SURFACE-WATER QUALITY IN PEQUEA CREEK BASIN, PENNSYLVANIA, 1977-79

By Janice R. Ward

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 85-4250

Prepared in cooperation with the

SUSQUEHANNA RIVER BASIN COMMISSION

Harrisburg, Pennsylvania

1987

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
P.O. Box 1107
Harrisburg, Pennsylvania 17108-1107

Copies of this report can be purchased from:

U.S. Geological Survey
Books and Open-file Reports
Box 25425, Federal Center
Building 41
Denver, Colorado 80225
Telephone: (303) 236-7476

CONTENTS

ILLUSTRATIONS

TABLES

FACTORS FOR CONVERTING INCH-POUND UNITS TO METRIC UNITS

Multiply Inch-Pound Unit	by	To Obtain Metric Unit
inch (in.)	2.540	centimeter (cm)
foot (ft)	0.03048	meter (m)
mile (mi)	1.609	kilometer (km^2)
acre	4,047	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
gallon (gal)	3.785	liter (L)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (ft^3/s)
pound (lb)	0.4545	kilogram (kg)
ton (short)	0.9072	megagram (Mg)
ton per square mile (ton/mi^2)	0.3503	megagram per square kilo-meter (Mg/km^2)
ton per acre (ton/acre)	224.2	megagram per square kilometer (Mg/km^2)
micromho (μmho)	1.00	microsiemen (μS)

Temperature in degrees Farenheit (°F) can be converted to degrees Celcius (°C) as follows:

$$°F = 1.8°C + 32$$

SURACE-WATER QUALITY IN PEQUEA CREEK BASIN PENNSYLVANIA, 1977-79

By Janice R. Ward

ABSTRACT

A study of the Pequea Creek basin was conducted by the U.S. Geological Survey, in cooperation with the Susquehanna River Basin Commission and the U.S. Environmental Protection Agency, from February 1977 through March 1979. Pequea Creek drains an intensive agricultural area of 154 square miles in southeastern Pennsylvania and enters the Susquehanna River 30 miles north of the Chesapeake Bay.

The objective of the study was to (1) determine the total discharges of suspended sediment, nitrogen, and phosphorus from Pequea Creek basin; (2) determine the variations in stormflow and base-flow discharges of suspended sediment, nitrogen, phosphorus, organic carbon, and pesticides from seven sub-basins; and (3) evaluate the factors that affect the occurrence and transport of suspended sediment, nitrogen, and phosphorus.

The study included measurement of streamflow and collection of water and bottom-material samples from seven sites in the basin during selected base flows and storms. Water samples were collected daily at a site near the mouth of Pequea Creek. Samples were analyzed for suspended sediment, nitrogen and phosphorus species, organic carbon, and pesticides. Some ground-water samples also were collected and analyzed for nitrate.

Annual yields measured from the basin during the study period were 1,950 ton/mi^2 (ton per square mile) for suspended sediment, 13.8 ton/mi^2 for total nitrogen, and 1.8 ton/mi^2 for phosphorus. These yields are five times higher than any previously measured in the Susquehanna River basin. The discharges of all constitutents monitored increased with increasing flow, indicating that a large amount of material in the basin is available for transport to streams during storms. The large yields of nitrogen and phosphorus are probably caused by the intensive agriculture in the basin coupled with large applications of fertilizer and manure to farm fields. Chemical analyses of rainfall samples indicate that precipitation was not a significant source of nitrogen and phosphorus.

Excluding nitrate, all constituents measured were transported mainly during storms. Nitrate concentrations during base flow were as high as 10 milligrams per liter as N--the U.S. Environmental Protection Agency standard for domestic water supplies. Ground water sampled from farm wells had nitrate concentrations up to 28 milligrams per liter as N.

The largest concentrations of herbicides detected in Pequea basin were for 2,4-D, atrazine, and simazine. The maximum concentrations observed during storms were 1.2, 24, and 5.4 micrograms per liter, respectively. Of these

pesticides, only 2,4-D has a U.S. Environmental Protection Agency standard for domestic water supplies; the concentrations observed were well below the standard of 100 micrograms per liter.

The insecticides chlordane and DDT had mean concentrations of 0.02 and 0.01 micrograms per liter, respectively. These concentrations are two times and 10 times greater than the U.S. Environmental Protection Agency limits recommended for freshwater aquatic life. Lindane, PCB, and heptachlor slightly exceeded maximum limits during storms.

INTRODUCTION

The U.S. Geological Survey investigated the transport of suspended sediment, nitrogen, phosphorus, and pesticides in Pequea Creek--a tributary to the Susquehanna River in southeastern Pennsylvania. The study was done in cooperation with the Susquehanna River Basin Commission and was supported in part by the Chesapeake Bay Program of the U.S. Environmental Protection Agency (USEPA).

Pequea Creek basin is an intensively farmed area of 154 mi^2 in south-central Lancaster County. The boroughs of Strasburg and Quarryville are the only municipalities in the basin. Other than agriculture, tourism is the major industry. Because of the lack of point sources, the basin is ideally suited for demonstrating the effects of agricultural nonpoint sources. Agriculture, geology, and soils of the basin are typical of those in the lower Susquehanna River basin, which has been identified (Clark and others, 1973, 1974) as a major contributor of nutrients and suspended sediment to the upper Chesapeake Bay.

Purpose and Scope

This report describes the results of a study in Pequea Creek basin to (1) determine the total discharges of suspended sediment, nitrogen, and phosphorus from Pequea Creek basin; (2) determine variations of suspended sediment, nitrogen, phosphorus, organic carbon, and pesticides in stormflow and base-flow discharges from seven subbasins; and (3) evaluate the factors that affect the occurrence and transport of suspended sediment, nitrogen, and phosphorus.

Chemical discharges were monitored continuously at a site near the mouth of the basin. Rainfall and stream discharges were measured and sampled for analysis at seven sites during selected base flows and storms. Some groundwater samples also were collected and analyzed for nitrate. Land uses in the basin were mapped from aerial photographs taken in 1978.

This report includes data collected from February 1977 through March 1979. Results of data collected during 1977 also were presented in an interim report (Ward and Eckhardt, 1979).

Acknowledgments

Land-use data were provided by the USEPA Environmental Photographic Interpretation Center. Technical support of the project and assistance in

site location and land-use practices were provided by the Lancaster County Soil Conservation District. Field assistance by personnel of the Susquehanna River Basin Commission, Robert J. Bielo, Executive Director, is gratefully acknowledged.

BASIN CHARACTERISTICS

Physiography and Geology

Pequea Creek lies in a 28-mile long, narrow basin in the southern part of the Conestoga Valley--a section of the Appalachian Piedmont physiographic province that is underlain by carbonate and shale rocks (fig. 1). The 154-mi^2 basin originates in the Welsh Mountains near the Lancaster-Chester County line. Pequea Creek flows about 60 miles to the Susquehanna River, 5 miles upstream of Holtwood Dam. The average slope of Pequea Creek is 2.3 percent.

The basin is underlain principally by limestone and dolomite of Ordovician and Cambrian age; average elevations are from 400 to 500 feet above sea level. The northeastern border is underlain by quartzite, schist, and gneiss of Cambrian and Precambrian age. Some schist of early Paleozoic and Precambrian age underlies the southern border of the basin.

Soils

Most soils in the basin are silt loams and are derived from underlying bedrock, except for bottomland soils that were formed by alluvial deposition. The soils belong primarily to the Conestoga-Hollinger, Duffield-Hagerstown, and Chester-Glenelg associations. They are generally deep, well-drained, productive, and have high moisture-retention capacities (U.S. Department of Agriculture, 1959). Soils are commonly classified as moderately eroded throughout the basin, although scattered instances of severe erosion are present. Slopes are usually less than 15 percent.

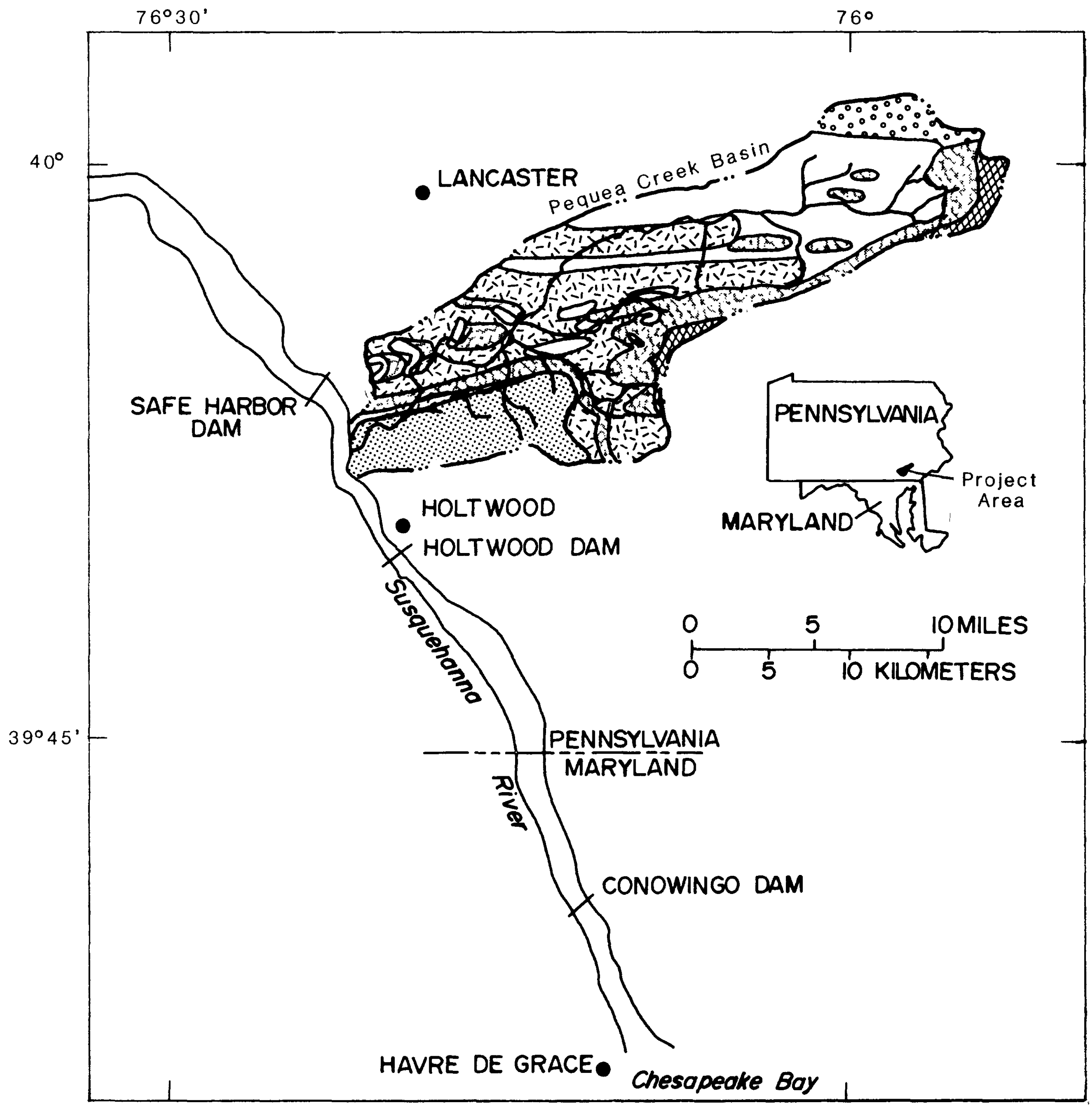
Climate

The climate is a modified-continental type. Annual rainfall averages about 37 inches at the National Weather Service station at Holtwood (table 1). The maximum monthly rainfall during the study was 8.11 inches in January 1979, and the minimum monthly rainfall was 0.60 inches in February 1978. During the study period, annual rainfall was 2 to 4 inches above the average measured at Holtwood from 1951 to 1974.

The growing season generally extends from May until October and averages 160 days. Approximately 50 percent of the yearly precipitation falls from May through September. Subfreezing temperatures typically occur during December, January, and February. Average snow accumulations from November to April range from a maximum of 9 inches in March to a minimum of 0.3 inch in April.

Land Use

Land use was interpreted from aerial photographs of the basin taken twice in 1978 by the USEPA Environmental Photographic Interpretation Center. For



EXPLANATION

Conestoga Limestone } ORDOVICIAN AND CAMBRIAN

Ledger, Dolomite, Kinzers Formation, and Vintage Dolomite, undivided

Antietam and Harper Formations, undivided } CAMBRIAN

Chickies Quartzite

Wissahickon Formation — LOWER PALEOZOIC AND PRECAMBRIAN

Metamorphic and igneous rocks of Honeybrook uplift — PRECAMBRIAN

Basin boundary

Figure 1.--Location of study area and general geology.

Table 1.--Monthly precipitation

Site	Year	Precipitation, in inches												
		J	F	M	A	M	J	J	A	S	O	N	D	Total
Pequea basin Theissen distribution (based on 4 recording raingages)	1977	--	--	4.64	4.60	0.78	4.89	2.74	6.93	2.90	3.56	4.66	4.68	40.08
	1978	7.69	0.60	4.36	1.55	4.78	5.67	4.06	4.44	1.52	1.85	1.93	4.59	43.04
	1979	8.11	3.50	1.71	--	--	--	--	--	--	--	--	--	13.32
National Weather Service Station at Holtwood	1977	--	--	4.45	3.90	.70	3.10	3.84	3.00	3.37	3.78	4.10	5.65	35.89
	1978	7.66	.58	4.80	1.61	4.98	3.69	5.09	3.72	1.01	1.14	2.17	5.01	41.46
	1979	7.14	4.63	1.69	--	--	--	--	--	--	--	--	--	13.46
Holtwood Monthly Average	1951-74	2.33	2.48	3.09	3.20	2.96	3.78	3.69	3.65	3.39	2.32	3.30	3.15	37.34

the purposes of this report, 1978 land use was used to represent that of the entire study period. Land uses of the seven subbasins that were sampled during the study (table 2) are shown in table 3. Several of the land-use categories in table 3 are explained below. Small grains areas include land on which the following crops were raised: hay, alfalfa, wheat, barley, and straw. Farmstead areas include farmhouses, barns and associated buildings, lawns, and small vegetable plots. Stable areas are included in pasture. Fallow areas include land that was plowed but not planted in the July and September photographs. Idle areas are any lands not specifically agricultural, forested, or residential, such as meadows or forest clearings. Residential areas include houses, lawns, driveways, vegetable plots, and small vacant lots. Industrial areas include motels, quarries, and tourist attractions. Only measureable areas of highways, ponds, and streams, such as four-lane highways and the mainstem of the Pequea Creek, are delineated.

The data in table 3 show that subbasin 6 contains the largest percentage of agricultural area (96 percent), and subbasin 2 contains the least percentage of agricultural area (32 percent). Except for these two subbasins, agricultural use ranges from 65 to 76 percent of subbasin land use. Pasture is 11 to 16 percent, small grains 22 to 25 percent, row crops 29 to 37 percent, and farmsteads 2 to 3 percent of agricultural land use. Corn is the predominant row crop, constituting about 92 percent of all row crops. Forest is the other major land use, constituting from 14 to 24 percent of total land use. Idle and residential uses comprise most of the remaining area.

Usage of fertilizers and pesticides has been estimated for each subbasin based on land-use information, surveys of local farmers, and estimates of usage from the Lancaster County Soil Conservation District (table 4). Except for subbasin 4, the amounts of nitrogen and phosphorus applied as manure are higher than amounts applied as commercial fertilizer.

The applications shown in table 4 are calculated for total application divided by total cropland area. These numbers do not indicate, for example, the nitrogen applied to a corn field. In Pequea Creek basin, total nitrogen applied to a corn field as commercial fertilizer and manure would probably be 150-200 lb/acre, and atrazine applied to a corn field would be 1.5 lb/acre.

SAMPLING NETWORK AND DATA COLLECTION AND ANALYSIS

The sampling network consisted of one site equipped with a continuous stage recorder and automatic sampler, six sites equipped with either wire-weight or staff gages for intermittent stage readings, and four continuously recording rain gages (fig. 2).

Subbasin 1--Pequea Creek at Martic Forge--is about 3 miles upstream from the mouth of Pequea Creek and has a drainage area of 148 mi^2. The other six subbasins range in size from 0.66 to 72.9 mi^2 (table 2). Subbasin 2 is on a small tributary to Pequea Creek draining mostly forest. Subbasins 3 and 4 are in the Big Beaver Creek basin, the largest tributary to Pequea Creek. Big Beaver Creek drains a mixture of forested, agricultural, and residential land. Subbasin 6 is on a tributary to Pequea Creek that drains an area of intense

Table 2.--Subbasins and drainage areas

USGS Identification number	Subbasin number	Subbasin name	Drainage area (mi^2)
01576787	1	Pequea Creek at Martic Forge	148
01576786	2	Pequea Creek tributary near Martic Forge	1.56
	2A	Raingage	
01576777	3	Big Beaver Creek at Refton	20.4
01576775	4	Big Beaver Creek tributary at New Providence	.66
	4A	Raingage	
01576769	5	Pequea Creek at Strasburg	72.9
01576768	6	Pequea Creek tributary near Strasburg	1.63
	6A	Raingage	
01576763	7	Pequea Creek at New Milltown	42.8
	7A	Raingage	

Table 3.--Land use in each subbasin

Land use	Percentage of subbasin area						
	1	2	3	4	5	6	7
Agriculture	68.4	32.1	65.8	76.3	73.7	96.1	67.4
Pasture	11.8	1.1	10.9	15.8	12.8	13.7	12.6
Small Grains	22.2	7.6	22.9	21.7	24.5	33.5	23
Row Crops	31.4	22.4	29.3	36.6	33.5	44.7	29.1
Corn	29	21.9	26.6	33.9	31.2	39.3	26.9
Tobacco	1.5	.5	1.7	1.2	1.6	.9	1.2
Soybeans	.4	0	.9	0	.3	0	.4
Vegetables	.5	0	.1	.4	.4	4.5	.3
Orchard	.4	0	.3	.4	.2	0	.3
Farmsteads	2.5	1	2.4	2.6	2.6	4.2	2.3
Fallow	.1	0	0	.3	.1	0	.1
Idle	3.3	1	5.1	4	1.8	0	2.4
Residential	7.6	4.5	9.3	5.6	5.6	.7	5.4
Industrial	.7	.3	1.4	.2	.8	2.9	.6
Railway	.2	0	.6	0	.2	0	0
Highway	.1	0	0	0	0	0	0
Forest	19.6	62.1	17.6	14.3	17.9	.4	24.5
Ponds and Streams	.1	0	.2	0	.1	0	.1

Table 4.--Estimated usage of nitrogen, phosphorus, and triazine herbicides

Application in lb/acre of cropland	Subbasin 1	2	3	4	5	6	7
Nitrogen applied as:							
Commercial fertilizer	30.0	30.0	30.0	70.0	65.0	40.0	60.0
Manure	95	40	100	40	95	100	90
Phosphorus applied as:							
Commercial fertilizer	35	20	30	65	30	35	30
Manure	75	30	80	25	75	70	75
Triazine herbicides	.6	.4	.6	.6	.5	.9	.6

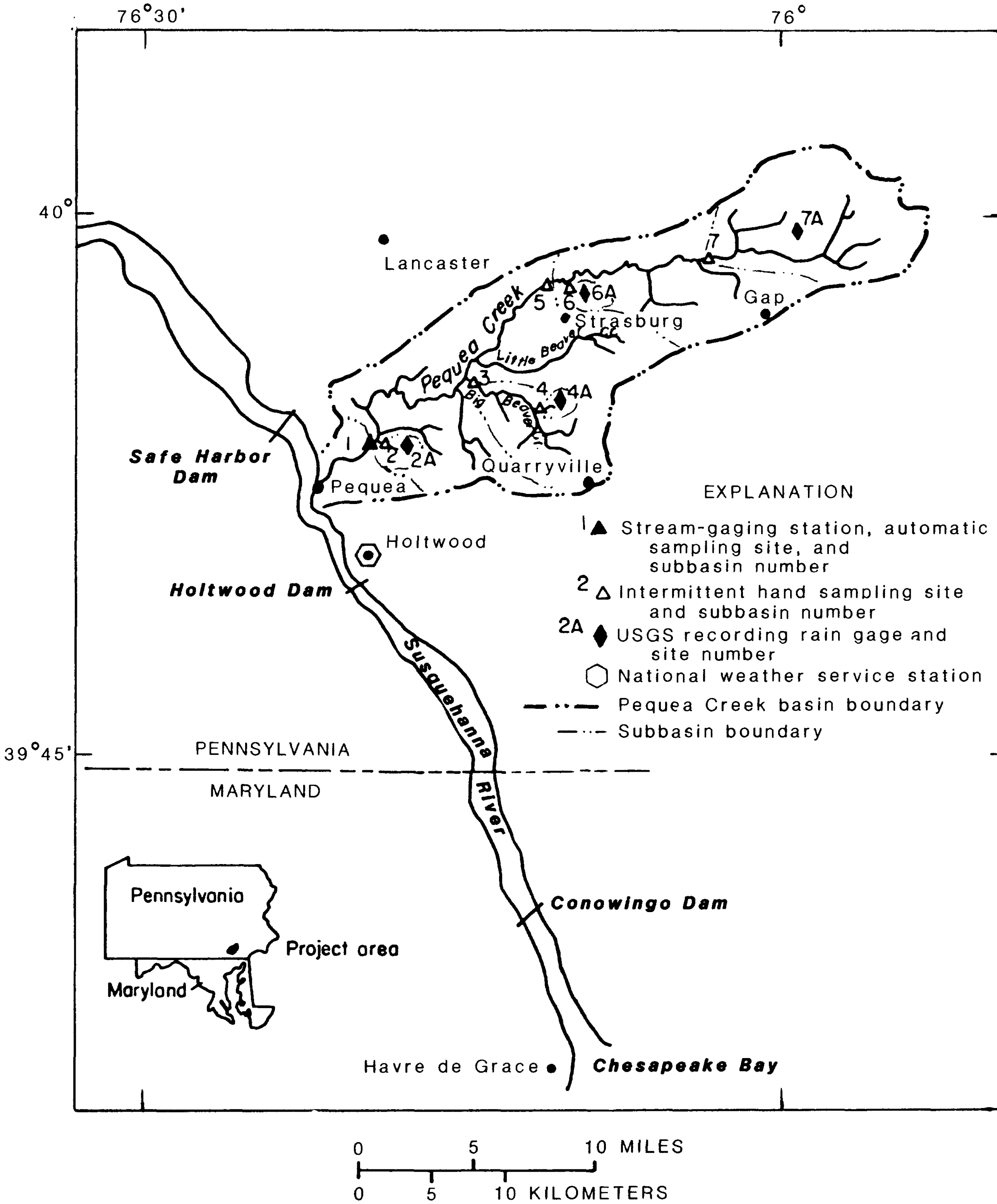


Figure 2.--Data-collection sites.

agriculture. Subbasins 5 and 7 are on Pequea Creek about midway and one-third of the way, respectively, from the headwaters to the mouth. Rain gages were located in subbasins 2, 4, 6, and 7 to provide coverage throughout the basin.

Hydrographs of stream stage at subbasin 1 were converted to discharge using a stage-discharge relationship defined by stage and discharge measurements made at various stages (Carter and Davidian, 1965). An automatic PS-69 sampler collected water samples for analysis twice daily during periods of steady or slowly changing stage, and hourly during storms. The sampler was modified to keep the samples chilled to 4°C in a thermostatically controlled water bath. Samples during each storm and each 36-hour base-flow period were selected, based on the gage height and estimated sediment concentration, and analyzed for:

Suspended sediment	Total Kjeldahl nitrogen
Suspended organic carbon	Total nitrite-plus-nitrate nitrogen
Dissolved organic carbon	Total phosphorus

Water samples also were collected from the stream cross section manually using discharge-incremented and depth-integrated techniques described by Guy and Norman (1970) and Culbertson and Feltz (1972) at various flows. The manually collected samples were compared with those collected automatically to determine if the automatic samples were representative of the water quality in the stream cross section.

Continuous records were developed from these data for the above constituents. Daily mean streamflows and constituent concentrations and discharges were computed from February 24, 1977, to March 4, 1979.

In addition, 18 base flows and streamflow during 8 storms were sampled manually during the study at all 7 subbasin sites. The stormflow samples were collected on the rise, peak, and recession of the hydrograph until the stage stabilized near its prestorm level. Measurements of stage at each subbasin were made as often as necessary to define the storm hydrograph. Because of a lack of stable controls at some subbasins, a new rating was developed from three to five measurements taken during each storm sampled.

A part of each water sample collected during the selected base flows and storms was filtered using a 0.45 micron filter. The whole and filtered samples were analyzed for:

Nitrate nitrogen	Orthophosphate
Nitrite nitrogen	Phosphorus
Ammonia nitrogen	Organic carbon
Organic nitrogen	

Suspended-sediment and particle-size samples were analyzed in the U.S. Geological Survey's laboratory in Harrisburg by methods described by Guy (1969). The other determinations were done in the Survey's Central Laboratory at Doraville, Georgia. Inorganic chemical constituents were determined by methods described by Skougstad and others (1979), and organic carbon was determined by methods described by USEPA (1974). Samples shipped to Doraville were chilled to 4°C from the time of collection to analysis.

Discharge and chemical concentrations in storms were plotted against time for the duration of each storm sampled at each subbasin. A storm was defined as beginning with the first rise in stage and ending when the change in streamflow was less than 10 percent in 1 hour, or until the stage approached its prestorm level.

The total storm discharge of each chemical constituent was computed for each site from the chemographs using streamflow and concentration integration techniques described by Porterfield (1972). The total storm discharges were then subdivided into base-flow (BF) discharges and runoff (RO) discharges. The BF concentration was assumed to be the midpoint of the linear extension from the concentration of each constituent at the start of the storm to its concentration at the end of the storm. The RO concentration for the storm was then calculated using the following equations:

$$D_s = \overline{C}_s \times \overline{Q}_s \times .0027 \times \frac{HR_s}{24} \qquad \text{(eq. 1)}$$

$$D_{BF} = \overline{C}_{BF} \times \overline{Q}_{BF} \times .0027 \times \frac{HR_s}{24} \qquad \text{(eq. 2)}$$

$$D_{RO} = D_s - D_{BF} \qquad \text{(eq. 3)}$$

$$\overline{C_{RO}} = \frac{D_{RO}}{.0027 \times \overline{Q}_{RO}} \times \frac{24}{HR_s} \qquad \text{(eq. 4)}$$

Where D = total discharge, in tons;

$\overline{C}$ = mean concentration, in mg/L;

$\overline{Q}$ = mean flow, in ft^3/s;

HR_s = duration of storm, in hours;

s = stormflow

BF = base flow and

RO = runoff

D_s and D_{BF} were first calculated from $\overline{C}$, $\overline{Q}$, and HR_s (fig. 3) using equations 1 and 2. D_{RO} was then calculated from equation 3, and $\overline{C_{RO}}$ was calculated from equation 4 using D_{RO}, $\overline{Q_{RO}}$, and HR_s from figure 3. The RO and BF contributions of daily flows and concentrations were used to determine seasonal effects of climate and land use on water quality.

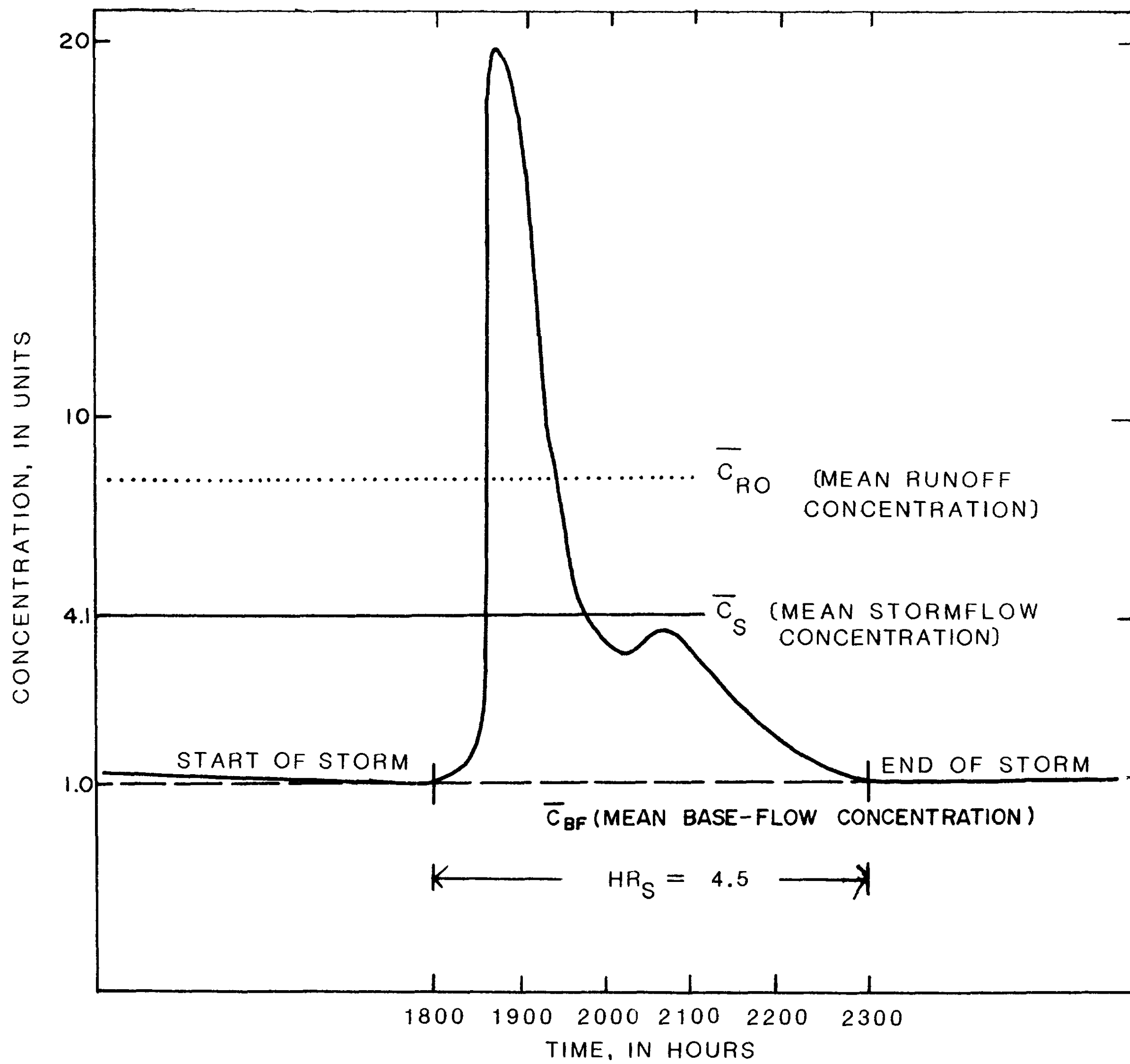


Figure 3.--Graphical method used to compute mean runoff and stormflow concentrations.

Base-flow and stormflow samples also were analyzed for selected organics. Water samples were collected at base and peak flows of selected storms at the subbasin sites to compare concentrations during different seasons. Most of the organics analyzed were pesticides in the organochlorine and organophosphate insecticide and chlorophenoxy-acid and triazine herbicide groups (table 5). Samples were collected by sediment and nutrient sampling techniques modified for pesticide handling as described by Goerlitz and Brown (1972) and the Federal Working Group on Pesticide Management (1974).

Water sampling for selected base flows was supplemented with bottom-material sampling, done five times seasonally at each subbasin. Samples were collected at 8 to 10 sites across the streambed, composited, and then subsampled by techniques described by the Federal Working Group on Pesticide Management (1974). Bottom samples were analyzed for the nutrients and pesticides described above (except triazine herbicides) and for particle size.

During selected storms, precipitation samples were collected using a 9-inch glass funnel and sample bottle stored inside a portable ice-filled chest. The ice chest and sampler were placed outside at the start of the storm and retrieved at the end of the storm. Precipitation samples were analyzed for specific conductance, pH, alkalinity, and acidity in the field. Laboratory analyses included dissolved ammonia nitrogen, nitrite-plus-nitrate nitrogen, Kjeldahl nitrogen, phosphorus, sodium, potassium, calcium, magnesium, chloride, and sulfate.

Selected wells and springs in subbasins 3, 5, and 6 were sampled. The samples were collected from faucets after flushing pipes and chilled for nitrate analysis. These data supplemented base-flow nitrate concentrations at the three subbasins.

WATER QUALITY IN PEQUEA CREEK BASIN

Streamflow

The mean streamflow at subbasin 1 from February 24, 1977 to March 5, 1979, was 282 ft^3/s, or about 1.9 $(ft^3/s)/mi^2$. Flow ranged from 63 to 12,500 ft^3/s or about 0.4 to 84 $(ft^3/s)/mi^2$. Storms contributed 34 percent of the flow from the basin. Although there are no long-term records for gaging stations in similar basins for comparison, rainfall records show that the period sampled was wetter than the long-term average.

Suspended Sediment, Nutrients, and Organic Carbon

Daily Mean Concentrations and Discharges

Daily mean concentrations and discharges of suspended sediment, organic carbon, nitrogen, and phosphorus (table 6) were calculated for the study period from data collected at subbasin 1. The stream bottom could be seen only rarely at depths of 2 to 3 feet during base flow because of turbidity caused principally by agricultural activities upstream. The mean concentration of suspended sediment was 173 mg/L during base flow and 2,710 mg/L during storms. About 89 percent of the suspended sediment was discharged

Table 5.--Organic compounds monitored

Insecticides	
Organochlorines	**Organophosphates**
Aldrin	Diazinon
Chlordane	Ethion
DDD	Malathion
DDE	Methyl parathion
DDT	Methyl trithion
Dieldrin	Ethyl Parathion
Endosulfan	Ethyl Trithion
Endrin	
Heptachlor	
Heptachlor epoxide	
Lindane	
Methoxychlor	
Mirex	
Perthane	
Toxaphene	

Herbicides	
Chlorinated phenoxy-acid	**Triazines**
2,4-D	Ametryne
2,4-DP	Atratone
2,4,5-T	Atrazine
Silvex	Cyanazine
	Cyprazine
	Prometone
	Prometryne
	Propazine
	Simazine
	Simetone
	Simetryne
	Alachlor 1/

Other organics
PCB
PCN

1/ Belongs to anide and anilide class of herbicides

Table 6.--Summary of daily mean suspended-sediment, nitrogen, phosphorus, and organic carbon data

Constituent	Total yield [(ton/mi^2)/yr]	Percentage of total discharge contributed by storms	Daily mean concentration (mg/L)		Daily mean discharge (tons)		Daily mean concentration (mg/L) during	
			Mean	Range	Mean	Range	Base flow	Storms
Streamflow	-	34	-	-	282 (ft^3/s)	68-5,310 (ft^3/s)	-	-
Suspended sediment	1,950	89	1,040	3.0-6,630	792	.66-67,900	173	2,710
Nitrite-plus-nitrate Nitrogen as N	7.6	14	4.2	0.85-7.6	3.2	.77-24	5.3	1.7
Kjeldahl nitrogen as N	6.2	84	3.3	<.01-25	2.5	0-260	.80	8.1
Phosphorus as P	1.8	85	1.0	.01-5.8	.77	.01-47	.22	2.4
Dissolved organic carbon	12.9	50	6.8	.2-30	5.2	.20-222	5.2	10
Suspended organic carbon	14.7	82	7.9	<.1-84	6.0	0-444	2.1	19

from the basin during storms. Annual yields of suspended sediment from the basin averaged 1,950 ton/mi^2 or 3 ton/acre. Only data from short-term construction areas in the lower Susquehanna River basin have been reported greater than 350 (ton/mi^2)/yr. Previous studies indicate that 13.9 (ton/acre)/yr of soil for nonconservation treated cropland are eroded in Pequea Creek basin. The sediment-delivery ratio (the amount of sediment transported by a stream divided by the total gross erosion) was calculated to be 8.5 percent (Dumper and Kirkaldie, 1967). Using this delivery ratio, an average of 35 (ton/acre)/yr of soil were eroded in the basin during the study period.

The majority of suspended organic carbon, phosphorus, and Kjeldahl (ammonia + organic) nitrogen was discharged during storms. Mean storm concentrations for these constituents were 19, 2.4, and 8.1 mg/L, respectively. Base-flow concentrations averaged 2.1, 0.22, and 0.80 mg/L. Mean daily concentrations were as high as 84, 5.8, and 25 mg/L.

Half of the dissolved organic carbon was discharged during storms. The mean base-flow concentration was 5.2 mg/L, and the mean storm concentration was 10 mg/L. Dissolved organic carbon was 47 percent of the total organic carbon discharge, almost equal to the suspended organic carbon discharge.

Only nitrite-plus-nitrate nitrogen was discharged mostly during base flow. The mean base-flow concentration was 5.3 mg/L, compared to a mean storm concentration of 1.7 mg/L. Mean daily concentrations ranged from 0.85 to 7.6 mg/L. Nitrite-plus-nitrate nitrogen made up 55 percent of the total nitrogen discharged from the basin. The drinking water standard of 10 mg/L as N was not exceeded at this site.

Double-mass curves for the constituents discussed above are shown in figure 4. A positive change in slope indicates a higher proportion of constituent discharge was being carried for the same increase in flow. This is usually indicative of an increase in transport because of seasonal factors. Suspended sediment, suspended organic carbon, and phosphorus showed similar seasonal trends. The highest discharges of these constituents occurred during the winter months and May. Frozen soils and lack of vegetative cover usually caused more runoff for a given storm in winter than during the rest of the year. Suspended-sediment discharge was usually higher during the winter because higher flows occurred more frequently, scouring stream bottoms and eroding stream banks that were unstable from freezing and thawing. The increase shown in May was probably due to spring plowing and planting. Soils were generally more susceptible to erosion at this time than during any other time in the growing season. Because suspended organic carbon and phosphorus are closely associated with sediment, these constituents increased correspondingly with increased sediment discharges.

Kjeldahl nitrogen shows a limited seasonal trend which was also probably related to its association with sediment. The most dramatic increase occurred in January 1979. Decreased rates of nitrification during the winter coupled with manure spreading could have caused an increase in Kjeldahl nitrogen.

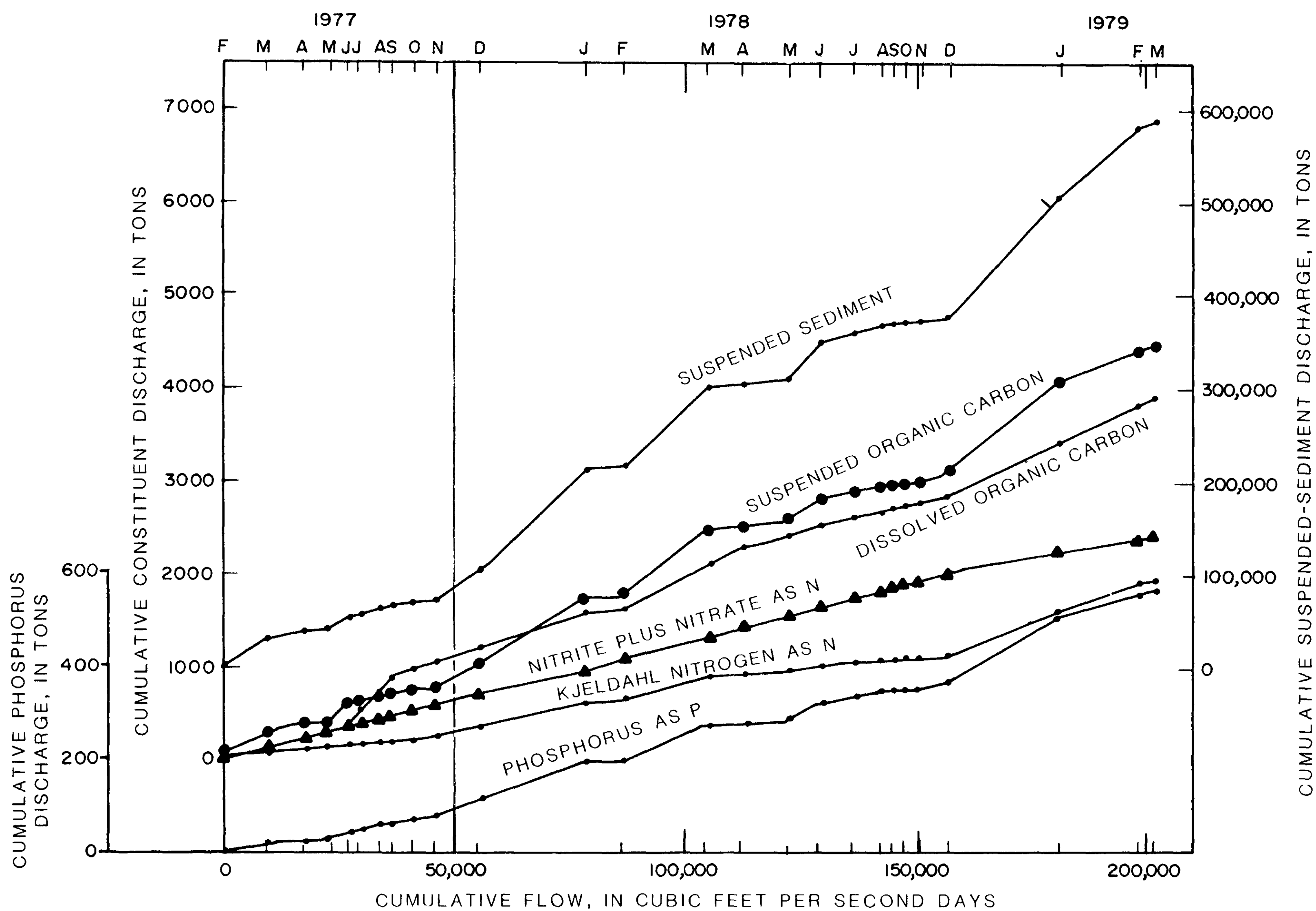


Figure 4.--Double-mass curves for Pequea Creek basin.

Dissolved organic carbon showed a marked increase in the summer of 1977, but this increase was not observed in 1978. There was a small increase during winter periods of 1977 and 1978. Decomposition of material left over from harvesting should have been relatively slow because of cold winter temperatures. The increase seen during the winter may have been related to manure spreading.

Nitrite-plus-nitrate nitrogen showed virtually no seasonal changes during base flows or storms even though large quantities of fertilizer were applied in spring. This indicates that the material available for transport from the basin was sufficient to maintain the high levels observed, despite seasonal increases or decreases in application rates.

Multiple-regression analyses of the constituents monitored daily were run using the Statistical Analysis System (Barr and others, 1976) to determine how much of the nitrogen and phosphorous variations could be explained by variations in streamflow and suspended sediment. The most successful regressions (table 7) used the equation $y = ax + b$.

All of the constituents shown in table 7 except specific conductance increased with increasing streamfow and suspended-sediment. Specific conductance decreased with increasing streamflow as expected because of dilution by precipitation during storms. Only about half of the variance in specific conductance was explained by streamflow. About 90 percent of the variance of suspended-sediment discharge was explained by streamflow. Most of the variances of suspended organic carbon, Kjeldahl nitrogen, and phosphorus were explained by suspended-sediment. These relationships are expected because the majority of sediment and these constituents were contributed during storms.

Nitrite-plus-nitrate nitrogen, however, was contributed by ground-water discharge during base flow and by runoff during storms. Streamflow and specific conductance explained about 60 percent of the variance in nitrite and nitrate nitrogen.

More precise predictions of suspended sediment, nitrogen, phosphorus, and organic carbon must include additional variables such as precipitation, runoff, antecedent flow, soil moisture, season, days elapsed since plowing or planting, fertilizer and manure applications, reaction rates, and time of travel.

Precipitation Inputs

Rainfall samples were collected for chemical analysis during five of the storms sampled at subbasin 6. Median concentrations in the samples (table 8) are similar to data collected at 179 sites in the north-central and northeastern United States (Peters and Bonelli, 1982). Rainfall generally has low pH, acidity, and specific conductance. Calcium is consistently the largest cation concentration, followed by magnesium, potassium, and sodium. Calcium, potassium, sodium, and magnesium are contributed, in part, by soil dust. The chloride-to-sodium ratio of 1:7 is nearly equivalent to that of seawater (Gambell and Fisher, 1966), which is the main source of these ions in precipitation.

Table 7.--Regression analyses of daily data for subbasin 1

x	y	Range of x values used to develop relation	Number of samples	a	b	Standard error	R^2
Streamflow (ft^3/s)	Specific conductance (µS/cm at 25°C)	68-5,310	471	-0.0570	373	0.0025	0.52
Streamflow (ft^3/s)	Suspended-sediment discharge (tons)	68-5,310	737	8.093	-1,408	.1132	.87
Streamflow (ft^3/s)	Nitrite-plus-nitrate nitrogen discharge (tons)	68-5,310	737	.0034	2.249	.0006	.59
Specific conductance (µS/cm at 25°C)	Nitrite-plus-nitrate nitrogen concentration (mg/L)	83-445	471	.0178	-.782	.0001	.65
Suspended-sediment concentration (mg/L)	Suspended organic carbon concentration (mg/L)	3-6,630	468	.0067	.935	.0002	.77
Suspended-sediment concentration (mg/L)	Kjeldahl nitrogen concentration (mg/L)	3-6,630	471	.0027	.478	.0001	.77
Suspended-sediment concentration (mg/L)	Phosphorus concentration (mg/L)	3-6,630	471	.0009	.131	.0000	.87

Table 8.--Summary of rainfall quality

Constituent	Concentration, in mg/L except as noted		
	Maximum	Minimum	Median
Total rainfall (inches)	1.35	0.40	0.72
pH (units)	4.70	3.90	4.25
Specific conductance (μS/cm at 25°C)	54	23	40
Acidity as $CaCO_3$	10	0	5.5
Alkalinity as $CaCO_3$	0	0	0
Calcium	1.3	.4	.9
Magnesium	.9	.1	.4
Sodium	.5	.2	.3
Potassium	.7	<.1	.4
Sulfate	5.0	1.7	4.3
Chloride	1.1	.1	.5
Nitrate nitrogen as N	.52	.25	.36
Nitrite nitrogen as N	.01	.01	.01
Ammonia nitrogen as N	1.4	.29	.39
Organic nitrogen as N	.80	.07	.21
Total nitrogen as N	1.9	.77	1.1
Orthophosphate as P	.10	<.01	.01
Total phosphorus as P	.13	<.01	.01

Sulfate, nitrate, and phosphorus are probably contributed from a variety of sources including gaseous compounds (natural and anthropogenic) from industries and soil dust. Nitrate and ammonia comprise nearly equal portions of the total nitrogen. Almost all of the phosphorus is orthophosphate.

Average yearly inputs of acidity, major cations and anions, nitrogen, and phosphorus to the basin from precipitation are estimated in table 9. Data from Fisher (1968) indicate that nitrate and sulfate loads are relatively constant from year to year. Annual variations of cations, however, are generally dependent on localized soil dust conditions.

Comparison of Precipitation Inputs to Basin Discharges

The amount of rainfall and discharges of Kjeldahl nitrogen, nitrite-plus-nitrate nitrogen, and phosphorus are compared to total discharge from Pequea Creek subbasin 1 (table 10). The average contribution from rainfall for the 25-month period March 1977 through March 1979 shows that evapotranspiration and ground-water storage account for 46 percent of total precipitation. Precipitation contains 33 percent of the Kjeldahl nitrogen discharge and less than 2 percent of the phosphorus discharge. Precipitation accounts for only 17 percent of the total nitrogen and less than 0.1 percent of the total phosphorus which is added to the basin as fertilizer and manure. Precipitation inputs are minor if compared to inputs of fertilizer and manure to the basin.

Pesticides

Daily Mean Concentrations and Discharges, Spring 1978

In addition to the constituents discussed above, daily mean concentrations and discharges of selected pesticides were calculated from data collected May 3 to June 7, 1978. Detectable pesticide concentrations are shown in table 11. None of the herbicides exceeded USEPA drinking-water standards (U.S. Environmental Protection Agency, 1976). No drinking-water standards have been set by USEPA for atrazine and simazine, the most abundant of the pesticides analyzed. The suggested USEPA maximum concentrations for fresh-water aquatic life were exceeded for chlordane (0.01 μg/L), DDT (0.001 μg/L), lindane (0.01 μg/L), and PCBs (0.001 μg/L). Most of the insecticides detected were present in small quantities, and were probably associated with suspended sediment.

Concentrations of atrazine, simazine, and 2,4-D were the highest of the herbicides analyzed. They usually peaked simultaneously, but were not directly related to flow and suspended-sediment concentration. The herbicide concentrations always increased during storms, but the extent of the increase was affected by the amount of time since herbicide application as well as by storm size (fig. 5). Herbicide peaks occurred on May 10 near planting time without a large corresponding increase in flow or suspended sediment. Peak herbicide concentrations during storms soon after planting were much larger than those during the rest of the year.

Table 9.--Average yearly input of acidity, major cations and anions, nitrogen, and phosphorus by precipitation to Pequea Creek basin

Constituent	Average yearly input, in tons, except as noted
Total precipitation (inches)	46.29
Acidity as $CaCO_3$	2,730
Calcium	447
Magnesium	199
Sodium	149
Potassium	199
Sulfate	2,140
Chloride	297
Nitrate nitrogen as N	178
Nitrite nitrogen as N	4.9
Ammonia nitrogen as N	194
Organic nitrogen as N	104
Total nitrogen as N	547
Orthophosphate as P	4.9
Total phosphorus as P	4.9

Table 10.--Comparison of input from precipitation and input from fertilizer and manure to total discharge, March 1977 through March 1979

[A dash indicates not measured]

	Total, in tons, except as noted			Percentage of precipitation contributed to:	
	Discharge measured at subbasin 1	Input from precipitation	Input from fertilizer and manure	Total discharge measured at subbasin 1	Total input from fertilizer and manure
Streamflow (ft^3/s-d)	207,000	383,000	--	185	--
Kjeldahl Nitrogen as N	1,890	621	--	33	--
Nitrite-plus-nitrate nitrogen as N	2,340	382	--	16	--
Total nitrogen as N	4,230	1,000	5,920	24	17
Total phosphorus as P	567	10.3	5,070	1.8	< 0.1

Table 11.--Summary of detectable daily pesticide concentrations

	Daily mean concentration µg/L)			Daily mean discharge (lb/day)		
Pesticide	Median	Mean	Range	Median	Mean	Range
Atrazine	0.27	0.64	0.01-2.9	0.29	1.11	0.009-7.4
Simazine	.20	.35	.05-1.8	.26	.51	.11-2.3
Propazine	<.1	<.1	<.1 -.10	0	0	0-.008
Chlordane	<.1	<.1	<.1 -.10	0	.008	0-.18
DDD	<.01	<.01	<.01-.01	0	0	0-.002
DDT	<.01	<.01	<.01-.01	0	0	0-.02
Diazinon	<.01	<.01	<.01-.01	0	0	0-.002
Dieldrin	<.01	<.01	<.01-.01	0	.002	0-.06
Lindane	<.01	<.01	<.01-.01	0	.001	0-.004
PCB	<.1	<.1	<.1 -.05	0	.011	0-.24
Silvex	<.01	<.01	<.01-.10	0	.003	0-.11
2,4-D	.03	.05	<.01-.29	.03	.10	0-1.1
2,4,5-T	<.01	<.01	<.01-.01	0	.002	0-.04

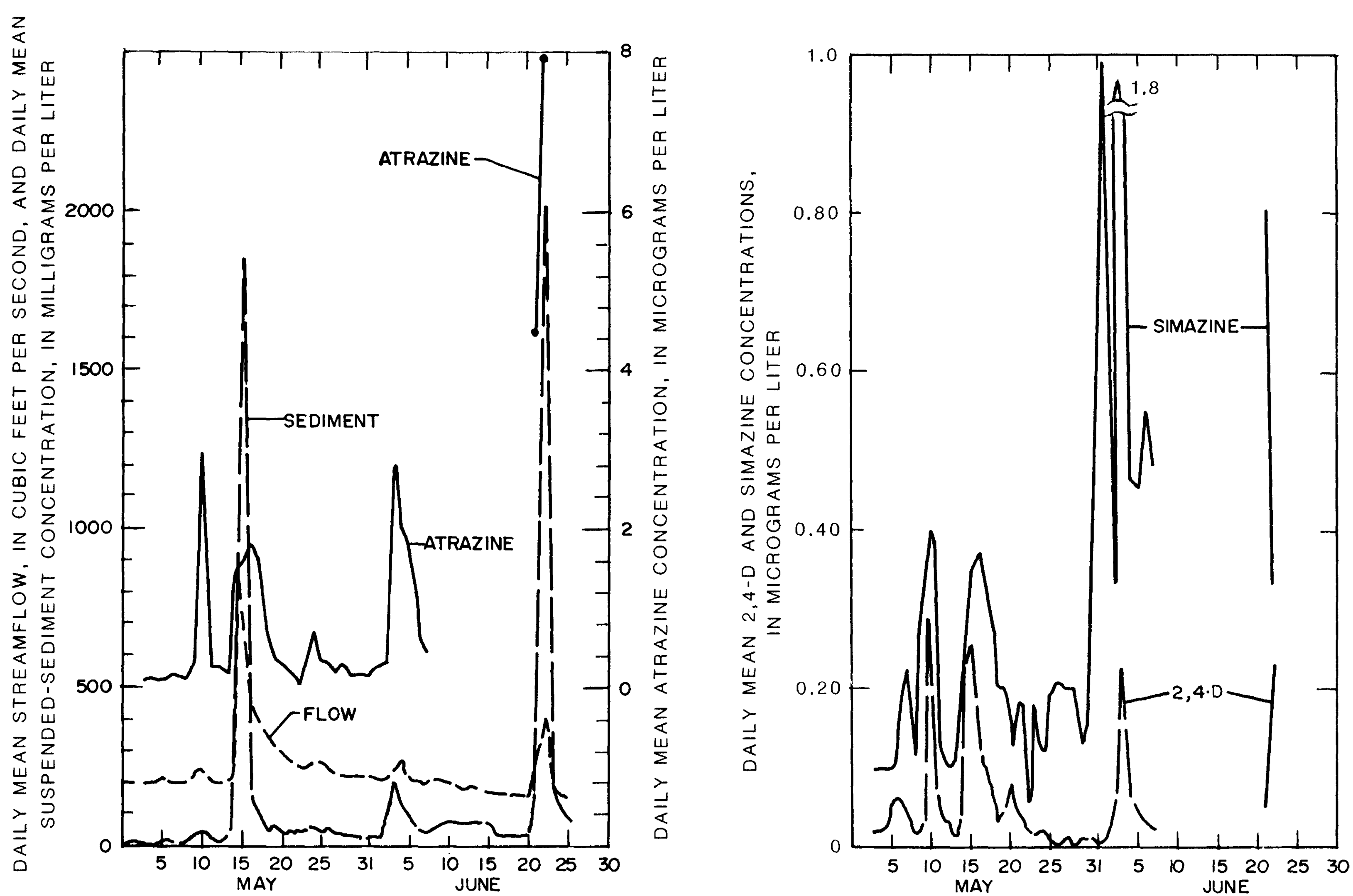


Figure 5.--Comparisons of herbicide concentrations to flow and suspended sediment at subbasin 1, May and June 1978.

Comparison of Atrazine in Pequea Creek Basin and Susquehanna River Basin at Harrisburg

Atrazine was the most commonly detected herbicide in the basin. A comparison of atrazine data collected concurrently from Pequea Creek and from Susquehanna River at Harrisburg (fig. 6) showed that the yields from both streams are similar. The data from Harrisburg were collected by the Survey for the USEPA Annapolis Field Office and were reported by Austin, Jr. and others (1978). Because of poor horizontal mixing in the Susquehanna River at Harrisburg, water samples were collected at three cross sections in the east and west channels of the Susquehanna River, and the samples from each channel were composited for analysis. The west channel contained about twice as much atrazine as the east channel, probably because there is more agriculture in the western basins above Harrisburg.

The yield of atrazine for Pequea Creek corresponds closely to the yield of the Susquehanna River. The largest variations occurred during June and were probably due to storms in the Pequea basin that did not affect the Susquehanna River basin at Harrisburg. During the period May 3 to June 8, 1978, atrazine yields were 0.28 and 0.16 lb/mi^2 at Pequea Creek and Susquehanna River at Harrisburg, respectively.

Concentrations of atrazine in Pequea Creek are much higher than those in the Susquehanna River (fig. 7). Mean daily concentrations in Pequea Creek were as high as 7.8 µg/L. The west channel of the Susquehanna River reached only 2.15 µg/L during the same period.

Generally, discharges of atrazine from Pequea Creek (154 mi^2) are only about 1 percent of those from the Susquehanna River at Harrisburg (24,100 mi^2). However, because of the longer travel time necessary for storm runoff in the Susquehanna River basin to reach the lower river, storm runoff from Pequea Creek enters the Susquehanna River first. This means that discharges from Pequea Creek frequently can have a greater effect than would be expected. An example of such a storm is June 22, 1978 (figs. 5 and 6). Calculations indicate that the atrazine discharge of the Susquehanna River was increased by 25 percent because of that storm, and the concentration increased from 0.44 to 0.62 µg/L.

Base Flow

Diel variations of water temperature, pH, dissolved oxygen, and specific conductance were monitored several times during base flow using a NERA 41/ water-quality monitor. Measurements of these constituents were made every 30 minutes to determine the variance in water quality during base flow which can

1/ The use of a brand name in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

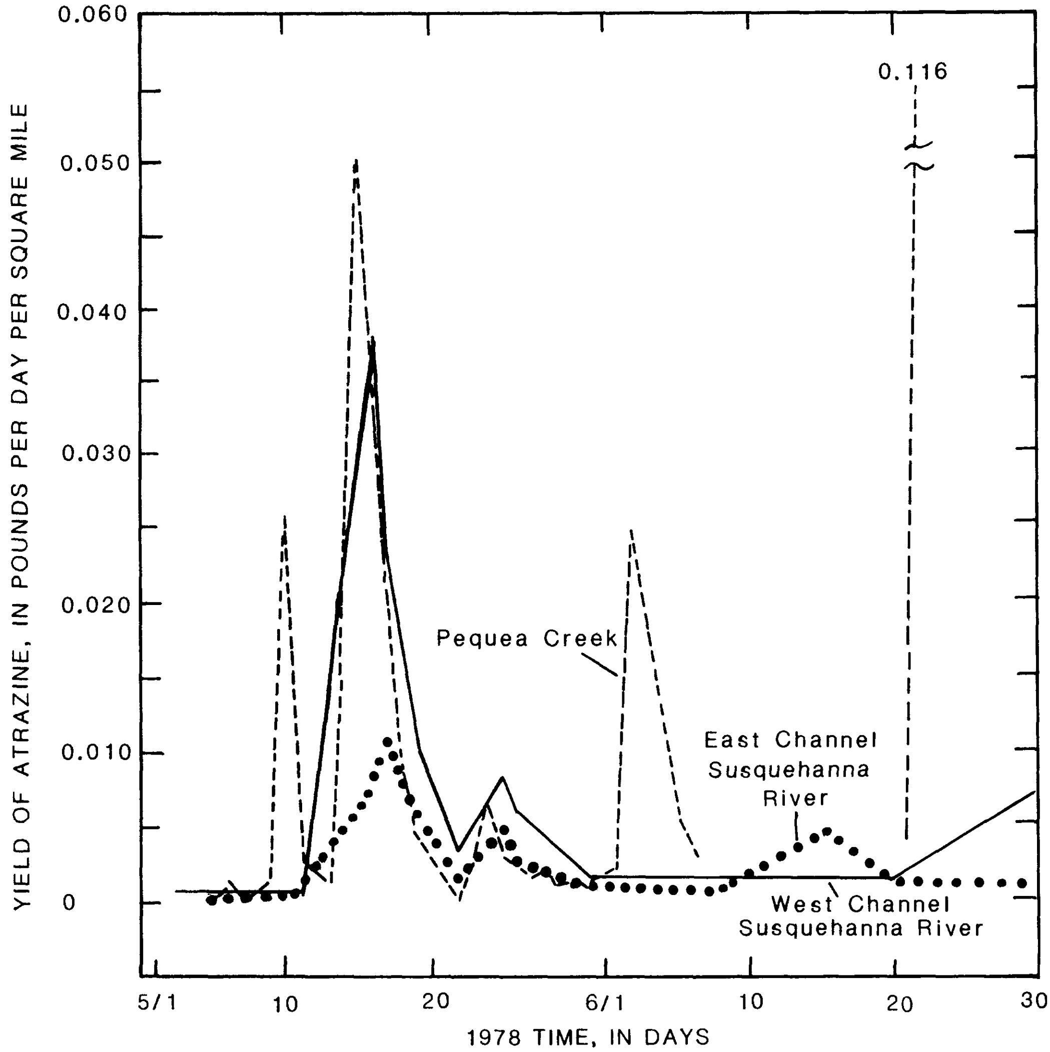


Figure 6.--Comparison of atrazine yields measured concurrently in Pequea Creek basin and Susquehanna River at Harrisburg.

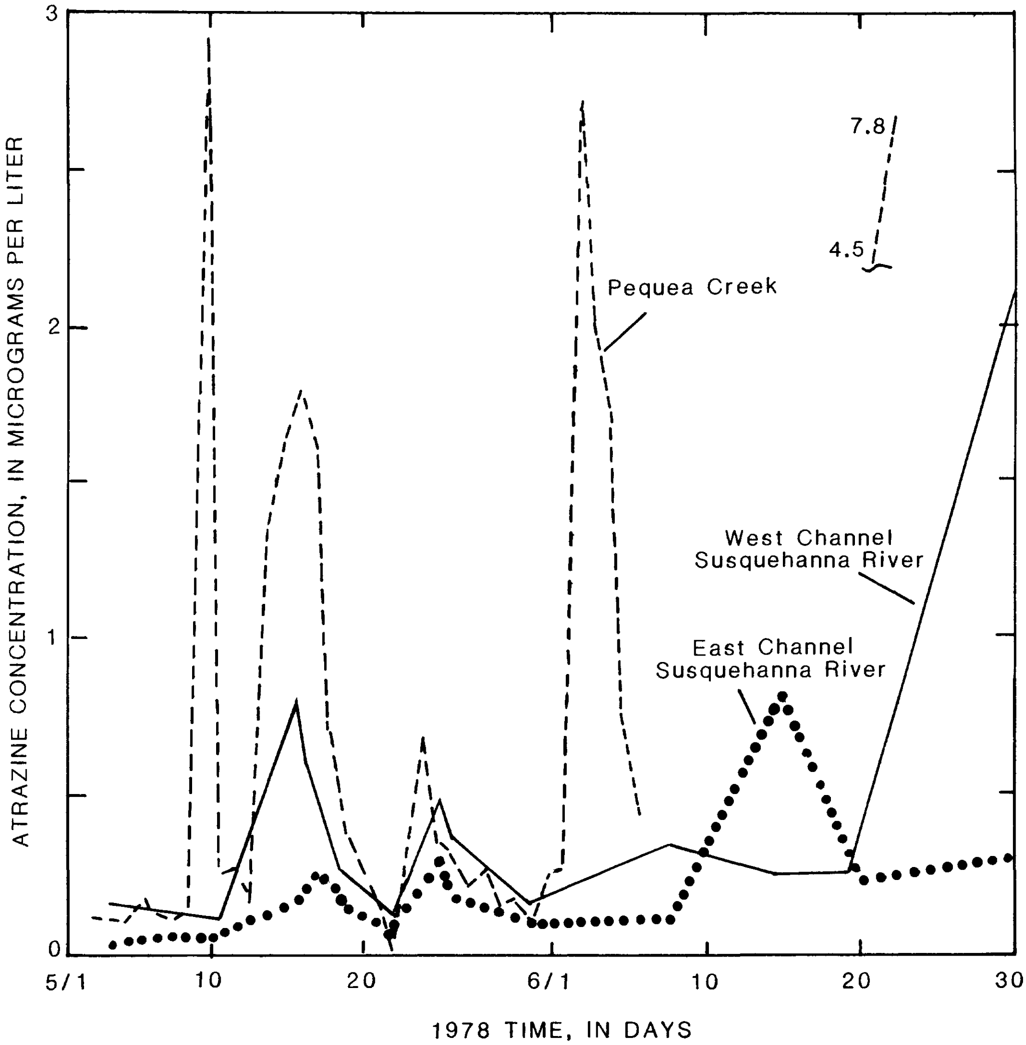


Figure 7.--Comparison of atrazine concentrations measured concurrently in Pequea Creek basin and Susquehanna River at Harrisburg.

be expected due to photosynthesis and respiration. Subbasin 6 and Pequea Creek are extremely alkaline streams because of underlying carbonates. Figure 8 illustrates variations observed during two monitoring periods at subbasin 6, July 22-23, 1977 and June 15-16, 1978. Similar variations were measured in Pequea Creek at subbasin 1.

Water temperature and pH peaked at about 1600 hours and declined to a low at about 0700 hours each day. Dissolved oxygen and percent saturation peaked between 1400 and 1500 hours and declined to a low at 2100 hours. Specific conductance declined slightly at 1800 hours each day.

During daylight hours, water temperature rose in response to sunlight. Sunlight triggered photosynthesis by algae and plants, which increased dissolved oxygen concentrations. The stream became supersaturated with dissolved oxygen by early afternoon. The peak in pH that accompanied the peak in dissolved oxygen reflected a shift in the carbonate-bicarbonate equilibrium caused by the uptake of carbon dioxide during photosynthesis. Conversely, at night, respiration used oxygen and produced carbon dioxide, reversing the equilibrium shift. The decrease in specific conductance that occurred each day concurrently with the peak in pH and dissolved oxygen was a result of the carbonate equilibrium shift because of photosynthesis.

In addition to the automated diel measurements of water temperature, pH, dissolved oxygen, and specific conductance, from 10 to 17 water samples were collected manually at each subbasin during base flow for chemical analyses. Subbasin 1 had additional samples collected automatically during base flows. Results are summarized in table 12. There was little correlation between water quality and season or land use during base flow. Variations in the concentrations of selected constituents during base flows are shown in figures 9-12. Suspended-sediment concentrations are not shown because they were consistently low at all sites.

Specific conductance (fig. 9) showed the largest variance among sites during base flow. The lowest conductances were found at subbasin 2, which had the highest percentage of forested area and is underlain by schist. The elevated mean specific-conductance values at subbasin 1, 5, and 6 were probably attributed to cations dissolved from underlying limestone rather than by land applications of fertilizer and manure.

Average base-flow concentrations of dissolved nitrite-plus-nitrate nitrogen were from 2 to 6 mg/L as N except for subbasin 6, which was 7.1 mg/L as N. Nitrite-plus-nitrate nitrogen concentrations at subbasin 6 may have been elevated because of higher applications of manure and fertilizer in the basin.

Nitrate samples were collected from wells and springs of differing depths used for domestic water supplies and for dairy cattle in subbasins 3, 5, and 6 from July 1977 to October 1978. Of 40 samples collected, the average nitrate nitrogen concentration was 11.6 mg/L as N. Wells used for water supply to barns had nitrate nitrogen concentrations of 16 mg/L as N compared to 10.6 mg/L nitrate nitrogen as N in wells and springs for homes. The average nitrate nitrogen concentration from springs was 6.8 mg/L as N. These data

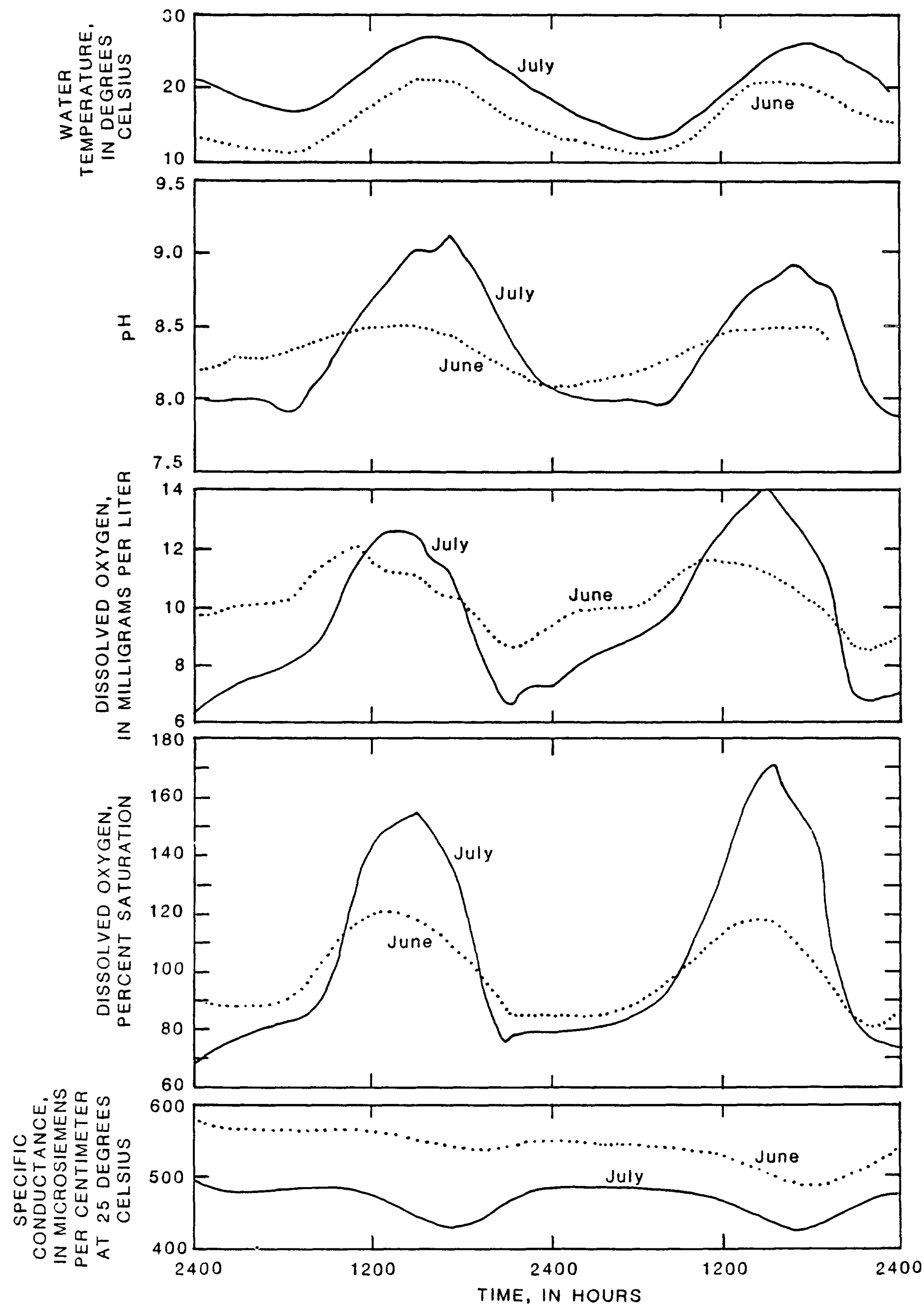


Figure 8.--Diel variations of water temperature, pH, dissolved oxygen, and specific conductance at subbasin 6, July 22-23, 1977 and June 15-16, 1978.

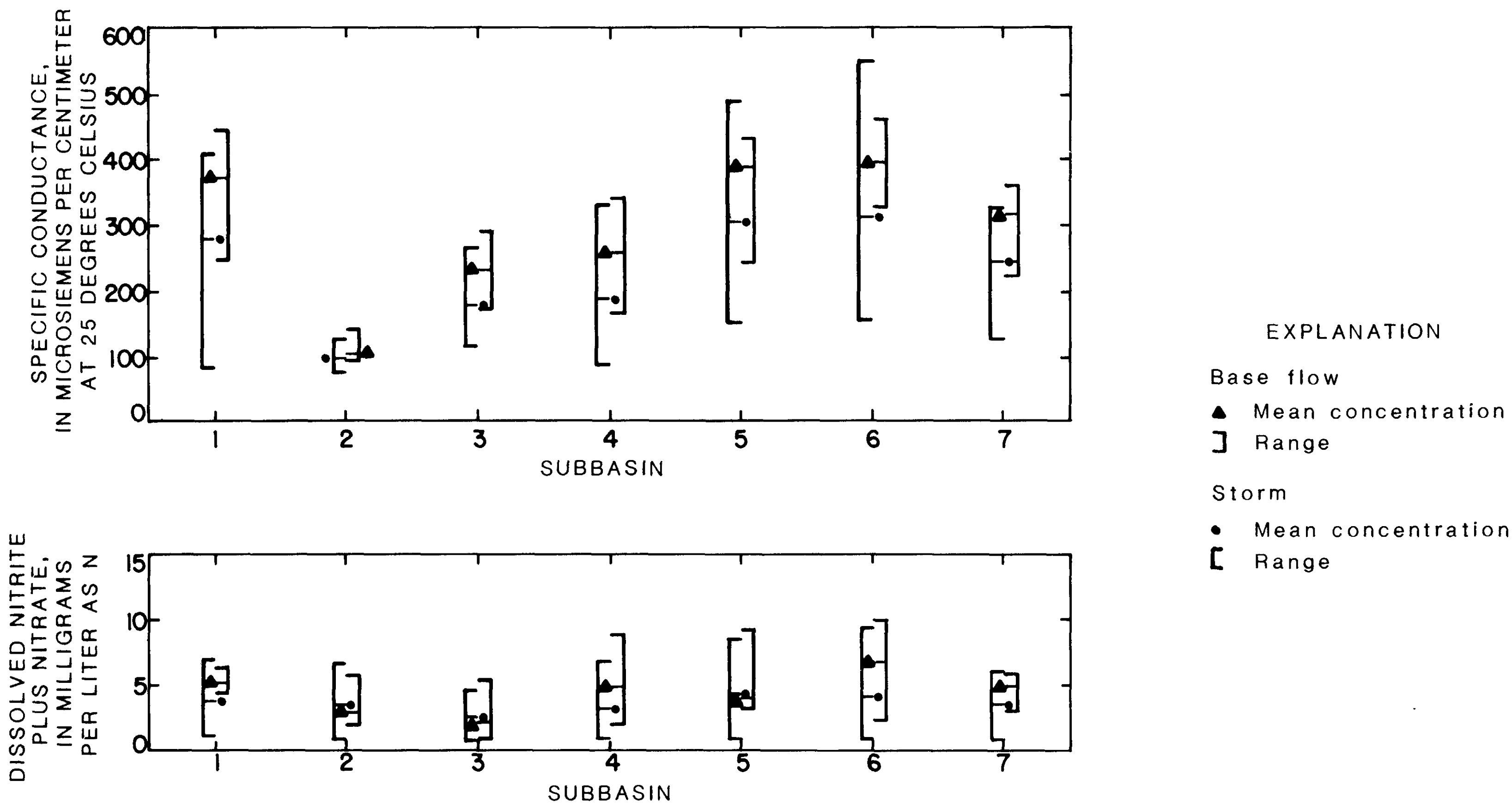


Figure 9.--Ranges of specific conductance and dissolved nitrite plus nitrate nitrogen during base flows and storms.

Table 12.--Summary of base-flow analyses

Site 1, Pequea Creek at Martic Forge							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	365	156	69.6	65.0	424	359	4,849
Turbidity (JTU)	341	18.0	16.7	3.0	205	202	281
Specific Conductance (μS/cm at 25°C)	234	374	22	254	445	191	469
Nitrogen, Total (mg/L as N)	264	6.3	1.1	4.1	16	12	1
Nitrogen, Organic Total (mg/L as N)	13	1.2	1.7	<.01	6.6	6.6	3
Nitrogen, Organic Dissolved (mg/L as N)	11	.46	.35	<.01	1.2	1.2	0
Nitrogen, Ammonia Dissolved (mg/L as N)	11	.25	.46	<.01	1.6	1.6	0
Nitrogen, Ammonia Total (mg/L as N)	13	.29	.57	.01	2.1	2.1	0
Nitrogen, Nitrite Dissolved (mg/L as N)	11	.05	.04	.01	.12	.11	0
Nitrogen, Nitrite Total (mg/L as N)	13	.06	.05	.02	.17	.15	0
Nitrogen, Nitrate Dissolved (mg/L as N)	11	5.2	.82	4.3	6.6	2.3	1
Nitrogen, Nitrate Total (mg/L as N)	13	5.5	.94	4.3	6.8	2.5	1
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	11	.71	.66	.09	2.2	2.1	0
Nitrogen, Ammonia + Organic Total (mg/L as N)	265	1.0	1.3	.05	13	13	2
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	277	5.4	.98	1.2	7.6	6.4	1
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	11	5.2	.80	4.3	6.6	2.3	1
Phosphorus, Total (mg/L as P)	278	.32	.44	.01	3.4	3.4	0
Phosphorus, Dissolved (mg/L as P)	10	.16	.15	.01	.53	.52	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	11	.11	.13	<.01	.44	.44	0
Carbon, Organic Dissolved (mg/L as C)	267	3.6	3.2	.2	23	23	10
Carbon, Organic Suspended (mg/L as C)	255	.9	.7	.1	7.0	6.9	0
Phosphorus, Orthophosphate Total (mg/L as P)	18	.15	.13	<.01	.54	.54	0
Sediment, Suspended (mg/L)	360	42	32.2	2.0	301	299	1,036
Sediment Discharge, Suspended (ton/d)	359	18.0	20.1	.45	241	240	404
Perthane, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Simetryne, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Simazine, Total (μg/L)	19	.2	.3	0	1.1	1.1	0
Prometone, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Prometryne, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Aldrin, Total (μg/L)	19	<.01	0	<.01	.01	.01	0
Lindane, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Chlordane, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
DDD, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
DDE, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
DDT, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Dieldrin, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Endosulfan, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Endrin, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Ethion, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Toxaphene, Total (μg/L)	19	<1	0	<1	<1	0	0
Heptachlor, Total (μg/L)	19	<.01	0	<.01	.01	.01	0
Heptachlor Epoxide, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
PCB, Total (μg/L)	19	<.1	<.1	0	.2	.2	0
Malathion, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Parathion, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Diazinon, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Methyl Parathion, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Atrazine, Total (μg/L)	19	.20	.18	<.01	.80	.80	0
2,4-D, Total (μg/L)	19	.01	.01	<.01	.05	.05	0
2,4,5-T, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Silvex, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Methyl Trithion, Total (μg/L)	19	<.01	0	<.01	<.01	0	0
Ametryne, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Atratone, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Cyanazine, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Cyprazine, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Simetone, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Alachlor, Total (μg/L)	19	<.1	0	<.1	<.1	0	0
Trithion, Total (μg/L)	19	<.01	0	<.01	<.01	0	0

Table 12.--Summary of base-flow analyses--(Continued)

Site 2, Pequea Creek Tributary near Martic Forge							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	16	2.4	2.6	0.50	11.0	10.5	7
Turbidity (JTU)	15	3.0	1.1	1.0	4.5	3.5	1
Specific Conductance (µS/cm at 25°C)	11	113	16	97	148	51	262
Nitrogen, Total (mg/L as N)	10	5.8	4.1	3.0	17	14	17.0
Nitrogen, Organic Total (mg/L as N)	9	1.3	1.2	.31	4.0	3.7	1
Nitrogen, Organic Dissolved (mg/L as N)	10	.48	.37	.11	1.4	1.3	0
Nitrogen, Ammonia Dissolved (mg/L as N)	10	.11	.15	<.01	.34	.34	0
Nitrogen, Ammonia Total (mg/L as N)	9	.12	.20	<.01	.49	.49	0
Nitrogen, Nitrite Dissolved (mg/L as N)	10	.01	.01	<.01	.02	.02	0
Nitrogen, Nitrite Total (mg/L as N)	10	.02	.03	<.01	.07	.07	0
Nitrogen, Nitrate Dissolved (mg/L as N)	10	2.9	1.2	2.0	5.5	3.5	1
Nitrogen, Nitrate Total (mg/L as N)	10	3.0	1.3	2.0	5.9	3.9	2
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	10	.58	.46	.21	1.7	1.5	0
Nitrogen, Ammonia + Organic Total (mg/L as N)	10	2.8	4.5	.31	15	15	20
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	10	3.1	1.3	2.1	5.9	3.8	2
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	10	2.9	1.2	2.0	5.5	3.5	1
Phosphorus, Total (mg/L as P)	10	.52	.83	.03	2.7	2.7	1
Phosphorus, Dissolved (mg/L as P)	10	.04	.03	.01	.08	.07	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	10	.02	.02	<.01	.05	.05	0
Carbon, Organic Dissolved (mg/L as C)	16	4.4	3.4	.4	12	1.6	12
Carbon, Organic Suspended (mg/L as C)	13	.5	.3	.1	1.0	.9	0
Phosphorus, Orthophosphate Total (mg/L as P)	10	.06	.07	<.01	.19	.19	0
Sediment, Suspended (mg/L)	16	9.9	8.3	3.0	37	34	70
Sediment Discharge, Suspended (ton/d)	16	.08	.12	.01	.53	.52	0
Perthane, Total (µg/L)	2	<.1	0	<.1	<.1	0	0
Simetryne, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Simazine, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Prometone, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Prometryne, Totsl (µg/L)	3	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (µg/L)	2	<.1	0	<.1	<.1	0	0
Aldrin, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Lindane, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Chlordane, Total (µg/L)	2	<.1	0	<.1	<.1	0	0
DDD, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
DDE, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
DDT, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Dieldrin, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Endosulfan, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Endrin, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Ethion, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Toxaphene, Total (µg/L)	2	<1	0	<1	<1	0	0
Heptachlor, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
PCB, Total (µg/L)	2	<.1	0	<.1	<.1	0	0
Malathion, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Parathion, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Diazinon, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Methyl Parathion, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Atrazine, Total (µg/L)	3	.13	.11	<.01	.20	.20	0
2,4-D, Total (µg/L)	1	<.01	--	<.01	<.01	0	--
2,4,5-T, Total (µg/L)	1	<.01	--	<.01	<.01	0	--
Silvex, Total (µg/L)	1	<.01	--	<.01	<.01	0	--
Methyl Trithion, Total (µg/L)	1	<.01	--	<.01	<.01	0	--
Ametryne, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Atratone, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Cyanazine, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Cyprazine, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Simetone, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Alachlor, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Trithion, Total (µg/L)	1	0	--	0	0	0	--

Table 12.--Summary of base-flow analyses--(Continued)

Site 3, Big Beaver Creek at Refton							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	16	27.5	21.6	11.0	97.0	86.0	469
Turbidity (JTU)	15	9.9	10.1	2.0	40.0	38.0	101
Specific Conductance (µS/cm at 25°C)	12	244	29	173	290	117	833
Nitrogen, Total (mg/L as N)	13	6.7	3.3	3.2	15	12	11
Nitrogen, Organic Total (mg/L as N)	13	3.8	3.0	.04	9.1	9.1	9
Nitrogen, Organic Dissolved (mg/L as N)	12	.78	.43	.04	1.3	1.3	0
Nitrogen, Ammonia Dissolved (mg/L as N)	12	.40	.30	.03	1.0	.97	0
Nitrogen, Ammonia Total (mg/L as N)	12	.49	.38	.03	1.1	1.1	0
Nitrogen, Nitrite Dissolved (mg/L as N)	12	.04	.03	.01	.10	.09	0
Nitrogen, Nitrite Total (mg/L as N)	12	.07	.04	.01	.15	.14	0
Nitrogen, Nitrate Dissolved (mg/L as N)	12	2.1	1.3	.98	5.5	4.5	2
Nitrogen, Nitrate Total (mg/L as N)	12	2.2	1.2	1.1	5.4	4.3	2
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	12	1.2	.64	.07	2.1	2.0	0
Nitrogen, Ammonia + Organic Total (mg/L as N)	13	4.3	3.1	.02	10	10	10
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	12	2.2	1.2	1.1	5.4	4.3	2
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	12	2.1	1.3	1.0	5.5	4.5	2
Phosphorus, Total (mg/L as P)	13	1.8	1.8	.01	5.6	5.6	3
Phosphorus, Dissolved (mg/L as P)	12	.19	.14	<.01	.54	.54	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	12	.16	.14	<.01	.50	.50	0
Carbon, Organic Dissolved (mg/L as C)	16	5.2	4.5	1.3	16	15	20
Carbon, Organic Suspended (mg/L as C)	15	.8	.9	.2	3.9	3.7	1
Phosphorus, Orthophosphate Total (mg/L as P)	12	.25	.17	<.01	.62	.62	0
Sediment, Suspended (mg/L)	16	30.6	38.8	5.0	164	159	1,510
Sediment Discharge, Suspended (ton/d)	16	4.1	10.5	.15	43	42.8	111
Perthane, Total (µg/L)	2	<.1	0	<.1	<.1	0	0
Simetryne, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Simazine, Total (µg/L)	3	.17	.30	<.1	.52	.52	0
Prometone, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Prometryne, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (µg/L)	2	<.1	0	<.1	<.1	0	0
Aldrin, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Lindane, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Chlordane, Total (µg/L)	2	<.1	0	<.1	<.1	0	0
DDD, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
DDE, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
DDT, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Dieldrin, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Endosulfan, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Endrin, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Ethion, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Toxaphene, Total (µg/L)	2	<1	0	<1	<1	0	0
Heptachlor, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
PCB, Total (µg/L)	2	<.1	0	<.1	<.1	0	0
Malathion, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Parathion, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Diazinon, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Methyl Parathion, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Atrazine, Total (µg/L)	3	.17	.15	<.01	.30	.30	0
2,4-D, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
2,4,5-T, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Silvex, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Methyl Trithion, Total (µg/L)	2	<.01	0	<.01	<.01	0	0
Ametryne, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Atratone, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Cyanazine, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Cyprazine, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Simetone, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Alachlor, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Trithion, Total (µg/L)	2	<.01	0	<.01	<.01	0	0

Table 12.--Summary of base-flow analyses--(Continued)

Site 4, Big Beaver Creek Tributary at New Providence							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	16	0.82	0.74	0.17	3.3	3.1	1
Turbidity (JTU)	15	6.4	8.0	2.3	35.0	32.7	65
Specific Conductance (μS/cm at 25°C)	11	258	47	173	348	175	2,200
Nitrogen, Total (mg/L as N)	14	5.9	1.3	4.3	9.1	4.8	2
Nitrogen, Organic Total (mg/L as N)	14	.74	.68	.06	2.4	2.3	0
Nitrogen, Organic Dissolved (mg/L as N)	14	.31	.29	<.01	1.1	1.1	0
Nitrogen, Ammonia Dissolved (mg/L as N)	14	.10	.13	.01	.44	.43	0
Nitrogen, Ammonia Total (mg/L as N)	14	.14	.14	.01	.48	.47	0
Nitrogen, Nitrite Dissolved (mg/L as N)	14	.03	.03	.01	.11	.10	0
Nitrogen, Nitrite Total (mg/L as N)	14	.04	.03	.01	.12	.11	0
Nitrogen, Nitrate Dissolved (mg/L as N)	14	4.9	1.6	1.9	8.8	6.9	2
Nitrogen, Nitrate Total (mg/L as N)	14	5.0	1.6	1.9	8.9	7.0	2
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	14	.42	.33	.01	1.2	1.2	0
Nitrogen, Ammonia + Organic Total (mg/L as N)	14	.88	.76	.10	2.7	2.6	1
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	14	5.0	1.6	2.0	8.9	6.9	2
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	14	4.9	1.6	1.9	8.8	6.9	2
Phosphorus, Total (mg/L as P)	14	.24	.29	.01	.98	.97	0
Phosphorus, Dissolved (mg/L as P)	14	.05	.06	.01	.21	.20	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	14	.04	.05	<.01	.16	.16	0
Carbon, Organic Dissolved (mg/L as C)	15	5.7	6.4	1.0	23	22	40
Carbon, Organic Suspended (mg/L as C)	14	.6	.7	.1	2.5	2.4	0
Phosphorus, Orthophosphate Total (mg/L as P)	14	.06	.06	<.01	.21	.21	0
Sediment, Suspended (mg/L)	15	14.5	17.9	4.0	74	70	321
Sediment Discharge, Suspended (ton/d)	15	.06	.17	<.01	.66	.66	0
Perthane, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Simetryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Simazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Prometone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Prometryne, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Aldrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Lindane, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Chlordane, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
DDD, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
DDE, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
DDT, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Dieldrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Endosulfan, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Endrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Ethion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Toxaphene, Total (μg/L)	2	<1	0	<1	<1	0	0
Heptachlor, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
PCB, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Malathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Parathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Diazinon, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Methyl Parathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Atrazine, Total (μg/L)	3	.13	.23	<.01	.40	.40	.1
2,4-D, Total (μg/L)	1	<.01	--	<.01	<.01	0	--
2,4,5-T, Total (μg/L)	1	<.01	--	<.01	<.01	0	--
Silvex, Total (μg/L)	1	<.01	--	<.01	<.01	0	--
Methyl Trithion, Total (μg/L)	1	<.01	--	<.01	<.01	0	--
Ametryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Atratone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Cyanazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Cyprazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Simetone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Alachlor, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Trithion, Total (μg/L)	1	<.01	--	<.01	<.01	0	--

Table 12.--Summary of base-flow analyses--(Continued)

Site 5, Pequea Creek at Strasburg							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	17	106	83.2	42.0	390	348	6,930
Turbidity (JTU)	15	36.1	42.4	8.0	180	172	1,800
Specific Conductance (μS/cm at 25°C)	12	389	49	251	429	178	2,400
Nitrogen, Total (mg/L as N)	15	7.5	1.2	6.1	10	3.9	1
Nitrogen, Organic Total (mg/L as N)	15	1.8	1.3	.23	4.7	4.5	2
Nitrogen, Organic Dissolved (mg/L as N)	15	.68	.44	<.01	1.6	1.6	0
Nitrogen, Ammonia Dissolved (mg/L as N)	15	.25	.29	<.01	1.1	1.1	0
Nitrogen, Ammonia Total (mg/L as N)	15	.35	.33	<.01	1.2	1.2	0
Nitrogen, Nitrite Dissolved (mg/L as N)	15	.06	.05	.01	.13	.12	0
Nitrogen, Nitrite Total (mg/L as N)	15	.08	.05	.03	.16	.13	0
Nitrogen, Nitrate Dissolved (mg/L as N)	15	5.2	1.6	3.3	9.3	6.0	3
Nitrogen, Nitrate Total (mg/L as N)	15	5.3	1.6	3.3	9.4	6.1	3
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	15	.94	.58	.07	1.9	1.8	0
Nitrogen, Ammonia + Organic Total (mg/L as N)	15	2.2	1.6	.33	5.6	5.3	3
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	15	5.4	1.6	3.4	9.4	6.0	3
Nitrogen, NO_2 + NO_3 Dissolved (mg/L aa N)	15	5.2	1.6	3.3	9.3	6.0	3
Phosphorus, Total (mg/L as P)	15	.63	.49	.04	1.9	1.9	0
Phosphorus, Dissolved (mg/L as P)	15	.18	.11	.02	.39	.37	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	15	.16	.09	.01	.35	.34	0
Carbon, Organic Dissolved (mg/L as C)	17	5.8	7.6	.7	33	32	59
Carbon, Organic Suspended (mg/L as C)	15	2.5	4.9	.3	20	20	24
Phosphorus, Orthophosphate Total (mg/L as P)	15	.22	.13	.01	.50	.49	0
Sediment, Suspended (mg/L)	17	98	118	12.0	517	505	13,900
Sediment Discharge, Suspended (ton/d)	17	48.8	129	3.2	544	541	16,600
Perthane, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Simetryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Simazine, Total (μg/L)	3	.1	.2	<.1	.30	.30	0
Prometone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Prometryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Aldrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Lindane, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Chlordane, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
DDD, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
DDE, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
DDT, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Dieldrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Endosulfan, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Endrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Ethion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Toxaphene, Total (μg/L)	2	<1	0	<1	<1	0	0
Heptachlor, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
PCB, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Malathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Parathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Diazinon, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Methyl Parathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Atrazine, Total (μg/L)	3	.07	.11	<.01	.20	.20	0
2,4-D, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
2,4,5-T, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Silvex, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Methyl Trithion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Ametryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Atratone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Cyanazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Cyprazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Simetone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Alachlor, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Trithion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0

Table 12.--Summary of base-flow analyses--(Continued)

Site 6, Pequea Creek Tributary near Strasburg							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	16	2.6	2.7	.76	12.0	11.2	7
Turbidity (JTU)	11	18.6	19.2	2.0	70.0	68.0	370
Specific Conductance (μS/cm at 25°C)	12	395	37	327	462	135	1,390
Nitrogen, Total (mg/L as N)	15	8.6	1.1	5.9	10	4.1	1
Nitrogen, Organic Total (mg/L as N)	15	.93	1.6	.05	5.9	5.8	2
Nitrogen, Organic Dissolved (mg/L as N)	15	.46	.52	<.01	1.7	1.7	0
Nitrogen, Ammonia Dissolved (mg/L as N)	15	.28	.46	.01	1.4	1.4	0
Nitrogen, Ammonia Total (mg/L as N)	15	.38	.63	.02	2.0	2.0	0
Nitrogen, Nitrite Dissolved (mg/L as N)	15	.04	.02	.01	.09	.08	0
Nitrogen, Nitrite Total (mg/L as N)	15	.06	.06	.01	.20	.19	0
Nitrogen, Nitrate Dissolved (mg/L as N)	15	7.1	2.2	2.3	10	7.7	5
Nitrogen, Nitrate Total (mg/L as N)	15	7.2	2.3	2.3	10	7.7	5
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	15	.74	.91	.04	2.7	2.7	1
Nitrogen, Ammonia + Organic Total (mg/L as N)	15	1.3	2.0	.09	6.6	6.5	4
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	15	7.3	2.3	2.3	10	7.7	5
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	15	7.1	2.3	2.3	10	7.7	5
Phosphorus, Total (mg/L as P)	15	.43	.88	.01	3.4	3.4	1
Phosphorus, Dissolved (mg/L as P)	15	.17	.22	<.01	.72	.72	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	15	.14	.20	<.01	.67	.67	0
Carbon, Organic Dissolved (mg/L as C)	16	3.9	3.8	.8	15	14	15
Carbon, Organic Suspended (mg/L as C)	13	.8	.5	.1	1.6	1.5	0
Phosphorus, Orthophosphate Total (mg/L as P)	15	.20	.30	<.01	1.1	1.1	0
Sediment, Suspended (mg/L)	16	60	33.2	15.0	140	125	1110
Sediment Discharge, Suspended (ton/d)	15	.45	.67	.03	2.8	2.8	0
Perthane, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Simetryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Simazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Prometone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Prometryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Aldrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Lindane, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Chlordane, Total (μg/L)	2	.05	.07	<.1	.10	.10	0
DDD, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
DDE, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
DDT, Total (μg/L)	2	.04	.05	<.01	.07	.07	0
Dieldrin, Total (μg/L)	2	.03	.04	<.01	.06	.06	0
Endosulfan, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Endrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Ethion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Toxaphene, Total (μg/L)	2	<1	0	<1	<1	0	0
Heptachlor, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (μg/L)	2	<.01	.01	<.01	.01	.01	0
PCB, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Malathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Parathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Diazinon, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Methyl Parathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Atrazine, Total (μg/L)	3	.10	.17	<.01	.30	.30	.03
2,4-D, Total (μg/L)	1	<.01	--	<.01	<.01	0	--
2,4,5-T, Total (μg/L)	1	<.01	--	<.01	<.01	0	--
Silvex, Total (μg/L)	1	<.01	--	<.01	<.01	0	--
Methyl Trithion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Ametryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Atratone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Cyanazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Cyprazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Simetone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Alachlor, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Trithion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0

Table 12.--Summary of base-flow analyses--(Continued)

Site 7, Pequea Creek at New Milltown							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	16	65.9	43.4	28.0	200	172	1,890
Turbidity (JTU)	15	21.4	18.0	8.0	74.0	66.0	322
Specific Conductance (μS/cm at 25°C)	12	321	33	236	360	1.2	1,060
Nitrogen, Total (mg/L as N)	13	6.2	1.2	5.2	10	4.8	2
Nitrogen, Organic Total (mg/L as N)	13	.91	1.2	<.01	4.4	4.4	1
Nitrogen, Organic Dissolved (mg/L as N)	13	.36	.48	<.01	1.9	1.9	0
Nitrogen, Ammonia Dissolved (mg/L as N)	13	.26	.70	.01	2.6	2.6	0
Nitrogen, Ammonia Total (mg/L as N)	13	.33	.86	.02	3.2	3.2	1
Nitrogen, Nitrite Dissolved (mg/L as N)	13	.05	.03	.01	.11	.10	0
Nitrogen, Nitrite Total (mg/L as N)	13	.06	.03	.01	.12	.11	0
Nitrogen, Nitrate Dissolved (mg/L as N)	13	4.8	.75	2.8	6.1	3.3	1
Nitrogen, Nitrate Total (mg/L as N)	13	4.9	.76	2.8	6.1	3.3	1
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	13	.62	1.2	.02	4.5	4.5	1
Nitrogen, Ammonia + Organic Total (mg/L as N)	13	1.2	2.0	.02	7.6	7.6	4
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	13	5.0	.76	2.8	6.1	3.3	1
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	13	4.9	.74	2.8	6.1	3.3	1
Phosphorus, Total (mg/L as P)	13	.19	.25	.02	.96	.94	0
Phosphorus, Dissolved (mg/L as P)	13	.10	.16	.02	.63	.61	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	13	.07	.13	.01	.51	.50	0
Carbon, Organic Dissolved (mg/L as C)	16	4.9	4.4	1.0	18	17	20
Carbon, Organic Suspended (mg/L as C)	14	1.0	.7	.3	3.0	2.7	0
Phosphorus, Orthophosphate Total (mg/L as P)	11	.10	.17	.01	.61	.60	0
Sediment, Suspended (mg/L)	16	60	54.4	23.0	236	213	2,960
Sediment Discharge, Suspended (ton/d)	15	15.0	31.2	2.6	127	124	970
Perthane, Total (μg/L)	1	<.1	--	<.1	<.1	0	--
Simetryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Simazine, Total (μg/L)	3	.12	.10	<.1	.20	.20	0
Prometone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Prometryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Aldrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Lindane, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Chlordane, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
DDD, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
DDE, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
DDT, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Dieldrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Endosulfan, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Endrin, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Ethion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Toxaphene, Total (μg/L)	2	<1	0	<1	<1	0	0
Heptachlor, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
PCB, Total (μg/L)	2	<.1	0	<.1	<.1	0	0
Malathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Parathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Diazinon, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Methyl Parathion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Atrazine, Total (μg/L)	3	.03	.06	<.01	.10	.10	0
2,4-D, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
2,4,5-T, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Silvex, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Methyl Trithion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0
Ametryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Atratone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Cyanazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Cyprazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Simetone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Alachlor, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Trithion, Total (μg/L)	2	<.01	0	<.01	<.01	0	0

indicate that ground water can account for all of the nitrate nitrogen present in streams during base flow.

Ammonia nitrogen (fig. 10) was mostly dissolved during base flow, and the variance between samples did not appear to be related to flow or season. Subbasins 1, 5, 6, and 7 had the highest concentrations of ammonia. Mean concentrations ranged from 0.01 to 0.40 as N. Maximum concentrations reached 2.6 mg/L at subbasin 7, and may have been related to the proximity of pastures to streams.

Variations in nitrogen and phosphorus concentrations during base flow are shown in figure 11. Nitrogen concentrations were composed mainly of nitrite plus nitrate nitrogen. Mean concentrations among sites were similar. Phosphorus consisted mainly of orthophosphate; concentrations were highest at subbasin 3.

Nearly all of the organic carbon in base flow was dissolved (fig. 12). Mean concentrations among sites were similar, and the highest concentrations were found at subbasin 5.

Only two or three water samples were collected at each site for pesticide analyses during base flow. Pesticide concentrations were low (table 15). Ordinarily it is expected that only soluble pesticides are found during base flow because sediment concentrations are low. Atrazine, a triazine herbicide, was detected at every subbasin; simazine, also a triazine herbicide, was found in four subbasins. Mixtures of triazine herbicides are widely used in Pequea basin for controlling broadleaf weeds in corn crops. Samples from subbasin 1 contained small quantities of the insecticides aldrin and heptachlor and the herbicide 2,4-D. Samples from subbasin 6 contained the insecticides chlordane, DDT, dieldrin, and heptachlor epoxide. The mean concentrations of chlordane (0.05 μg/L) and DDT (0.04 μg/L) exceeded the USEPA suggested limits for fresh water aquatic life of 0.01 and 0.001 μg/L, respectively (U. S. Environmental Protection Agency, 1976). The insecticides found at subbasin 6 were also detected in bottom-material samples. These insecticides may still be in use somewhere in the basin, or they may be desorbing from bottom material during base flow.

Chemistry of Bottom Material

Bottom material provides one mechanism for examining long-term water chemistry. The presence of a compound in bottom material indicates that there is or was a source of that compound in the basin. The source or the amount of time since the introduction of the compound to the stream can rarely be determined, because bottom material moves in a cyclic process of transport, settling, and resuspension that depends on the velocity of the stream and the particle size of the bottom material. Base-flow sources of dissolved constituents can influence bottom-material chemistry if the consituents tend to sorb to sediments rather than remaining dissolved, such as phorphorus. The successive inputs of nitrogen, phosphorus, and organic carbon to the stream during storms also impact bottom-material chemistry.

Summaries of the bottom-material analyses are shown in tables 13 and 14. Table 13 lists the maximum, minimum, and median values found at each subbasin

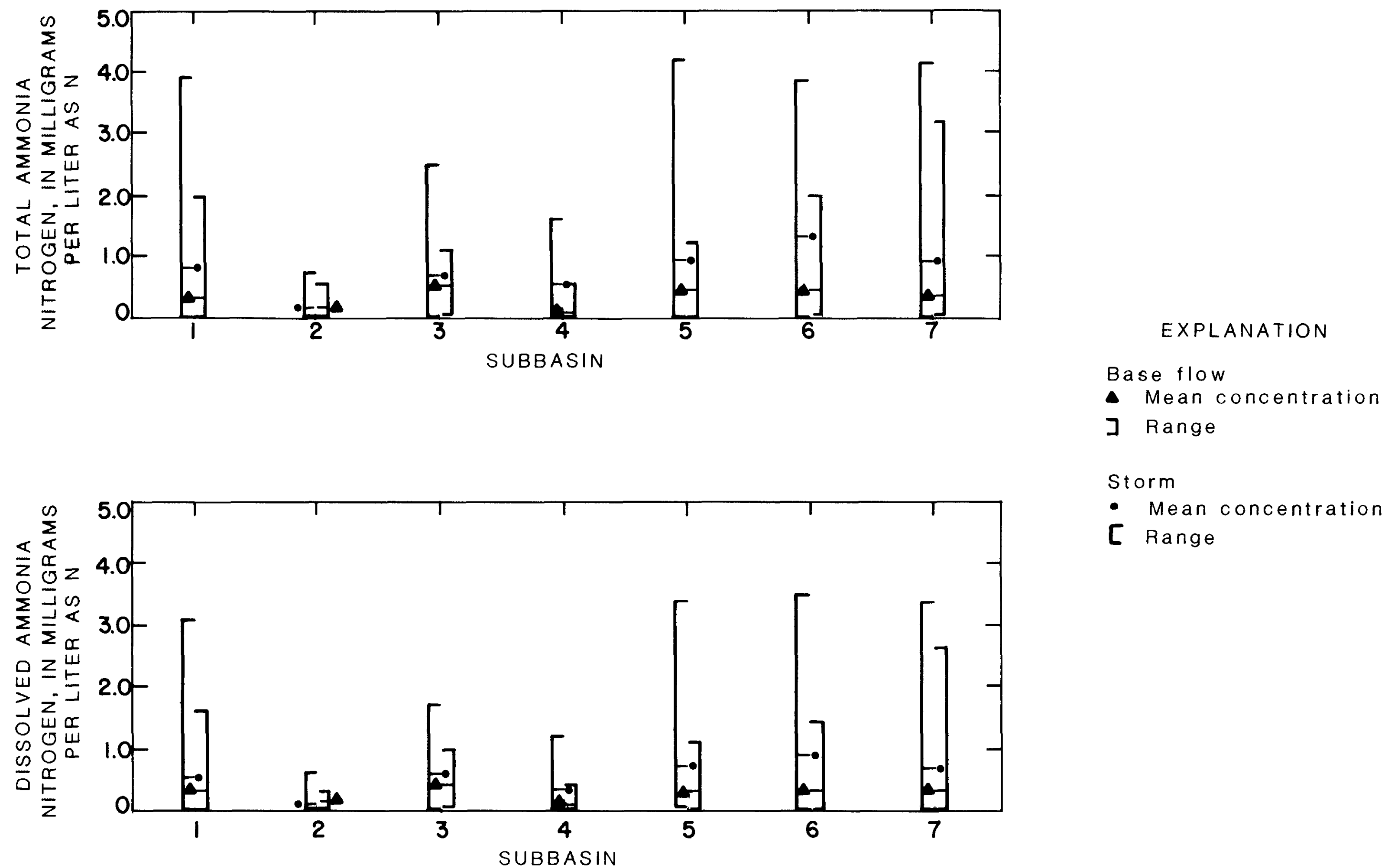


Figure 10.--Ranges of total and dissolved ammonia nitrogen during base flows and storms.

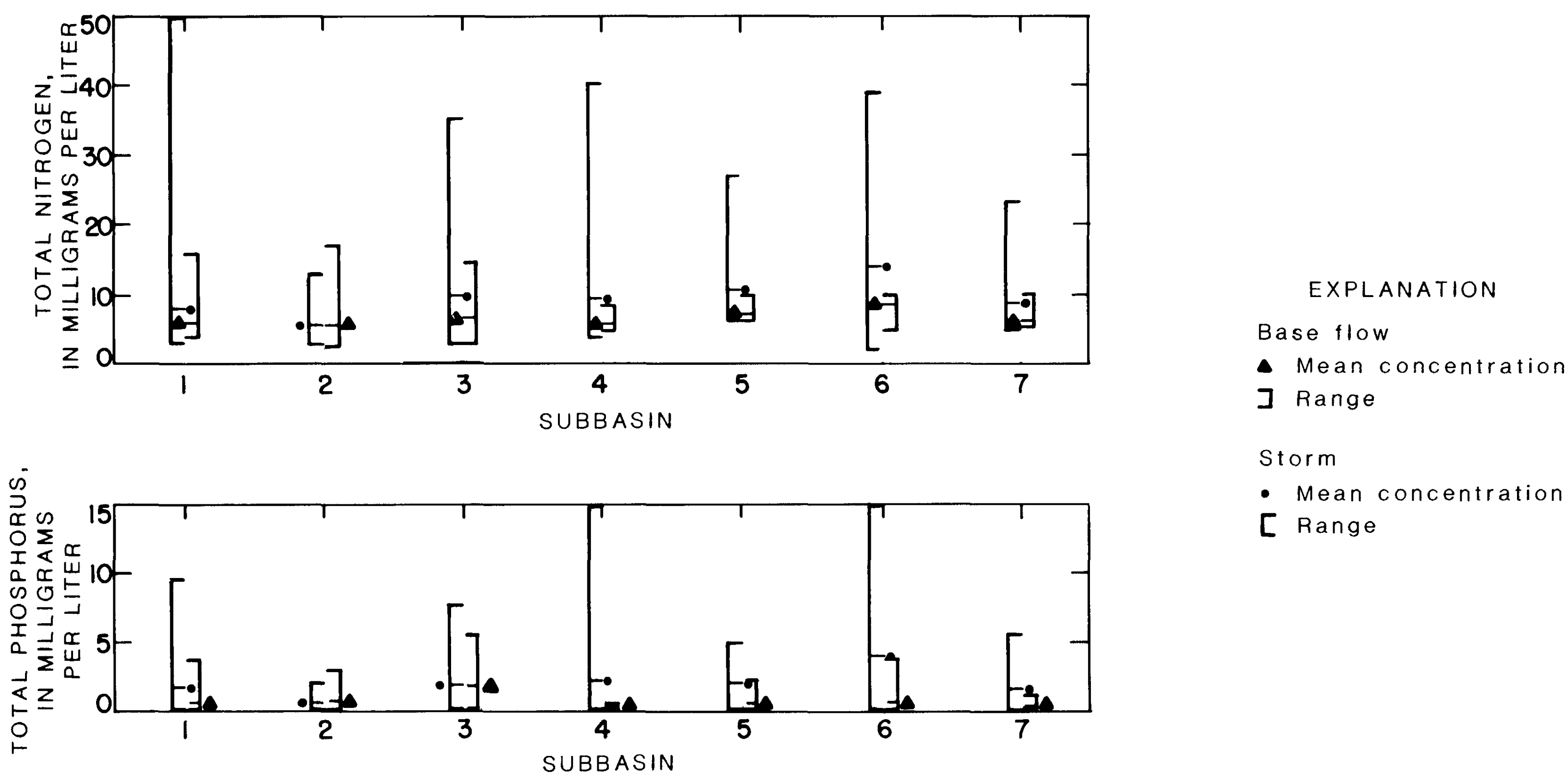


Figure 11--Ranges of total nitrogen and phosphorus during base flows and storms.

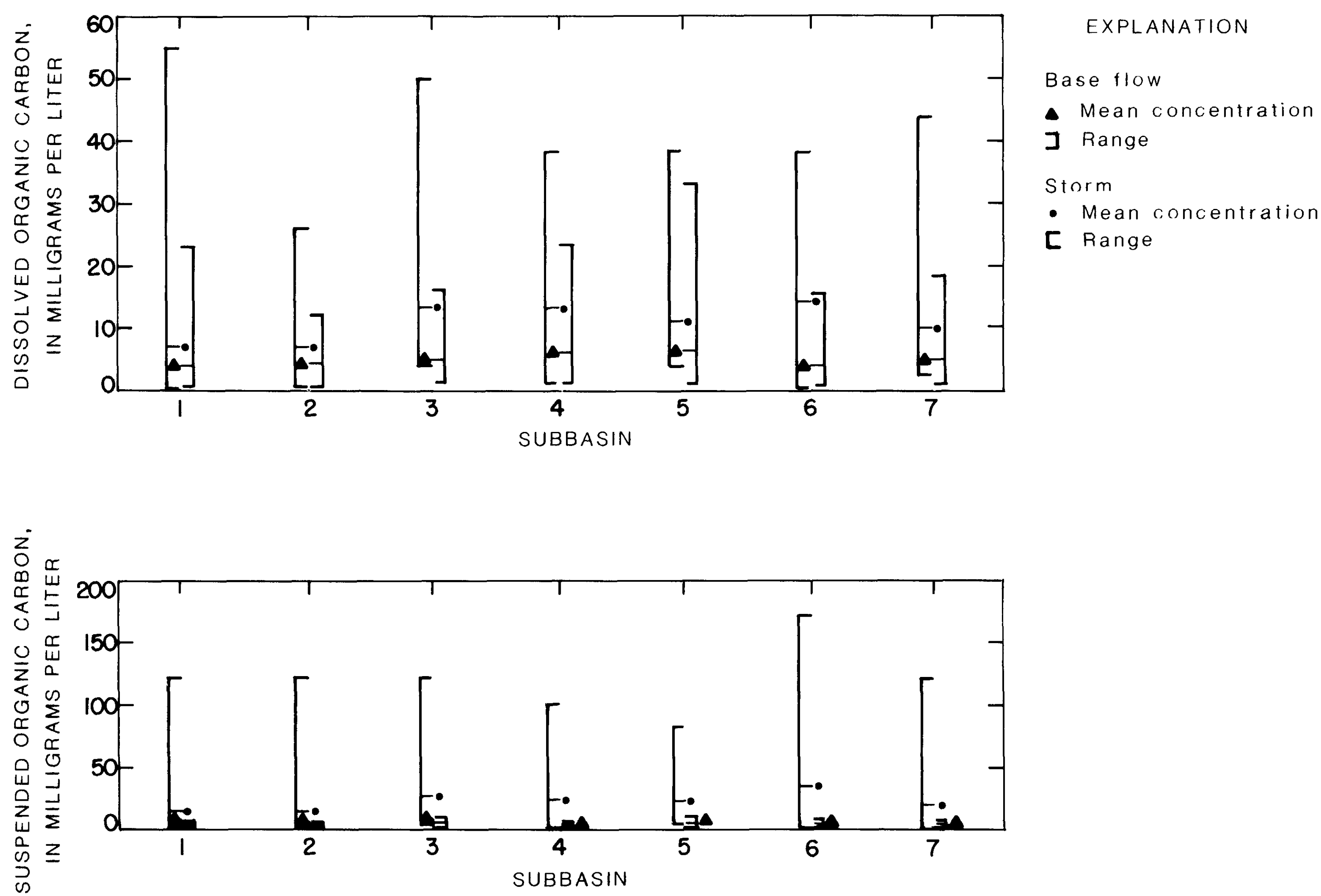


Figure 12.--Ranges of dissolved and suspended organic carbon during base flows and storms.

for constituents whose concentrations varied and were detectable. Table 14 lists the particle-size distribution of the bottom material and concentrations of constituents that were consistently below detectable limits.

The largest concentrations of organic carbon, ammonia nitrogen, Kjeldahl nitrogen, phosphorus, silt, and clay were found in upper Pequea Creek basin. Median concentrations of nutrients at subbasins 5, 6, and 7 were generally twice those found at the lower subbasins 2, 3, and 4. Concentrations of the above constituents generally were higher in subbasin 1 than in the rest of the lower basin, possibly because of movement of bottom material from the upper basin. Organic nitrogen comprised the majority of nitrogen in all of the bottom-material samples.

Two duplicate bottom-material samples that were collected at sites 6 and 7 in January 1978 were analyzed individually for nutrients and organic carbon in two different fractions: the complete sample and the silt-plus-clay fraction. The fractions were sieved at the site using a 0.62mm screen and native water. Concentrations in the sand fraction were computed. The results (table 15) show that concentrations of organic carbon were higher in the sand fraction than in the silt-plus-clay fraction for both samples. The sand fraction may have contained detritus of irregular shape that was retained during sieving, which could have raised the organic carbon concentration. Kjeldahl nitrogen was significantly lower and ammonia nitrogen twice as high in the sand fraction than in the silt-plus-clay fraction. Phosphorus in the sand fraction at subbasin 6 was 50 percent higher than that in the silt-plus-clay fraction. Subbasin 7 had less phosphorus in the sand fraction. Generally, the adsorption of nitrogen and phosphorus is believed to be related to surface area. This would indicate that the silt-plus-clay fraction should have higher concentrations of nitrogen and phosphorus than the sand fraction.

Only 7 of the 27 pesticides analyzed in bottom material were detected. Median pesticide concentrations were highest in the upper Pequea Creek basin (table 13). Subbasin 6 was especially high in the DDT series of pesticides. The only median concentration in the lower basin that was moderately high (4.7 μg/kg) was DDT at subbasin 2. Pesticide concentrations at subbasin 1 were higher than concentrations at subbasins 2, 3, and 4 because of upstream influences, except for DDE and DDT, which were highest at subbasin 2.

Studies by Feltz (1980) and Goerlitz and Law (1974) suggest that sorption is probably controlled by organic matter content as well as surface area (particle size) of the particles. Organic carbon content of bottom material in the upper Pequea Creek basin was 1.3 to 2.0 percent, and the lower basin had 0.04 to 1.3 percent organic carbon. The higher concentrations of nitrogen, phosphorus, and pesticides detected in bottom material in the upper basin may partially be due to the higher silt-plus-clay percentages and higher organic carbon concentrations found in the upper basin than the lower basin.

Table 13.--Maximum, minimum, and median concentrations in bottom material

Constituent		Subbasin 1	2	3	4	5	6	7
Organic Carbon (mg/kg)	max.	13,000	23,000	19,000	6,100	21,000	16,000	21,000
	min.	800	5,400	3,600	1,300	16,000	11,000	11,000
	median	9,400	13,000	6,400	3,900	20,000	13,000	15,000
Phosphorus as P (mg/kg)	max.	570	360	900	370	980	740	780
	min.	150	160	150	140	380	190	280
	median	560	260	290	320	800	600	530
Kjeldahl Nitrogen as N (mg/kg)	max.	36,000	4,300	14,000	1,700	3,800	5,200	6,700
	min.	390	560	340	190	2,000	870	980
	median	2,400	2,500	1,300	1,200	5,100	4,200	4,400
Ammonia Nitrogen as N (mg/kg)	max.	36	7.4	24	12	70	25	27
	min.	7.6	2.6	1.3	2.7	6.5	10	8.5
	median	10	4.4	4.9	4.8	26	18	11
Nitrite-plus-Nitrate Nitrogen as N (mg/kg)	max.	5.7	5.8	2.7	5.4	5.9	6.5	20
	min.	1.4	0.5	1.2	1.0	1.4	1.2	1.0
	median	3.4	1.6	2.0	1.7	1.7	1.5	1.3
Nitrite Nitrogen as N (mg/kg)	max.	.1	<.01	1.0	<.01	.1	.2	.1
	min.	<.01	<.01	<.01	<.01	<.01	<.01	<.01
	median	0	<.01	.1	<.01	.1	.1	<.01
Chlordane (μg/kg)	max.	24	12	39	1	57	16	21
	min.	<.1	<.1	<.1	<.1	10	<.1	<.1
	median	11	6	4	<.1	25	4	3
DDD (μg/kg)	max.	1.7	1.9	2.2	<.01	6.4	9.5	12
	min.	<.01	<.01	<.01	<.01	<.01	<.01	<.01
	median	1.1	.8	<.01	<.01	1.6	7.8	.7
DDE (μg/kg)	max.	4.8	6.2	5.1	1.1	24	45	8.7
	min.	1.2	.8	<.01	<.01	1.6	3.9	1.7
	median	2.4	3.2	.3	<.01	8.9	15	4.7
DDT (μg/kg)	max.	2.5	11	1.4	<.01	11	97	27
	min.	<.01	1.0	<.01	<.01	1.9	1.5	.7
	median	.8	4.7	<.01	<.01	4.4	8.4	3.4
Dieldrin (μg/kg)	max.	1.7	1.6	.4	.4	8.0	6.2	6.0
	min.	.7	<.01	<.01	<.01	1.4	.4	.6
	median	1.0	.3	<.01	.2	3.5	1.9	1.8
Heptachlor Epoxide (μg/kg)	max.	.2	.2	<.01	<.01	.3	2.9	.2
	min.	<.01	<.01	<.01	<.01	<.01	<.01	<.01
	median	<.01	<.01	<.01	<.01	<.01	.4	<.01
PCB (μg/kg)	max.	<.1	4	13	<.1	<.1	<.1	2
	min.	<.1	<.1	<.1	<.1	<.1	<.1	<.1
	median	<.1	<.1	<.1	<.1	<.1	<.1	<.1

Table 14.--Median particle-size distribution of bottom material and constituents with concentrations below detectable limits

Constituent	Subbasin 1	2	3	4	5	6	7
Percent Sand	69	87	90	96	25	61	57
Percent Silt	25	12	6	4	51	35	40
Percent Clay	6	1	4	0	24	4	3

Constituents with concentrations below detectable limits

Aldrin	Methyl parathion
Diazinon	Methyl trithion
Endosulfan	Mirex
Endrin	PCN
Ethion	Perthane
Ethyl parathion	Silvex
Ethyl trithion	Toxophene
Heptachlor	2,4-D
Lindane	2,4-DP
Malathion	2,4,5-T

Table 15.--Comparison of concentrations of organic carbon, nitrogen, and phosphorus in two size fractions of bottom material

Constituent	Concentration and sample type, in mg/kg					
	Subbasin 6			Subbasin 7		
	Complete sample	Silt-plus-clay fraction	Computed sand fraction	Complete sample	Silt-plus-clay fraction	Computed sand fraction
Organic carbon	16,000	13,000	21,000	15,000	12,000	19,500
Phosphorus as P	600	500	760	400	430	360
Kjeldahl nitrogen as N	4,200	5,200	2,600	4,400	4,800	3,800
Nitrite-plus-nitrate nitrogen as N	2.5	2.6	2.3	1.3	3.0	--
Ammonia nitrogen as N	10	7.9	13	11	6.9	17
Nitrite nitrogen as N	<.01	<.01	<.01	<.01	<.01	<.01
Percent sand	38	0	100	40	0	100

Effects of Storms

Storm Characteristics

From 50 to 65 water samples were collected for analysis at each of the seven subbasins during eight storms. Subbasin 1 had additional samples collected automatically during storms. Eight storms were selected to represent various types and intensities of precipitation, soil moisture, vegetative cover, and phases in the agricultural growing season. Table 16 summarizes the storm characteristics and describes the soil conditions preceding each storm.

Sampled storms ranged from 0.36 to 1.63 inches of precipitation. Runoff from steady, gentle rains (March 22, 1977) and from thunderstorms (June 21, 1978) was sampled. Maximum intensities ranged from 0.17 to 1.23 inches per hour. The percentages of precipitation that occurred in each third of the storm are approximate measures of storm type. The amount of runoff produced from two different storm types with the same intensities can be quite different. If the period of maximum-intensity precipitation occurs at the end of the storm after the soils have become saturated, there will be more runoff than if the period of maximum-intensity precipitation occurs at the beginning of the storm when the soils can still absorb some of the rainfall. However, the larger the maximum intensities are, the less effect storm type has on runoff. With maximum intensities of 1 inch per hour or more, most of the rainfall runs off before it can be absorbed into the soil.

Streamflows during storms were sampled during different times in the agricultural growing season, which included two snow-melt periods. Soil covers varied during storms from little or no protection during the winter to maximum protection just before corn was harvested (August 17, 1977). Soil moistures varied from near saturation during the winter to fairly dry during the growing season.

Variation in Water Quality During Storms

An example of the variations in concentrations of nutrients and suspended sediment during a storm on March 22, 1977 at subbasin 6 is shown in figures 13 and 14. Rainfall for this storm totaled 1.75 inches, of which 0.25 inch fell between 0600 and 0800 hours and did not cause any rise in streamflow. The remaining 1.50 inches fell between 0900 and 1400 hours. Figure 9 is a plot of time and dissolved constituent concentrations. Flow increased sharply from 0900 to 1130 hours on March 22 and leveled off until about 1200 hours, when it rose sharply again until it peaked at 1300 hours. Peak flow was about 70 ft^3/s. The first sharp rise in streamflow was accompanied by a rise in all the dissolved constituents plotted except nitrate, which dropped sharply, and nitrite, which remained essentially constant. As soon as streamflow leveled off, the dissolved constituents, except nitrate, peaked and began to fall as sharply as they had risen. A second peak in dissolved constituents, except nitrate and nitrite, occurred shortly after the peak of the hydrograph. The second phosphorus peak lagged behind the others, in contrast to the initial peaks, which were simultaneous. Nitrate recovered to near-initial concentrations when streamflow had decreased and leveled to less than 10 ft^3/s. The rest of the constituents gradually returned to initial levels once streamflow had stabilized.

Table 16.--Characteristics of sampled storms

Storm date	Total precipitation (in.)	Maximum precipitation intensity (in.), during 15 min.	30 min.	60 min.	Percentages of precipitation that occurred in each third of the storm: First	Second	Last
Feb. 24, 1977	0.55	0.27	0.32	0.40	71	22	7
Mar. 22, 1977	1.63	.14	.20	.32	17	44	39
June 1, 1977	1.32	.60	.98	1.23	30	52	18
Aug. 17, 1977	.55	.45	.50	.55	69	27	4
Nov. 10, 1977	.64	.34	.56	.60	93	6	1
Dec. 21, 1977	.86	.05	.10	.17	15	18	67
Mar. 14, 1978	.36	.19	.24	.25	6	13	81
June 21, 1978	1.47	.80	.85	.90	50	1	49

Storm date	Days since last storm	Air temperature (°F) Maximum	Minimum	Description of soil and field conditions
Feb. 24, 1977	4.0	58	34	Snow melt, top 2 in. of soil thawed, little ice cover
Mar. 22, 1977	2.0	44	39	Top 2 in. of soil thawed, soils wet
June 1, 1977	.5	81	60	Soils dry, corn 12 in. tall, some vegetal protection
Aug. 17, 1977	3.0	85	71	Soils moist, corn 7 ft tall, good vegetal protection
Nov. 10, 1977	.15	64	35	Soils wet, corn harvested, winter cover crops 2 in. tall
Dec. 21, 1977	1.0	42	33	Soils wet, manure spreading
Mar. 14, 1978	6.0	53	37	Snow melt, top 1 in. of soil thawed, soils wet
June 21, 1978	2.0	85	67	Soils dry for first thunderstorm, wet for second, corn 1.5 ft tall, tobacco planting in progress

The initial peaks observed are a "flushing" effect, in which easily soluble material and readily transportable soil is washed into the stream during the initial stages of runoff. Generally, after the flush of easily soluble and transportable material is carried into the stream channel, constituent concentrations in a stream depend on (1) contact time between precipitation and the land surface; and (2) land use. For a given land use, constituent concentrations are basically a function of contact time, which, in turn depends on the intensity of the storm.

During low and moderate runoff, the proportion of surface runoff to precipitation is low. Subsurface flow and surface runoff which slowly meanders to the stream channel have ample opportunity for contact with soil particles. As surface runoff increases, velocities increase and runoff concentrates into straight rills and gullies, thus decreasing contact with soil particles.

Figure 14 is a plot of time and suspended-constituent concentrations during the same period as that shown on figure 13. The suspended fraction of orthophosphate, total phosphorus, organic carbon, ammonia nitrogen, and organic nitrogen shows two peaks similar to those in figure 13. Suspended nitrate and nitrite concentrations were small. The first peak of the concentrations of suspended constituents occurred just before the peak of suspended-sediment concentration, which just preceeded the peak flow. The second peaks of all contitutents except for total phosphorus and orthophosphate occurred shortly after the peak of the hydrograph. An examination of the suspended-sediment curve shows that, during the initial rise in streamflow, the concentration of suspended sediment did not increase as fast as the concentrations of the other constituents. This indicates that the initial "flush" of sediment contained higher concentrations of nutrients than suspended sediment transported during and after peak flow.

The hydrographs for each subbasin differed, depending on the characteristics of the subbasin, the magnitude and intensity of the storms, and the season. Concentrations of all constituents except for dissolved nitrate consistently increased with flow during all storms sampled. Discharges of all constituents increased as flows increased, regardless of land use or season. Apparently, the amount of material available for transport in either the dissolved or suspended phases in Pequea Creek basin is not limiting, as is commonly the case in other areas.

Mean Water Quality During Storms

The results of samples collected during storms are summarized in table 17. Subbasin 6 had the highest mean (5,150 mg/L) and maximum (26,700 mg/L) suspended-sediment concentrations. Subbasin 3 had the next highest mean concentration of 3,240 mg/L. Subbasin 2 is mainly forested and had the lowest mean (537 mg/L) and maximum (4,480 mg/L) suspended-sediment concentrations. Pequea Creek subbasins 1, 5, and 7 averaged from 1,200 to 2,700 mg/L of suspended-sediment during storms. The maximum concentration observed at subbasin 1 was 13,700 mg/L. Suspended-sediment concentration and streamflow were directly related in each subbasin.

Variations in stormflow concentrations of selected constituents are shown in figures 9-12. Specific conductance generally decreased with increasing

(page 52 follows)

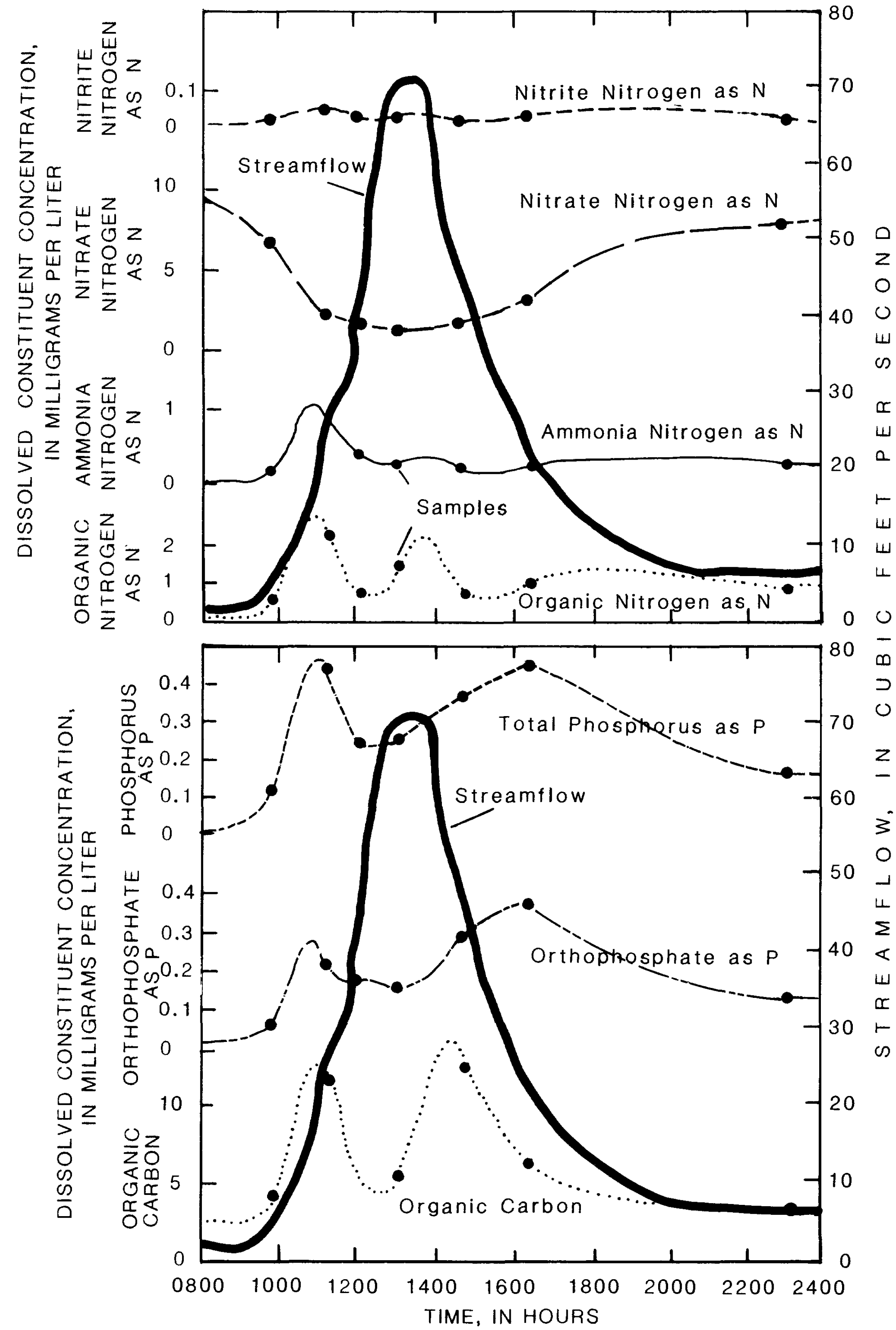


Figure 13.--Variations of dissolved constituents at subbasin 6, March 22, 1977.

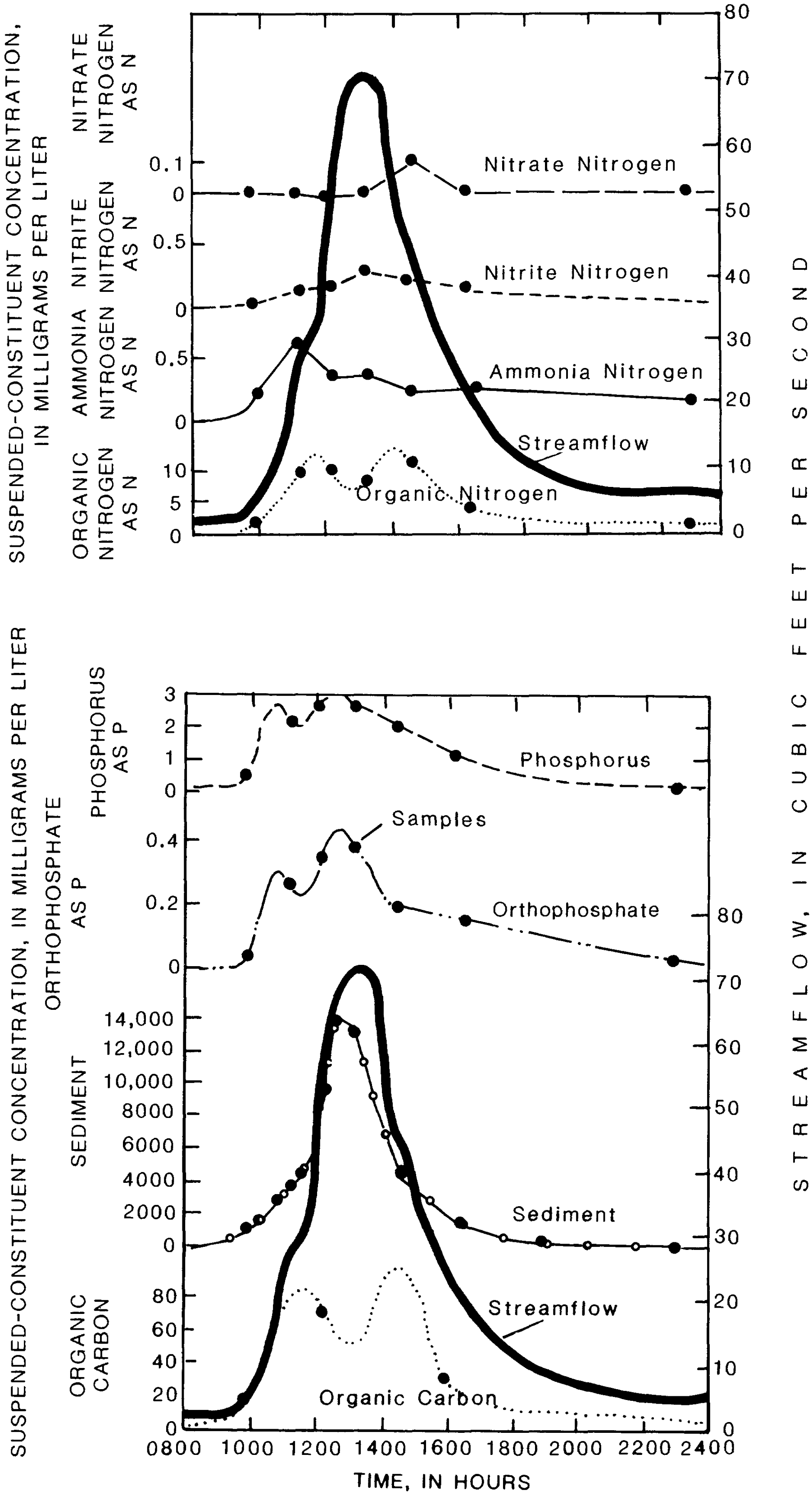


Figure 14.--Variations of suspended constituents at subbasin 6, March 22, 1977.

Table 17.--Summary of stormflow analyses

Site 1, Pequea Creek at Martic Forge							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	1,448	967	1,560	73	12,200	12,100	2,430,000
Turbidity (JTU)	1,405	470	692	4.0	4,900	4,900	478,000
Specific Conductance (µS/cm at 25°C)	951	277	80	83	428	345	6,350
Nitrogen, Total (mg/L as N)	887	8.0	4.1	3.2	51	48	17
Nitrogen, Organic Total (mg/L as N)	64	6.1	5.8	<.01	24.0	24.0	34
Nitrogen, Organic Dissolved (mg/L as N)	64	.86	.48	<.01	2.1	2.1	0
Nitrogen, Ammonia Dissolved (mg/L as N)	64	.54	.62	<.01	3.1	3.1	0
Nitrogen, Ammonia Total (mg/L as N)	64	.76	.87	.02	3.9	3.9	1
Nitrogen, Nitrite Dissolved (mg/L as N)	64	.06	.04	.01	.14	.13	0
Nitrogen, Nitrite Total (mg/L as N)	64	.09	.06	.02	.23	.21	0
Nitrogen, Nitrate Dissolved (mg/L as N)	64	3.8	1.4	1.1	7.0	5.9	2
Nitrogen, Nitrate Total (mg/L as N)	64	4.0	1.5	1.2	7.4	6.2	2
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	64	1.4	.99	.07	4.9	4.8	1
Nitrogen, Ammonia + Organic Total (mg/L as N)	890	3.8	4.6	<.01	50	50	21
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	895	4.2	1.4	.46	7.6	7.1	2
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	64	3.8	1.4	1.1	7.0	5.9	2
Phosphorus, Total (mg/L as P)	888	1.3	1.5	.01	9.4	9.4	2
Phosphorus, Dissolved (mg/L as P)	64	.20	.10	.03	.51	.48	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	64	.16	.08	.02	.40	.38	0
Carbon, Organic Dissolved (mg/L as C)	859	7.4	5.5	.8	55	54	30
Carbon, Organic Suspended (mg/L as C)	808	12	15	<.1	120	120	235
Phosphorus, Orthophosphate Total (mg/L as P)	112	.25	.12	.03	.62	.59	0
Sediment, Suspended (mg/L)	1,429	1,290	1,860	4.0	13,700	13,700	3,450,000
Sediment Discharge, Suspended (ton/d)	1,428	7,539	18,200	3.3	14,400	14,400	331,000,000
Perthane, Total (µg/L)	35	<.1	0	<.1	<.1	0	0
Simetryne, Total (µg/L)	38	<.1	0	<.1	<.1	0	0
Simazine, Total (µg/L)	38	.5	.9	<.1	5.4	5.4	1
Prometone, Total (µg/L)	38	<.1	.1	<.1	.7	.7	0
Prometryne, Total (µg/L)	38	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (µg/L)	37	<.1	0	<.1	<.1	0	0
Aldrin, Total (µg/L)	37	<.01	0	<.01	<.01	0	0
Lindane, Total (µg/L)	37	<.01	0	<.01	.03	.03	0
Chlordane, Total (µg/L)	37	<.1	<.1	0	.2	.2	0
DDD, Total (µg/L)	37	<.01	0	<.01	.01	.01	0
DDE, Total (µg/L)	37	<.01	0	<.01	.01	.01	0
DDT, Total (µg/L)	37	<.01	.01	<.01	.04	.04	0
Dieldrin, Total (µg/L)	37	<.01	.01	<.01	.03	.03	0
Endosulfan, Total (µg/L)	35	<.01	0	<.01	<.01	0	0
Endrin, Total (µg/L)	37	<.01	0	<.01	<.01	0	0
Ethion, Total (µg/L)	35	<.01	0	<.01	<.01	0	0
Toxaphene, Total (µg/L)	37	<1	0	<1	<1	0	0
Heptachlor, Total (µg/L)	37	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (µg/L)	37	<.01	0	<.01	.02	.02	0
PCB, Total (µg/L)	37	<.1	0	<.1	<.1	0	0
Malathion, Total (µg/L)	35	<.01	0	<.01	<.01	0	0
Parathion, Total (µg/L)	35	<.01	0	<.01	<.01	0	0
Diazinon, Total (µg/L)	35	<.01	.02	<.01	.08	.08	0
Methyl Parathion, Total (µg/L)	35	<.01	0	<.01	<.01	0	0
Atrazine, Total (µg/L)	38	2.4	3.3	<.01	12.0	12.0	11
2,4-D, Total (µg/L)	35	.18	.26	<.01	1.2	1.2	0
2,4,5-T, Total (µg/L)	35	<.01	.01	<.01	.04	.04	0
Silvex, Total (µg/L)	35	.01	.02	<.01	.09	.09	0
Methyl Trithion, Total (µg/L)	35	<.01	0	<.01	<.01	0	0
Ametryne, Total (µg/L)	36	<.1	0	<.1	<.1	0	0
Atratone, Total (µg/L)	36	<.1	0	<.1	<.1	0	0
Cyanazine, Total (µg/L)	36	<.1	0	<.1	<.1	0	0
Cyprazine, Total (µg/L)	36	<.1	0	<.1	<.1	0	0
Simetone, Total (µg/L)	36	<.1	0	<.1	<.1	0	0
Alachlor, Total (µg/L)	36	<.1	0	<.1	<.1	0	0
Trithion, Total (µg/L)	35	<.01	0	<.01	<.01	0	0

Table 17.--Summary of stormflow analyses--(Continued)

Site 2, Pequea Creek Tributary near Martic Forge							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	91	15.2	20.4	.62	145	144	417
Turbidity (JTU)	70	2.5	378	2.0	2,200	2,200	143,000
Specific Conductance (µS/cm at 25°C)	46	102	12	77	126	49	143
Nitrogen, Total (mg/L as N)	54	5.7	2.2	3.4	13	9.6	5
Nitrogen, Organic Total (mg/L as N)	54	1.9	2.5	<.01	11	11	6
Nitrogen, Organic Dissolved (mg/L as N)	54	.36	.31	<.01	1.5	1.5	0
Nitrogen, Ammonia Dissolved (mg/L as N)	54	.08	.14	<.01	.60	.60	0
Nitrogen, Ammonia Total (mg/L as N)	53	.10	.18	<.01	.70	.70	0
Nitrogen, Nitrite Dissolved (mg/L as N)	54	.01	.01	<.01	.10	.10	0
Nitrogen, Nitrite Total (mg/L as N)	54	.02	.02	<.01	.13	.13	0
Nitrogen, Nitrate Dissolved (mg/L as N)	54	3.5	1.2	.65	6.7	6.0	1
Nitrogen, Nitrate Total (mg/L as N)	54	3.7	1.4	1.5	8.3	6.8	2
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	54	.43	.38	<.01	1.7	1.7	0
Nitrogen, Ammonia + Organic Total (mg/L as N)	54	2.0	2.5	<.01	11	11	6
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	54	3.7	1.4	1.5	8.3	6.8	2
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	54	3.5	1.2	.7	6.7	6.0	2
Phosphorus, Total (mg/L as P)	54	.31	.46	<.01	1.9	1.9	0
Phosphorus, Dissolved (mg/L as P)	54	.03	.03	<.01	.19	.19	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	54	.02	.03	<.01	.16	.16	0
Carbon, Organic Dissolved (mg/L as C)	50	7.8	5.0	1.8	26	24	25
Carbon, Organic Suspended (mg/L as C)	47	15	23	.2	120	120	527
Phosphorus, Orthophosphate Total (mg/L as P)	54	.03	.05	<.01	.25	.25	0
Sediment, Suspended (mg/L)	92	537	823	2.0	4,480	4,480	677,000
Sediment Discharge, Suspended (ton/d)	91	45.2	158	.01	1,370	1,370	25,100
Perthane, Total (µg/L)	7	<.1	0	<.1	<.1	0	0
Simetryne, Total (µg/L)	5	<.1	0	<.1	<.1	0	0
Simazine, Total (µg/L)	5	<.1	0	<.1	<.1	0	0
Prometone, Total (µg/L)	5	<.1	0	<.1	<.1	0	0
Prometryne, Total (µg/L)	5	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (µg/L)	7	<.1	0	<.1	<.1	0	0
Aldrin, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Lindane, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Chlordane, Total (µg/L)	7	<.1	<.1	<.1	.1	.1	0
DDD, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
DDE, Total (µg/L)	7	<.01	.01	<.01	.02	.02	0
DDT, Total (µg/L)	7	.01	.01	0	.03	.03	0
Dieldrin, Total (µg/L)	7	.01	.01	0	.02	.02	0
Endosulfan, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Endrin, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Ethion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Toxaphene, Total (µg/L)	7	<1	0	<1	<1	0	0
Heptachlor, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
PCB, Total (µg/L)	7	<.1	0	<.1	<.1	0	0
Malathion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Parathion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Diazinon, Total (µg/L)	7	.01	.01	<.01	.03	.03	0
Methyl Parathion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Atrazine, Total (µg/L)	5	2.64	5.79	<.01	13.0	13.0	33
2,4-D, Total (µg/L)	6	<.01	0	<.01	<.01	0	0
2,4,5-T, Total (µg/L)	6	<.01	0	<.01	.01	.01	0
Silvex, Total (µg/L)	6	<.01	0	<.01	<.01	0	0
Methyl Trithion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Ametryne, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Atratone, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Cyanazine, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Cyprazine, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Simetone, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Alachlor, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Trithion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0

Table 17.--Summary of stormflow analyses--(Continued)

Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Site 3, Big Beaver Creek at Refton							
Streamflow, Instantaneous (ft^3/s)	82	376	385	11.0	1,650	1,639	148,000
Turbidity (JTU)	75	1,220	1,250	25.0	5,700	5,680	1,560,000
Specific Conductance (μS/cm at 25°C)	45	176	39	114	268	154	1,540
Nitrogen, Total (mg/L as N)	62	9.8	7.8	3.0	35	32	61
Nitrogen, Organic Total (mg/L as N)	61	6.4	7.5	.2	30	30	56
Nitrogen, Organic Dissolved (mg/L as N)	60	.90	.54	<.01	2.3	2.3	0
Nitrogen, Ammonia Dissolved (mg/L as N)	60	.54	.47	.01	1.7	1.7	0
Nitrogen, Ammonia Total (mg/L as N)	59	.66	.60	.01	2.3	2.3	0
Nitrogen, Nitrite Dissolved (mg/L as N)	60	.06	.04	.01	.14	.13	0
Nitrogen, Nitrite Total (mg/L as N)	60	.09	.06	.02	.22	.20	0
Nitrogen, Nitrate Dissolved (mg/L as N)	60	2.5	1.0	.84	4.5	3.7	1
Nitrogen, Nitrate Total (mg/L as N)	60	2.6	1.0	.84	4.7	3.9	1
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	60	1.4	.88	.18	3.5	3.3	1
Nitrogen, Ammonia + Organic Total (mg/L as N)	62	7.1	7.6	.26	31	31	58
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	60	2.6	1.0	.92	4.7	3.8	1
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	60	2.5	1.0	.86	4.5	3.6	1
Phosphorus, Total (mg/L as P)	60	1.9	1.9	.06	7.3	7.2	4
Phosphorus, Dissolved (mg/L as P)	60	.20	.11	.05	.54	.49	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	61	.15	.10	.02	.44	.42	0
Carbon, Organic Dissolved (mg/L as C)	58	13	8.3	4.3	50	46	69
Carbon, Organic Suspended (mg/L as C)	56	28.3	27	2.0	120	118	715
Phosphorus, Orthophosphate Total (mg/L as P)	60	.26	.14	.02	.57	.55	0
Sediment, Suspended (mg/L)	81	3,240	3,280	46.0	12,200	12,200	10,800,000
Sediment Discharge, Suspended (ton/d)	81	5,640	9,450	1.7	45,000	45,000	89,300,000
Perthane, Total (μg/L)	4	<.1	0	<.1	<.1	0	0
Simetryne, Total (μg/L)	5	<.1	0	<.1	<.1	0	0
Simazine, Total (μg/L)	5	.4	.7	<.1	1.7	1.7	0
Prometone, Total (μg/L)	5	<.1	0	<.1	<.1	0	0
Prometryne, Total (μg/L)	5	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (μg/L)	4	<.1	0	<.1	<.1	0	0
Aldrin, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Lindane, Total (μg/L)	4	.01	.01	0	.03	.03	0
Chlordane, Total (μg/L)	4	<.1	.1	0	.2	.2	0
DDD, Total (μg/L)	4	<.01	0	<.01	.01	.01	0
DDE, Total (μg/L)	4	.01	.02	<.01	.03	.03	0
DDT, Total (μg/L)	4	<.01	0	<.01	.01	.01	0
Dieldrin, Total (μg/L)	4	<.01	.01	<.01	.01	.01	0
Endosulfan, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Endrin, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Ethion, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Toxaphene, Total (μg/L)	4	<1	0	<1	<1	0	0
Heptachlor, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
PCB, Total (μg/L)	4	<.1	0	<.1	<.1	0	0
Malathion, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Parathion, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Diazinon, Total (μg/L)	4	<.01	.01	<.01	.02	.02	0
Methyl Parathion, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Atrazine, Total (μg/L)	5	5.4	10.4	<.01	24.0	24.0	109
2,4-D, Total (μg/L)	4	.31	.60	<.01	1.2	1.2	0
2,4,5-T, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Silvex, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Methyl Trithion, Total (μg/L)	4	<.01	0	<.01	<.01	0	0
Ametryne, Total (μg/L)	4	<.1	0	<.1	<.1	0	0
Atratone, Total (μg/L)	4	<.1	0	<.1	<.1	0	0
Cyanazine, Total (μg/L)	4	<.1	0	<.1	<.1	0	0
Cyprazine, Total (μg/L)	4	<.1	0	<.1	<.1	0	0
Simetone, Total (μg/L)	4	<.1	0	<.1	<.1	0	0
Alachlor, Total (μg/L)	4	<.1	0	<.1	<.1	0	0
Trithion, Total (μg/L)	4	<.01	0	<.01	<.01	0	0

Table 17.--Summary of stormflow analyses--(Continued)

Site 4, Big Beaver Creek Tributary at New Providence							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	107	12.9	19.7	.05	138	138	389
Turbidity (JTU)	94	1,330	2,170	5.4	13,000	13,000	4,710,000
Specific Conductance (µS/cm at 25°C)	68	190	66	91	339	248	4,420
Nitrogen, Total (mg/L as N)	58	9.7	6.7	3.7	40	36	45
Nitrogen, Organic Total (mg/L as N)	58	5.4	6.3	.03	32	32	40
Nitrogen, Organic Dissolved (mg/L as N)	57	.88	.66	<.01	3.1	3.1	0
Nitrogen, Ammonia Dissolved (mg/L as N)	57	.35	.34	<.01	1.2	1.2	0
Nitrogen, Ammonia Total (mg/L as N)	58	.51	.48	.01	1.6	1.6	0
Nitrogen, Nitrite Dissolved (mg/L as N)	57	.03	.02	<.01	.08	.08	0
Nitrogen, Nitrite Total (mg/L as N)	58	.08	.07	.01	.32	.31	0
Nitrogen, Nitrate Dissolved (mg/L as N)	57	3.5	1.7	.73	6.8	6.1	3
Nitrogen, Nitrate Total (mg/L as N)	58	3.6	1.7	.73	6.8	6.1	3
Nitrogen, Ammonia + Organic Dissolved (mg/L ss N)	57	1.2	.88	.01	3.9	3.9	1
Nitrogen, Ammonia + Orgsnic Total (mg/L as N)	58	5.9	6.5	.05	33	33	42
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	58	3.7	1.7	.90	7.0	6.1	3
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	57	3.5	1.7	.75	6.9	6.2	3
Phosphorus, Total (mg/L as P)	58	1.8	2.5	.02	15	15	6
Phosphorus, Dissolved (mg/L as P)	57	.11	.12	.01	.61	.60	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	57	.07	.10	<.01	.49	.49	0
Csrbon, Organic Dissolved (mg/L as C)	54	13	8.6	1.5	38	36	74
Carbon, Organic Suspended (mg/L as C)	53	25	26	.4	100	100	650
Phosphorus, Orthophosphate Total (mg/L as P)	58	.19	.20	<.01	.87	.87	0
Sediment, Suspended (mg/L)	106	2,900	4,010	10.0	20,200	20,200	16,100,000
Sediment Discharge, Suspended (ton/d)	106	211	575	<.01	4,990	4,990	331,000
Perthane, Total (µg/L)	8	<.1	0	<.1	<.1	0	0
Simetryne, Total (µg/L)	6	<.1	0	<.1	<.1	0	0
Simazine, Total (µg/L)	6	.30	.48	<.1	1.2	1.2	0
Prometone, Total (µg/L)	6	<.1	0	<.1	<.1	0	0
Prometryne, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (µg/L)	8	<.1	0	<.1	<.1	0	0
Aldrin, Total (µg/L)	8	<.01	0	<.01	<.01	0	0
Lindane, Total (µg/L)	8	<.01	0	<.01	.01	.01	0
Chlordane, Total (µg/L)	8	<.1	<.1	0	.1	.1	0
DDD, Total (µg/L)	8	<.01	0	<.01	.01	.01	0
DDE, Total (µg/L)	8	<.01	0	<.01	.01	.01	0
DDT, Total (µg/L)	8	.01	.01	<.01	.02	.02	0
Dieldrin, Total (µg/L)	8	.02	.03	<.01	.08	.08	0
Endosulfan, Total (µg/L)	8	<.01	0	<.01	<.01	0	0
Endrin, Total (µg/L)	8	<.01	0	<.01	<.01	0	0
Ethion, Total (µg/L)	8	<.01	0	<.01	<.01	0	0
Toxaphene, Total (µg/L)	8	<1	0	<1	<1	0	0
Heptachlor, Total (µg/L)	8	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (µg/L)	8	<.01	0	<.01	.01	.01	0
PCB, Total (µg/L)	8	<.1	0	<.1	<.1	0	0
Malathion, Total (µg/L)	8	<.01	0	<.01	<.01	0	0
Parathion, Total (µg/L)	8	<.01	0	<.01	<.01	0	0
Diazinon, Total (µg/L)	8	<.01	0	<.01	<.01	0	0
Methyl Parathion, Total (µg/L)	8	<.01	0	<.01	<.01	0	0
Atrazine, Total (µg/L)	6	3.5	5.5	<.01	14.0	14.0	30
2,4-D, Total (µg/L)	7	.08	.18	<.01	.49	.49	0
2,4,5-T, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Silvex, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
Methyl Trithion, Totsl (µg/L)	8	<.01	0	<.01	<.01	0	0
Ametryne, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Atratone, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Cyanazine, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Cyprazine, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Simetone, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Alachlor, Total (µg/L)	4	<.1	0	<.1	<.1	0	0
Trithion, Total (µg/L)	8	<.01	0	<.01	<.01	0	0

Table 17.--Summary of stormflow analyses--(Continued)

Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Site 5, Pequea Creek at Strasburg							
Streamflow, Instantaneous (ft^3/s)	75	540	673	55.0	3,070	3,020	453,000
Turbidity (JTU)	55	838	1,060	40.0	7,000	6,960	1,120,000
Specific Conductance (μS/cm at 25°C)	35	308	83	149	488	389	6,860
Nitrogen, Total (mg/L as N)	59	11	4.1	6.1	27	21	17
Nitrogen, Organic Total (mg/L as N)	59	5.1	4.5	<.01	24	24	20
Nitrogen, Organic Dissolved (mg/L as N)	59	1.0	.73	<.01	3.2	3.2	1
Nitrogen, Ammonia Dissolved (mg/L as N)	59	.71	.86	.01	3.4	3.4	1
Nitrogen, Ammonia Total (mg/L as N)	59	.94	1.1	.01	4.2	4.2	1
Nitrogen, Nitrite Dissolved (mg/L as N)	59	.07	.04	.01	.13	.12	0
Nitrogen, Nitrite Total (mg/L as N)	59	.10	.05	.02	.21	.19	0
Nitrogen, Nitrate Dissolved (mg/L as N)	59	4.4	1.7	.93	8.6	7.7	3
Nitrogen, Nitrate Total (mg/L as N)	59	4.6	1.7	.93	8.6	7.7	3
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	59	1.7	1.5	.02	6.6	6.6	2
Nitrogen, Ammonia + Organic Total (mg/L as N)	59	6.0	5.2	.02	25	25	27
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	59	4.7	1.7	1.0	8.6	7.6	3
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	59	4.5	1.7	.97	8.6	7.6	3
Phosphorus, Total (mg/L as P)	59	1.9	1.5	.03	4.7	4.7	2
Phosphorus, Dissolved (mg/L as P)	59	.33	.22	.02	.79	.77	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	59	.28	.20	.01	.70	.69	0
Carbon, Organic Dissolved (mg/L as C)	56	11	7.4	3.9	38	34	54
Carbon, Organic Suspended (mg/L as C)	53	23	20	2.0	90	88	391
Phosphorus, Orthophosphate Total (mg/L as P)	59	.39	.26	.01	.86	.85	0
Sediment, Suspended (mg/L)	74	1,860	2,000	55.0	9,260	9,200	4,020,000
Sediment Discharge, Suspended (ton/d)	74	3,800	6,640	8.2	39,000	39,000	44,100,000
Perthane, Total (μg/L)	7	<.1	0	<.1	<.1	0	0
Simetryne, Total (μg/L)	6	<.1	0	<.1	<.1	0	0
Simazine, Total (μg/L)	6	.2	.2	<.1	.6	.6	0
Prometone, Total (μg/L)	6	<.1	0	<.1	<.1	0	0
Prometryne, Total (μg/L)	6	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (μg/L)	7	<.1	0	<.1	<.1	0	0
Aldrin, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
Lindane, Total (μg/L)	7	<.01	0	<.01	.01	.01	0
Chlordane, Total (μg/L)	7	<.1	<.1	0	.1	.1	0
DDD, Total (μg/L)	7	<.01	0	<.01	.01	.01	0
DDE, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
DDT, Total (μg/L)	7	.01	.01	<.01	.03	.03	0
Dieldrin, Total (μg/L)	7	.02	.02	<.01	.06	.06	0
Endosulfan, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
Endrin, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
Ethion, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
Toxaphene, Total (μg/L)	7	<1	0	<1	<1	0	0
Heptachlor, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (μg/L)	7	<.01	.01	<.01	.02	.02	0
PCB, Total (μg/L)	7	<.1	0	<.1	<.1	0	0
Malathion, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
Parathion, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
Diazinon, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
Methyl Parathion, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
Atrazine, Total (μg/L)	6	4.1	6.2	<.01	13.0	13.0	38
2,4-D, Total (μg/L)	5	.19	.30	<.01	.70	.70	0
2,4,5-T, Total (μg/L)	5	<.01	0	<.01	<.01	0	0
Silvex, Total (μg/L)	5	.01	.02	<.01	.05	.05	0
Methyl Trithion, Total (μg/L)	7	<.01	0	<.01	<.01	0	0
Ametryne, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Atratone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Cyanazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Cyprazine, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Simetone, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Alachlor, Total (μg/L)	3	<.1	0	<.1	<.1	0	0
Trithion, Total (μg/L)	7	<.01	0	<.01	<.01	0	0

Table 17.--Summary of stormflow analyses--(Continued)

Site 6, Pequea Creek Tributary near Strasburg							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	86	39.9	60.0	.95	312	311	3,600
Turbidity (JTU)	74	2,650	3,410	12.0	15,000	15,000	11,600,000
Specific Conductance (µS/cm at 25°)	48	308	113	154	553	399	12,700
Nitrogen, Total (mg/L as N)	59	14	7.6	1.9	39	37	58
Nitrogen, Organic Total (mg/L as N)	59	8.5	7.6	.05	33	33	58
Nitrogen, Organic Dissolved (mg/L as N)	59	1.4	1.0	.05	5.2	5.2	1
Nitrogen, Ammonia Dissolved (mg/L as N)	59	.86	.86	.01	3.5	3.5	1
Nitrogen, Ammonia Total (mg/L as N)	61	1.3	1.0	.01	3.8	3.8	1
Nitrogen, Nitrite Dissolved (mg/L as N)	59	.08	.06	.01	.23	.22	0
Nitrogen, Nitrite Total (mg/L as N)	58	.17	.10	.02	.43	.41	0
Nitrogen, Nitrate Dissolved (mg/L as N)	59	4.1	2.4	.67	9.5	8.8	6
Nitrogen, Nitrate Total (mg/L as N)	58	4.2	2.5	.39	9.6	9.2	6
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	59	2.3	1.7	.06	8.7	8.6	3
Nitrogen, Ammonia + Organic Total (mg/L as N)	59	9.8	8.4	.06	36	36	70
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	61	4.2	2.5	.42	9.6	9.2	6
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	59	4.2	2.5	.70	9.5	8.8	6
Phosphorus, Total (mg/L as P)	61	3.8	3.6	.03	15	15	13
Phosphorus, Dissolved (mg/L as P)	59	.48	.30	.02	1.3	1.3	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	59	.40	.27	<.01	1.1	1.1	0
Carbon, Organic Dissolved (mg/L as C)	59	14	9.1	.5	38	38	83
Carbon, Organic Suspended (mg/L as C)	59	37	37	.5	170	170	1,390
Phosphorus, Orthophosphate Total (mg/L as P)	61	.60	.35	.01	1.6	1.6	0
Sediment, Suspended (mg/L)	86	5,150	6,040	20.0	26,700	26,700	36,500,000
Sediment Discharge, Suspended (ton/d)	86	1,230	3,270	.05	22,500	22,500	10,700,000
Perthane, Total (µg/L)	7	<.1	0	<.1	<.1	0	0
Simetryne, Total (µg/L)	6	<.1	0	<.1	<.1	0	0
Simazine, Total (µg/L)	6	.1	.2	<.1	.5	.5	0
Prometone, Total (µg/L)	6	<.1	0	<.1	<.1	0	0
Prometryne, Total (µg/L)	6	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (µg/L)	7	<.1	0	<.1	<.1	0	0
Aldrin, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Lindane, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
Chlordane, Total (µg/L)	7	<.1	<.1	<.1	.1	.1	0
DDD, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
DDE, Total (µg/L)	7	<.01	.03	<.01	.07	.07	0
DDT, Total (µg/L)	7	.04	.05	<.01	.12	.12	0
Dieldrin, Total (µg/L)	7	.02	.03	<.01	.08	.08	0
Endosulfan, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Endrin, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Ethion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Toxaphene, Total (µg/L)	7	<1	0	<1	<1	0	0
Heptachlor, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
Heptachlor Epoxide, Total (µg/L)	7	.01	.01	<.01	.03	.03	0
PCB, Total (µg/L)	7	<.1	0	<.1	<.1	0	0
Malathion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Parathion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Diazinon, Total (µg/L)	7	.01	.03	<.01	.08	.08	0
Methyl Parathion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Atrazine, Total (µg/L)	6	3.4	5.2	<.01	11.0	11.0	27
2,4-D, Total (µg/L)	7	.09	.13	<.01	.33	.33	0
2,4,5-T, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
Silvex, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Methyl Trithion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Ametryne, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Atratone, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Cyanazine, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Cyprazine, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Simetone, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Alachlor, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Trithion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0

Table 17.--Summary of stormflow analyses--(Continued)

Site 7, Pequea Creek at New Milltown							
Constituent	Number of observations	Mean	Standard Deviation	Minimum Value	Maximum Value	Range	Variance
Streamflow, Instantaneous (ft^3/s)	77	358	464	31.0	1,800	1,770	215,000
Turbidity (JTU)	63	580	880	9.0	5,500	5,490	777,000
Specific Conductance (µS/cm at 25°C)	35	254	61	133	329	196	3,750
Nitrogen, Total (mg/L as N)	54	8.2	3.5	4.7	23	18	12
Nitrogen, Organic Total (mg/L as N)	54	3.7	3.3	.05	16	16	11
Nitrogen, Organic Dissolved (mg/L as N)	54	.95	.56	.02	3.4	3.4	0
Nitrogen, Ammonia Dissolved (mg/L as N)	54	.56	.68	.04	3.0	3.0	0
Nitrogen, Ammonia Total (mg/L as N)	54	.77	.85	.05	3.7	3.7	1
Nitrogen, Nitrite Dissolved (mg/L as N)	54	.06	.04	.01	.14	.13	0
Nitrogen, Nitrite Total (mg/L as N)	54	.08	.04	.02	.19	.17	0
Nitrogen, Nitrate Dissolved (mg/L as N)	54	3.6	1.2	.81	6.3	5.5	1
Nitrogen, Nitrate Total (mg/L as N)	54	3.7	1.2	.90	6.3	5.4	1
Nitrogen, Ammonia + Organic Dissolved (mg/L as N)	54	1.5	1.2	.07	6.4	6.3	1
Nitrogen, Ammonia + Organic Total (mg/L as N)	54	4.4	4.0	.10	20	20	16
Nitrogen, NO_2 + NO_3 Total (mg/L as N)	54	3.8	1.2	.98	6.3	5.3	1
Nitrogen, NO_2 + NO_3 Dissolved (mg/L as N)	54	3.6	1.2	.84	6.3	5.5	1
Phosphorus, Total (mg/L as P)	54	1.3	1.3	.07	5.6	5.5	2
Phosphorus, Dissolved (mg/L as P)	54	.25	.17	.03	.77	.74	0
Phosphorus, Orthophosphate Dissolved (mg/L as P)	54	.20	.14	.02	.60	.58	0
Carbon, Organic Dissolved (mg/L as C)	50	9.6	7.6	2.2	44	42	57
Carbon, Organic Suspended (mg/L as C)	46	20	24	.7	120	120	563
Phosphorus, Orthophosphate Total (mg/L as P)	54	.29	.19	.03	.77	.74	0
Sediment, Suspended (mg/L)	79	1,360	1,800	18.0	9,960	9,940	3,250,000
Sediment Discharge, Suspended (ton/d)	76	2,650	4,700	2.1	19,300	19,300	22,100,000
Perthane, Total (µg/L)	6	<.1	0	<.1	<.1	0	0
Simetryne, Total (µg/L)	6	<.1	0	<.1	<.1	0	0
Simazine, Total (µg/L)	6	.1	.2	<.1	.6	.6	0
Prometone, Total (µg/L)	6	<.1	.1	<.1	.7	.7	0
Prometryne, Total (µg/L)	6	<.1	0	<.1	<.1	0	0
Naphthalenes, Polychlor. Total (µg/L)	7	<.1	0	<.1	<.1	0	0
Aldrin, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Lindane, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
Chlordane, Total (µg/L)	7	<.1	<.1	<.1	.10	.10	0
DDD, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
DDE, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
DDT, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
Dieldrin, Total (µg/L)	7	.01	.01	<.01	.03	.03	0
Endosulfan, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Endrin, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Ethion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Toxaphene, Total (µg/L)	7	<1	0	<1	<1	0	0
Heptachlor, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Heptachlor Epoxide, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
PCB, Total (µg/L)	7	<.1	0	<.1	<.1	0	0
Malathion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Parathion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Diazinon, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Methyl Parathion, Total (µg/L)	7	.01	.02	<.01	.06	.06	0
Atrazine, Total (µg/L)	6	.17	.23	<.01	.60	.60	0
2,4-D, Total (µg/L)	7	.04	.10	<.01	.27	.27	0
2,4,5-T, Total (µg/L)	7	<.01	0	<.01	.01	.01	0
Silvex, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Methyl Trithion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0
Ametryne, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Atratone, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Cyanazine, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Cyprazine, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Simetone, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Alachlor, Total (µg/L)	3	<.1	0	<.1	<.1	0	0
Trithion, Total (µg/L)	7	<.01	0	<.01	<.01	0	0

streamflow (fig. 9). Mean stormflow concentrations were much lower than mean base-flow concentrations except at subbasin 2, where little difference was observed. Subbasin 2 contained mostly forest and was underlain by schist, whereas the other sites were mostly agricultural and were underlain by limestone.

Mean nitrite-plus-nitrate nitrogen concentrations were usually lower during storms (fig. 9) than base flows, and ranged from 3 to 7 mg/L as N. Mean concentrations of ammonia nitrogen and total nitrogen (figs. 10 and 11) during storms were two to three times greater than base-flow concentrations at all subbasins except subbasin 2. Maximum and mean concentrations for dissolved ammonia were about half that of total ammonia, indicating that nearly equal amounts of ammonia nitrogen were transported in the dissolved and suspended phases. Mean stormflow concentrations of total and dissolved ammonia nitrogen ranged from 0.1 to 0.5 mg/L as N at all sites. The maximum stormflow concentration of total ammonia nitrogen was 4.2 mg/L at subbasin 5. Elevated concentrations also were found at subbasins 1, 6, and 7. Maximum stormflow concentrations of total nitrogen ranged from 13 mg/L as N at subbasin 2 to 51 mg/L as N at subbasin 1. Total organic nitrogen was the largest component of total nitrogen. The organic nitrogen was mainly suspended, and was probably a combination of material that was sorbed to sediment particulate and material that was transported in colloidal or particulate form during storms.

Mean total phosphorus concentrations during storms, except at subbasin 2, were between 1 and 4 mg/L as P--about two to three times higher than concentrations during base flow. Only 10 to 20 percent of the total phosphorus in stormflow was dissolved, and most of the dissolved phosphorus was in the form of orthophosphate. The suspended phosphorus fraction was mostly organic and hydrolyzable phosphorus. Subbasins 4 and 6 had the highest stormflow concentrations of total phosphorus, 15 mg/L as P. The maximum phosphorus concentrations occurred simultaneously with the highest observed suspended-sediment concentrations.

Mean dissolved organic carbon concentrations during storms (fig. 12) were from 7 to 13 mg/L, which is two times higher than concentrations during base flow. Dissolved organic carbon concentrations at subbasins 1 and 3 reached 50 mg/L or more during storms, while concentrations at subbasins 4 to 7 were between 38 and 44 mg/L. The concentration at subbasin 2 only reached 26 mg/L.

Mean suspended organic carbon concentrations during storms were from 10 to 30 mg/L, which is 5 to 15 times higher than concentrations during base flow. Maximum concentrations reached 170 mg/L at subbasin 6 during storms, and ranged from 90 to 120 mg/L at the other subbasins. Maximum suspended organic carbon concentrations at subbasin 2 were just as high as at most of the other subbasins, probably because of humus and leaf litter from the forest.

From four to eight samples were collected at each subbasin for pesticide analysis during storms. Nearly 40 pesticide samples were collected at subbasin 1 (table 18). Many more pesticides were found in samples collected during storms than during base flow, and a summary of these data is shown in table 18. Subbasins 1 and 6 contained most of the highest levels of pesti-

Table 18.--Summary of pesticide analyses during storms

Pesticide	Concentration, in µg/L mean	Concentration, in µg/L maximum	Subbasin(s) with maximum concentration
Atrazine	1.9	24	3
Simazine	.38	5.4	1
Prometone	.01	.7	1
Lindane	<.01	.03	1,3
Chlordane	.02	.2	1,3
DDD	<.01	.01	1,6
DDE	<.01	.07	6
DDT	.01	.12	6
Diazinon	<.01	.08	1,6
Dieldrin	.01	.08	4,6
Silvex	<.01	.09	1
PCB	<.1	.2	1
2,4-D	.09	1.2	1,3
2,4,5-T	<.01	.04	1
Heptachlor	<.01	.01	6
Heptachlor epoxide	<.01	.03	6
Methyl parathion	<.01	.06	7
Methoxychlor	.02	.02	6

cides sampled. Herbicides were prevalent throughout the basin; the triazine herbicides, in particular, were present in the highest concentrations. Atrazine was by far the most abundant triazine, with a mean concentration of 1.9 μg/L and a maximum concentration of 24 μg/L during storms.

Chlordane and DDT had mean concentrations above the USEPA recommended limits of 0.01 and 0.001 μg/L, respectively, for freshwater aquatic life. Storm concentrations of lindane, PCB, and heptachlor slightly exceeded the USEPA recommended limits of 0.01, 0.001, and 0.001 μg/L, respectively, for freshwater aquatic life (U.S. Environmental Protection Agency, 1976).

SUMMARY AND CONCLUSIONS

The transport of suspended sediment, nitrogen, phosphorus, and pesticides were studied in Pequea Creek basin, a tributary to the Susquehanna River in southeastern Pennsylvania. The objective of the study was to (1) determine the total discharges of suspended sediment, nitrogen, and phosphorus from Pequea Creek basin; (2) determine the variations in stormflow and base-flow discharges of suspended sediment, nitrogen, phosphorus, organic carbons, and pesticides from seven subbasins; and (3) evaluate the factors that affect the occurrence and transport of suspended sediment, nitrogen, and phosphorus.

Pequea Creek basin is 68 percent agricultural, and nearly half of that is planted with corn. The agriculture and abundance of carbonate rocks in the basin impact both base-flow and storm water quality in Pequea Creek and its tributaries.

Alkalinity, pH, and specific conductance increase in Pequea Creek during base flow because of the underlying carbonate rocks. Concentrations of nitrogen and phosphorus species are generally low during base flow, except for nitrite-plus-nitrate nitrogen, that averaged 5.3 mg/L as N. Nitrate concentrations during base flow did not exhibit much seasonal variation despite large applications of nitrogen in the spring. Fine suspended-sediment particles can be transported during base flows, especially from pasture areas.

The study period was slightly wetter than the long-term average. Streamflow averaged 282 ft^3/s for Pequea Creek at Martic Forge. Average annual yields from the basin were 1,950 ton/mi^2 for suspended sediment, 13.8 ton/mi^2 for total nitrogen, and 1.8 ton/mi^2 for phosphorus. These yields are five times higher than any previously measured in the Susquehanna River basin.

Chemical analyses of rainfall samples indicated that precipitation was not a major source of nitrogen and phosphorus. In fact, assuming that all of the constituents measured in precipitation were discharged from the basin without any uptake by plants or sorption by soils, precipitation would account for only 33 percent of organic ammonia nitrogen and less than 2 percent of phosphorus.

About 34 percent of the flow from the basin occurred during storms. Storms transported 89 percent of the suspended sediment, 85 percent of the phosphorus, 84 percent of the Kjeldahl nitrogen, 55 percent of the total nitrogen, 82 percent of the suspended organic carbon, 50 percent of the dissolved organic carbon, and 14 percent of the nitrite-plus-nitrate nitrogen. The discharges of all species of nitrogen and phosphorus, suspended sediment, and pesticides increased with increasing flow at each subbasin. This indicated that the amount of material available for transport to streams during storms exceeded what was actually transported. The long-term application of fertilizers, manure, and pesticides to cropland apparently created this overabundance.

Discharges of suspended sediment, suspended organic carbon, and phosphorus from Pequea Creek basin were largest in May and during the winter. During these two periods, the soil is the least protected from erosion, and rainfall easily washes soil particles to the stream for transport. Organic carbon and phosphorus were directly related to suspended sediment.

Most of the pesticides monitored that were detected were present in small quantities during base flows and stormflows. The highest concentrations of herbicides detected were for 2,4-D, atrazine, and simazine. The highest concentrations occurred in the spring during and immediately after planting. Concentrations decreased through the year, but there was carryover of some herbicides from one spring to the next. Although the concentrations of triazine herbicides detected were not high enough to kill aquatic weeds and grasses in the streams, the discharges of these pesticides may temporarily increase the load carried by the Susquehanna River to the upper Chesapeake Bay by as much as 25 percent. The insecticides chlordane and DDT had mean concentrations of 0.02 and 0.01 μg/L, respectively, which exceeded USEPA limits for freshwater aquatic life. Lindane, PCB, and heptachlor slightly exceeded maximum limits during storms.

Bottom-material samples contained two times more nutrients in the upper Pequea basin than the lower basin. The DDT series of pesticides was also highest at one upper subbasin site. The increased percentage of agriculture, coupled with increased applications of fertilizers and pesticides for many years, probably contributed to the increased incidence of nutrients and pesticides in bottom material.

REFERENCES CITED

Austin, J. J., Jr., Bubeck, R. C., and Munson, T. O., 1978, Monitoring of the upper Chesapeake Bay for the symetrical triazine herbicides atrazine and simazine: 12th Middle Atlantic Meeting of the American Chemical Society, Maryland.

Barr, A. J., Goodnight, J. H., Sall, J. P., and Helwig, J. T., 1976, "A User's Guide to SAS-76," SAS Institute Inc., Raleigh, North Carolina, 329 p.

Carter, R.W. and Davidian, Jacob, 1965, Discharge Ratings at Gaging Stations: Book 1, Chapter 12, U.S. Geological Survey Surface Water Techniques, 36 p.

Clark, L. J., Donnelly, D. K., and Villa, Orterio, 1973, Nutrient enrichment and control requirements in the upper Chesapeake Bay: Environmental Protection Agency, Region III, Annapolis field office, Technical Report 56, 58 p.

Clarke, L. J., Guide, Victor, and Phieffer, T. H., 1974, Summary and Conclusions - Nutrient transport and accountability in the lower Susquehanna River basin: U.S. Environmental Protection Agency, Region III, Annapolis field office, Technical Report 60, 91 p.

Culbertson, J. K., and Feltz, H. R., 1972, Sampling procedures and problems in determining pesticide residues in the hydrologic environment: Pesticides Monitoring Journal, v. 6, no. 3, p. 171-178.

Dumper, T. A., and Kirkaldie, Louis, 1967, Sediment and erosion estimates for Pennsylvania River basins: U.S. Department of Agriculture, Soil Conservation Service, 36 p.

Federal Working Group on Pesticide Management, 1974, Guidelines on sampling and statistical methodologies for ambient pesticide monitoring: U.S. Government Printing Office-1975-626-592/216 3-1, 50 p.

Feltz, H. R., 1980, Significance of bottom material data in evaluating water quality: Contaminants and Sediments, v. 1, Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, p. 271-287.

Fisher, D. W., 1968, Annual variations in chemical composition of atmospheric precipitation--eastern North Carolina and southeastern Virginia: U.S. Geological Survey Water-Supply Paper 1535-M, 21 p.

Gambell, A. W., and Fisher, D. W., 1966, Chemical composition of rainfall--eastern North Carolina and southeastern Virginia: U.S. Geological Survey Water-Supply Paper 1535K, 41 p.

Goerlitz, D. F., and Brown, Eugene, 1972, Methods for analysis of organic substances in water: Book 5, Chapter A3, U.S. Geological Survey Techniques of Water-Resources Investigations, 40 p.

Goerlitz, D. F., and Law, L. M., 1974, Distribution of chlorinated hydrocarbons in stream-bottom material: U.S. Geological Survey Journal of Research, v. 2, no. 5, p. 541-543.

Guy, H. P., 1969, Laboratory theory and methods for sediment analysis: Book 5, Chapter C1, U.S. Geological Survey Techniques of Water-Resources Investigations, 58 p.

Guy, H. P., and Norman, V. W., 1970, Field methods for measurement of fluvial sediment: Book 3, Chapter C2, U.S. Geological Survey Techniques of Water-Resources Investigations, 59 p.

Lietman, P. L., Ward, J. R., and Behrendt, T. E., 1983, Effects of Specific Land uses in Nonpoint Sources of Suspended Sediment, Nutrients, and Herbicides-Pequea Creek Basin, Pennsylvania. 1979-80: U.S. Geological Survey Water-Resources Investigations Report 83-4113, 88 p.

Peters, N. E. and Bonelli, J. E., 1982, Chemical Composition of Bulk Precipitation in the North-Central and Northeastern United States, December 1980 through February 1981: U.S. Geological Survey Circular 874, 63 p.

Porterfield, George, 1972, Computation of fluvial-sediment discharge: Book 3, Chapter C3, U.S. Geological Survey Techniques of Water-Resources Investigations, 66 p.

Skougstad, M. W., and others (eds), 1979, Methods for the determination of inorganic substances in water and fluvial sediments: Book 5, Chapter A1, U.S. Geological Survey Techniques of Water-Resources Investigations, 626 p.

U.S. Department of Agriculture, 1959, Soil Survey, Lancaster County: Pennsylvania Soil Conservation Service Report, ser. 1956, no. 4, 131 p.

U.S. Environmental Protection Agency, 1974, Methods for chemical analysis of water and wastes: EPA-625-16-74-003.

______, 1976, Quality Criteria for Water: EPA-440-9-76-023, 501 p.

Ward, J. R., and Eckhardt, D. A., 1979, Nonpoint-source discharges in Pequea Creek basin, Pennsylvania, 1977: U.S. Geological Survey Water-Resources Investigations 79-88, 110 p.