Section 319 Nonpoint Source National Monitoring Program

Successes and Recommendations

November 2000 (pre-print)

Report prepared for
U.S. EPA
by
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The Section 319 National Monitoring Program projects have quantified water quality improvements from nonpoint source controls and strengthened strategies for effective future watershed programs.

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This publication should be sited as: Lombardo, L.A., G.L. Grabow, J. Spooner, D.E. Line, D.L. Osmond, and G.D. Jennings. 2000. *Section 319 Nonpoint Source National Monitoring Program Successes and Recommenda-tions*. NCSU Water Quality Group, Biological and Agricultural Engineering Department, NC State University, Raleigh, North Carolina.

Cover: Riparian area before and 2.5 years after livestock exclusion on a tributary to Long Creek in North Carolina. Effective riparian restoration and pasture management have resulted in dramatic decreases in sediment, phosphorus, and bacterial pollutants entering the creek.

Contents

Disclaimer: *This publication was developed by the NCSU Water Quality Group, North Carolina State University, a part of the North Carolina Cooperative Extension Service, under U.S. Environmental Protection Agency (USEPA) Grant No. X825012. The contents and views expressed in this document are those of the authors and do not necessarily reflect the policies or positions of the North Carolina Cooperative Extension Service, the USEPA, or other organizations named in this report. The mention of trade names for products or software does not constitute their endorsement.*

Section 319 National Monitoring Program: *Overview*

During the past eight years of the Section 319 Nonpoint Source National Monitoring Program (NMP), information has been gathered that can be of use to watershed professionals, the agricultural community, policy makers and staff, and citizens. This report shares some of the successes and lessons learned from the NMP. From these lessons, recommendations are made to help enhance future watershed projects and state nonpoint source water quality programs.

Under Section 319 of the Clean Water Act, the USEPA developed the National Monitoring Program to address nonpoint source pollution. The program's objectives are twofold:

1) To scientifically evaluate the effectiveness of watershed technologies designed to control nonpoint source pollution; and

2) To improve our understanding of nonpoint source pollution.

To achieve these objectives, watershed projects across the country have been selected for an increased level of funding and technical assistance. This increased focus on a few projects has facilitated the understanding of processes that govern the transport and control of nonpoint source pollution, which can then be transferred to state and local organizations for use in addressing water quality problems. Currently, 23 projects are part of the NMP. Additional NMP projects are being solicited.

Water quality monitoring coordinated with effective land treatment is an integral component of all the projects in the NMP. Typically, monitoring of baseline conditions is conducted for at least 2 years, followed by Best Management Practices (BMP) implementation and monitoring for an additional 3 to 6 years, for a total project period of 5 to 10 years. Data from pre- and post-BMP periods are statistically analyzed to evaluate whether water quality changes can be attributed to BMP implementation.

Most projects are in the post-BMP and evaluation phase and many accomplishments are being realized. Projects nearing completion are beginning to show water quality improvements based on preliminary data investigations and are summarized under *Key Project Accomplishments*. Long-term projects can provide tremendous information to improve our ability to ensure the implementation of the appropriate land management practices to achieve water quality goals.

Recommendations for Successful Projects based upon the experiences in the National Monitoring Program are also summarized. *Highlights* of all the NMP projects, including successes and lessons learned, are included at the end of this report. More detailed summaries of all the current NMP projects can be found at *http://h2osparc.wq.ncsu.edu/319index.html.*

National Monitoring Program: *Key Project Accomplishments*

Highlights from a few of the National Monitoring Program projects that have documented improvements in water quality after BMP implementation include:

CALIFORNIA – Morro Bay

Morro Bay, one of the few intact natural estuaries along California's coast, is being impaired primarily by sediment. Brushland, rangeland, and streambank erosion contribute the largest portion of sediment deposited in the Bay. The Morro Bay Watershed project is evaluating the effectiveness of sediment-reducing BMP systems, such as creation of smaller pastures, installation of cattle watering systems, stabilization and revegetation of streambanks, and installation of water bars and culvert on farm roads.

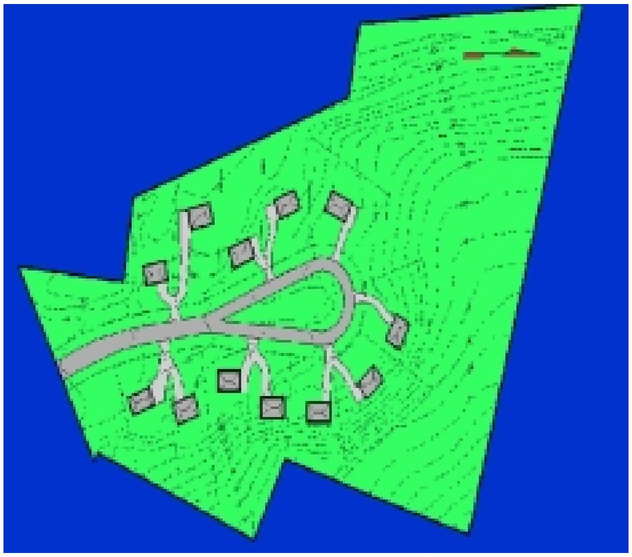
- At one of the watershed study sites, a 49% reduction in turbidity was documented. A suite of BMPs, including improved grazing management, riparian fencing and re-vegetation, was responsible for the reduction in turbidity.
- Riparian fencing and improved grazing management has proven to be effective in reducing bacteria levels in adjacent streams in the watershed.

Degraded tributary due to over grazing (Morrow Bay, California).

Tributary riparian area and watershed improvements after rangeland management, grazing rotation, and vegetative planting (Morro Bay, California).

CONNECTICUT — Jordan Cove

Jordan Cove, a small estuary fed by Jordan Brook, is part of the Long Island Sound. Water quality sampling has indicated that the cove does not meet bacteriological standards for safe shellfish collection. The watershed that drains Jordan Cove estuary is primarily forest and wetlands (74%) with increasing urban land use (19%). As urbanization continues, concern has increased about the impact of suburbanization on the estuary during and after construction. The pollutant of concern during construction is sediment, whereas the pollutants of concern after construction are bacteria, phosphorus and nitrogen. This project will help characterize polluted runoff from urbanized areas.



Treatment watershed site plan includes construction BMPs, shared driveways, pervious pavement and bioretention gardens (Jordan Cove, Connecticut).

Runoff from three subdivisions is being monitored to assess the effects of construction and urban development. The three sites are: an established subdivision with 43 houses, a subdivision that is being built with generally accepted traditional construction practices, and a subdivision being built using BMPs. Non-structural construction BMPs consist of earthen berms, phased grading, immediate seeding of stockpiled topsoil, maintenance of vegetation around the construction area, and immediate temporary seeding of proposed lawn areas. Structural practices include sediment detention basins and swales, bioretention areas and a road of permeable concrete pavers (concrete blocks with holes in them), and the minimization of impervious surfaces. Post-construction, non-structural BMPs will consist of street sweeping, implementation of fertilizer and pesticide management plans, pet waste management, and yard waste pickups.

- In the traditional watershed, where houses are being built using generally accepted construction practices, weekly flow and peak discharge significantly increased by almost 100% due to land development, with increased concentrations and loading of nitrate-nitrogen (NO3-N). Sediment export increased 90% and total phosphorus increased 89% during construction. Loading of copper, lead and zinc also increased during the construction period.
- Results from the construction period at the traditional site suggest that increased runoff, rather than erosion, was the cause of increased pollutant export from the site.

Pervious concrete pavers for roadway in BMP subdivision. Swales will be used instead of curb and gutter (Jordan Cove, Connecticut).

ILLINOIS — Lake Pittsfield

Lake Pittsfield was constructed in 1961 to serve as a flood control structure and as a public water supply for the city of Pittsfield, a western Illinois community of approximately 4,500 people. The 7,000-acre watershed (Blue Creek Watershed) that drains into Lake Pittsfield is agricultural, consisting primarily of corn and soybean cropland.

Sedimentation is the major water quality problem in Lake Pittsfield. Sediment from farming operations, gullies, and shoreline erosion has decreased the capacity of Lake Pittsfield by 25 percent in the last 33 years.

To reduce sediment transport into Lake Pittsfield, settling basins were constructed throughout the watershed, including a large basin at the upper end of Lake Pittsfield. Additional sediment-reducing practices were installed such as conservation tillage, integrated crop management, livestock exclusion, filter strips, terraces, settling basins, and wildlife habitat management.

Lake Pittsfield (Illinois).

The objective of the NMP project was to evaluate the effectiveness of the settling basins in reducing sedimentation into the lake. Water quality monitoring consisted of tributary sampling after rainstorms (to determine sediment loads); monthly water quality monitoring at three lake sites (to determine trends in water quality); and lake sedimentation rate monitoring (to determine changes in sediment deposition rates and patterns).

- ◆ A 90% reduction in sediment loading to Lake Pittsfield was achieved through the installation of several water and sediment control basins. The large (147 ac-ft) sediment basin just upstream of the lake was more effective in general than the smaller basins located upstream.
- ◆ Stream stabilization on Blue Creek was an important component in the overall program to reduce sediment loading to the lake. Installation of low stone weirs prevented further channel incision and mass wasting of stream banks.

Sediment retention basin (Lake Pittsfield, Illinois).

ILLINOIS — Waukegan River

The Waukegan River, located in Waukegan, Illinois, about 35 miles north of Chicago, has a watershed area of 7,640 acres in a mostly urban setting. This is an urban stream restoration project. High-volume runoff from impervious surfaces and a lack of storm water controls is creating channel instability in urban streams. Habitat quality is degraded as evidenced by low oxygen levels, shallow pool depths, and limited cobble substrate.

The project used biotechnical bank restoration (a combined vegetative and structural approach) to stabilize streambanks and low stone weirs to restore pool and riffle sequences. Several sites were restored using a combination of lunkers (structures that stabilize banks and provide fish habitat), a-jacks (structures that look like playing jacks that stabilize streams), and riparian plants such as dogwood, arrowhead, and willow. An upstream/downstream habitat monitoring design was used to document water quality changes in the Waukegan River at the South Branch stations.

- ◆ Pool and riffle restoration has improved biological diversity. The implementation of the pool/riffle series on the South Branch of the Waukegan River has increased the Index of Biotic Integrity (IBI) and the overall population of the fish collected during the season sampling events.

Streambank erosion (Waukegan River, Illinois).

Riffles were installed downstream of lunkers to improve fish habitat (Waukegan River, Illinois).

MICHIGAN — Sycamore Creek

Sycamore Creek is located in south-central Michigan. The creek has a drainage area of 67,740 acres, which includes the towns of Holt and Mason and part of the city of Lansing. The major commodities produced in this primarily agricultural county are corn, wheat, soybeans, and some livestock. Sycamore Creek is a tributary to the Red Cedar River, which flows into the Grand River. The Grand River discharges into Lake Michigan.

The major pollutants of Sycamore Creek are sediment, phosphorus, nitrogen, and agricultural pesticides. Sediment deposition is adversely affecting fish and macroinverte-brate habitat, and the decay of organic soils is depleting oxygen in the water column. Sycamore Creek was selected for monitoring because it is representative of creeks throughout lower Michigan.

Streambank erosion control is being conducted under a Section 319 grant to the County Drain Commissioner. Land management consists primarily of sediment- and nutrient-reducing BMPs on cropland, pastureland, and hayland. These practices were funded as part of the USDA Sycamore Creek Hydrologic Unit Area (HUA) project.

Water quality monitoring was conducted in three subwatersheds: Haines Drain, Willow Creek, and Marshall Drain. The Haines subwatershed, where some BMPs had already been installed, was the control and is outside the Sycamore Creek watershed.

Soil sampling for nutrient management planning (Sycamore Creek, Michigan).

◆ The Sycamore Creek project documented a reduction in sediment load of 57% in one subwatershed (Willow Creek). A direct correlation between the extent of no-till land and sediment reduction was detected. However a significant reduction in sediment load was not measured in another subwatershed (Marshall Dain) where no-till implementation was greater. The main difference between these subwatersheds was the implementation of stream bank erosion control in Willow Creek but not in Marshall Drain.

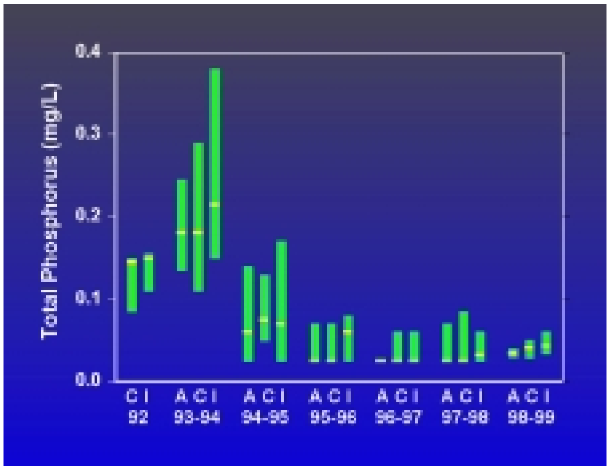
NORTH CAROLINA – Long Creek

The Long Creek Watershed, situated in the southwestern Piedmont of North Carolina, encompasses 8300 ha of land in agricultural and urban uses. Long Creek is the primary water supply for Bessemer City, which is located in the headwaters area of the creek. Water quality problems in watershed streams include high sediment, bacteria, and nutrient levels.

◆ The stream channel near the Bessemer City water supply intake has historically required dredging three to four times per year due to sediment accumulation. Conservation practices implemented upstream of the intake pool have reduced the need for dredging to less than once per year.

Dredged sediment at water supply intake prior to project initiation (Long Creek, North Carolina).

- The implementation of primarily livestock exclusion fencing along with riparian vegetation establishment in a 57-ha dairy pasture resulted in significant reductions in sediment (83%), total phosphorus (76%), total Kjeldahl nitrogen (78%), and nitrate+nitrite (33%) loads in a tributary to Long Creek. Greater than a 70% reduction in fecal coliform bacteria level was also documented in weekly grab samples.
- Total phosphorus concentrations in Long Creek decreased from a median of around 0.18 mg/l during the first year of the project to less than 0.04 mg/l during the last three years of monitoring. Reductions in bacteria and sediment levels in the last two years have also been documented.



Reduction of phosphorus after implementation of nutrient and sediment erosion controls in watershed cropland and animal operations; Sites A, C, and I are an upstream to downstream squence and are downstream of most BMPs (Long Creek, North Carolina).

OREGON — Upper Grande Ronde Basin

The project is located in northeast Oregon, within the 695-square mile Upper Grand Ronde Basin. Streams of the Grande Ronde basin have historically provided a rich habitat for cold water fish, such as rainbow trout, salmon, summer steelhead, and bull trout. However, cold water fish production has been declining since 1970 as land use changes have reduced riparian vegetation by 75% and simplified in-stream habitat due to grazing practices and channel modifications. Stream temperatures have risen as riparian vegetation that once shaded the streams has been lost and channels have been straightened and widened. Higher temperatures in the stream have resulted in reduced cold water fish populations.

Unrestored section of McCoy Creek (Upper Grande Ronde Basin, Oregon).

The objective of this project is to document the effects of habitat restoration on stream temperatures and aquatic communities. A paired watershed design is being used. Monitoring is focused primarily on biological indicators, such as fish, macroinvertebrates, and habitat. The treatment stream, a segment of McCoy Creek, was treated by stabilizing and revegetating riparian areas, restoring wet meadow conditions and restoring old channels to allow the stream to naturally meander.

- Beavers have built several new dams in the restored segment of McCoy Creek, which form excellent pools for fish and waterfowl. The narrower and deeper channel of the restored reach has also resulted in some reduction in water temperatures within the restored channel segment.
- Fish snorkel surveys in 1998 and 1999 showed the reconstructed reach to have the highest concentration of fish of the McCoy Creek sites. In addition, numbers of rainbow trout juveniles in the restored reach have increased each year since 1997. Rainbow trout numbers in adjacent reaches without restoration have remained unchanged during the same time period.

McCoy Creek after natural channel design restoration (Upper Grande Ronde Basin, Oregon).

VERMONT — Lake Champlain Basin

Lake Champlain fails to meet Vermont water quality standards for phosphorus, largely due to excessive nonpoint source loads from agriculture. The Missisquoi River contributes the greatest share of nonpoint source phosphorus to Lake Champlain, and is itself impacted by phosphorus, bacteria and organic matter from agricultural sources, primarily animal wastes from dairies, cropland, and livestock activity within streams and riparian areas.

Riparian zone in Godin Brook after 1.5 years of livestock exclusion by fencing (Lake Champlain Basin, Vermont).

Within the Missisquoi River basin, average bacteria counts in tributary streams often exceed Vermont water quality standards. Phosphorus and nitrogen levels indicate significant nutrient enrichment. Fish and macro-invertebrate data suggest moderate to severe impacts due to nutrients and organic matter.

The project is designed to implement and evaluate the effectiveness of livestock exclusion, streambank protection, and riparian zone restoration in reducing the concentrations and loads of nutrients, sediment and bacteria from agricultural sources. One control watershed and two treatment watersheds receiving similar treatment at different intensities are being monitored. The treatments implemented include controlled livestock access to streams, improved livestock stream crossings, bioengineered streambank protection, and riparian zone protection.

- Two years of post-BMP data suggest that bacteria counts and concentrations and loads of nutrients and sediment have decreased significantly in one or both of the treatment watersheds. In the treatment watershed where treatment was most extensive, mean bacteria counts and phosphorus loads have decreased by about 50% following treatment.
- Although statistical significance is lacking, two years of post-treatment biomonitoring data suggest slight improvements in both the fish and macroinvertebrate assemblages in the treated watersheds. These slight gains in the treatment streams are in contrast to continued deterioration of the biological communities in the project control watershed and in the local reference stream.

New stream crossing on Godin Brook (Lake Champlain Basin, Vermont).

WISCONSIN — Otter Creek

The largely agricultural, 7,040-acre Otter Creek Watershed drains to Lake Michigan via the Sheboygan River. Biological monitoring within the watershed has shown that the fish community lacks fishable numbers of warmwater sport fish, largely due to inadequate fish habitat and polluted water. Dissolved oxygen concentrations occasionally drop below Wisconsin's State standard, and bacteria levels exceed Wisconsin's recreational standard.

Strip cropping and contouring best management practices to control soil erosion (Otter Creek, Wisconsin).

Project goals include improving the fishery, restoring the endangered striped shiner in Otter Creek, improving recreational uses by reducing bacteria levels, reducing pollutant loadings to the Sheboygan River and Lake Michigan, and restoring riparian vegetation.

Improved management of barnyard runoff and manure, nutrient management and reduced tillage on cropland, streambank fencing, and shoreline and streambank stabilization are all being implemented to control sources of phosphorus, sediment, bacteria, and streambank erosion in the watershed.

Paired watershed and upstream/downstream monitoring studies covering eight monitoring sites are employed to evaluate the benefits of the BMPs. Meeme River serves as the control watershed and Otter Creek is the treatment watershed. Monitoring sites are located above and below a dairy with barnyard and streambank stabilization BMPs.

- Within the treatment watershed, two years of post-BMP monitoring data indicate that the system of BMPs was responsible for downstream reductions in suspended solids (81%), total phosphorus (88%), ammonia nitrogen (97%), BOD (80%), and fecal coliforms (84%).

Buffer strips (Otter Creek, Wisconsin).

Nonpoint Source Pollution:
The Problem

Clean water is one of our Nation's most vital resources. Since 1972, the Clean Water Act has successfully reduced many threats to our water resources by regulating *point* sources of pollution. But what about pollutants from everyday activities associated with agriculture, residential and commercial development and forestry? These pollutants are much harder to control because they come from not so easily identified, or *nonpoint*, sources. According to the United States Environmental Protection Agency (USEPA), nonpoint sources of pollution include agricultural, urban, and forest land that contribute pollutants to waterways primarily during precipitation events. Nonpoint sources are reported to cause the majority of water pollution problems in the United States today. Pollutants such as nutrients, sediment, pesticides and pathogens are transported to surface water bodies in runoff from nonpoint sources causing degradation. Many of these pollutants also reach ground water. Without a clear understanding of how to minimize pollution from these nonpoint sources, state and local organizations will be unable to develop strategies to protect their water resources.

As enforcement of the Clean Water Act regulations and standards reduced point source pollution from municipalities and industries, the magnitude of nonpoint source pollution became more apparent. Based on waters assessed by States in 1998, nonpoint sources are prominent among the Nation's five leading water pollution sources. Table 1 lists the top five sources by water resource type.

National Monitoring Program:
Working Toward Solutions

The National Monitoring Program was established in 1991 to evaluate the effectiveness of nonpoint source pollution controls in designated watershed projects. The NMP projects are supported by USEPA funds authorized by Section 319 of the 1987 Amendments to the Clean Water Act. While the USEPA funding is used primarily for monitoring and evaluation, support from other funding sources and programs is leveraged to provide the needed technical and financial assistance for land treatment. Each watershed project is expected to coordinate funding sources and programs.

Table 1. Five leading sources of water pollution in the United States.

Rank	Rivers and Streams	Lakes, Ponds and Reservoirs	Estuaries	Great Lakes Shoreline	Ocean Shoreline
1	Agriculture	Agriculture	Municipal point sources	Atmospheric deposition	Urban runoff / storm sewers
2	Hydromodification	Hydromodification	Urban runoff / storm sewers	Discontinued discharges from pipes	Land disposal
3	Urban runoff / storm sewers	Urban runoff / storm sewers	Atmospheric deposition	Contaminated sediment	Municipal point sources
4	Municipal point sources	Municipal point sources	Industrial discharges	Industrial discharges	Spills
5	Resource extraction	Atmospheric deposition	Agriculture	Urban runoff / storm sewers	Industrial discharges

Source: *The Quality of Our Nation's Waters. A Summary of the National Water Quality Inventory: 1998 Report to Congress*. 2000. United States Environmental Protection Agency (USEPA), EPA 841-S-00-001, Washington, D.C.

The monitoring program aims to scientifically evaluate the effectiveness of control technologies and to improve our understanding of nonpoint source pollution in these selected watersheds. To facilitate comparisons, each project follows national guidelines, including the use of an appropriate experimental design and water quality monitoring protocols.

While the NMP may require a different monitoring design than other water quality assessment programs, the data collected are frequently complementary. In addition, sampling and analysis requirements are similar to those of other programs and agencies. For example, to assess the diversity of aquatic life, projects use USEPA's Rapid Bioassessment Protocols and follow quality assurance plans approved by the USEPA for physical and chemical analyses of water samples. The raw monitoring data are entered into the national databases, BIOS and STORET, to supplement data collected from other monitoring programs.

National Monitoring Program: *Project Selection*

USEPA's regional offices nominate projects for the NMP by forwarding State proposals to USEPA headquarters for review and approval. Since 1991, States have proposed numerous projects for inclusion in the program. USEPA works with States to develop approvable 6- to 10-year projects. Proposed projects are assessed based on many factors including:

- Identification of water quality threats or problems, along with a listing of major pollutant(s) causing the problems, substantiated by previous water quality monitoring data;
- Nonpoint source control objectives, including the probability of adequately treating pollutant sources with the proposed BMPs;
- Characterization of watershed, including delineation of "critical areas" for pollutant(s) and summary of land uses;
- Land treatment implementation plan (including BMP location and timing of implementation);
- Water quality monitoring design; and
- Evaluation and reporting plan.

USEPA has reviewed proposals for approximately 60 projects under the NMP, approving 23 to date (see Figure 1). Twenty two of these involve monitoring surface water, particularly streams; and one is a ground water project. The major pollutants of concern in the projects are sediment, nutrients, and fecal coliform.

Most projects are cooperative efforts between Federal, State, and Local agencies, and often between two or more Federal water quality programs, such as the U.S. Geological Survey National Water Quality Assessment, and U.S. Department of Agriculture Hydrologic Unit Area and Water Quality Demonstration program. Projects with a strong local interest and highly valued water resources tend to be selected because participants in these projects often have greater incentive to improve water quality.

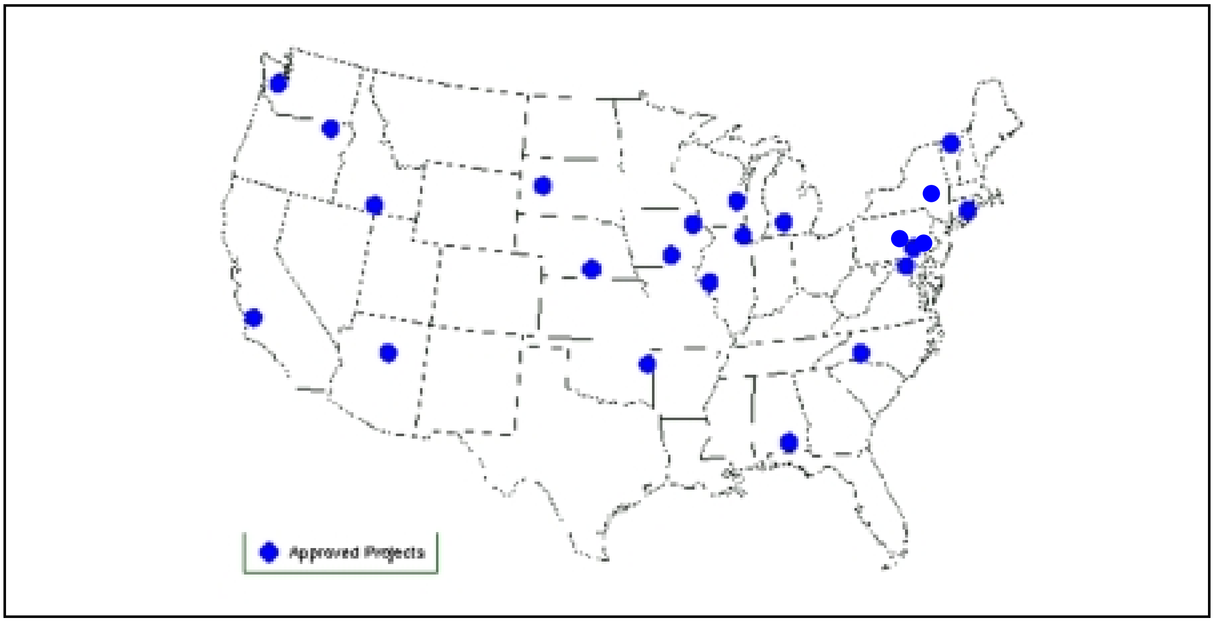


Figure 1. Locations of the Section 319 National Monitoring Program Projects.

National Monitoring Program:

Recommendations for Successful Projects

The experience gained through the NMP projects provides valuable information for personnel involved in all nonpoint source pollution control programs and projects. This experience reveals the following key recommendations for project success.

Program and Project Organization and Administration

- ***Clearly define roles and responsibilities*** of federal, state/regional, and local governments for effective interagency coordination and cooperation.
- ***Involve all major agencies and landowners*** in project selection and planning to maintain long-term commitments.
- ***Close coordination is needed*** between water quality monitoring and land treatment implementation agencies and personnel.
- ***Ensure up-front commitment of funds for the multi-year project period.*** Due to the long-term nature of NMP projects, reliable funding is needed to facilitate long-term planning and budgeting. A short-funding cycle or a requirement to request and compete for funds annually does not ensure full implementation of project activities, continuity of project staff, and reduces the effectiveness of projects.

Effective Water Quality and Land Treatment Monitoring Strategies

Water quality monitoring is the primary and most defensible means for evaluating the effectiveness of nonpoint source pollution controls. While making the definitive link between BMP implementation and subsequent water quality improvements at a watershed scale is difficult, the following are key elements of monitoring needed to ease the difficulty:

- ***Water quality problem documentation*** (use impairment, pollutant(s) causing the problem, and critical pollutant areas). Complete problem documentation allows for a realistic and quantitative set of water quality and land treatment goals, which in turn assists in quantifying project successes.
- ***Monitoring / tracking of land treatment and land use changes***. Documentation of significant changes in land treatment and land use over time, in coordination with water quality monitoring, is necessary to show that changes in water quality are due to land treatment.
- ***Ensure sufficient storm event monitoring.*** Because nonpoint source pollution is primarily precipitation driven, monitoring discharge and pollutant concentrations for at least 15% of the precipitation events is essential, especially in small watersheds.
- ***Use an appropriate experimental design*** such as the paired watershed (Clausen and Spooner, 1993; Grabow et al., 1999), upstream/downstream moni-

tored before, during, and after land treatment; or multiple watershed monitoring. The paired watershed design, in which two or more similar subwatersheds are monitored before and after implementation of BMPs in one of the watersheds, is the best method for documenting BMP effectiveness in a limited number of years (three to five). One of the key challenges of this design is to have 'control' of the land use in the control watershed, as well as the treatment watershed.

- ***Conduct multiple years of pre- and post-BMP implementation monitoring*** to increase chances of documenting water quality changes. Year-to-year variability is often so large that at least two to three years each of pre- and post- BMP implementation monitoring is required to document a significant water quality change following BMP implementation. Also, longer duration monitoring is necessary where water quality changes are likely to occur gradually. Sampling frequency and collection must be consistent across years.
- ***Ensure that pollutants monitored correspond to pollutants being treated by BMP systems***. In addition, monitoring ***explanatory variables*** will help adjust for major sources of variability other than that attributable to BMPs. Other factors not related to BMPs may be causing water quality changes, such as changes in animal numbers, cropping patterns or land uses; amount of impervious areas; stream discharge, precipitation, ground water table depth, or other climatic or hydrologic variables. Explanatory variables should be monitored at the same frequency as the principal water quality variables.

Land Treatment Implementation

- ***Implement appropriate and sufficient BMPs*** that address the water quality problem. A high level of BMP implementation is needed because it is necessary to affect changes of at least 20 percent in the water quality pollutant levels or loads before statistical linkage can be made.
- ***Target BMP implementation*** to the critical pollutant source areas and pollutants, to reduce the delivery of the pollutants to the water quality resource of concern.
- ***Provide long-term operation and maintenance (O&M) of BMPs*** for both management and structural BMPs. Questions of who is responsible for O&M need to be addressed up front for all parties involved in the project.
- ***Employ systems of BMPs***. The installation of one structural or management BMP is rarely sufficient to entirely control the pollutant of concern. Combinations of BMPs that control the same pollutant are generally most effective.

Information and Education

- ***Provide information and education*** (I&E) for a high level of land owner participation, prior to project implementation and continued throughout the project. I&E efforts conducted early in the project may be necessary to increase general awareness of the water quality problem, gain public support for the project, and improve land owner understanding of their contributions to the problem. Continuing I&E efforts are needed to assist land owners in the management and maintenance of implemented BMPs.

National Monitoring Program: *Future Directions*

Landowners, taxpayers, and program administrators need to be confident that nonpoint source pollution control practices installed will protect or improve water quality. Through the National Monitoring Program, USEPA is continuing to gather data to demonstrate the types and extent of water quality improvements that can result from the installation of control practices. The current mix of projects is focused on agricultural sources, but USEPA continues to seek projects focused on other land uses such as forests and urban areas. USEPA is currently soliciting new projects for the NMP and encourages interested states to submit proposals.

Reducing nonpoint source pollution will require the concerted effort of all people who spend time in the watershed. Each of us will have to learn how what we do affects water quality and how we can change our actions to protect one of our Nation's most vital resources: water. The NMP is just one way in which these important lessons can be learned, demonstrated, documented and disseminated.

National Monitoring Program: *Project Highlights*

The following section presents highlights, including key successes and lessons learned, of both ongoing and completed NMP projects. A more detailed summary of the projects can be found at *http://h2osparc.wq.ncsu.edu/319index.html.*

ALABAMA — Lightwood Knot Creek

Water Quality Concern:

The W.F. Jackson Lake (southeastern Alabama) was built for recreational uses. Excessive sedimentation of the lake, caused by agricultural activities in the watershed, is impairing aquatic habitat, increasing bridge maintenance costs and flooding potential, and reducing the lake's water holding capacity.

Twenty-eight percent of the watershed is cropped. Within the project area, there are 6 poultry operations that produce a total of 375,000 chickens every 8 to 10 weeks, and approximately 150 head of cattle.

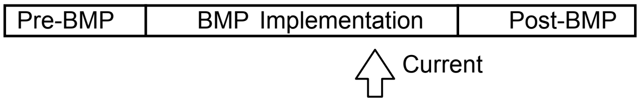
Headcut on a tributary to Lightwood Knot Creek (Lightwood Knot Creek, Alabama).

Project Description:

During the Lightwood Knot Creek project, BMPs have been implemented on the cropland to reduce erosion and on the poultry farms to reduce nutrient and fecal coliform levels in runoff. The water quality monitoring design is a four-way pair, with two treatment watersheds and two control watersheds. BMPs will be implemented in the two treatment watersheds.

Three years of water quality data have been collected to document the pre-BMP condition of each of the four project watersheds. Water quality monitoring consists of weekly composite sampling from April through August for nitrogen and phosphorus forms and total solids. Weekly grab samples are analyzed for fecal coliform and streptococcus. Grab samples collected weekly during September to March are analyzed for total dissolved solids and total suspended solids.

Overall Project Timeline:



Key Successes and Lessons Learned:

- Repair and stabilization of several gully erosion critical areas is underway and is expected to decrease sediment concentrations in treatment watershed streams. Improved pasture and nutrient management plans, exclusion of cattle from streams, and sedimentation basins are also being implemented to improve water quality.
- Underground disposal of poultry mortalities has ceased in the treatment watersheds. Future mortalities and excess litter will be composted and land applied to pasture and hayland within the watershed. These improved management practices are expected to reduce nutrient and bacterial concentrations in groundwater.
- The selection of landowners to participate in the project should not only be based on water quality priorities and critical areas, but also on their willingness to participate and cooperate.

ARIZONA — Oak Creek Canyon

Water Quality Concern:

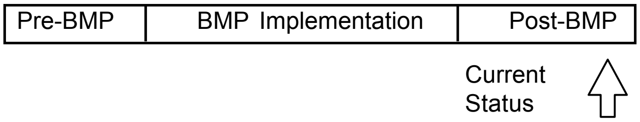
Oak Creek, located in Oak Creek Canyon, Arizona, experiences an annual seasonal (summer) deterioration in water quality from fecal pollution. The Oak Creek project has determined that these impacts to water quality occur only when a reservoir of sediments containing fecal coliform becomes established in the creek and when the sediment is disturbed by recreational use of the waters, heavy rains, or both. The sources of fecal pollution include recreational use (more than a quarter of a million visitors swim in Oak Creek each summer), septic systems, and wildlife.

Project Description:

The Oak Creek project used an upstream/downstream water quality monitoring design to compare the effectiveness of BMPs at two recreational swimming areas, Slide Rock State Park (treatment) and Grasshopper Point (control), and at two campgrounds, Pine Flats campground (treatment) and Manzanita campground (control). Weekly grab samples were taken on Saturday afternoons (peak tourist time) from May 15 through September 15, and monthly samples were collected for the remainder of the year. BMPs implemented at Slide Rock State Park and Pine Flats campground include enhanced restroom facilities and an educational program to promote visitor compliance with park and campground regulations on facility use and waste disposal. Upgrading septic systems and monitoring the proportion of human versus animal waste in Oak Creek water and sediment are also being pursued.

Slide Rock Creek, Slide Rock State Park (Oak Creek Canyon, Arizona).

Overall Project Timeline:



Key Successes and Lessons Learned:

- BMPs implemented resulted in limited improvement in water quality of Oak Creek. While the NMP project ended in 1998, efforts, including genotyping, outside of the NMP, are ongoing and have unveiled potential origins and definite contributions to fecal loading. Agitation of contaminated sediment was identified as a source, resulting in closure of recreation areas.
- The NMP project had a very extensive public education campaign. A public education specialist was hired by the US Forest Service to continue and expand the effort. Bilingual brochures and a three-stage alert signage system were developed for park visitors. Educational programs were delivered to elementary school children and their parents that visit the area. Road signs were installed throughout the canyon alerting visitors to use toilets. A public service announcement slide was produced and shown before every movie in Northern Arizona theaters during the intensive recreational use period.
- The NMP project complemented several other federal, state and local programs located in the Verde Valley.

CALIFORNIA — Morro Bay

Water Quality Concern:

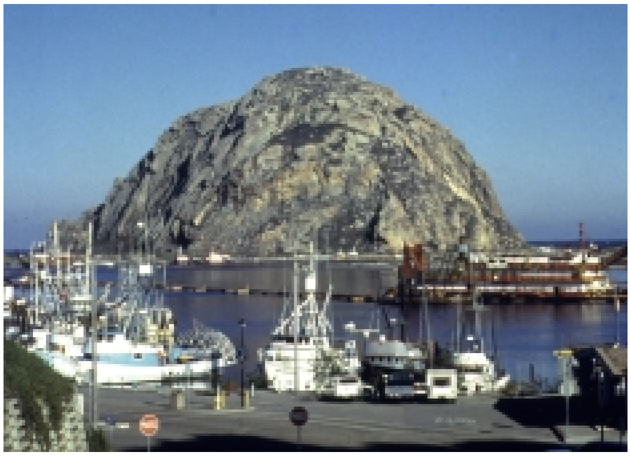
The Morro Bay watershed is located on the central coast of California, 237 miles south of San Francisco in San Luis Obispo County. This 76-square mile watershed is an important biological and economic resource. Two creeks, Los Osos and Chorro, drain the watershed into the Bay. Included within the watershed boundaries are two urban areas, prime agricultural and grazing lands, and a wide variety of natural habitats that support a diversity of animal and plant species.

Morro Bay, one of the few intact natural estuaries along California's coast, is being harmed by sediment and to a lesser extent by bacteria, metals, nutrients and habitat loss. Brushland, rangeland, and streambank erosion contribute the largest portion of the sediment that is deposited in the Bay. Recent loss of vegetation due to wildfire, followed by floods, increased the sedimentation.

Riparian oaks on Chumash Creek after grazing rotation and riparian area protection implemented (Morro Bay, California).

Project Description:

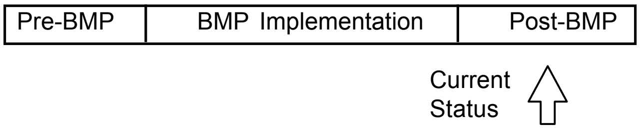
The Morro Bay Watershed project is evaluating the effectiveness of different sediment-reducing BMP systems. A paired watershed study on tributaries of Chorro Creek (Chumash and Walters creeks) is evaluating the effectiveness of a rangeland BMP system —creation of smaller pastures, installation of cattle watering systems, stabilization and revegetation of streambanks, and installation of water bars and culverts on farm roads. Another important part of this study is an analysis of whether event and regular-interval sampling are effective in detecting change.



Morro Rock (Morro Bay, California).

Upstream/downstream water quality monitoring sites have been established to evaluate the effectiveness of other BMP systems: sediment retention through flood plain reconnection, cattle exclusion, and managed grazing. Water and habitat quality data are also being taken throughout the watershed to document trends in overall watershed health.

Overall Project Timeline:



Key Successes and Lessons Learned:

- In the paired watershed study, a 49% reduction in turbidity was documented. A suite of BMPs, including improved grazing management, riparian fencing and re-vegetation, was responsible for the reduction in turbidity.
- Riparian fencing and improved grazing management has proven to be effective practices in reducing bacterial levels in adjacent streams in the Morro Bay Watershed along the central coast of California.
- Funding at project initiation was important in ensuring data collection for the entire project duration.
- Partnerships with public and private landowners, and numerous watershed stakeholders has been an effective mechanism for continued public outreach, implementation, and monitoring.
- Fact sheets to improve communication with ranchers and farmers in the watershed would have been very useful at the beginning of the project.

4-H Watershed Model, a replica of Morro Bay watershed created by 4-H Modelers (Morro Bay, California).

CONNECTICUT — Jordan Cove

Water Quality Concern:

Jordan Cove, a small estuary fed by Jordan Brook, is part of the Long Island Sound. Water quality sampling has indicated that the cove does not meet bacteriological standards for safe shellfish collection. The Jordan Cove estuary watershed is primarily forest and wetlands (74%) with increasing urban land use (19%). As urbanization continues, concern has increased about the impact of suburbanization on the estuary during and after construction. The pollutant of concern during construction is sediment, whereas the pollutants of concern after construction are bacteria, phosphorus and nitrogen. This project will help characterize polluted runoff from urbanized areas.

Traditional neighborhood site plan serves as a control comparison (Jordan Cove, Connecticut).

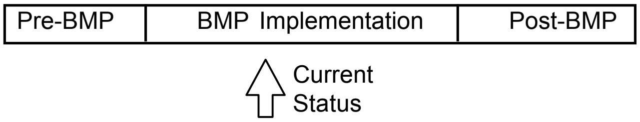
Project Description:

Runoff from three subdivisions is being monitored to assess the effects of construction and urban development. The three sites are: an established subdivision with 43 houses, a subdivision that is being built with generally accepted traditional construction practices, and a subdivision being built using BMPs. Non-structural construction BMPs consist of earthen berms, phased grading, immediate seeding of stockpiled topsoil, maintenance of vegetation around the construction area, and immediate temporary seeding of proposed lawn areas. Structural practices include sediment detention basins and swales, bioretention areas and a road of permeable concrete pavers (concrete blocks with holes in them), and the minimization of impervious surfaces. Post-construction, non-structural BMPs will consist of street sweeping, implementation of fertilizer and pesticide management plans, pet waste management, and yard waste pickups.

Rainwater runoff from each subdivision is being collected and analyzed for sediment and nutrients. The paired watershed approach allows for comparison of the quality of the storm-water runoff from each of the three subdivisions.

Treatment watershed site plan includes construction BMPs, shared driveways, pervious pavement and bioretention gardens (Jordan Cove, Connecticut).

Overall Project Timeline:



Key Successes and Lessons Learned:

- In the traditional watershed, where houses are being built using generally accepted construction practices, weekly flow and peak discharge significantly increased by almost 100% due to land development, with increased concentrations and loading of nitrate-nitrogen (NO3-N). Sediment export increased 90% and total phosphorus increased 89% during construction. Loading of copper, lead and zinc also increased during the construction period.
- Results from the construction period at the traditional site suggest that increased runoff, rather than erosion, was the cause of increased pollutant export from the site.

IDAHO — Eastern Snake River Plain

Water Quality Concern:

The Idaho Eastern Snake River Plain is located in south-central Idaho in an area dominated by irrigated agricultural land. The Eastern Snake River Plain aquifer system provides much of the drinking water for approximately 40,000 people living in the project area. The aquifer also serves as an important source of water for irrigation.

Excessive irrigation, a common practice in the area, coupled with sandy soils, creates the potential for nitrate and pesticide leaching into the aquifer below. Ground water monitoring has shown that nitrate levels in the shallow aquifer underlying the project area frequently exceed the drinking water standard of 10 mg/l.

Project Description:

The Eastern Snake River Plain project is the only Section 319 National Monitoring Program project to evaluate the effects of agricultural BMPs on ground water quality. Two paired test fields were evaluated.

Ground water quality was monitored monthly. The effects of irrigation water application rates on ground water quality in terms of nitrate,

Lysimeter installation in potato crops (Eastern Snake River Plain, Idaho).

total dissolved solids, dissolved oxygen concentrations, electrical conductance, and pH were being evaluated for one paired field (Moncur). The effects of crop rotation on these same parameters are being evaluated for the other paired field (Forgeon). Nitrate is the key ground water indicator parameter for evaluation of BMP effectiveness for both paired test fields.

Overall Project Timeline:

Key Successes and Lessons Learned:

- Crop rotation was shown to be important in reducing nitrate concentrations in groundwater

ILLINOIS — Lake Pittsfield

Water Quality Concern:

Lake Pittsfield was constructed in 1961 to serve as a flood control structure and as a public water supply for the city of Pittsfield, a western Illinois community of approximately 4,500 people. The 7,000-acre watershed (Blue Creek Watershed) that drains into Lake Pittsfield is agricultural, consisting primarily of corn and soybean cropland.

Sedimentation is the major water quality problem in Lake Pittsfield. Sediment from farming operations, gullies, and shoreline erosion has decreased the capacity of Lake Pittsfield by 25 percent in the last 33 years.

Project Description:

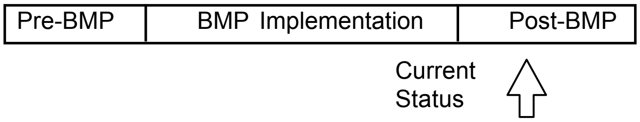
Based on a thorough analysis of lake problems and pollution control needs conducted under the Clean Lakes Program, project coordinators developed a strategy to reduce sediment transport into Lake Pittsfield. The keystone of the land management strategy was the construction of settling basins throughout the watershed, including a large basin at the upper end of Lake Pittsfield. USDA Environmental Quality Incentive Project and Illinois Conservation Practices Program funds provided for installation of additional sediment-reducing practices such as conservation tillage, integrated crop management, livestock exclusion, filter strips, terraces, WASCOBs, and wildlife habitat management. Land-based data and a geographical information system (GIS) were used to develop watershed maps of sediment sources and sediment yields.

The objective of the Lake Pittsfield Section 319 National Monitoring Program project was to evaluate the effectiveness of the settling basins in reducing sedimentation into the lake. Water quality monitoring consisted of tributary sampling after rainstorms (to determine sediment loads); monthly water quality monitoring at three lake sites (to determine trends in water quality); and lake sedimentation rate monitoring (to determine changes in sediment deposition rates and patterns).

Sediment retention basin (Lake Pittsfield, Illinois).

Overall Project Timeline:

Key Successes and Lessons Learned:



- A 90% reduction in sediment loading to Lake Pittsfield was achieved through the installation of several water and sediment control basins. The large (147 ac-ft) sediment basin just upstream of the lake was more effective in general than the smaller basins located upstream. The effectiveness of 29 smaller upland basins was dependent upon watershed geology and basin position.
- Stream stabilization on Blue Creek was an important component in the overall program to reduce sediment loading to the lake. Installation of low stone weirs prevented further channel incision and mass wasting of stream banks.
- Strong local partnerships along with interagency cooperation have combined to help in the success of this project.

ILLINOIS — Waukegan River

Water Quality Concern:

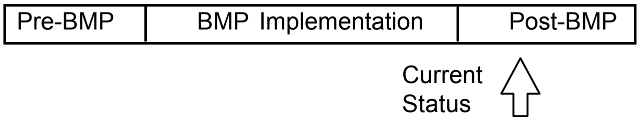
The Waukegan River, located in Waukegan, Illinois, about 35 miles north of Chicago, has a watershed area of 7,640 acres in a mostly urban setting. This is an urban stream restoration project. High-volume runoff from impervious surfaces and a lack of storm water controls is creating channel instability in urban streams. Habitat quality is degraded as evidenced by low oxygen levels, shallow pool depths, and limited cobble substrate.

Project Description:

The project used biotechnical bank restoration (a combined vegetative and structural approach) to stabilize streambanks and low stone weirs to restore pool and riffle sequences. Several sites in Powell Park and Washington Park were restored using a combination of lunkers (structures that stabilize banks and provide fish habitat), a-jacks (structures that look like playing jacks that stabilize streams), and riparian plants such as dogwood, arrowhead, and willow.

An upstream/downstream habitat monitoring design was used to document water quality changes in the Waukegan River at the South Branch stations. This design assured that urban water quality affected both the control and the rehabilitated stations uniformly. Biological parameters, which include fish, macroinvertebrate and habitat samples, were measured three times per year from May through September. Flows are monitored continuously.

Overall Project Timeline:



Key Successes and Lessons Learned:

- Pool and riffle restoration has improved biological diversity. The implementation of the pool/riffle series on the South Branch of the Waukegan River has increased the Index of Biotic Integrity (IBI) and the overall population of the fish collected during the season sampling events.
- While bank stabilization protected parklands in an aesthetically pleasing manner, it did not improve stream fisheries significantly.
- Strong project partnerships along with interagency cooperation have combined to help in the success of this project.

Streambank erosion, 1994 (Waukegan River, Illinois).

Waukegan River after riparian revegetation and installation of lunkers and riffles, July 2000 (Waukegan River, Illinois).

IOWA — Sny Magill Creek

Water Quality Concern:

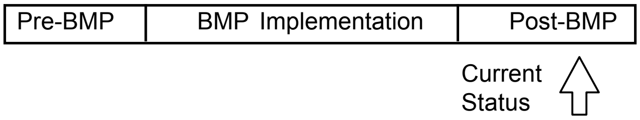
Sny Magill Creek, located in northeastern Iowa, is one of the more widely used streams for recreational trout fishing in Iowa. Sny Magill Creek, a coldwater stream, drains a 22,780-acre agricultural watershed consisting of land used for row crops, pasture, forest and forested pasture, and cover crops. There are approximately 98 dairy, beef, and swine producers in the watershed, with farm sizes averaging 275 acres. Excess sediment deposition in the creek is harming the trout fishery.

Project Description:

A long-term goal of the project is to reduce sediment delivery to Sny Magill by one-half. To meet this goal, sediment control measures were implemented from 1992 through 1999. Because nitrogen, phosphorus, and pesticide levels were also concerns, planned land management included reducing nutrient and pesticide use and implementation of animal waste management systems.

The project uses a paired watershed design, with the adjacent 24,064-acre Bloody Run Creek watershed serving as the control. Monitoring sites at the outlet of each watershed are documenting discharge and suspended sediment. Water quality is monitored through bi-monthly sampling of the benthic organisms, an annual fisheries survey, an annual aquatic habitat assessment, and weekly to monthly chemical monitoring of both outlet sites, as well as subwatershed sites within each watershed.

Overall Project Timeline:



Key Successes and Lessons Learned:

- Conservation plans have been written for all highly erodible land within the Sny Magill watershed (>10,000 acres), and 40% of those plans have been completely implemented. Eighty-one percent of the watershed's 98 landowners have participated in the project.
- The following BMPs have been implemented in the Sny Magill watershed: 379,305 feet of terraces, 96 grade-stabilization structures, 60 water and sediment control basins, 2 agricultural waste structures, nutrient and pesticide management plans on 6,723 acres, and timber stand improvement plans on 705 acres.

Electro-shocking for fish diversity assessment (Sny Magill Creek, Iowa).

- Five streambank stabilization demonstrations have been implemented using soil bioengineering technology and warm season grass species. These demonstrations have served as a laboratory of innovative, lower-cost stream protection measures that are being adopted elsewhere in Iowa. A handicap-accessible site was one of the demonstrations.
- Pesticide and nutrient loading have been reduced on 45% of cropland acres in the watershed through the delivery of the Nutrient and Pest Management Incentive Education (NPMI) program, a producer education program designed to enhance long-term adoption of refined crop and manure management practices. State agencies have sanctioned the use of the NPMI as a model for other Iowa water quality projects.
- Monitoring of the benthic organisms suggests some improvement in the water quality of Sny Magill Creek; similar improvements have not been seen in the control watershed, Bloody Run Creek.

IOWA — Walnut Creek

Water Quality Concern:

The objective of the Walnut Creek project is to monitor water quality improvements as portions of the watershed are restored to pre-settlement conditions. Walnut Creek, which drains into the Des Moines River, does not support its designated uses and Squaw Creek, the control watershed, only partially supports its uses. Primary biological productivity is low, and the condition of the fish community is poor. These streams are affected by agriculturally-derived pollutants (sediment, nutrients, pesticides, and animal wastes) as well as sediment from streambank erosion.

Buffalo grazing on native prairie grasses (Walnut Creek, Iowa).

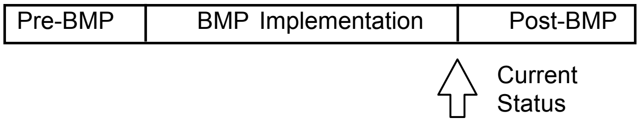
As of 1998, corn and soybeans comprised 60% of the watershed acreage of Walnut Creek and 76% of Squaw Creek. The U.S. Fish and Wildlife Service, the agency in charge of the Neil Smith National Wildlife Refuge and Prairie Learning Center, is implementing land use changes within the refuge. From 1992 to 1997, land use changes were implemented on 19% of the watershed including conversion of 13% from row crop to native tall grass prairie. Riparian and wetland zones are also being restored. For the portion of the watershed that remains in cropland agriculture (6%), soil erosion control measures and pesticide and nutrient management BMPs are mandatory.

Conversion to native tall grass prairie and fencing exclusion for buffalo (Walnut Creek, Iowa).

Project Description:

The Walnut Creek 319 National Monitoring Program project uses a paired watershed design with upstream/downstream stations on both Walnut Creek (treatment watershed) and Squaw Creek (the control watershed). To document the changes in water quality, ten stations within the project drainage area are monitored biweekly to monthly in April through September. Four stations are monitored four times per year. Stream discharge and suspended sediment are collected daily at three stations. Habitat and biological assessment of aquatic macroinverte-brates and fish is performed yearly.

Overall Project Timeline:



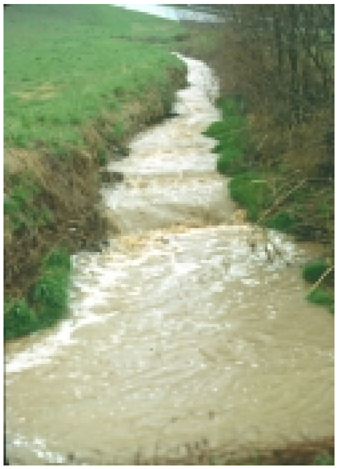
Key Successes and Lessons Learned:

- As of 1997, approximately 1,730 acres of the 12,895-acre Walnut Creek watershed were restored from row crop to native prairie. In the remainder of the Walnut Creek watershed, erosion control measures have been implemented and nutrient and pesticide application rates have been reduced. Comparison of upstream and downstream data for the Walnut Creek watershed shows a reduction in nitrate-N loading between the upstream sub-basin and the remainder of the basin. Linear regression shows that the amount of nitrogen lost per acre of land is lower in the downstream portion of the watershed containing the land use changes.
- Water quality improvements are observed when land use changes are isolated into smaller subwatersheds. For example, water draining restored prairie had nitrate concentrations less than 1 mg/l, whereas subwatersheds dominated by row crop had nitrate concentrations greater than 15 mg/l. At the mouth of the watershed, water quality improvements have been difficult to detect since most of the land use changes are located in the core of the watershed. Recent sampling has shown that 84% of the nitrate load in Walnut Creek was coming from non-refuge land located in headwater areas.
- A visitor center was opened in April 1997 on the Walnut Creek refuge. From November 1, 1994 to July 30, 1998, 253,524 visitors, including 30,000 students, have visited the refuge. During the school year, approximately 150 school children participate in environmental education activities presented by refuge staff each week day. One of the displays at the center features improvement in water quality.

MARYLAND — Warner Creek

Water Quality Concern:

Warner Creek is a small stream in northcentral Maryland that drains 830 acres. The Creek delivers excess levels of nutrients to the Monocacy River and subsequently the Chesapeake Bay.



Warner Creek (Maryland).

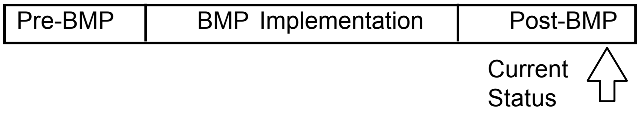
Project Description:

Subwatersheds in the headwaters area are being monitored to compare continuous beef production in one, with improved (BMPs implemented) dairy production in the other.

The focus of the project is reducing nutrient runoff from dairy operations through the implementation of waste management systems, cropland conservation practices and livestock exclusion.

Water quality sampling is performed weekly from February to June, with bi-weekly sampling during the remainder of the year for all monitoring stations. Storm-event sampling is conducted at the outlet of the watershed. Samples are analyzed for nutrients and sediment to determine if changes in land treatment practices are affecting water quality.

Overall Project Timeline:



Key Successes and Lessons Learned:

- Monitoring results indicate that high levels of nitrate are being delivered from the beef operations during baseflow resulting in baseflow having a dominant role in delivering nitrate-nitrogen to Warner Creek. These results can be used to convince farmers to implement BMPs.

MICHIGAN — Sycamore Creek

Water Quality Concern:

Sycamore Creek is located in south-central Michigan (Ingham County). The creek has a drainage area of 67,740 acres, which includes the towns of Holt and Mason and part of the city of Lansing. The major commodities produced in this primarily agricultural county are corn, wheat, soybeans, and some livestock. Sycamore Creek is a tributary to the Red Cedar River, which flows into the Grand River. The Grand River discharges into Lake Michigan.

The major pollutants of Sycamore Creek are sediment, phosphorus, nitrogen, and pesticides. Sediment deposition is adversely affecting fish and macroinvertebrate habitat and depleting oxygen in the water column due to BOD demand. Sycamore Creek was selected for monitoring not because of any unique characteristics, but because it is representative of creeks throughout lower Michigan.

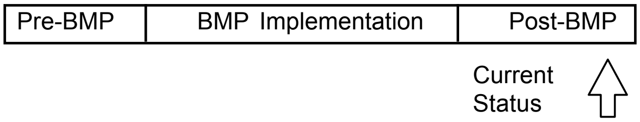
Project Description:

Streambank erosion control was conducted under a Section 319 grant to the County Drain Commissioner. Land management consisted primarily of sediment- and nutrient-reducing BMPs on cropland, pastureland, and hayland. These practices were funded as part of the USDA Sycamore Creek Hydrologic Unit Area (HUA) project.

Water quality monitoring was conducted in three sub-watersheds: Haines Drain, Willow Creek, and Marshall Drain. The Haines subwatershed, where some BMPs had already been installed, was the control and is outside the Sycamore Creek watershed. Stormflow and baseflow water quality samples from each watershed were taken from March through July of each project year. Water was sampled for turbidity, total suspended solids, chemical oxygen demand, nitrogen, and phosphorus. A fourth station was added above the mouth of the creek in 1995 and sampled for the same parameters.

Sycamore Creek (Michigan).

Overall Project Timeline:



Key Successes and Lessons Learned:

- The Sycamore Creek project documented a reduction in sediment load of 57% in one subwatershed (Willow Creek). A direct correlation between the extent of no-till land and sediment reduction was detected. However a significant reduction in sediment load was not measured in another subwatershed (Marshall Dain) where no-till implementation was greater. The main difference between these subwatersheds was the implementation of stream bank erosion control in Willow Creek but not in Marshall Drain.
- Measured average annual sediment loading near the watershed outlet was only 6% - 12% of planning estimates that were based on erosion rates and delivery ratios.

NEBRASKA — Elm Creek

Water Quality Concern:

Elm Creek is a spring-fed stream that drains 35,800 acres of rural land in south-central Nebraska, near the Kansas border. Wheat and sorghum, pasture, range, and irrigated corn cover most of the land. High intensity, short duration thunderstorms common to this region produce peak flows that degrade water and habitat quality through erosion and sedimentation.

Trout productivity in Elm Creek is currently limited by inadequate in-stream habitat, elevated water temperatures, and deposition of fine sediments onto the stream substrate, mostly during runoff events.

Intergravel dissolved oxygen monitoring (Elm Creek, Nebraska).

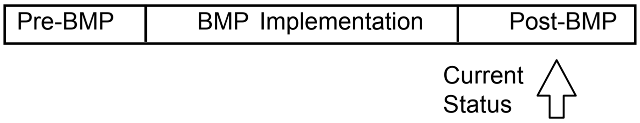
Project Description:

The project objectives are to reduce in-stream summer maximum temperatures, reduce in-stream sedimentation, reduce peak flows, and improve in-stream aquatic habitat.

Modeling and field surveys were initially conducted to identify critical erosion areas in need of nonpoint source control measures (BMPs). Conventional and non-conventional BMPs have been implemented extensively throughout Elm Creek's watershed since the project was initiated in 1992. In addition, a portion of Elm Creek was the focus of a 1996 lunker demonstration to improve in-stream habitat while stabilizing eroding streambanks. Implementation activities have been funded in part under the USDA Elm Creek Hydrologic Unit Area Project and by local cost-share dollars in conjunction with Section 319 funds.

Physical, chemical, biological, and land management monitoring are conducted to determine if project water quality objectives are achieved. Both an upstream/downstream design as well as a single-downstream station study design are employed. Weekly monitoring of stream chemistry is conducted from March through September because nonpoint source impacts are greatest during this period. Biological and habitat data are typically collected in both spring and fall. Monitoring efforts will be continued for at least two years after BMP implementation activities cease.

Overall Project Timeline:



Key Successes and Lessons Learned:

- Adoption of erosion and sediment control practices on cropland in the Elm Creek Watershed has been widespread and has been estimated by NRCS to have saved approximately 40,0000 tons of soil per year.
- In 1992, the Nebraska Game and Parks Commission (NGPC) installed cedar tree revetments on a stream segment to reduce stream bank erosion and provided additional trout habitat. In the spring of 1996, ‘lunker’ structures were placed in the same site to stabilize the toe of the streambank. In the fall of 1996, to partially mitigate habitat destruction by the local railroad project, additional habitat improvements were installed by NGPC and NDEQ (lunkers, double wing deflectors, and boulder/rock clusters). To date, water quality and habitat monitoring from the Elm Creek Watershed project has not documented improvements in water quality. A longer period of post-BMP monitoring record will be required.
- The Elm Creek Watershed Section 319 NMP project provides the water quality monitoring for the area HUA project.
- No significant reduction in suspended solids has been measured in Elm Creek. Elm Creek remains subject to high flow events, which contribute to high suspended sediment levels during runoff events.
- Non-project activities can mask the improvements due to BMP implementation. Increased streambank erosion and decreased biological habitat has been observed at one of the upstream sites due to recent railroad construction and stream modification activities.
- A paired watershed would have been a stronger design than the upstream/downstream monitoring design employed. Preliminary evaluation of the project monitoring design (upstream/downstream and single downstream) and water quality data suggests that the large size of the watershed above the upstream monitoring station (approximately 31,142

acres) inhibits documentation of water quality improvements due to land treatment implementation. More specifically, this problem can be attributed to the variability associated with regional and watershed conditions. The majority of non-structural BMPs recommended by the NRCS implemented in the Elm Creek watershed are designed only to control runoff from one-in-ten year storm events. When such storm events occur in the watershed, water quality (including in-stream habitat) remains good. However, with such a large watershed area above the perennial stream reach, even slightly larger storm events contribute to high flows, which degrade water and habitat quality and make it difficult to detect improvements.

Installation of willow stakes (Elm Creek, Nebraska).

Elm Creek after installation of lunkers to stabilize the toe, fascine and willow stakes for riparian revegetation (Elm Creek, Nebraska).

NEW YORK — New York City Watershed

Water Quality Concern:

New York City's three major systems of drinking water supply, the Catskill, Delaware, and Croton, are located to the north and northeast of the City within a 125-mile radius, and provide water for 9 million people. The total watershed area is 1,950 square miles, covering 8 counties and containing 19 surface water reservoirs. A major land use in the Catskill/Delaware portion of the watershed is agriculture; the 550 farms located there are predominantly dairy and livestock enterprises.

The Federal Safe Drinking Water Act requires filtration for most water supply systems that draw water from surface sources. Currently, water from the New York City (NYC) systems is of sufficient quality to avoid filtration. However, there is a continual threat of waterborne pathogens such as Cryptosporidium and Giardia, as well as the pollutants phosphorus and sediment, entering and degrading the unfiltered drinking water supplies from agricultural and other land uses. In order to avoid the need for a costly filtration system, NYC has opted to implement agricultural and urban nonpoint source management measures, together with more stringent point source controls, in its watershed.

Cannonsville Reservoir, used for New York City drinking water and trout fishing, has eutrophication problems due to excess phosphorus from dairy agriculture and point source discharges (New York City Watershed, New York).

The NYC Watershed Agricultural Program (WAP), a voluntary incentive-based program, was established to implement the agricultural nonpoint source portion of the management program. Whole Farm Planning (WFP) was adopted by the WAP as the primary means of protecting NYC water supplies from farm-related nonpoint source pollution, as well as maintaining a viable agricultural community in the watershed. In Phase I of the WAP, which began in 1993, ten demonstration farms in five counties were selected on which to develop, test and demonstrate the WFP method. Phase II intended to have 85 percent of the farms within the watershed participating in WFP by 1997, a goal that has been met.

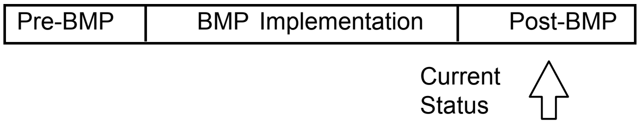
Project Description:

One of the demonstration farms was accepted into the Section 319 National Monitoring Program in June 1997 and is being studied to evaluate the WFP approach for water quality protection and improvement. This representative farm is located in the West Branch of the Delaware River (WBDR) watershed where most of the dairy agriculture of the entire NYC watershed occurs. Major sources of nonpoint phosphorus include winter spreading of manure, barnyard runoff and overfertilization of cropland.

The project incorporates a modified paired watershed monitoring design, with the farm as the treatment watershed and a forested watershed as the control. The event-based monitoring program includes measurement of stream flow, precipitation, nutrients, organic carbon, suspended sediment, pathogens and macroinvertebrates. In addition, records of farm activities before and after BMP implementation are being kept.

Manure storage at the treatment farm (New York City Watershed, New York).

Overall Project Timeline:



Key Successes and Lessons Learned:

- The amount of time in which runoff events occurred, when added together, constituted only about 30-35 days annually, or less than 10% of the year. However, loads of most measured pollutants delivered during those event periods were typically 50-75% of the annual total.
- The documented correlation of runoff periods with pollutant loads supported the selection and implementation of agricultural BMPs that aim to reduce losses during these critical periods. On the treated farm, these included 9-month storage of manure, barnyard runoff management, relocation of a silage storage bag away from the stream, manure spreading schedules based on field hydrologic sensitivity (field wetness and moisture) and soil phosphorus test results, and correction of erosion problems.
- After analysis of two years of post-implementation monitoring and normalization of the data to variations in annual precipitation amounts and patterns, there are indications that reductions in farm loads of total dissolved phosphorus, total phosphorus, and ammonia have occurred. Loads of particulate phosphorus, organic carbon, nitrate and sediment have not yet changed appreciably, however.
- Results of macroinvertebrate monitoring have shown an improvement in the stream community of the treatment site.

NORTH CAROLINA — Long Creek

Water Quality Concern:

The Long Creek Watershed, situated in the southwestern Piedmont of North Carolina, is an 8,300-ha area of mixed agricultural and urban land uses. Long Creek serves as the primary water supply for Bessemer City, which is located in the headwaters area of the creek.

Degradation before restoration (Long Creek, North Carolina).

Water quality concerns in Long Creek include high sediment, bacteria, and nutrient levels. The stream channel near the Bessemer City water supply intake in the headwaters area has historically required frequent dredging due to sediment accumulation. Downstream of the intake, aquatic habitat is degraded due to excessive sediment and nutrient loading from agricultural and urban nonpoint sources.

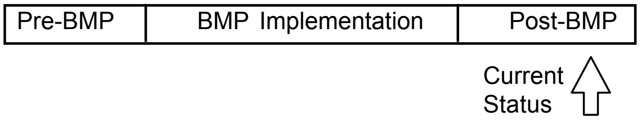
Project Description:

Conservation practices have been implemented upstream of the water supply intake to reduce cropland erosion. Downstream of the intake, BMPs implemented include fencing to exclude cows from streams and animal waste management. At the largest dairy farm in the watershed, a system of BMPs including 1) livestock exclusion from perennial and ephemeral streams, 2) streambank stabilization and riparian buffer establishment, and 3) an improved waste management system, have been implemented.

Water quality monitoring includes weekly and monthly grab sampling at five locations on the mainstem of, and at two locations on a tributary (Kiser Branch) to, Long Creek. In addition, storm event runoff sampling from two paired drainage areas on a cropland field and on Kiser Branch is also conducted. Samples are being analyzed for nitrogen and phosphorus forms, sediment, and bacteria to provide the data needed to assess the effectiveness of the nonpoint source controls. Precipitation and stream discharge are also being monitored.

Riparian area 4.5 years after livestock exclusion (Long Creek, North Carolina).

Overall Project Timeline:



Key Successes and Lessons Learned:

- The implementation of primarily livestock exclusion fencing along with riparian vegetation establishment in a 140-acre dairy pasture resulted in 83, 76, 78, and 33% reductions in sediment, total phosphorus, total Kjeldahl nitrogen, and nitrate+nitrite loads, respectively. Greater than 70% reductions in fecal coliform bacteria levels were also documented in weekly grab samples.
- A dense vegetated buffer developed within 2-3 months of livestock exclusion from Kiser Branch. Trees, native to the area, were planted without significant cultivation in the excluded buffer and excellent survival rates were achieved.
- Total phosphorus concentrations in Long Creek decreased from an annual median of 0.18 mg/l during the first year of the project to less than 0.04 mg/l during the last three years of monitoring. Reductions in bacteria and sediment levels in the last two years have also been documented.
- Flexibility in the use of funding and labor to meet the needs of landowners and our changing understanding of the water quality problem is essential in treating NPS pollution.
- The continual interaction and cooperation of research and extension personnel with agencies providing technical and financial assistance is necessary to meet the goals of the project and agencies simultaneously.
- The inclusion and training of various university faculty, graduate students, and external audiences has provided fresh perspectives to the project while improving many peoples' understanding of NPS pollution. People trained as part of the Long Creek project have conducted 30+ similar projects statewide.
- High turnover in EPA and state NPS coordinators has presented a challenge.

OKLAHOMA — Peacheater Creek

Water Quality Concern:

The land use of the watershed that surrounds Peacheater Creek, a stream located in eastern Oklahoma, is agricultural, mainly pasture and forest. There are many livestock operations — 51 poultry houses, 9 dairies, and 1,200 beef cattle — in this watershed. The adjacent Tyner Creek Watershed is similar in size to Peacheater Creek for land use and number of livestock operations.

Fish and macroinvertebrate habitats are impaired by large gravel bars generated by streambank erosion caused by cattle traffic and past forestry activities. Elevated nitrogen and phosphorus levels, caused by runoff containing animal waste, contribute to the growth of algae in the Illinois River and eutrophication in Lake Tenkiller, both downstream of Peacheater Creek.

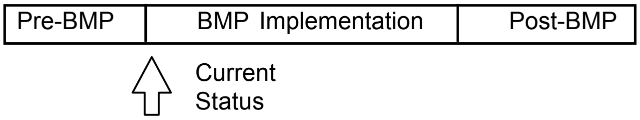
Project Description:

The water quality monitoring design is a paired watershed study. Nutrient management, animal waste management structures, mortality composters (dead chicken composters), and riparian area stabilization are the primary BMPs that are being implemented in the treatment watershed (Peacheater Creek). The control watershed (Tyner Creek) will not be treated.

Water quality monitoring stations are located at the outlet of each watershed, whereas habitat and biological monitoring are conducted at several locations in each stream. Chemical monitoring is conducted weekly from February through June (monthly during the rest of the year) and during storm events. Macroinvertebrates and periphyton productivity are measured twice per year. Fish and intensive habitat assessments are done yearly. An extensive habitat assessment of the whole stream length is performed on alternate years with an assessment of streambank erosion.

Measuring streambank erosion (Peacheater Creek, Oklahoma).

Overall Project Timeline:



Key Successes and Lessons Learned:

- A challenge with the paired watershed design is landowner cooperation; sometimes it is necessary to remain flexible as to the choice of control vs. treatment watersheds after the calibration period is complete. Peacheater Creek watershed was originally planned to be the treatment watershed in the paired watershed design, with Tyner Creek watershed as the control. However, significant landowner resistance to cooperation in the Peacheater Creek watershed caused the project team to question whether BMP implementation efforts should be shifted towards the Tyner Creek and use of Peacheater Creek watershed as the control watershed.
- A public meeting held for the landowners of Peacheater Creek was well attended, and was successful in garnering local support for project implementation in the watershed. As a result, 10 landowners agreed to participate and have had whole farm plans drafted. Practices primarily include riparian fencing, off stream watering, and pasture and nutrient management.
- The Peacheater Creek project compliments a larger program to improve the water quality of the Illinois River and Lake Tenkiller. An effort to establish a Total Maximum Daily Load (TMDL) for the system has been initiated, which may build upon the results in Peacheater Creek.

OREGON — Upper Grande Ronde Basin

Water Quality Concern:

The project is located in northeast Oregon, within the 695-square mile Upper Grand Ronde Basin. Streams of the Grande Ronde basin have historically provided a rich habitat for cold water fish, such as rainbow trout, salmon, summer steelhead, and bull trout. However, cold water fish production has been declining since 1970 as land use changes have reduced riparian vegetation by 75% and simplified in-stream habitat due to grazing practices and channel modifications. Stream temperatures have risen as riparian vegetation that once shaded the streams has been lost and channels have been straightened and widened. Higher temperatures in the stream have resulted in reduced cold water fish populations.

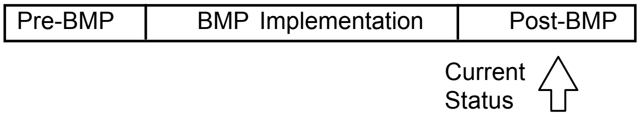
Unrestored section of McCoy Creek (Upper Grande Ronde Basin, Oregon).

Project Description:

The objective of this project is to document the effects of habitat restoration on stream temperatures and aquatic communities. A paired watershed design is being used. Monitoring is focused primarily on biological indicators, such as fish, macroinvertebrates, and habitat. Water quality, habitat, and macroinvertebrate surveys are conducted three times per year and fish snorkel surveys are carried out once per year. The treatment stream, a segment of McCoy Creek, was treated by stabilizing and revegetating riparian areas, restoring wet meadow conditions and restoring old channels to allow the stream to naturally meander. Water quality data for the treatment area is being compared with data from the control stream, Dark Canyon Creek. Three other streams are monitored to provide background information.

McCoy Creek after natural channel design restoration (Upper Grande Ronde Basin, Oregon).

Overall Project Timeline:



Key Successes and Lessons Learned:

- Restoration work on McCoy Creek was completed in 1997. Additional restoration work is being considered for another half mile of McCoy Creek below the completed project, if funding allows.
- Beavers have built several new dams in the restored segment of McCoy Creek, which form excellent pools for fish and waterfowl. The narrower and deeper channel of the restored reach has also resulted in some reduction in water temperatures within the restored channel segment.
- Fish snorkel surveys in 1998 and 1999 showed the reconstructed reach to have the highest concentration of fish of the McCoy Creek survey sites. In addition, numbers of rainbow trout juveniles in the restored reach have increased each year since 1997. Rainbow trout numbers in adjacent reaches without restoration have remained unchanged during the same time period.
- Recent riparian plantings of willow and cottonwood have yet to provide much shade in the restored channel reach. Improvements observed to date appear to be the result of improved instream habitat (primarily more and deeper pools) and improved connection with ground water.

Biological monitoring (Upper Grande Ronde Basin, Oregon).

PENNSYLVANIA — Pequea and Mill Creek

Water Quality Concern:

The Big Spring Run is a spring-fed stream located in the Mill Creek Watershed of south-central Pennsylvania, which is in the larger Chesapeake Bay Watershed. Elevated levels of nutrients and poor macroinvertebrate habitat are the primary water quality concerns. The main source of pollutants in the area is cows lounging in and around the streams.

Project Description:

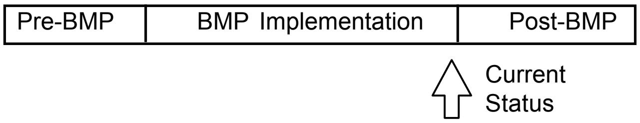
Because both paired watersheds contain pastures along the streams, the primary land management treatment is to fence cows out of streams in the 896-acre treatment watershed. This allows grasses and shrubs to stabilize streambanks and potentially filter pollutants from pasture runoff.

Water quality monitoring includes the collection of grab samples every 10 days at the outlet of each paired watershed and at three upstream sites in the treatment basin from April through November. Monitoring also includes storm event, monthly ground water, and macroinvertebrate sampling. Precipitation and discharge are continuously monitored in both streams.

Degraded stream in the treatment watershed prior to BMP implementation (Pequea and Mill Creek, Pennsylvania).

Stream after livestock exclusion fencing (Pequea and Mill Creek, Pennsylvania).

Overall Project Timeline:



Key Successes and Lessons Learned:

- Preliminary monitoring results indicate a considerable increase in taxa richness of macroinvertebrates at all three sites in the treatment watershed for the first sampling following implementation of livestock exclusion fencing.
- Livestock exclusion fencing is acceptable to most farmers if they have input regarding the type, location, and quality of the fence. Fencing was installed only 10-12 ft from the stream in these watersheds. A dense vegetative buffer developed within 2-3 months after fencing.
- A problem exists with maintaining control on land use in the paired watersheds. The control watershed has experienced a loss of small farms and increased non-agricultural development.

PENNSYLVANIA — Stroud Preserve Watershed

Water Quality Concern:

Nutrient export from cropland is a water quality concern in the Brandywine River Watershed of southeastern Pennsylvania. Elevated levels of nutrients, particularly nitrate, in the stream draining the Stroud Preserve, exist.

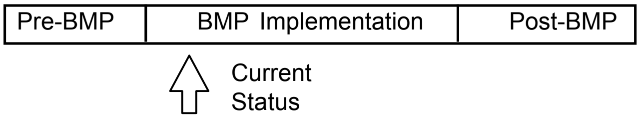
Revegetated buffer and level spreader (Stroud Preserve Watershed, Pennsylvania).

Project Description:

Water quality monitoring is based on a paired watershed design with three paired watersheds. In one of the treatment watersheds (Morris Run), a level spreader and riparian buffer, planted in hardwood seedlings, were installed in 1992. A second treatment watershed (Half Way Run) was taken out of agricultural production and reforested in its entirety. The control watershed (Mine Hill Run) has, and will be, maintained, in agricultural production. Prior to 1992, all three watersheds were primarily in crop production under a soil conservation plan including contouring and crop rotation.

Water quality monitoring for nutrients and suspended sediments includes grab samples collected every 14 days from all three streams, storm event sampling eight times a year (Morris Run and Mine Hill Run), sampling of overland flow (Morris Run), and quarterly sampling of groundwater (Morris Run). Discharge and rainfall are continuously monitored in all three watersheds.

Overall Project Timeline:



Key Successes and Lessons Learned:

- As of 1998 nutrient chemistry in the stream with the reforested buffer has shown no evidence of reduction in nutrients. Comparisons of groundwater with streamwater concentrations; however, suggest that some nitrogen removal has occurred within the riparian zone. In the watershed that was entirely reforested, streamwater concentrations of both nitrogen and phosphorus have declined steadily since 1992.
- Monitoring storm runoff only four times per year is not enough to document pollutant loads or assess the effectiveness of practices; therefore, the minimum number of monitored storms was increased to eight.

PENNSYLVANIA — Swatara Creek

Water Quality Concern:

Coal mine drainage (CMD) from abandoned mines has affected more than 2,400 miles of streams and associated ground water in Pennsylvania. Approximately half the discharges from bituminous and anthracite coal mines in Pennsylvania are acidic, having pH <5.0 Acidic CMD typically contains elevated concentrations of dissolved sulfate (SO_4^{2-}), dissolved and particulate iron (Fe), and other metals produced by the oxidation of pyrite (FeS_2). Elevated concentrations of sulfate and metals in mine drainage and receiving streams make the water unfit for most uses. Losses of surface water to, and CMD from abandoned anthracite mines within the northern 43 mi^2 of the 576-mi^2 Swatara Creek Basin degrade the aquatic ecosystem and impair uses of Swatara Creek to its mouth on the Susquehanna River 70 miles downstream from the mined area.

Limestone diversion wells to neutralize acidic coal mine drainage (Swatara Creek, Pennsylvania).

Monitoring acid mine drainage (Swatara Creek, Pennslyvania).

Project Description:

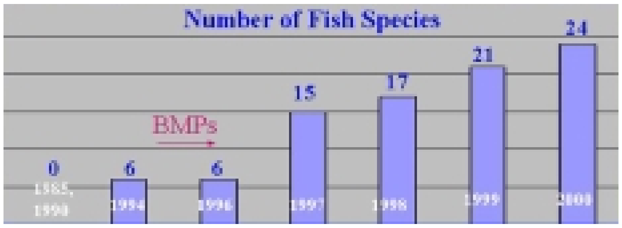
To neutralize the acidic CMD and reduce the transport of dissolved metals in the Swatara Creek watershed, innovative passive-treatment systems are being implemented and monitored in the 43 mi^2 northern Swatara Creek Basin. These treatment systems include limestone-sand dosing, open limestone channels, anoxic and oxic limestone drains, limestone diversion wells, and limestone-based wetlands. The performance of these new and existing treatment systems is being evaluated using upstream/downstream and before/after monitoring schemes.

Overall Project Timeline:

Key Successes and Lessons Learned:

- The anoxic limestone drain near the headwaters of Swatara Creek has shown the greatest benefit to water quality, producing significant improvements in pH and alkalinity, measurable several miles downstream.
- The diversion wells show great potential to treat stormflow, which generally is more acidic than baseflow.
- Wetlands attenuated dissolved and particulate metals, but had negligible effects on pH, alkalinity, and sulfate.
- Alkalinity-producing systems, such as limestone diversion wells or limestone drains combined with wetlands or settling basins, generally are needed to attenuate metals transport.

- Open limestone channel and limestone sand dosing had negligible effect on water quality.
- The precipitation process has a detrimental side effect of putting sludge with high metal content in the bottom of the creeks.



Observed increase in fish species since BMP implementation (Swatara Creek, Pennslyvania).

SOUTH DAKOTA — Bad River

Water Quality Concern:

The Bad River is located in west-central South Dakota, where it discharges to the Missouri River near Ft. Pierre (10 miles downstream of Oahe Reservoir). The drainage basin of the Bad River comprises 3,209 square miles. The sediment load carried by the Bad River is filling in the channel in the Missouri River and impairing power generation at Oahe Dam. Also, the combination of ice jams and the silted-in channel on the Missouri River cause localized flooding in the City of Pierre during peak discharges in winter months.

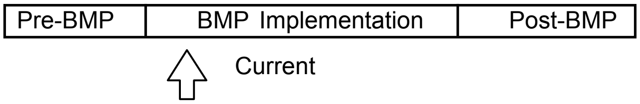
Land use in the watershed consists primarily of livestock grazing with some dry-land wheat farming. Improper grazing practices and streambank erosion are the main causes of sedimentation in the watershed.

Project Description:

To control erosion and reduce sedimentation, rotational grazing, riparian plantings, alternative watering and feeding areas, and possibly some structural BMPs are being implemented in the treatment watersheds. The two-paired watershed design includes four monitored watersheds: one pair in the eastern part and one pair in the western part of the Bad River Watershed.

Rangeland and riparian conditions will be monitored during the project. Water quality monitoring is storm-event driven because the streams are ephemeral, flowing only during snow melt and intense summer thunderstorms. Sediment, rainfall, and discharge will be monitored.

Overall Project Timeline:



Key Successes and Lessons Learned:

- In remote project locations, consideration should be given to data acquisition systems. Remote collection of data using telemetry can prevent data from being lost.

Incised stream through rangeland (Bad River, South Dakota).

VERMONT — Lake Champlain Basin

Water Quality Concern:

Lake Champlain fails to meet Vermont water quality standards for phosphorus, largely due to excessive nonpoint source loads from agriculture. The Missisquoi River contributes the greatest share of nonpoint source phosphorus to Lake Champlain, and is itself impacted by phosphorus, bacteria and organic matter from agricultural sources, primarily animal wastes from dairies, cropland, and livestock activity within streams and riparian areas.

Within the Missisquoi River basin, average bacteria counts in tributary streams often exceed Vermont water quality standards; counts as high as 200,000 organisms/100 ml have been recorded in the study streams. Phosphorus and nitrogen levels indicate significant nutrient enrichment. Fish and macro-invertebrate data suggest moderate to severe impacts due to nutrients and organic matter.

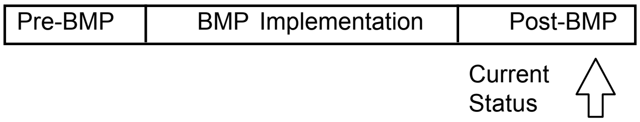
Project Description:

The Lake Champlain Agricultural Watersheds National Monitoring Program project is designed to implement and evaluate the effectiveness of livestock exclusion, streambank protection, and riparian zone restoration in reducing the concentrations and loads of nutrients, sediment and bacteria from agricultural sources. One control watershed (Berry Brook — WS3) and two treatment watersheds (WS1 – Samsonville Brook and WS 2- Godin Brook) receiving similar treatment at different intensities are being monitored. The treatments implemented include controlled livestock access to streams, improved livestock stream crossings, bioengineered streambank protection, and riparian zone protection.

The three watersheds have been monitored since May 1994. Monitoring included a three-year calibration period before BMP implementation, one year of land treatment implementation, and three years of post-treatment monitoring. Streamflow is recorded continuously at all sites, and weekly flow-proportional composite samples are collected for nutrients and suspended solids analysis. Grab samples for bacteria analysis are collected twice weekly. Macroinvertebrate and fish assemblages are sampled annually in each watershed and at an additional reference site. Land use, agricultural management and BMP status are monitored primarily through aerial photography and farmer records and interviews.

Fish electro-shocking by Vermont Department of Environmental Conservation biologists (Lake Champlain Basin, Vermont).

Overall Project Timeline:



Key Successes and Lessons Learned:

- Two years of post-BMP data suggest that bacteria counts and concentrations and loads of nutrients and sediment have decreased significantly in one or both of the treatment watersheds. In WS 2, where treatment was most extensive, mean bacteria counts and phosphorus loads have decreased by about 50% following treatment.
- Although statistical significance is lacking, two years of post-treatment biomonitoring data suggest slight improvements in both the fish and macroinvertebrate assemblages in the treated watersheds. These slight gains in the treatment streams are in contrast to continued deterioration of the biological communities in the project control watershed and in the local reference stream.
- The principal impediment to project progress is the dramatic expansion of a large dairy farm operation in one treatment watershed. Land clearing, excessive animal waste applications, concentrated overland flow, and lack of riparian buffers, along with the inability of the state agriculture department to correct the problems, have skewed water quality data in WS 2 since mid-1999. Another impediment has been funding, both mechanism and quantity.

WASHINGTON — Totten and Eld Inlets

Water Quality Concern:

Totten and Eld Inlets, located in southern Puget Sound, are exceptional shellfish production areas. The most significant nonpoint source pollution threat in these inlets is bacterial contamination from agricultural animal waste and effluent from failing on-site septic systems. Pollution from urban, suburban, and rural growth that has occurred within the last decade - and shows no signs of abatement - further threatens the water quality of the inlets. To restore and protect these natural resources, local and state governments have combined their efforts to reduce nonpoint source pollution, particularly fecal coliform (FC) pollution, from failing septic systems and livestock-keeping practices.

Project Description:

The Totten and Eld Inlets project is using a paired watershed approach to document changes in water quality as a result of BMP implementation. The Kennedy watershed, which is sparsely populated and has few livestock, serves as the control watershed. Implementation of BMPs is occurring in the Schneider watershed (treatment). A single-monitoring site before/after approach is being used in four other watersheds (McLane, Perry, Pierre, and Burns). FC count is monitored weekly from early November through mid-April. Other variables such as discharge (flow), conductivity, total suspended solids, and turbidity are also being monitored; precipitation data have been obtained historically NOAA (NCDC).

Numerous recreational, noncommercial livestock farms contribute to closure of shellfish beds (Totten and Eld Inlets, Washington).

Overall Project Timeline:

Key Successes and Lessons Learned:

- ◆ On-site septic system surveys were completed for 15 out of 36 systems in three sub-basins.
- ◆ Water quality monitoring efforts need to be continued beyond immediate post-BMP years. FC levels, which showed downward trends for several years during and/or post-BMP implementation, have risen more recently. Further monitoring is needed to determine whether declines seen during the last (1999-2000) wet season are transitory or representative of new trends.
- ◆ Loading needs to be considered in monitoring design and analysis. Freshwater FC loading to the marine inlet receiving waters is probably more meaningful than FC counts. Also, within-year loading patterns can indicate whether the pollutant source is direct (e.g. animals in streams, defective septic system at a shoreline), or indirect (from surface runoff). At streams where FC long-term trends appear to be downward, FC loading trends appear to be flat or upward; in cases where FC count trends are upward, so are FC loading trends.
- ◆ Monitoring design adequate for measuring concentrations (FC counts) may not be adequate for accurate loading measurement; more work needs to be done in this area.
- ◆ Improved project planning is needed to improve ability to monitor during severe weather events.
- ◆ Changes within state and local agencies' staffs, structures, and directions reduced their ability to meet original pollution control goals. Mechanisms are needed for maintaining commitment to projects through changes in administrations and from reorganizations and personnel changes.
- ◆ State-issued grant language needs to be explicit with regard to: expectations and requirements; BMP monitoring requirements; accountability; and data/information recording and communication requirements.
- ◆ BMP maintenance needs to be monitored. Simple enumeration of projects completed is inadequate for answering questions regarding the effect of BMPs on water quality.
- ◆ Rapid demographic change can impair ability to track land-use and BMP implementation.
- ◆ Land-use change unrelated to BMPs can impair ability to link water-quality change to BMPs.

WISCONSIN — Otter Creek

Water Quality Concern:

The largely agricultural, 7,040-acre Otter Creek Watershed drains to Lake Michigan via the Sheboygan River. Biological monitoring within the watershed has shown that the fish community lacks fishable numbers of warmwater sport fish, largely due to inadequate fish habitat and polluted water. Dissolved oxygen concentrations occasionally drop below Wisconsin's State standard of 5.0 mg/l. In addition, bacteria levels exceed Wisconsin's recreational standard of 400 fecal coliforms per 100 ml in many samples.

Project Description:

Modeling and field inventories have identified critical areas needing treatment to achieve the NMP project goals of improving the fishery, restoring the endangered striped shiner in Otter Creek, improving recreational uses by reducing bacteria levels, reducing pollutant loadings to the Sheboygan River and Lake Michigan, and restoring riparian vegetation.

Installation of stream fencing for livestock exclusion (Otter Creek, Wisconsin).

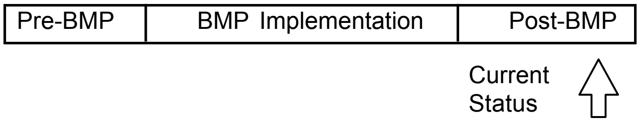
Improved management of barnyard runoff and manure, nutrient management and reduced tillage on cropland, and shoreline and streambank stabilization are all being implemented to control sources of phosphorus, sediment, bacteria, and streambank erosion in the watershed. State cost-share funds have been used to install these BMPs.

Paired watershed and upstream/downstream monitoring studies covering eight monitoring sites are employed to evaluate the benefits of the BMPs. Meeme River serves as the control watershed and Otter Creek is the treatment watershed in the paired watershed study. Monitoring sites are located above and below a dairy with barnyard and streambank stabilization BMPs.

Improved cattle crossing (Otter Creek, Wisconsin).

Habitat, fish, and macroinvertebrates are being sampled each year during the summer. Water chemistry is tracked through analysis of 30 weekly samples collected each year from April to October at the paired watershed and upstream/downstream sites. Runoff events are also sampled at the upstream/downstream sites and at the single-downstream station site at the outlet of Otter Creek.

Overall Project Timeline:



Key Successes and Lessons Learned:

- 8100 feet of streambank fencing have been installed, as well as a significant change in cropping practices, to reduce upland soil erosion.
- BMPs installed on dairy farms included rainwater diversions, concrete loafing areas, filter screens to trap large solids in runoff, and grassed filter strips for treating runoff.
- Within the treatment watershed, two years of post-BMP monitoring data indicate that the system of BMPs was responsible for reductions in suspended solids (81%), total phosphorus (88%), ammonia nitrogen (97%), BOD (80%), and fecal coliforms (84%).

Level spreader for treated barnyard runoff (Otter Creek, Wisconsin).

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