

*Front cover photograph:
Big Elk Creek at Maple Grove, Pa. (Site 59 - 01494953)
Photograph by Stacy Lathrop, U.S. Geological Survey*

U.S. Department of the Interior
U.S. Geological Survey

Assessment of Water Chemistry, Habitat, and Benthic Macroinvertebrates at Selected Stream-Quality Monitoring Sites in Chester County, Pennsylvania, 1998-2000

by Andrew G. Reif

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In cooperation with the
CHESTER COUNTY WATER RESOURCES AUTHORITY

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U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS AND ABBREVIATIONS

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
<u>Length</u>		
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
<u>Area</u>		
square mile (mi ²)	2.590	square kilometer
<u>Flow rate</u>		
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second
<u>Temperature</u>		
degree Fahrenheit (°F)	°C = 5/9 (°F-32)	degree Celsius

Abbreviated water-quality units used in report:

m	meter
μg/kg	micrograms per kilogram
μg/L	micrograms per liter
μm	micron
μS/cm	microsiemens per centimeter at 25 degrees Celsius
mg/L	milligrams per liter
m ²	square meter

ASSESSMENT OF WATER CHEMISTRY, HABITAT, AND BENTHIC MACROINVERTEBRATES AT SELECTED STREAM-QUALITY MONITORING SITES IN CHESTER COUNTY, PENNSYLVANIA, 1998-2000

by *Andrew G. Reif*

ABSTRACT

Biological, chemical, and habitat data have been collected from a network of sites in Chester County, Pa., from 1970 to 2003 to assess stream quality. Forty sites in 6 major stream basins were sampled between 1998 and 2000. Biological data were used to determine levels of impairment in the benthic-macroinvertebrate community in Chester County streams and relate the impairment, in conjunction with chemical and habitat data, to overall stream quality. Biological data consisted of benthic-macroinvertebrate samples that were collected annually in the fall. Water-chemistry samples were collected and instream habitat was assessed in support of the biological sampling.

Most sites in the network were designated as nonimpacted or slightly impacted by human activities or extreme climatic conditions on the basis of biological-metric analysis of benthic-macroinvertebrate data. Impacted sites were affected by factors, such as nutrient enrichment, erosion and sedimentation, point discharges, and droughts and floods. Streams in the Schuylkill River, Delaware River, and East Branch Brandywine Creek Basins in Chester County generally had low nutrient concentrations, except in areas affected by wastewater-treatment discharges, and stream habitat that was affected by erosion. Streams in the West Branch Brandywine, Christina, Big Elk, and Octoraro Creek Basins in Chester County generally had elevated nutrient concentrations and stream-bottom habitat that was affected by sediment deposition.

Macroinvertebrate communities identified in samples from French Creek, Pigeon Creek (Schuylkill River Basin), and East Branch Brandywine Creek at Glenmoore consistently indicate good stream conditions and were the best conditions measured in the network. Macroinvertebrate communities identified in samples from Trout Creek (site 61), West Branch Red Clay Creek (site 55) (Christina River Basin), and Valley Creek near Atglen (site 34) (Octoraro Creek Basin) indicated fair to poor stream conditions and were the worst

conditions measured in the network. Trout Creek is heavily impacted due to erosion, and Valley Creek near Atglen and West Branch Red Clay Creek are influenced by wastewater discharges.

Hydrologic conditions in 1999, including a prolonged drought and a flood, influenced chemical concentrations and macroinvertebrate community structure throughout the county. Concentrations of nutrients and ions were lower in 1999 when compared to 1998 and 2000 concentrations. Macroinvertebrate communities identified in samples from 1999 contained lower numbers of individuals when compared to 1998 and 2000 but had similar community structure. Results from chemical and biological sampling in 2000 indicated that the benthic-macroinvertebrate community structure and the concentrations of nutrients and ions recovered to pre-1999 levels.

INTRODUCTION

The Chester County Water Resources Authority (CCWRA) and the U.S. Geological Survey (USGS) established the "Stream Conditions of Chester County Biological Monitoring Network" in 1970. The data from this network represents one of the longest nearly continuous water-quality data sets in the country. The goals of the network are to assess the impairment of streams in Chester County and to further the understanding of stream changes in response to urbanization by the use of benthic-macroinvertebrate data (Lium, 1977). Benthic macroinvertebrates are aquatic insects and other invertebrates that live on the stream bottom. They are useful in evaluating the overall health (quality) of a stream because their habitat preference and low mobility make them good indicators for assessing changes in the aquatic system. By evaluating the diversity and community structure of benthic-macroinvertebrate populations, a determination of stream quality can be made.

Purpose and Scope

This report describes chemical, habitat, and biological conditions from 1998 to 2000 at 40 stream sites that were part of the Stream Conditions of Chester County Biological Monitoring Network. Stream quality was assessed by analyzing benthic-macroinvertebrate communities. Chemical and habitat data were related to benthic-macroinvertebrate data to provide a more complete assessment of stream conditions. This report provides a station-by-station evaluation of the sites in the network. This information is needed to assist Chester County in identifying streams or reaches of streams that are biologically stressed and will help the County assess the effects of past land-use practices. In addition, this information is needed for water-resources management in accordance with Chester County's Landscapes Comprehensive Plan (Chester County, 1996).

Previous Investigations

The physical, chemical, and biological data previously collected in the Network are contained in three USGS data reports. Complete analytical and biological results are given by Moore (1989) for 1969-80, by Reif (1999) for 1981-94, and by Reif (2000) for 1995-97. The physical and chemical data for the 1974-2001 water years¹ also were published in the USGS annual water-data reports for Pennsylvania (U.S. Geological Survey, 1975-2001). The data were evaluated in numerous reports listed below.

Lium (1977) developed a biotic index that used a 10-point rating scale to assess the environmental conditions at the original 50 sites in the Network on the basis of data in his previous report (Lium, 1976). The ratings developed by Lium indicated most streams studied were experiencing nutrient enrichment and (or) sediment deposition. In 1967-68, a study was conducted by Miller and others (1971) in the Pickering and East Branch Brandywine Creek Basins to document the hydrologic conditions of these two small basins prior to urbanization.

Moore (1987) evaluated the physical, chemical, and biological data collected as part of the Stream Conditions of Chester County Biological Monitoring Network from 1969 to 1980. This study showed statistically valid upward trends in Brillouin's

diversity index during 1970 to 1980 at 27 sites where improved environmental quality was indicated. Both Lium (1977) and Moore (1987) observed that total dissolved solids correlated significantly with the biotic index and the diversity index.

Sloto (1987) evaluated the effects of urbanization on the water resources of eastern Chester County. This study showed basins with the greatest change in land use, from undeveloped to developed, had the greatest upward change in macroinvertebrate diversity. Sloto attributed this to decreased pesticide use in urbanizing basins and to the burial and (or) flushing of older pesticides.

Hardy and others (1995) examined land-use changes and concentrations of organochlorine compounds in stream-bottom sediment in relation to the trends in diversity indices of benthic-macroinvertebrate communities. This report showed that upward trends in benthic-macroinvertebrate community diversities were associated with increases in residential land use and decreases in agricultural land use. It also described an association between low community-diversity values and organochlorine compound concentrations above 45 µg/kg in stream-bottom material. Data collected as part of the Stream Conditions of Chester County Biological Monitoring Network were used in this report.

Reif (2002) evaluated the physical, chemical, and biological data collected as part of the Stream Conditions of Chester County Biological Monitoring Network from 1981 to 1997. Most sites in the network were assessed as nonimpacted or slightly impacted between 1981 and 1997. The poorest stream quality was found at sites with greater than 50 percent agricultural land use, greater than 10 percent impervious surface, and sites affected by discharges from wastewater-treatment plants. Trend analysis indicated that calculated biological metrics at most sites improved or remained unchanged between 1981 and 1997. Trend analysis on chemical constituents indicated that concentrations of nitrate and chloride were increasing, and concentrations of phosphorus and ammonia were unchanged or declining.

¹ The 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends.

Description of Study Area

Chester County is a 760-mi² area in southeastern Pennsylvania (fig. 1). It lies in the Piedmont Physiographic Province of the Appalachian Highlands. The area is characterized by gently rolling hills underlain by deeply weathered crystalline rock. The streams included in this study drain nearly 95 percent of Chester County. The largest basin is the Brandywine Creek Basin, which drains 290 mi² (38 percent) of the County. The eastern part of the County is more developed; the southern and western parts of the County contain more farm and pasture land (fig. 2). Major crops are hay, corn, vegetables, and mushrooms. Dairy and equestrian farms are common in the area.

Chester County has undergone and continues to experience rapid population growth. The County population nearly doubled between 1960 and 1995, increasing from 210,600 to 412,000 (Chester County, 1996). Population projections indicate the County will have 489,000 residents by 2020 (Chester County, 1996). In response to this rapid growth, open space and farmland have been converted to residential and commercial land. Farmland in the County decreased from 47 percent in 1974 to 37 percent in 1992. The percentage of developed land is projected to increase from 23 percent in 1990 to 38 percent in 2020 (Chester County, 1996). Land-use data used in this report have been supplied by Lancaster County (Lancaster County, 2002) and the Delaware Valley Planning Commission (Delaware Valley Regional Planning Commission, 1997).

Climate

The study area has a humid, modified continental climate characterized by warm summers and moderately cold winters. The normal (1971-2000) mean annual temperature at Phoenixville is 53.2°F. The normal (1971-2000) mean temperature for January, the coldest month, is 30.2°F, and the normal mean temperature for July, the warmest month, is 75.1°F. The normal (1971-2000) annual precipitation at Phoenixville is 43.87 in. (National Oceanic and Atmospheric Administration, 2002). Precipitation is distributed fairly evenly throughout the year; however, slightly more occurs during the warmer months because of localized thunderstorms.

Description of Network

In 1969, a reconnaissance of Chester County was conducted by the USGS to determine the general conditions of streams and identify land-use patterns. In 1970, the reconnaissance served as a guide to establishing a chemical and biological stream-quality network of 40 sites in 13 stream basins. The sites were established on the basis of equal cumulative square miles of drainage area within each basin (Lium, 1977). Each site was established away from any known source of pollution so that the quality of the overall stream could be assessed. Twelve sites were added and 9 sites discontinued between 1972 and 1982. Between 1981 and 1997, 43 sites were sampled.

Since 1997, the Stream Conditions of Chester County Biological Monitoring Network has consisted of 18 fixed sites (fig. 1) that are sampled annually in the fall for benthic macroinvertebrates and water chemistry, along with assessments of habitat conditions. These 18 sites are in the major drainage basins throughout the County, which include Pigeon, French, Pickering, Valley, Crum, Ridley, East Branch Chester, Red Clay, White Clay, Brandywine, and Big Elk, East Branch Octoraro Creeks and Buck Run. All streams sampled originate within the boundaries of Chester County, except for the headwaters of the West Branch Brandywine, French, and Octoraro Creeks. Octoraro Creek forms part of the western border of the County, and its headwaters are in Chester and Lancaster Counties (fig. 1). Headwaters for the West Branch Brandywine Creek are in Lancaster County, and the headwaters for French Creek are in Berks County.

In addition to the 18 fixed sites, 22 miscellaneous sites were sampled from 1998 through 2000 (table 1). In 2000, eight miscellaneous sites were located in the Valley Creek Basin as part of a synoptic sampling effort (table 2). These sites were chosen to provide information on small drainages not covered by the fixed sites or to provide more detailed information for a drainage area with a fixed site. Miscellaneous sites are commonly on tributaries to the creeks listed above, upstream or downstream of a fixed site, or synoptic sampling locations in a single basin. These miscellaneous sites may be previously sampled sites or newly established sites.

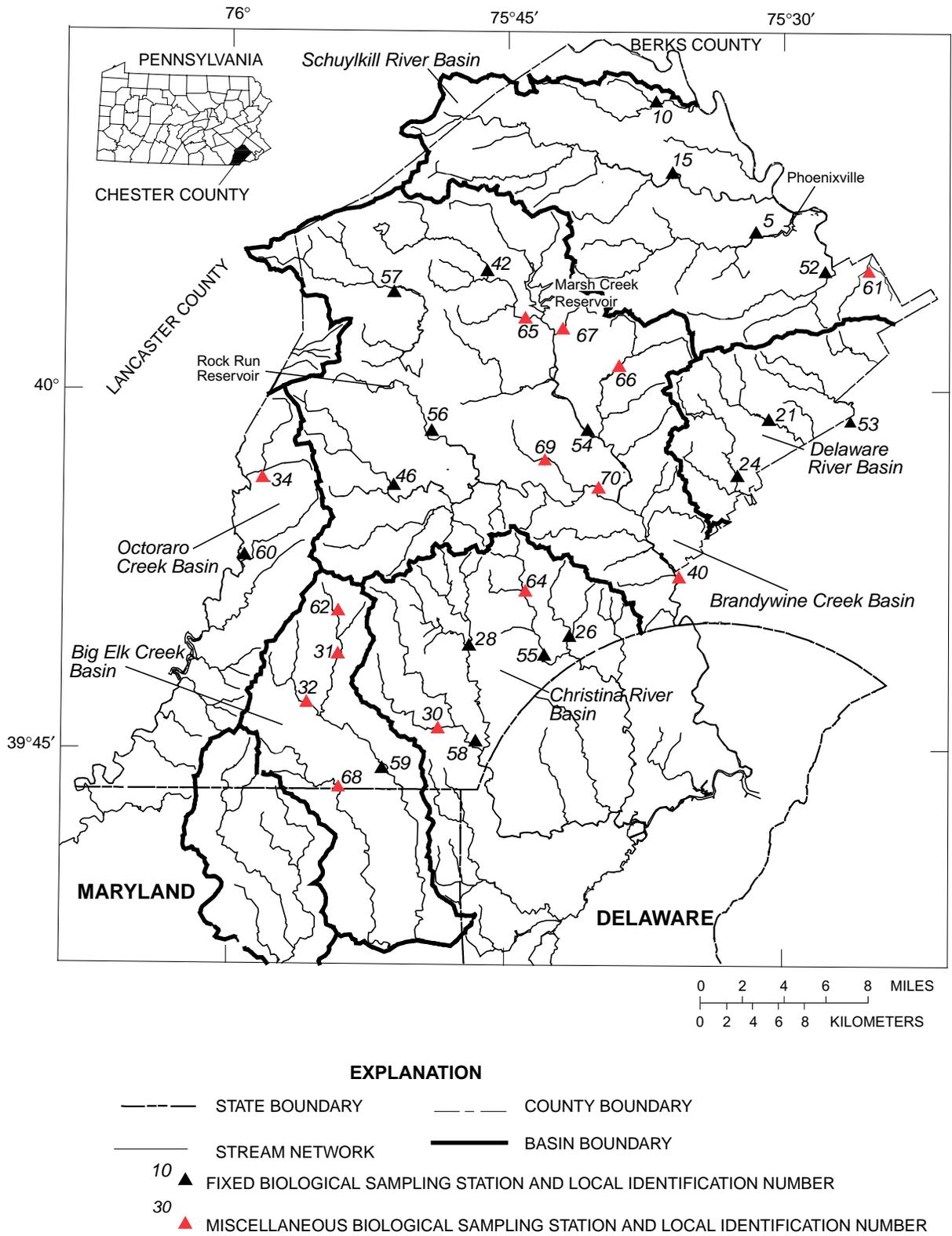


Figure 1. Biological sampling sites and major drainage basins in Chester County, Pennsylvania, and surrounding area.

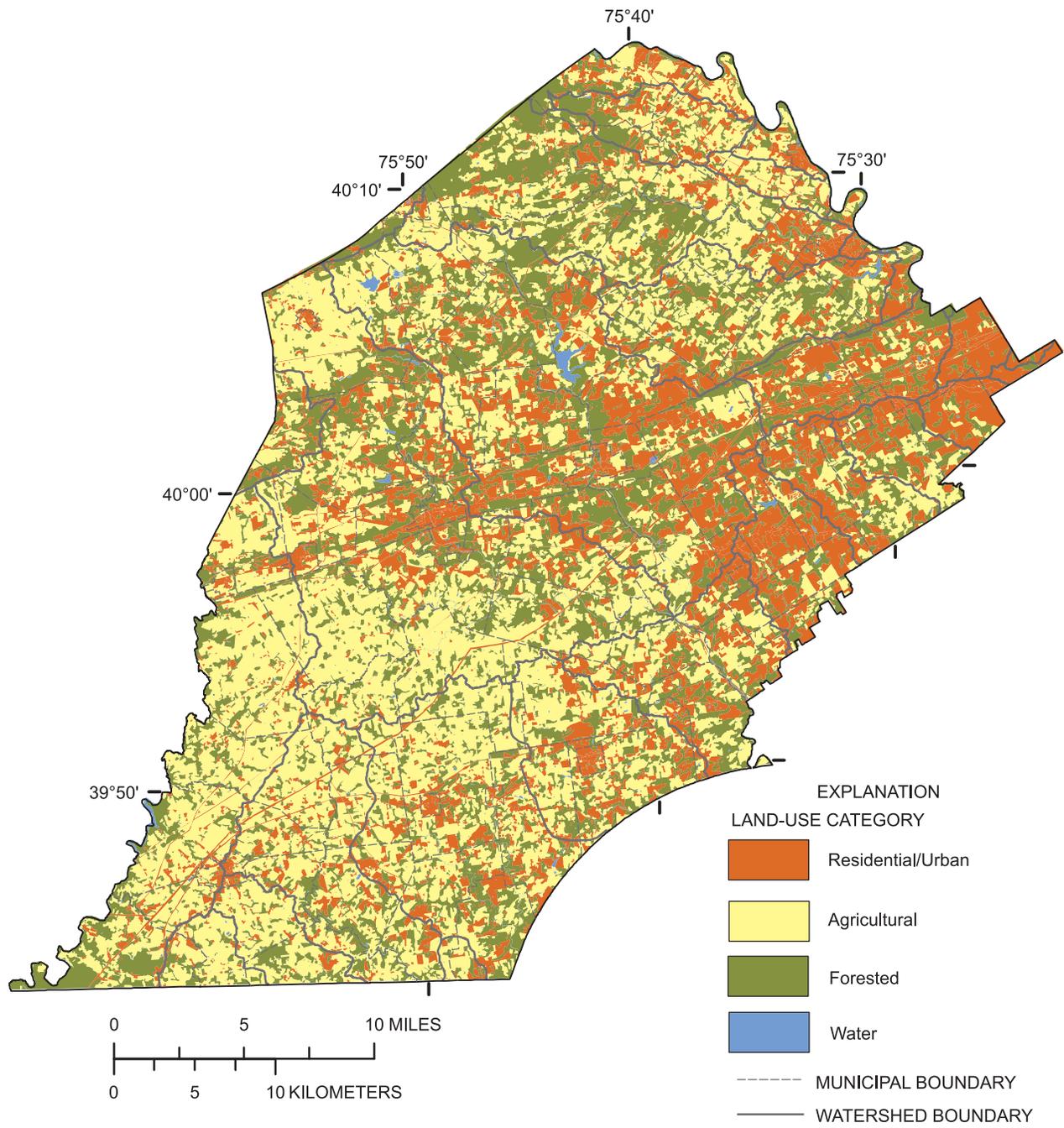


Figure 2. Land use in Chester County, Pennsylvania.

Table 1. Sampling sites in the Chester County Biological Monitoring Network, Chester County, Pennsylvania, 1998-2000

U.S. Geological Survey station identification number	Local number	Station name	Latitude	Longitude	Drainage area (square miles)	Sampling year
<u>Schuylkill River Basin</u>						
01472080	¹ 10	Pigeon Creek near Slonaker, Pa.	40°12'03"	75°37'10"	12.0	1998-2000
01472157	¹ 15	French Creek near Phoenixville, Pa. (Reference station)	40°09'05"	75°36'06"	59.1	1998-2000
01472190	¹ 5	Pickering Creek near Phoenixville, Pa.	40°06'33"	75°31'42"	31.4	1998-2000
01473169	¹ 52	Valley Creek at Pa. Turnpike Bridge near Valley Forge, Pa.	40°04'45"	75°27'40"	20.8	1998-2000
01473197	61	Trout Creek at Pa. Turnpike Bridge near Valley Forge, Pa.	40°05'22"	75°25'26"	3.67	2000
<u>Delaware River Basin</u>						
01475850	¹ 53	Crum Creek at Newtown Square, Pa.	39°58'35"	75°26'13"	15.8	1998-2000
01476435	¹ 21	Ridley Creek at Dutton Mill near West Chester, Pa.	39°58'52"	75°31'02"	9.71	1998-2000
01476835	¹ 24	East Branch Chester Creek at Westtown, Pa.	39 56'26"	75°32'30"	10.4	1998-2000
<u>Christina River Basin</u>						
01478120	¹ 28	East Branch White Clay Creek at Avondale, Pa.	39°49'42"	75°46'52"	11.3	1998-2000
01478220	30	West Branch White Clay Creek near Chesterville, Pa.	39°45'56"	75°47'47"	9.92	1998
01478230	¹ 58	Middle Branch White Clay Creek near Avondale, Pa.	39°45'02"	75°46'19"	25.5	1998-2000
01479679	64	West Branch Red Clay Creek above Kennett Square, Pa.	39°50'59"	75°43'28"	8.63	1998-99
01479700	¹ 55	West Branch Red Clay Creek near Kennett Square, Pa.	39°48'39"	75°42'19"	16.9	1998-2000
01479800	¹ 26	East Branch Red Clay Creek near Five Points, Pa.	39°49'11"	75°41'29"	10.2	1998-2000
<u>Brandywine Creek Basin</u>						
01480300	¹ 57	West Branch Brandywine Creek near Honey Brook, Pa.	40°04'22"	75°51'40"	18.7	1998-2000
01480617	¹ 56	West Branch Brandywine Creek at Modena, Pa.	39°57'42"	75°48'06"	55.0	1998-2000
01480629	¹ 46	Buck Run at Doe Run, Pa.	39°55'46"	75°49'24"	22.6	1998-2000
01480636	69	Broad Run at Romansville, Pa.	39°57'06"	75°43'33"	2.86	1999
01480638	70	Broad Run at Northbrook, Pa.	39°55'49"	75°41'06"	6.39	1999
01480653	¹ 42	East Branch Brandywine Creek at Glenmoore, Pa.	40°05'48"	75°46'44"	16.5	1998-2000
01480662	65	Culbertson Run at Lyndell, Pa.	40°03'29"	75°45'07"	3.92	1998
01480697	67	Shamona Creek at Dowlin, Pa.	40°02'28"	75°41'57"	3.85	1998-99
01480870	¹ 54	East Branch Brandywine Creek below Downingtown, Pa.	39°58'07"	75°40'25"	89.9	1998-2000
01480883	66	West Valley Creek at Clover Mill Road near Exton, Pa.	40°00'43"	75°39'20"	11.8	1998
01481000	40	Brandywine Creek at Chadds Ford, Pa.	39°51'15"	75°35'58"	291	1999
<u>Big Elk Creek Basin</u>						
01494800	62	East Branch Big Elk Creek at Faggs Manor, Pa.	39°50'45"	75°54'22"	3.55	1998
01494900	31	East Branch Big Elk Creek at Elkview, Pa.	39°48'45"	75°54'04"	11.1	1998-99
01494950	32	West Branch Big Elk Creek near Oxford, Pa.	39°46'45"	75°55'27"	10.0	1998-99
01494953	¹ 59	Big Elk Creek at Maple Grove, Pa.	39°45'44"	75°55'16"	26.6	1998-2000
01495300	68	Little Elk Creek at Elk Mills, Pa.	39°43'36"	75°54'28"	11.8	1999
<u>Octoraro Creek Basin</u>						
01578343	34	Valley Creek near Atglen, Pa.	39°56'23"	75°59'06"	10.5	1998-99
01578347	¹ 60	East Branch Octoraro Creek near Steelville, Pa.	39°52'58"	75°59'31"	37.3	1998-2000

¹ Fixed biological sampling site.

Table 2. Miscellaneous sites sampled during synoptic sampling in the Valley Creek Basin, Chester County, Pennsylvania, October 2000

U.S. Geological Survey station identification number	Local number	Station name	Latitude	Longitude	Drainage area (square miles)
01473154	63	Valley Creek at Mill Lane, Pa.	40°03'03"	75°33'17"	4.14
01473155	71	Valley Creek at Rt. 202 at Mill Lane, Pa.	40°03'05"	75°33'03"	5.10
01473160	72	Valley Creek near Devault, Pa.	40°03'37"	75°31'44"	6.22
01473163	73	Valley Creek at Cedar Hollow, Pa.	40°04'03"	75°31'01"	9.23
01473167	49	Little Valley Creek at Howellville, Pa.	40°04'00"	75°28'22"	6.45
01473168	50	Valley Creek near Valley Forge, Pa.	40°04'11"	75°28'25"	12.7
01473170	74	Valley Creek at Wilson Road near Valley Forge, Pa.	40°04'53"	75°27'25"	22.0
01473180	75	Valley Creek at Valley Forge, Pa.	40°06'00"	75°27'47"	23.4

Hydrologic Conditions

Hydrologic conditions can have a significant impact on the chemistry, habitat, and chemical constituents. Extreme low-flow conditions can result in higher water temperatures, decreased dissolved oxygen levels, and an increased concentration of chemical constituents. All of these can cause a shift in the benthic-macroinvertebrate community found at a site. High-flow conditions can cause physical alteration to the stream bottom that will negatively impact the benthic-macroinvertebrate community.

Both a prolonged regional drought and flooding related to Hurricane Floyd occurred in 1999. The USGS streamflow-gaging station at site 54 (fig. 1), East Branch Brandywine Creek below Downingtown, Pa., was established in February 1972. The lowest daily mean discharge of 23 ft³/s was recorded on July 23, 1999, and the highest daily mean discharge of 3,080 ft³/s with a peak discharge of 3,600 ft³/s was recorded on September 16, 1999, less than 3 weeks before the 1999 sampling began (U.S. Geological Survey, 1999). The extreme hydrologic conditions that occurred in 1999 had a major effect on stream conditions as evidenced by the chemical, habitat, and biological data collected in 1999.

Hydrologic conditions in 1998 and 2000 were typical of normal flow conditions found in the area during October and November. Flow conditions usually are at their lowest values in August and September and they begin to slightly increase in October and November and continue rise to their peaks in the spring when streamflow begins to

decreases through the summer. Similar to long-term hydrologic patterns, the USGS streamflow-gaging station at site 54 (fig. 1), East Branch Brandywine Creek below Downingtown, Pa., recorded the lowest monthly mean discharges of 1998 and 2000 during August through November (U.S. Geological Survey, 1998, 2000).

Acknowledgments

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METHODS OF INVESTIGATION

Sampling and Analytical Methods

A summary of the methods used to collect and analyze the data are presented in the following section.

Field Measurements

Dissolved oxygen, pH, water temperature, specific conductance, alkalinity, and streamflow were measured during each biological site visit. Field measurements were made at the same time and location as the biological sample collection. Measurements were made from a single point near the center of flow. Field meters were calibrated prior to each use, and records of the performance of each meter were kept with the meter and recorded on each field data sheet. Calibration standards for pH and specific conductance were obtained from the USGS laboratory in Ocala, Fla.

Chemical Analysis

Samples for chemical analysis were collected at each sampling location using techniques described by Wilde and others (1999). Because the samples were collected under base-flow conditions and many of the streams are shallow, a non-isokinetic dip sample was collected at all sites. At sites greater than 3 m wide, multiple dip samples were collected and composited. Chemical samples were analyzed at the USGS National Water Quality Laboratory in Arvada, Colo., for nutrients, major ions, and selected metals according to methods in Fishman and Friedman (1989) and Wershaw and others (1987). Quality-control samples consisting of replicates and field blanks were collected to quantify information on the precision and bias of the overall field and laboratory process. Constituent concentrations in field blanks were less than the minimum reporting levels and replicate samples generally were within 10 percent. This indicates no systematic bias and good precision in the reported water-quality data.

Habitat Assessment

An assessment of habitat quality was performed at each site at the time of biological sampling and during the summer months. The habitat assessment was conducted according to the U.S. Environmental Protection Agency's (USEPA) Rapid Bioassessment Protocols (Barbour and others, 1999). Measurements such as stream width

and depth, available substrate, embeddedness, sediment deposition, and bank stability were made. Measurements were taken from several cross sections in a 100-m reach that included the biological sampling area (riffle). All evaluations were done at base-flow conditions. These measurements, along with the chemical and benthic-macroinvertebrate data, were used in the evaluation of overall stream quality. Although the habitat assessment was qualitative, quality assurance was evaluated by having multiple assessments done by different individuals at selected sites to check for inconsistencies and bias in the ratings.

Biological Assessment

Biological samples consisted of benthic macroinvertebrates collected from within a riffle. Three samples were collected from areas of various velocities using a Hess sampler with a mesh size of 500 μm . The Hess sampler is a metal cylinder with a net attached to capture dislodged organisms (Merritt and Cummings, 1996). The metal cylinder is approximately 0.5 m in diameter and samples an area of 0.8 m^2 . Three samples will cover an area of 2.4 m^2 . The samples were composited into a container, preserved in 95 percent ethanol, and returned to the laboratory for sorting and identification. The entire sample was sieved through a 500- μm sieve and sorted in the laboratory. Sorting efficiency was evaluated by resorting of selected completed samples. The samples were identified at the USGS office in Malvern, Pa. Benthic macroinvertebrates were identified to the lowest taxonomic level possible. Unusual taxa were confirmed by an expert taxonomist. A reference collection of identified organisms is stored at the USGS office in Malvern, Pa. A list of taxonomic references on which the identifications were based is given in table 3.

Table 3. List of taxonomic references used to identify benthic-macroinvertebrate samples

Taxonomic groups	Reference
Turbellaria, Nemertea, Nematoda, Gastropoda, Bivalvia, Annelida, and Arachnida	Pennak, 1989
Crustacea, Ephemeroptera, Odonata, Plecoptera, Lepidoptera, Coleoptera, Megaloptera, Neuroptera, and Diptera	Peckarsky and others, 1990
Trichoptera	Wiggins, 1996

Data Storage and Availability

The habitat, chemical, and biological data collected between 1970 and 1997 are contained in three USGS data reports. Complete analytical and biological results are given by Moore (1989) for 1969-80, by Reif (1999) for 1981-94, and by Reif (2000) for 1995-97. Chemical data for the 1974-2001 water years also have been published in the USGS annual water-data reports for Pennsylvania (U.S. Geological Survey, 1975-2001). Chemical data also are available through the USGS National Water Information System database at <http://waterdata.usgs.gov/nwis>. The biological data for the 1998-2001 water years are published in the USGS annual water resources data reports for Pennsylvania (U.S. Geological Survey, 1975-2001). Biological and habitat data are stored in local databases at the USGS office in Malvern, Pa., and are available by request.

Assessment of Stream Quality

A summary of the stream-quality assessment criteria along with a description of the biological metrics used in the assessment are presented in the following section.

Biological Metrics Evaluation

The evaluation of overall stream quality on the basis of benthic-macroinvertebrate sampling uses various biological metrics. Biological metrics commonly used to describe benthic-macroinvertebrate communities include taxa richness, Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness, percentage EPT individuals, and Hilsenhoff's biotic index (HBI). Each biological metric evaluates a different aspect of the invertebrate community and how it relates to overall stream quality. By examining all these biological metrics together, an evaluation of the overall stream quality can be made. The biological metrics used are described below.

Taxa richness is a measure of the number of different kinds of organisms (taxa) in a collection. Taxa richness measures the overall diversity of the biological community sampled. Taxa richness is decreased by decreasing stream quality (Weber, 1973; Resh and Grodhaus, 1983). The availability of adequate food, habitat, and niche space to support a variety of taxa is an indication of a healthy biological community and will be reflected in increasing taxa richness (Barbour and others, 1999). Thus, higher taxa richness is an indication of a healthy benthic-macroinvertebrate community.

EPT taxa richness is the total number of taxa within the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). **Percentage EPT individuals** is the total number of EPT individuals divided by the total number of individuals in the sample. These three orders of insects generally are considered pollution-sensitive and their presence is associated with good stream quality (Lenat, 1988). EPT taxa richness and the percentage EPT individuals generally increase with improving stream quality.

HBI is based on the sensitivity of organisms to organic pollution, water quality, and habitat conditions. The HBI uses assigned tolerance values that range from 0 to 10. A value of 0 is assigned to organisms least tolerant of organic pollution, poor water quality, and poor habitat conditions, and a 10 is assigned to organisms most tolerant of organic pollution, poor water quality, and poor habitat conditions. Organisms intermediate in their tolerance of organic pollution, poor water quality, and poor habitat conditions are assigned intermediate values (Hilsenhoff, 1982). The HBI is calculated by multiplying the number of individuals of each taxon by its assigned tolerance value, summing these products, and dividing by the total number of individuals. Tolerance values are from the genus and species-level biotic index developed by the State of New York (Bode, 1991). HBI values from 0 to 4.5 have been associated with nonimpacted sites, 4.51 to 6.50 have been associated with slightly impacted sites, 6.51 to 8.50 have been associated with moderately impacted sites, and 8.51 to 10 have been associated with severely impacted sites (Bode, 1993). (Note that unlike the other metrics, a lower score for the HBI indicates better water quality.)

Stream-Quality Assessment Criteria

Streams in the network were assessed as non-impacted, slightly impacted, moderately impacted, or severely impacted on the basis of calculated biological metric values (table 4). Each biological metric assesses a different part of the structure of the benthic-macroinvertebrate community to produce an overall assessment of stream quality.

Nonimpacted: Biological metrics indicate excellent stream quality. The benthic-macroinvertebrate community is balanced, diverse, and dominated by "pollution sensitive" and intermediate taxa (taxa that are intermediate in their pollution tolerance) including mayflies, stoneflies, and caddisflies. "Pollution tolerant" groups may be

Table 4. Stream-quality assessment criteria for Chester County streams (adapted from Bode, 1993)

[EPT, Ephemeroptera, Plecoptera, and Trichoptera; HBI, Hilsenhoff's biotic index; >, greater than]

Stream-quality assessment	Taxa richness	EPT taxa richness	HBI
Nonimpacted	>30	>10	0 - 4.50
Slightly impacted	21 - 30	6 - 10	4.51 - 6.50
Moderately impacted	11 - 20	2 - 5	6.51 - 8.50
Severely impacted	0 - 10	0 - 1	8.51 - 10

present but are not dominant. Water quality and habitat conditions are not limiting the benthic-macroinvertebrate community. Nonimpacted sites include pristine habitats and those receiving inputs that minimally affect the benthic-macroinvertebrate community.

Slightly Impacted: Biological metrics indicate good stream quality. The benthic-macroinvertebrate community is less diverse than at nonimpacted sites but still contains mayflies, caddisflies, and possibly some stoneflies. The community structure typically is dominated by a few taxa including caddisflies, elmids (riffle beetles), and chironomids (midges). Water quality and habitat conditions are having an effect on the benthic-macroinvertebrate community. Slightly impacted sites commonly receive some wastewater inputs and (or) agricultural/urban runoff.

Moderately Impacted: Biological metrics indicate fair stream quality. The benthic-macroinvertebrate community is disturbed and noticeably altered from a nonimpacted site. Mayflies and stoneflies are rare, and caddisfly taxa may be limited. The benthic-macroinvertebrate community is dominated by "pollution tolerant" and intermediate organisms including midges and oligochaetes (aquatic earthworms). One or a few groups usually dominate the community. Water quality and habitat conditions are having a significant effect on the benthic-macroinvertebrate community. Moderately impacted sites commonly receive heavy wastewater inputs and (or) agricultural/urban runoff.

Severely Impacted: Biological metrics indicate poor stream quality. The benthic-macroinvertebrate community is severely limited with poor diversity. Mayflies, stoneflies, and caddisflies are rare, and the community usually is dominated by chironomids and aquatic earthworms. The com-

munity may have low numbers of individuals or very high numbers of individuals from a few taxa. Severely impacted sites commonly receive inputs of a toxin or have extremely low concentrations (less than 4.0 mg/L) of dissolved oxygen. Water quality and habitat conditions are having a severe effect on the benthic-macroinvertebrate community. Severely impacted sites commonly receive heavy wastewater or industrial inputs, agricultural/urban runoff, and possible input of toxic substances.

Selection of Reference Sites

Reference sites represent very good, or best available, stream quality in a particular area. Reference sites are considered those that are least affected by input from anthropogenic sources. They have stable habitat, nontoxic concentrations of constituents analyzed for, and healthy biological conditions. Other sites with similar stream characteristics can be compared to the reference reach for evidence of degraded stream quality.

The site on French Creek near Phoenixville (site 15) was chosen as the reference site because it had a very diverse and healthy benthic-macroinvertebrate community, stable habitat, and consistent nontoxic concentrations of constituents analyzed for. Data has been collected at this site since 1971. The French Creek site received no direct discharges and had stable land use that is low in impervious surface and low in percentage of intense agricultural land use. Areas minimally affected by human activities are difficult to find in Chester County. Although the reference site is affected by input from anthropogenic sources, including agricultural activities, it represents stable, best-available stream quality in the area.

STREAM-QUALITY ASSESSMENTS

Assessments of stream conditions, on the basis of macroinvertebrate criteria, are presented in table 5. Sampling sites are located in the Schuylkill, Delaware, Christina, Brandywine, Big Elk, and Octoraro Creek Basins. The stream-quality assessments use biological metrics derived from data collected in 1998-2000. The biological metrics used in the assessments are taxa richness, EPT taxa richness, and the HBI index. The station location, drainage area, and setting are given for each site along with a discussion of chemical and habitat conditions and a description of the benthic-macroinvertebrate community. Some sites have historical data available prior to 1998, but only the data from 1998-2000 are discussed in this report.

Nutrients (nitrogen and phosphorus compounds) are naturally occurring compounds that are needed for plant and algae growth and are commonly found in elevated concentrations due to human activities. Sources of nutrients include commercial fertilizers and manure, wastewater-treatment discharges, septic systems, and atmospheric deposition. Elevated concentrations of nutrients can cause increased plant and algae growth in a stream that can alter benthic-macroinvertebrate communities, and indirectly cause low oxygen concentrations that can be fatal to aquatic organisms. A nitrate drinking water standard of 10 mg/L has been established, although concentrations above 0.3 mg/L can cause increased plant productivity (U.S. Environmental Protection Agency, 1994). Other factors such as water temperature and the amount of sunlight reaching the stream also contribute to the growth of plants and algae. All of these factors together control the nuisance plant growth. Phosphorus concentrations greater than 0.02 mg/L, when found in combination with elevated levels of inorganic nitrogen, can cause nuisance plant growth, which can lead to low concentrations of dissolved oxygen, which can cause decreased benthic-macroinvertebrate diversity (Buck and others, 2000). Sources of nitrate and phosphorus are commonly associated with nonpoint and wastewater discharges. Nonpoint sources encompass animal wastes and fertilizers, including fertilizers and animals in nonfarm (urban) situations. Sewage discharges include effluent from wastewater-treatment plants and ground-water flow from septic and spray irrigation systems.

Boron concentrations are related to the amount of wastewater discharge in the stream because wastewater discharge usually contains elevated concentrations of boron, which is an ingredient in many laundry detergents. Boron can be used as a conservative tracer of wastewater because of its high solubility and its insensitivity to evaporation, volatilization, and oxidation-reduction reactions (Vengosh, 1998; Pitt and others, 2000). Natural background concentrations of boron in Chester County are generally 30 µg/L or less (Sloto, 1987). Concentrations of boron above the natural background concentrations may be associated with wastewater discharges. Elevated concentrations of boron in Valley Creek (01473169) have been associated with ground-water discharge from a lithium/boron processing plant near the headwaters of Valley Creek and are not related to wastewater discharges (Sloto, 1987).

Metals and trace elements in small quantities are needed for normal plant and animal development. However, some metals and trace elements, such as mercury and arsenic, can be toxic at relatively low concentrations (Meade, 1995). Metals and trace elements in stream samples come from natural as well as artificial sources. Natural sources are from rock weathering, soil erosion, and the dissolution of salts. Artificial sources include wastewater discharges, industrial activities, mining, and agriculture. Samples for metals and trace elements were collected at selected stations.

Hydrologic conditions in 1999 were influenced by a drought in the summer of 1999 and the flood caused by Hurricane Floyd in September 1999. Discharge at many stations was 50 to 80 percent greater in October 1999 than in October 1998. Increased discharges can cause extreme physical disturbance of the bottom habitat of streams. In general, chemical samples had lower concentrations of nutrients and ions in 1999. At most stations, the 1999 benthic-macroinvertebrate samples contain lower numbers of individuals but taxa richness and EPT taxa richness were not greatly reduced and community structure was similar (U.S. Geological Survey, 2000, 2001). HBI values were generally higher and percentage EPT taxa values were lower in the 1999 samples.

Table 5. Designation of stream quality and median values of taxa richness, EPT taxa richness, and Hilsenhoff's biotic index for sites in the Stream Conditions of Chester County Biological Monitoring Network, 1998-2000

[EPT, Ephemeroptera, Plecoptera, and Trichoptera]

U.S. Geological Survey station identification number	Local number	Station name	Taxa richness	EPT taxa richness	Hilsenhoff's biotic index
Schuylkill River Basin					
01472080	10	Pigeon Creek near Slonaker, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01472157	15	French Creek near Phoenixville, Pa. (Reference station)	Nonimpacted	Nonimpacted	Nonimpacted
01472190	5	Pickering Creek near Phoenixville, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01473169	52	Valley Creek at Pa. Turnpike Bridge near Valley Forge, Pa.	Slightly impacted	Slightly impacted	Slightly impacted
01473197	61	Trout Creek at Pa. Turnpike bridge near Valley Forge, Pa.	Slightly impacted	Slightly impacted	Slightly impacted
Delaware River Basin					
01475850	53	Crum Creek at Newtown Square, Pa.	Nonimpacted	Nonimpacted	Slightly impacted
01476435	21	Ridley Creek at Dutton Mill near West Chester, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01476835	24	East Branch Chester Creek at Westtown, Pa.	Nonimpacted	Nonimpacted	Slightly impacted
Christina River Basin					
01478120	28	East Branch White Clay Creek at Avondale, Pa.	Slightly impacted	Nonimpacted	Slightly impacted
01478220	30	West Branch White Clay Creek near Chesterville, Pa.	Slightly impacted	Nonimpacted	Nonimpacted
01478230	58	Middle Branch White Clay Creek near Avondale, Pa.	Slightly impacted	Nonimpacted	Nonimpacted
01479679	64	West Branch Red Clay Creek above Kennett Square, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01479700	55	West Branch Red Clay Creek near Kennett Square, Pa.	Moderately impacted	Moderately impacted	Slightly impacted
01479800	26	East Branch Red Clay Creek near Five Points, Pa.	Slightly impacted	Slightly impacted	Slightly impacted
Brandywine Creek Basin					
01480300	57	West Branch Brandywine Creek near Honey Brook, Pa.	Nonimpacted	Nonimpacted	Slightly impacted
01480617	56	West Branch Brandywine Creek at Modena, Pa.	Slightly impacted	Slightly impacted	Slightly impacted
01480629	46	Buck Run at Doe Run, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01480636	69	Broad Run at Romansville, Pa.	Nonimpacted	Nonimpacted	Slightly impacted
01480638	70	Broad Run at Northbrook, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01480653	42	East Branch Brandywine Cr. at Glenmoore, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01480662	65	Culbertson Run at Lyndell, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01480697	67	Shamona Creek at Dowlin, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01480870	54	East Branch Brandywine Creek below Downingtown, Pa.	Nonimpacted	Nonimpacted	Slightly impacted
01480883	66	West Valley Creek at Clover Mill Road near Exton, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01481000	40	Brandywine Creek at Chadds Ford, Pa.	Nonimpacted	Nonimpacted	Slightly impacted

Table 5. Designation of stream quality and median values of taxa richness, EPT taxa richness, and Hilsenhoff's biotic index for sites in the Stream Conditions of Chester County Biological Monitoring Network, 1998-2000—Continued

[EPT, Ephemeroptera, Plecoptera, and Trichoptera]

U.S. Geological Survey station identification number	Local number	Station name	Taxa richness	EPT taxa richness	Hilsenhoff's biotic index
Big Elk Creek Basin					
01494800	62	East Branch Big Elk Creek at Faggs Manor, Pa.	Nonimpacted	Nonimpacted	Nonimpacted
01494900	31	East Branch Big Elk Creek at Elkview, Pa.	Slightly impacted	Moderately impacted	Slightly impacted
01494950	32	West Branch Big Elk Creek near Oxford, Pa.	Slightly impacted	Nonimpacted	Slightly impacted
01494953	59	Big Elk Creek at Maple Grove, Pa.	Slightly impacted	Slightly impacted	Slightly impacted
01495300	68	Little Elk Creek at Elk Mills, Pa.	Nonimpacted	Nonimpacted	Slightly impacted
Octoraro Creek Basin					
01578343	34	Valley Creek near Atglen, Pa.	Slightly impacted	Slightly impacted	Slightly impacted
01578347	60	East Branch Octoraro Creek near Steelville, Pa.	Nonimpacted	Nonimpacted	Slightly impacted

Schuylkill River Basin

The Schuylkill River Basin drains the north-eastern part of Chester County and is itself a tributary to the Delaware River. The fixed sites sampled annually in the Schuylkill River Basin from 1998 to 2000 were Pigeon, French, Pickering, and Valley Creeks. One miscellaneous site, Trout Run, was sampled in 2000 (fig. 1). All of these sites discharge directly into the Schuylkill River. A description of the sampling location, chemical and habitat conditions, benthic-macroinvertebrate community structure, and plots of the biological metrics are presented for each sampling location.

Eight of the nine miscellaneous sites established in 2000 were in the Valley Creek Basin as part of a synoptic investigation of stream quality throughout the basin. The eight miscellaneous sites (table 2) and the fixed site on Valley Creek were sampled between October 16, 2000, and October 24, 2000. Sampling of many sites during a short time interval (synoptic sampling) allows evaluation of the basin under essentially the same environmental conditions. This was the only synoptic sampling done between 1998 and 2000.

Pigeon Creek near Slonaker, Pa.
(Site 10) (01472080)

Location: Latitude 40°12'03", longitude 75°37'10", 50 ft upstream from bridge on Ellis Woods Road, 2.3 mi upstream from Schuylkill River, and 3.0 mi south of Pottstown in East Coventry Township.

Drainage area: 12.0 mi².

Station setting: Pigeon Creek, upstream of site 10 (fig. 1), flows through light residential areas within agricultural and forested land. No major population centers or known point discharges were upstream of site 10. Predominant land-use categories in the basin were agriculture (36 percent), forested (36 percent), and residential (25 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nutrient concentrations measured at site 10 were elevated above the reference conditions measured at site 15 but were relatively low from 1998 to 2000. The maximum concentrations of nutrients were nitrate, 2.42 mg/L; phosphorus, 0.04 mg/L; and ammonia, 0.04 mg/L. The nutrient concentrations measured at site 10 were sufficient to cause increased plant growth, which can lead to decreased dissolved oxygen concentra-

tions that can result in decreased benthic-macroinvertebrate diversity (Buck and others, 2000). Boron concentrations ranged between 16 and 22 µg/L; these low concentrations suggest agriculture was the major nutrient source. Major ion concentrations and field characteristics measured at site 10 were similar to those measured at the reference site from 1998 to 2000.

Habitat: The stream was approximately 30 ft wide, had a mean depth of 0.6 ft, and was well shaded at the sampling location. The riffle consisted of cobbles that were 30 percent embedded with gravel and sand. A series of three small riffles was sampled in the 150-ft reach; no other riffles were in the immediate area. Both banks had wide and undisturbed riparian areas. The left bank had a 7-ft-high vertical cut bank with exposed roots and bare areas that had a high potential for erosion. The right bank was covered with vegetation and had little potential for erosion.

Benthic macroinvertebrates: Pigeon Creek was assessed as nonimpacted between 1998 and 2000 on the basis of calculated biological metrics (fig. 3). The benthic-macroinvertebrate data collected at this site indicated a diverse and stable community with numerous "pollution-sensitive" organisms. EPT taxa accounted for between 47 and 66 percent of the total population and "pollution-tolerant" organisms were present in low numbers. The 1999 samples had an increase in the percentage of midges, a "pollution tolerant" taxon, that caused a slight rise in the HBI value. Although the higher HBI value indicates degraded stream quality in 1999, the increase in taxa richness and EPT taxa richness indicated improved stream quality. The HBI values decreased in 2000, indicating the conditions causing the increased HBI value were temporary. Water-chemistry data indicated no change in quality in 1999, but habitat data indicated increased sedimentation at the site. A flood in September 1999 is the most likely cause of the change in habitat.

Summary: The chemical and biological data collected between 1998 and 2000 indicated low nutrient concentrations and a benthic-macroinvertebrate community that represented nonimpacted stream quality. Habitat data indicated active erosion and deposition in Pigeon Creek, which did not seriously affect the benthic-macroinvertebrate community at site 10.

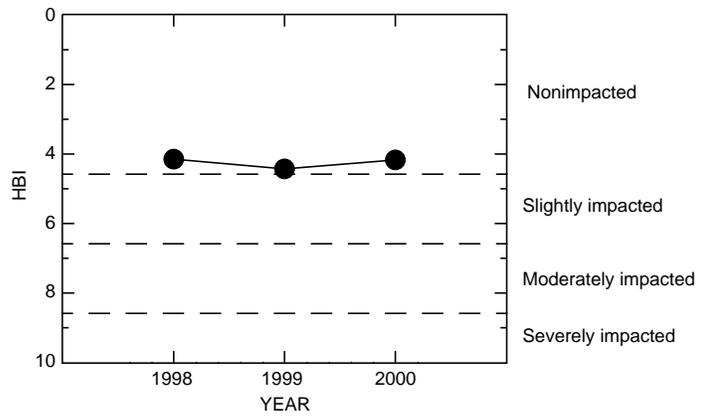
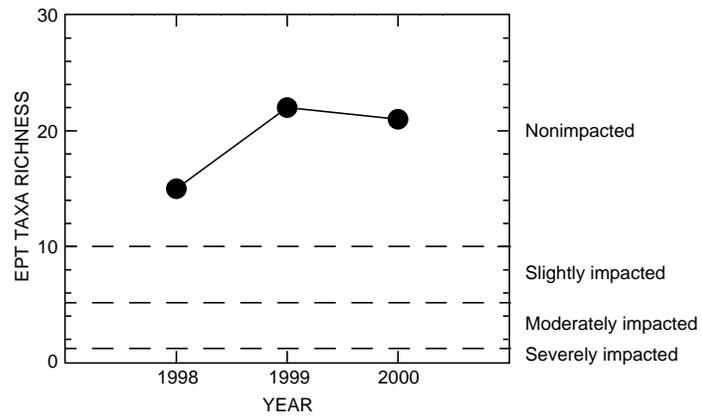
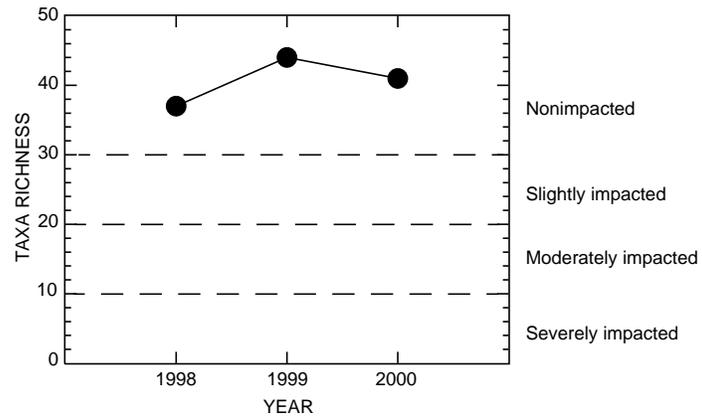


Figure 3. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Pigeon Creek near Slonaker, Pa. (Site 10) (01472080), 1998-2000.

French Creek near Phoenixville, Pa.
(Site 15) (01472157)

Location: Latitude 40°09'05", longitude 75°36'06", 150 ft upstream from a County bridge on French Creek Road, 4.5 mi northwest of Phoenixville, and 7.3 mi upstream from Schuylkill River, on the border between East Vincent and West Vincent Townships.

Drainage area: 59.1 mi².

Station setting: Site 15 (fig. 1) is upstream from the Borough of Phoenixville in the northeastern part of Chester County. The headwaters lie in French Creek State Park on the Chester/Berks County border, and the creek flows into the Schuylkill River in Phoenixville. Predominant land-use categories in the basin were forested (52 percent), agriculture (36 percent), and residential (9 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Low concentrations of nutrients and ions were measured at site 15 from 1998 to 2000. Site 15 was considered the reference site for the Stream Conditions of Chester County Biological Monitoring Network and generally had the lowest concentrations of nutrients and major ions of all the streams measured in the network. The maximum nitrate concentration detected was 1.19 mg/L, phosphorus concentrations were <0.02 mg/L, and ammonia concentrations were <0.04 mg/L. Boron concentrations ranged between 8 and 19 µg/L; these low concentrations suggest agriculture was the major nutrient source.

Habitat: The stream was approximately 48 ft wide, had a mean depth of 0.7 ft, and was mostly shaded at the sampling location. The habitat assessment indicated stable instream and riparian conditions. The sampling location was a cobble/gravel riffle with little sedimentation or embeddedness and light algal cover. The riparian area was greater than 18 m wide, heavily vegetated, and undisturbed. The stream was shaded by mature trees, and bank erosion was light to moderate.

Benthic macroinvertebrates: French Creek was assessed as nonimpacted between 1998 and 2000 on the basis of calculated biological metrics (fig. 4). The benthic-macroinvertebrate community had high taxa richness and EPT taxa richness, which indicate good stream quality. "Pollution-sensitive" and intermediate organisms dominated the benthic-macroinvertebrate community at this site;

69-75 percent of the individuals collected were EPT taxa. "Pollution-tolerant" organisms were present but represented a small percentage of the total population. These factors indicate a diverse and stable benthic-macroinvertebrate community at site 15.

Summary: The chemical, habitat, and biological data collected between 1998 and 2000 indicated low concentrations of nutrients and major ions, stable habitat, and benthic-macroinvertebrate communities that indicated nonimpacted stream quality at site 15. French Creek had the highest taxa richness, EPT taxa richness, and the second lowest HBI values in the Network from 1998 to 2000.

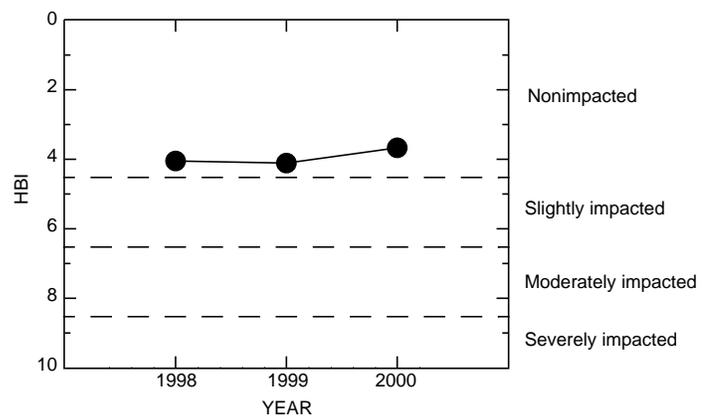
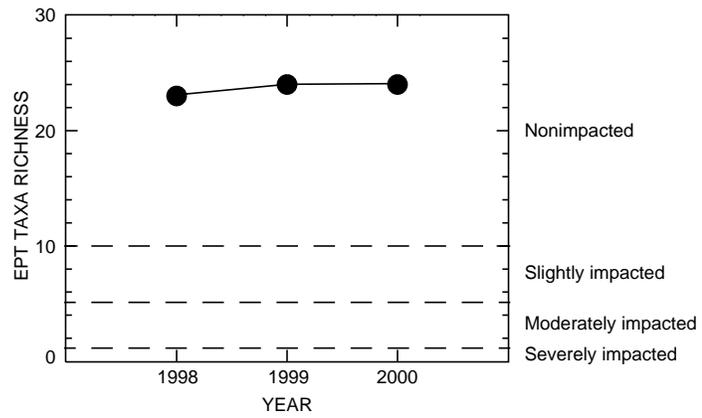
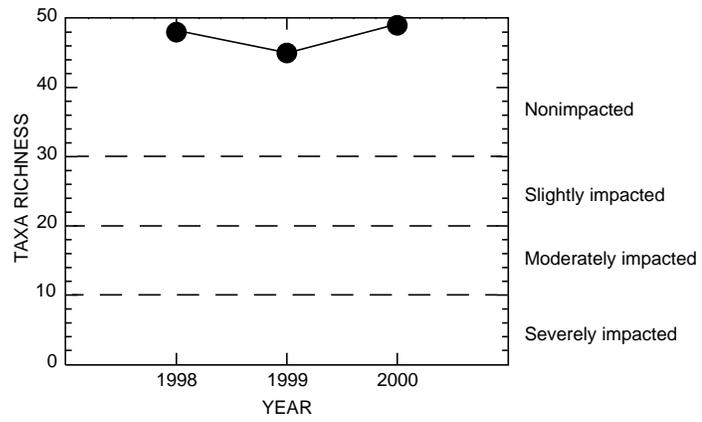


Figure 4. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from French Creek near Phoenixville, Pa. (Site 15) (01472157), 1998-2000.

Pickering Creek near Phoenixville, Pa.
(Site 5) (01472190)

Location: Latitude 40°06'33", longitude 75°31'42", 500 ft upstream from bridge on Creek Road, 1.0 mi upstream from the Pickering Creek Reservoir, and 0.5 mi southwest of Phoenixville in Schuylkill Township.

Drainage area: 31.4 mi².

Station setting: Pickering Creek, upstream of site 5 (fig. 1), flows through light residential areas within agricultural and forested land. The headwaters of Pickering Creek were in a light industrial/housing area and had no known point discharges upstream of site 5. Predominant land-use categories in the Pickering Creek Basin were agriculture (42 percent), forested (36 percent), and residential (17 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate concentrations measured at site 5 were elevated above the reference conditions measured at site 15 but were relatively low from 1998 to 2000. Phosphorus and ammonia concentrations were low and similar to those measured at the reference site. The maximum nitrate concentration was 1.76 mg/L, phosphorus concentrations were <0.02 mg/L, and ammonia concentrations were <0.04 mg/L. Boron concentrations ranged between 14 and 18 mg/L; these low concentrations suggest agriculture was the major nutrient source. The concentrations of major ions measured were elevated above those measured at the reference site from 1998 to 2000.

Habitat: The stream was approximately 45 ft wide, had a mean depth of 0.7 ft, and was partly shaded at the sampling location. The sampling reach consisted of a 200-ft series of very stable cobble riffles with little sedimentation or embeddedness. Algae cover was light throughout the reach. The streambanks had some erosional scars including exposed tree roots and undercut banks. The riparian area on the right bank was wide, undisturbed, and dominated by mature trees. The riparian area on the left bank was narrow with a few trees between the stream and mowed lawns from nearby homes. The site also was affected by its proximity to State Rt. 29, which runs parallel to Pickering Creek upstream of the sampling location.

Benthic macroinvertebrates: Pickering Creek was assessed as nonimpacted in 1998 and 2000 on the basis of the calculated biological metrics

(fig. 5). The benthic-macroinvertebrate community contained high taxa richness and low HBI values (fig. 5). The community contained greater than 63 percent EPT taxa. "Pollution-tolerant" organisms were present in sufficient numbers that HBI values were close to the slightly impacted category indicating a minor disturbance. The benthic macroinvertebrates collected in 1999 contained similar values of taxa richness and EPT taxa richness as in 1998 and 2000, but the structure of the benthic-macroinvertebrate community was different. The benthic-macroinvertebrate community had a decrease in EPT individuals as opposed to taxa in 1999. EPT individuals accounted for only 36 percent of total individuals in 1999 compared to 78 percent in 1998. This caused the HBI value for 1999 to increase to the slightly impacted category. Because the community structure was similar in 1998 and 2000, the 1999 assessment of slightly impacted appears to be a temporary condition. Water-chemistry data indicated no change in stream quality in 1999, but habitat data indicated increased sedimentation at the site in 1999. A flood in September 1999 is the most likely cause of the change in habitat.

Summary: The chemical, habitat, and biological data collected between 1998 and 2000 indicated low concentrations of nutrients and major ions, moderate amounts of streambank erosion, and benthic-macroinvertebrate communities that indicated stable nonimpacted stream quality at site 5.

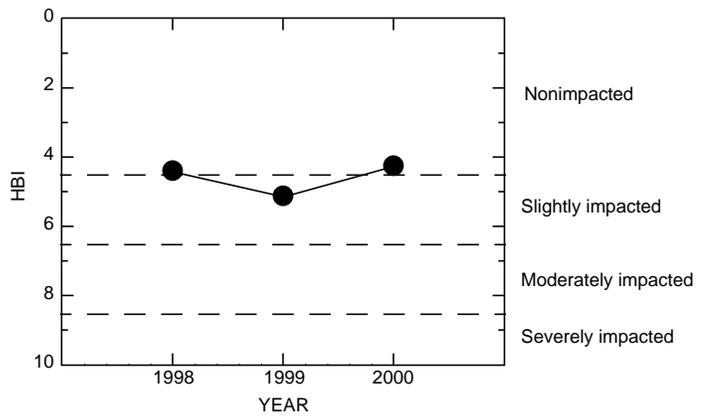
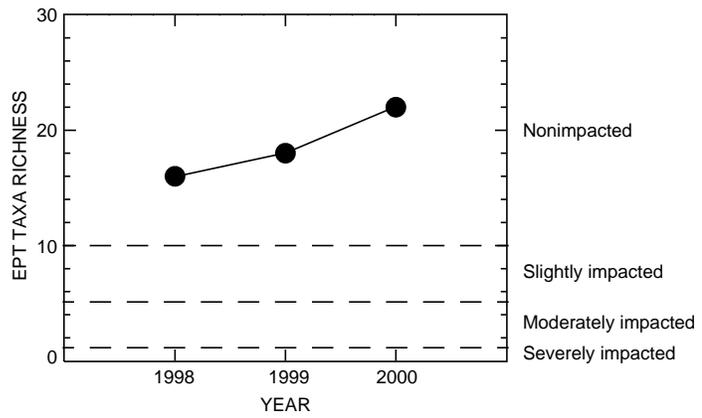
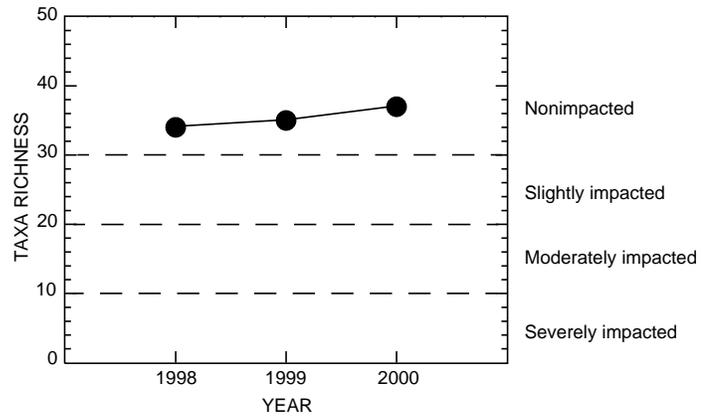


Figure 5. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Pickering Creek near Phoenixville, Pa. (Site 5) (01472190), 1998-2000.

Valley Creek at Pa. Turnpike Bridge near
Valley Forge, Pa.
(Site 52) (01473169)

Location: Latitude 40°04'45", longitude 75°27'40", 350 ft upstream from the Pa. Turnpike Bridge, 2.0 mi upstream from the Schuylkill River, and 1.0 mi south of Valley Forge in Tredyffrin Township.

Drainage area: 20.8 mi².

Station setting: Valley Creek flows through a limestone valley in eastern Chester County. Its headwaters lie in a heavily residential area and the stream flows through mixed land use including residential, corporate parks, light industrial sites, and major highways including State Route 202 and the Pennsylvania Turnpike before reaching site 52 (fig. 1). The predominant land-use categories in the basin were forested (32 percent), residential (32 percent), commercial/community services and manufacturing (16 percent), and agriculture (7 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Valley Creek is a limestone stream that has high specific conductance and alkalinity related to the limestone geology and quarrying in the basin. This site is not comparable to the reference site because of its unique chemistry caused by the limestone-influenced ground-water discharge. The maximum specific conductance measured was 634 $\mu\text{S}/\text{cm}$, and the maximum alkalinity was 220 mg/L. Low nitrate concentrations and high ion concentrations were measured at site 52 from 1998 to 2000. The maximum nitrate concentration was 1.77 mg/L, phosphorus concentrations were <0.02 mg/L, and ammonia concentrations were <0.04 mg/L. The maximum boron concentration was 56 $\mu\text{g}/\text{L}$, which is elevated over background concentrations. Elevated concentrations of boron were recorded in this area in the past and were associated with mineral-processing wastes that have contaminated the ground water in the area (Sloto, 1987). Boron cannot be used as a tracer of wastewater in the Valley Creek Basin because of the ground-water contamination noted by Sloto.

Habitat: The stream was approximately 33 ft wide, had a mean depth of 0.5 ft, and was shaded at the sampling location. The sampling reach was 150 ft of riffle/run habitats that consisted of a stable mixture of cobbles and gravel that were 50 percent embedded by sand. Algae cover was light in shaded areas and moderate in areas receiv-

ing sunlight. Both streambanks had wide riparian areas that were minimally disturbed. Areas upstream and downstream from the sampling reach were heavily eroded, but the erosion noted in the sampling reach was minor.

Benthic macroinvertebrates: Valley Creek was assessed as slightly impacted between 1998 and 2000 on the basis of taxa richness and EPT taxa richness (fig. 6). HBI values indicated variable conditions between nonimpacted and slightly impacted. The benthic-macroinvertebrate community contained low values of taxa richness and EPT taxa richness but also had low numbers of "pollution-tolerant" organisms. The percentage of EPT individuals ranged from 18 to 40 percent; only six EPT taxa were collected in 2000. Taxa richness and EPT taxa richness decreased and HBI values increased from 1998 to 2000, which indicated deteriorating stream quality. Water chemistry did not change between 1998 and 2000, but active erosion and deposition were noted in the habitat assessments and were possible causes of the deteriorating stream quality.

The benthic-macroinvertebrate communities in Valley Creek also may have been affected by extreme weather conditions in 1999. Low flows caused by drought conditions followed by a flood may have caused the decreased numbers of individuals and taxa, but because the communities did not recover by 2000, other environmental factors may be involved in the deteriorating stream quality at site 52 between 1998 and 2000.

Summary: The biological data collected between 1998 and 2000 indicated deteriorating stream quality. Site 52 is currently assessed as slightly impacted. Chemical and habitat data indicated high concentrations of major ions and heavy amounts of erosion and deposition may be degrading the stream quality.

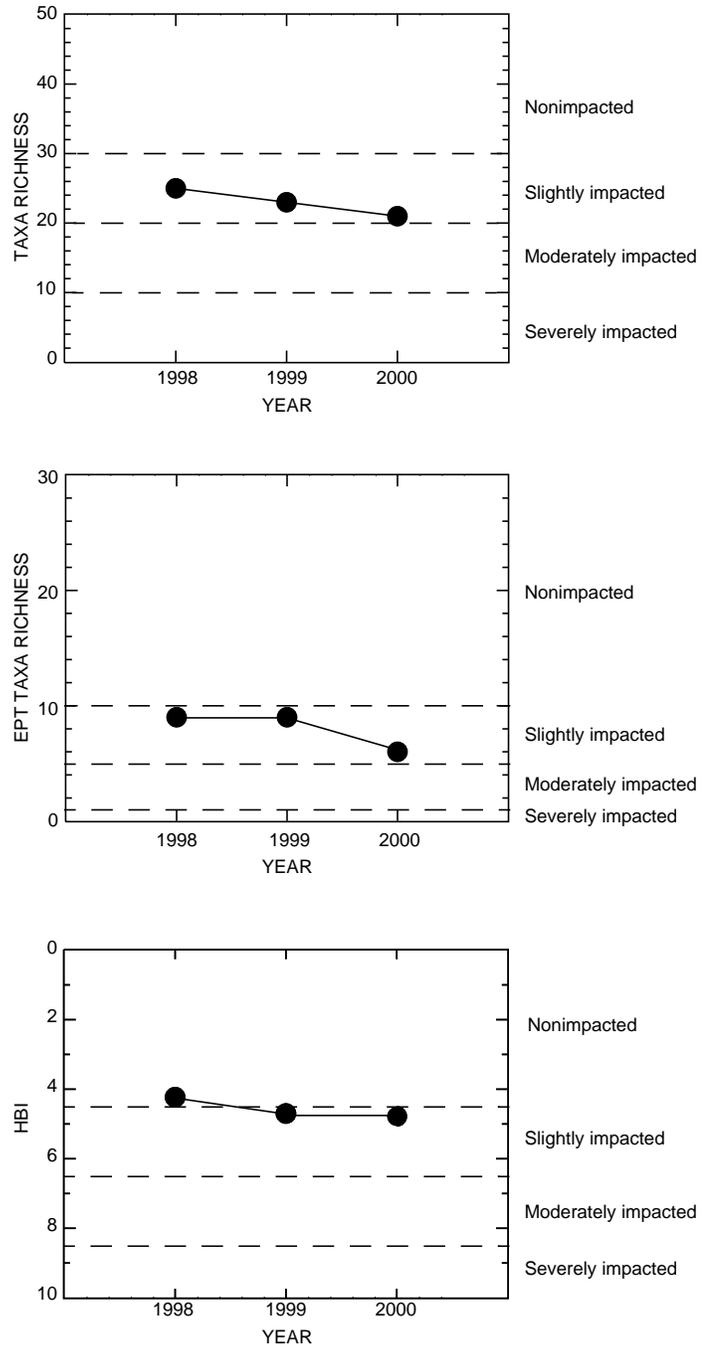


Figure 6. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Valley Creek at Pa. Turnpike Bridge near Valley Forge, Pa. (Site 52) (01473169), 1998-2000.

Trout Creek at Pa. Turnpike Bridge near
Valley Forge, Pa.
(Site 61) (01473197)

Location: Latitude 40°05'22", longitude 75°25'26", 10 ft upstream from a bridge on Glenhardie Road, 0.2 mi north of the Pa. Turnpike, 3.0 mi upstream from the Schuylkill River, and 0.5 mi south of Valley Forge National Historical Park in Tredyffrin Township.

Drainage area: 3.67 mi².

Station setting: Trout Creek flows through a residential area from its headwaters to the Schuylkill River. The predominant land-use categories in the basin were residential (72 percent), forested (10 percent), and recreation (6 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Trout Creek is a limestone-influenced stream that has naturally high specific conductance and alkalinity. This site is not comparable to the reference site because of its unique chemistry caused by the limestone-influenced ground-water discharge. The specific conductance in 2000 was 475 $\mu\text{S}/\text{cm}$, the alkalinity was 161 mg/L, and major ion concentrations were elevated above the reference conditions at site 15. Low concentrations of nutrients were measured at site 61 in 2000. The nitrate concentration was 1.94 mg/L, the phosphorus concentration was <0.02 mg/L, and the ammonia concentration was <0.04 mg/L. The boron concentration was low, 9 mg/L. This indicates that there were no wastewater treatment plants in the basin and the sewer lines apparently had few leaks. Detectable concentrations of arsenic (2.0 $\mu\text{g}/\text{L}$), copper (1.9 $\mu\text{g}/\text{L}$), mercury (0.23 $\mu\text{g}/\text{L}$), molybdenum (3.1 $\mu\text{g}/\text{L}$), nickel (2.4 $\mu\text{g}/\text{L}$) and zinc (20 $\mu\text{g}/\text{L}$) were measured. None were above concentrations recommended for protection of aquatic life (U.S. Environmental Protection Agency, 2002).

Habitat: The stream channel was approximately 34 ft wide but had flow in only 9 ft of the channel. The stream had a mean depth of 0.3 ft and was open to sunlight. The sampling reach was 75 ft of riffle/run/pool habitats that consisted of an unstable mixture of sand and gravel with cobbles laying on top. Algae cover was light, there were no fine sediments, and there was evidence that the stream bottom was frequently disturbed. The streambanks had disturbed riparian areas that consisted of cut grass extending to vertical cut banks. The stream habitat at Trout Creek was degraded by severe erosion at the sampling location.

Benthic macroinvertebrates: Trout Creek was assessed as slightly impacted in 2000 on the basis of the calculated biological metrics (fig. 7). The benthic-macroinvertebrate community contained numerous "pollution-tolerant" and intermediate organisms. EPT individuals made up only 13 percent of the community; midges, a "pollution-tolerant" taxon, accounted for 67 percent. This indicates a disturbed benthic-macroinvertebrate community. Trout Creek is in a heavily urbanized basin, and habitat data indicated severe erosion at the sampling location. The frequent scour events in the basin are the most likely cause of the impaired benthic-macroinvertebrate community at this site.

Summary: The chemical, habitat, and biological data collected in 2000 indicated stream quality was degraded in Trout Creek because of poor habitat from severe erosion. The severe erosion is related to the high amount of residential land use (72 percent) and impervious surface (14 percent) in the basin. Stream degradation is likely to occur when percent impervious reaches 10 to 20 percent in the basin (Schueler, 1995). Elevated concentrations of dissolved metals also may be impairing the benthic-macroinvertebrate communities at site 61.

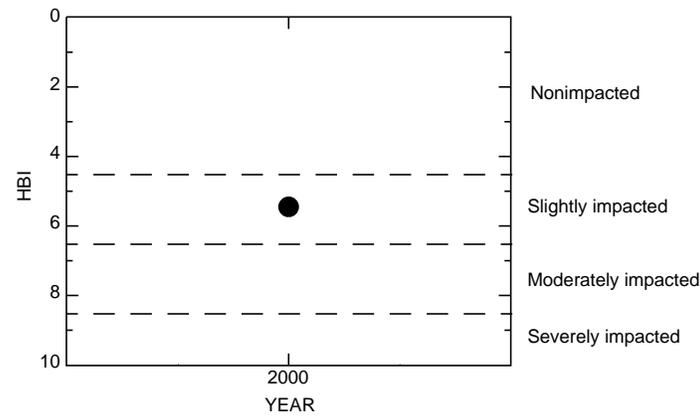
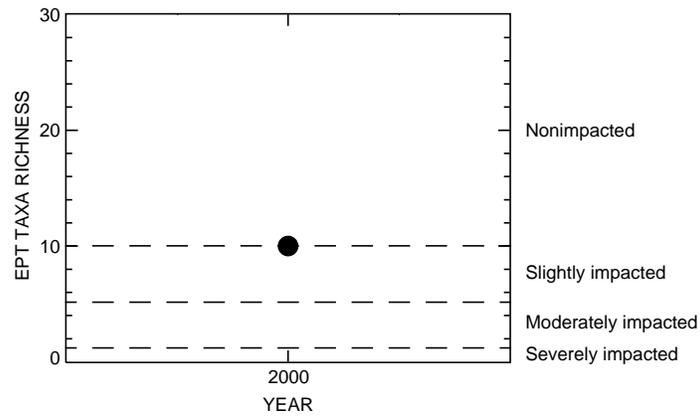
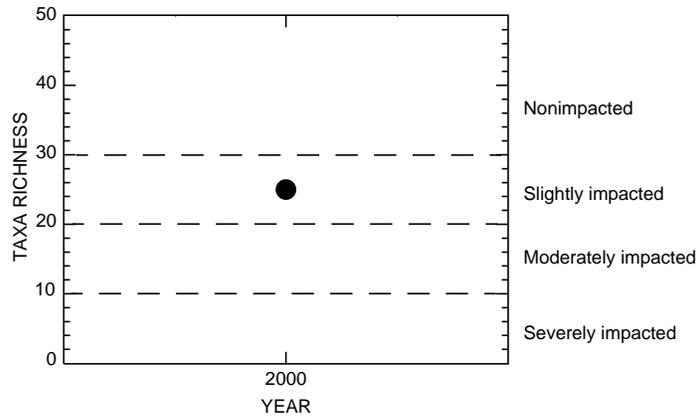


Figure 7. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Trout Creek at Pa. Turnpike Bridge near Valley Forge, Pa. (Site 61) (01473197), 2000.

Valley Creek Synoptic Sampling - October 2000

Introduction: Valley Creek, in the Schuylkill River Basin, is in eastern Chester County in a limestone valley that drains into the Schuylkill River. Eight of the nine miscellaneous sites sampled in 2000 were in the Valley Creek Basin (table 2). These sites, along with site 52, were sampled in 2000 to provide a more detailed look at the entire Valley Creek Basin (fig. 8). This sampling was conducted to provide data to a multiagency effort to study Valley Creek.

Drainage area: 23.4 mi² at site 75 at Valley Forge.

Setting: Sites were in the Valley Creek Basin from the headwaters, in a heavily residential/commercial area, to the confluence with the Schuylkill River in Valley Forge National Historical Park. The stream flows through mixed land use including residential, corporate parks, light industrial sites, and major highways including State Route 202 and

the Pennsylvania Turnpike. The stream also received discharge from a quarry that flows into the creek upstream of site 73. The predominant land-use categories in the basin, as measured at site 75 at Valley Forge, were forested (32 percent), residential (32 percent), commercial/community services and manufacturing (16 percent), and agriculture (7 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Valley Creek had high specific conductance and alkalinity related to the limestone bedrock and quarrying in the basin. The maximum specific conductance measured was 860 $\mu\text{S}/\text{cm}$, and the maximum alkalinity was 340 mg/L. The chemical analyses indicated generally low nutrient concentrations and high concentrations of major ions in 2000.

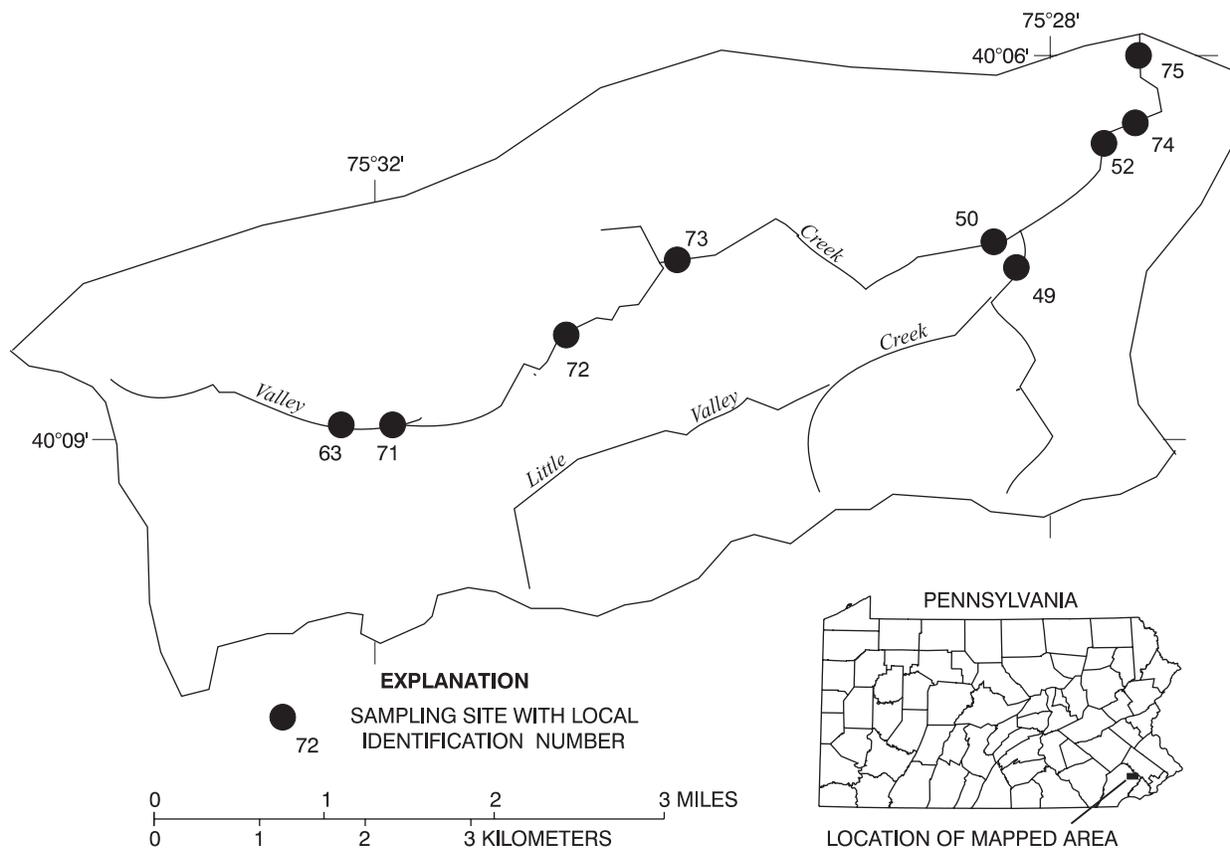


Figure 8. Biological sampling sites in the Valley Creek Basin, Chester County, Pennsylvania, October 2000.

The maximum concentrations of nutrients were 2.78 mg/L of nitrate and 0.09 mg/L of phosphorus. Ammonia concentrations were less than 0.06 mg/L, except for site 72, where ammonia was 0.85 mg/L. The source of the ammonia at site 72 was contaminated ground water entering the stream around the State Route 29 bridge upstream from site 72 (U.S. Geological Survey, 1998). The concentration of ammonia in the ground-water discharge above site 72 was 3.1 mg/L in 1998. The ammonia concentrations decreased rapidly from the source and returned to low concentrations by the next downstream sampling location, site 73. The concentrations of nitrate and phosphorus were largest in the headwaters around sites 63 and 71, where there are more septic systems and agricultural/pasture lands, and generally decreased downstream.

The maximum boron concentration was 273 mg/L, which was elevated compared to background concentrations of less than 20 mg/L. Elevated concentrations of boron have been recorded in this area in the past and were associated with mineral-processing wastes that have contaminated the ground water in the headwaters of Valley Creek (Sloto, 1987). The boron concentrations decreased downstream to a low of 50 mg/L at site 75. Concentrations of major ions were elevated compared to surrounding stream basins, because of the influence of ground water from the limestone valley and the large amount of urban runoff from developed land in the basin.

The water chemistry indicated generally stable nutrient concentrations that decreased in a downstream direction, except at site 74 at Wilsons Bridge. Concentrations of phosphorus and ammonia were elevated at this site, and nitrate concentrations were less than those at sites upstream (site 52) and downstream (site 75). A large input of ground water between sites 52 and 74 increased streamflow from 13.7 to 19.6 ft³/s. The source of the elevated concentrations of phosphorus and ammonia is unknown but may be related to contaminated ground-water discharge upstream from site 74.

Habitat: The stream channel at site 63, the most upstream site, was approximately 13 ft wide, had a mean depth of 0.4 ft, was shaded, and had a streamflow of 1.67 ft³/s. The stream channel at site 75, the most downstream site, was approximately 80 ft wide but had flow in only 33 ft of the channel. At site 75, the stream had a mean depth of 1.0 ft,

was partially shaded, and the streamflow was 21 ft³/s. The sampling reaches at all sites were riffles consisting of cobbles, gravel, and sand. Algae cover generally was light throughout the basin.

The sampling locations in the headwaters (sites 63 and 72-73) had limited available substrates for benthic-macroinvertebrate colonization. The riffles were not embedded but sand and gravel were deposited in pool areas. Streambank erosion was moderate, and riparian areas were limited.

The downstream sampling locations (sites 50, 52, 74, 75) had good stable substrate for benthic-macroinvertebrate colonization. Although the substrate was good, it was heavily embedded with sand and gravel. The riparian areas were wider than the upstream sites, but erosion was heavy in and near the sampling areas. Site 49 in Little Valley Creek had good substrate that was minimally embedded, but there was active erosion at the sampling site.

Benthic macroinvertebrates: The sites in the Valley Creek Basin were assessed as slightly to moderately impacted in 2000 on the basis of taxa richness and EPT taxa richness (fig. 9). HBI values generally indicated nonimpacted to slightly impacted stream quality. The benthic-macroinvertebrate communities contained low taxa richness and low EPT taxa richness but also had low numbers of "pollution-tolerant" organisms. The percentage of EPT individuals ranged from 7 to 47 percent; the maximum number of EPT taxa collected in 2000 was 10 and the minimum was 4. Taxa richness and EPT taxa richness were consistently low throughout the entire Valley Creek Basin, which indicated impaired conditions.

The benthic-macroinvertebrate communities at most sites had similar structure, which resulted in similar assessments of stream quality. Because taxa richness and EPT taxa richness were low compared to streams in surrounding basins, most sites were assessed as slightly to moderately impacted. Because the HBI values for these sites indicated better stream quality, the assessment was between nonimpacted and slightly impacted. The low taxa richness and EPT taxa richness that indicated the streams were slightly to moderately impacted may be the result of the basin having greater than 10 percent impervious surfaces, which can cause erosion similar to that noted in the habitat assessments (Schueler, 1995). Increased amounts of impervious surfaces in a basin cause higher peak flows, which can cause erosion and decrease

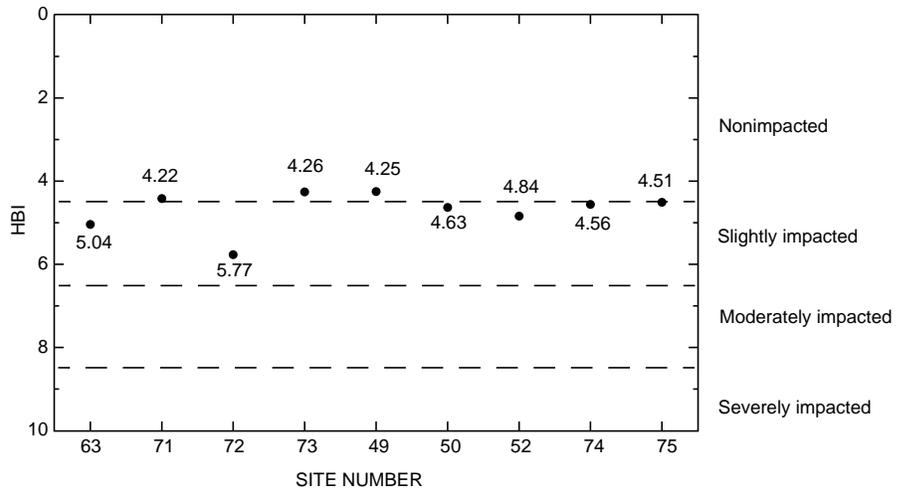
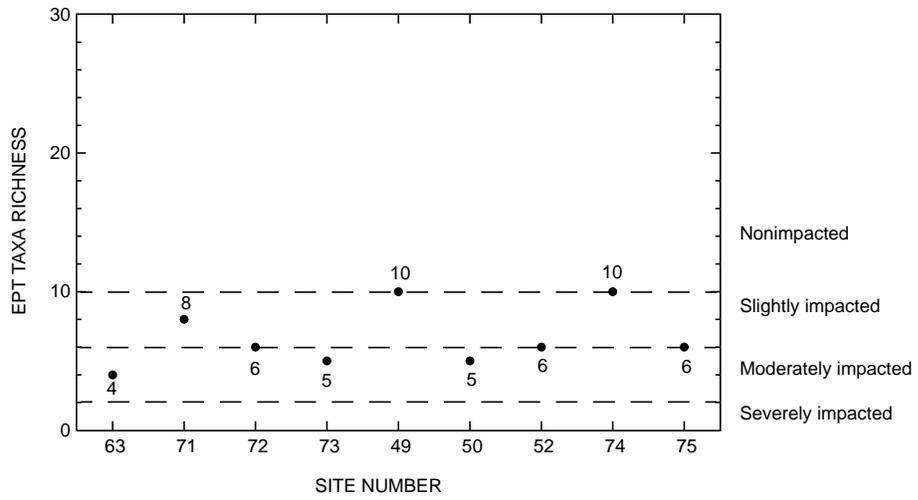
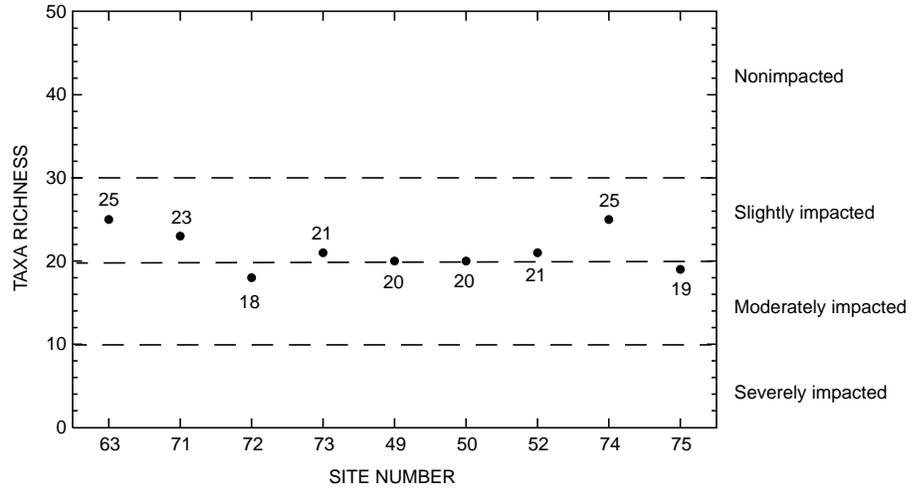


Figure 9. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from sites in the Valley Creek Basin, Chester County, Pennsylvania, 2000.

benthic-macroinvertebrate habitat. Valley Creek and Little Valley Creek were affected by PCB contamination from a Superfund Site in the 1970s and 1980s, although recently collected samples of stream-bottom sediment contained low concentrations of PCBs. All these factors may be related to the decreased taxa richness and EPT taxa richness.

The site with the lowest taxa richness and highest HBI values was site 72 at Devault. This site had elevated concentrations of ammonia from a contaminated ground-water discharge upstream of the site. Taxa richness and EPT taxa richness decreased between sites 74 and 75, apparently because of unstable habitat at site 75. The stream bottom was shifting and subject to heavy erosion at the site. Stream quality improved between sites 52 and 74, despite increased concentrations of phosphorus and ammonia at site 74. Site 73, which

was downstream from a quarry discharge, had benthic-macroinvertebrate communities, chemical concentrations, and habitat features similar to the other sites in the basin. This indicated that the quarry discharge was not degrading the stream quality at site 73.

Summary: The biological data collected in 2000 indicated slightly or moderately impacted stream quality related to low values of taxa richness and EPT taxa richness throughout the Valley Creek Basin. The stream quality was worst at site 72, which is downstream of a ground-water discharge contaminated with ammonia. The water chemistry at most sites sampled in the basin indicated low nutrient concentrations and elevated concentrations of major ions. Erosion was the major cause of degraded habitat in the basin.

Delaware River Basin

The Delaware River Basin drains the southeastern part of Chester County and contains mostly the headwater portion of streams that discharge directly into the Delaware River. The fixed sites sampled annually in the Delaware River Basin from 1998 to 2000 were Crum Creek, Ridley Creek, and the East Branch Chester Creek (fig. 1). No miscellaneous sites were sampled in the Delaware River Basin between 1998 and 2000. A description of the sampling location, chemical and habitat conditions, benthic-macroinvertebrate community structure, and plots of the biological metrics are presented for each sampling location.

Crum Creek at Newtown Square, Pa.
(Site 53) (01475850)

Location: Latitude 39°58'35", longitude 75°26'13", 25 ft downstream from Pa. State Route 3, 0.7 mi upstream from Springton Reservoir, and 2.0 mi west of Newtown Square.

Drainage area: 15.8 mi².

Station setting: Crum Creek, upstream of site 53 (fig. 1), flows through residential and forested areas. No major population centers or known point discharges were upstream of site 53. Predominant land-use categories in the basin were residential (34 percent), forested (30 percent), and agriculture (24 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate concentrations measured at site 53 were elevated above the reference conditions measured at site 15 but were relatively low from 1998 to 2000. Phosphorus and ammonia concentrations were low and similar to those measured at the reference site. The maximum nitrate concentration was 1.93 mg/L, phosphorus concentrations were <0.02 mg/L, and ammonia concentrations were <0.04 mg/L. The maximum boron concentration was 20 µg/L, which suggests agriculture was the major nutrient source. The concentrations of major ions measured were elevated above those measured at the reference site from 1998 to 2000.

Habitat: The stream was approximately 36 ft wide, had a mean depth of 0.4 ft, and was partly shaded at the sampling location. The sampling reach was 150 ft long with a large pool area upstream and downstream of a cobble riffle. This was the only riffle in the immediate area and it had

shifted several times since a flood in September 1999. The riffle consisted of layered cobbles that were 25 percent embedded by sand and gravel. Algae cover was light in the riffle but heavy in the shallow pool areas. Both stream banks were stable with no evidence of erosion. The riparian areas were wide and minimally disturbed although there were commercial buildings within 200 ft of the stream on both the left and right bank. The site was downstream from State Rt. 3 and was affected by runoff from the roadway.

Benthic macroinvertebrates: In 1998, Crum Creek was assessed as nonimpacted on the basis of taxa richness and EPT taxa richness, but the HBI value indicated slightly impacted stream quality. Between 1998 and 2000, values of taxa richness and EPT taxa richness decreased, the percentage of EPT individuals decreased from 60 to 35 percent, and HBI values increased (fig. 10). These changes indicate degrading stream quality over the 3-year sampling period. By 2000, the stream quality was assessed as slightly impacted based on taxa richness and HBI values. The degraded stream quality between 1998 and 2000 most likely was related to the shifting nature of the riffle noted in the habitat assessments.

Summary: The biological data collected between 1998 and 2000 indicated deteriorating stream quality from a nonimpacted assessment to slightly impacted because of a reduction in taxa including "pollution-sensitive" organisms. Chemical and habitat data indicated stable concentrations of nutrients and major ions, but an unstable stream bottom is impairing the benthic-macroinvertebrate community at site 53.

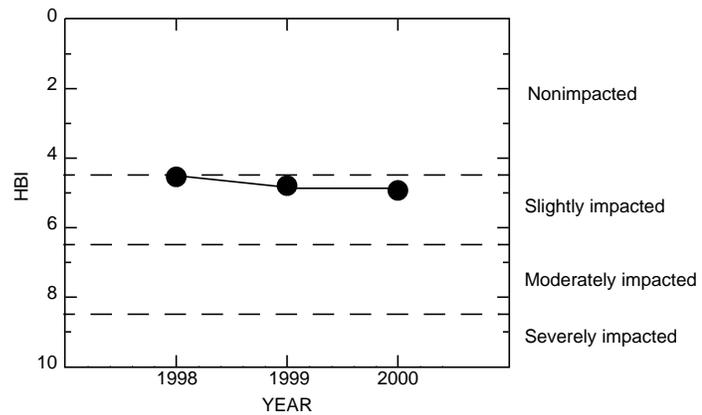
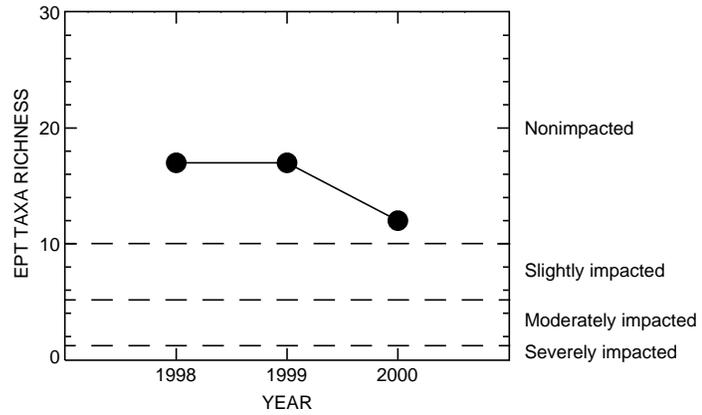
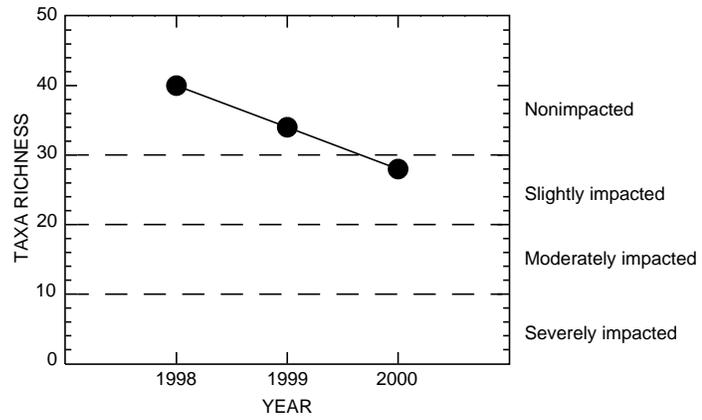


Figure 10. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Crum Creek at Newtown Square, Pa. (Site 53) (01475850), 1998-2000.

Ridley Creek at Dutton Mill near West Chester, Pa.
(Site 21) (01476435)

Location: Latitude 39°58'52", longitude 75°31'02", 10 ft downstream from Strasburg Road, and 2.5 mi east of West Chester in East Goshen Township.

Drainage area: 9.71 mi².

Station setting: Ridley Creek, upstream from site 21 (fig. 1), flows through residential and forested areas. The headwaters lie in an area of relatively dense residential land. A small reservoir was 0.5 mi upstream of site 21. Predominant land-use categories in the basin were residential (46 percent), forested (22 percent), and agriculture (21 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate and phosphorus concentrations measured at site 21 were elevated above the reference conditions measured at site 15 from 1998 to 2000. Ammonia concentrations were low and similar to those measured at the reference site. The nitrate concentrations ranged from 2.99 to 4.13 mg/L, ammonia concentrations were <0.04 mg/L, and phosphorus concentrations ranged from 0.09 to 0.38 mg/L. The elevated nutrient concentrations measured at site 21 can result in increased plant growth, which can result in decreased dissolved oxygen concentrations, and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). Boron concentrations ranged from 25 to 71 µg/L. The nutrient and boron concentrations measured at site 21 suggest Ridley Creek received intermittent wastewater discharge. The concentrations of major ions measured were elevated above those measured at the reference site from 1998 to 2000.

Habitat: The stream was approximately 32 ft wide, had a mean depth of 0.6 ft, and was partly shaded at the sampling location. The sampling reach was 100 ft in length with pool areas upstream and downstream of a stable cobble riffle. This was the only riffle in the immediate area, and it consisted of small and large cobbles covered with moderate amounts of algae. Small amounts of sand and gravel were present, but the cobbles were not embedded. The riparian area was undisturbed and consisted of trees, shrubs, and herbaceous plants. The left bank had minor erosion. The site was downstream of Strasburg Road and receives road runoff.

Benthic macroinvertebrates: Ridley Creek was assessed as nonimpacted on the basis of taxa richness and EPT taxa richness. HBI values also assessed the site as nonimpacted in 1998 and 2000 but indicated slightly impacted conditions in 1999 (fig. 11). The benthic-macroinvertebrate community is diverse and contained between 42 and 68 percent EPT taxa. The benthic-macroinvertebrate community also contained a small but consistent community of "pollution-tolerant" organisms. The HBI values increased in 1999 because of decreased numbers of individuals in all taxa except the "pollution-tolerant" midges. The samples collected in 2000 had a better balance between "pollution-tolerant" and "pollution-sensitive" organisms and the HBI again indicated nonimpacted conditions. Water-quality and habitat data did not indicate a change in conditions that explains the shift in the benthic-macroinvertebrate community in 1999. A flood in September 1999 is the most likely cause of the shift in the benthic-macroinvertebrate community.

Summary: The chemical, habitat, and biological data collected between 1998 and 2000 indicated nutrient enrichment, possibly from wastewater, was present in Ridley Creek at site 21. The benthic-macroinvertebrate community generally was assessed as nonimpacted but HBI values were at or near the slightly impacted level.

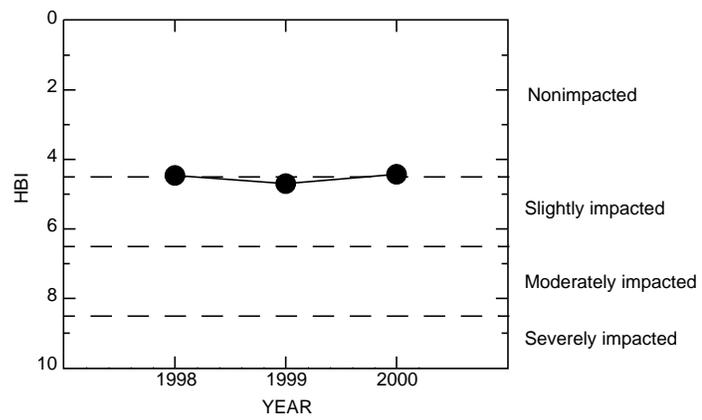
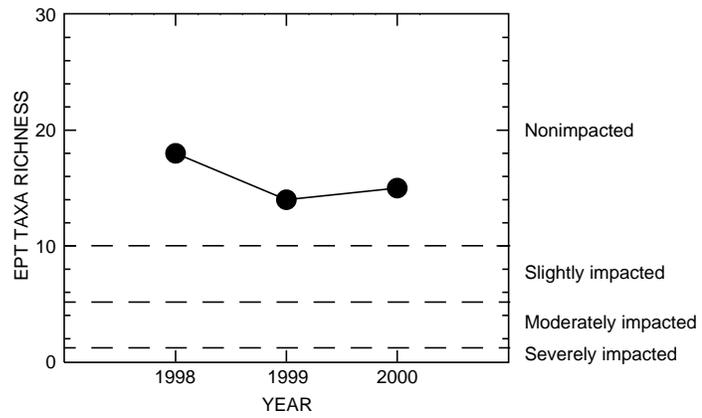
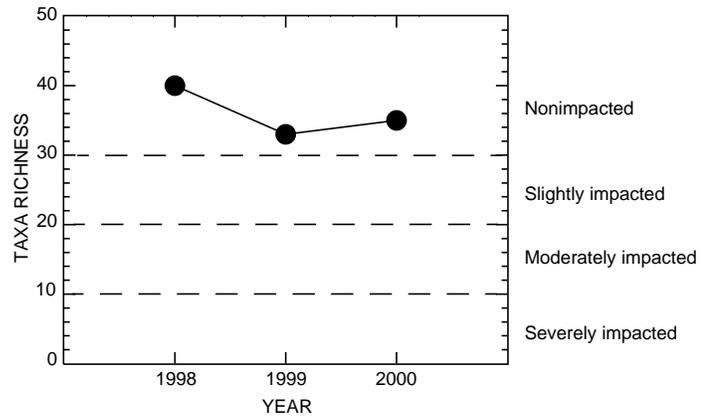


Figure 11. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Ridley Creek at Dutton Mill near West Chester Pa. (Site 21) (01476435), 1998-2000.

East Branch Chester Creek at Westtown, Pa.
(Site 24) (01476835)

Location: Latitude 39°56'26", longitude 75°32'30", 0.7 mi downstream from Westtown Lake, and 3.5 mi east of West Chester in Westtown Township.

Drainage area: 10.4 mi².

Station setting: East Branch Chester Creek, upstream of site 24 (fig. 1), flows through residential and forested areas. The headwaters lie in an area of relatively dense residential land. Two reservoirs are on East Branch Chester Creek and a third discharges into the creek upstream of site 24. The creek also received discharge from a small wastewater treatment plant 1.0 mi upstream from site 24. Predominant land-use categories in the basin were residential (56 percent), forested (17 percent), and agriculture (11 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate and phosphorus concentrations measured at site 24 were elevated above the reference conditions measured at site 15 from 1998 to 2000. Ammonia concentrations were low and similar to those measured at the reference site. The maximum nitrate concentration was 4.10 mg/L, ammonia concentrations were <0.04 mg/L, and phosphorus concentrations ranged from 0.10 to 0.37 mg/L. The nutrient concentrations measured at site 24 can cause increased plant growth that can result in decreased dissolved oxygen concentrations and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The concentrations of major ions measured were approximately double those measured at the reference site from 1998 to 2000. The elevated concentrations of nitrate, phosphorus, and major ions, along with boron concentrations that ranged between 26 and 47 µg/L, suggest agriculture and intermittent wastewater discharges were the major nutrient sources.

Habitat: The stream was approximately 20 ft wide, had a mean depth of 0.5 ft, and was partly shaded at the sampling location. The sampling reach was 75 ft in length and consisted of a small riffle with pool areas upstream and downstream. The riffle consisted of gravel and sand with cobbles that were 25 percent embedded and covered with moderate amounts of algae. Both streambanks had erosional scars including exposed roots and bare soil. The riparian area was undisturbed and consisted of trees, shrubs, and herbaceous plants. The

riparian area was wide on the right bank but Westtown Road was within 25 ft of the left bank at the sampling location.

Benthic macroinvertebrates: In 1998 and 1999, East Branch Chester Creek was assessed as nonimpacted on the basis of taxa richness and EPT taxa richness, but the HBI values indicated slightly impacted conditions (fig. 12). The slightly impacted assessment based on HBI values, along with the moderate nutrient, boron, and ion concentrations, indicated that organic enrichment, from agricultural and wastewater sources, had an effect on the stream quality at site 24.

The benthic-macroinvertebrate community collected in 2000 was assessed as slightly impacted in all categories. Taxa richness declined from 40 in 1999 to 27 in 2000, and EPT taxa richness decreased from 14 to 6. This shift in the benthic-macroinvertebrate community caused the HBI values to increase. Chemical and habitat data do not indicate any large changes between 1999 and 2000 to explain the sudden changes in the benthic-macroinvertebrate community at site 24.

Summary: The chemical, habitat, and biological data collected between 1998 and 2000 indicate stream quality was degraded by organic enrichment from agricultural and wastewater sources. The benthic-macroinvertebrate community indicated degraded stream quality between 1999 and 2000, although water chemistry and habitat data indicated no change in conditions at site 24. The dip in invertebrate metrics for this site in 2000 emphasizes the need to carefully scrutinize future sampling results.

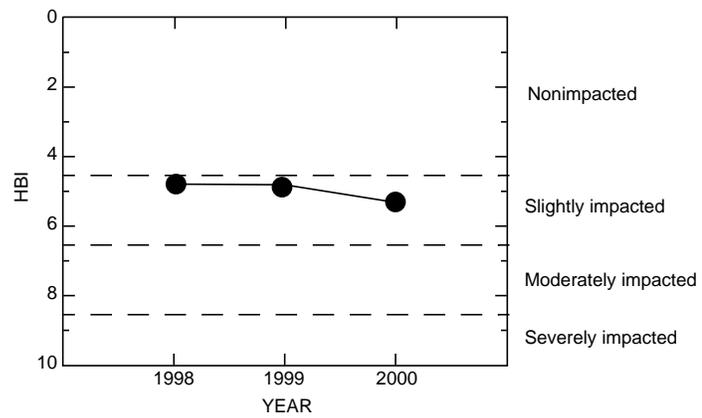
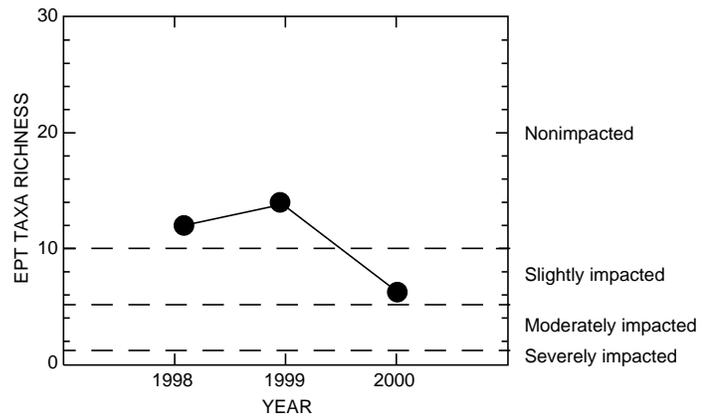
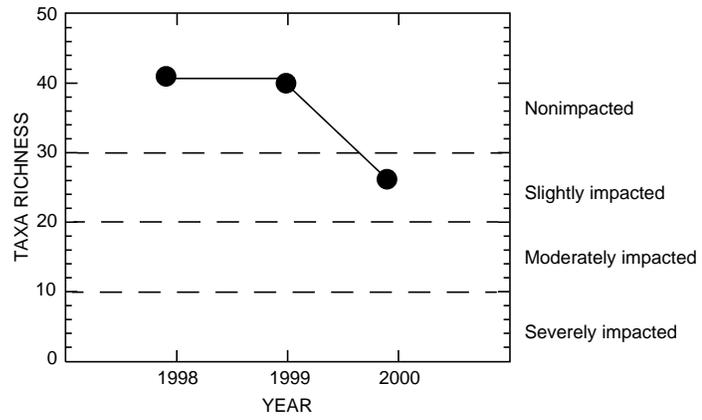


Figure 12. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from East Branch Chester Creek at Westtown, Pa. (Site 24) (01476835), 1998-2000.

Christina River Basin

The Christina River Basin drains the southern part of Chester County and contains mostly the headwater portion of streams that discharge directly into the Christina River, which is a tributary to the Delaware River. The fixed sites sampled annually in the Christina River Basin from 1998 to 2000 were East Branch White Clay Creek, Middle Branch White Clay Creek, East Branch Red Clay Creek, and West Branch Red Clay Creek (fig. 1). Two miscellaneous sites were sampled in the Christina River Basin between 1998 and 2000. They were on the West Branch White Clay Creek (1998) and in the headwaters of the West Branch Red Clay Creek (1998-99) (fig. 1). A description of the sampling location, chemical and habitat conditions, benthic-macroinvertebrate community structure, and plots of the biological metrics are presented for each sampling location.

Although the Brandywine Creek sites are in the Christina River Basin, they are discussed in the Brandywine Creek Basin section because of the large number of sites sampled.

East Branch White Clay Creek at Avondale, Pa.
(Site 28) (01478120)

Location: Latitude 39°49'42", longitude 75°46'52", 75 ft downstream from 3rd Street Bridge in Avondale Borough.

Drainage area: 11.3 mi².

Station setting: East Branch White Clay Creek flows from its headwaters in an area dominated by agricultural land use, including mushroom operations, to the Borough of Avondale. Predominant land-use categories in the basin were agriculture (71 percent), forested (21 percent), and residential (4 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate concentrations measured at site 28 were elevated above the reference conditions measured at site 15 from 1998 to 2000. Phosphorus and ammonia concentrations were low and similar to those measured at the reference site. The maximum concentrations of nutrients were nitrate 5.20 mg/L and phosphorus 0.03 mg/L. Nitrate concentrations above 5.0 mg/L were measured at only 9 of the 40 sites sampled between 1998 and 2000. Ammonia concentrations were <0.04 mg/L. The nutrient concentrations measured at site 28 were sufficient to cause increased plant growth, which can result in

decreased concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). Boron concentrations were 16 µg/L, which suggest agriculture was the major nutrient source. The concentrations of major ions measured were approximately double those measured at the reference site from 1998 to 2000.

Habitat: The stream channel was approximately 35 ft wide but had flow in only 20 ft of the channel. The stream had a mean depth of 0.5 ft and was mostly shaded. The sampling reach was 120 ft of stable cobble riffle. The riffle consisted of layered cobbles that were 50 percent embedded by sand and gravel. Algae cover was light in the riffle but heavy in shallow pool areas. Both streambanks had erosional scars including cut banks and exposed roots. The riparian areas were vegetated, but there were disturbed areas within 10 to 25 ft of the stream. Upstream from the site, the riparian areas included cow pastures, and at the sampling riffle, the riparian area consisted of a recreational area with cut grass and paved areas.

Benthic macroinvertebrates: East Branch White Clay Creek at site 28 was assessed as slightly impacted on the basis of taxa richness but varied between nonimpacted and slightly impacted on the basis of EPT taxa richness and the HBI values (fig. 13). These values indicate that the stream quality is intermediate between nonimpacted and slightly impacted.

The benthic-macroinvertebrate community consisted of a mix of "pollution-tolerant," "pollution-sensitive," and intermediate organisms. Hydropsychid caddisflies and riffle beetles, taxa intermediate in pollution sensitivity, were the most dominant groups making up between 44 and 70 percent of the individuals collected between 1998 and 2000. The HBI values varied from year to year, depending on the abundance of these dominant organisms, but generally indicated some disturbance, possibly from organic enrichment.

Summary: The chemical, habitat, and biological data collected between 1998 and 2000 indicated that the benthic-macroinvertebrate community at site 28 was being affected negatively by organic enrichment. The benthic-macroinvertebrate communities collected were inconsistent from year to year indicating variable conditions at this site. Some erosion and deposition at the site was causing habitat degradation.

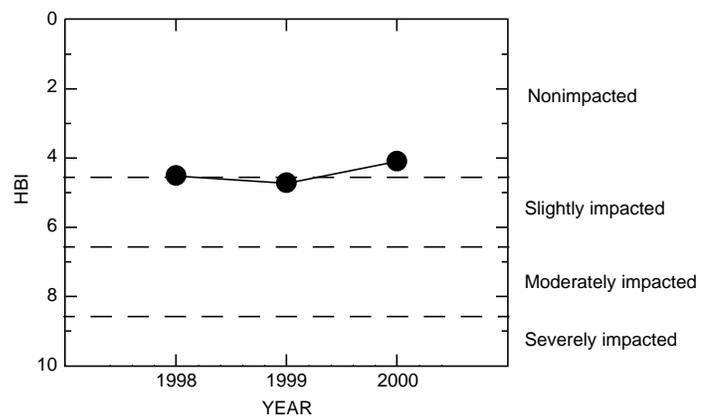
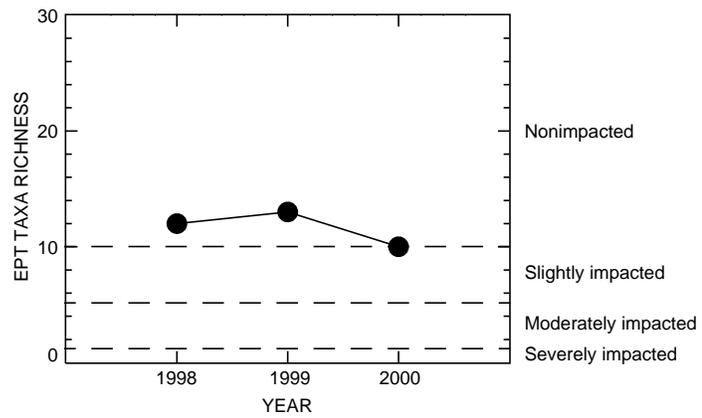
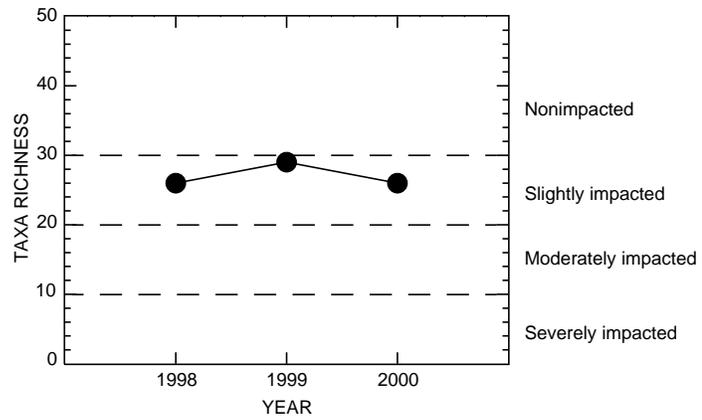


Figure 13. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from East Branch White Clay Creek at Avondale, Pa. (Site 28) (01478120), 1998-2000.

West Branch White Clay Creek near
Chesterville, Pa.
(Site 30) (01478220)

Location: Latitude 39°45'56", longitude 75°47'47", 25 ft upstream from bridge at Mercer Mill and Creek Roads, and 2 mi west of Landenberg, in London Britain Township.

Drainage area: 9.92 mi².

Station setting: West Branch White Clay Creek, upstream of site 30 (fig. 1), flows through agricultural and forested land. No major population centers or known point discharges were upstream of site 30. Predominant land-use categories in the basin were agriculture (50 percent), forested (27 percent), and residential (18 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate concentrations measured at site 30 were elevated above the reference conditions measured at site 15 in 1998. Phosphorus, ammonia, and major ion concentrations were low and similar to those measured at the reference site. The nitrate concentration was 4.15 mg/L, the phosphorus concentration was <0.02 mg/L, and the ammonia concentration was 0.04 mg/L. Although the nitrate concentration measured was sufficient to cause nuisance plant growth, the phosphorus concentration was low and could limit excessive plant growth. The boron concentration was <16 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream channel was approximately 37 ft wide, had a mean depth of 0.4 ft, and was partly shaded. The sampling reach was 100 ft of riffle and run habitat that consisted of cobbles that were 20 percent embedded with gravel and sand. Algae cover was light in the riffle but heavy in shallow pool areas. The left streambank had erosional scars including cut banks and exposed roots. The riparian areas were a mixture of trees and grasses and were minimally disturbed.

Benthic macroinvertebrates: West Branch White Clay Creek was assessed as slightly impacted in 1998 on the basis of taxa richness but was assessed as nonimpacted on the basis of EPT taxa richness and the HBI value (fig. 14). Although the benthic-macroinvertebrate community was assessed as slightly impacted on the basis of taxa richness, it consisted of 75 percent EPT organisms and a low percentage of "pollution-tolerant" organisms. The dominant taxon in the benthic-macroinvertebrate community was Hydropsychid caddisflies, which made up 54 percent of all organisms collected.

These caddisflies are intermediate in their pollution tolerance. The dominance by Hydropsychid caddisflies indicates that water quality and habitat conditions had a minor effect on the benthic-macroinvertebrate community at site 30.

Summary: The chemical, habitat, and biological data collected in 1998 indicated that habitat degradation, from erosion and sedimentation, and organic enrichment had a minor effect on the benthic-macroinvertebrate community at site 30, which was assessed as nonimpacted to slightly impacted.

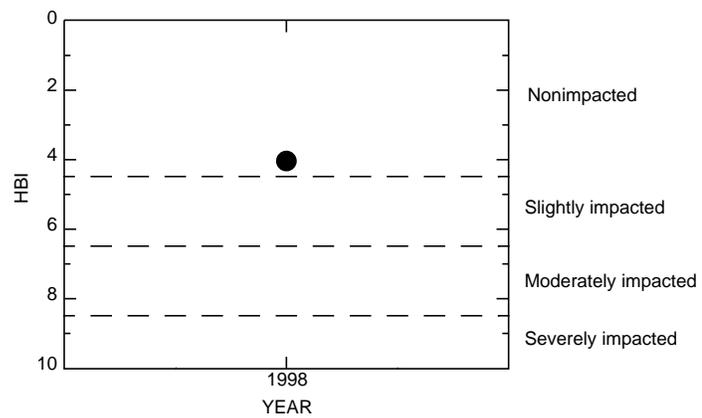
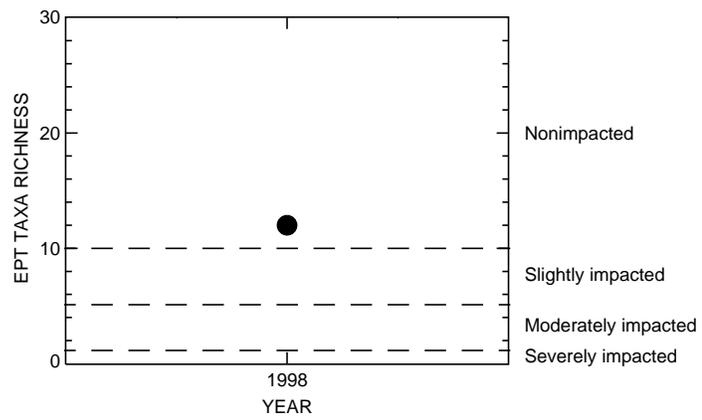
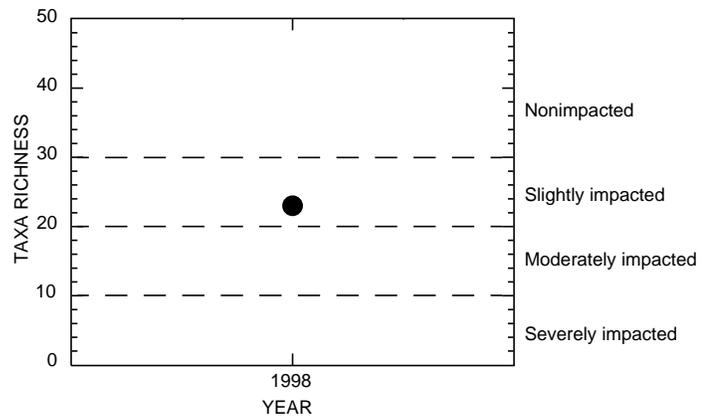


Figure 14. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from West Branch White Clay Creek near Chesterville, Pa. (Site 30) (01478220), 1998.

Middle Branch White Clay Creek near
Avondale, Pa.
(Site 58) (01478230)

Location: Latitude 39°45'02", longitude 75°46'19", 1,500 ft upstream from the main stem of White Clay Creek, in the White Clay Creek State Preserve, and 1.5 mi northeast of Strickersville, in London Britain Township.

Drainage area: 25.5 mi².

Station setting: Middle Branch White Clay Creek, upstream of site 58 (fig. 1), flows through agricultural and forested land, including the White Clay Creek Preserve. Parts of the Borough of West Grove drain into the headwaters of the Middle Branch, and there were no known point discharges. Predominant land-use categories in the basin were agriculture (52 percent), forested (25 percent), and residential (19 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of major ions, nitrate, and phosphorus measured at site 58 were elevated above the reference conditions measured at site 15 from 1998 to 2000. Ammonia concentrations were low and similar to those measured at the reference site. The maximum concentrations of nutrients were nitrate 4.53 mg/L, phosphorus 0.07 mg/L, and ammonia <0.04 mg/L. The nutrient concentrations measured at site 58 were sufficient to cause increased plant growth that can result in decreased concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The maximum boron concentration was 25 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream was approximately 36 ft wide, had a mean depth of 0.7 ft, and was partly shaded at the sampling location. The sampling reach was 175 ft in length and was a series of stable riffles and runs. The riffles consisted of cobbles that were 40 percent embedded with sand and gravel. Heavy sediment deposition caused the formation of mid-channel bars. Algae cover was light in the riffle but heavy in areas of slow streamflow. Both streambanks had vertical cut banks that were up to 8 ft high. The riparian area was a wide undisturbed forested area with dirt walking trails.

Benthic macroinvertebrates: Middle Branch White Clay Creek was assessed as slightly impacted on the basis of taxa richness and as non-impacted on the basis of EPT taxa richness. The HBI values assessed the site as both nonimpacted and slightly impacted (fig. 15).

The benthic-macroinvertebrate community consisted of a mix of "pollution tolerant," "pollution sensitive", and intermediate organisms. Hydropsychid caddisflies, a taxon intermediate in pollution sensitivity, were the most dominant group making up 60 percent of the individuals collected in 2000. "Pollution sensitive" organisms were present but represented a relatively small percentage of the total population. The community structure at site 58 indicated slightly degraded stream quality.

Summary: The biological data collected at site 58 indicated that stream quality was intermediate between nonimpacted and slightly impacted. Chemical and habitat data indicated that nutrient enrichment and sedimentation may be negatively affecting the benthic-macroinvertebrate community.

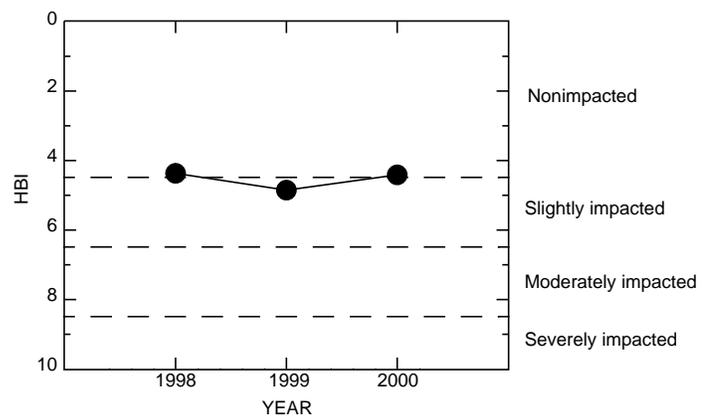
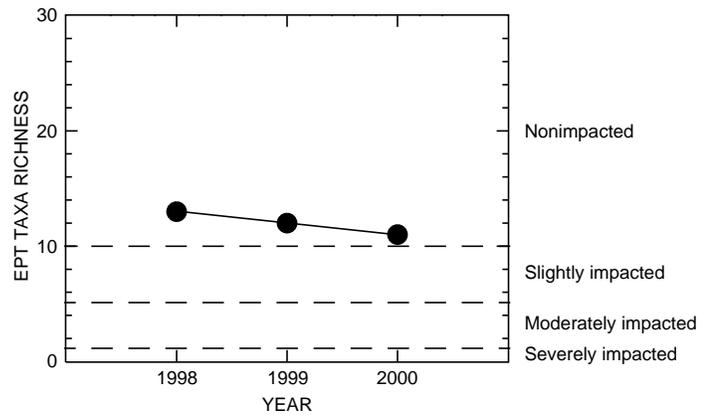
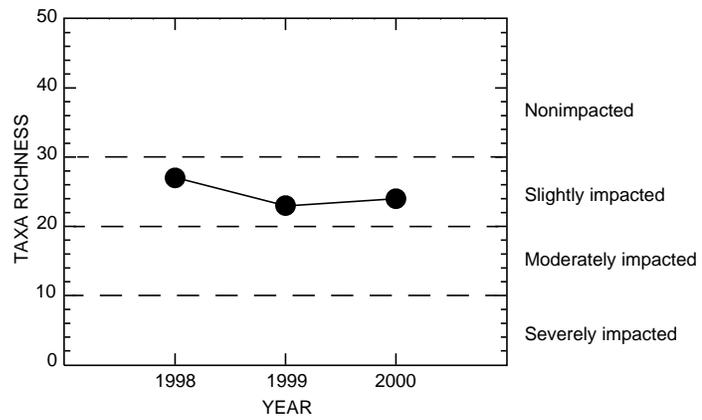


Figure 15. Taxa richness, Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness, and Hilsenhoff's biotic index (HBI) values from Middle Branch White Clay Creek near Avondale, Pa. (Site 58) (01478230), 1998-2000.

West Branch Red Clay Creek above
Kennett Square, Pa.
(Site 64) (01479679)

Location: Latitude 39°50'59", longitude 75°43'28", 75 ft upstream from a bridge at Cedarcroft Road, and 0.25 mi northwest of Kennett Square, in Kennett Township.

Drainage area: 8.63 mi².

Station setting: West Branch Red Clay Creek, upstream of site 64 (fig. 1), flows through agricultural and light residential areas. No major population centers were upstream of site 64, but the creek received discharge from a small tributary that drains a spray-irrigation field immediately upstream from the sampling site. Predominant land-use categories in the basin were agriculture (60 percent), forested (19 percent), and residential (17 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of major ions and nitrate measured at site 64 were elevated above the reference conditions measured at site 15 from 1998 to 1999. Phosphorus and ammonia concentrations were low and similar to those measured at the reference site. The nitrate concentration was 4.6 mg/L, the phosphorus concentration was 0.01 mg/L, and the ammonia concentration was <0.02 mg/L. Although the nitrate concentration measured was sufficient to cause nuisance plant growth, the phosphorus concentration was low and could limit excessive plant growth. Boron concentrations were <16 µg/L, which suggest agriculture was the major nutrient source.

Habitat: The stream channel was approximately 20 ft wide but only 11 ft of the channel had flow. The stream had a mean depth of 0.7 ft and was partly shaded. The sampling reach was 100 ft in length and consisted of a riffle and run area of cobbles and gravel. The cobble and gravel riffle was slightly embedded with sand and silt, and the cobbles had light algal cover. Both streambanks had evidence of erosion including cut banks and exposed tree roots. The riparian areas were less than 20 ft wide and were mostly grass up to the stream channel with a few trees along the streambank.

Benthic macroinvertebrates: West Branch Red Clay Creek at site 64 was assessed as nonimpacted in 1998 and 1999 on the basis of the calculated biological metrics (fig. 16). The benthic-macroinvertebrate community contained high taxa richness and

low HBI values. The community contained greater than 66 percent EPT individuals and had moderate numbers of "pollution sensitive" organisms. The West Branch Red Clay Creek had the highest EPT taxa richness in the Network from 1998 through 2000. "Pollution-tolerant" taxa were present but represented a relatively low percentage of the total population. This community composition indicates good stream quality.

Hydropsychid caddisflies, a taxon intermediate in pollution sensitivity, were the most dominant group and made up 57 percent of the individuals collected in 1998 and 29 percent in 1999. Heavy dominance of one taxon can indicate a disturbed community; however, the presence of a diverse collection of "pollution sensitive" taxa at site 64 suggests good stream quality.

Summary: Chemical and habitat data indicated that nutrient enrichment and sedimentation are affecting the stream quality at site 64. The biological data indicated stream quality is nonimpacted; numerous "pollution sensitive" organisms were present, which indicates the chemical and habitat conditions are having only a minor effect on the benthic-macroinvertebrate community.

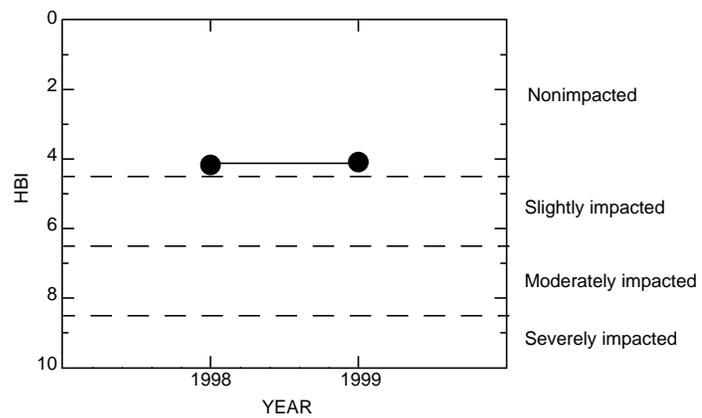
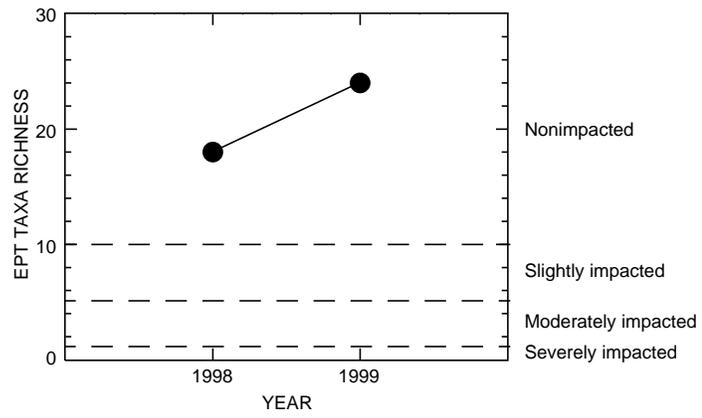
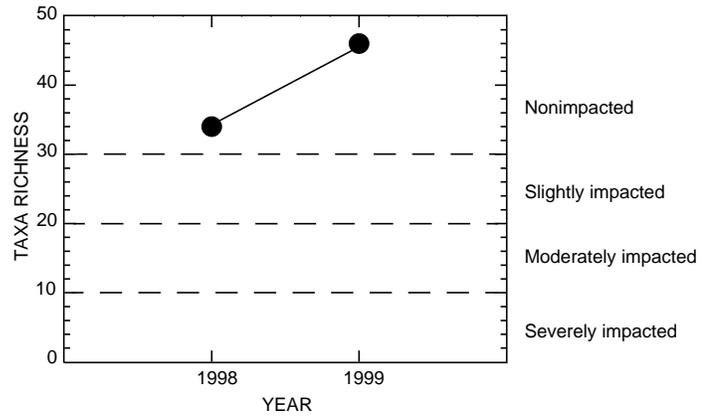


Figure 16. Taxa richness, Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from West Branch Red Clay Creek above Kennett Square, Pa. (Site 64) (01479679), 1998-99.

West Branch Red Clay Creek near Kennett Square, Pa. (Site 55) (01479700)

Location: Latitude 39°48'39", longitude 75°42'19", 100 ft upstream from the state bridge on Koalin Road (Rt. 82), 1 mi upstream from the main stem of Red Clay Creek, and 2 mi south of Kennett Square, in Kennett Township.

Drainage area: 16.9 mi².

Station setting: Site 55 (fig. 1) is downstream from the Borough of Kennett Square in southern Chester County. Predominant land-use categories in the basin were agriculture (53 percent), forested (21 percent), and residential (17 percent) (Delaware Valley Regional Planning Commission, 1997). Discharge from a sewage treatment plant and intense mushroom farming were upstream of the sampling location. Stream-bottom sediment collected in 1983 and 1993 from the West Branch Red Clay Creek was contaminated with pesticides and polychlorinated biphenyls (PCBs) (Reif, 1999).

Water chemistry: Concentrations of nitrate, phosphorus, and ammonia were consistently higher at site 55 than those measured at the reference site (site 15) from 1998 to 2000. Nitrate concentrations ranged between 2.8 and 5.2 mg/L, and phosphorus concentrations were greater than 0.8 mg/L. Nitrate concentrations above 5.0 mg/L were measured at only 9 of the 40 sites sampled between 1998 and 2000. The concentrations of nutrients measured at site 55 are likely to cause increased plant growth that can result in low concentrations of dissolved oxygen and decreased macroinvertebrate diversity (Buck and others, 2000). Concentrations of boron ranged from 27 to 38 µg/L; these concentrations suggest agriculture was the major nutrient source, but the site also was receiving some wastewater inputs. Concentrations of chloride and sulfate were elevated slightly over typical background concentrations, which could be related to sewage discharge, mushroom operations, or general urban influences. Elevated concentrations of aluminum (21 µg/L) in 1999 and copper in 1998 and 1999 (2.6 µg/L and 4.0 µg/L) also were detected.

Habitat: The stream was approximately 45 ft wide but had flow in only 25 ft of the channel. The stream had a mean depth of 0.5 ft and was partially shaded. The sampling reach was 175 ft of riffle, run, and pool habitats consisting of cobbles that were 50 percent embedded with gravel and sand. Algae cover was heavy, and fine sediment was deposited in the pools and along the edges of the

stream. Both streambanks had erosional scars and had potential for erosion during high flows. The riparian area on the left bank was wide. The riparian area on the right bank was mostly grass up to the stream channel with a few trees along the streambank. The area between the stream and State Rt. 82 was less than 20 ft.

Benthic macroinvertebrates: The West Branch Red Clay Creek near Kennett Square was assessed as slightly impacted or moderately impacted on the basis of taxa richness and the HBI values and as moderately impacted on the basis of EPT taxa richness (fig. 17). The benthic-macroinvertebrate community at site 55 was dominated by "pollution tolerant" organisms including midges and worms. The community contained much lower numbers of taxa and EPT taxa compared to other sites in surrounding basins. The large number of "pollution tolerant" organisms along with low EPT taxa richness indicate an impaired benthic-macroinvertebrate community.

This site contained the lowest number of taxa (18) and EPT taxa (2) and had the highest HBI value (7.11) of the 31 sites sampled in Chester County between 1998 and 2000. Site 55 was the only site in the Network between 1998 and 2000 with an HBI value greater than 6. Low taxa richness and EPT taxa richness along with the high HBI values indicate poor stream quality.

Summary: The biological, chemical, and habitat data collected from the West Branch Red Clay Creek near Kennett Square indicate poor stream quality. The benthic-macroinvertebrate community was being affected by degraded habitat and water quality, including elevated concentrations of nutrients, major ions, and dissolved metals. Stream-bottom sediments that were contaminated by pesticides and PCBs also may be affecting the benthic-macroinvertebrate community.

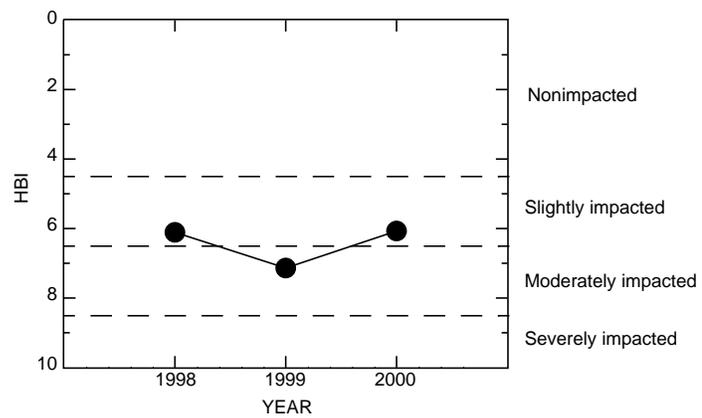
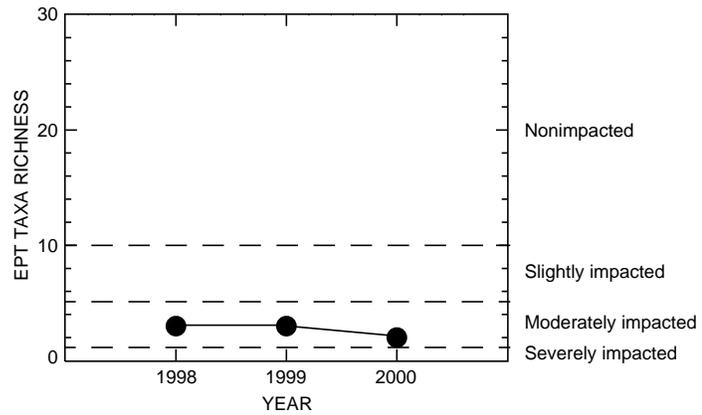
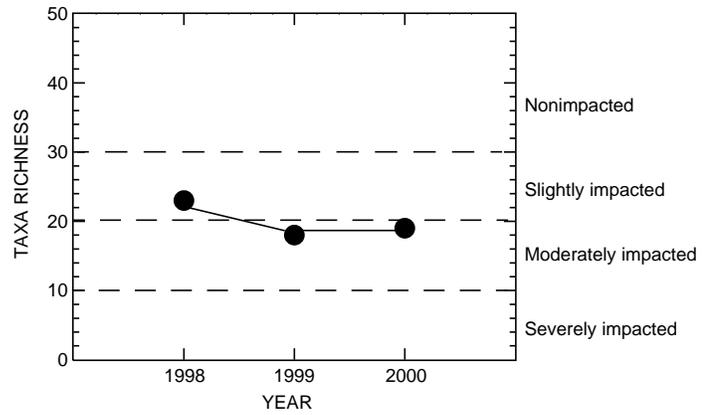


Figure 17. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from West Branch Red Clay Creek near Kennett Square, Pa. (Site 55) (01479700), 1998-2000.

East Branch Red Clay Creek near Five Points, Pa.
(Site 26) (01479800)

Location: Latitude 39°49'11", longitude 75°41'29", 750 ft upstream from the main stem of Red Clay Creek, and 1.5 mi southwest of Kennett Square, in Kennett Township.

Drainage area: 10.2 mi².

Station setting: East Branch Red Clay Creek, upstream of site 26 (fig. 1), flows through residential and agricultural lands, including mushroom operations, and the Borough of Kennett Square. The stream receives a small wastewater discharge upstream of the sampling site. Predominant land-use categories in the basin were agriculture (45 percent), residential (23 percent), and forested (22 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate and phosphorus concentrations measured at site 26 were elevated above the reference conditions measured at site 15 from 1998 to 2000. Ammonia concentrations were low and similar to those measured at the reference site. The maximum concentrations of nutrients were nitrate 3.29 mg/L, phosphorus 0.05 mg/L, and ammonia <0.04 mg/L. The nutrient concentrations measured at site 26 were sufficient to cause increased plant growth that can result in decreased concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The maximum boron concentration was 25 µg/L, which suggests agriculture was the major nutrient source. The concentrations of major ions measured were elevated above those measured at the reference site from 1998 to 2000.

Habitat: The stream was approximately 25 ft wide, had a mean depth of 0.5 ft, and was partly shaded at the sampling location. The sampling reach was 100 ft in length and consisted of a stable cobble riffle. The riffle consisted of cobbles that were 50 percent embedded with sand and gravel and had heavy algal cover. Sediment deposition in the pools near the riffle was heavy, and a mid-channel bar was forming in the reach. Both stream-banks had vertical cut banks that were up to 5 ft high. The riparian area on the left bank was a wide undisturbed forested area, and the riparian area on the right bank consisted of trees along the bank then becoming an open field.

Benthic macroinvertebrates: East Branch Red Clay Creek was assessed as intermediate between nonimpacted and slightly impacted on the basis of taxa richness and the HBI values (fig. 18). The

assessment based on EPT taxa indicated the site is slightly impacted but improving towards nonimpacted (fig. 18).

The benthic-macroinvertebrate community consisted of a mix of "pollution-tolerant," "pollution-sensitive," and intermediate organisms. The community composition was highly variable in taxa and number of individuals. Historically, this site has been assessed as slightly to moderately impacted (Reif, 1999), but the benthic-macroinvertebrate samples collected between 1998 and 2000 indicated improving stream quality.

Summary: The biological, chemical, and habitat data indicated stream-quality conditions were affected slightly but were improving towards non-impacted conditions. Moderate nutrient concentrations and erosion/sedimentation were degrading the stream quality. Conditions appear to be steady or improving over time.

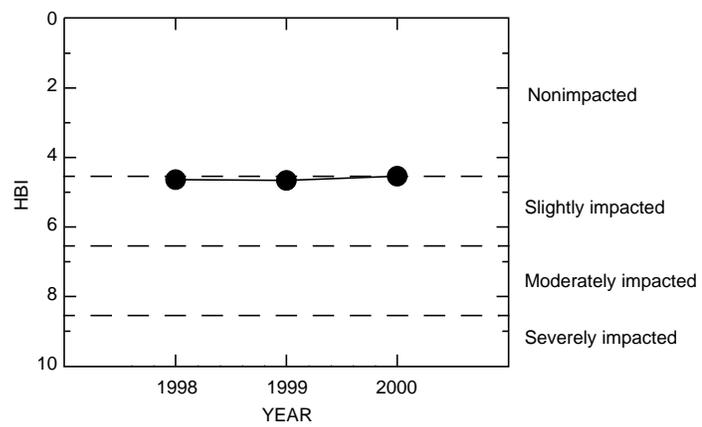
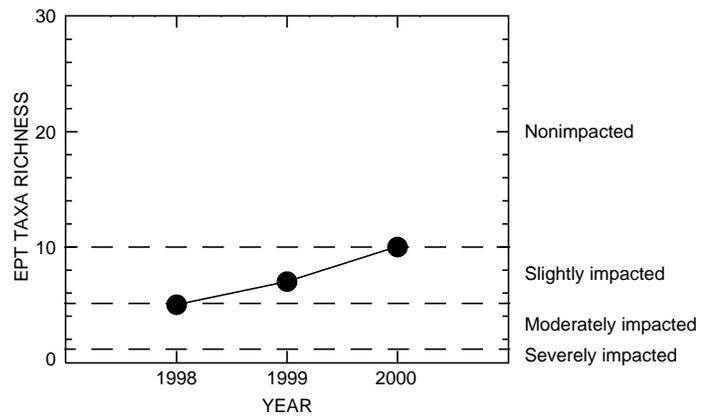
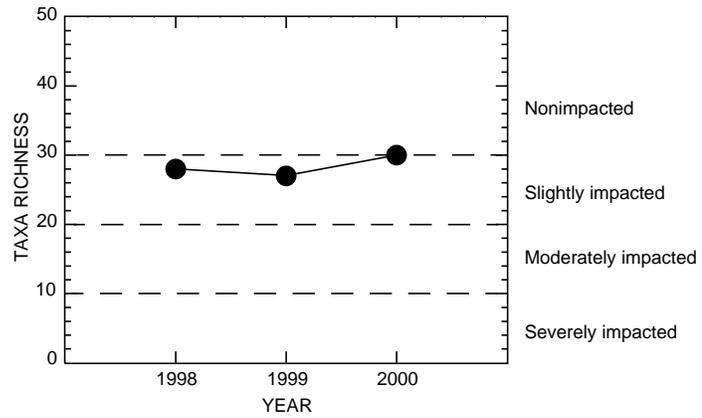


Figure 18. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from 01479800 East Branch Red Clay Creek near Five Points, Pa. (Site 26) (01479800), 1998-2000.

Brandywine Creek Basin

The Brandywine Creek Basin drains the central part of Chester County and is the largest basin in the county. The Brandywine Creek discharges directly into the Christina River, which is a tributary to the Delaware River. The fixed sites sampled annually in the Brandywine Creek Basin from 1998 to 2000 were West Branch Brandywine Creek at Honey Brook, West Branch Brandywine Creek at Modena, Buck Run, East Branch Brandywine Creek at Glenmoore, and the East Branch Brandywine below Downingtown (fig. 1). Six miscellaneous sites were sampled in the Brandywine Creek Basin between 1998 and 2000. Two sites were on Broad Run (1999) while Culbertson Run (1998), Shamona Creek (1998-99), West Valley Creek (1998), and the main stem Brandywine (1999) each had one sampling location (fig. 1). A description of the sampling location, chemical and habitat conditions, benthic-macroinvertebrate community structure, and plots of the biological metrics are presented for each sampling location.

West Branch Brandywine Creek near
Honey Brook, Pa.
(Site 57) (01480300)

Location: Latitude 40°04'22", longitude 75°51'40", on the downstream side of the bridge at Birdell Road, 0.5 mi downstream from Two Log Run, and 3.0 mi southeast of Honey Brook, in Honey Brook Township.

Drainage area: 18.7 mi².

Station setting: West Branch Brandywine Creek, upstream from site 57 (fig. 1), flows through agricultural land and the Borough of Honey Brook. A sewage treatment plant discharge and intense farming, including Amish farms, were upstream from the sampling location. Predominant land-use categories in the basin were agriculture (60 percent), forested (20 percent) and residential (9 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate and phosphorus concentrations measured at site 57 were elevated above the reference conditions measured at site 15 from 1998 to 2000. Ammonia concentrations were low and similar to those measured at the reference site. The maximum nitrate concentration was 6.44 mg/L, phosphorus concentrations ranged from 0.08 to 0.12 mg/L, and ammonia concentrations were <0.04 mg/L. Nitrate concentrations above 6.0 were measured at only four sites

between 1998 and 2000. The combination of elevated nitrate and phosphorus concentrations measured at site 57 are sufficient to cause nuisance plant growth that can result in low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). Boron concentrations ranged between 17 and 61 µg/L. The elevated concentrations of nutrients and ions, along with the occasionally high boron concentrations, suggest the stream received nutrient inputs from agricultural sources along with intermittent wastewater inputs. The concentration of major ions measured at site 57 were approximately double those measured at the reference site from 1998 to 2000.

Habitat: The stream was approximately 23 ft wide, had a mean depth of 0.5 ft, and was open to sunlight at the sampling location. The sampling reach was 75 ft long and consisted of a small riffle with pool areas upstream and downstream. This riffle consisted of gravel and sand with cobbles that were 25 to 50 percent embedded. Heavy silt and sand deposits and algal growth were evident in the pools and along the stream edges. Both streambanks were stable with little potential for erosion. The riparian areas on both banks were wide but degraded because they consisted of unmowed grass fields with only a few trees.

Benthic macroinvertebrates: West Branch Brandywine Creek near Honey Brook was assessed as nonimpacted or slightly impacted between 1998 and 2000 on the basis of the calculated biological metrics (fig. 19). Taxa richness indicates nonimpacted conditions but the HBI values indicated slightly impacted conditions. The benthic-macroinvertebrate community contained numerous taxa, including EPT taxa, but was dominated by three groups of organisms. Hydropsychid caddisflies and riffle beetles (intermediate) and midges ("pollution-tolerant") made up between 80 and 90 percent of the total individuals collected. The unbalanced structure of the benthic-macroinvertebrate community along with the HBI values above 4.5 indicate a disturbed community, possibly from organic enrichment. Taxa richness decreased from 35 to 31, EPT taxa richness decreased from 14 to 9, and the HBI values increased to greater than 5, indicating degraded stream quality in the West Branch Brandywine Creek near Honey Brook between 1998 and 2000.

Summary: The chemical, habitat, and biological data collected between 1998 and 2000 indicated a downward trend in stream quality in the West

Branch Brandywine Creek near Honey Brook related to habitat degradation from sedimentation and organic enrichment.

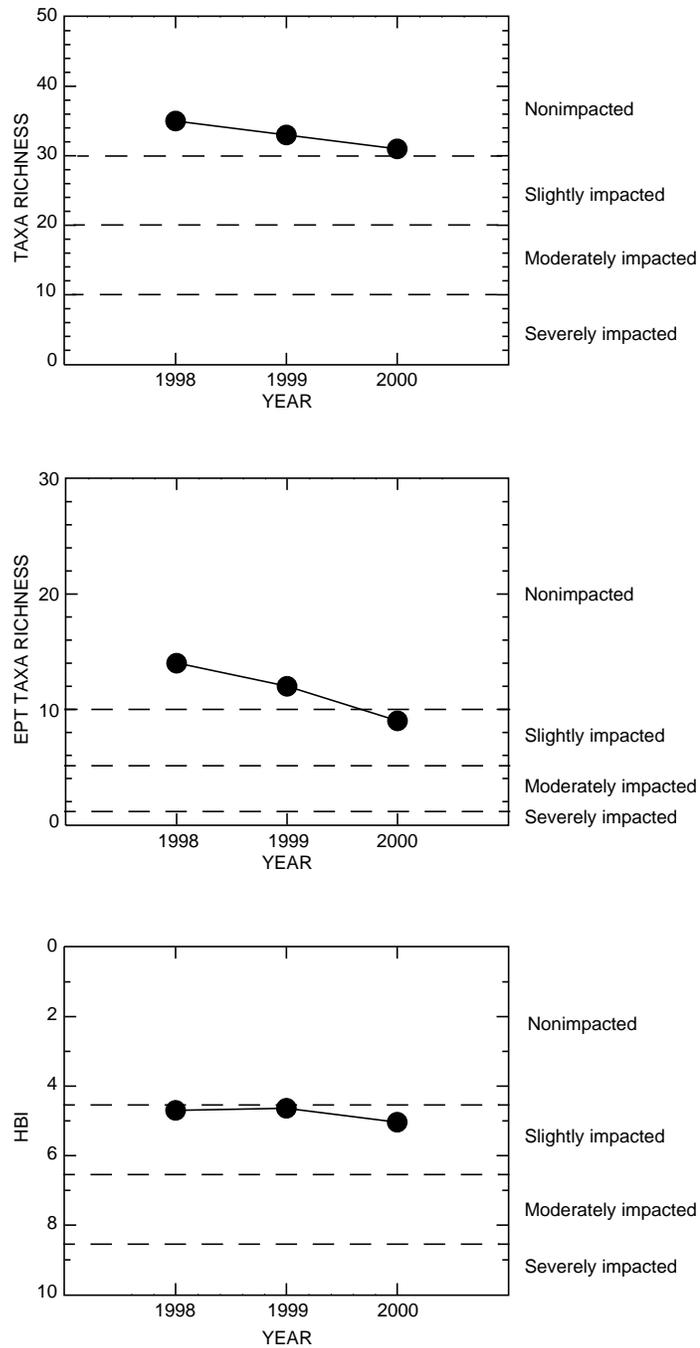


Figure 19. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from West Branch Brandywine Creek near Honey Brook, Pa. (Site 57) (01480300), 1998-2000.

West Branch Brandywine Creek at Modena, Pa.
(Site 56) (01480617)

Location: Latitude 39°57'42", longitude 75°48'06", on the downstream side of the bridge at Union Street, and 100 ft upstream from Dennis Run in the Borough of Modena.

Drainage area: 55.0 mi².

Station setting: West Branch Brandywine Creek, upstream from site 56 (fig. 1), flows from its headwaters in an agricultural area through residential and urban areas including the City of Coatesville. The creek received wastewater treatment discharges in Honey Brook and Coatesville, industrial point discharges and storm water runoff in Coatesville, and discharges from reservoirs on Rock Run and Birch Run. Predominant land-use categories in the basin were agriculture (38 percent), forested (32 percent), and residential (20 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate and phosphorus concentrations measured at site 56 were elevated above the reference conditions measured at site 15 from 1998 to 2000. Ammonia concentrations were low and similar to those measured at the reference site. The maximum nitrate concentration was 4.6 mg/L, phosphorus concentrations ranged between 0.07 and 0.11 mg/L, and ammonia concentrations were <0.04 mg/L. The combination of elevated nitrate and phosphorus concentrations measured at site 56 were sufficient to cause nuisance plant growth that can result in low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The concentrations of boron ranged between 63 and 80 µg/L, which suggest that wastewater was a major nutrient source. The concentration of major ions measured at site 57 were approximately double those measured at the reference site from 1998 to 2000. Maximum concentrations of aluminum (18.9 µg/L), chromium (6.4 µg/L), copper (4.7 µg/L), manganese (42.2 µg/L), mercury (0.23 µg/L), molybdenum (67.0 µg/L), and nickel (12.5 µg/L) were measured. These concentrations were above USEPA-recommended concentrations but were below toxic levels (U.S. Environmental Protection Agency, 1999). Industrial processes in the City of Coatesville are the most likely source of the dissolved metals.

Habitat: The stream was approximately 66 ft wide but had flow in only 50 to 60 percent of the channel. The stream had a mean depth of 0.5 ft and was

partially shaded at the sampling location. The sampling reach was 200 ft of stable continuous cobble riffle that was 50 percent embedded with gravel and sand and was covered with moderate amounts of algae. The left bank had minor erosional scars and a wide riparian area that consisted of 10 to 50 ft of forested area that opened to a mowed grass field. The right bank had erosional scars including exposed tree roots and bare areas. The riparian area on the right bank was highly disturbed by a house with a lawn that is close to the streambank.

Benthic macroinvertebrates: West Branch Brandywine Creek at Modena was assessed as slightly impacted between 1998 and 2000 on the basis of most of the calculated biological metrics (fig. 20). The benthic-macroinvertebrate community contained relatively low taxa richness and EPT taxa richness and HBI values that indicated degraded stream quality. Hydropsychid caddisflies were the dominant group, ranging from 31 to 68 percent of the individuals collected. Hydropsychid caddisflies are intermediate in their tolerance for pollution. Although EPT taxa richness was relatively low, indicating degraded conditions, the number of "pollution-tolerant" taxa and individuals also was relatively low. Degraded habitat from sedimentation along with elevated nutrient concentrations were affecting the benthic macroinvertebrates at site 56.

Summary: The chemical, habitat, and biological data collected between 1998 and 2000 indicated degraded stream quality in the West Branch Brandywine Creek at Modena possibly because of organic enrichment, elevated metal concentrations, and sedimentation.

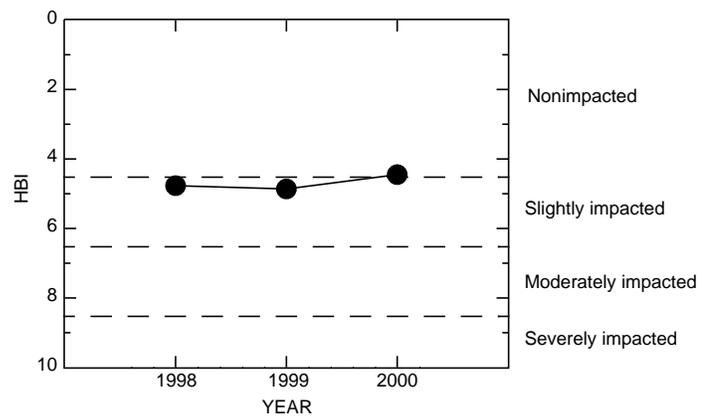
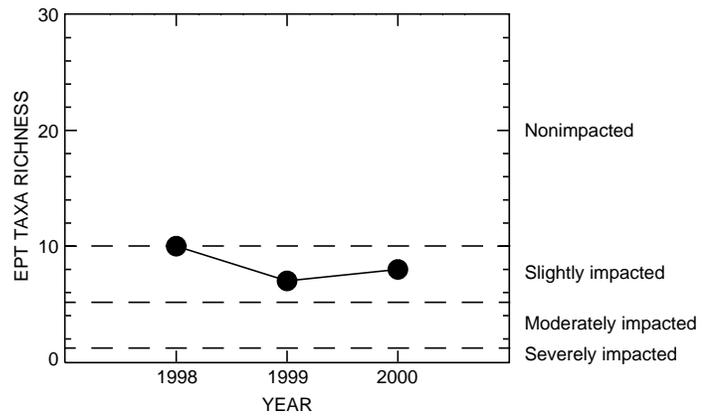
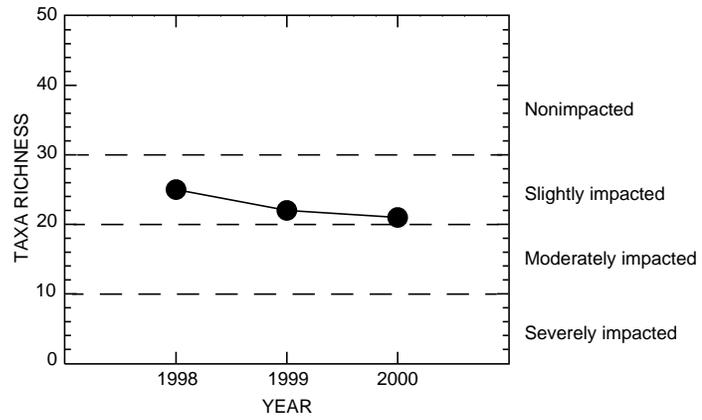


Figure 20. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from West Branch Brandywine Creek at Modena, Pa. (Site 56) (01480617), 1998-2000.

Buck Run at Doe Run, Pa.
(Site 46) (01480629)

Location: Latitude 39°55'46", longitude 75°49'24", 750 ft upstream from covered bridge on Hephzibah Hill Road, and 1.0 mi northwest of Doe Run, on the border between East Fallowfield and West Marlborough Townships.

Drainage area: 22.6 mi².

Station setting: Buck Run, upstream of site 46 (fig. 1), flows from its headwaters through agricultural, forested, and residential areas. The headwaters run through the Borough of Parkesburg and receive wastewater treatment discharge. The area immediately upstream of site 46 was dominated by field/pasture land use. Predominant land-use categories in the basin were agriculture (57 percent), forested (26 percent), and residential (12 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate concentrations measured at site 46 were elevated above the reference conditions measured at site 15 from 1998 to 2000. Concentrations of phosphorus and ammonia were low and similar to those measured at the reference site. The nitrate concentrations ranged from 4.6 to 4.9 mg/L, phosphorus concentrations were <0.02 mg/L, and ammonia concentrations were <0.04 mg/L. The maximum boron concentration was 27 µg/L, which suggests agriculture was the major nutrient source. The concentrations of major ions measured were elevated above those measured at the reference site from 1998 to 2000.

Habitat: The stream was approximately 31 ft wide, had a mean depth of 0.7 ft, and was partly shaded at the sampling location. The sampling reach was 100 ft in length with pool areas upstream and downstream of a stable riffle. This was the only riffle in the immediate area and it consisted of large cobbles that were 20 percent embedded by gravel and sand. There was heavy algal growth and deposition of sand and silt in the pools. Both streambanks were stable with minor evidence of erosion. The riparian area on the left bank was very steep and undisturbed with some minor erosional scars. The riparian area on the right bank was heavily vegetated for 10 to 20 ft then opened into an undisturbed meadow.

Benthic macroinvertebrates: Buck Run was assessed as nonimpacted between 1998 and 2000 on the basis of the calculated biological metrics (fig. 21). The benthic-macroinvertebrate community contained high taxa richness and low HBI val-

ues. The numbers of "pollution-sensitive" and intermediate organisms were proportional in the samples collected, indicating a balanced community. In 2000, 47 percent of the taxa and 77 percent of the individuals collected were from EPT taxa. The numbers of "pollution-tolerant" organisms were consistent but relatively small. The structure of the benthic-macroinvertebrate community indicates healthy stream conditions.

Summary: Although Buck Run was affected by agriculture and a wastewater treatment discharge in its headwaters, it represents good stream conditions for agricultural areas in the southern and western parts of Chester County. The site had stable habitat, non-toxic water chemistry, and generally healthy biological conditions.

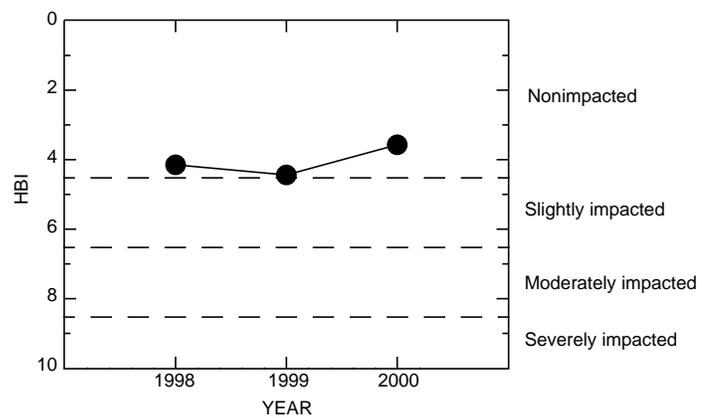
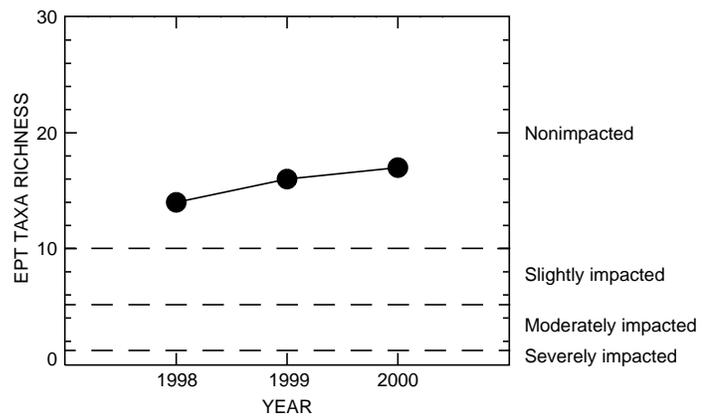
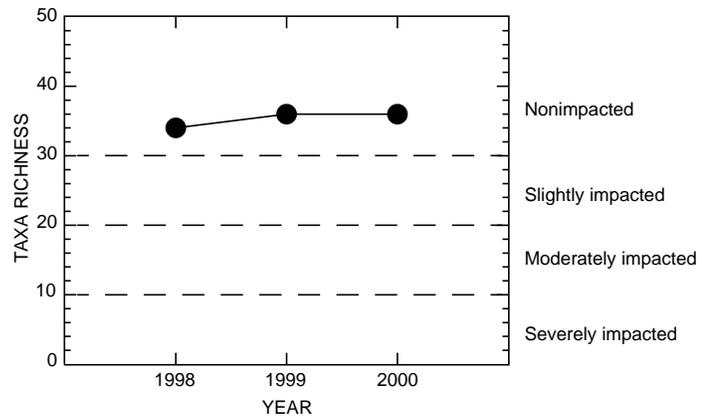


Figure 21. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Buck Run at Doe Run, Pa. (Site 46) (01480629), 1998-2000.

Broad Run at Romansville, Pa.
(Site 69) (01480636)

Location: Latitude 39°57'06", longitude 75°43'33", 750 ft downstream from a bridge on Lieds Road in West Bradford Township.

Drainage area: 2.86 mi².

Station setting: Broad Run, at site 69 (fig. 1), is a small headwater stream that drains an area of field/pasture, forested, and light residential land. No major population centers or known point discharges were upstream of site 69. Predominant land-use categories in the basin were agriculture (35 percent), forested (33 percent), and residential (28 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: In 1999, the nitrate concentration measured at site 69 was elevated above the reference conditions measured at site 15 but was relatively low. Concentrations of phosphorus, ammonia, and major ions were low and similar to those measured at the reference site (site 15). The nitrate concentration was 2.80 mg/L, the phosphorus concentration was <0.01 mg/L, and the ammonia concentration was <0.02 mg/L. The boron concentration was 16 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream was approximately 4.5 ft wide, had a mean depth of 0.5 ft, and was open to sunlight at the sampling location. The sampling reach was 40 ft in length and consisted of a small stable cobble riffle on a clay substrate. Algae cover and sedimentation were light in the reach. The riparian areas were wide and consisted of grasses up to the stream channel. Erosion was not evident at the site.

Benthic macroinvertebrates: In 1999, Broad Run at Romansville was assessed as nonimpacted on the basis of taxa richness and EPT taxa richness, but the HBI value was in the slightly impacted range (fig. 22). The benthic-macroinvertebrate community was very diverse for a small headwater stream; 43 taxa were collected including 27 EPT taxa. Although the benthic-macroinvertebrate community was diverse in taxa, it was dominated by midges, a "pollution-tolerant" taxon, that accounted for 40 percent of all individuals collected. This dominance by a "pollution-tolerant" group caused the higher HBI values, indicating slightly degraded stream quality.

Summary: The chemical and habitat data collected in 1999 indicated good overall water quality but the habitat was slightly degraded because of disturbed riparian areas that allow sunlight to reach the stream. The benthic-macroinvertebrate community was diverse and contained numerous "pollution-sensitive" taxa that indicate good stream quality. The HBI values indicate slightly degraded stream quality although chemical data do not indicate the presence of elevated nutrients. Habitat data indicated minor disturbances. Additional sampling is needed to fully describe the stream conditions at this site.

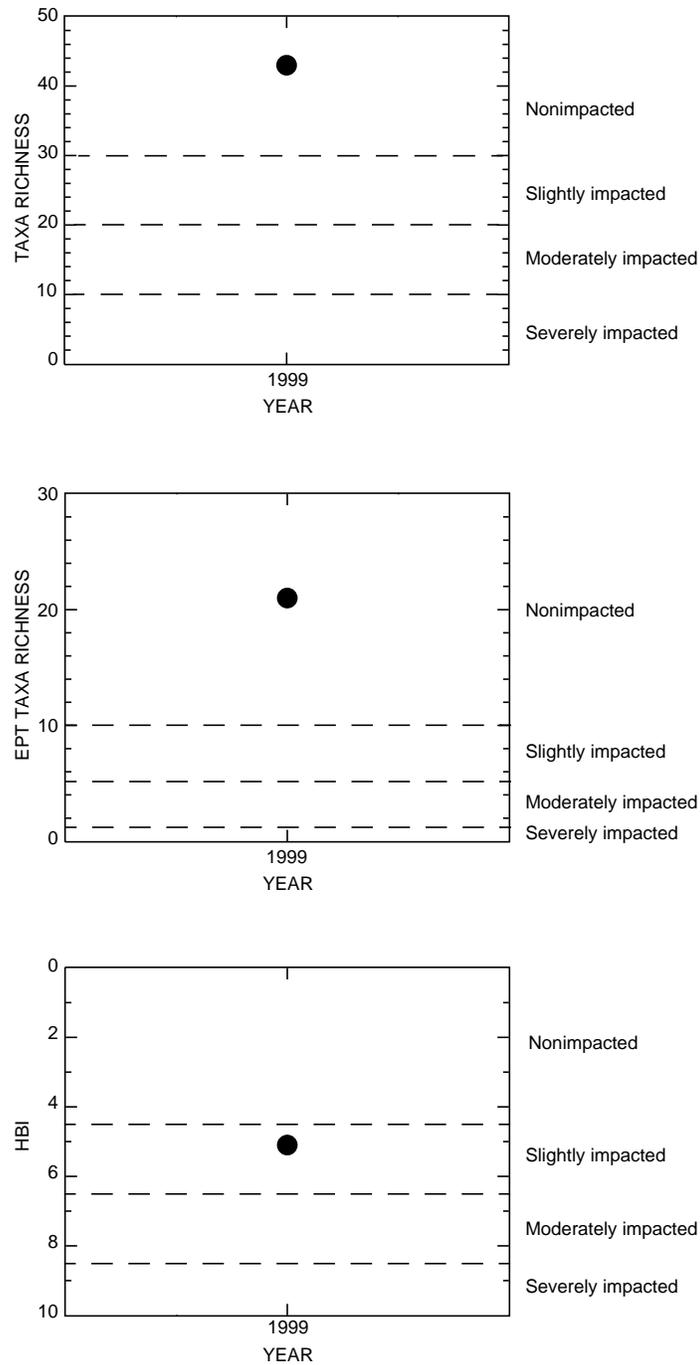


Figure 22. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Broad Run at Romansville, Pa. (Site 69) (01480636), 1999.

Broad Run at Northbrook, Pa.
(Site 70) (01480638)

Location: Latitude 39°55'49", longitude 75°41'06", 20 ft upstream from a bridge on Northbrook Road in West Bradford Township.

Drainage area: 6.39 mi².

Station setting: Broad Run, at site 70 (fig. 1), drains an area of field/pasture, forested, and light residential land. No major population centers or known point discharges were upstream of site 70. The stream flows through a golf course upstream from the sampling location, and a commercial orchard was present in the basin. Predominant land-use categories in the basin were agriculture (37 percent), residential (30 percent), and forested (29 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: In 1999, nitrate concentration measured at site 69 was elevated above the reference conditions measured at site 15 but was relatively low. Concentrations of phosphorus, ammonia, and major ions were low and similar to those measured at the reference site. The nitrate concentration was 2.60 mg/L, the phosphorus concentration was <0.01 mg/L, and the ammonia concentration was <0.02 mg/L. The boron concentration was <16.0 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream was approximately 11 ft wide, had a mean depth of 0.6 ft, and was mostly shaded at the sampling location. The sampling reach was 35 ft in length and consisted of a small stable cobble riffle that was 40 percent embedded with gravel. Pool areas were upstream and downstream from the reach. Algae cover was light, and sedimentation in the pools was heavy. The riparian areas consisted of 10 to 20 ft of multiflora rose then open pasture. Erosion at the site was minor.

Benthic macroinvertebrates: In 1999, Broad Run at Northbrook was assessed as nonimpacted on the basis of all the calculated biological metrics (fig. 23). The benthic-macroinvertebrate community contained numerous "pollution-sensitive" and intermediate taxa. Forty-six percent of the 36 taxa collected were EPT taxa, and the most dominant taxon was riffle beetles, which made up 46 percent of all individuals. "Pollution tolerant" taxa were collected but represented a small percentage of the total individuals. The structure of the benthic-macroinvertebrate community indicated healthy stream conditions.

Summary: The chemical, habitat, and biological data collected in 1999 indicated good overall stream quality in Broad Run. The site had low nutrient concentrations and diverse macroinvertebrate communities that indicated good stream quality. Broad Run was moderately affected by sedimentation at the sampling location.

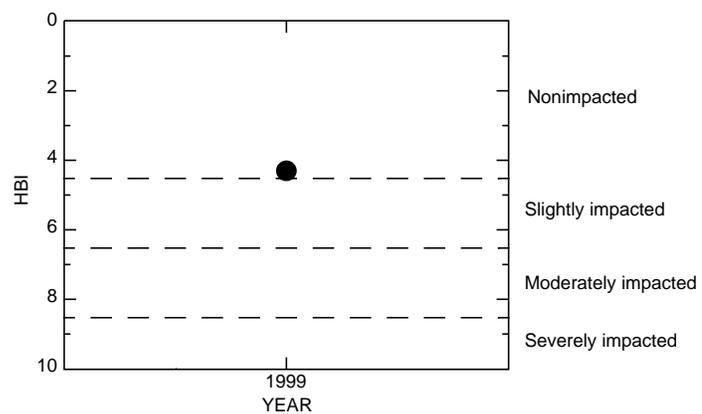
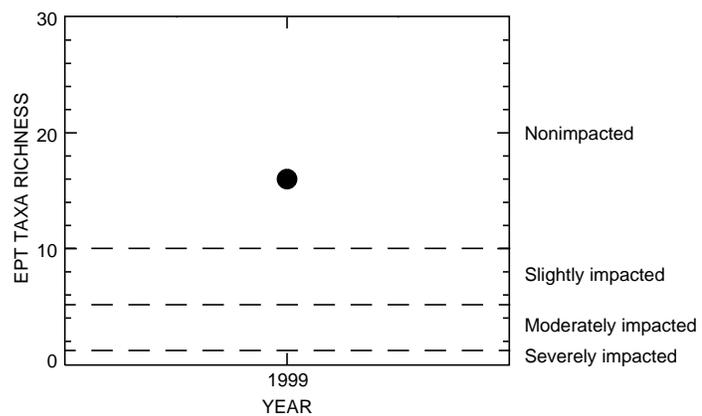
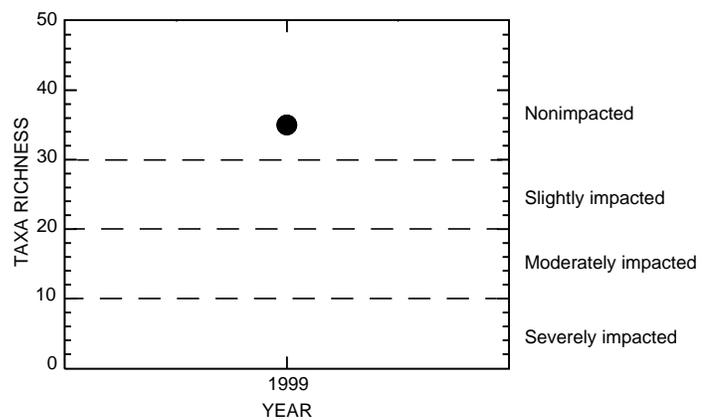


Figure 23. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Broad Run at Northbrook, Pa. (Site 70) (01480638), 1999.

East Branch Brandywine Creek at Glenmoore, Pa.
(Site 42) (01480653)

Location: Latitude 40°05'48", longitude 75°46'44", 500 ft downstream from a bridge on State Route 282, 1.5 mi upstream from Indian Run, and 0.5 mi north of Glenmoore, in Wallace Township.

Drainage area: 16.5 mi².

Station setting: The headwaters of the East Branch Brandywine Creek flow out of Struble Lake through forested, field/pasture, and agricultural lands. No major population centers or known point discharges were upstream of site 42 (fig. 1). Predominant land-use categories in the basin were agriculture (51 percent), forested (34 percent), and residential (10 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of phosphorus, ammonia, and major ions measured at site 42 from 1998 to 2000 were low and similar to those measured at the reference site (site 15). Nitrate concentrations were elevated compared to those measured at the reference site. The nitrate concentrations ranged from 2.8 to 3.6 mg/L, and phosphorus and ammonia concentrations were <0.02 mg/L. The maximum boron concentration was 20 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream was approximately 35 ft wide, had a mean depth of 0.75 ft, and was mostly shaded at the sampling location. The sampling reach was 100 ft in length with pool areas upstream and downstream of a small riffle and run area. This was the only riffle in the immediate area, and it consisted of large cobbles that were 25 to 40 percent embedded by gravel and sand. Deposition of sand and silt in the pools and along the stream edges was heavy. Both riparian areas were wide and undisturbed. The left bank was flat and had no erosional scars. The right bank was steep with exposed roots and erosional scars.

Benthic macroinvertebrates: East Branch Brandywine Creek at Glenmoore was assessed as non-impacted between 1998 and 2000 on the basis of the calculated biological metrics (fig. 24). The benthic-macroinvertebrate community had taxa richness and EPT taxa richness that indicated healthy stream conditions. "Pollution-sensitive" and intermediate organisms dominated the macroinvertebrate community at this site; 59-81 percent of the benthic-macroinvertebrate individuals collected belong to EPT taxa. Hydropsychid caddis-

flies, a taxon intermediate in its pollution tolerance, was the dominant taxon in all 3 years, making up between 34 and 57 percent of the total individuals collected. The number of "pollution-tolerant" taxa and individuals was relatively low and represented a small part of the total sample. The dominance of EPT taxa and low number of "pollution-tolerant" taxa indicate healthy nonimpacted stream conditions.

Summary: The benthic-macroinvertebrate data collected between 1998 and 2000 indicated nonimpacted stream conditions despite nitrate concentrations that were slightly elevated above those measured at the reference site and moderate sedimentation at the sampling site. This site had the second highest taxa richness of all sites sampled between 1998 and 2000.

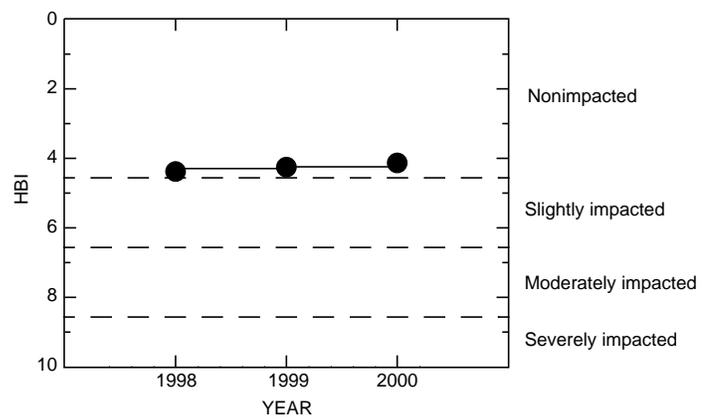
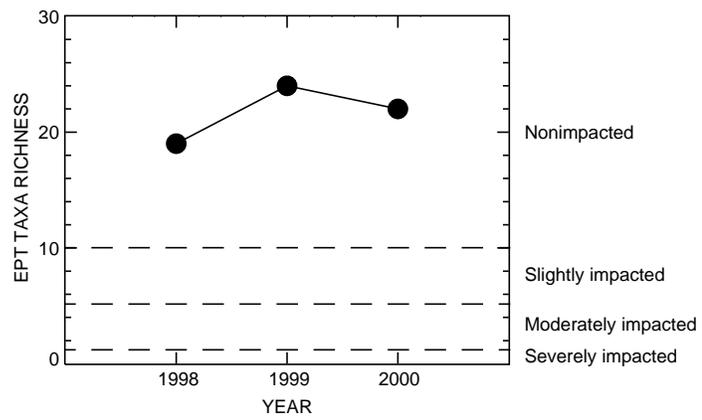
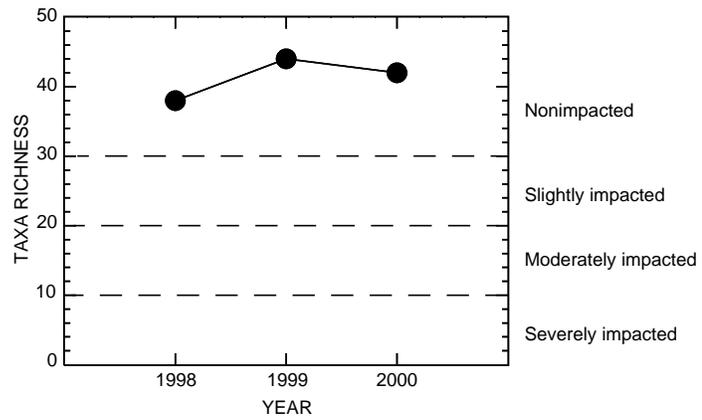


Figure 24. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from East Branch Brandywine Creek at Glenmoore, Pa. (Site 42) (01480653), 1998-2000.

Culbertson Run at Lyndell, Pa.
(Site 65) (01480662)

Location: Latitude 40°03'29", longitude 75°45'07", 20 ft downstream from a bridge on State Route 282, and 75 ft upstream from East Branch Brandywine Creek, at Lyndell, in East Brandywine Township.

Drainage area: 3.92 mi².

Station setting: Culbertson Run flows through forested, field/pasture, and residential land and empties into the East Branch Brandywine Creek. No major population centers or known point discharges were upstream from site 65 (fig. 1). Predominant land-use categories in the basin were agriculture (42 percent), residential (39 percent), and forested (17 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of nutrients and major ions measured at site 65 in 1998 were elevated over those measured at the reference site (site 15). The nitrate concentration was 3.41 mg/L, the phosphorus concentration was 0.04 mg/L, and the ammonia concentration was 0.03 mg/L. The nitrate and phosphorus concentrations were sufficient to cause nuisance plant growth that can result to low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The boron concentration was 24 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream was approximately 15 ft wide, had a mean depth of 0.4 ft, and was partly shaded at the sampling location. The sampling reach was 50 ft long and consisted of a small cobble gravel riffle. Minor amounts of fine sediment and algae were evident in the reach, and erosion was minor. The riparian area on the right bank was mowed grass up to the stream channel. The left bank had a buffer of trees and shrubs between the stream and a grass area.

Benthic macroinvertebrates: In 1998, Culbertson Run at Lyndell was assessed as nonimpacted on the basis of the calculated biological metrics (fig. 25). The benthic-macroinvertebrate community contained a diverse mix of "pollution-sensitive" and intermediate taxa. Fifty percent of the taxa and 48 percent of the individuals were EPT taxa, which indicates good stream quality. "Pollution-tolerant" taxa were present but in low numbers. Hydropsychid caddisflies were the dominant group collected but made up only 28 percent of

total individuals. The high number of EPT taxa and low number of "pollution-tolerant" taxa indicate good stream quality.

Summary: The chemical and habitat data collected in 1998 indicated slightly elevated nitrate concentrations but relatively low concentrations of phosphorus and ammonia along with stable habitat. The benthic macroinvertebrates collected indicated nonimpacted stream conditions at site 65.

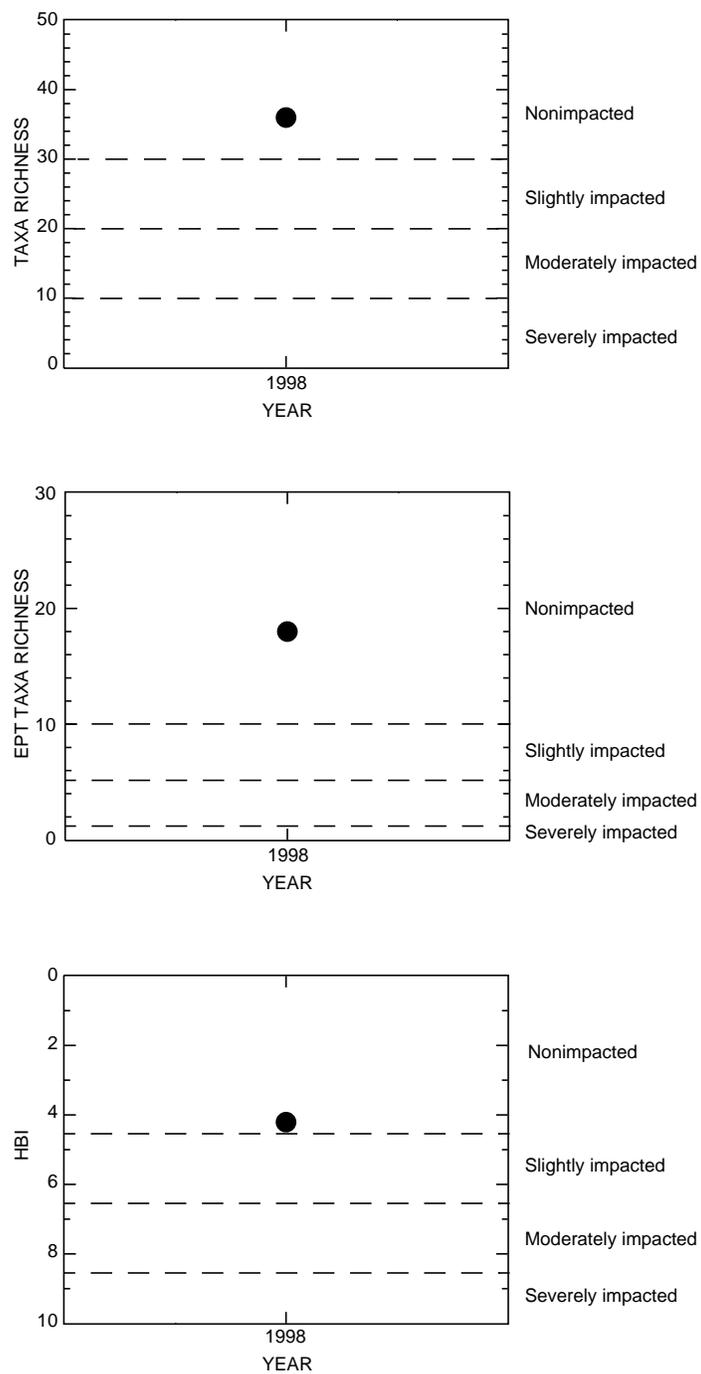


Figure 25. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Culbertson Run at Lyndell, Pa. (Site 65) (01480662), 1998.

Shamona Creek at Dowlin, Pa.
(Site 67) (01480697)

Location: Latitude 40°02'28", longitude 75°41'57", 0.5 mi upstream from East Branch Brandywine Creek, 0.25 mi south of Shamona Park, and 2 mi north of Downingtown, in Uwchlan Township.

Drainage area: 3.85 mi².

Station setting: Shamona Creek flows through forested, field/pasture, and residential land and empties into the East Branch Brandywine Creek. Its headwaters lie in a corporate and residential area; no known point discharges were upstream from site 67 (fig. 1). Predominant land-use categories in the basin were residential (35 percent), agriculture (33 percent), and forested (20 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of nitrate and major ions measured at site 67 in 1998 and 1999 were elevated over those measured at the reference site (site 15). Concentrations of phosphorus and ammonia were low and similar to those measured at the reference site. The maximum concentrations of nutrients were nitrate 2.98 mg/L and phosphorus and ammonia 0.02 mg/L. Boron concentrations were 27 and 28 µg/L; these low concentrations suggest agriculture was the major nutrient source.

Habitat: The stream channel was approximately 25 ft wide but had flow in only 15 ft of the channel. The stream had a mean depth of 1.0 ft and was mostly shaded. The sampling reach was 200 ft long and consisted of a long continuous riffle of boulders, cobbles, and gravel. The reach contained very little silt or sand, and the cobbles were free of algae. The left bank had a very wide and forested riparian area and was very steep and heavily eroded. The right bank had many scoured areas and a high potential for erosion. The right bank had a narrow forested riparian area between Dorlans Mill Road and the stream.

Benthic macroinvertebrates: Shamona Creek at Dowlin was assessed as nonimpacted during 1998 and 1999 on the basis of the calculated biological metrics (fig. 26). The benthic-macroinvertebrate community contained 30 or more taxa but a relatively low numbers of organisms. EPT individuals accounted for between 55 and 70 percent of the individuals collected. "Pollution-tolerant" organisms represented a relatively small part of the sample. The dominant taxon collected in 1998 was Hydropsychid caddisflies, an intermediate taxon.

In 1999, the dominant taxon was a "pollution-sensitive" stonefly taxon. In general, stoneflies are considered to require the best water quality of all insects. The high percentage of EPT individuals and low number of "pollution-tolerant" taxa indicate good stream quality in Shamona Creek at Dowlin.

Summary: The chemical, habitat, and biological data collected during 1998 and 1999 indicated slightly elevated concentrations of nitrate and major ions, low concentrations of phosphorus and ammonia, and an erosional habitat. The benthic macroinvertebrates collected indicate nonimpacted stream conditions at site 67. Site 67 was one of only three sites that had an HBI value below 4.0 between 1998 and 2000.

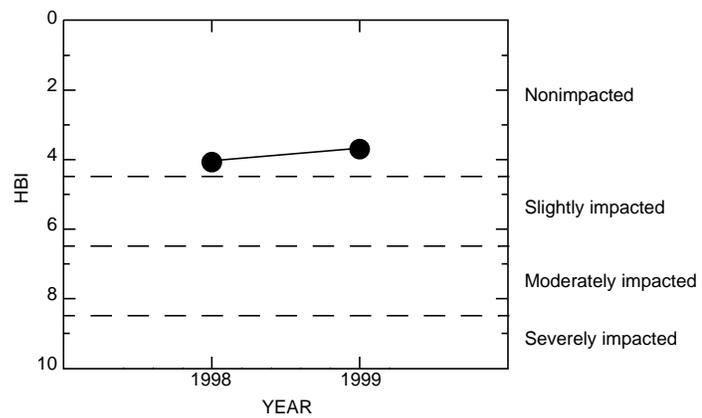
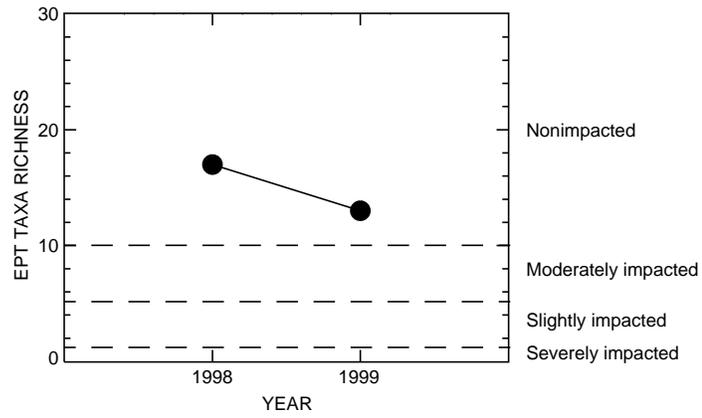
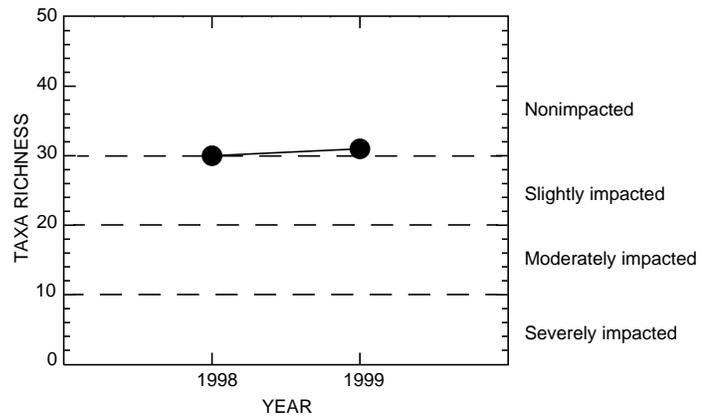


Figure 26. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Shamona Creek at Dowlin, Pa. (Site 67) (01480697), 1998-99.

East Branch Brandywine Creek below
Downingtown, Pa.
(Site 54) (01480870)

Location: Latitude 39°58'07", longitude 75°40'25", on the downstream side of Sugars Bridge (U.S. Highway 322), 2,000 ft upstream from West Valley Creek, 1.5 mi north of Marshallton, and 3.3 mi southeast of Downingtown, on the border between East Bradford and West Bradford Townships.

Drainage area: 89.9 mi².

Station setting: East Branch Brandywine Creek, upstream of site 54 (fig. 1), flows from its headwaters in a forested and field/pasture area through residential and urban areas including the Borough of Downingtown. The creek received wastewater treatment and industrial point discharges in Downingtown and discharges from the Marsh Creek Reservoir and Struble Lake. Predominant land-use categories in the basin were forested (36 percent), agriculture (33 percent), and residential (23 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of nitrate, phosphorus, and major ions measured at site 54 were elevated over concentrations measured at the reference site (site 15) from 1998 to 2000. The maximum nitrate concentration was 4.0 mg/L, phosphorus concentrations ranged between 0.06 and 0.19 mg/L, and ammonia concentrations were <0.04 mg/L. The elevated concentrations of nitrate and phosphorus were sufficient to cause nuisance plant growth that can result in low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The concentrations of boron ranged between 67 and 118 µg/L, which suggest that wastewater was the major nutrient source. Dissolved metals were measured at relatively low concentrations.

Habitat: The stream was approximately 75 ft wide but had flow in only 70 percent of the channel. The stream had a mean depth of 0.6 ft and was partially shaded at the sampling location. The sampling reach was 200 ft of stable continuous cobble riffle that was 40 percent embedded with gravel and sand and was covered with light amounts of algae. Both banks had greater than 50 ft of undisturbed forested riparian areas. Minor erosion was evident within the sampling reach, but areas of heavy erosion were evident upstream and downstream of the sampling reach.

Benthic macroinvertebrates: East Branch Brandywine Creek below Downingtown was assessed as nonimpacted in 1998 and 2000 on the basis of EPT taxa richness and the HBI values and as slightly impacted on the basis of taxa richness (fig. 27). The benthic-macroinvertebrate community contained greater than 56 percent EPT individuals and had relatively low numbers of "pollution-tolerant" organisms. The high percentage of EPT taxa and low numbers of "pollution-tolerant" organisms indicate healthy stream conditions. The benthic macroinvertebrates collected in 1999 had taxa richness similar to 1998 and 2000 but less EPT taxa richness and the structure of the benthic-macroinvertebrate community was different. In 1999, the benthic-macroinvertebrate community was dominated by midges (72 percent), a "pollution-tolerant" taxa. The stream was assessed as slightly impacted on the basis of all three biological metrics in 1999 but recovered to its 1998 conditions by the 2000 sampling.

Because the EPT taxa richness, percentage EPT, and HBI values in 2000 indicated nonimpacted conditions and are similar to 1998 values, the most likely reason for the change in the benthic-macroinvertebrate community in 1999 is the extreme weather conditions, including a drought and a flood during that year.

Summary: The biological data collected in 1998 and 2000 indicated nonimpacted to slightly impacted stream quality. Chemical and habitat data indicated moderate nutrient enrichment most likely from a mix of wastewater discharge and agricultural sources and areas of erosion and deposition.

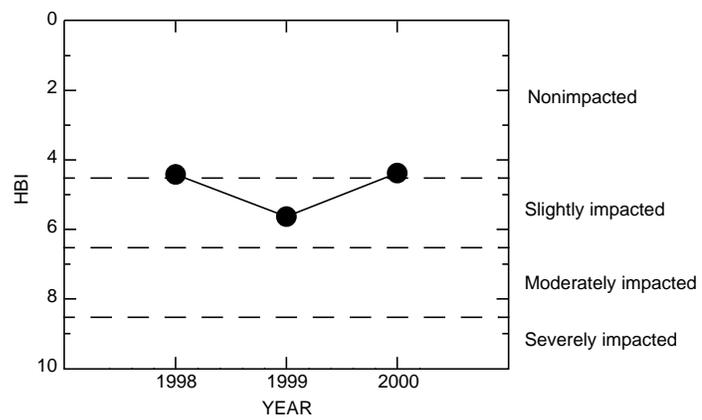
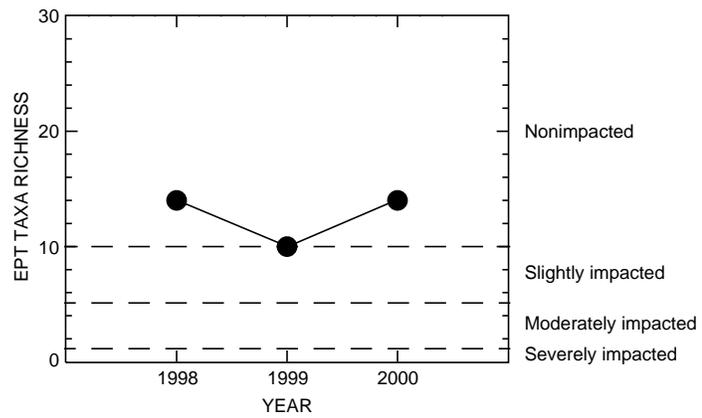
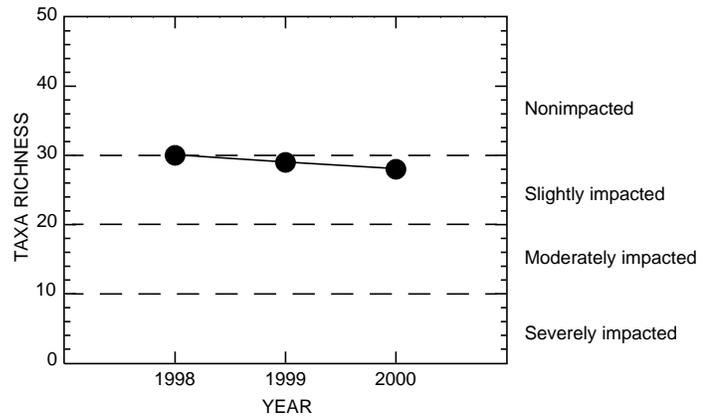


Figure 27. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from East Branch Brandywine Creek below Downingtown, Pa. (Site 54) (01480870), 1998-2000.

West Valley Creek at Clover Mill Road near
Exton, Pa.
(Site 66) (01480883)

Location: Latitude 40°00'43", longitude 75°39'20", 75 ft downstream from bridge on U.S. Highway 30 (Exton By-pass) and 2 mi southwest of Exton, in West Whiteland Township.

Drainage area: 11.8 mi².

Station setting: West Valley Creek headwaters lie in a residential area and the stream flows through mixed land use including residential, corporate parks, shopping malls, light industrial sites, and major highways including State Routes 100 and 30. The predominant land-use categories in the basin were residential (30 percent), forested (28 percent), agriculture (21 percent), and commercial/community services and manufacturing (14 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of nitrate and ammonia measured in 1998 at site 66 were similar to those measured at the reference site (site 15); concentrations of phosphorus and major ions were elevated over those at the reference site. The concentrations of nutrients were nitrate 1.38 mg/L, phosphorus 0.08 mg/L, and ammonia 0.02 mg/L. Nutrient concentrations measured at site 66 were sufficient to cause nuisance plant growth that can result in low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The boron concentration was 30 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream channel was approximately 19 ft wide, had a mean depth of 0.4 ft, and was partly shaded. The sampling reach was 50 ft in length and consisted of a long continuous riffle of cobbles and gravel. The reach contained very little silt or sand, and the cobbles were free of algae. Both riparian areas were large forested areas; the banks had minor erosional scars and were heavily vegetated.

Benthic macroinvertebrates: West Valley Creek at Clover Mill Road was assessed as nonimpacted on the basis of the calculated biological metrics in 1998 (fig. 28). Although the site was assessed as nonimpacted, the HBI value was at the cutoff between nonimpacted and slightly impacted, indicating some effect at the site. The benthic-macroinvertebrate community was dominated by riffle beetles (65 percent), which are intermediate in their pollution tolerance. The number of "pollution

tolerant" organisms was low, indicating good stream conditions. The heavy dominance of one group along with the HBI value near the slightly impacted level indicates disturbance but more sampling is needed to better describe the community at this site.

Summary: The biological data collected in 1998 indicated nonimpacted to slightly impacted stream quality. Chemical and habitat data indicated slightly elevated concentrations of phosphorus and major ions along with stable habitat and little deposition at the sampling site.

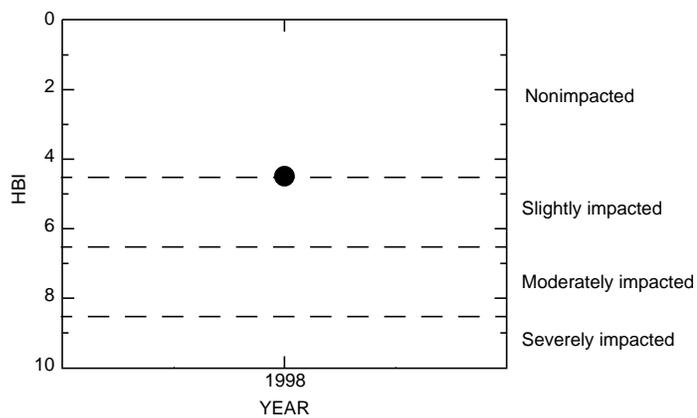
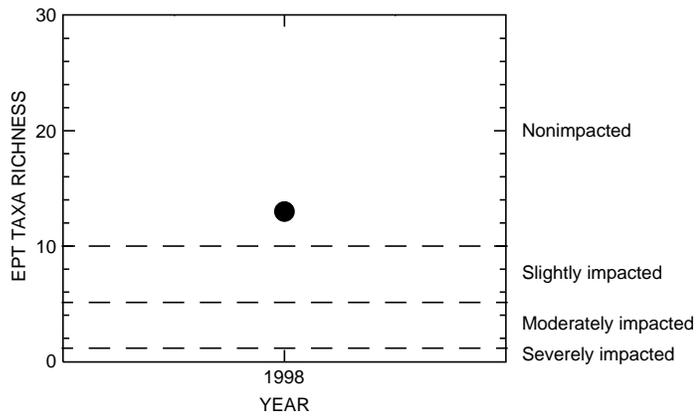
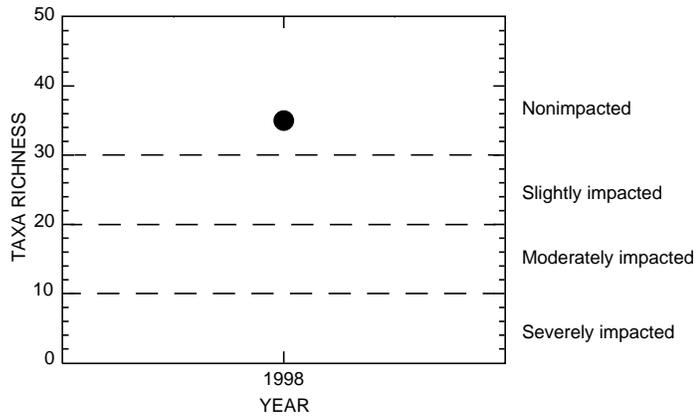


Figure 28. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from West Valley Creek at Clover Mill Road near Exton, Pa. (Site 66) (01480883), 1998.

Brandywine Creek at Chadds Ford, Pa.
(Site 40) (01481000)

Location: Latitude 39°51'15", longitude 75°35'58", 2,000 ft downstream of bridge on U.S. Highway 1 and 50 ft downstream from Harvey Run, at Chadds Ford, on the border between Birmingham and Pennsbury Townships.

Drainage area: 291 mi².

Station setting: The Brandywine Creek at Chadds Ford at site 40 (fig. 1) is in an area of mixed land use dominated by residential and field/pasture land. It also receives wastewater treatment discharges from both the East and West Branches of the Brandywine Creek along with point and nonpoint discharges from urban and agricultural lands. The predominant land-use categories in the basin were agriculture (39 percent), forested (31 percent), and residential (21 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: In 1999, concentrations of nitrate, phosphorus, and major ions measured at site 40 were elevated compared to those measured at the reference site (site 15). The nitrate concentration was 3.30 mg/L, the phosphorus concentration was 0.06 mg/L, and the ammonia concentration was <0.02 mg/L. The elevated concentrations of nitrate and phosphorus were sufficient to cause nuisance plant growth that can result in low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). Concentrations of major ions were slightly elevated over those measured at the reference site, and the concentration of boron (49 µg/L) indicates that some wastewater discharge was present. This site receives a mix of agricultural and suburban influences on the water chemistry.

Habitat: The stream was approximately 89 ft wide, had a mean depth of 1.1 ft, and was mostly open to sunlight at the sampling location. The sampling reach was 100 ft of stable continuous cobble riffle that was 60 percent embedded with gravel and sand and was covered with moderate amounts of algae. Both banks had greater than 50 ft of undisturbed forested riparian areas, were heavily vegetated, and had minor erosional scars.

Benthic macroinvertebrates: Brandywine Creek at Chadds Ford was assessed as nonimpacted on the basis of taxa richness and EPT taxa richness in 1999 but was slightly impacted on the basis of the HBI value (fig. 29). The benthic-macroinvertebrate community was dominated by riffle beetles (73 percent), which are intermediate in their pollu-

tion tolerance. The heavy dominance of one group can indicate disturbance, but historical sampling indicates that dominance by riffle beetles is not typical at site 40 (Reif, 1999). Future sampling may be needed to determine if the dominance of riffle beetles is a trend or a temporary situation. The number of "pollution-tolerant" organisms was low and the number of EPT taxa was high, which indicate good stream conditions.

Summary: The biological data collected in 1999 indicated nonimpacted to slightly impacted stream quality. Chemical and habitat data indicated moderate concentrations of nutrients and major ions along with degraded habitat because of sediment deposition.

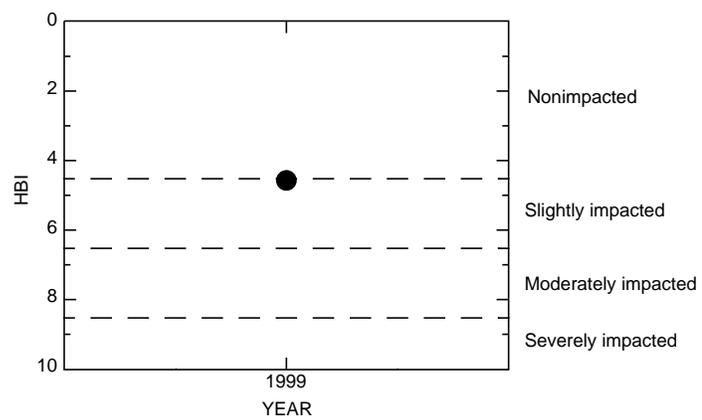
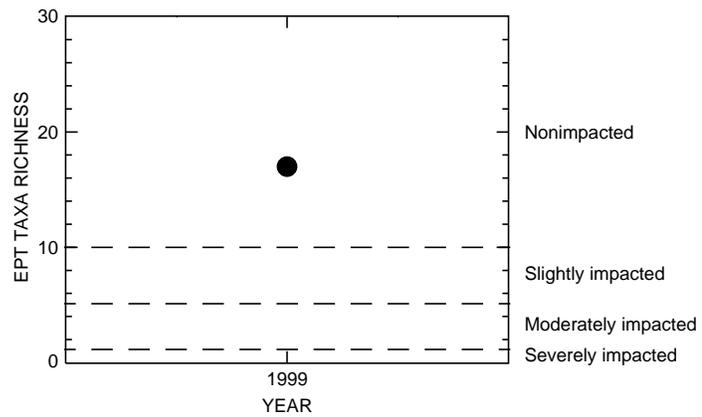
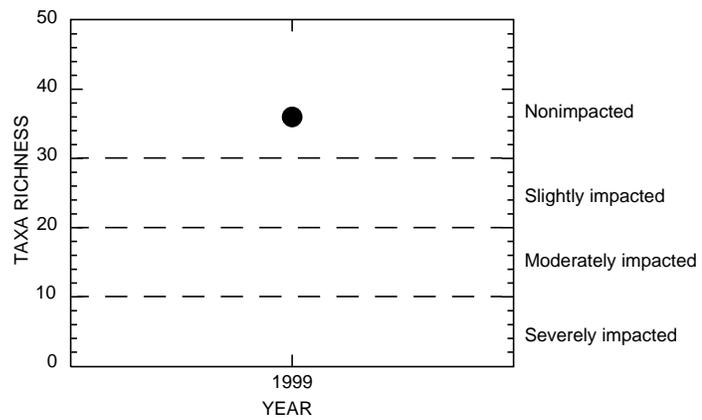


Figure 29. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Brandywine Creek at Chadds Ford, Pa. (Site 40) (01481000), 1999.

Big Elk Creek Basin

The Big Elk Creek Basin drains the southwest part of Chester County and discharges directly into the Chesapeake Bay. Big Elk Creek at Maple Grove was the only fixed site sampled annually in the Big Elk Creek Basin from 1998 to 2000 (fig. 1). Four miscellaneous sites were sampled in the Big Elk Creek Basin between 1998 and 2000. They were on the East Branch Big Elk at Faggs Manor (1998), East Branch Big Elk Creek at Elkview (1998-99), West Branch Big Elk Creek near Oxford (1998-99), and Little Elk Creek (1999) (fig. 1). A description of the sampling location, chemical and habitat conditions, benthic-macroinvertebrate community structure, and plots of the biological metrics are presented for each sampling location.

East Branch Big Elk Creek at Faggs Manor, Pa.
(Site 62) (01494800)

Location: Latitude 39°50'45", longitude 75°54'22", 50 ft downstream from a bridge on Ewing Road, and 1 mi south of Faggs Manor, on the border between Londonderry and Upper Oxford Townships.

Drainage area: 3.55 mi².

Station setting: East Branch Big Elk Creek at site 62 (fig. 1), is a small headwater stream that drains an area of agricultural land. No major population centers or known point discharges were upstream. Predominant land-use categories in the basin were agriculture (78 percent), forested (14 percent), and residential (5 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Nitrate concentrations measured at site 62 were elevated above the reference conditions measured at site 15 in 1998. Concentrations of phosphorus, ammonia, and major ions were low and similar to those measured at the reference site. The nitrate concentration was 5.6 mg/L, and the phosphorus and ammonia concentrations were <0.02 mg/L. Nitrate concentrations above 5.0 mg/L were measured at only 9 of the 40 sites sampled between 1998 and 2000. The boron concentration was 21 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream channel was approximately 28 ft wide but had flow in only 10 ft of the channel. The stream had a mean depth of 0.6 ft and was mostly open to sunlight. The sampling reach was a 150 ft riffle, run, and pool habitat that consisted of

gravel and cobbles that were 20 percent embedded. Algae cover was moderate. Fine sediments in the pools and areas of erosion were evident throughout the sampling reach. The streambanks were generally grass covered but very steep, and the riparian areas were grass-covered fields.

Benthic macroinvertebrates: East Branch Big Elk Creek at site 62 was assessed as nonimpacted in 1998 on the basis of the calculated biological metrics (fig. 30). The benthic-macroinvertebrate community contained high taxa richness and low HBI values. The community contained an even mix of "pollution sensitive" taxa and intermediate taxa. "Pollution-tolerant" organisms were present but in relatively low numbers.

Summary: The biological data collected in 1998 indicated nonimpacted stream quality. Chemical and habitat data indicated elevated nitrate concentrations and slightly degraded habitat caused by erosion and sediment deposition.

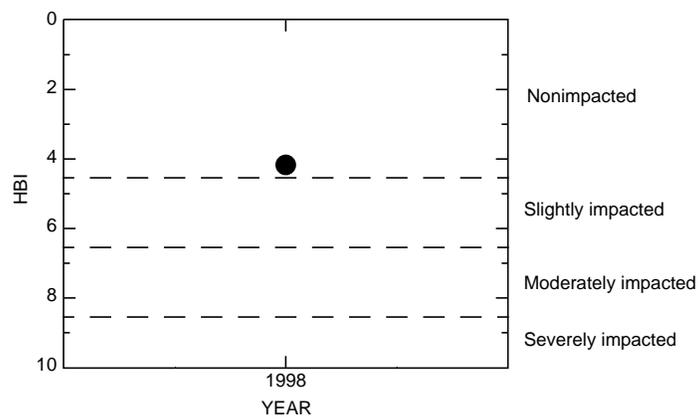
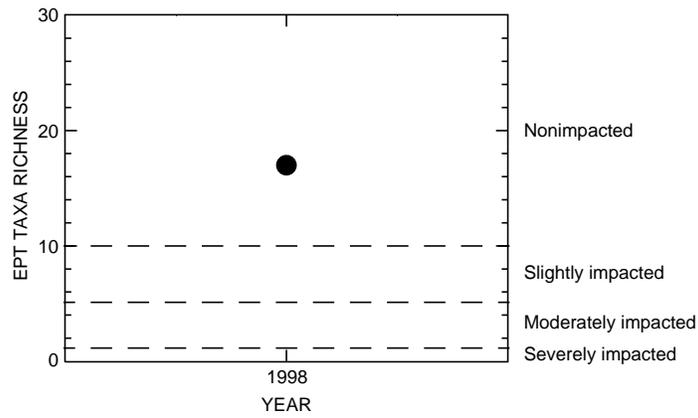
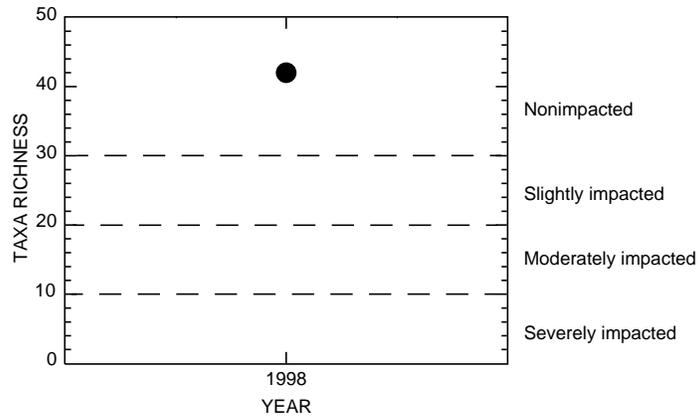


Figure 30. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from East Branch Big Elk Creek at Faggs Manor, Pa. (Site 62) (01494800), 1998.

East Branch Big Elk Creek at Elkview, Pa.
(Site 31) (01494900)

Location: Latitude 39°48'45", longitude 75°54'04", 500 ft upstream of bridge on State Route 896, and 3.5 mi west of West Grove, on the border between Penn and Upper Oxford Townships.

Drainage area: 11.1 mi².

Station setting: East Branch Big Elk Creek upstream of site 31 (fig. 1) drains an area of agricultural and field/pasture land. No major population centers or known point discharges were upstream from site 31, but the creek crosses U.S. Highway 1. Predominant land-use categories in the basin were agriculture (71 percent), forested (14 percent), and residential (9 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of nitrate and phosphorus measured at site 31 in 1998 and 1999 were elevated over those measured at the reference site (site 15). Concentrations of ammonia and major ions were similar to those measured at the reference site. The maximum concentrations of nutrients were nitrate 5.9 mg/L, phosphorus 0.03 mg/L, and ammonia <0.02 mg/L. Nitrate concentrations above 5.0 mg/L were measured at only 9 of the 40 sites sampled between 1998 and 2000. The elevated concentrations of nitrate and phosphorus were sufficient to cause nuisance plant growth can result in low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). Boron concentrations were <16 µg/L; these low concentrations suggest agriculture was the major nutrient source.

Habitat: The stream was approximately 15 ft wide, had a mean depth of 0.7 ft, and was mostly shaded at the sampling location. The sampling reach was 125 ft long and consisted of a small cobble and gravel riffle. Minor amounts of fine sediment and algae were evident in the reach, and erosion was minor. The riparian area on the right bank was an undisturbed forested area. The left bank had a 25 ft buffer of trees between the stream and a pasture.

Benthic macroinvertebrates: For 1998 and 1999, the East Branch Big Elk Creek at site 31 was assessed as slightly impacted or moderately impacted on the basis of the calculated biological metrics (fig. 31). This site contained low taxa richness and EPT taxa richness and had high HBI values, all indications of poor stream conditions. This

site contained the fewest taxa and second fewest EPT taxa of all the sites sampled between 1998 and 2000.

"Pollution-tolerant" taxa were dominant but inconsistent between the 1998 and 1999 samples. Proboscis worms and water mites made up 41 percent of individuals in 1998 but only 4 percent in 1999; midges made up 14 percent of individuals in 1998 and 60 percent in 1999. "Pollution-sensitive" taxa were a small part of the invertebrate community both years. The dominance of "pollution-tolerant" taxa and the small number of "pollution-sensitive" organisms indicate significantly degraded stream quality.

Summary: The biological data collected in 1998 and 1999 indicated moderately impacted stream quality. The benthic-macroinvertebrate community indicated significant disturbance that resulted in an assessment of slightly to moderately impacted. Chemical and habitat data indicated elevated nutrient concentrations and stable habitat conditions. The level of degradation suggested by the benthic-macroinvertebrate community appears to be the result of factors in addition to nutrient enrichment.

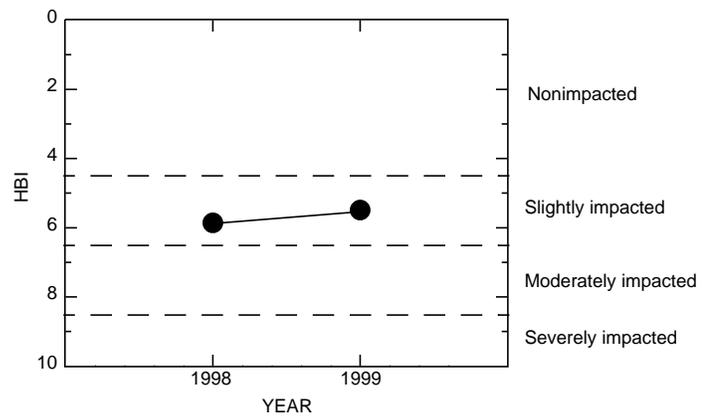
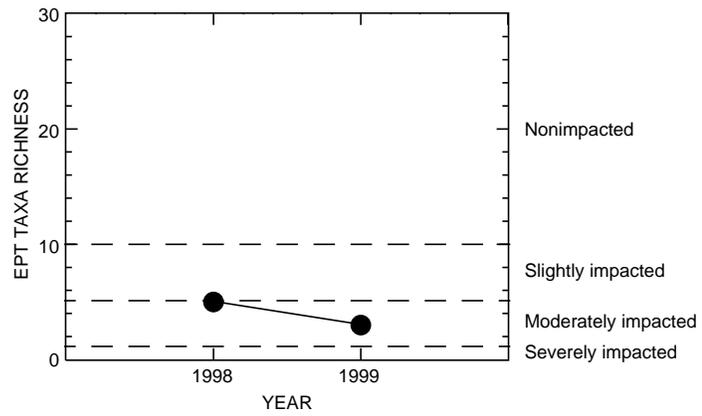
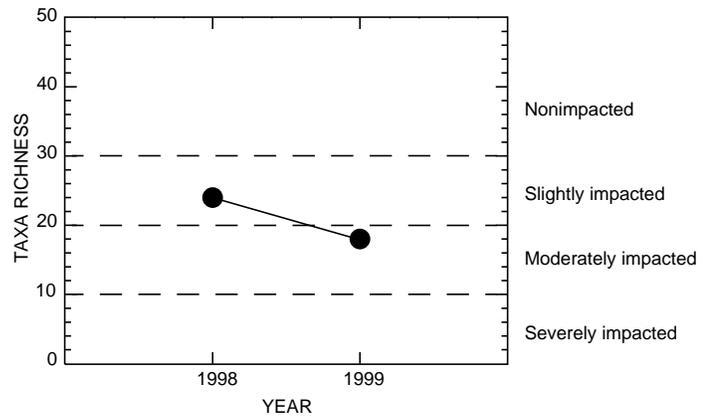


Figure 31. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from East Branch Big Elk Creek at Elkview, Pa. (Site 31) (01494900), 1998-99.

West Branch Big Elk Creek near Oxford, Pa.
(Site 32) (01494950)

Location: Latitude 39°46'45", longitude 75°55'27", 200 ft downstream of a bridge on Little Elk Creek Road, 1.0 mi northeast of Maple Grove, and 1.0 mi southwest of Elkdale, in East Nottingham Township.

Drainage area: 10.0 mi².

Station setting: West Branch Big Elk Creek upstream of site 32 (fig. 1) drains an area of agricultural and field/pasture land use. The creek receives some runoff from the Borough of Oxford but does not receive wastewater effluent from Oxford. Predominant land-use categories in the basin were agriculture (61 percent), forested (15 percent), and residential (15 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of major ions and nutrients measured at site 32 from 1998 to 1999 were elevated compared to concentrations measured at the reference site (site 15). The maximum concentrations of nutrients were nitrate 6.49 mg/L (third highest measured in the Network) and phosphorus and ammonia 0.09 mg/L. The elevated concentrations of nitrate and phosphorus are sufficient to cause nuisance plant growth that can result in low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The maximum boron concentration was 20 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream was approximately 30 ft wide, had a mean depth of 0.9 ft, and was mostly shaded at the sampling location. The sampling reach was 200 ft of stable continuous boulder and cobble riffle that was 60 percent embedded with gravel and sand and was covered with light amounts of algae. Both banks had small vertical cut banks and had greater than 50 ft of undisturbed forested riparian areas.

Benthic macroinvertebrates: West Branch Big Elk Creek near Oxford in 1998 and 1999 was assessed as slightly impacted on the basis of taxa richness and the HBI values and was assessed as nonimpacted on the basis of EPT taxa richness (fig. 32). Although EPT taxa richness indicated nonimpacted conditions, most of the EPT taxa were Hydropsychid caddisflies, which are intermediate in their tolerance to pollution. Few "pollution-sensitive" taxa were collected, and they were found in small numbers of individuals. The HBI values increased between 1998 and 1999 because of

a shift in dominant taxa from Hydropsychid caddisflies to the more "pollution-tolerant" midges. These indicate the stream conditions at site 32 were slightly impacted.

Summary: The biological data collected in 1998 and 1999 indicated slightly impacted stream quality. "Pollution-sensitive" taxa were relatively rare at this site, which indicates degraded conditions. Chemical and habitat data indicate that elevated nutrients along with degraded habitat from erosion and sediment deposition were degrading the stream quality in the West Branch Big Elk Creek at site 32.

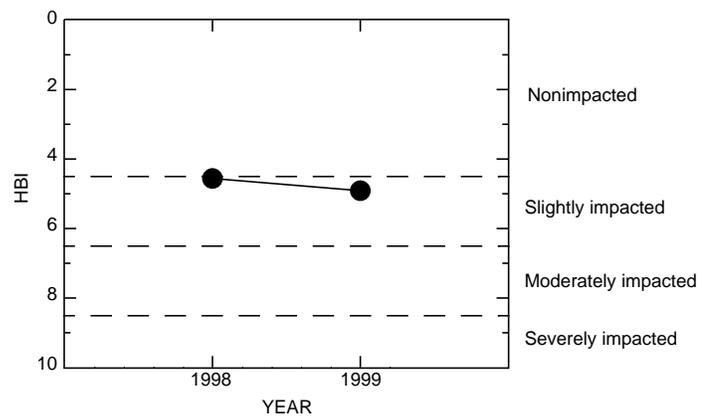
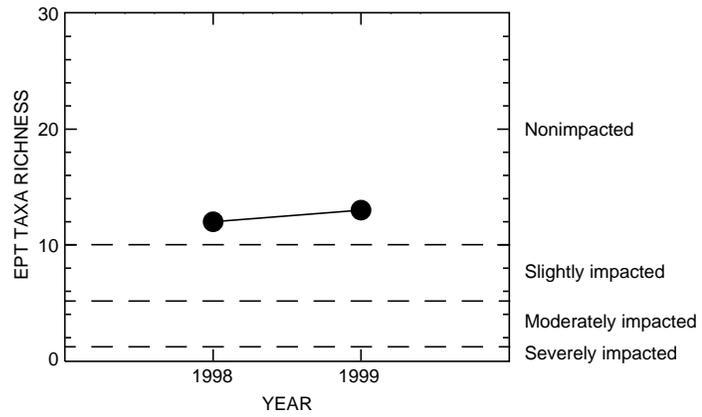
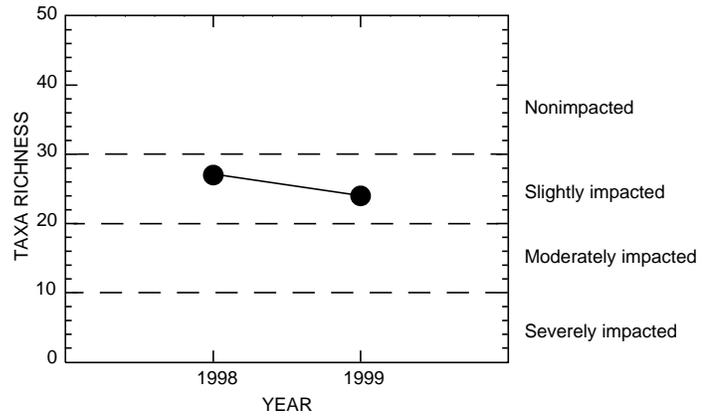


Figure 32. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from West Branch Big Elk Creek near Oxford, Pa. (Site 32) (01494950), 1998-99.

Big Elk Creek at Maple Grove, Pa.
(Site 59) (01494953)

Location: Latitude 39°45'44", longitude 75°55'16", 200 ft downstream of a bridge on Saginaw Road, 1.0 mi southeast of Maple Grove, and 0.5 mi south of Camp Saginaw, on the border between New London and East Nottingham Townships.

Drainage area: 26.6 mi².

Station setting: Big Elk Creek upstream of site 59 (fig. 1) drains an area of mixed forested, agricultural, and field/pasture land. Several major highways including State Routes 10 and 472 and U.S. Highway 1 are in the basin. The creek receives some runoff from the Borough of Oxford but no wastewater effluent from Oxford. Predominant land-use categories in the basin were agriculture (64 percent), forested (17 percent), and residential (12 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of major ions and nutrients measured at site 32 were elevated compared to concentrations measured at the reference site (site 15) during the period 1998-2000. The maximum concentrations of nutrients were nitrate 5.8 mg/L, phosphorus 0.07 mg/L, and ammonia 0.03 mg/L. Nitrate concentrations above 5.0 mg/L were measured at only 9 of the 40 sites sampled between 1998 and 2000. The elevated concentrations of nitrate and phosphorus were sufficient to cause nuisance plant growth can result in low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The maximum boron concentration was 20 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream channel was approximately 60 ft wide but had flow in only 38 ft of the channel. The stream had a mean depth of 0.6 ft and was mostly open to sunlight. The sampling reach was 225 ft of stable riffle/run/pool habitats that consisted of cobbles that were 20 percent embedded by gravel and sand. Heavy deposits of sand and fine sediments and heavy algae were evident in the pools. The stream had vertical cut banks in isolated areas within the reach and exposed tree roots and bare areas throughout the reach. The riparian area on the left bank was a mowed grass field with a few trees along the bank. The riparian area on the right bank was a steep rocky undisturbed area that was heavily vegetated.

Benthic macroinvertebrates: Big Elk Creek at Maple Grove generally was assessed as slightly impacted on the basis of the calculated biological metrics between 1998 and 1999 (fig. 33). The benthic-macroinvertebrate community in 1998 and 1999 was dominated by midges (40-66 per-cent), a "pollution-tolerant" taxa. "Pollution-sensitive" taxa were present but represented a small part of the community. High HBI values along with the elevated nutrient concentrations suggest organic enrichment may be degrading the benthic-macroinvertebrate community at site 59. The structure of the benthic-macroinvertebrate community changed between 1999 and 2000. The percentage of midges in the 2000 sample declined and the percentage of Hydropsychid caddisflies increased, which resulted in a decrease in the HBI value to a nonimpacted level. Although this indicates improved stream quality, Hydropsychid caddisflies are intermediate in their pollution tolerance, and the benthic-macroinvertebrate community at site 59 still has relatively few "pollution-sensitive" taxa.

Summary: The biological data collected between 1998 and 2000 indicated slightly impacted stream quality. "Pollution-sensitive" taxa were relatively rare at this site, which indicates degraded conditions. Chemical and habitat data indicated that elevated nutrient concentrations along with degraded habitat from erosion and sediment deposition were degrading the stream quality in the Big Elk Creek at site 59.

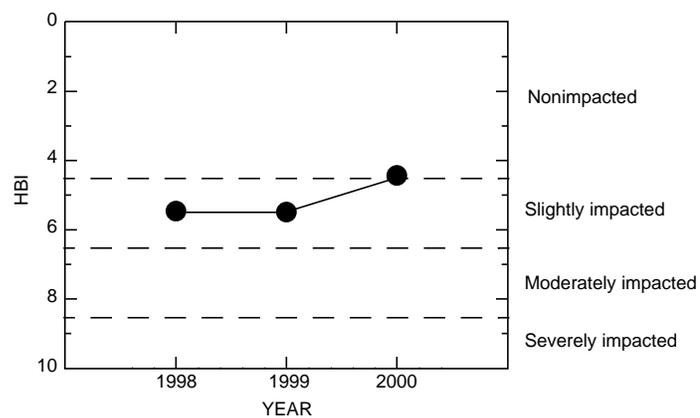
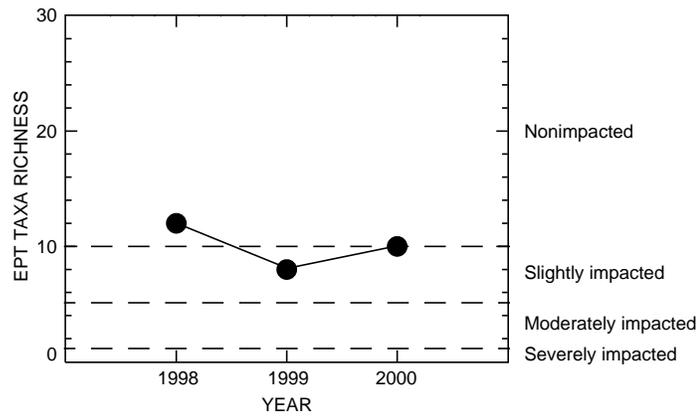
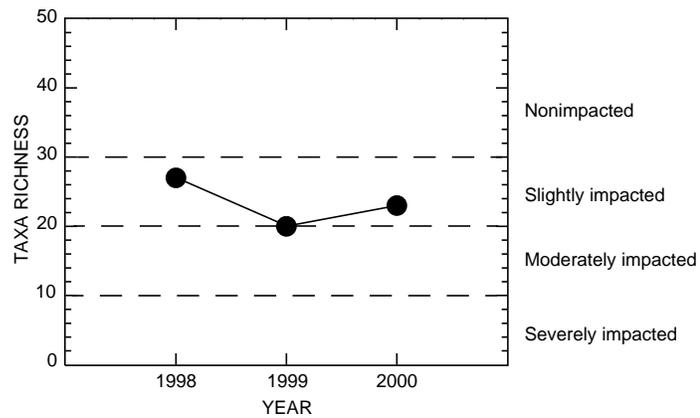


Figure 33. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Big Elk Creek at Maple Grove, Pa. (Site 59) (01494953), 1998-2000.

Little Elk Creek at Elk Mills, Pa.
(Site 68) (01495300)

Location: Latitude 39°43'36", longitude 75°54'28", 150 ft upstream of a bridge on Glenn Hope Road, 0.5 mi north of Maryland State Line, and 1.25 mi south of Peacedale, in Elk Township.

Drainage area: 11.8 mi².

Station setting: Little Elk Creek upstream from site 68 (fig. 1) drains an area of agricultural and field/pasture land use. No major population centers or known point discharges were upstream. Predominant land-use categories in the basin were agriculture (59 percent), forested (20 percent), and residential (7 percent) (Delaware Valley Regional Planning Commission, 1997).

Water chemistry: Concentrations of phosphorus, ammonia, and major ions measured at site 68 in 1999 were low and similar to those measured at the reference site (site 15), but the nitrate concentration is elevated compared to the concentration measured at the reference site. The maximum concentrations of nutrients were nitrate 4.4 mg/L, phosphorus <0.01 mg/L, and ammonia <0.02 mg/L. The boron concentration was <16 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream channel was approximately 54 ft wide with streamflow in only 21 ft of the channel. The stream had a mean depth of 0.5 ft and was mostly shaded. The sampling reach was 100 ft of riffle and run habitat that consisted of boulders and cobbles that are 20 percent embedded with gravel and sand. The reach contained very little silt, and the cobbles had a small amount of algae. The riparian areas generally were wide and undisturbed. Both banks were stable with only minor evidence of erosion.

Benthic macroinvertebrates: In 1999, Little Elk Creek at Elk Mills was assessed as nonimpacted on the basis of taxa richness and EPT taxa richness, but the HBI value indicated slightly impacted conditions (fig. 34). The benthic-macroinvertebrate community contained 18 EPT taxa but was dominated by "pollution-tolerant" taxa. Midges and worms accounted for 40 percent of all individuals in the sample. The slightly impacted assessment, based on the HBI values, and the dominance by "pollution-tolerant" taxa indicate the stream quality is degraded at site 68.

Summary: Chemical and habitat data collected at site 68 indicated stable habitat conditions along with moderate concentrations of nitrate and low concentrations of phosphorus and ammonia. However, the biological data collected in 1999 indicate stream quality was being slightly degraded.

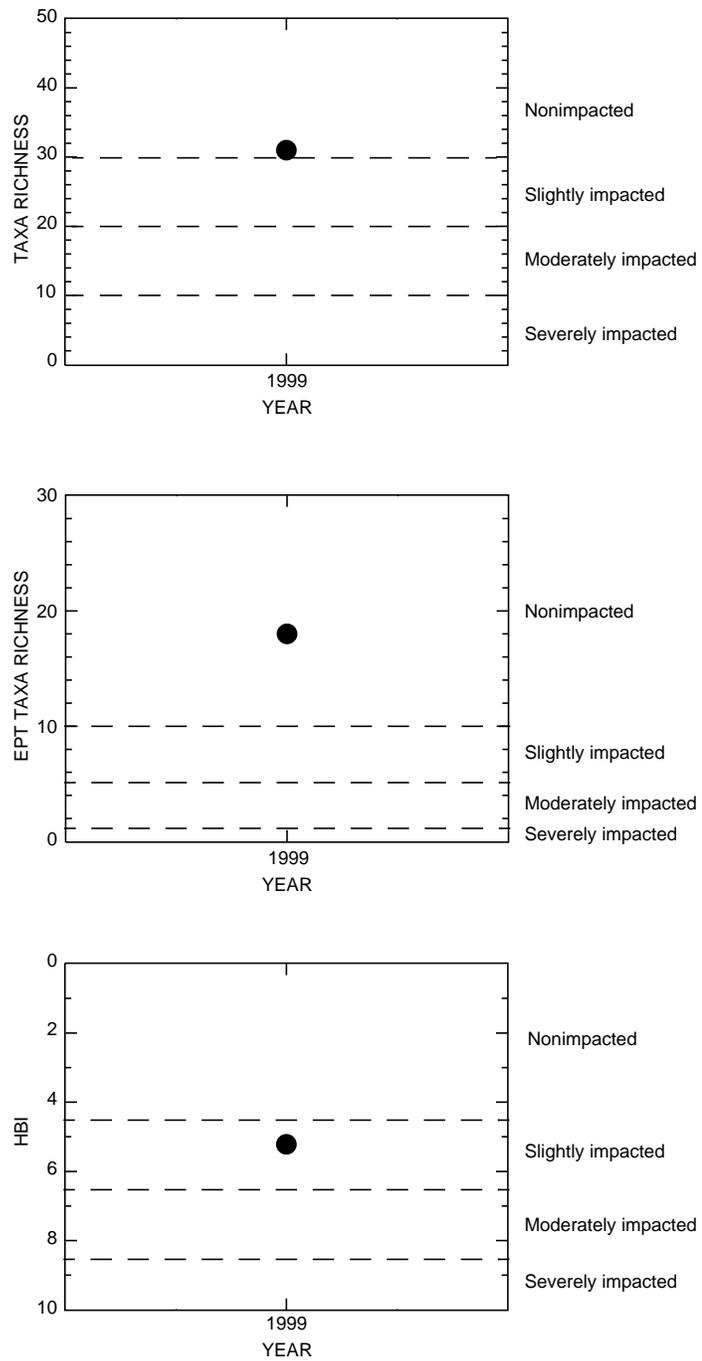


Figure 34. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Little Elk Creek at Elk Mills, Pa. (Site 68) (01495300), 1999.

Octoraro Creek Basin

The Octoraro Creek Basin drains the western part of Chester County and discharges into the Susquehanna River, which empties into the Chesapeake Bay. East Branch Octoraro Creek at Steelville was the only fixed site sampled annually in the Octoraro Creek Basin from 1998 to 2000 (fig. 1). The only miscellaneous site sampled in the Octoraro Creek Basin was Valley Creek, which was sampled in 1998 and 1999 (fig. 1). A description of the sampling location, chemical and habitat conditions, benthic-macroinvertebrate community structure, and plots of the biological metrics are presented for each sampling location.

Valley Creek near Atglen, Pa.
(Site 34) (01578343)

Location: Latitude 39°56'23", longitude 75°59'06", 350 ft downstream from a bridge on Old Newport Road, and 0.75 mi upstream from East Branch Octoraro Creek, in the Borough of Atglen.

Drainage area: 10.5 mi².

Station setting: Valley Creek flows from its headwaters through light industrial and agricultural areas through the Borough of Atglen. A sewage treatment plant discharges into the creek upstream of site 34. Predominant land-use categories in the basin were agriculture (39 percent), forested (36 percent), and residential (18 percent) (Delaware Valley Regional Planning Commission, 1997, Lancaster County, 2002).

Water chemistry: Concentrations of nutrients and major ions measured at site 34 in 1998 and 1999 were elevated compared to those measured at the reference site (site 15). The maximum concentrations of nutrients were nitrate 7.8 mg/L (highest concentration measured at all sites between 1998 and 2000), phosphorus 0.14 mg/L, and ammonia 0.64 mg/L. The elevated concentrations of nitrate and phosphorus were sufficient to cause nuisance plant growth that can lead to low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The maximum boron concentration was 62 µg/L, which suggests the site received wastewater discharge.

Habitat: The stream channel was approximately 23 ft wide, had a mean depth of 0.5 ft, and was partly shaded. The sampling reach was 100 ft of stable riffle/run/pool habitats that consisted of

cobbles that were 20 percent embedded by gravel and sand. Heavy deposits of sand and fine sediments and heavy algae were evident in the pools. The streambanks were stable with only minor evidence of erosion within the reach. The riparian area on the right bank was a mowed grass field with a few trees along the bank. The riparian area on the left bank consisted of trees and grasses between the stream and a roadway that was 10 to 25 ft away.

Benthic macroinvertebrates: Benthic-macroinvertebrate samples collected in 1998 and 1999 indicated dramatically different stream conditions. The site was assessed as moderately impacted on the basis of taxa richness and EPT taxa richness in 1998 but was assessed as nonimpacted on the basis of the same biological metrics in 1999. The site was assessed as slightly impacted on the basis of the HBI values both years, but the HBI value decreased from 5.38 in 1998 to 5.10 in 1999 (fig. 35). Historical data at this site indicated that the low number of taxa and EPT taxa collected in 1998 were not typical, but the slightly impacted HBI values were typical. The 1998 metric values indicated that the benthic-macroinvertebrate community was responding to a change in stream quality that affected all taxa equally.

Although the samples were very different between the 2 years, there were some similarities. The benthic-macroinvertebrate community in both years had large numbers of "pollution-tolerant" taxa including leeches, worms, and midges, which indicate degraded water quality. This type of community is typical of sites downstream of a wastewater treatment discharge. The degraded benthic-macroinvertebrate communities in 1998 appear to be related directly to concentrations of ammonia and phosphorus that were three times higher than those measured in 1999.

Summary: Biological, chemical, and habitat data collected at site 34 indicated unstable conditions. Nutrient concentrations were elevated and appear to be causing degraded benthic-macroinvertebrate communities. Elevated concentrations of phosphorus and ammonia were measured in 1998 when biological metrics indicated moderately impacted conditions. Conditions improved in 1999, but the site was still affected by organic enrichment.

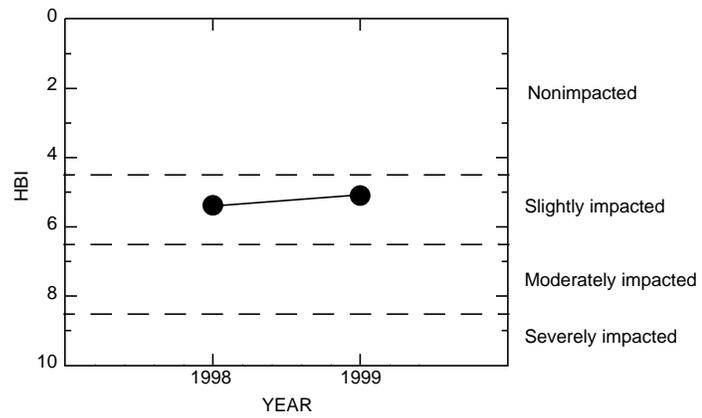
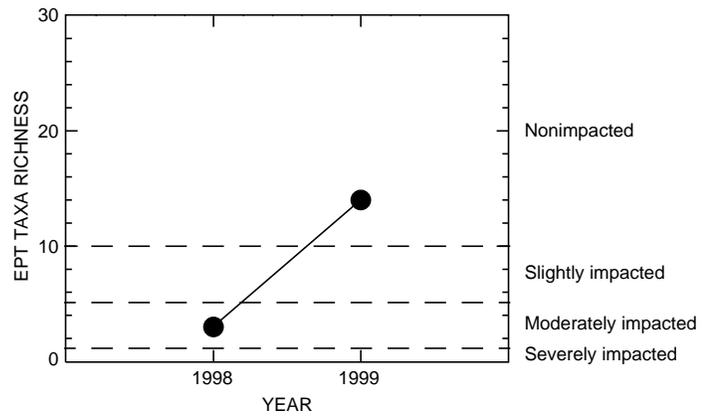
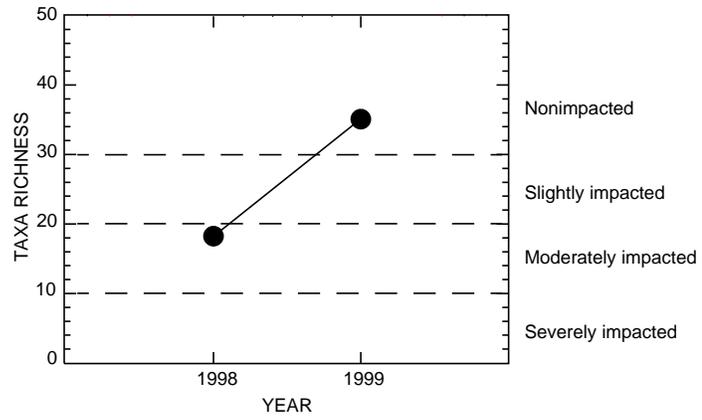


Figure 35. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from Valley Creek near Atglen, Pa. (Site 34) (01578343), 1998-1999.

East Branch Octoraro Creek near Steelville, Pa.
(Site 60) (01578347)

Location: Latitude 39°52'58", longitude 75°59'31", 20 ft upstream from a bridge on Ross Fording Road and 0.6 mi upstream from Knights Run, in West Fallowfield Township along the Lancaster County border.

Drainage area: 37.3 mi².

Station setting: East Branch Octoraro Creek, upstream of site 60 (fig. 1) drains mainly agricultural land. The stream also receives urban runoff from the Boroughs of Oxford and Atglen as well as wastewater discharge. Predominant land-use categories in the basin were agriculture (63 percent), forested (20 percent), and residential (10 percent) (Delaware Valley Regional Planning Commission, 1997, Lancaster County, 2002).

Water chemistry: Concentrations of major ions, nitrate, and phosphorus were elevated compared to those measured at the reference site (site 15) from 1998 to 2000. The maximum concentrations of nutrients were nitrate 7.2 mg/L (second highest concentration measured at all sites sampled between 1998 and 2000), phosphorus 0.04 mg/L, and ammonia <0.02 mg/L. The elevated concentrations of nitrate and phosphorus were sufficient to cause nuisance plant growth that can result in low concentrations of dissolved oxygen and decreased benthic-macroinvertebrate diversity (Buck and others, 2000). The maximum boron concentration was 27 µg/L, which suggests agriculture was the major nutrient source.

Habitat: The stream was approximately 55 ft wide, had a mean depth of 0.5 ft, and was partly shaded at the sampling location. The sampling reach was 250 ft of a stable cobble riffle that was 20 percent embedded with gravel and sand and was covered with moderate amounts of algae. Heavy deposits of sand and fine sediments were evident in the pools. The left bank was a steep bedrock outcrop that had little vegetation. The riparian area on the right bank was a mowed grass field with a few trees along the bank. The reach contained no areas of heavy erosion.

Benthic macroinvertebrates: Octoraro Creek near Steelville was assessed as nonimpacted on the basis of taxa richness and EPT taxa richness, but the HBI values indicated slightly impacted conditions in 1998 and 1999 (fig. 36). The benthic-macroinvertebrate samples collected at this site contained large numbers of individuals representing a mix of "pollution-sensitive," "pollution-tolerant," and intermediate taxa.

Abundant taxa included Ephemerella mayflies ("pollution-sensitive"), Hydropsychid caddisflies and riffle beetles (intermediate), and midges ("pollution-tolerant"). HBI values were near the cutoff between nonimpacted and slightly impacted, indicating some disturbance. The samples collected in 2000 contained less taxa but decreased HBI values because the majority of the taxa lost were "pollution-tolerant" taxa. The benthic-macroinvertebrate communities indicated good stream quality despite the elevated nitrate concentrations measured at this site.

Summary: Chemical and habitat data collected at site 60 indicated stable habitat conditions along with elevated nitrate concentrations and low concentrations of phosphorus and ammonia. The biological data indicated that stream quality was being degraded slightly, possibly by organic enrichment.

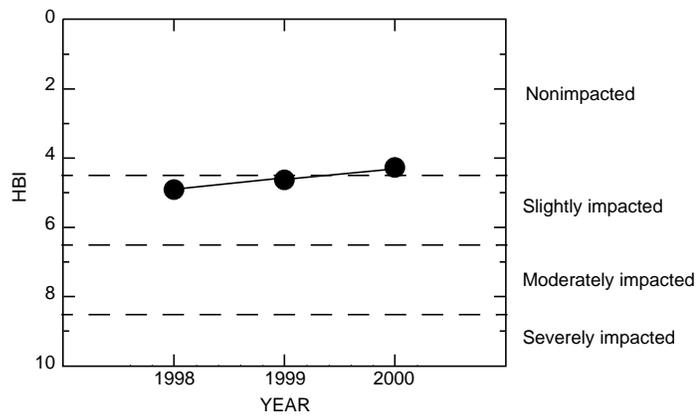
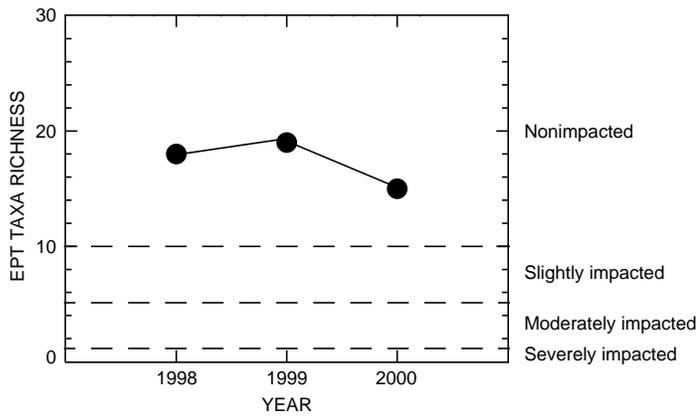
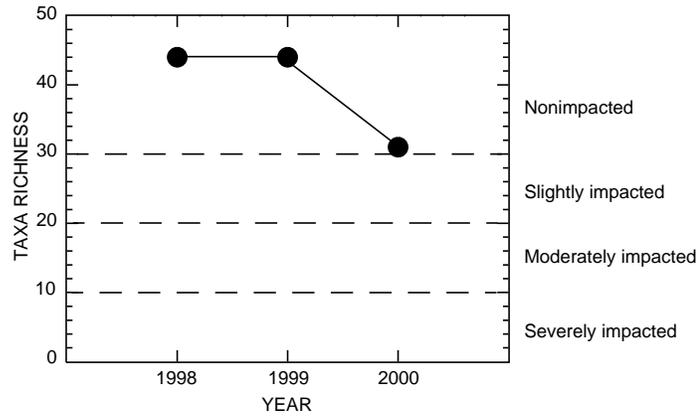


Figure 36. Taxa richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; and Hilsenhoff's biotic index (HBI) values from East Branch Octoraro Creek near Steelville, Pa. (Site 60) (01578347), 1998-2000.

SUMMARY AND CONCLUSIONS

Chester County is a 760-mi² area in southeast Pennsylvania. The county has more than doubled its population since 1960, and as a result, open space and farmland have been converted to residential and commercial areas. In 1970, the U.S. Geological Survey and the Chester County Water Resources Authority established a program to evaluate and monitor the conditions of the major streams in Chester County. Benthic-macroinvertebrate sampling was chosen as the basis for the program and sampling has continued since 1970. The major goals of the program are to evaluate local stream conditions and to study stream response to changing land use. There were 18 fixed stations that were sampled annually and 22 miscellaneous sites that were sampled once or twice between 1998 and 2000 for biological, chemical, and habitat information.

Benthic-macroinvertebrate samples collected in Chester County from 1998 through 2000 indicated nonimpacted or slightly impacted conditions at most of the 32 sites sampled. Sites in Pigeon, French, Pickering, and upper East Branch Brandywine Creek Basins generally were assessed as non-impacted with stable physical and chemical conditions. These sites received minimal disturbance. Sites in the Crum, Ridley, Chester, Valley, Trout, and lower East Branch Brandywine Creek Basins were assessed as slightly impacted and were being degraded from the reference conditions. These sites are in heavily populated areas and the streams receive increased runoff from paved surfaces and some receive discharges from wastewater-treatment plants. Increased erosion and nutrient enrichment were the most common cause of the impairments at these sites.

Benthic-macroinvertebrate communities at sites in the West Branch Brandywine, Red Clay, White Clay, Big Elk, and Octoraro Creek Basins were assessed as impacted and were being degraded from the reference conditions. These basins had the highest percentage of agricultural land in the county. Increased sedimentation and nutrient enrichment were the most common cause of the impairments at these sites.

Valley Creek is a 24-mi² basin within the Schuylkill River Basin in the eastern part of Chester County. In 2000, eight miscellaneous sites and one fixed site were sampled within a week of each other. The intent of this sampling was to allow evaluation of the basin under essentially the same

environmental conditions. The sampling was done in support of a multiagency effort to study the entire Valley Creek Watershed. The benthic-macroinvertebrate, chemical, and habitat data collected in 2000 indicated slightly impacted or moderately impacted stream quality. The benthic macroinvertebrate samples at all the sampling locations contained reduced numbers of taxa and EPT taxa when compared to the reference site and to other sites in adjacent basins. The site with the worst stream quality was downstream of a ground-water discharge contaminated with ammonia. The water chemistry at most sites sampled in the basin indicated low nutrient concentrations and elevated concentrations of major ions. Habitat alteration due to erosion was the major cause of the degraded stream quality in the Valley Creek Basin.

The streams that were degraded from reference condition in Chester County between 1998 and 2000 were affected by two major factors. Habitat alteration due to erosion was a cause of impairment at sites with a high percentage of residential land use and sedimentation was a cause of impairment at sites with a high percentage of agricultural land use. Habitat alteration disturbs or eliminates the stream-bottom substrate needed for benthic organisms to survive. Nutrient enrichment was the other major factor affecting degraded streams in the county. Nutrient enrichment can come from many sources but agricultural activities and wastewater-treatment discharges are the major sources in Chester County. Elevated concentrations of nutrients can cause increased plant growth, which indirectly cause low dissolved oxygen concentrations that can be fatal to aquatic organisms.

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