Pequea and Mill Creek Watershed
Section 319
National Monitoring Program Project

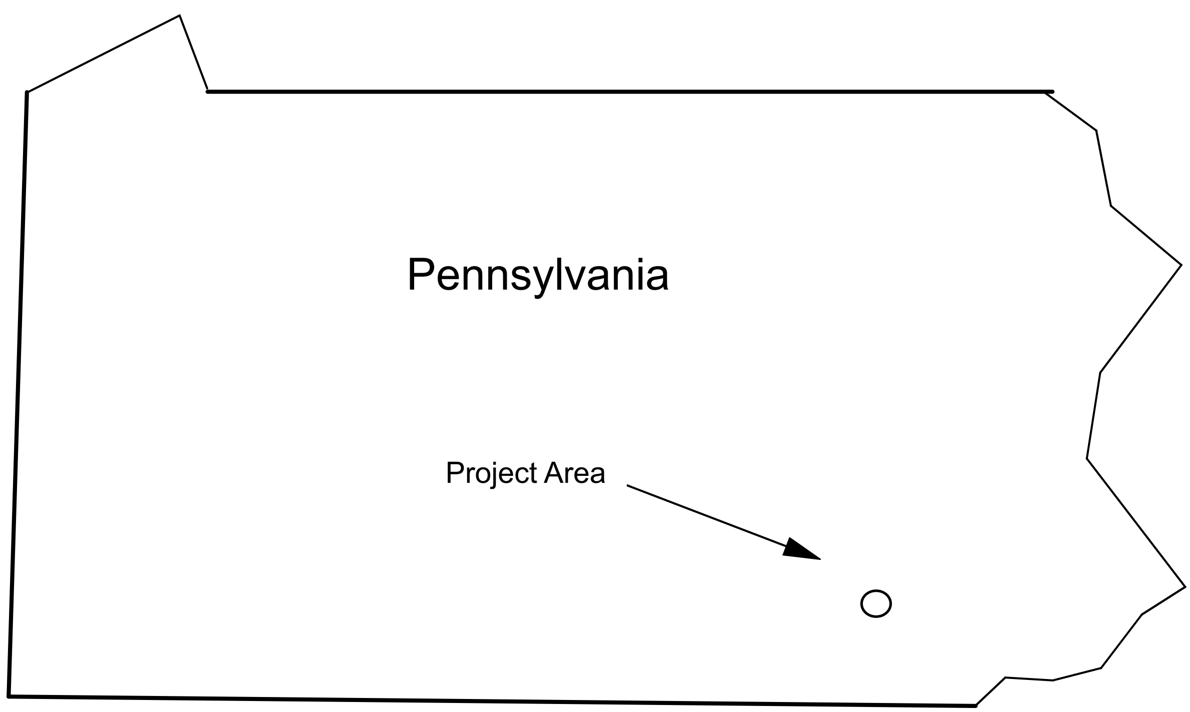

Figure 38: Pequea and Mill Creek (Pennsylvania) Watershed Project Location

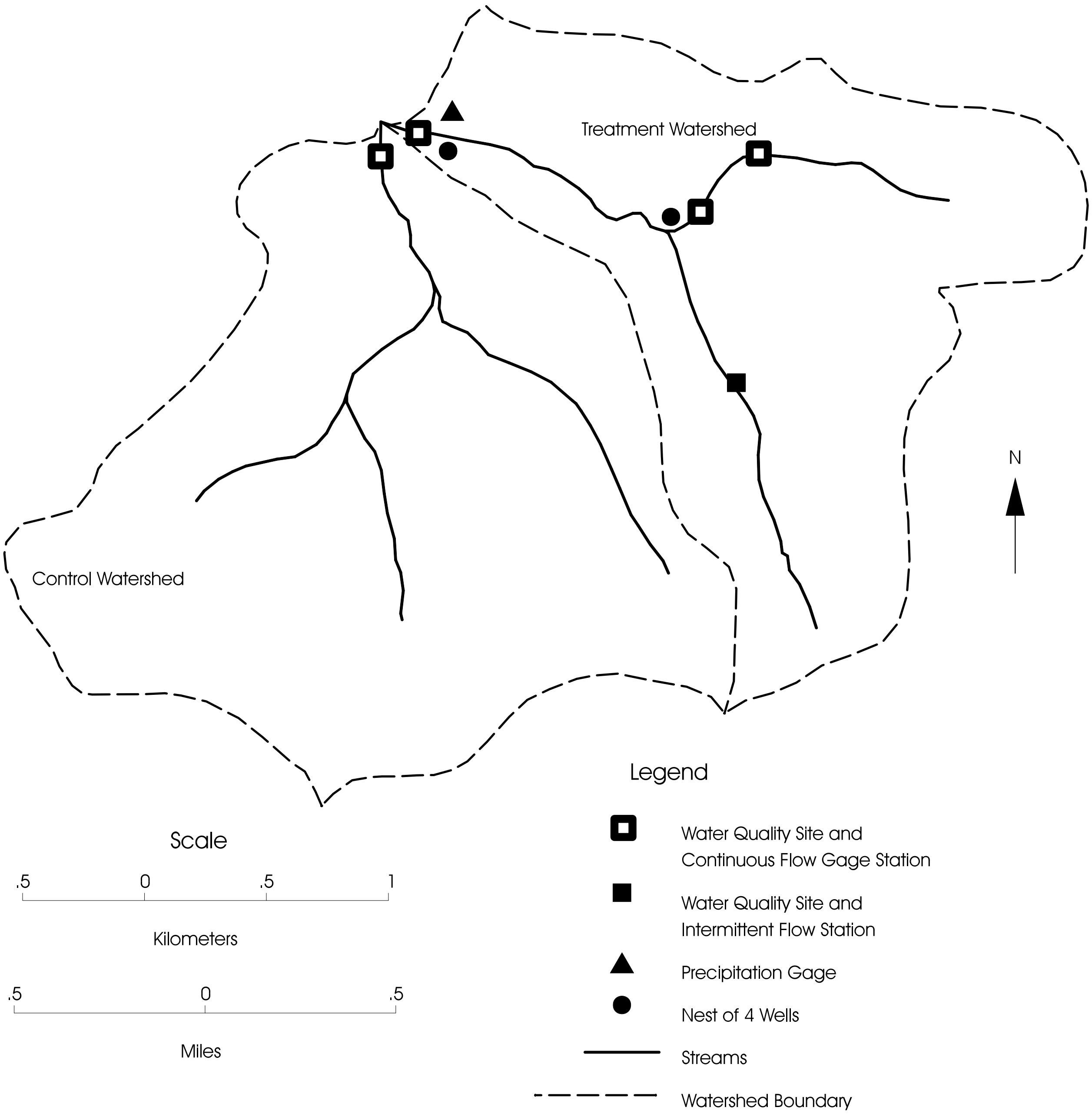

Figure 39: Water Quality Monitoring Stations for Pequea and Mill Creek (Pennsylvania) Watershed

PROJECT OVERVIEW

The Big Spring Run is a spring-fed stream located in the Mill Creek Watershed of southcentral Pennsylvania (Figure 38). Its primary uses are livestock watering, aquatic life support, and fish and wildlife support. In addition, receiving streams are used for recreation and public drinking water supply. Stream uses such as recreation and drinking water supply are impaired by elevated bacteria and nutrient concentrations.

Uncontrolled access of about 200 dairy cows and heifers to each of the two watershed streams is considered to be a major source of pollutants. Pastures adjacent to streams and upgradient cropland also are thought to contribute significant amounts of nonpoint source pollutants. Therefore, land treatment was to focus on streambank fencing to exclude livestock from streams, except for cattle crossings, which were also to be used for drinking water access for the cattle. This was to allow a natural riparian buffer to become established, stabilizing streambanks and potentially filtering pollutants from pasture runoff.

Water quality monitoring was based on a paired and upstream-downstream watershed design in which the proposed nonpoint source control was to implement livestock exclusion fencing on nearly 100 percent of the stream miles in the treatment subwatershed (Figure 39). Grab samples were collected approximately every 10 days at the outlet of each paired subwatershed and at upstream sites in the treatment subwatershed from April through November. Storm event, ground water, biological, and other monitoring were conducted to help document the effectiveness of fencing in the treatment subwatershed.

Livestock exclusion fencing was completed in the treatment watershed in July, 1997. Water quality sampling in the study area was discontinued in July 2001.

The final report and summary fact sheet have been completed. Copies of both reports are available on the internet and in hard copy.

PROJECT BACKGROUND

Project Area

Total area is 3.2 square miles (mi^2); Control = 1.8 mi^2; Treatment = 1.4 mi^2

Relevant Hydrologic, Geologic, and Meteorologic Factors

The average annual precipitation is 43 inches. The watershed geology consists of deep well-drained silt-loam soils underlain by carbonate rock. About five percent of each subwatershed is underlain by noncarbonate rock.

Land Use

Type	**Control Watershed**		**Treatment Watershed**	
	Acres	%	Acres	%
Agricultural	922	80	762	85
Urban	150	13	116	13
Commercial	80	7	18	2
Total	1152	100	896	100

Water Resource Type and Size

The study area encompasses about 2.8 and 2.7 miles of tributary streams in the treatment and control subwatersheds, respectively. Annual mean discharges for 1994–2000 water years were 1.69 and 2.92 cfs at the outlets of the treatment (T-1) and control (C-1) subwatersheds, respectively.

Water Uses and Impairments

The subwatershed streams have relatively high nutrient and fecal coliform and streptococcus concentrations that contribute to use impairments of receiving waters.

Pollutant Sources

The primary source of pollutants was believed to be pastured dairy cows and heifers with uncontrolled access to stream and streambanks, along with the application of nutrients to croplands used for silage corn and soybean production. At the beginning of the project, about 200-400 animals were pastured in each of the treatment and control watersheds. The PA Department of Environmental Protection estimated that grazing animals deposit an average of 40 pounds of nitrogen and 8 pounds of phosphorus annually per animal. Other (commercial, urban, and septic) sources of pollutants were considered insignificant.

Pre-Project Water Quality

Onetime baseflow grab sampling at four and seven locations in the control and treatment subwatershed are presented in tabular form:

	Fecal coliform (mg/l)	TP (mg/l)	OP (mg/l)	NH_3+Organic N (mg/l)	NO_3+NO_2
Treatment	1,100-38,000	.06-.25	.03-.15	.3-1.6	10-18
Control	10,000	.02-.04	.01-.03	.1-.3	4-12

Water Quality Objectives

The overall objective was to evaluate the effect of streambank fencing of pasture land on surface- and near-stream ground-water quality within a small watershed underlain by carbonate bedrock.

Project Time Frame

September, 1993 to June 2001 (field work); report preparation and printing complete by winter 2006.

Modifications Since Project Started

A new residential community was developed in the treatment subwatershed directly upstream of site T-4.

PROJECT DESIGN

Nonpoint Source Control Strategy

The control strategy involved installing streambank fencing on nearly 100 percent of the pasture land adjacent to the stream draining the treatment subwatershed. All of the farmers in this watershed had agreed to install fencing. A stabilizing vegetative buffer naturally developed soon after the fencing was installed.

Project Schedule

Surface-water site	Basin	Station type	Pre-BMP monitoring interval (MM/YY)	Date of BMP installation	Post-BMP monitoring interval
C-1	Control	Continuous	09/93 – 06/97		07/97 - 06/01
C1-2	Control	Benthic	05/96 – 05/97		09/97 – 05/01
T-1	Treatment	Continuous	09/93 – 06/97	04/97 – 06/97	07/97 - 06/01
T1-3	Treatment	Benthic	09/93 - 05/97	04/97 – 06/97	09/97 – 05/01
T-2	Treatment	Continuous	10/93 – 06/97	04/97 – 06/97	07/97 - 06/01
T2-3	Treatment	Benthic	09/93 - 05/97	04/97 – 06/97	09/97 – 05/01
T-3	Treatment	Low flow	10/93 – 06/97	04/97 – 06/97	07/97 - 06/01
T-4	Treatment	Continuous	10/93 – 06/97	04/97 – 06/97	07/97 - 06/01

Station Type
Continuous – Low-flow and stormflow water-quality sampling, and continuous discharge.

Benthic – Only sampled for macroinvertebrates and water quality twice a year, in May and September

Low flow – Sampled on fixed, grab sample interval. No storm sampling was conducted, and no continuous recorder was present.

Water Quality Monitoring

The water quality monitoring effort was based on paired watershed and upstream-downstream experimental designs (Figure 36).

Parameters Measured

Biological

Habitat survey
Benthic invertebrate monitoring
Algal mass
Fecal streptococcus (FS) (only during base flow)

Chemical and Other

pH
Temperature
Specific Conductance
Dissolved Oxygen
Turbidity
Suspended sediment (SS)
Total and dissolved ammonia (NH_3) plus organic nitrogen
Dissolved ammonia (NH_3)
Dissolved nitrate + nitrite (NO_3 + NO_2)
Dissolved nitrite (NO_2)
Total and dissolved phosphorus (TP and DP)
Dissolved orthophosphate (OP)

Covariates

Continuous streamflow
Continuous precipitation
Ground water level

Sampling Scheme

Continuous Streamflow Sites (T-1, T-2, T-4, C-1):
Type: grab and storm event composite
Frequency and season: grab approximately every 10 days from April through November. Monthly grab December through March. Fifteen to 30 composite storm flow samples per year were collected at each site.

Partial Streamflow Site (T-3):
Type: grab
Frequency and season: approximately every 10 days from April through November. Monthly grab December through March.

Ground Water (8 wells):
Type: grab
Frequency and season: The six shallow wells were sampled monthly and analyzed for fecal streptococcus. On a quarterly basis, all eight wells were sampled, including two deeper wells completed in bedrock. Analysis includes dissolved NO_2, NO_3 + NO_2, NH_3, ammonia plus organic nitrogen, and phosphorus.

Habitat, benthic invertebrate, and algal mass surveys were conducted twice per year, during May and September, at the outlet of each subwatershed (T-1 and C-1), at two points upstream (T1-3 and T2-3) in the treatment subwatershed, and at one point upstream (C1-2) in the control subwatershed.

Continuous discharge was recorded at watershed outlets and two tributary sites and partial discharge at four upstream sites. Continuous precipitation amount was recorded at one site. Additionally, ground water level was continuously monitored in seven wells.

Monitoring Scheme for the Pequea and Mill Creek Section 319 National Monitoring Program Project

Design	Sites or Activities	Primary Parameters	Covariates	Frequency of WQ Sampling	Frequency of Habitat/Biological Assessment	Duration
Paired watershed	Treatment and control watershed	Habitat and benthic invertebrate survey Algal mass SS Total organic nitrogen NH_3, OP, FS NO_3 + NO_2 NO_2, TP, DP, TP	Discharge Precipitation	Sampling every 10 days (Apr.-Nov.) Monthly sampling from Dec. to March	May and September of each year (at sites T-1, T1-3, T2-3, C-1, and C1-2	4 yrs pre-BMP 4 yrs post-BMP
Upstream-Downstream	Treatment watershed		Discharge Precipitation Ground-water level and quality	Storm event samples (15-30 per year) (at sites T-1, T-2, T-4, and C-1)		

Modifications Since Project Start

Additional biological, chemical , and continuous discharge monitoring sites were added to the treatment watershed to make an upstream-downstream design.

A new biological site was added upstream in the control subwatershed. A new continuous monitoring station and water quality site was added to the treatment subwatershed to document effects of a new residential development upstream of pasture land.

Piezometers were installed at two locations in the treatment basin (T-1 and T-2) and one location in the control basin (C-1) during 1999. They were located near and within the stream channel to determine the altitudes of hydraulic heads in the shallow ground water near the stream channel. This was used to estimate potential shallow ground-water flow directions. Nitrogen isotope and age-dating samples were collected in the piezometers, shallow ground-water wells, and stream sites in order to develop an understanding of the interaction between ground water and surface water at the sites.

Progress To Date

Streambank fencing in pastured areas of the treatment basin was completed in July, 1997. Several stable stream crossings for cattle were also installed.

DATA MANAGEMENT AND ANALYSIS

Data were stored and maintained locally by U.S. Geological Survey (USGS) and entered into the USGS WATSTORE database. The following data were collected during the critical season (April through November). Data for 2001 were collected from April through June (termination of data collection).

NPSMS Data Summary

DATA TYPE: Fixed Time
STATION TYPE: CONTROL (C-1) **STUDY TYPE:** Paired
CHEMICAL PARAMETERS

	QUARTILE VALUES				**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Parameter Name	**-75-**	**-50-**	**-25-**	**Counts/Season**						
TEMPERATURE, WATER (CENTIGRADE)	15.9	15.2	12.5	Highest	5	5	7	8	2	0
				High	20	1	2	1	2	1
				Low	10	10	5	7	12	4
				Lowest	6	7	7	8	7	4
PRECIPITATION, TOTAL (INCHES PER DAY)	0.64	.31	.11	Highest	21	8	11	12	15	3
				High	15	10	12	9	16	9
				Low	15	24	16	24	28	8
				Lowest	35	40	32	12	43	4
FLOW, STREAM, INSTANTANEOUS, CFS	2.2	1.8	1.4	Highest	18	1	8	1	7	3
				High	4	3	2	1	4	3
				Low	1	3	2	6	4	2
				Lowest	0	16	10	16	8	1
TURBIDITY, HACH TURBIDIMETER	9	6.1	3.5	Highest	6	8	6	3	0	5
				High	3	6	4	2	3	3
				Low	5	5	7	3	7	1
				Lowest	9	4	5	16	11	0
SPECIFIC CONDUCTANCE	700	691	682.5	Highest	5	5	0	10	15	9
				High	5	0	0	1	1	0
				Low	5	2	0	1	1	0
				Lowest	8	15	21	12	6	0
OXYGEN, DISSOLVED	10.8	10.1	9.4	Highest	7	8	8	9	10	3
				High	4	2	4	2	8	3
				Low	8	6	4	5	1	1
				Lowest	4	4	5	7	4	2

Parameter Name	-75-	-50-	-25-		1996	1997	1998	1999	2000	2001
PH (STANDARD UNITS)	7.86	7.75	7.5	Highest	3	2	2	4	5	1
				High	3	4	4	3	6	1
				Low	12	8	8	9	11	4
				Lowest	5	9	7	8	1	3
NITROGEN, AMMONIA, DISSOLVED	0.05	0.04	0.02	Highest	4	5	8	6	0	0
				High	4	3	4	2	3	0
				Low	14	7	8	9	7	8
				Lowest	1	8	2	7	13	1
NITROGEN, NITRITE, DISSOLVED	0.04	0.03	0.02	Highest	8	11	5	10	5	3
				High	4	6	8	3	3	2
				Low	9	3	7	5	5	2
				Lowest	2	3	2	6	10	2
NITROGEN, AMMONIA+ORGANIC, DISSOLVED	0.30	<0.20	<0.20	Highest	4	2	6	9	3	0
				High	6	7	8	6	8	4
				Low	13	14	8	0	0	0
				Lowest	0	0	0	9	12	5
NITROGEN, AMMONIA+ORGANIC, TOTAL	0.40	0.30	<0.20	Highest	5	4	6	7	2	0
				High	1	1	4	5	5	2
				Low	7	6	9	8	11	7
				Lowest	10	12	3	4	5	0
NITROGEN, NITRITE+NITRATE, DISSOLVED	10	10	9.7	Highest	15	20	10	2	1	1
				High	3	0	0	0	0	0
				Low	2	1	3	1	1	1
				Lowest	3	2	9	21	21	7
PHOSPHORUS, TOTAL (MG/L)	0.08	0.04	0.03	Highest	4	2	8	3	0	0
				High	6	6	7	5	8	4
				Low	5	5	2	9	7	2
				Lowest	8	10	5	7	8	3

Parameter Name	**QUARTILE VALUES** -75-	-50-	-25-		**1996** Counts/Season	**1997**	**1998**	**1999**	**2000**	**2001**
PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE	0.04	0.03	0.02	Highest	3	4	9	-	0	0
				High	5	2	2	-	0	0
				Low	6	3	5	-	1	1
				Lowest	9	14	5	-	0	1
PHOSPHORUS, DISSOLVED	0.03	0.03	0.02	Highest	6	5	13	7	10	2
				High	7	0	0	1	0	0
				Low	7	12	5	7	7	4
				Lowest	3	6	4	9	6	3
STREPTOCOCCI, FECAL, KF AGAR	5720	3580	2190	Highest	4	1	0	2	0	0
				High	0	1	1	1	0	0
				Low	3	2	2	1	0	0
				Lowest	1	4	5	4	8	3
SUSPENDED SEDIMENT	107	84	20	Highest	2	1	0	0	0	0
				High	0	1	0	0	0	0
				Low	8	13	14	5	4	1
				Lowest	11	8	8	19	19	8

DATA TYPE: Fixed Time
STATION TYPE: STUDY (T-1)
CHEMICAL PARAMETERS

Parameter Name	**QUARTILE VALUES** -75-	-50-	-25-		**1996** Counts/Season	**1997**	**1998**	**1999**	**2000**	**2001**
TEMPERATURE, WATER (CENTIGRADE)	20.5	18.7	13	Highest	0	2	4	6	0	0
				High	4	4	3	2	2	0
				Low	12	8	7	9	13	5
				Lowest	7	9	7	7	8	4
PRECIPITATION, TOTAL (INCHES PER DAY)	0.64	.31	.11	Highest	21	8	11	12	15	3
				High	15	10	12	9	16	9
				Low	15	24	16	24	28	8
				Lowest	35	40	32	12	43	4
FLOW, STREAM, INSTANTANEOUS, CFS	1.5	.9	.6	Highest	18	1	8	1	3	1
				High	5	6	3	2	8	5
				Low	0	4	2	7	4	3
				Lowest	0	12	9	14	8	0
TURBIDITY, HACH TURBIDIMETER	7	4	3	Highest	8	6	4	1	4	1
				High	5	6	2	4	5	7
				Low	5	2	5	4	3	1
				Lowest	5	9	11	15	9	0
SPECIFIC CONDUCTANCE	680	640	609	Highest	3	0	0	9	13	8
				High	10	4	2	4	7	0
				Low	5	6	4	4	0	1
				Lowest	5	12	15	7	2	0

OXYGEN, DISSOLVED	12.4	11.4	9.8	Highest	3	6	2	4	3	1
				High	4	1	1	3	3	1
				Low	4	5	8	5	10	3
				Lowest	12	9	8	12	7	4
PH (STANDARD UNITS)	8	7.84	7.67	Highest	0	2	4	4	5	0
				High	3	2	7	1	6	1
				Low	4	6	1	5	6	0
				Lowest	16	13	8	14	6	8
NITROGEN, AMMONIA, DISSOLVED	0.06	0.035	0.03	Highest	7	3	5	5	0	0
				High	9	6	4	4	5	1
				Low	1	3	3	5	0	0
				Lowest	6	11	10	10	18	8
NITROGEN, NITRITE, DISSOLVED	0.07	0.06	0.05	Highest	11	8	3	3	1	0
				High	3	3	3	3	1	0
				Low	3	2	1	2	1	2
				Lowest	6	10	15	15	20	7
NITROGEN, AMMONIA+ORGANIC, DISSOLVED	0.42	0.3	0.2	Highest	4	4	8	9	2	0
				High	7	2	7	7	6	3
				Low	8	14	6	8	11	6
				Lowest	4	3	1	0	4	0
NITROGEN, AMMONIA+ORGANIC, TOTAL	0.7	0.55	0.38	Highest	3	2	5	4	0	0
				High	1	0	4	3	0	0
				Low	7	6	4	10	7	6
				Lowest	12	15	9	7	16	3
NITROGEN, NITRITE+NITRATE, DISSOLVED	12.2	11	9.4	Highest	3	0	0	0	0	0
				High	12	4	0	0	0	0
				Low	4	8	4	3	2	0
				Lowest	4	11	18	20	21	9

QUARTILE VALUES					1996	1997	1998	1999	2000	2001
Parameter Name	**-75-**	**-50-**	**-25-**		**Counts/Season**					
PHOSPHORUS, TOTAL (MG/L)	0.1	0.06	0.04	Highest	3	2	6	13	6	0
				High	1	1	7	6	10	0
				Low	3	7	6	3	3	3
				Lowest	16	13	3	2	4	6
PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE	0.06	0.025	0.02	Highest	3	3	7	-	0	0
				High	4	6	6	-	1	0
				Low	6	2	1	-	0	1
				Lowest	10	12	7	-	0	1
PHOSPHORUS, DISSOLVED	0.05	0.025	0.02	Highest	3	4	11	17	17	0
				High	4	5	4	5	2	2
				Low	7	3	1	0	1	2
				Lowest	9	11	6	1	3	5
STREPTOCOCCI, FECAL, KF AGAR	98320	10880	1710	Highest	0	0	0	0	0	0
				High	1	0	0	1	0	0
				Low	6	4	2	3	2	1
				Lowest	1	4	6	4	6	2
SUSPENDED SEDIMENT	54	26	6	Highest	2	3	1	0	0	1
				High	4	5	2	1	0	0
				Low	13	8	10	15	14	6
				Lowest	2	7	9	8	9	2

DATA TYPE: Storm

STUDY TYPE: Paired

STATION TYPE: CONTROL (C-1)

CHEMICAL PARAMETERS

QUARTILE VALUES					1996	1997	1998	1999	2000	2001
Parameter Name	**75-**	**-50-**	**-25-**		**Counts/Season**					
FLOW, STREAM, MEAN DAILY	23.14	13.38	9.39	Highest	8	4	0	3	4	1
				High	3	2	5	5	3	0
				Low	5	3	1	5	2	1
				Lowest	0	10	4	3	3	3
NITROGEN, AMMONIA, DISSO	.355	.255	.145	Highest	0	0	3	2	4	0
				High	1	2	0	3	1	0
				Low	6	5	11	5	4	2
				Lowest	9	8	0	6	3	3
NITROGEN, NITRITE, DISSOLV	.095	.075	.055	Highest	2	2	3	2	1	2
				High	1	0	2	3	3	0
				Low	3	3	6	2	4	3
				Lowest	10	10	3	9	4	0

NITROGEN, AMMONIA+ORGANIC, DISS	1.05	1	.75	Highest	2	2	4	4	5	1
				High	1	2	0	0	1	0
				Low	5	2	6	6	3	2
				Lowest	8	9	3	6	3	2
NITROGEN, AMMONIA+ORGANIC, TOTAL	2.95	2.3	1.9	Highest	0	3	1	4	6	1
				High	0	0	4	4	2	2
				Low	4	2	2	3	1	0
				Lowest	12	10	7	4	3	2
NITROGEN, NITRITE+NITRAT	4.05	3.6	2 .65	Highest	6	2	5	0	2	1
				High	1	1	2	2	2	1
				Low	4	5	2	5	4	2
				Lowest	5	7	5	9	4	1
PHOSPHORUS, TOTAL (MG/L)	1.3	.825	.57	Highest	0	0	1	3	6	1
				High	5	4	4	4	1	0
				Low	3	0	2	2	0	0
				Lowest	8	11	7	7	5	4
PHOSPHORUS, DISSOLVED	.54	.32	.21	Highest	4	0	0	1	1	0
				High	3	1	3	2	3	1
				Low	4	2	4	4	1	0
				Lowest	5	12	7	9	7	4
SUSPENDED SEDIMENT	718	501.5	347.5	Highest	6	1	5	2	6	1
				High	2	4	2	3	1	0
				Low	1	1	1	0	0	0
				Lowest	6	9	6	11	5	4

DATA TYPE: Storm **STUDY TYPE:** Paired
STATION TYPE: STUDY (T-1)
CHEMICAL PARAMETERS

	QUARTILE VALUES			**COUNTS/SEASON**						
	-75-	**-50-**	**-25-**		**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Parameter Name										
FLOW, STREAM, MEAN DAILY	15.58	5.37	4.41	Highest	7	0	2	1	2	1
				High	6	4	7	7	3	1
				Low	3	1	1	2	3	1
				Lowest	0	9	4	4	2	2
NITROGEN, AMMONIA, DISSO	.46	.26	.13	Highest	2	1	2	1	0	0
				High	4	5	6	6	5	0
				Low	8	5	3	3	2	3
				Lowest	2	3	3	4	3	2
NITROGEN, NITRITE, DISSOLV	.17	.1	.06	Highest	0	2	0	2	2	0
				High	5	3	5	4	1	3
				Low	8	8	5	6	4	2
				Lowest	3	1	4	2	3	0
NITROGEN, AMMONIA+ORGANIC, DISS	1.6	1.2	.9	Highest	2	2	3	3	3	0
				High	3	7	4	3	2	1
				Low	8	3	6	3	3	3
				Lowest	3	2	1	5	2	1
NITROGEN, AMMONIA+ORGANIC, TOTAL	3.2	2.3	1.9	Highest	1	2	3	3	4	1
				High	2	4	3	7	3	1
				Low	2	2	1	0	0	1
				Lowest	11	6	7	3	3	2
NITROGEN, NITRITE+NITRATE	7	5.9	2.6	Highest	2	1	2	0	0	0
				High	1	3	1	3	2	1
				Low	10	5	8	9	6	4
				Lowest	3	5	3	2	2	0
PHOSPHORUS, TOTAL (MG/L)	1.5	1.1	.73	Highest	1	1	2	2	4	1
				High	0	0	1	4	1	0
				Low	5	4	4	4	1	0
				Lowest	10	9	7	4	4	4
PHOSPHORUS, DISSOLVED	.76	.59	.38	Highest	1	1	0	0	2	0
				High	2	1	3	1	1	0
				Low	4	4	2	6	0	2
				Lowest	9	8	9	6	7	3
SUSPENDED SEDIMENT	735	376	125	Highest	6	0	0	0	2	1
				High	4	0	5	2	3	0
				Low	4	5	3	8	1	2
				Lowest	1	9	6	4	4	2

DATA TYPE: Bio/Habitat **STUDY TYPE:** Paired

STATION TYPE: CONTROL (C-1)

BIOLOGICAL PARAMETERS (Non-Chemical)									
			INDICES			**Scores/Values**			
Parameter Name	**Fully**	**Threatened**	**Partially**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
HILSENHOFF BIOTIC INDEX	0-6.5	6.51-8.5	8.51-10	5.62	6.33	5.69	6.75	6.50	5.04
TAXA RICHNESS	20	11	10	21	21.5	24	18.5	22	24
EPT INDEX	6	4	1	2	3.5	3	1.5	3	3
PERCENT DOMINANT TAXA	20	35	50	25.9	29.8	25.0	39.4	38.0	35.0
SCRAPERS/FILTER COLLECT	.8	.4	.2	.081	.031	.098	.012	.078	.096

STATION TYPE: STUDY (T-1)

BIOLOGICAL PARAMETERS (Non-Chemical)									
			INDICES			**Scores/Values**			
Parameter Name	**Fully**	**Threatened**	**Partially**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
HILSENHOFF BIOTIC INDEX	0-6.5	6.51-8.5	8.51-10	5.92	6.43	5.91	7.15	6.28	5.65
TAXA RICHNESS	20	11	10	26	26.0	30	23.5	24	29
EPT INDEX	6	4	1	3	2.5	5	2	2	1
PERCENT DOMINANT TAXA	20	35	50	25.2	35.2	22.4	32.9	20.6	31.3
SCRAPERS/FILTER COLLECT	.8	.4	.2	.072	.053	.325	.096	.211	.32

**Note that for years 1996-2000, index values are average for data collected in May and September of that year. Data for year 2001 are only for May sample collection.

Final Results

Field data were collected for about eight years, with four years of calibration data and four years of post-treatment data. Major differences in annual precipitation occurred from the pre- to post-treatment period, with approximately 5 inches more per year occurring during the pre-treatment period. This caused significant decreases to occur from the pre- to post-treatment period in nutrient and suspended sediment yields for both sites at the outlet of the treatment (T-1) and control (C-1) basins due to decreased stream discharge. This highlights the importance of paired analysis in order to detect changes in water quality caused by BMP implementation.
Paired relations between T-1 and C-1 were developed for fixed-time and storm samples using analysis of covariance. These results were combined in order to quantify an overall effect of streambank fencing on water quality during the post-treatment period. The combined results indicated that T-1 (relative to C-1) showed yield reductions in total nitrogen (19 percent), nitrate (18 percent), ammonia (36 percent), dissolved ammonia plus organic nitrogen (20 percent), total ammonia plus organic nitrogen (26 percent), and suspended sediment (37 percent). The yield of dissolved phosphorus at T-1 increased by 19 percent, and this was mainly attributed to increased subsurface movement of dissolved phosphorus in the upper parts of the treatment basin. However, there was a more substantial reduction in the yield of suspended phosphorus, thus there was a significant reduction at T-1 in the yield of total phosphorus (14 percent).

Benthic-macroinvertebrate data collected (in both May and September of each year) at T-1 and C-1 showed improvement at T-1 relative to C-1 for three metrics, the Hilsenhoff Biotic Index, taxa richness, and percent dominant taxa. Physical characteristics of the stream that affect benthic-macroinvertebrate communities also showed improved conditions at T-1. Improvement was detected in the pool/riffle or run/bend ratio (improvement in this ratio indicated that riffles and bends were becoming more common than straight runs or uniform depth reaches) and bank stability. September sampling indicated improvements at T-1 in bottom substrate and scour, and better velocity to depth ratios (improvement in this indicated an increase in flow and depth variability in the channel, thus creating a more varied habitat).

Results from this study indicated streambank fencing resulted in decreases in stream N-species, total-P, and suspended-sediment con-centrations and yields at the outlet of the treatment basin relative to untreated sites; however, dissolved-P concentrations and yields increased. It is not possible to determine what the effects of fencing would be on dissolved P if an upgradient field was not acting as a source. These results indicate that nutrient management, in conjunction with streambank fencing, is important in helping to control nutrient loadings to streams in this agricultural setting.

Benthic-macroinvertebrate data indicated streambank fencing had a positive influence on benthic macroinvertebrates and their habitat. More improvement was detected at the outlet of the treatment basin than the upstream sites. Biological metrics indicated that fencing caused improvement. Probably the most important biological metric, taxa richness, indicated a greater number of benthic-macroinvertebrate taxa at treated relative to control sites after fencing. Results indicated fencing improved shallow ground-water quality (for the well nest in a stream-gaining area), as noted by decreased concentrations of N species and fecal streptococcus counts. This improvement only occurred at the well nest for which the ground-water flow path was from the shallow ground-water system through the subsurface zone below the fenced area and into the stream (a gaining stream reach).

This study indicated that a small buffer width (5 to 12 ft) can have a positive influence on surface-water quality, benthic mac-roinvertebrates, and near-stream shallow ground-water quality. However, results showed that streambank fencing in itself can not alleviate excessive nutrient inputs that are transported through subsurface zones into the stream system. Overland runoff processes that move suspended sediment to the stream were controlled (or reduced) to some extent by the vegetative buffer established inside the fenced area.

Copies of the final project report and 4-page factsheet summarizing project results may be obtained by contacting Dan Galeone at the address given below. Both the final report and the factsheet are available in printed form and on the internet.

INFORMATION, EDUCATION, AND PUBLICITY

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) has had an important role in the information and education (I&E) programs in the Pequea and Mill Creek watershed. NRCS provided an employee to gather nutrient management data in the watershed. The Lancaster County Conservation District and the Pennsylvania State University Cooperative Extension Service maintained active I&E programs in the area. Also, as part of the USDA-funded Pequea-Mill Creeks Hydrologic Unit Area (HUA), the landowners in the watersheds were to be targeted for additional educational programs.

The study watersheds have been used for numerous field tours. In 2003 and 2004, high school students from Annapolis, MD collected benthic-macroinvertebrate and water quality samples. Project personnel helped with the sampling, provided data from the fencing study for comparative purposes, and helped the students understand how their results were reflective of agricultural watersheds.

Progress Towards Meeting Goals

The Pennsylvania State University Cooperative Extension Service has produced an educational video which includes information about the project and participating farmers.

TOTAL PROJECT BUDGET

	Funding Required									
Project Element	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Personnel	$91,980	$67,656	$90,097	$94,207	$98,424	$92,472	$86,382	$93,614	$75,438	$2,348
Equipment and Supplies	$5,600	$5,020	$4,000	$4,000	$5,000	$4,000	$4,000	$3,040	$200	$0
Contracted Services	$14,200	$6,200	$7,380	$6,181	$8,875	$9,070	$8,800	$10,288	$0	$0
USGS (lab and gauging)	$38,800	$40,770	$30,500	$31,057	$27,900	$30,240	$23,928	$32,375	$0	$0
USGS Overhead	$139,834	$109,214	$121,393	$119,614	$112,133	$107,842	$98,942	$109,498	$74,634	$2,496
Other	$2,000	$3,000	$4,000	$10,241	$11,920	$13,040	$5,158	$2,634	$1,260	$2,092
TOTAL*	$292,404	$231,860	$257,370	$265,300	$264,252	$256,664	$227,210	$251,450	$151,532	$6,936

*50% of total funds are USGS matching funds, except for 2003, when only 43% of total funds were USGS match.
** Total funding for 1993 was $236,300.

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

The Chesapeake Bay Program, which has set a goal of a 40% reduction in annual loads of total ammonia plus organic nitrogen and total phosphorus to the Bay, has had a significant impact on the project. The Bay Program has provided 100% cost-share money to help landowners install streambank fencing.

OTHER PERTINENT INFORMATION

Water quality monitoring for the project was discontinued in July 2001. Thus, for this project, four years of pre-treatment and four years of post-treatment data were collected to document the effectiveness of streambank fencing in reducing the load of nutrients and suspended sediment to receiving streams.

PROJECT CONTACTS

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Water Quality Monitoring, Data Analysis, Land Treatment and Project Results

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