomah, Tama Muscatine and Haymond Wakeland soil series comprise 47%, 17% and 10% of the watershed, respectively (USDA-NRC S 2006). Most soils in the upper watershed are loess-derived and can be highly erosive. These soils developed under prairie vegetation. Soils in the middle and lower portion of the watershed developed on a steeper, forested landscape.

Though soil in the entire watershed is generally of the same age, the western part of the watershed has a more highly dissected drainage network and steeper slope angles than that of the

eastern third of the watershed. The western portion of the watershed in the study area also occurs along the eastern boundary of a driftless (nonglaciated) area, one of the few nonglaciated areas occurring in the state. The eastern side of this nonglaciated area is adjacent to a topographically high drainage divide that delineates the western boundary of the Blue Creek watershed study area. This drainage divide is an Illinoisian-aged moraine that has been highly dissected because of its higher local relief compared to the less dissected eastern third of the study area. In some places it is as much as 30 m above the Blue Creek floodplain and 15 m above the eastern (opposite) drainage divide. As such, the drainage patterns of the western two-thirds and eastern third of the study area are relatively distinct. Topography of the upper watershed has comparatively gentle slopes and generally grassed gullies. The rolling land has many narrow forested ravines, particularly in the lower portion of the watershed. The middle and lower sections of stream longitudinal profiles are comparatively steep.

Land Treatment

Early efforts to curb the lake sedimentation problem mainly used vegetative practices such as grassed waterways, reduced tillage systems, filter strips, and some structural methods such as terraces and dry dams to decrease runoff volumes and velocities, and reduce net erosion. As a result, annual rates of sedimentation in the lake dropped from 13 t/ha in 1974 to 7.7 t/ha in 1979 following introduction of vegetative controls in 1979 (Lee et al. 1981, Lee et al. 1983, Roseboom et al. unpublished, 1993). Later ISWS lake sedimentation surveys continued to show reductions in sediment deposition in Lake Pittsfield following the 1979 controls. In fact, although heavy flooding in the Midwest caused severe damage in the watershed in 1993, sediment yields in the Lake Pittsfield watershed were still half the 1974 rate of 13 t/ha. However, the data also confirmed that the lake was continuing to fill with sediment at an excessive rate. However, as Davenport (1983) indicated, in Illinois, erosion control had been used as a surrogate for sediment control because sediment control is less amenable to quantitative analysis and from a water quality point of view, erosion control practices are not necessarily a control of sediment. Clearly, additional conservation practices would be required to protect area infrastructures, the City of Pittsfield's water supply, and ecological function in the lake and its watershed.

From 1993 to 1995, USDA Water Quality Incentive Project (WQIP) money funded additional conservation practices such as conservation tillage, integrated crop management, livestock exclusion, filter strips, and wildlife habitat management. The Pike County Soil and Water Conservation District (SWCD) conducted an information and education program on the implementation of BMPs for controlling sediment, fertilizers, and pesticides. In 1994, the USEPA, IEPA, and the ISWS, in cooperation with the City of Pittsfield and the Pike County SWCD, formally initiated the Lake Pittsfield project as a component of the USEPA Section 319 National Nonpoint Source Monitoring Program to further control the rate of sedimentation in Lake Pittsfield and to document the effectiveness of the sediment control practices through monitoring.

The SWCD/NRCS constructed 29 Water and Sediment Control Basins (WASCOBs) in 1995 as part of the LPNMP project. WASCOBs consist of earth embankments generally constructed across a sloping area of the farmed landscape and smaller drainage channels to increase sediment trapping and water detention. These structures often help sustain agriculture on sloping land,

reduce watercourse and gully erosion, reduce on-site and downstream runoff, and improve downstream water quality (NRCS 2003). In the Blue Creek watershed above Lake Pittsfield, WASCOBs were installed to meet specific standards on sites that had:

- generally irregular topography,
- problems with watercourse or gully erosion,
- runoff and sediment damage to land and infrastructure,
- suitable soil and site conditions, and
- adequate outlets for drainage

The geomorphologic conditions and available monitoring data in this watershed strongly suggested that most sediment was being delivered to the lake from Blue Creek. Therefore, in 1996 a sediment retention basin (SRB) was constructed at the mouth of Blue Creek. The SRB was constructed by damming Blue Creek just above Lake Pittsfield for the purpose of retaining sediment, providing water detention for stormwater control and establishing higher quality plant and animal habitat. The SRB was constructed to have a 337,842 m^3 water holding capacity at the top level of the dam and a design life of 50 years. Sediment basins such as the SRB described here are generally effective in trapping sediment that flows into them, but some sediment does pass through. Therefore, this SRB is used in concert with watershed erosion control BMPs to reduce the net amount of sediment delivered to the lake.

Construction of WASCOBs was only possible where landowners were willing to participate. Of the 53 WASCOBs originally planned for implementation in the watershed, only 29 (55%) were constructed. Construction of WASCOBs occurred between May and October of 1995. Subwatersheds and the location of WASCOBs within those watersheds as well as the SRB are shown in Figure 3. Thirty-six percent of the entire watershed above Lake Pittsfield drains into the 29 WASCOBs. While subwatershed I had the smallest overall watershed area (170.5 ha), subwatershed I had the highest percent of subwatershed area (69%) draining into WASCOBs. Subwatershed D had the largest watershed area (710.6 ha), and the second highest percent of subwatershed area (45%) draining into WASCOBs. Subwatershed C was 634.1 ha in size, of which 41% drained into WASCOBs. Subwatershed B included 672.2 ha, of which 13.4% drains into WASCOBs. The entire 627.7 ha of Subwatershed A drains directly into the lake. Approximately 214.9 ha or 34% drains directly into WASCOBs prior to reaching the lake.

Reduction of sediment delivery to the mainstem from other BMPs installed prior to or during the construction of WASCOBs was anticipated to be minimal below the WASCOBs located in subwatersheds B, C, and D. An inspection of the NRCS 1993 aerial flyovers (USDA-Aerial Photography Field Office 1993) revealed that 66 small ponds were constructed before 1993 throughout the study area. Also, other conservation BMPs may have been installed during construction of the WASCOBs and may have contributed to sediment reduction. However, the actual number and types of BMPs installed, potential amount of sediment stabilized, and values for sediment transport reduction from other BMPs that may have been installed during the construction of the WASCOBs are unknown. Funding limitations did not allow detailed monitoring below the location of the SRB, but sediment transport to Lake Pittsfield from these watershed source areas was considered to be minor compared to areas draining into the SRB.

Methods

A before/after-BMP monitoring design was devised for the LPNMP effort. Project monitoring lasted ten years from November 1992 through August 2003.

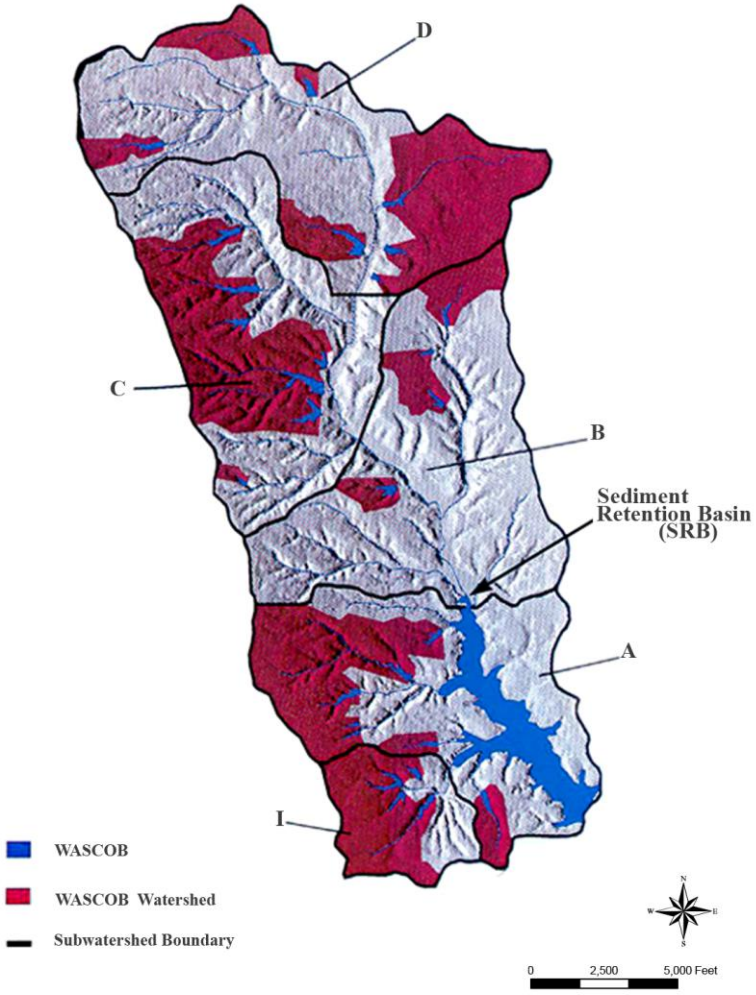

Figure 3. Location of subwatersheds, WASCOBs and the SRB

Monitoring was initiated in 1992 prior to the formal initiation of the LPNMP in 1994 because interest from the local groups and funding opportunity from USEPA and IEPA existed prior to official LPNMP designation.

Rainfall was collected using tipping bucket rain gauges connected to ISCO flow meters that recorded both flow and rainfall data. As part of the LPNMP, a series of eight stream sampling and flow gauging stations and four precipitation gauges were installed across five subwatersheds in the study area. In addition, three water quality stations were located in the lake (Figure 4). Due to logistical and funding issues however, stream sampling was reduced to four gauging stations

on the main channel by 1995. Discharges were manually measured in accordance with United States Geological Survey procedures (Rantz 1982) at each station during storm events using a Marsh-McBirney Flo-Mate model 2000 velocity meter. These measured discharges were used to develop rating curves. Gage height data collected by the ISCO flow meters during storm events were used in conjunction with the rating curves to obtain stream discharge values.

Subwatersheds were determined by station locations and topography. Sediment monitoring stations were located at the mouth of each of the subwatersheds as shown in Figure 4. Sediment loads were calculated by numeric integration of Total Suspended Solids (TSS) (hereafter will be referred to as TSS or 'sediment') concentration and discharge over sampling time intervals. Streambank erosion was monitored by establishing stream cross-sections to determine channel morphological change over time.

At stations B, C, D, and H (Figure 4), sediment samples were collected at 15-minute intervals with an automatic sampler to ensure sample collection during rising and maximum discharge stages of storm events. The ISCO flow meters were set to activate the samplers after a one-foot rise above base level of the stream. After 1998, sampling interval was increased to 1 hour to reduce cost. At all stations, manual samples were collected using a DH 59 sampler. From 1992 to 1995 grab samples were taken from the spillway at the dam of Lake Pittsfield (Station A) during storm events so some caparisons could be made between TSS coming into the lake at Station B and going out of the lake at Station A. It was not practical to monitor discharges at Station A so loading yields were not calculated. Total suspended solids coming out of the lake at Station A were very low compared to TSS values coming in to the lake at Station B indicating that the vast majority of sediment coming in to Lake Pittsfield at Station B was being deposited in the lake. Monthly sediment samples were collected at station C to determine sediment yield at stream base levels. Samples were analyzed for TSS gravimetrically after being dried at 105^{o} C following the specified USEPA methodology (USEPA 1983). It should be noted, however, that the analysis used for this study determined TSS and not Suspended Sediment Concentrations (SSC) as currently performed by the ISWS Sediment Laboratory.

Samples for water quality analysis were obtained between 1993 and 1995 from the three water quality stations in the lake using methods described in the IEPA Quality Assurance and Field Methods Manual (1987). Water samples were obtained from various depths and analyzed for dissolved oxygen, transparency, total and volatile suspended solids, pH, alkalinity, conductivity, ammonia, nitrite, nitrate, total nitrogen, ortho phosphate, total phosphate, and atrazine (USEPA 1983, USEPA 1991, USEPA 1991, Twait and Raman 1993).

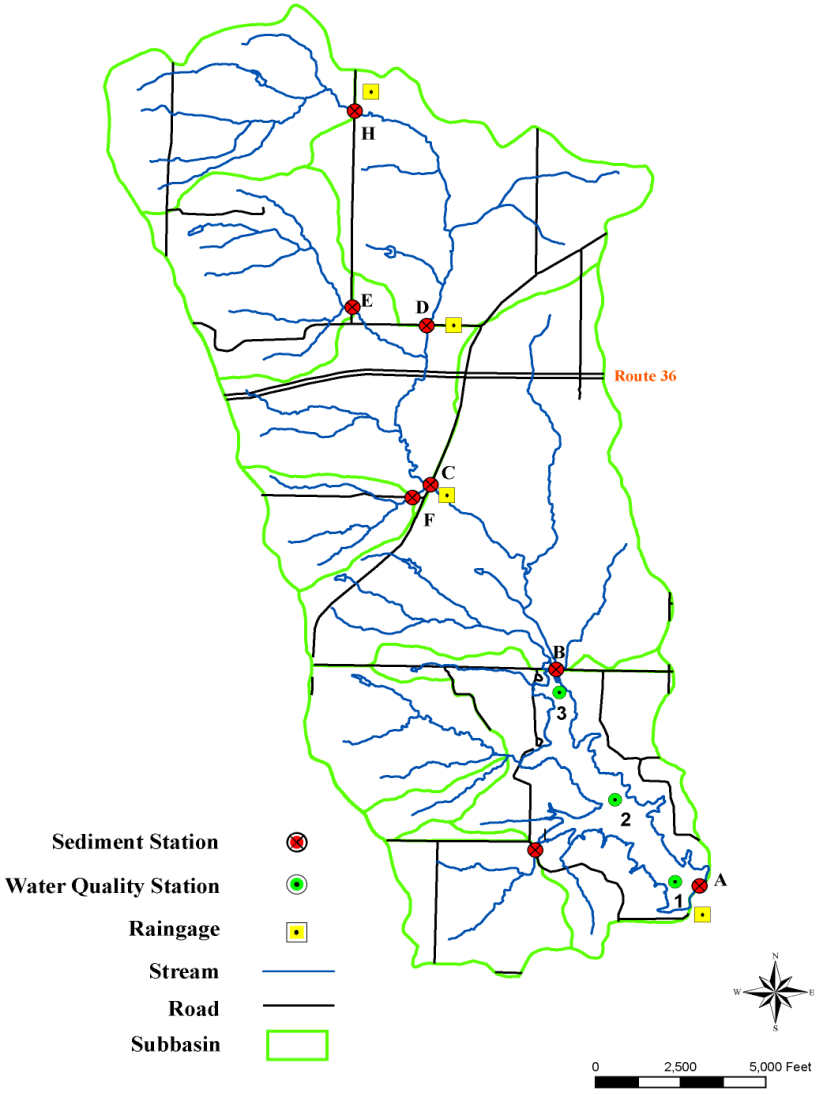

Figure 4. Monitoring stations in the watershed above Lake Pittsfield

From February 1992 to February 1998, sediment samples and lake water quality samples were analyzed at the ISWS laboratories in Peoria and Champaign, Illinois. Due to changes in ISWS laboratory certification status in 1998, sediment samples were thereafter sent to the IEPA certified Peoria Disposal Company (IELAP, section 1, 2007) laboratory in Peoria, Illinois for analysis. Duplicate and "spiked" samples were analyzed at all three of these laboratories and used to ensure sample quality control.

Project data were analyzed in two stages. Preliminary data (1992-1998) were analyzed by Grabow (unpublished, 1999), while LPNMP project staff conducted subsequent analysis on complete project data (1992 to 2003). Grabow (unpublished, 1999) first evaluated discrete changes in sediment yield, then gradual changes and lastly year-by-year changes. To analyze discrete changes in sediment yield, Grabow (unpublished, 1999) conducted multiple regression analysis on data from 1992-1998 using the variables 'period', 'season' and 'discharge'. The variable 'period' defined data from 1992 to 1996 as being pre-BMP, while data from 1997-1998 was defined as post-BMP. Sediment yield per storm event was the dependent variable. Storm water discharge, period and season (winter/spring and summer/fall) were explanatory variables. Grabow (unpublished, 1999) used the nonparametric Kendall's tau-b (Kendall, 1938) to corroborate findings from the test for gradual change in sediment yield from storm events from 1992 to 1998. Analysis of Covariance (ANCOVA) was used to detect differences in sediment yield between specific years. The data were log transformed due to the skewness of the data. Further details on these procedures can be found in Grabow et al. (1999a, b, and c).

Multiple regression analysis was also used to analyze updated data covering 1992 to 2003 consistent with Grabow's (unpublished, 1999) methodology. As before, the variables 'season,' 'discharge,' and 'period' were used as explanatory variables, with the 'period' variable redefined as pre-BMP (1992–1996) and post-BMP (1997-2003). Storm event sediment yield was the dependent variable. Storm water discharge, period and season (winter/spring and summer/fall) were explanatory variables. Statistical tests and results are summarized in Table 1. Kendall tau b and ANCOVA results for gradual and yearly change in sediment yield from storm events from 1992 to 2003 will be published elsewhere. All statistical analyses were done using appropriate SAS procedures (SAS Institute 2001). The impact of potential differences in the intensity of individual storm events was not examined in this study and could affect conclusions presented here regarding trends in erosion and sediment yield. The authors are in the process of investigating this issue.

Monitoring Results and Discussion

Lake sedimentation survey data provided information on the effectiveness of earlier erosion control programs. Additional analysis of previous data (Bogner 1979 and 1986; Lee 1981; Lee et. al 1983' Roseboom et. al 1993; and Allgire 1993) and data collected during the LPNMP project revealed that past erosion control efforts (primarily vegetative, using no-till cultivation) were somewhat effective and enhanced the impacts of BMPs installed during the monitoring period of the LPNMP. Traditional BMPs continued to be installed during the LPNMP but the primary BMPs installed during this time included WASCOBs and a few habitat restoration strategies (e.g., in-stream riffle and pool structures).

Data were collected and analyzed from stations B, C, D and H, which were still operational after 1995. Due to the small size of subwatershed H and correspondingly small discharge events, and because few WASCOBs were installed in this subwatershed, the existing data from this station are not addressed in detail in this article.

The network of WASCOBS significantly reduced delivery of sediment from stations B, C and D. Sediment yields from individual storm events at stations C and D both before and after the WASCOBs and SRB were installed can be viewed in Figures 5 and 6. In Grabow's (1999)

multiple regression analyses, the variable 'period' was significant at α=0.01, and pre- and post-BMP sediment yield data at stations C and D indicated that sediment yields dropped by 45% and 48%, respectively (Grabow 1999). Sediment yields in 1998 in subwatershed C (after construction of upland WASCOBs) were 1.1 – 2.2 kg/ha lower than in 1993-1994 (before construction of upland WASCOBs) (Figure 5). Updated data analysis show similar results, where multiple regression analysis on sediment yield data over the entire project period (from 1993 to 2003) show decreases of 68% and 61% at stations C and D, respectively (Table 1).

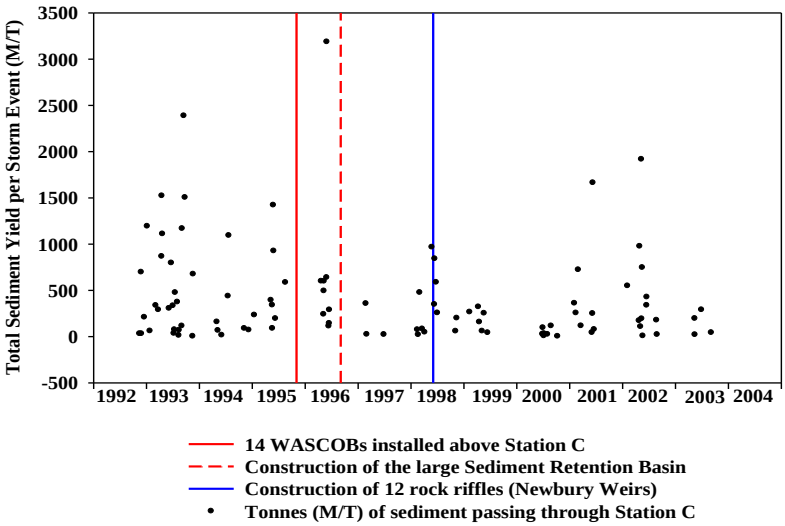

Figure 5. Sediment yields from storm events, monitoring station C, 1992-2003. The number of WASCOBs cited represents the cumulative number constructed above the monitoring station.

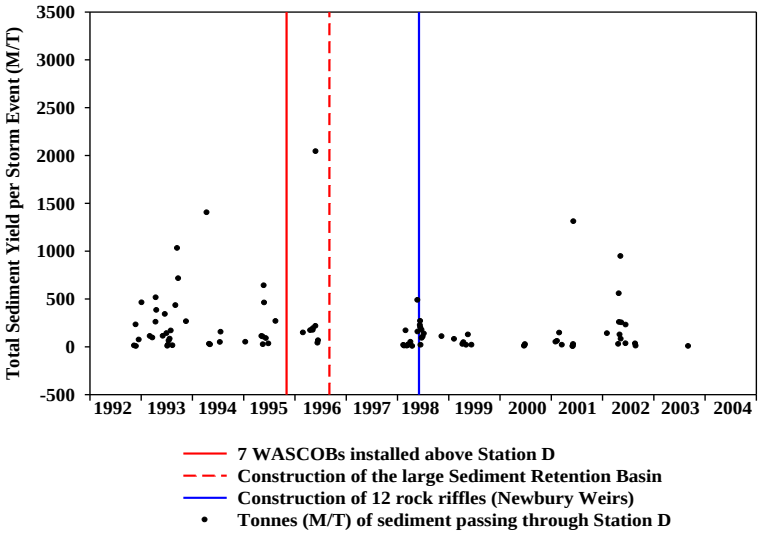

Figure 6. Sediment yields from storm events at monitoring station D, 1992-2003. The number of WASCOBs cited represents the cumulative number constructed above the monitoring station.

Table 1. Summary of Findings by Station[1] (modified from Grabow (1999))

Station		Analysis Method[3]		
	Period covered	**Pre/Post**	**Yearly**	**Gradual**
B	1992-1998	90% reduction	1997 and 1998 lower than all previous years	Significant trend, reduction from 330 to 70 kg at avg flow (79% reduction)
	1992-2003	91% reduction*	--	--
C	1992-1998	45% reduction	1998 lower than 1993, 1994 and 1996	No significant trend over period covered
	1992-2003	67.8% reduction*	--	--
D[2]	1992-1998	48% reduction	1998 lower than 1993 and 1996, higher than 1992. 1996 higher than all other years	No significant trend over period covered
	1992-2003	61% reduction*	--	--

[1]Sediment yield and reductions based on average flow
[2] No data collected in 1997
[3] All statistical results presented are significant at α=0.05
* These results were obtained by the authors. All other results were obtained by Grabow (unpublished, 1999)

Of all the stations monitored, station B showed the most dramatic reduction in sediment delivery presumably because of its location at the SRB (See Figures 4 and 7). Sediment loads measured at station B declined from 8480 t/yr (4200 kg/ha/yr), before construction of the SRB in 1996, to 328 t/yr (162 kg/ha/yr) after construction of the SRB. As with stations C and D, multiple regression analysis of sediment yield data from Station B using the variable 'period,' as defined by Grabow (1999) showed the variable 'period' was significant at α=0.01 and that pre- and post-BMP sediment yield data suggest a 90% reduction in sediment yield at station B (Grabow 1999). Results from statistical tests for yearly and gradual changes in sediment yield corroborate with those from tests for discrete changes, except for tests for gradual change at stations C and D, which were not significant (Table 1). Multiple regression analysis results from sediment yield data at station B over the entire project period (1992-2003) also show almost 91% reduction between pre-BMP vs. post-BMP period (Table 1). Impressive storm events occurring in 2001 and 2002 produced significant sediment yields with WASCOBs in place, yet sediment passing station B was still about half of what had been transported prior to WASCOB construction (895 tons in 2001 and 611 tons in 2002 vs. 8480 tons/yr before SRB construction) (Figure 7).

Reduction of sediment yield as a result of WASCOB installation was also apparent during individual seasons. In Illinois, the winter-spring season is the period of highest surface water run-off rates and sediment discharge during the year due to the prevalence of frozen soil and lack of

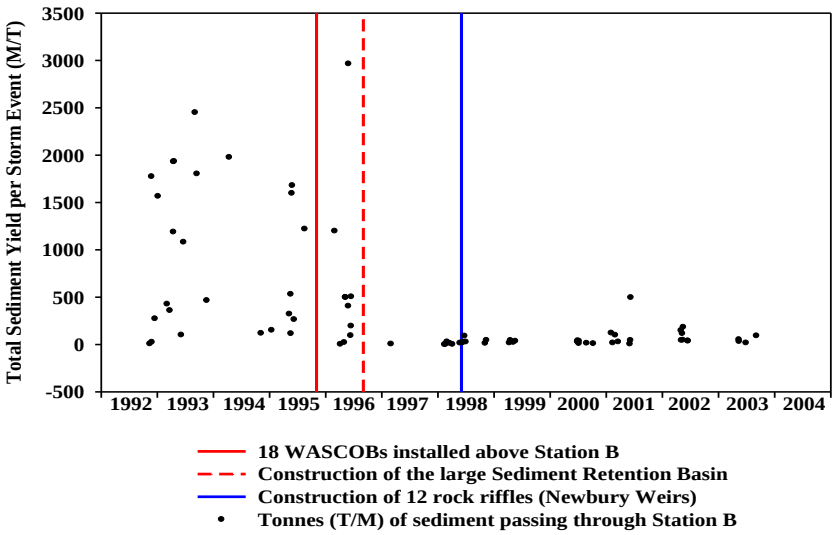

Figure 7. Total sediment yield, monitoring station B, 1992-2003. The number of WASCOBs cited represents the cumulative number constructed above the monitoring station.

vegetation on land surfaces (Roseboom et al. unpublished, 2001). This season is characterized by high soil moisture content, high-intensity storms, and highest annual discharge events. Average sediment concentrations and discharge during the winter-spring period (January 1-July 30) from 1992 to 2003 at stations C and D are shown in Figure 8. Winter and spring storms at both stations produced high average sediment concentrations from 1993 to 1996. After drought conditions in 1997, average sediment concentrations remained lower, despite high discharges in 2001 and 2002. Results also show lower yield of sediment per hectare-meter of water discharge after 1997 (Figure 9). These components of analysis support the overall trend of reduced sediment yields.

Decreased total sediment yield and average sediment concentrations calculated from data collected at stations C and D during the LPNMP monitoring project does not appear to be due to reduced precipitation associated with seasons. Analysis of annual precipitation data obtained from the Mid-Western Regional Climate Center (Station name: Pittsfield No. 2, Station ID: 116837) revealed that total annual precipitation over the project period showed no increasing or decreasing trend and winter and spring precipitation actually increased over time. Stations C and D, however, had a spike in sediment delivery in 2002 (Figure 8) either because total annual precipitation for 2002 was higher than average annual precipitation over the project period (1092.2 mm/yr vs. 952.5 mm/yr, Mid-Western Regional Climate Center, 2008) or because of other concerns still under investigation.

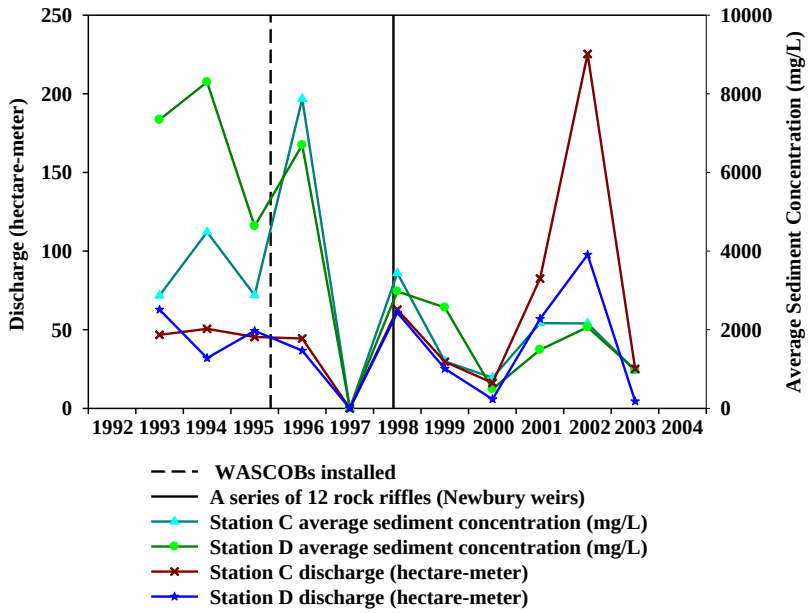

Figure 8. Winter-Spring discharge and average annual sediment concentration at monitoring stations C and D, 1993-2003

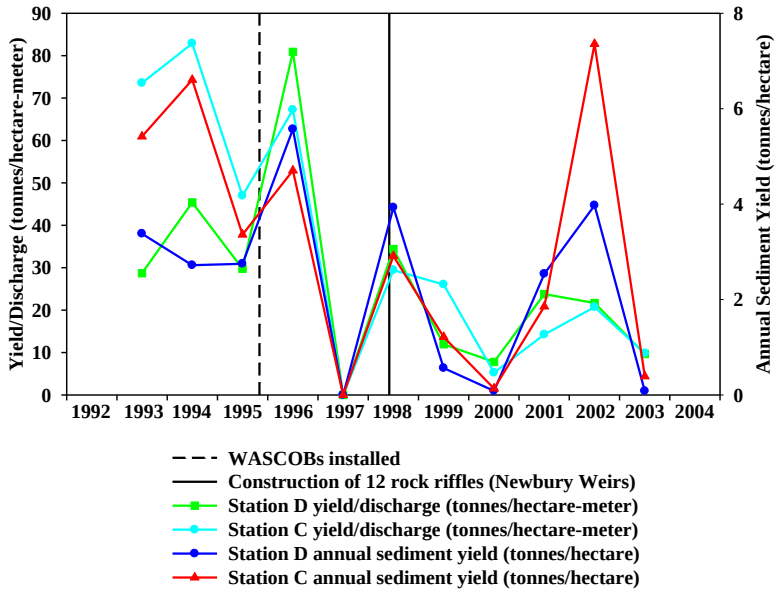

Figure 9. Winter-Spring sediment yield and yield/discharge from data obtained at monitoring stations C and D, 1992-2003.

As such, the influence of drought conditions has been ruled out with the clear exception of the 1997 drought, which had significantly low total winter-spring precipitation and no appreciable

discharge events. As briefly suggested earlier in this article, the impact of potential differences in the intensity of individual storm events could affect conclusions presented here regarding trends in erosion and sediment yield, therefore the authors are continuing to investigate this issue.

One exception to the decreasing trend in sediment yield after WASCOB installation is apparent from a large area in subwatershed D. In 1996 and 1998, sediment yield doubled even though approximately 45% of subwatershed D drained through several WASCOBs before reaching the Blue Creek mainstem. The increase in sediment yield as monitored at station D was found to coincide with massive channel erosion in the stream segment downstream of the installed WASCOBs (Roseboom et al. 2001). While definitive proof of cause and effect is lacking, the authors believe it is possible that the stream became more unstable as less sediment was being transported to the channel downstream of WASCOB construction in that portion of subwatershed D. For example, Simon and Darby (1977) related that various types of grade-control structures have been successfully used to arrest the upstream propagations of knickpoints and ensuing degradation. However, Simon and Darby (1977) further indicated that if the structure ponds water as a dam, resulting in sediment deposition upstream from the structure, a new wave of degradation is induced by 'clear water flows' downstream. This same geomorphic response seems to have occurred in Blue Creek. Lower or no significant sediment reduction from statistical tests for gradual change in sediment yields at stations C and D could also possibly be due to the channel adjustment as a result of BMP installation (clear water flows) (Grabow 1999). By applying adaptive management concepts, further channel stabilization and stream system naturalization and restoration was implemented to counteract downstream channel erosion potentially initiated by the construction of WASCOBs. Nonetheless, it is still possible that channel degradation was initiated because of hydraulic adjustments caused by other land treatments.

The data also show that topography influences soil erosivity. Forested and pasture areas on steeper slopes (in subwatershed C) contributed more sediment than row-cropped fields in flatter areas (in subwatershed D). Stream monitoring results from 1993 and 1994 indicated that mean event sediment yield from station D (272 t and 330 t per event) was at least half that from station C (624 and 918 t per event). Though soils in both subwatersheds C and D are of the same age, the steeper topography in subwatershed C renders the soil more erosive, leading to more intricate drainage and steeper valley slope.

Twelve pool and riffle structures were constructed within a key segment of the channel in subwatershed D in 1998 as a multi-objective solution for stabilizing the channel system (Figure 10). These structures were funded by a separate contract from the NMP funds (including federal Clean Water Act Section 319 and state Conservation 2000 funds). The pool and riffle structures were installed specifically to mimic natural stream pools and riffles by stabilizing the channel bed and banks, providing quality in-stream habitat and aeration for fish and other aquatic species, and enhancing aesthetics. An example of the pool and riffle structures is shown in Figure 11.

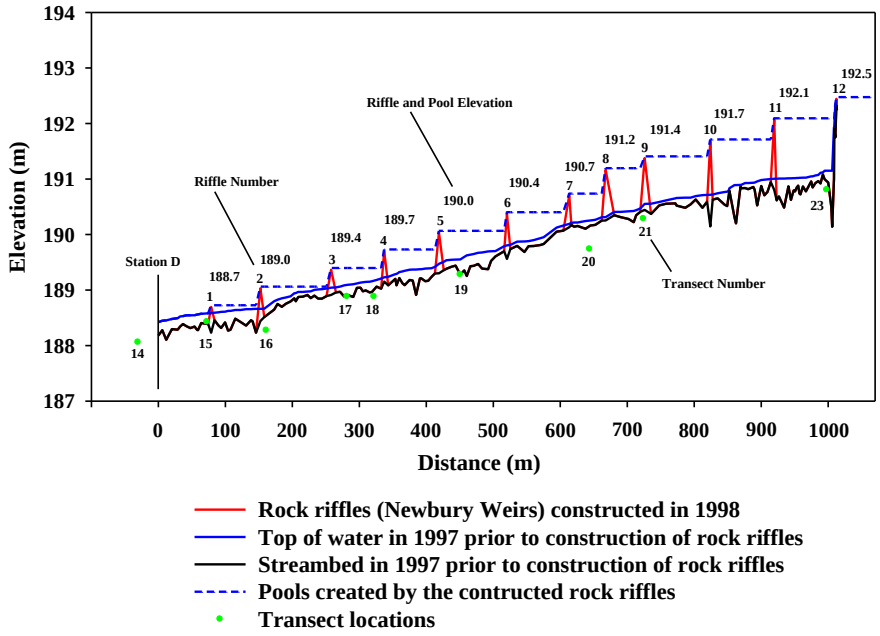

Figure 10. Pool and riffle structures in the Blue Creek watershed constructed above station D

Figure 11. Pool and riffle structure in Blue Creek watershed

Annual inspections and video and photo-documentation from 1998 to 2003 indicate that the pool and riffle structures have stabilized streambanks and the channel bed and reduced sediment input into Lake Pittsfield. Formerly bare eroding stream banks are now vegetated and the riffle

structures have become somewhat embedded by vegetation growth. Mass wasting sites along the channel have also stabilized.

Dredging operations in the lake were carried out in 1999 after excessive erosion in the watershed and sediment transport to the lake was better controlled. The uppermost 7 ha of Lake Pittsfield were dredged to an average depth of 5.5 m, removing 167,777 m^3 of sediment. Sediment yield data through 2003 indicated that erosion control features continue to function very well, especially since construction of the SRB and pool and riffle structures.

Conclusions

The network of WASCOBs and SRB, enhanced by existing erosion control strategies, has reduced sediment yields into Lake Pittsfield. Also, project experience has shown that the highest levels of erosion and sediment transport tend to occur in physiographic areas with the most topographic relief, loess soils and steepest slopes, and are somewhat independent of land use and land cover. The very different nature in slopes of the subwatersheds in the study area (subwatersheds C and D) illustrate the need to consider different water and soil erosion control management applications for each area based on soils, drainage patterns, slope, and other soil geomorphic and physiographic factors.

Another important finding of the project is that channel and near channel sources such as unstable streambanks and streambeds are significant contributors to watershed sediment yield. Such sources contribute a significant or even dominant portion of overall sediment loads to streams. Furthermore, watershed managers need to consider that stream channel instability can be forced by both upstream and downstream control measures. In the Blue Creek watershed, sediment detention by WASCOBs, and perhaps other land treatments may have reduced sediment transport, but induced or increased the rate of lateral migration (streambank erosion) or downcutting (channel incision). As such, it is important to consider addressing the equilibrium of the stream channel system by using appropriate channel design techniques as a component of any regular conservation land treatment project. This is of particular importance downstream of sediment control structures. Also, further research is still necessary on channel equilibrium, stream channel threshold levels, sediment yields and specific impacts of individual storm events.

Several meaningful partnerships were formed during the course of this project. Coordinating participants include the USEPA, IEPA, Illinois Department of Natural Resources (IDNR) Office of Resource Conservation and ISWS, Illinois Department of Agriculture, USDA FSA and NRCS, Pike County SWCD, City of Pittsfield, Illinois Farm Bureau, and private landowners.

Commitment by the USEPA and IEPA to monitor Lake Pittsfield and its watershed was instrumental for the ISWS to obtain the necessary information about the system to reduce sediment delivery to Lake Pittsfield. The 1992-2003 monitoring data offers a science-based framework to focus land treatment more efficiently and effectively. Today, the biological and water-supply functions of Lake Pittsfield are better protected than before. Data from this project effort continue to help evaluate the channel design techniques installed (pools and riffles) and guide the operation and maintenance of them.

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