WATER-QUALITY ASSESSMENT OF THE LOWER SUSQUEHANNA RIVER BASIN, PENNSYLVANIA AND MARYLAND: DESIGN AND IMPLEMENTATION OF WATER-QUALITY STUDIES, 1992-95

by Steven F. Siwiec, Robert A. Hainly, Bruce D. Lindsey, Michael D. Bilger, and Robin A. Brightbill

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http://wwwrvares.er.usgs.gov/nawqa/nawqa_home.html

FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for a specific contamination problem; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for, and likely consequences of, new policies.

To address these needs, the Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

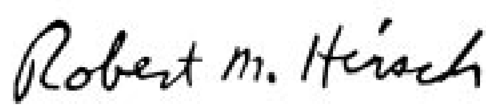
- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 59 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 59 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.



Robert M. Hirsch
Chief Hydrologist

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CONVERSION FACTORS AND ABBREVIATED UNITS OF MEASURE

	Multiply	by	To obtain
Length			
	inch (in.)	25.4	millimeter
	foot (ft)	0.3048	meter
	mile (mi)	1.609	kilometer
Area			
	square foot (ft^2)	0.09290	square meter
	square mile (mi^2)	2.590	square kilometer
Volume			
	gallon (gal)	3.785	liter
Temperature			
	degree Fahrenheit (°F)	°C=5/9 (°F-32)	degree Celsius

Abbreviated water-quality units used in this report:

g, grams
g/kg, grams per kilogram
g/m^2, grams per square meter
L, liter
m, meter
µg/g, micrograms per gram
µg/kg, micrograms per kilogram
µg/L, micrograms per liter
µm, micrometer
µS/cm, microsiemens per centimeter at 25°Celsius
mg/kg, milligrams per kilogram
mg/L, milligrams per liter
mg/m^2, milligrams per square meter
mL, milliliter
mm, millimeter
pCi/L, picoCuries per liter

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ABSTRACT

From 1992 through 1995, nearly 1,200 water-quality samples from about 500 sites were collected, processed, and analyzed for the U.S. Geological Survey's (USGS) National Water-Quality Assessment (NAWQA) Program in the Lower Susquehanna River Basin in Pennsylvania and Maryland. Sites were selected and samples were collected for 28 integrated water-quality studies designed to provide a comprehensive and nationally consistent description of current water-quality conditions, to begin to identify trends in water quality, and to determine the major factors that affect observed water quality. To achieve this, stream-water, ground-water, streambed-sediment, and biota samples were collected, and habitat assessments were conducted at selected data-collection sites.

This report discusses the water-quality study design, site-selection strategy, and implementation steps used to obtain water-quality and related data. Methods employed to collect, process, and analyze samples, characterize sites, and assess habitat are described. A comprehensive list of all sites employed in these studies and their characteristics is provided. Sample analyses conducted for the water-quality studies described in this report, including nutrients, pesticides, major ions, volatile organic compounds (VOC's), and trace elements, as well as measured or observed physical properties and habitat characteristics, also are listed.

INTRODUCTION

In 1991, the U.S. Geological Survey (USGS) implemented a full-scale National Water-Quality Assessment (NAWQA) Program (Leahy and others, 1990). The primary goal of the NAWQA Program is to provide relevant and nationally consistent water-quality information to assist policy makers who must address water-resource management issues at the national, state, and local levels. The NAWQA Program plans to assess water quality in 59 individual study units, which comprise large river basins and/or aquifer systems ranging from 1,200 to 62,000 mi^2 and represent 50 to 70 percent of the Nation's water usage. The Lower Susquehanna River Basin NAWQA study is 1 of 20 study units implemented in 1991.

The objectives of the NAWQA Program are to:

1. provide a nationally consistent description of current water-quality conditions for a large part of the Nation's water resources;
2. define long-term trends (or lack thereof) in water-quality data; and
3. identify, describe, and explain, to the extent possible, the major natural and anthropogenic factors that affect observed water-quality conditions and trends (Leahy and others, 1990).

The water-quality studies described in this report were designed to address local, regional, and national water-quality issues (table 1) and meet the NAWQA Program objectives. A technical advisory liaison committee representing Federal, State, and local agencies assisted study-unit scientists in the identification of important local and regional water-quality issues. Priority national issues for the 20 NAWQA study units that began in 1991 are described in Gilliom and others (1995).

Table 1. *Local, regional, and national water-quality issues addressed by the Lower Susquehanna NAWQA study unit*

Scale	Water-quality issue
local	effects of agricultural practices on nutrients and pesticides in ground and surface water
local	effects of urban land-use practices on volatile organic compounds in ground and surface water
local	general ground- and surface-water quality in carbonate-rock settings
regional	occurrence, distribution, and concentrations of radon in ground water
national	occurrence, distribution, and concentrations of pesticides in ground and surface water
national	occurrence, distribution, and concentrations of nutrients in ground and surface water
national	occurrence, distribution, and concentrations of volatile organic compounds in ground and surface water
national	occurrence, distribution, and concentrations of organochlorine pesticides in fish tissue
national	occurrence, distribution, and concentrations of trace elements in fish tissue

The NAWQA Program is designed such that water-quality data can be collected, synthesized, and interpreted at different spatial and temporal scales. Study-unit investigations provide the foundation on which regional- and national-scale syntheses of water-quality results are made. Synthesis and interpretation of water-quality data from multiple study units at the regional and national scale requires that the data be comparable among study units. National protocols established for sample collection, processing, and analysis are followed to ensure consistency and comparability of water-quality data obtained by individual study units.

In the Lower Susquehanna study unit, following a retrospective analysis of existing water-quality information and description of the environmental setting of the study unit, a period of intensive data collection or "high-intensity phase" was conducted from 1992 to 1995. This first phase of data collection will be followed in subsequent years by alternating low- and high-intensity data-collection phases.

Purpose and Scope

This report describes the design and implementation of water-quality studies conducted from 1992 to 1995, the first high-intensity data-collection phase of the USGS NAWQA Program in the Lower Susquehanna River Basin study unit in Pennsylvania and Maryland. The discussion includes an overview of study objectives, the strategy employed in study design and sample-site selection, and a summary of the types of water-quality studies conducted. The methods used for sample collection, processing, and analysis for each type of water-quality study also are described.

Results of water-quality sample analysis and site assessments are beyond the scope of this report and are not presented herein. Much of the data collected for the water-quality studies described in this report are available in Durlin and Schaffstall (1994; 1996; 1997) and in selected USGS topical reports.

The Lower Susquehanna River Basin Study Unit

The Lower Susquehanna River Basin was selected for study as part of the NAWQA Program because of its agricultural and urban land uses, different bedrock lithologies (carbonate, siliciclastic, and crystalline), and physiographic diversity (Breen and others, 1991). These characteristics provide a combination of settings that are well suited to the study of major natural and anthropogenic factors that affect water quality.

The Lower Susquehanna River Basin study unit contains 9,200 mi^2 of the Susquehanna River Basin from the confluence of the West Branch and the main stem of the Susquehanna River near Sunbury, Pa., downstream to the Chesapeake Bay at Havre de Grace, Md. (fig. 1). The study unit also contains parts (about 150 mi^2) of the Northeast and Elk Creek Basins, which are located just to the northeast of Havre de Grace, Maryland, and the fall line, and drain directly into the Chesapeake Bay (fig. 1).

The environmental setting of the Lower Susquehanna River Basin is described in detail in Risser and Siwiec (1996). The study unit contains parts of five physiographic provinces: the Appalachian Plateaus, the Ridge and Valley, the Blue Ridge, the New England, and the Piedmont (fig. 2). The Ridge and Valley Province and the Piedmont Province account for 68 and 29 percent of the study unit's total area respectively, whereas the other three physiographic provinces comprise less than 4 percent of the study unit.

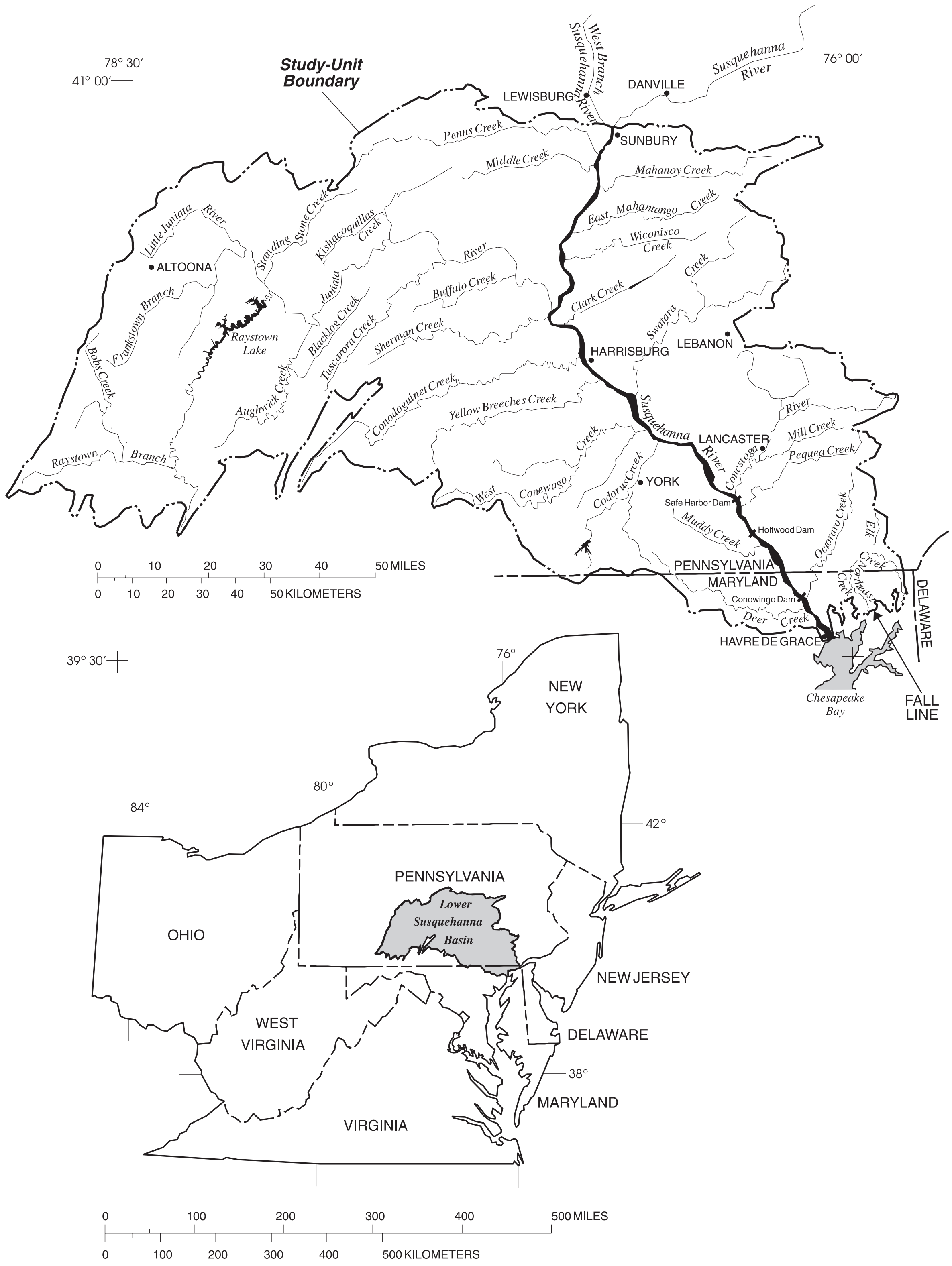

Figure 1. Location of the Lower Susquehanna NAWQA study unit.

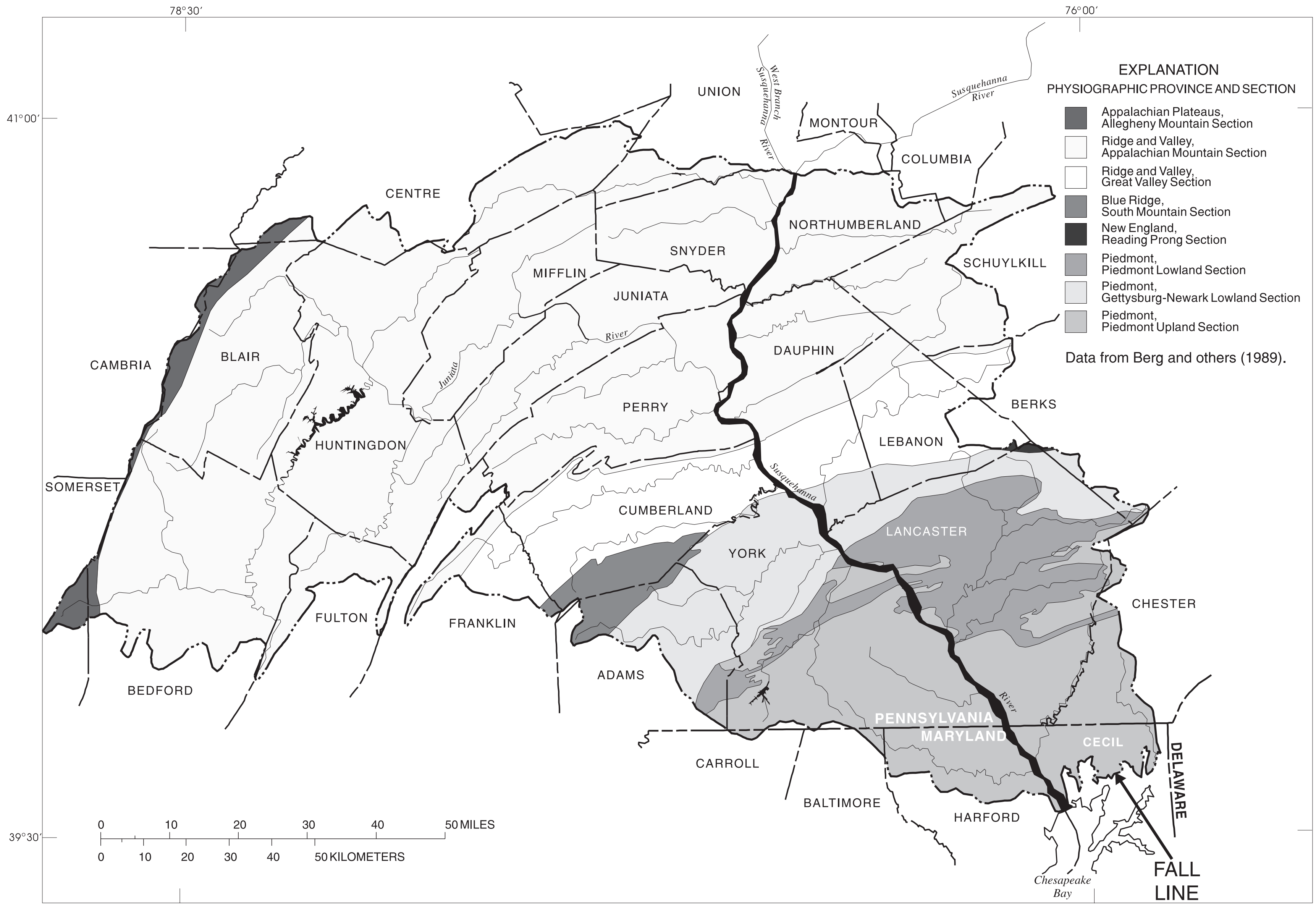

Figure 2. Physiographic provinces and sections in the Lower Susquehanna NAWQA study unit.

The physiography of the study unit is largely controlled by the lithology of the underlying bedrock (fig. 3). The Ridge and Valley Physiographic Province is predominantly comprised of siliciclastic rocks (sandstone, shale, siltstone, and conglomerate), which form a series of resistant ridges. These ridges are interrupted by narrow valleys of mostly carbonate bedrock (limestone and dolomite). The largest of these carbonate valleys forms the Great Valley Section of the Ridge and Valley Province.

The Piedmont Physiographic Province is divided into three sections: the Piedmont Upland, the Piedmont Lowland, and the Gettysburg-Newark Lowland. The Piedmont Upland, which contacts the Coastal Plain along the fall line at the southeast corner of the study unit, is predominantly gneiss, quartzite, and metamorphic crystalline bedrock. The Piedmont Lowland, situated between the Piedmont Upland and the Gettysburg-Newark Lowland, is comprised of limestone and dolomite. Sandstone and shale containing diabase dikes and sills form the Gettysburg-Newark Lowland.

The study unit is 47 percent forested, the majority of which is located in the mountainous areas of the Appalachian Plateaus, Ridge and Valley, and Blue Ridge Physiographic Provinces (fig 4). Agricultural land use dominates the Piedmont Province, the Great Valley, and carbonate valleys of the Ridge and Valley Province, and occupies another 47 percent of the study unit's total area. Approximately 4 percent of the study unit is used for urban purposes, mainly in the Great Valley and Piedmont Province. The remaining area in the study unit consists of water bodies and barren land (primarily mines and quarries).

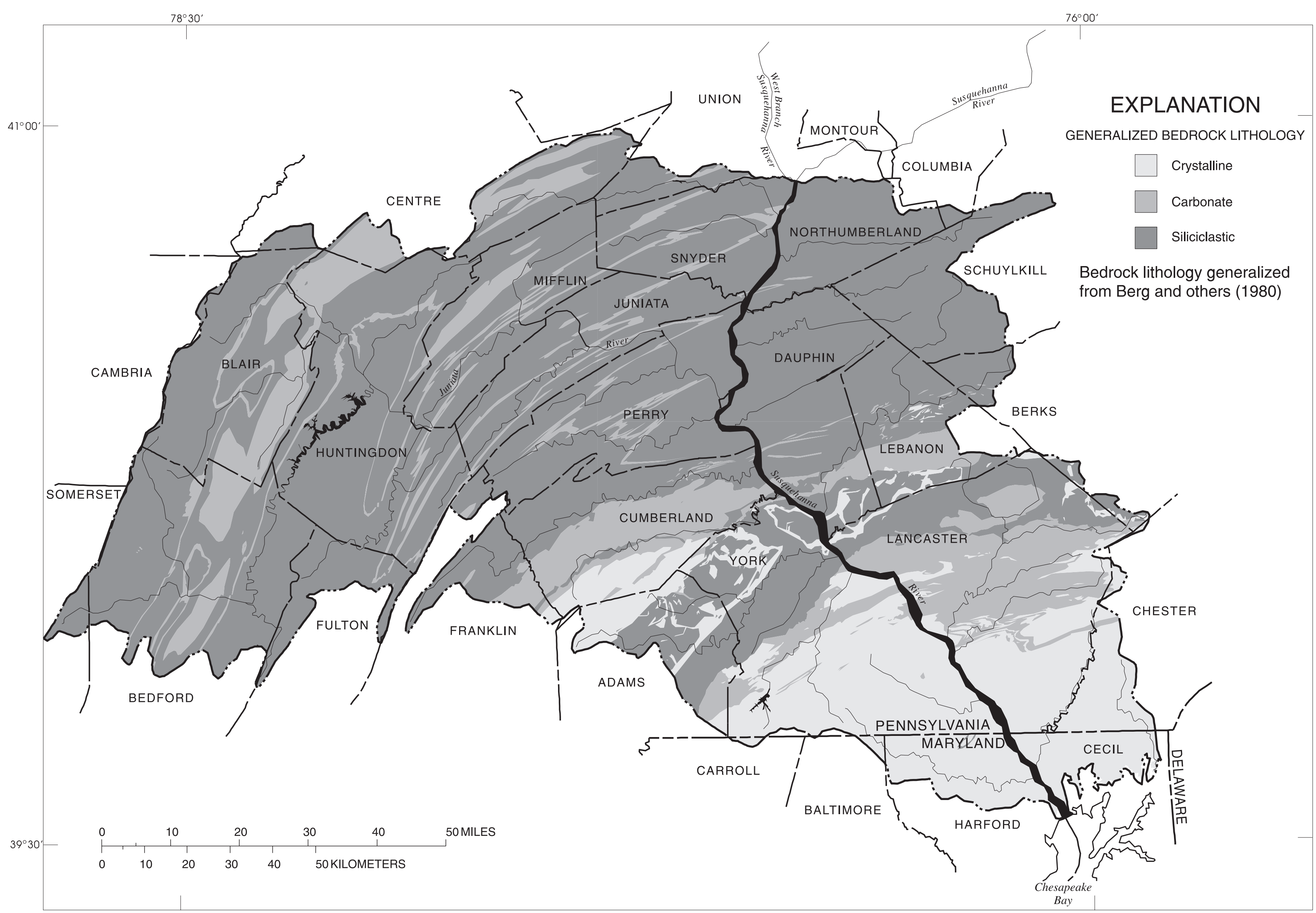

Figure 3. Generalized bedrock lithology in the Lower Susquehanna NAWQA study unit.

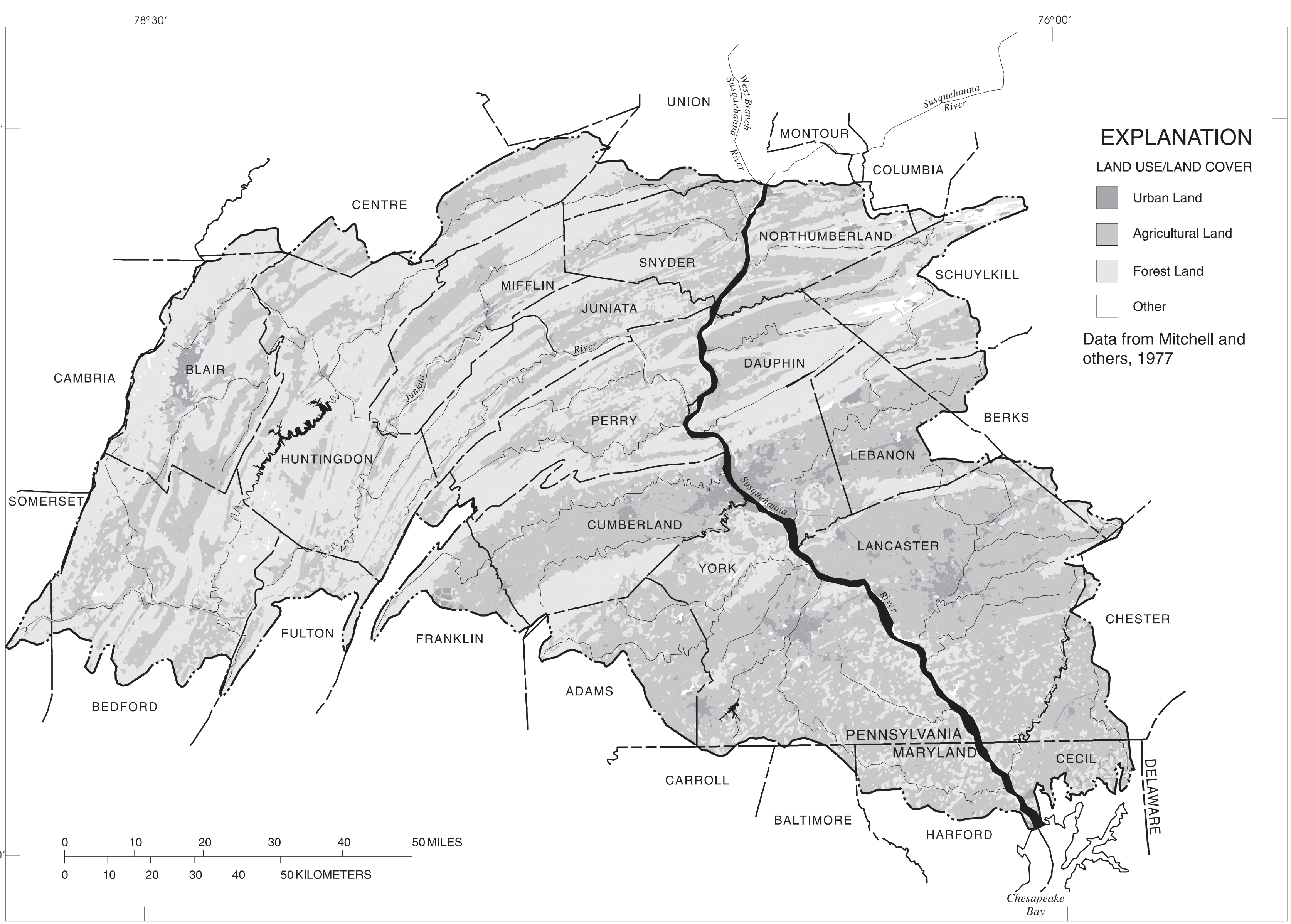

Figure 4. Generalized land use/land cover in the Lower Susquehanna NAWQA study unit.

DESIGN AND IMPLEMENTATION OF WATER-QUALITY STUDIES

During the first high-intensity phase of study in the Lower Susquehanna study unit, six types of water-quality studies were conducted. Four of these were types of surface-water studies that included measurement of physical, chemical, and biological properties of study-unit streams. Two types of ground-water studies also were conducted, in which ground-water samples were collected from existing, newly installed, or refurbished wells in the study unit.

To provide a design framework for the study of water quality in the study unit and assess the influences of major natural and human factors on water quality, the study unit was stratified into subunits—areas of relatively homogeneous physiography, bedrock lithology, and in some cases, land use and land cover. Because these factors were assumed to have the most dominant influences on water quality in the study unit, areas with relatively homogeneous combinations of these factors would be expected to have relatively similar water-quality characteristics.

A geographic information system (GIS) was utilized to stratify the study unit into subunits. A digital representation of physiographic provinces and sections (fig. 2) was developed from Berg and others (1989). Bedrock lithology was generalized as carbonate, siliciclastic, or crystalline, on the basis of a digital representation of bedrock geology (fig. 3) developed from Berg and others (1980). By use of the GIS, these two data layers were digitally overlaid, producing a composite data layer from which subunits were delineated. An additional data layer of generalized land use and land cover (fig. 4), as described in Mitchell and others (1977), was overlaid on the resulting subunits to further define them for selected studies where land use was an important factor in study design and site selection. High-priority subunits were then identified for study in the first high-intensity phase of data collection in the study unit.

Surface-Water-Quality Studies

Surface-water-quality studies conducted in the study unit can be broadly categorized into four major types: annual monitoring studies, basinwide studies, focused synoptic studies, and subunit synoptic studies (table 2). Annual monitoring studies were initiated to obtain baseline stream-water-quality data of selected subunits in the study unit and provide information for analysis of temporal water-quality variability. Basinwide studies were conducted to assess specific water-quality issues at the study-unit scale. Focused and subunit synoptic studies were undertaken to provide water-quality information in basins not included in the annual monitoring studies and augment water-quality information collected as part of the annual monitoring studies.

Each of these types of water-quality studies are described in the following sections. A comprehensive listing of all sampling sites, including selected site and basin characteristics, and maps showing the locations of sampling sites appear in Appendix A.

Annual monitoring studies

Two annual monitoring studies were conducted in the study unit during the first high-intensity phase of study. A long-term monitoring study was initiated at seven “fixed” sites (hereafter called the fixed-station study) to provide water-quality data representative of specific high-priority subunits in the study unit. The seven fixed sites were “indicator” sites, intended to provide data that is indicative of specific natural and human factors affecting water quality. A tissue trends study also was initiated at five “integrator” sites to

Table 2. *Summary of surface-water-quality studies conducted for the Lower Susquehanna River NAWQA study from 1992 to 1995*

					Environment sampled or assessed					Number of samples analyzed or site assessments made										
Name of water-quality study	Table and figure number in Appendix A	Number of sites sampled	Number of samples collected	Year(s) of study (19--)	Surface water	Ground water	Biota	Bed sediment	Habitat	Nutrients	Major ions	Pesticides and other organic compounds	Volatile organic compounds	Trace elements	Algal biomass and chlorophyll	Particle size	Suspended-sediment concentration	Field measurements	Habitat assessment	Taxonomic identification
Annual Monitoring Studies																				
Fixed station	A-1	7	504	93, 94, 95	✔		✔	✔	✔	316	254	250	13	5	75	311	310	316	11	75
Tissue trends	A-2	5	24	93, 94, 95			✔			0	0	24	0	23	0	0	0	0	0	0
Basinwide Studies																				
Triazine herbicide and nutrient synoptic	A-3	47	47	93	✔					47	47	47	0	0	0	0	0	47	0	0
Bed sediment and tissue contaminant survey	A-4	22	45	92, 95			✔	✔		0	0	45	0	43	0	21	0	22	0	0
Ecological synoptic	A-5	45	90	93, 94, 95			✔		✔	0	0	0	0	0	90	0	0	45	45	90
Focused Synoptic Studies																				
Cedar Run synoptic #1	A-6	5	5	94	✔					5	5	0	5	0	0	1	5	5	0	0
Cedar Run synoptic #2	A-7	5	6	94	✔					6	6	6	0	0	0	2	5	6	0	0
Cedar Run synoptic #3	A-8	8	8	95	✔					8	8	8	0	0	0	1	8	8	0	0
Cedar Run ecological synoptic	A-9	3	18	94			✔		✔	0	0	0	0	0	9	0	0	3	3	9
High-flux synoptic #1	A-10	20	20	94	✔					20	20	20	0	0	0	3	20	20	0	0
High-flux synoptic #2	A-11	6	8	95	✔					8	8	8	0	0	0	1	8	8	0	0
Mahanoy Creek synoptic	A-12	3	5	94	✔		✔	✔		0	0	0	0	5	0	0	2	2	0	0
Bachman Run synoptic	A-13	9	9	95	✔					9	9	9	0	0	0	1	9	9	0	0
Kishacoquillas Creek synoptic	A-14	11	11	95	✔					11	5	11	0	0	0	1	11	11	0	0
Muddy Creek synoptic	A-15	15	15	95	✔					15	7	15	0	0	0	1	15	15	0	0
Mill Creek synoptic	A-16	19	19	95	✔					19	11	14	0	0	0	1	14	19	0	0

Table 2. *Summary of surface-water-quality studies conducted for the Lower Susquehanna River NAWQA study from 1992 to 1995—Continued*

Name of water-quality study	Table and figure number in Appendix A	Number of sites sampled	Number of samples collected	Year(s) of study (19--)	Environment sampled or assessed: Surface water	Ground water	Biota	Bed sediment	Habitat	Number of samples analyzed or site assessments made: Nutrients	Major ions	Pesticides and other organic compounds	Volatile organic compounds	Trace elements	Algal biomass and chlorophyll	Particle size	Suspended-sediment concentration	Field measurements	Habitat assessment	Taxonomic identification
Subunit Synoptic Studies																				
Piedmont crystalline agricultural synoptic	A-17	17	17	94	✔					17	17	17	0	0	0	1	17	17	0	0
Piedmont carbonate agricultural synoptic	A-18	16	16	94	✔					16	16	16	0	0	0	1	16	16	0	0
Appalachian Mountain siliciclastic forested synoptic	A-19	16	16	95	✔					16	16	16	0	0	0	1	15	16	0	0
Appalachian Mountain carbonate agricultural synoptic	A-20	16	16	94	✔					16	16	15	0	0	0	1	16	16	0	0
Great Valley carbonate agricultural synoptic	A-21	10	10	94	✔					10	10	10	0	0	0	1	10	10	0	0
Great Valley urban synoptic	A-22	11	11	94	✔					11	11	11	0	0	0	1	11	11	0	0

determine the presence and year-to-year variability of concentrations of selected contaminants in fish tissue. Unlike indicator sites, integrator sites are intended to integrate the effects of a heterogeneous mixture of natural and human factors on water quality. Annual monitoring sites will be sampled in subsequent high-intensity data-collection phases. Data collected from these studies during the first high-intensity phase will provide the initial basis for identification of long-term changes or trends in the concentrations of selected contaminants in the study unit and nationally.

The seven indicator stream-sampling sites of the fixed-station study were selected to represent the baseline stream-water quality of seven different subunits in the study unit and to provide for specific comparisons of water-quality data among the fixed stations (table 3). In selecting the fixed stations, subunits were prioritized on the basis of important local, regional, and national water-quality issues. In the study unit, water quality associated with agricultural land use was considered the most important water-quality issue. Because the most intense agricultural land use in the study unit occurs in areas underlain by carbonate bedrock, agricultural land use and carbonate bedrock were primary criteria for the selection of stream basins within which to establish fixed stations. Effects on water quality resulting from the conversion of agricultural land to commercial, industrial, and residential uses in the "urban corridor" located in the Great Valley also were considered important water-quality issues and also were considered in the selection of the fixed stations.

Table 3. *Planned comparisons of water-quality data resulting from the fixed-station study conducted for the Lower Susquehanna NAWQA study unit in 1992-95.*

Fixed station	Physiographic province (section)	Bedrock lithology	Land use/ land cover	Planned comparisons of water-quality data
East Mahantango Creek	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Agricultural	Siliciclastic vs. Carbonate
Bobs Creek	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Forested	Agricultural vs. Forested
Kishacoquillas Creek	Ridge and Valley (Appalachian Mountain)	Carbonate	Agricultural	Appalachian Mountain vs. Great Valley vs. Piedmont
Cedar Run	Ridge and Valley (Great Valley)	Carbonate	Urban	Urban vs. Agricultural
Bachman Run	Ridge and Valley (Great Valley)	Carbonate	Agricultural	
Mill Creek	Piedmont	Carbonate	Agricultural	
Muddy Creek	Piedmont	Crystalline	Agricultural	Carbonate vs. Crystalline

The seven fixed stations were classified into two types—basic and intensive. All of the fixed stations were sampled at fixed-time intervals, although the sampling frequency and measured water-quality characteristics differed between the basic and intensive fixed stations. This difference was a result of the study design. The water-quality data collected from basic sites were designed to provide a relatively cursory evaluation of nutrient and other inorganic compound concentrations from lower priority subunits. At the basic sites, samples were collected monthly and analyzed for concentrations of nutrients and other inorganic compounds.

Intensive-site studies were designed with water-quality sampling programs that, in addition to nutrients and other inorganic compound concentrations, also provided information on the occurrence and magnitude of pesticide concentrations. At the intensive sites, stream-water samples were collected every week for the first year (1993) and every 2 weeks for the second year (1994).

Both basic and intensive sites were sampled monthly from December through February. Samples were collected at the fixed stations over an 18-month period from April 1993 to September 1994, in part to establish baseline data for fixed stations and in part to determine if seasonal changes occurred in base-flow stream concentrations.

During the spring and early summer of 1994, in addition to the regular fixed-interval samples, water-quality samples also were collected from the fixed stations during selected high-flow events. The purpose of these samples was to assess concentrations of selected constituents during periods when overland runoff was likely to enter the streams and stream-water quality was likely to better reflect differences in land use and land cover.

In 1995, the third year of intensive data collection, additional data were collected at two of the seven fixed stations. Water-quality samples were collected over the hydrograph of selected spring and summer runoff events by an automatic sampler. The majority of the storms selected followed the application of fertilizer and pesticides in agricultural areas. Water-quality samples were collected during these storms to determine the variability of constituent concentrations in the streams during storm events when source material is expected to be most available.

In addition to the collection of stream-water samples, ecological assessments also were conducted at the fixed stations to gather information on the biological communities and habitat characteristics that contribute to a conceptual model of factors affecting water quality and to improve understanding of the relations among physical, chemical, and biological characteristics of streams. Basic ecological assessments were conducted for a single stream reach once at each of the four basic fixed stations. At the three intensive fixed stations, intensive ecological assessments were conducted. These assessments were conducted each year from 1993 to 1995. In 1994, assessments were conducted at three reaches at each site.

Intensive ecological assessments were completed at the three intensive fixed stations to provide information on spatial and temporal variability of the biological communities and habitat characteristics among selected stream segments. Sites for the intensive ecological assessment were chosen to cover a range of base-flow water-quality conditions, stream sizes, and habitat factors. To measure reach-to-reach variability, multiple reaches (minimum of three) were sampled within the stream segment. Year-to-year variability was addressed by sampling one of these three reaches each year during 1993 through 1995.

The second annual monitoring study conducted in the study unit was the tissue-trends study. The study was designed to provide a 3-year baseline dataset of contaminant concentrations in fish tissue. Unlike the fixed stations, which were indicator sites, the sites sampled for the tissue-trends study were integrator sites. Integration of factors that could affect water quality and adequate spatial coverage were the primary criteria used for site selection. The sites selected integrate complex combinations of land use, point sources, and natural factors. The drainage areas above the sites also are known to contribute a range of concentrations of various organic compounds and trace elements.

Five large-river integrator sites were selected for the tissue-trends study. Two are inflow sites (one on each of the two main branches into the study unit) and one is the outflow site (the inflow to the system of three reservoirs formed by Safe Harbor, Holtwood, and Conowingo Dams) (fig. 1). The fourth integrator site is the outflow of the largest tributary (the Juniata River), and the fifth is a reference site considered to be least-affected by human activities (Deer Creek).

Samples were collected annually at the tissue-trend sites from 1993 through 1995. Tissue from two species of fish—white sucker and smallmouth bass—was analyzed for trace elements and selected organic compounds.

Basinwide studies

The purpose of basinwide water-quality and ecological studies was to provide information relating to the occurrence and magnitude of measurable water-quality, sediment-quality, and tissue concentrations and the characterization of stream ecology and water quality using ecological measures. The objective of determining spatial water-quality and ecological-quality variability was the focus of designs for basinwide studies.

A basinwide triazine herbicide and nutrient synoptic study was conducted in June 1993. The purpose of the study was to characterize the occurrence and magnitude of agriculture-related constituents and compounds throughout the study unit and develop a mass balance for selected constituents. The study design incorporated the selection of indicator and integrator sites that allowed an evaluation of the contribution of specific subunits and subbasins within the study unit.

In 1992, a contaminant survey of bed sediment and fish tissue was conducted to determine the spatial occurrence of a broad range of organic and inorganic contaminants in selected areas that are affected by land use or known point sources. Sites were selected to include both indicator and integrator sites. Sites on the main stem of the Susquehanna River (large integrator streams) also were included. Available historical data were evaluated and used to select sites with known water-quality problems and sites that were considered "least-affected," or reference sites. Historical data also were examined to determine if some sites could be co-located with those sampled for previous studies to provide for temporal comparisons.

Bed-sediment and tissue samples were collected at 5 of the 7 surface-water-quality fixed stations and at 17 other sites within an areally distributed network. Two of the seven surface-water-quality fixed stations were not sampled because of the lack of fine-grained depositional materials or the absence of the target fish species. One of the non-fixed-station sites was sampled for bed sediment and not tissue because of the absence of the target fish species. Bed-sediment and fish-tissue samples were collected at 1 fixed station and the 17 other sites from September through November 1992, whereas the 4 remaining fixed stations were sampled in June 1995.

A basinwide ecological synoptic study was conducted over three summers from 1993 to 1995 to provide improved spatial resolution within the study unit and, using historical data, to evaluate trends. The data were compared to the ecological data collected at the fixed stations and allowed a better evaluation of selected ecological characteristics in relation to causative factors, such as land use, contaminant sources, or instream habitat conditions. The ecological synoptic study differed from the more comprehensive ecological assessments at the fixed stations by targeting specific and more narrowly defined conditions for ecological characterization at a greater number of locations. Sites were selected largely on the basis of two previous investigations conducted in the 1970's and 1980's (Brezina and others, 1980; McMorran, 1986). Sites common to both previous studies that were suitable for NAWQA ecological methods were given first priority. Also, consideration was given to the spatial distribution of subunits in the study unit in selecting sites. Finally, some sites were selected in conjunction with the surface-water synoptic studies to address issues of local, regional, or national importance.

Focused synoptic studies

Focused synoptic studies were designed to provide information on specific water-quality issues within the study unit or to provide more intensive water- and ecological-quality information within selected subbasins—generally the basins draining the areas upstream of the fixed stations.

In June of 1994 and 1995, two “high-flux” synoptic studies were conducted to define the sources and transport of constituents within a selected basin. The studies were labeled as "high-flux" because the data were collected during periods when agriculture-related constituents such as nutrients and pesticides were most likely to be transported in the streams of the study unit. For these studies, stream sites were generally located at the mouths of tributaries and along the main stem of the Lower Susquehanna River. Except for the fixed-station sites included in the studies, the subunit characteristics of the sites were not generally considered; the location within the stream network was the most important criteria in selecting sites. Water samples were analyzed for nutrient, other inorganic compound, and pesticide concentrations.

Focused synoptic studies also were conducted in five of the basins where fixed stations were located to provide a basis for explaining observed water-quality conditions at the fixed stations and to determine sources of constituents measured at the fixed stations. Due to a multitude of water- and ecological-quality issues identified in the basin, the Cedar Run Basin was the subject of four separate focused synoptic studies from 1994 through 1995. Three of the studies were conducted to determine the distribution and sources of nutrients, other inorganic compounds, volatile organic compounds (VOC’s), and pesticides in the water. In addition, a synoptic survey was conducted to determine the spatial variability of ecological characteristics within the basin. Sites were generally selected along the main stem of Cedar Run between tributaries and near the mouths of tributaries. This design allowed the development of a generalized mass balance for the constituents of concern during the sampling period.

Four other fixed-station basins—Bachman Run, Kishacoquillas Creek, Muddy Creek, and Mill Creek—were the subjects of focused synoptic studies to determine the distribution and sources of nutrients, other inorganic compounds, and pesticides in the streams and their tributaries. Sampling sites were selected in a manner similar to those selected for the Cedar Run Basin studies and similar methods were used to describe the data.

Finally, a focused synoptic study was undertaken within the lower Mahanoy Creek Basin to describe the occurrence and distribution of trace metals commonly associated with mine drainage in the lower Mahanoy Creek. Three regularly spaced sites along the main stem of lower Mahanoy Creek were sampled. The study design provided an opportunity to compare changes, in a downstream manner, in concentrations of trace metals in the water column and the bed material, as well as in the armored material removed from rocks on the streambed. Concentrations of trace metals in fish tissue from one site also were measured.

Subunit synoptic studies

Subunit synoptic studies were conducted in six subunits in 1994 and 1995 (fig. 5) to help determine the representativeness and transferability of water-quality data collected at the fixed stations (table 4). The studies were designed to enhance the development of a regional water-quality pattern within the study unit on the basis of subunit characteristics. For these studies, sites were selected so that the subunit characteristics (physiographic province, bedrock lithology, and land use) of the synoptic site basins would be similar to those of the basin drained by the stream at the fixed stations. Qualitative analyses of these characteristics were used in the selection process. Depending on the area of the subunit and the availability of streams that met the selection criteria, between 10 and 17 sites were selected for sampling in each of the subunits with fixed stations. Samples collected for the subunit synoptic studies were analyzed for nutrients, other inorganic compounds, and pesticides

Data-collection methods

The surface-water-quality studies described in this report included collection of stream-water, streambed-sediment, and biota samples and assessment of habitat along stream reaches. Hundreds of water-quality characteristics were measured in the field or laboratory. The tables in Appendix B (at back of report) provide a comprehensive list of all water-quality characteristics measured in these studies. Methods of data collection are described in the following sections.

Stream-water samples

General guidelines for the methods used to collect and process stream-water samples are described by Shelton (1994). More specific pesticide sample processing and equipment cleaning procedures are described by Manning and others (1994, p. 3-13). All routine samples were collected with a DH-81 sampler and teflon[1] or glass bottles using the equal-width-increment (EWI) and depth-integrated methods. For large rivers or high flows, a D-77 TM sampler suspended from a bridge rig and 3-L teflon bottles were used. A teflon cone (decaport) splitter was used exclusively for sample splitting. Samples for organic analysis were filtered through a 0.7-µm glass-fiber filter. A teflon diaphragm pump and teflon tubing were used to force the sample through the plate filter. Samples for organic carbon analysis were filtered through a 47-mm-diameter 0.45 µm silver filter in a stainless steel chamber pressurized by nitrogen gas. All sampling and processing equipment was rinsed with native water before use. The fixed-endpoint method was used for alkalinity titrations. Dissolved oxygen measurements were made using a meter during all years of data collection. From 1993 to 1995, additional stream water was collected for the determination of dissolved oxygen by the Winkler titration method.

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[1] The use of trade or brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey or the Federal Government.

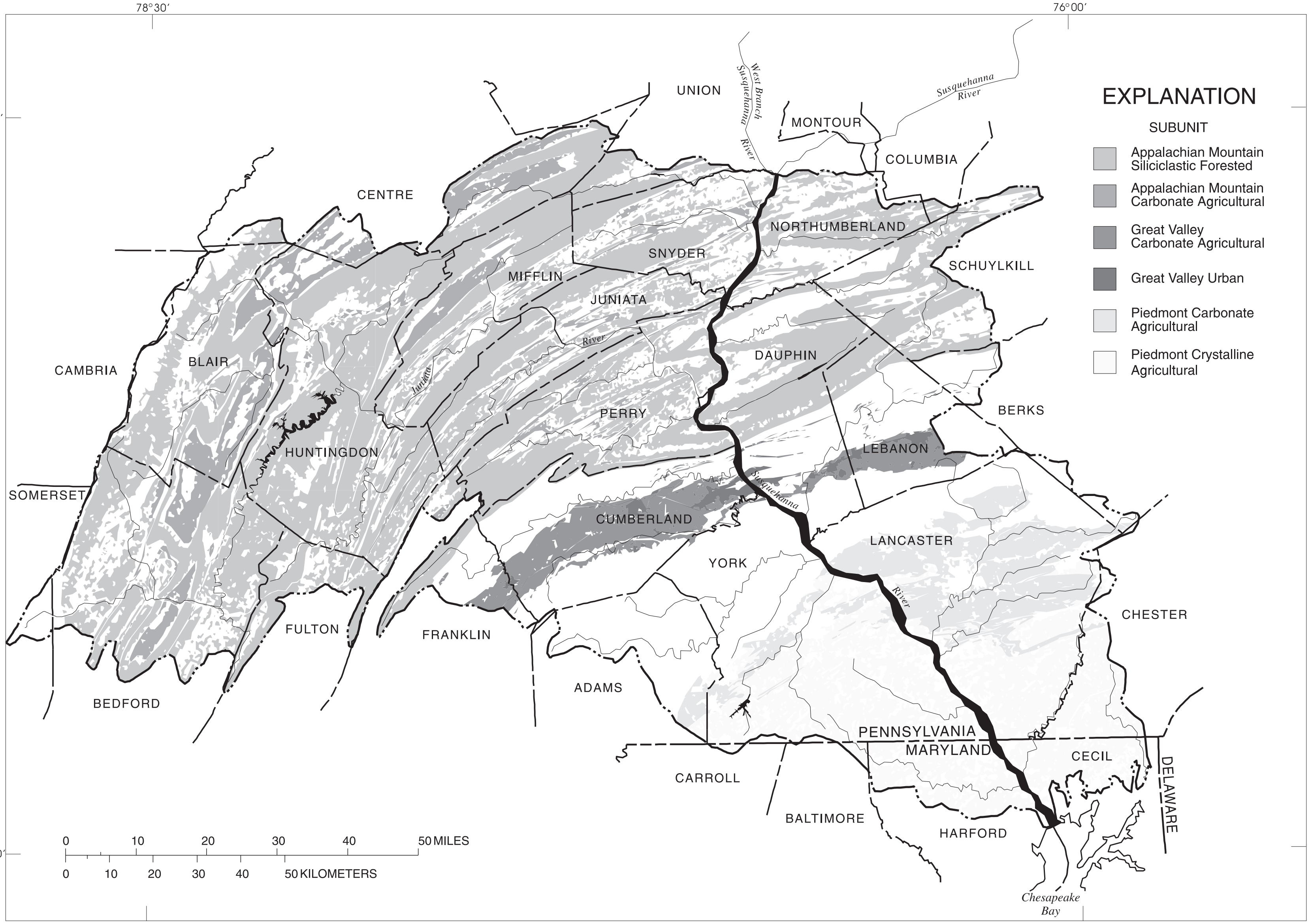

Figure 5. Locations of surface-water subunit synoptic studies undertaken in the Lower Susquehanna NAWQA study unit in 1994-95.

Table 4. *Subunits of the Lower Susquehanna NAWQA study unit studied in 1992-95*

Physiographic province	Physiographic section	Bedrock lithology	Land use/ land cover	Corresponding fixed station
Piedmont	Upland	Crystalline	Agricultural	Muddy Creek
Piedmont	Lowland	Carbonate	Agricultural	Mill Creek
Ridge and Valley	Appalachian Mountain	Siliciclastic	Forested	Bobs Creek
Ridge and Valley	Appalachian Mountain	Carbonate	Agricultural	Kishacoquillas Creek
Ridge and Valley	Great Valley	Carbonate	Agricultural	Bachman Run
Ridge and Valley	Great Valley	Mixed[1]	Urban	Cedar Run

[1] The Cedar Run Basin is underlain by predominantly carbonate bedrock.

Sample-collection methods described in Shelton (1994) and Manning and others (1994) were used for the collection of stream-water samples in the study unit with the following exceptions:

- Samples were composited by pouring each aliquot directly into the cone splitter. A stainless-steel milk can was not used for compositing samples.
- Following the first year of data collection (1992), samples were collected using standard methods but were processed on either the same or next day in the USGS Pennsylvania District laboratory. Streamflow, water temperature, air temperature, specific conductance, pH, dissolved oxygen, and barometric pressure measurements were made at the field site at the time of sample collection.
- Processing and preservation chambers were not used. Sample processing and preservation were completed in a closed vehicle during 1992 and in the Pennsylvania District laboratory in 1993 through 1995.
- All inorganic samples were filtered using a 142-mm-diameter aluminum plate filter stand with a 0.45-µm membrane filter.
- From 1993 to 1995, methanol was not used to rinse cleaned equipment.
- Because samples were not analyzed for trace metals, a 5-percent hydrochloric acid rinse was not used.

In addition to the EWI stream-water samples collected on a routine basis, a non-refrigerated automatic pumping sampler with teflon-lined intake tubing was used to collect samples over storm hydrographs at two of the fixed stations (Cedar Run and Bachman Run). The guidelines suggested by Shelton (1994, p. 17) for automatic samplers were followed.

All laboratory analyses were performed at the USGS National Water-Quality Laboratory (NWQL) in Arvada, Colo. Laboratory analytical methods are documented in Fishman and Friedman (1989) for nutrients and ions and Sandstrom and others (1992), Zaugg and others (1995), Lindley and others (1996), and Werner and others (1996) for selected pesticide compounds.

The methods used for sample collection and processing for synoptic studies were identical to those used for samples collected at the fixed stations with two exceptions. For the synoptic studies, samples were collected by hand instead of pumping samplers, and the EWI and depth-integrated sampling techniques were not used at streams with small widths or shallow depths. In these instances, a sample was dipped from the centroid of flow. Laboratory analytical methods for synoptic studies were identical to those used for samples from the fixed stations, with the exception that no samples were collected and analyzed for pesticides by high-pressure liquid chromatography (HPLC), and, at selected sites, analysis for major ions was not performed.

Streambed-sediment samples

Sampling methods for streambed sediment are described by Shelton and Capel (1994). Stream reaches sampled for streambed sediment extended about 100 m in length above a stream-water-sampling or streamflow-measurement site. Where available, 5-10 wadeable "depositional zones" where fine-grained particles accumulate on the streambed were sampled. If possible, the depositional zones included areas along both banks of the stream and in the center of the channel. Each depositional zone was subsampled several times and the subsamples were composited with samples from other depositional zones in the same reach. Streambed material collected at each site was composited to smooth out the local-scale variability and to provide an average contaminant concentration at the site. To avoid possible contamination of the samples, sample-collection equipment made of teflon and glass was used and powderless latex gloves were worn when the sampling and processing equipment were handled.

Once composited, the streambed sample was split into three discrete subsamples, and each subsample was processed separately for analysis of organic compounds (PCB's and organochlorines), trace elements, and particle size. The first subsample for trace elements and major ions was sieved into a glass bowl through a 63-µm nylon cloth secured on a plastic frame. The sieved material was then transferred to a plastic container. The second subsample was sieved through a 2-mm stainless-steel sieve into a pre-washed organic-free glass container and analyzed for organic compounds, total organic carbon, total inorganic carbon, and percent moisture. The third subsample was sieved through a 2-mm stainless-steel sieve into a plastic container and analyzed for particle-size distribution, which determined the percentages of material less than 2 mm, 63 µm, and 4 µm.

Streambed-sediment samples to be analyzed for organic compounds, carbon, and percent moisture were chilled and shipped to the USGS NWQL for analysis. Samples for trace-element analysis were initially dried in the Pennsylvania District Sediment Laboratory and then shipped unchilled to the USGS Geologic Division Laboratory in Lakewood, Colo. Particle-size samples were processed in the Pennsylvania District Sediment Laboratory. Laboratory analytical methods for organic compounds in bed material are documented in Foreman and others (1995) and Furlong and others (1996). Analytical methods for trace elements are given in Arbogast (1990). Methods for analysis of sediment particle size are described by Guy (1969).

Biota samples

General guidelines for studies of contaminants in biological tissues are described by Crawford and Luoma (1994). In the Lower Susquehanna study unit, white sucker (*Catostomus commersoni*) was selected from the NAWQA target taxa list for assessment of contaminants in tissue because it is widely distributed. Although the Asiatic clam (*Corbicula fluminea*) is the primary species of choice for both organic contaminants and trace elements, its distribution within the study unit is sparse. Smallmouth bass (*Micropterus dolomieui*) also were collected to assess contaminants in tissue because of its predatory feeding habits, recreational importance, and interest by state agencies.

Collection methods for fish were not quantitative; therefore, the sampling equipment most appropriate for the particular site conditions was used. The two primary fish-collection techniques were seining and electrofishing (backpack, tow barge, or boat). Once collected, fish were euthanized by a blow to the head and rinsed of debris and slime with native water. Fish were then identified to the species level, weighed, measured for total and standard length, and examined for external anomalies, such as tumors, lesions, parasites, and diseases. At this time, scales and/or pectoral fin ray samples were collected to determine the age of each fish. Powderless latex gloves were worn at all times when fish were handled.

The ideal fish-tissue sample was a composite of eight whole fish for analysis of selected organic compounds (PCB's and organochlorine pesticides) and eight liver specimens for analysis of trace elements. When an ideal fish-tissue sample could not be obtained, the minimum amount composited for a sample was five whole fish or five livers. All fish collected for a given sample were of similar total length.

For analysis of organic compounds, fish were dissected with a stainless steel scalpel blade (precleaned with methanol), examined for gender, and individually wrapped in heavy-duty aluminum foil (dull side towards fish). Each individual fish was placed into a labelled polyethylene bag and then in another polyethylene bag labelled on the outside. Following processing, all fish samples were placed on dry ice at -20°C at the field site in preparation for shipment to the analytical laboratory. When long-term storage was necessary, the samples were stored in a freezer.

For analysis of trace elements, the body cavity was opened with a stainless steel scalpel blade precleaned with nitric acid. Gender was determined. The liver tissue was exposed with a plastic forceps and excised by means of a second precleaned stainless steel scalpel blade to eliminate possible contamination from outside the body cavity. Caution was used so as not to puncture the gall bladder or contact any other organs. The dissected livers were placed into a precleaned and preweighed 125-mL glass jar. The jar and livers were then weighed and the weight recorded. A sample weighing 5 g was considered minimally acceptable, and a 10-g sample was optimal. The sample jar was labelled with the site identifier, date, location, species name, and the analyses to be performed and placed into a similarly labelled locking plastic bag. The bagged sample was placed into dry ice at the field site and shipped frozen to the laboratory. Samples held for long-term storage were placed into a freezer.

Laboratory analyses of fish tissue were performed at the USGS NWQL in Arvada, Colo. Laboratory analytical methods are documented in Leiker and others (1995) for chlorinated pesticides, and in Hoffman (1996) and NWQL Technical Memorandum 93-08 (M.W. Shockey, U.S. Geological Survey, Arvada, Colo., written commun., 1993) for trace elements.

Assessment of habitat and biological communities

Habitat assessments involved the collection of three major taxonomic groups—benthic algae, benthic invertebrates, and fish. Each of these groups responds differently to a variety of environmental stresses. Algae respond more quickly to changes in their environment and serve as good indicators of rapid water-quality changes. Benthic invertebrates (aquatic insects, mollusks, worms, crustaceans) react to water-quality changes throughout their life cycles of several months to several years in the water column and sediments and characterize changes in water quality very well over small spatial areas. Fish are long-term indicators of biological conditions because of their long life span (years to decades) and can be of considerable economic and recreational importance.

Habitat assessments were conducted along stream reaches, where stream, bank, and floodplain habitat were determined to be representative of the local area. Assessment reaches were located near fixed stations where stream-water samples were collected. At each fixed station, collections of biological communities and characterizations of riparian and instream habitat conditions were conducted for at least one reach. The length of the sampling reach was dependent on a combination of factors, such as geomorphology and meander wave length (Meador and others, 1993a). For wadeable streams, reach length ranged from 150 m to 500 m to ensure that the reach was of sufficient length to be representative of the fish community.

Both the algal and benthic invertebrate communities were sampled by collecting three distinct sample types from habitats within the designated reach (Porter and others, 1993; Cuffney and others, 1993a). Two types of semi-quantitative samples were collected to provide information on taxa presence and abundance for two targeted habitats: riffle habitat, which is designated richest targeted habitat (RTH) because it generally yields the richest number of taxa; and, at fixed sites, pool or depositional habitat, called depositional targeted habitat (DTH). In addition, a qualitative multiple habitat (QMH) sample was obtained for both communities from all habitat types within the reach. This QMH sample was composited to provide a more complete taxa list than the RTH and DTH samples.

The fish community was sampled by electrofishing or seining to determine species presence and abundance (Meador and others, 1993b). Following capture, fish were identified to the species level, measured for length and weight, examined for external anomalies (tumors, lesions, parasites, and/or diseases), and released.

Habitat characterizations of the channel, bank, and flood plain features followed a spatial hierarchy that incorporates basin, stream segment, stream reach, and cross-section descriptors (Meador and others, 1993a). Basin-level descriptors, such as ecoregion, physiographic province, geology, soils, climate, and land use were recorded for each site as part of the environmental-framework characterization. Stream-segment data, including information on stream meandering, gradient, elevation, and water-management features, were obtained primarily from USGS 1:24,000-scale topographic maps and GIS data layers. At the intensive fixed sites and all ecological synoptic sites, a first level (level I) habitat characterization was conducted, including geomorphic channel units (riffle, run, pool), as well as physical features of the bank, channel, flood plain, and vegetation (terrestrial and aquatic). Other cross-section characteristics were measured, including substrate particle size, water depth, velocity, embeddedness, and canopy angle. In addition, at all basic fixed stations, a more detailed (level II) habitat characterization was done to provide additional quantitative data on geomorphic and hydraulic properties that are critical to the evaluation of temporal changes in the environmental setting and stream habitat.

Reach assessments were done annually at each intensive fixed station during 1993 through 1995, during similar hydrologic and seasonal conditions for all sites. Scheduling of sample collection was dependent upon factors such as hydrology, life histories of the aquatic communities, accessibility of sites, and other logistical considerations.

Ground-Water-Quality Studies

Two types of ground-water studies were conducted in the study unit during the first high-intensity phase of study—land-use studies and subunit surveys (table 5). Land-use studies are intended to examine natural and human factors that affect the quality of shallow ground water underlying specific types of land use (Lapham and others, 1995). Subunit surveys are designed to provide an overview of water-quality characteristics within a subunit, independent of land use.

In the Lower Susquehanna study unit, land-use studies were conducted in four subunits of homogeneous physiography, bedrock lithology, and land use (fig 6). On the basis of high priority water-quality issues, previously discussed, four areas underlain by carbonate bedrock were targeted for the ground-water land-use studies—three agricultural areas and one urban area. In addition, two subunits were targeted for ground-water subunit surveys—areas of the Piedmont physiographic province underlain by crystalline bedrock and areas of the Appalachian Mountain Section of the Ridge and Valley Physiographic Province underlain by siliciclastic bedrock. These two subunits contain a mixture of land uses, including agricultural, forested, and urban.

Each ground-water-quality study was conducted over a 2- to 3-week time period in mid-summer to assess ground-water-quality conditions after annual application of manure, commercial fertilizers, and pesticides in each of the targeted subunits. Also, this time frame is coincident with the surface-water subunit synoptic studies, thereby allowing for valid comparisons of ground- and surface-water-quality data. Two of the six ground-water-quality studies were conducted each summer for 3 years, from 1993 to 1995, and each well was sampled once. The methods employed for selection of wells and collection and processing of ground-water samples were identical for both types of studies.

The majority of the wells sampled for the ground-water-quality studies were existing domestic supply wells. The first step in locating wells to sample was to select potential sampling areas within each subunit. Initially, remote outlying areas of targeted subunits were eliminated from consideration for sampling because of the potential that the water-quality samples obtained in these areas would not be representative of the subunit. Next, a GIS-based site-selection algorithm developed by Scott (1990) was used to subdivide each subunit into 20 or 30 equal-area cells and to locate candidate sampling locations. The algorithm randomly identified one primary and two alternative locations in each cell; these locations were used as starting points to search for wells that met the established criteria for domestic supply wells.

Well-selection criteria—land use, well construction, owner cooperation, sampling-point accessibility, and well yield—helped ensure that wells were viable for sampling and ground-water samples collected were representative of shallow ground-water conditions for the targeted subunit. Land use was verified on the first visit to a selected area. Wells were chosen in homogeneous land-use settings so that land use could be used as an explanatory variable in the interpretation of water-quality data.

Table 5. *Summary of ground-water-quality studies conducted for the Lower Susquehanna River NAWQA study from 1993 to 1995*

					Environment sampled or assessed					Number of samples analyzed or site assessments made										
Name of water-quality study	Table and figure number in Appendix A	Number of sites sampled	Number of samples collected	Year(s) of study	Surface water	Ground water	Biota	Bed sediment	Habitat	Nutrients	Major ions	Pesticides and other organic compounds	Volatile organic compounds	Trace elements	Algal biomass and chlorophyll	Particle size	Suspended-sediment concentration	Field measurements	Habitat assessment	Taxonomic identification
Land-Use Studies																				
Piedmont carbonate agricultural land-use study	A-23	30	30	1993		✔				30	30	30	30	0	0	0	0	30	0	0
Appalachian Mountain carbonate agricultural land-use study	A-24	30	30	1994		✔				30	30	30	9	0	0	0	0	30	0	0
Great Valley carbonate agricultural land-use study	A-25	30	30	1995		✔				30	30	30	20	0	0	0	0	30	0	0
Great Valley carbonate urban land-use study	A-26	20	20	1995		✔				20	20	20	20	0	0	0	0	20	0	0
Subunit Surveys																				
Piedmont crystalline subunit survey	A-27	30	30	1994		✔				30	30	30	10	0	0	0	0	30	0	0
Appalachian Mountain siliciclastic subunit survey	A-28	29	29	1993		✔				29	29	29	29	0	0	0	0	29	0	0

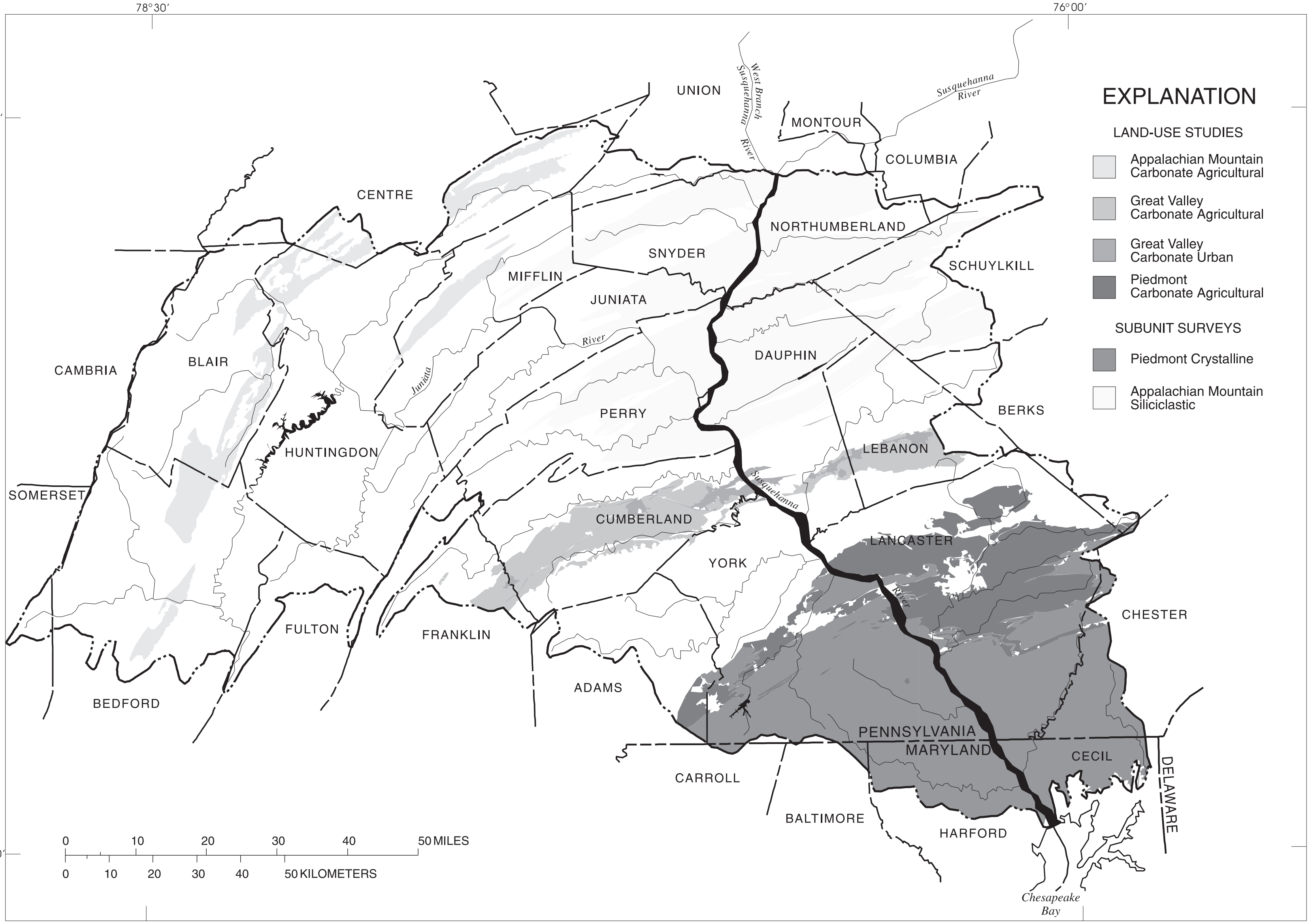

Figure 6. Locations of ground-water land-use studies and subunit surveys undertaken in the Lower Susquehanna NAWQA study unit in 1993-95.

If the area selected met the land-use criteria, state well records were searched to find wells in that area that met the well-construction criteria. The construction criteria included the type, depth, and age of the well. Wells for the sampling network were open boreholes, drilled and completed in bedrock aquifers, and cased with a steel or PVC casing. The maximum depth criteria for a well to be included in the network was 200 ft. This depth was chosen to sample shallow water-bearing zones that would most likely represent the overlying land use. Additionally, a maximum age limitation of 20 years was established to avoid wells that had deteriorated over time. In some cases, slightly older or deeper wells were selected. Driller's logs were obtained for 127 of 169 wells. Wells that had pressure tanks with an air/water interface were avoided.

When a suitable well was identified, a 20-minute single-well pumping test was conducted to ensure adequate yield for the sampling and calculate the specific capacity of the well. Wells that had excessive drawdown were not sampled. If all well-selection criteria were met, the site was added to the sampling network.

In the Great Valley carbonate urban subunit, the distribution of existing wells was not sufficient to conduct the sampling. Monitoring wells were drilled in those parts of the subunit where domestic supply wells were not available. Wells were drilled using the air-rotary drilling technique. Basic construction protocols for the NAWQA program were followed (Hardy and others, 1989). Specific drilling procedures included drilling a 12-in. borehole to a depth of 20 ft, or into competent bedrock, setting an 8-in. steel casing into the borehole, and then drilling an 8-in. borehole to the first water bearing zone. At this point, caliper, gamma, fluid-resistivity, temperature, and electrical downhole geophysical logs were run to help identify water-bearing zones. When logging was completed, a 4-in. PVC well was constructed within the 8-in. borehole with 10 ft of 0.01-in. slotted screen at the water-bearing zone and sand pack of number-one quartz sand spanning the screened interval. The annulus of the 8-in. hole above the screen was sealed with bentonite pellets, then grouted with a cement-bentonite slurry to the land surface. The annulus outside the 8-in. steel casing also was sealed with bentonite pellets and grouted to the land surface with the cement-bentonite mixture.

Two unused wells were located that did not meet the age-limit criteria for sampling but met all other criteria. For these two wells, geophysical logs were conducted to identify the characteristics of the open borehole. Then, a 2-in. PVC well was constructed inside the existing borehole with 20 ft of 0.01-in. slotted screen and sand pack of number-one quartz sand spanning the screened interval. The annulus of the 6-in. hole above the sand pack was sealed with bentonite pellets, then grouted with bentonite chips to the land surface.

Data-collection methods

The sampling procedures employed for the ground-water synoptic studies are described by Koterba and others (1995). Before sample collection, all sampling equipment was thoroughly cleaned. Sampling lines and hoses were cleaned by circulating a soap solution through the entire system with a peristaltic pump for 10 minutes. The lines were then rinsed with 3-4 gal of deionized water. All sampling and preservation chamber stands were washed with deionized water, and the bags covering the chamber were replaced. All filter assemblies were washed with a soap solution and rinsed with deionized water, with the exception of the dissolved organic carbon (DOC) filter, which was washed with deionized water and rinsed with blank water supplied by the USGS NWQL. Cleaned equipment was wrapped in aluminum foil and placed in clean plastic bags.

Before sample collection began, the static water level in the well was recorded. The pH meter, specific conductance meter, and the dissolved oxygen meter were each calibrated and the pH, specific conductance, dissolved oxygen, and temperature probes were placed in a flow-through chamber to measure field properties during purging. The minimum purging criteria was one well volume for domestic supply wells and three well volumes for monitoring wells and unused wells. Field-property stability was checked once the well-volume criteria had been met. Field property stability was defined as +/- 0.2°C for temperature, +/- 10 µS/cm for specific conductance, +/- 0.1 pH units for pH, and +/- 0.2 mg/L for dissolved oxygen. Once three consecutive field-property readings were within the established limits for all four field properties, sample collection began.

Samples were collected by filling containers in a sampling chamber made by placing a 6-mil polyethylene bag over a PVC frame. All bottles were filled inside the sampling chamber to minimize the potential for contamination by dust or other atmospheric contaminants. Holes were cut in the bag for the inflow hose, waste discharge, and access for sampling. Powderless latex gloves were worn during sampling and changed frequently.

To begin sampling, flow valves were switched to route the water into the sampling chamber and the sampling lines were flushed out for several minutes. For samples collected for organic analysis, all sampling lines and connections between the faucet and the sampling chamber were teflon or stainless steel. Except for baked bottles, all bottles were rinsed three times with pumped ground water before filling. Samples were collected at each site for analysis of field alkalinity, VOC's (Rose and Schroeder, 1995), pesticides by gas chromatography/mass spectrometry (GCMS), pesticides by HPLC, methylene blue active substances (MBAS) (Burkhardt and others, 1995), tritium, deuterium/oxygen isotopes, bacteria (total coliform, fecal coliform, fecal streptococcus, and *Escherichia coli* (*E. coli*)), DOC, major ions, nutrients, uranium, and radon. The tables in Appendix B (at back of report) list the constituent name, WATSTORE code, analytical method, minimum reporting level, and reporting units for each analyte for each analytical grouping used for ground-water samples.

The samples for analysis of pesticides were filtered using a 142-mm diameter glass fiber filter with openings 0.7 µm in size. The samples for pesticide analysis by GCMS were processed in the Pennsylvania District lab following the guidelines in Shelton (1994) and Manning and others (1994). The DOC sample was collected and filtered with a stainless steel filter assembly and a 47-mm diameter silver filter membrane with openings 0.45 µm in size. Filtration was done by pressure of nitrogen gas. The filter used in the 1993 sampling for major ions, nutrients, and uranium was a cellulose-nitrate filter with 0.45-µm openings, 142 mm in diameter, in an acrylic plate filter stand. In 1994 and 1995, a 0.45-µm pleated, disposable, encapsulated filter was used due to a change in protocols. The radon sample was collected last using a length of tygon tubing and a syringe (U.S. Geological Survey, Office of Water Quality Technical Memorandum 88.02, written commun., 1988). An additional 125 mL of water was collected and filtered for field analysis of nitrate with a spectrophotometer (Hach Company, 1992). Also, a 250-mL sample of filtered and acidified water for major-cation analysis and a 1-L raw-water sample were collected for archive purposes.

Samples were preserved and treated immediately after collection. The sample for VOC's was treated with a 1:1 hydrochloric acid (HCl) solution (1993 and 1995) to reduce the pH to 2. In 1994, a concentrated HCl solution was used to treat the samples for VOC's. The nutrient sample was preserved with 0.05 mL of mercuric chloride ($HgCl_2$) in 1993 and 1994; samples collected in 1995 were preserved by chilling only (Patton and Truitt, 1995). The sample for major cations was treated with 1 mL of nitric acid, and the sample for uranium was treated with 2 mL of nitric acid.

Alkalinity titrations were conducted on raw water samples. Both fixed-endpoint and incremental titrations were conducted using a digital titrator (Wood, 1976). Total coliform, fecal coliform, and fecal streptococcus were analyzed according to Britton and Greeson (1989). A blank plate was prepared for each type of analysis using a sterile funnel and sterile buffered water prior to processing each ground-water sample. Aliquots of 100 mL were filtered, and filter membranes were transferred to a petri dish containing the appropriate agar medium and placed in incubators. Two plates were prepared for each type of bacterial analysis. Membranes that were positive for total coliform were later transferred to another medium for *E. coli* confirmation testing in accordance with methods described by the U.S. Environmental Protection Agency (1991a). When sample preservation and processing were completed, the equipment cleaning procedures were repeated.

Quality Assurance

Because sources of bias and variability in water-quality data can be introduced during sample collection and processing, a quality-assurance plan as described by Shampine and others (1992) was developed and followed. To ensure that water-quality data were of sufficient quality to meet the objectives of the NAWQA Program, a series of quality-control samples (field blanks, replicates, and field-matrix-spike samples) were collected (Shelton, 1994).

In the Lower Susquehanna study unit, surface-water quality-control samples were collected at a ratio of about one for every five environmental samples. Generally, the ratio of environmental sample replicates (spiked or unspiked) to field blanks was about 2:1.

For the ground-water-quality studies, blank samples were collected at 10 percent of the sites. An equipment blank was prepared at the beginning of the first year of sampling; all subsequent blanks were field blanks collected to confirm equipment decontamination procedures. Following the collection, processing, and cleaning of sampling equipment at selected wells, the equipment was set up and blank samples were collected. The peristaltic pump used for cleaning was used to pump the blank water through the sampling lines. Inorganic-grade water was used for blank samples for major ions, nutrients, MBAS, uranium, and radon. Pesticide-grade water was used for blank samples for pesticides and DOC. VOC-grade water was used for VOC blanks.

Replicates or spiked replicates were collected at 10 percent of the sites immediately following collection of the environmental samples. Replicate samples were collected for major ions, nutrients, MBAS, uranium, DOC, and radon. Replicates for pesticides and VOC's were spiked with 100 μL of a solution prepared specifically for these analytical groupings by the USGS National Water-Quality Laboratory.

Procedures for the quality assurance of biological data described by Cuffney and others (1993b) for collection and processing of biological samples were followed. Taxonomic data were developed and verified, and voucher collections were created and maintained by the USGS Biological Unit in Arvada, Colo. Replicate fish-tissue samples were collected at 10 percent of the sites and voucher specimens were collected at each site to document taxonomic accuracy.

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APPENDIX A - SITE AND BASIN CHARACTERISTICS, BY WATER-QUALITY STUDY

[Basin characteristics: bedrock type is defined as the most predominant generalized lithology within a basin (and underlies at least 50 percent of the basin), with mixed indicating that no single lithology is predominant; land use is defined as the most predominant land use/land cover that occupies at least 40 percent of a basin, with mixed indicating that no single land use/land cover category is predominant.]

Table A-1. *Characteristics of sites and basins in the fixed-station study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
01555400	ODS25, 20, HFLX04, EFS06, BST21	East Mahantango Creek at Klingerstown, Pa.	403948/764130	Schuylkill	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	44.7	Susquehanna River
01559795	SILF05, EFS01, ODS44	Bobs Creek near Pavia, Pa.	401621/783555	Bedford	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	16.7	Dunning Creek
01564997	ACAR14, ODS45, KISHFS, EFS05, BST20	Kishacoquillas Creek at Lumber City, Pa.	403942/773601	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	57.4	Juniata River
01571490	ODS04, 32, HFLX10, GVUR07, CEDARFS, EFS02	Cedar Run at Eberlys Mill, Pa.	401330/765424	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	12.6	Yellow Breeches Creek
01573095	GVAG09, ODS46, BACHFS, EFS04, BST19	Bachman Run at Annville, Pa.	401859/763058	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	7.72	Quittapahilla Creek
01576540	HFLX16, 10, PCAR11, MILLFS, EFS03, BST11, ODS47	Mill Creek at Eshelman Mill Road near Lyndon, Pa.	400036/761639	Lancaster	Piedmont	Carbonate	Agriculture	54.3	Conestoga River
01577300	ODS36, 02, PCRS05, MUDDFS, EFS07, BST22	Muddy Creek at Muddy Creek Forks, Pa.	394827/762834	York	Piedmont	Crystalline	Agriculture	71.9	Susquehanna River

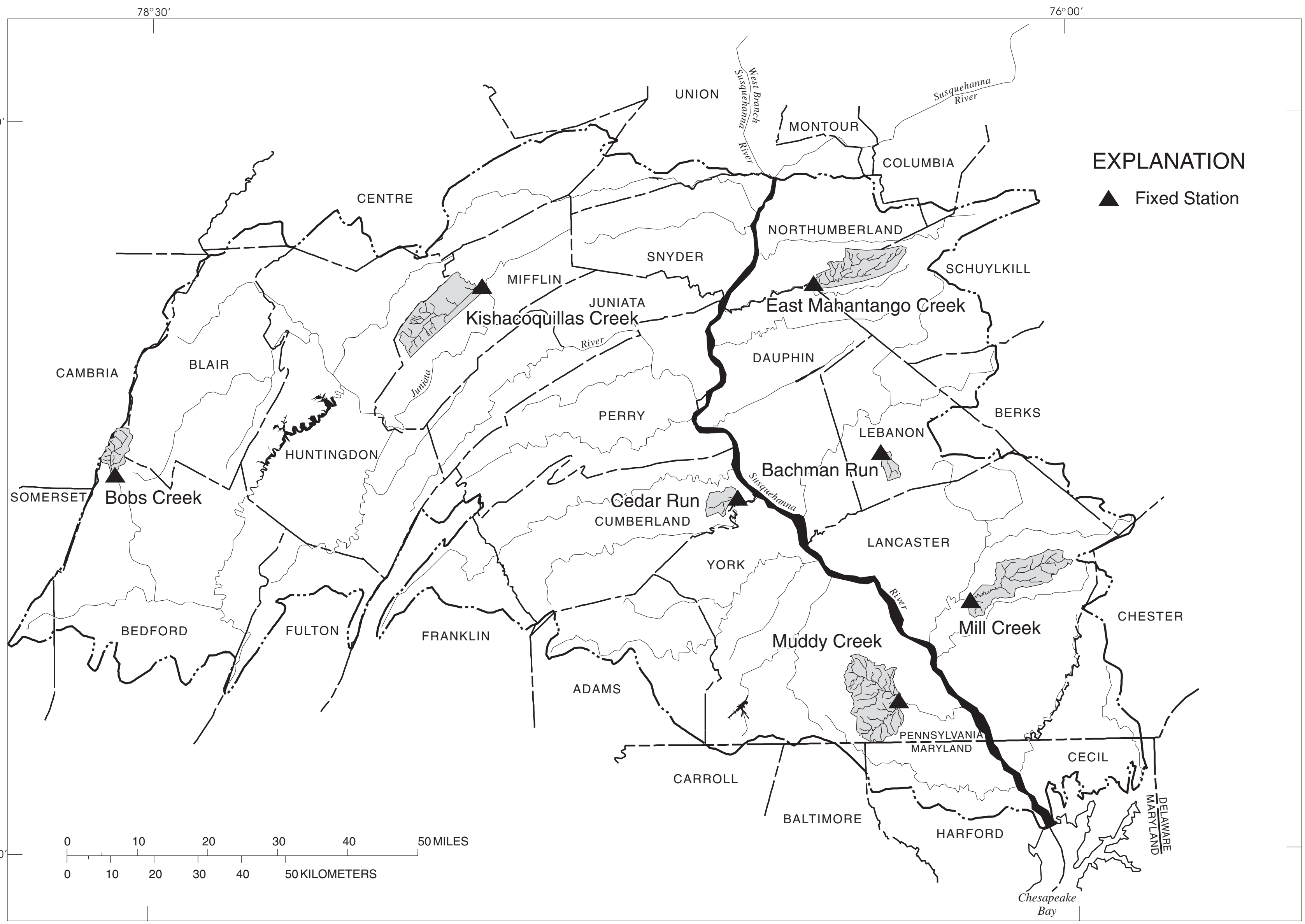

Figure A-1. Locations of sites sampled for the fixed-station study.

Table A-2. *Characteristics of sites and basins in tissue-trends study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
01540500	ODS08, 36, HFLX01, BST01, ESS13, TT01	Susquehanna River at Danville, Pa.	405729/763710	Montour	Mixed	Mixed	Mixed	11,200	Chesapeake Bay
01553500	ODS09, 37, HFLX02, BST02, ESS15, TT02	West Branch Susquehanna River at Lewisburg, Pa.	405802/765245	Northumberland	Mixed	Mixed	Mixed	6,840	Susquehanna River
01567000	HFLX06, BST08, ESS17, TT03	Juniata River at Newport, Pa.	402842/770746	Perry	Ridge and Valley (Appalachian Mountain)	Mixed	Mixed	3,340	Susquehanna River
400144076310701	ESS40, BST17, TT04	Susquehanna River at Columbia, Pa.	400144/763107	Lancaster	Mixed	Mixed	Mixed	26,000	Chesapeake Bay
394220076351501	ESS31, BST16, ODS43, PCRS14, 09, TT05	Deer Creek at Gorsuch Mills, Md.	394220/763515	Baltimore	Piedmont	Crystalline	Agriculture	25.7	Susquehanna River

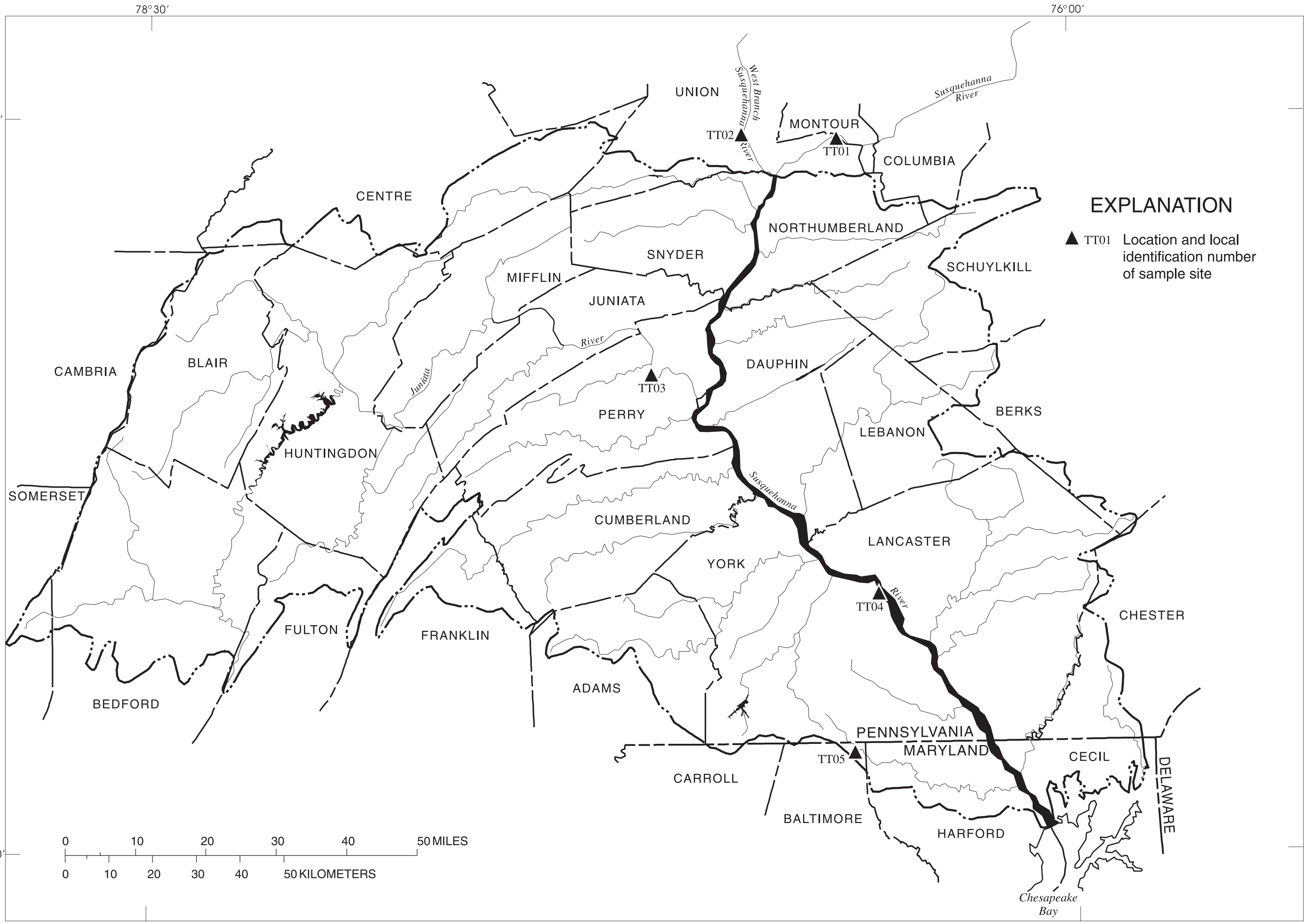

Figure A-2. Locations of sites sampled for the tissue-trends study.

Table A-3. *Characteristics of sites and basins in the triazine herbicide and nutrient synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/longitude at sample site	County	Physiographic province (section)	Bedrock type(s)	Land use(s)	Drainage area (square miles)	Next higher-order stream
01540500	36, ODS08, ESS13, HFLX01, BST01, TT01	Susquehanna River at Danville, Pa.	405729/763710	Montour	Mixed	Mixed	Mixed	11,200	Chesapeake Bay
01553500	37, ODS09, ESS15, HFLX02, BST02, TT02	West Branch Susquehanna River at Lewisburg, Pa.	405805/765225	Northumberland	Mixed	Mixed	Mixed	6,840	Susquehanna River
404317076440601	11, ODS16	Schwaben Creek above Middle Creek at Rebuck, Pa.	404317/764406	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	13.6	Mahanoy Creek
404309076435701	12, ODS17	Middle Creek at Rebuck, Pa.	404309/764357	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	2.92	Schwaben Creek
404258076464601	13, ODS18	Schwaben Creek at Red Cross, Pa.	404258/764646	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	22.7	Mahanoy Creek
404120076461601	14, ODS19	Mouse Creek below Urban, Pa.	404120/764616	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	2.77	Schwaben Creek
404146076511001	15, ODS20	Fidlers Run at mouth near Herndon, Pa.	404146/765110	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic/carbonate	Agriculture	6.87	Susquehanna River
404035076363801	16, ODS21	East Mahantango Creek above Little Mahantango Creek at Rough and Ready, Pa.	404035/763638	Schuylkill	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	19.1	Susquehanna River
404151076352201	17, ODS22	Little Mahantango Creek near Hepler, Pa.	404151/763522	Schuylkill	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	9.12	East Mahantango Creek
404224076352001	18, ODS23	Unnamed tributary at USDA-ARS Weir-38 near Hepler, Pa.	404224/763520	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	2.70	Little Mahantango Creek
404036076370301	19, ODS24	Little Mahantango Creek near mouth at Rough and Ready, Pa.	404036/763703	Schuylkill	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	15.0	East Mahantango Creek

Table A-3. *Characteristics of sites and basins in the triazine herbicide and nutrient synoptic study—Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type(s)	Land use(s)	Drainage area (square miles)	Next higher-order stream
01555400	20, ODS25, HFLX04, EFS06, BST21	East Mahantango Creek at Klingerstown, Pa.	403948/764130	Schuylkill	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	44.7	Susquehanna River
403809076370101	21, ODS26	Pine Creek above Deep Creek near Spring Glen, Pa.	403809/763701	Schuylkill	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture & mining	21	East Mahantango Creek
403810076365601	22, ODS27	Deep Creek at mouth near Spring Glen, Pa.	403810/763656	Schuylkill	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	32	Pine Creek
403900076412601	23, ODS28	Pine Creek at Erdman, Pa.	403900/764126	Dauphin	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture & mining	76	East Mahantango Creek
403808076475101	24, ODS29	Deep Creek at Pillow, Pa.	403808/764751	Dauphin	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	76	East Mahantango Creek
403835076474801	25, ODS30	East Mahantango Creek at Pillow, Pa.	403835/764748	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	157	Susquehanna River
01555500	26, ODS31, HFLX05	East Mahantango Creek near Dalmatia, Pa.	403640/765444	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	162	Susquehanna River
403448076475901	27, ODS32	Wiconisco Creek near Berrysburg, Pa.	403448/764759	Dauphin	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	76	Susquehanna River
403313076551201	28, ODS33	Little Wiconisco Creek at Killinger, Pa.	403313/765512	Dauphin	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	15.8	Wiconisco Creek
01559795	SILF05, EFS01, ODS44	Bobs Creek near Pavia, Pa.	401621/783555	Bedford	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	16.7	Dunning Creek
01564997	ACAR14, KISHFS, EFS05, BST20, ODS45	Kishacoquillas Creek at Lumber City, Pa.	403942/773601	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	57.4	Juniata River
400342077315801	29, ODS01	Middle Spring Creek below Shippensburg, Pa.	400342/773158	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	20.7	Conodoguinet Creek
01569800	30, ODS02, GVUR04	Letort Spring Run near Carlisle, Pa.	401404/770822	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	21.8	Conodoguinet Creek
401505077002601	31, ODS03, GVUR05	Trindle Spring Run at Hogestown, Pa.	401505/770026	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	17.8	Conodoguinet Creek

Table A-3. *Characteristics of sites and basins in the triazine herbicide and nutrient synoptic study—Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/longitude at sample site	County	Physiographic province (section)	Bedrock type(s)	Land use(s)	Drainage area (square miles)	Next higher-order stream
01570500	38, ODS10, HFLX09	Susquehanna River at Harrisburg, Pa.	401517/765311	Dauphin	Mixed	Mixed	Mixed	24,100	Chesapeake Bay
401454076510801	35, ODS07	Spring Creek at 19th Street at Harrisburg, Pa.	401454/765108	Dauphin	Ridge & Valley (Great Valley)	Carbonate	Urban	11.1	Susquehanna River
01571490	32, ODS04, HFLX10, GVUR07, CEDARFS, EFS02	Cedar Run at Eberlys Mill, Pa.	401330/765424	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	12.6	Yellow Breeches Creek
01573095	GVAG09, ODS46, BACHFS, EFS04, BST19	Bachman Run at Annville, Pa.	401859/763058	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	7.72	Quittapahilla Creek
402018076272901	33, ODS05, GVUR10	Quittapahilla Creek near Cleona, Pa.	402018/762729	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Urban	19.6	Swatara Creek
401709076404601	34, ODS06	Spring Creek at Hershey, Pa.	401709/764046	Dauphin	Ridge & Valley (Great Valley)	Carbonate	Urban	24.0	Swatara Creek
01573560	39, ODS11, HFLX12	Swatara Creek near Hershey, Pa.	401754/764005	Dauphin	Mixed	Mixed	Mixed	483	Susquehanna River
395853077140301	ODS34	Opossum Creek at Route 34 at Bendersville, Pa.	395853/771403	Adams	Piedmont	Crystalline	Agriculture	14.4	West Conewago Creek
01576000	40, ODS12, HFLX15	Susquehanna River at Marietta, Pa.	400316/763152	Lancaster	Mixed	Mixed	Mixed	25,600	Chesapeake Bay
01576540	10, HFLX16, ODS47, PCAR11, EFS03, MILLFS, BST11	Mill Creek at Eshelman Mill Road near Lyndon, Pa.	400036/761639	Lancaster	Piedmont	Carbonate	Agriculture	54.3	Conestoga River
01576754	41, ODS13, HFLX17	Conestoga River at Conestoga, Pa.	395647/762205	Lancaster	Mixed	Mixed	Mixed	468	Susquehanna River
01576787	42, ODS14, HFLX18	Pequea Creek at Martic Forge, Pa.	395421/761943	Lancaster	Mixed	Mixed	Mixed	148	Susquehanna River
394827076283601	01, ODS35, MUDD14	South Branch Muddy Creek at mouth at Muddy Creek Forks, Pa.	394827/762836	York	Piedmont	Crystalline	Agriculture	28.1	Muddy Creek
01577300	02, ODS36, PCRS05, MUDDFS, EFS07, BST22	Muddy Creek at Muddy Creek Forks, Pa.	394827/762834	York	Piedmont	Crystalline	Agriculture	71.9	Susquehanna River

Table A-3. *Characteristics of sites and basins in the triazine herbicide and nutrient synoptic study—Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type(s)	Land use(s)	Drainage area (square miles)	Next higher-order stream
01577500	03, ODS37, HFLX19, PCRS06	Muddy Creek at Castle Fin, Pa.	394621/761858	York	Piedmont	Crystalline	Agriculture	133	Susquehanna River
394549076100201	04, ODS38	Little Conowingo Creek at Wakefield, Pa.	394549/761002	Lancaster	Piedmont	Crystalline	Agriculture	6.42	Conowingo Creek
394549076101301	05, ODS39	Conowingo Creek at Wakefield, Pa.	394549/761013	Lancaster	Piedmont	Crystalline	Agriculture	20.3	Susquehanna River
01578310	43, ODS15, HFLX20	Susquehanna River at Conowingo, Md.	393928/761031	Harford	Mixed	Mixed	Mixed	27,100	Chesapeake Bay
395048076011401	06, ODS40, ESS25, PCRS09, BST13	East Branch Octoraro Creek near Kirkwood, Pa.	395048/760114	Lancaster	Piedmont	Crystalline	Agriculture	55.3	Octoraro Creek
01578440	07, ODS41, PCRS11	West Branch Octoraro Creek at White Rock, Pa.	394929/760525	Lancaster	Piedmont	Crystalline	Agriculture	39.6	Octoraro Creek
394230076352601	08, ODS42	Ebaughs Creek at Gorsuch Mills, Md.	394230/763526	Baltimore	Piedmont	Crystalline	Agriculture	6.92	Deer Creek
394220076351501	09, ODS43, PCRS14, ESS31, BST16, TT05	Deer Creek at Gorsuch Mills, Md.	394220/763515	Baltimore	Piedmont	Crystalline	Agriculture	25.7	Susquehanna River

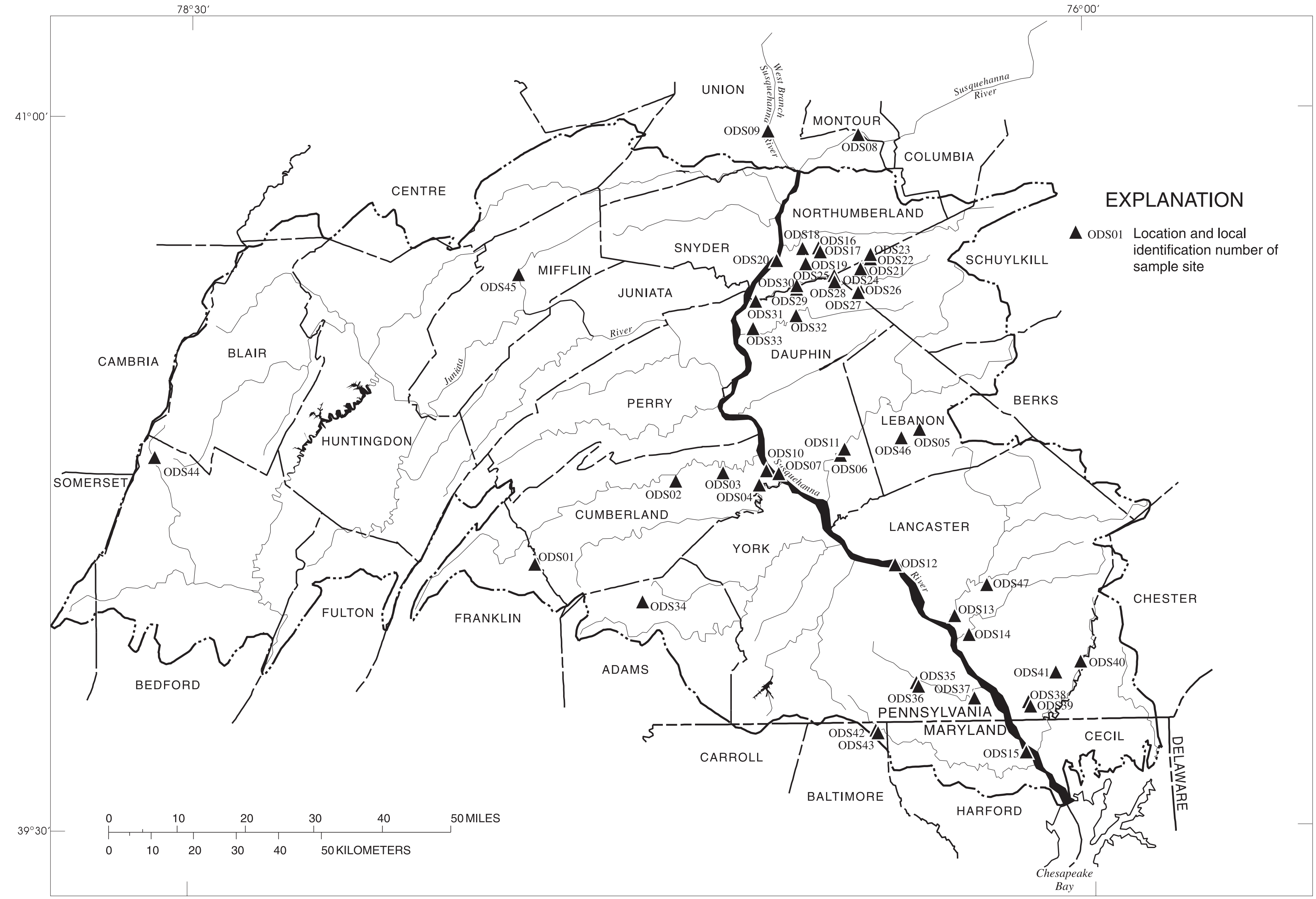

Figure A-3. Locations of sites sampled for the triazine herbicide and nutrient synoptic study.

Table A-4. *Characteristics of sites and basins in the bed sediment and tissue contaminant survey*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
01540500	ESS13, 36, ODS08, HFLX01, BST01, TT01	Susquehanna River at Danville, Pa.	405729/763710	Montour	Mixed	Mixed	Mixed	11,200	Chesapeake Bay
01553500	BST02, ODS09, 37, HFLX02, ESS15, TT02	West Branch Susquehanna River at Lewisburg, Pa.	405802/765245	Northumberland	Mixed	Mixed	Mixed	6,840	Susquehanna River
405121077342701	ESS05, BST03, ACAR01	Penns Creek at Spring Mills, Pa.	405121/773427	Centre	Ridge and Valley (Appalachian Mountain)	Carbonate	Agriculture	17.5	Susquehanna River
404422076325401	BST04	Mahanoy Creek near Gowen City, Pa.	404422/763254	Northumberland	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Forest	82	Susquehanna River
403847076575201	BST05, ESS18	West Mahantango Creek near Liverpool, Pa.	403847/765752	Snyder	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Agriculture	47	Susquehanna River
01555400	ODS25, 20, HFLX04, EFS06, BST21	East Mahantango Creek at Klingerstown, Pa.	403948/764130	Schuylkill	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Agriculture	44.7	Susquehanna River
402549078213001	ESS03, BST07	Frankstown Branch Juniata River near Hollidaysburg, Pa.	402549/782130	Blair	Ridge and Valley (Appalachian Mountain)	Mixed	Mixed	291	Juniata River
01564997	EFS05, ACAR14, KISHFS, BST20, ODS45	Kishacoquillas Creek at Lumber City, Pa.	403942/773601	Mifflin	Ridge and Valley (Appalachian Mountain)	Carbonate	Agriculture	57.4	Juniata River
403622077335601	ESS12, BST06	Kishacoquillas Creek at Lewistown, Pa.	403622/773356	Mifflin	Ridge and Valley (Appalachian Mountain)	Mixed	Mixed	190	Juniata River
01567000	BST08, ESS17, HFLX06, TT03	Juniata River at Newport, Pa.	402842/770746	Perry	Ridge and Valley (Appalachian Mountain)	Mixed	Mixed	3,340	Susquehanna River
01573095	EFS04, ODS46, GVAG09, BACHFS, BST19	Bachman Run at Annville, Pa.	401859/763058	Lebanon	Ridge and Valley (Great Valley)	Carbonate	Agriculture	7.72	Quittapahilla Creek

Table A-4. *Characteristics of sites and basins in the bed sediment and tissue contaminant survey—Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
402108076363701	ESS11, BST09	Quittapahilla Creek near Palmyra, Pa.	402108/763637	Lebanon	Ridge and Valley (Great Valley)	Mixed	Mixed	77.2	Swatara Creek
01573560	ESS21, BST10	Swatara Creek near Hershey, Pa.	401713/764046	Dauphin	Mixed	Mixed	Mixed	483	Susquehanna River
400037076423701	ESS29, BST15	Codorus Creek near Pleasureville, Pa.	400037/764237	York	Piedmont	Crystalline	Mixed	260	Susquehanna River
400144076310701	ESS40, TT04, BST17	Susquehanna River at Columbia, Pa.	400144/763107	Lancaster	Mixed	Mixed	Mixed	26,000	Chesapeake Bay
01576540	EFS03,, 10, HFLX16, PCAR11, MILLFS BST11, ODS47	Mill Creek at Eshelman Mill Road near Lyndon, Pa.	400036/761639	Lancaster	Piedmont	Carbonate	Agriculture	54.3	Conestoga River
395614076231401	ESS24, BST14	Conestoga River at Safe Harbor, Pa.	395614/762314	Lancaster	Mixed	Mixed	Mixed	477	Susquehanna River
395619076133901	ESS22, BST12, PCAR16	Big Beaver Creek near Refton, Pa.	395619/761339	Lancaster	Piedmont	Carbonate	Agriculture	18.0	Pequea Creek
01577300	ESF07, 02, BST22, ODS36, MUDDFS, PCRS05	Muddy Creek at Muddy Creek Forks, Pa.	394827/762834	York	Piedmont	Crystalline	Agriculture	71.9	Susquehanna River
394608076150801	BST18	Susquehanna River at Conowingo Reservoir, Pa.	394608/761508	Lancaster	Mixed	Mixed	Mixed	27,100	Chesapeake Bay
395048076011401	ESS25, 06, ODS40, PCRS09 BST13	East Branch Octoraro Creek near Kirkwood, Pa.	395048/760114	Lancaster	Piedmont	Crystalline	Agriculture	55.3	Octoraro Creek
394220076351501	ESS31, BST16, ODS43, PCRS14, 09, TT05	Deer Creek at Gorsuch Mills, Md.	394220/763515	Baltimore	Piedmont	Crystalline	Agriculture	25.7	Susquehanna River

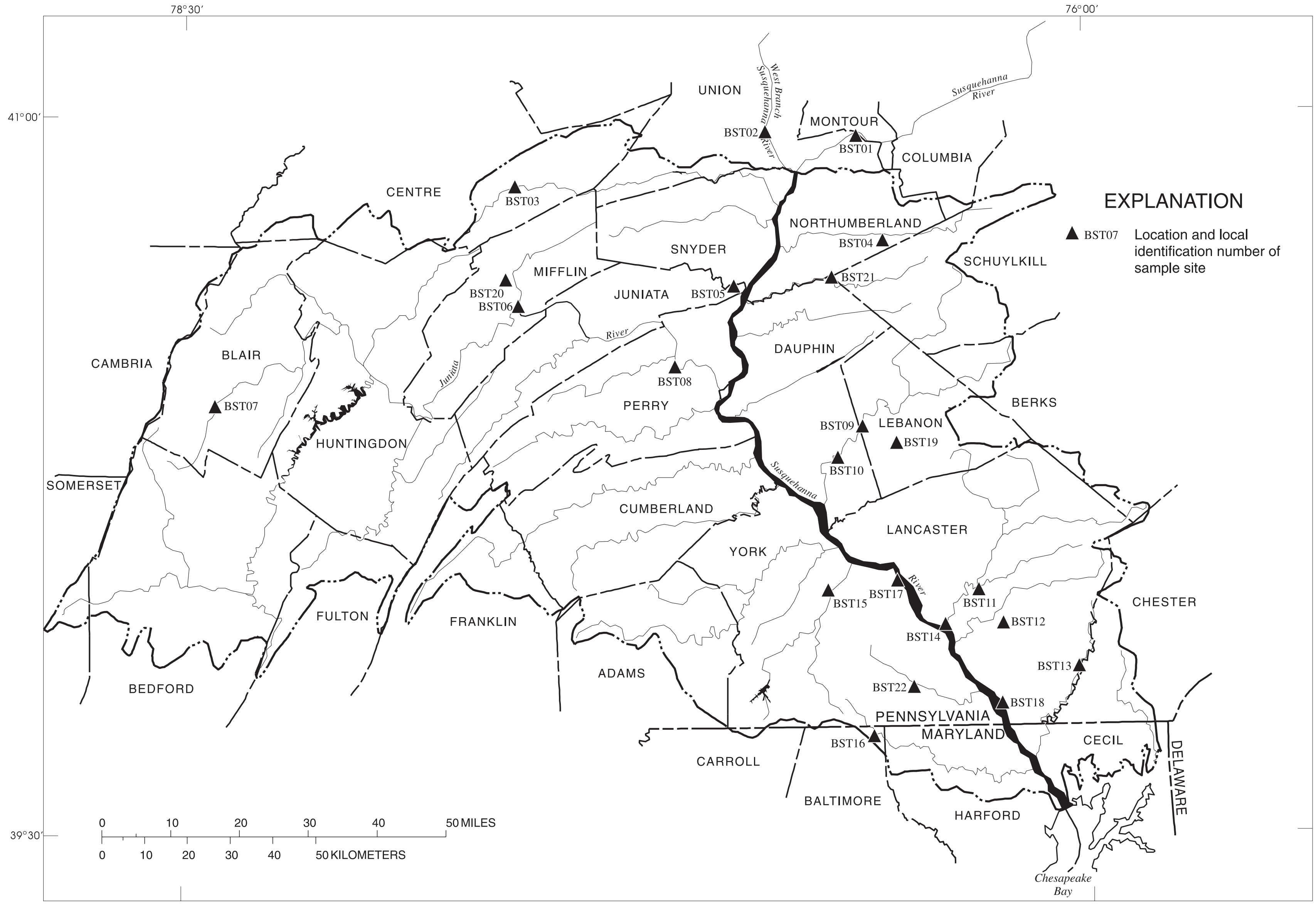

Figure A-4. Locations of sites sampled for the bed sediment and tissue contaminant survey.

Table A-5. *Characteristics of sites and basins in the ecological synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
01540500	ESS13, 36, ODS08, HFLX01, BST01, TT01	Susquehanna River at Danville, Pa.	405729/763710	Montour	Mixed	Mixed	Mixed	11,200	Chesapeake Bay
01553500	ESS15, 37, ODS09, HFLX02, BST02, TT02	West Branch Susquehanna River at Lewisburg, Pa.	405802/765245	Northumberland	Mixed	Mixed	Mixed	6,840	Susquehanna River
405101076482001	ESS43	Susquehanna River at Sunbury, Pa.	405101/764820	Northumberland	Mixed	Mixed	Mixed	18,300	Chesapeake Bay
405130076460001	ESS28	Little Shamokin Creek at Sunbury, Pa.	405130/764600	Northumberland	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Agricultural	29.0	Shamokin Creek
405145076463601	ESS42	Shamokin Creek near Sunbury, Pa.	405145/764636	Northumberland	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Mixed	135	Susquehanna River
404621077050901	ESS19	Middle Creek at Paxtonville, Pa.	404621/770509	Snyder	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Forest	115	Penns Creek
405121077342701	ESS05, BST03, ACAR01	Penns Creek at Spring Mills, Pa.	405121/773427	Centre	Ridge and Valley (Appalachian Mountain)	Carbonate	Agriculture	17.5	Susquehanna River
404334076501601	ESS14, MCS03	Mahanoy Creek near Herndon, Pa.	404334/765016	Northumberland	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Mixed	157	Susquehanna River
403847076575201	ESS18, BST05	West Mahantango Creek near Liverpool, Pa.	403847/765752	Snyder	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Agriculture	47	Susquehanna River
403415076590201	ESS44	Susquehanna River at Liverpool, Pa.	403415/765902	Perry	Mixed	Mixed	Mixed	19,500	Chesapeake Bay
403213076573801	ESS08	Wiconisco Creek at Millersburg, Pa.	403213/765738	Dauphin	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Agriculture	116	Susquehanna River
402432076585501	ESS07	Powell Creek at Inglenook, Pa.	402432/765855	Dauphin	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Mixed	39.7	Susquehanna River
402549078213001	ESS03, BST07	Frankstown Branch Juniata River near Hollidaysburg, Pa.	402549/782130	Blair	Ridge and Valley (Appalachian Mountain)	Mixed	Mixed	291	Juniata River

Table A-5. *Characteristics of sites and basins in the ecological synoptic study—Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
402836078103601	ESS04	Clover Creek near Williamsburg, Pa.	402836/781036	Blair	Ridge and Valley (Appalachian Mountain)	Carbonate	Agriculture	50.1	Frankstown Branch Juniata River
403936078152101	ESS02	Little Juniata River at Tyrone, Pa.	403936/781521	Blair	Ridge and Valley (Appalachian Mountain)	Mixed	Forest	106	Juniata River
401254078155401	ESS01	Raystown Branch Juniata River near Saxton, Pa.	401254/781554	Bedford	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Mixed	954	Juniata River
403622077335601	ESS12, BST06	Kishacoquillas Creek at Lewistown, Pa.	403622/773356	Mifflin	Ridge and Valley (Appalachian Mountain)	Mixed	Mixed	190	Juniata River
403155077225601	ESS10	Tuscarora Creek near Port Royal, Pa.	403155/772256	Juniata	Ridge and Valley (Appalachian Mountain)	Carbonate	Agriculture	270	Juniata River
01567000	ESS17, TT03, HFLX06, BST08	Juniata River at Newport, Pa.	402844/770746	Perry	Ridge and Valley (Appalachian Mountain)	Mixed	Mixed	3,340	Susquehanna River
402250077045701	ESS16	Sherman Creek at Dellville, Pa.	402250/770457	Perry	Ridge and Valley	Carbonate	Forest	241	Susquehanna River
400549077341401	ESS34	Conodoguinet Creek near Middle Spring, Pa.	400549/773414	Franklin	Ridge and Valley	Mixed	Agriculture	104	Susquehanna River
400554077334801	ESS36	Middle Spring Creek at Middle Spring, Pa.	400554/773348	Cumberland	Ridge and Valley (Great Valley)	Carbonate	Urban	48	Conodoguinet Creek
401045077233301	ESS33	Big Spring Creek near Newville, Pa.	401045/772333	Cumberland	Ridge and Valley (Great Valley)	Carbonate	Urban	1.41	Conodoguinet Creek
401404077083101	ESS06	Letort Spring Run at Carlisle, Pa.	401404/770831	Cumberland	Ridge and Valley (Great Valley)	Carbonate	Mixed	21.8	Conodoguinet Creek
401507077002701	ESS38	Trindle Spring Run near Hogestown, Pa.	401507/770027	Cumberland	Ridge and Valley (Great Valley)	Carbonate	Urban	17.8	Conodoguinet Creek
01570280	ESS35, HFLX08	Conodoguinet Creek at Enola, Pa.	401638/765700	Cumberland	Ridge and Valley (Great Valley)	Mixed	Mixed	502	Susquehanna River
01571000	GVUR06, ESS09	Paxton Creek near Penbrook, Pa.	401830/765100	Dauphin	Ridge & Valley (Great Valley)	Mixed	Urban	11.4	Susquehanna River
400634077105201	ESS37	Mountain Creek near RT 34 bridge at Mount Holly Springs, Pa.	400634/771052	Cumberland	Blue Ridge	Crystalline	Forest	44.9	Yellow Breeches Creek

Table A-5. *Characteristics of sites and basins in the ecological synoptic study*—*Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
400920076593001	ESS39	Yellow Breeches Creek at Messiah College, Pa.	400920/765930	Cumberland	Mixed	Mixed	Mixed	161	Susquehanna River
402709076303201	ESS41	Swatara Creek at Lickdale, Pa.	402709/763032	Lebanon	Ridge and Valley (Appalachian Mountain)	Siliciclastic	Mixed	178	Susquehanna River
402425076282401	ESS27	Little Swatara Creek at Jonestown, Pa.	402425/762824	Lebanon	Ridge and Valley (Great Valley)	Siliciclastic	Agricultural	98.9	Swatara Creek
402108076363701	ESS11, BST09	Quittapahilla Creek near Palmyra, Pa.	402108/763637	Lebanon	Ridge and Valley (Great Valley)	Mixed	Mixed	77.2	Swatara Creek
01573560	ESS21, BST10	Swatara Creek near Hershey, Pa.	401713/764046	Dauphin	Mixed	Mixed	Mixed	483	Susquehanna River
395553077114901	ESS32	Opossum Creek near the confluence with West Conewago Creek, Pa.	395553/771149	Adams	Piedmont	Mixed	Agriculture	37.6	Conewago Creek
395256077041101	ESS20	South Branch Conewago Creek near New Oxford, Pa.	395256/770411	Adams	Piedmont	Mixed	Agriculture	70.3	Conewago Creek
400513076433701	ESS30	Little Conewago Creek at Conewago Heights, Pa.	400513/764337	York	Piedmont	Crystalline	Agriculture	65.4	Conewago Creek
400037076423701	ESS29, BST15	Codorus Creek near Pleasureville, Pa.	400037/764237	York	Piedmont	Crystalline	Mixed	260	Susquehanna River
400144076310701	ESS40, TT04, BST17	Susquehanna River at Columbia, Pa.	400144/763107	Lancaster	Mixed	Mixed	Mixed	26,000	Chesapeake Bay
400038076332301	ESS45	Kreutz Creek at Wrightsville, Pa.	400038/763323	York	Piedmont	Carbonate	Agriculture	30.5	Susquehanna River
400749076135101	ESS23	Cocalico Creek near Brownstown, Pa.	400749/761351	Lancaster	Piedmont	Carbonate	Agriculture	139	Conestoga River
395614076231401	ESS24, BST14	Conestoga River at Safe Harbor, Pa.	395614/762314	Lancaster	Mixed	Mixed	Mixed	472	Susquehanna River
395619076133901	ESS22, BST12, PCAR16	Big Beaver Creek near Refton, Pa.	395619/761339	Lancaster	Piedmont	Carbonate	Agriculture	19.8	Pequea Creek
395356076210501	ESS26	Pequea Creek at PP&L recreation area at Pequea, Pa.	395356/762105	Lancaster	Mixed	Mixed	Mixed	152	Susquehanna River

Table A-5. *Characteristics of sites and basins in the ecological synoptic study—Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
395048076011401	ESS25, 06, ODS40, PCRS09 BST13	East Branch Octoraro Creek near Kirkwood, Pa.	395048/760114	Lancaster	Piedmont	Crystalline	Agriculture	55.3	Octoraro Creek
394220076351501	ESS31, BST16, ODS43, PCRS14, 09, TT05	Deer Creek at Gorsuch Mills, Md.	394220/763515	Baltimore	Piedmont	Crystalline	Agriculture	25.7	Susquehanna River

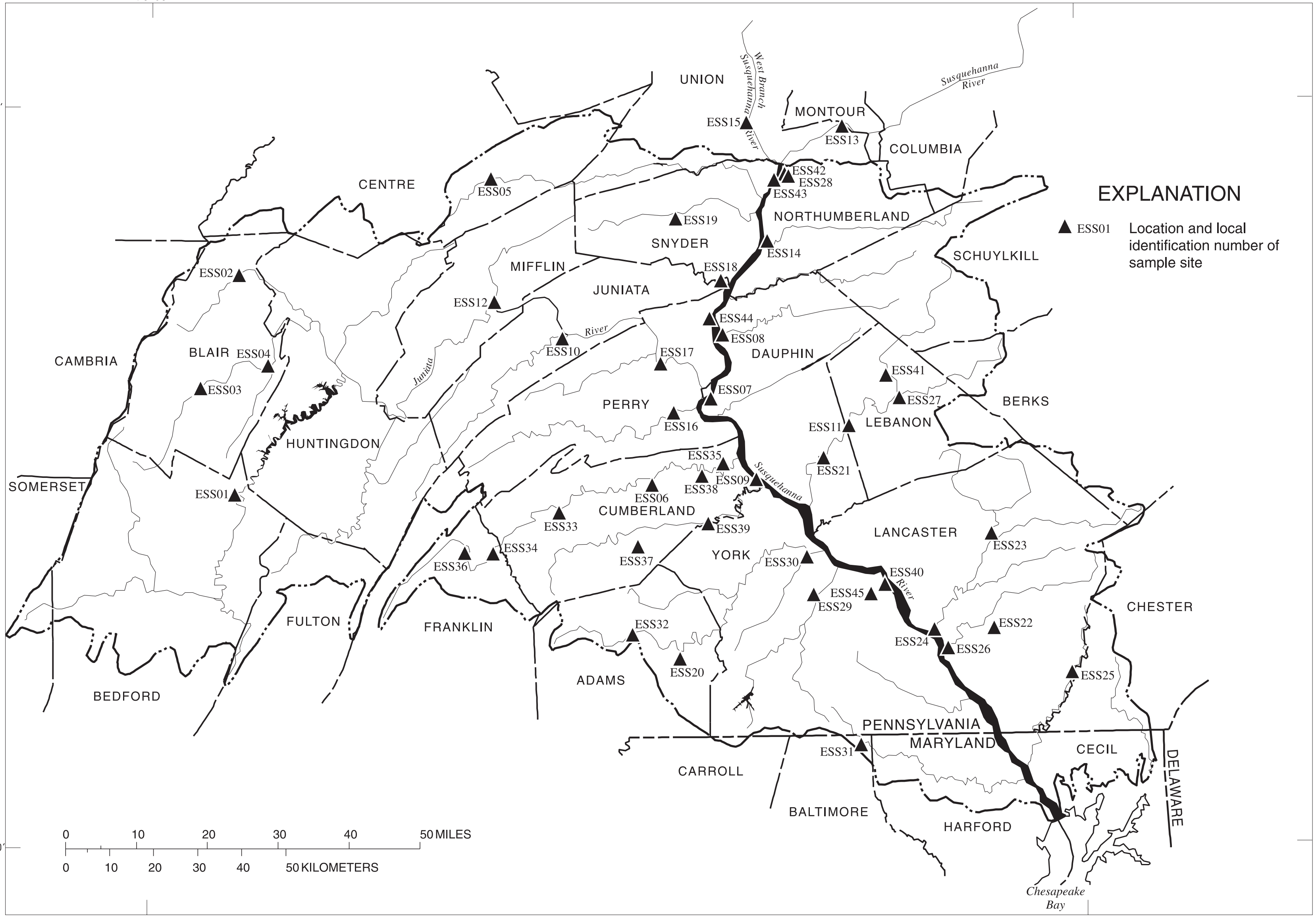

Figure A-5. Locations of sites sampled for the ecological synoptic study.

Table A-6. *Characteristics of sites and basins in the Cedar Run synoptic study #1*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
401351076565201	CEDAR01, Site 7	Unnamed northern tributary to Cedar Run at Shiremanstown, Pa.	401351/765652	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	2.49	Cedar Run
401353076564801	CEDAR02	Spring (SP CU-35) at Shiremanstown, Pa.	401353/765648	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	34.1	Unnamed northern tributary to Cedar Run
401333076550901	CEDAR03, Site 9	Unnamed tributary to unnamed northern tributary to Cedar Run at Eberlys Mill, Pa.	401333/765509	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	1.82	Unnamed northern tributary to Cedar Run
401323076550301	CEDAR04, Site 8	Cedar Run above unnamed northern tributary at Eberlys Mill, Pa.	401323/765503	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	6.73	Yellow Breeches Creek
01571490	ODS04, 32, HFLX10, GVUR07, EFS02, CEDARFS	Cedar Run at Eberlys Mill, Pa.	401330/765424	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	12.6	Yellow Breeches Creek

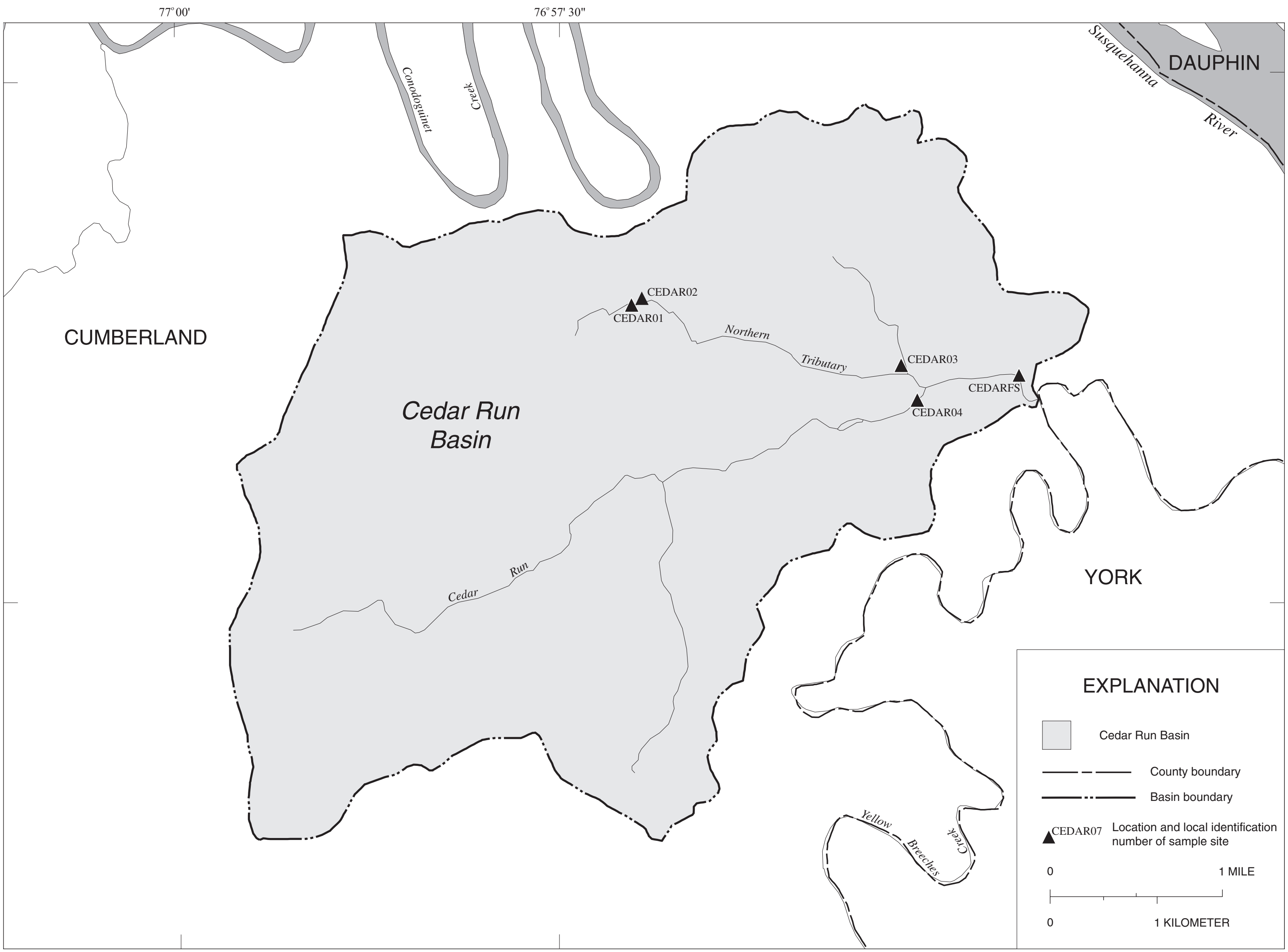

Figure A-6. Locations of sites sampled for the Cedar Run synoptic study #1.

Table A-7. *Characteristics of sites and basins in the Cedar Run synoptic study #2*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
401340076562901	CEDAR05	Unnamed northern tributary to Cedar Run at Shiremanstown, Pa.	401340/765629	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	2.97	Cedar Run
401334076551001	CEDAR06	Unnamed tributary to unnamed northern tributary to Cedar Run at Eberlys Mill, Pa.	401334/765510	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	1.82	Unnamed northern tributary to Cedar Run
401303076562001	CEDAR07	Cedar Run at Shiremanstown, Pa.	401303/765620	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	5.68	Yellow Breeches Creek
401327076550401	CEDAR08	Unnamed northern tributary to Cedar Run at Eberlys Mill, Pa.	401327/765504	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	5.46	Cedar Run
01571490	ODS04, 32, HFLX10, GVUR07, EFS02, CEDARFS	Cedar Run at Eberlys Mill, Pa.	401330/765424	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	12.6	Yellow Breeches Creek

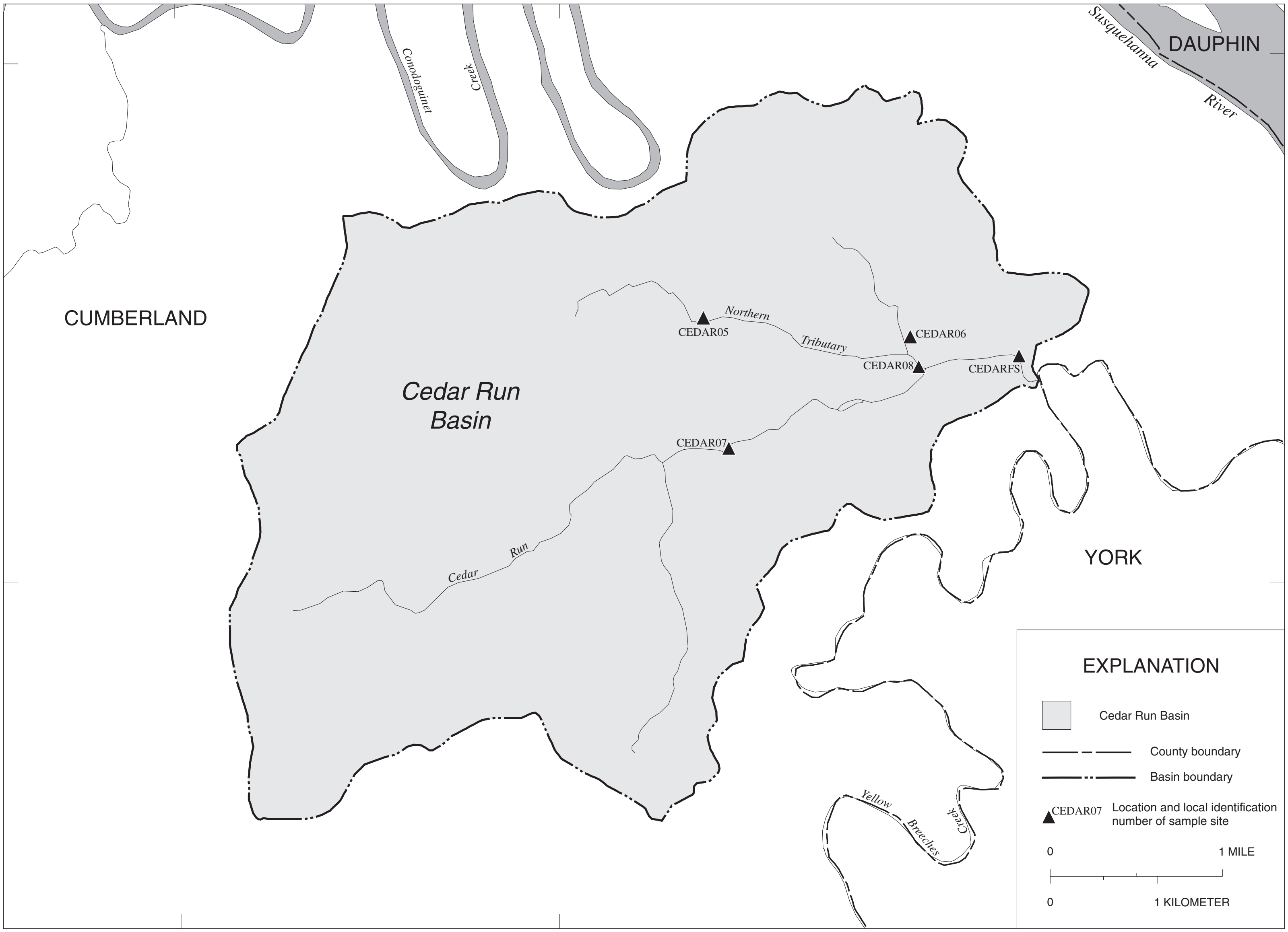

Figure A-7. Locations of sites sampled for the Cedar Run synoptic study #2.

Table A-8. *Characteristics of sites and basins in the Cedar Run synoptic study #3*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
401351076565201	CEDAR01, Site 7	Unnamed northern tributary to Cedar Run at Shiremanstown, Pa.	401351/765652	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	2.49	Cedar Run
401332076551001	CEDAR10	Unnamed northern tributary to Cedar Run above unnamed tributary at Eberlys Mill, Pa.	401332/765510	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	1.82	Cedar Run
401333076550901	CEDAR03, Site 9	Unnamed tributary to unnamed northern tributary to Cedar Run at Eberlys Mill, Pa.	401333/765509	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	1.82	Unnamed northern tributary to Cedar Run
401327076550401	CEDAR08	Unnamed northern tributary to Cedar Run at Eberlys Mill, Pa.	401327/765504	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	5.46	Cedar Run
401301076565501	CEDAR09	Cedar Run at Slate Hill Road at Shiremanstown, Pa.	401301/765655	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	3.85	Yellow Breeches Creek
401303076562001	CEDAR07	Cedar Run at Shiremanstown, Pa.	401303/765620	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	5.68	Yellow Breeches Creek
401323076550301	CEDAR04, Site 8	Cedar Run above unnamed northern tributary at Eberlys Mill, Pa.	401323/765503	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	6.76	Yellow Breeches Creek
01571490	ODS04, 32, HFLX10, GVUR07, EFS02, CEDARFS	Cedar Run at Eberlys Mill, Pa.	401330/765424	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	12.6	Yellow Breeches Creek

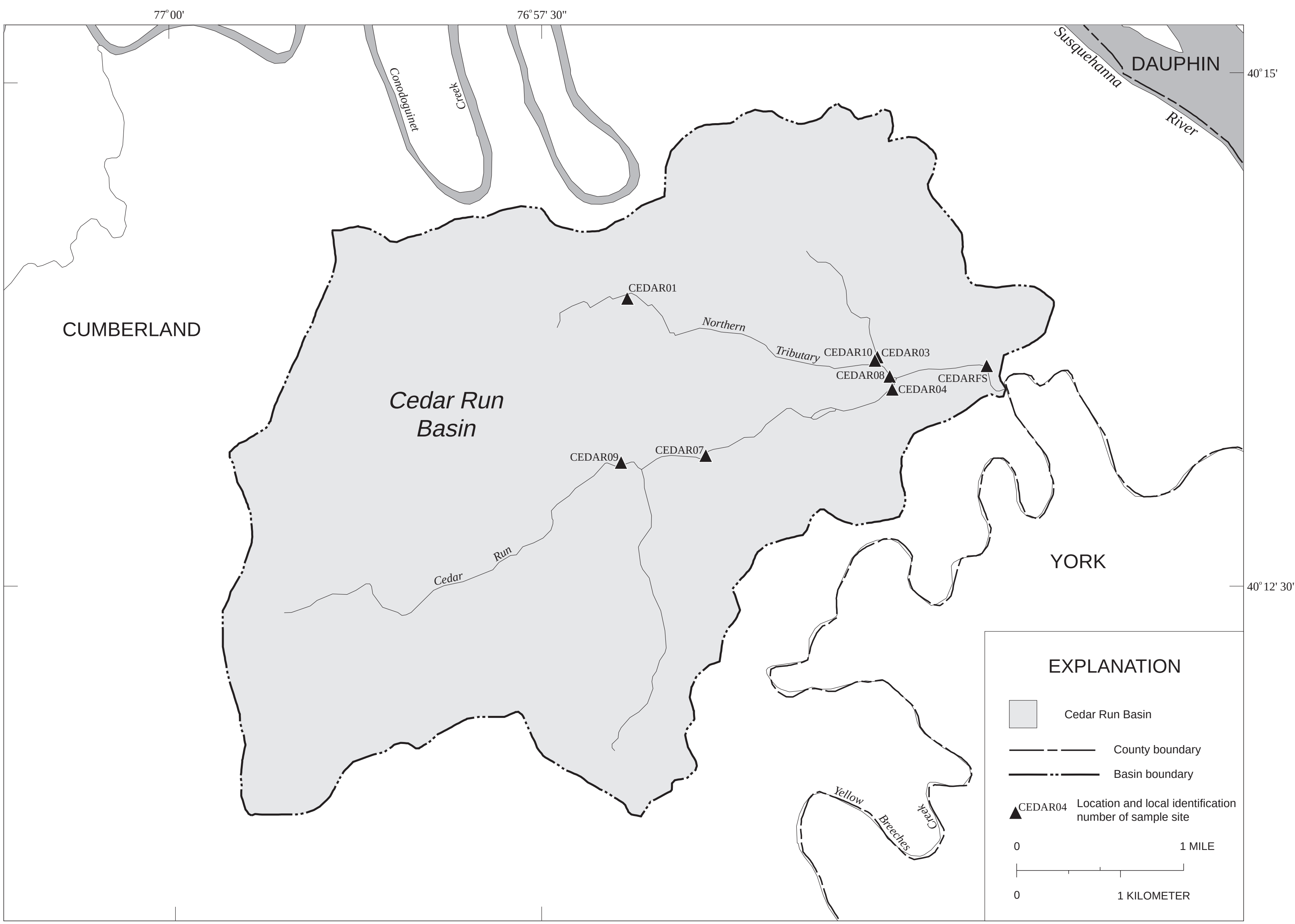

Figure A-8. Locations of sites sampled for the Cedar Run synoptic study #3.

Table A-9. *Characteristics of sites and basins in the Cedar Run ecological synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
401334076551001	CEDAR06	Unnamed tributary to unnamed northern tributary to Cedar Run at Eberlys Mill, Pa.	401334/765510	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	1.82	Unnamed northern tributary to Cedar Run
401327076550401	CEDAR08	Unnamed northern tributary to Cedar Run at Eberlys Mill, Pa.	401327/765504	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	3.60	Cedar Run
401303076562001	CEDAR07	Cedar Run at Shiremanstown, Pa.	401303/765620	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	5.68	Yellow Breeches Creek

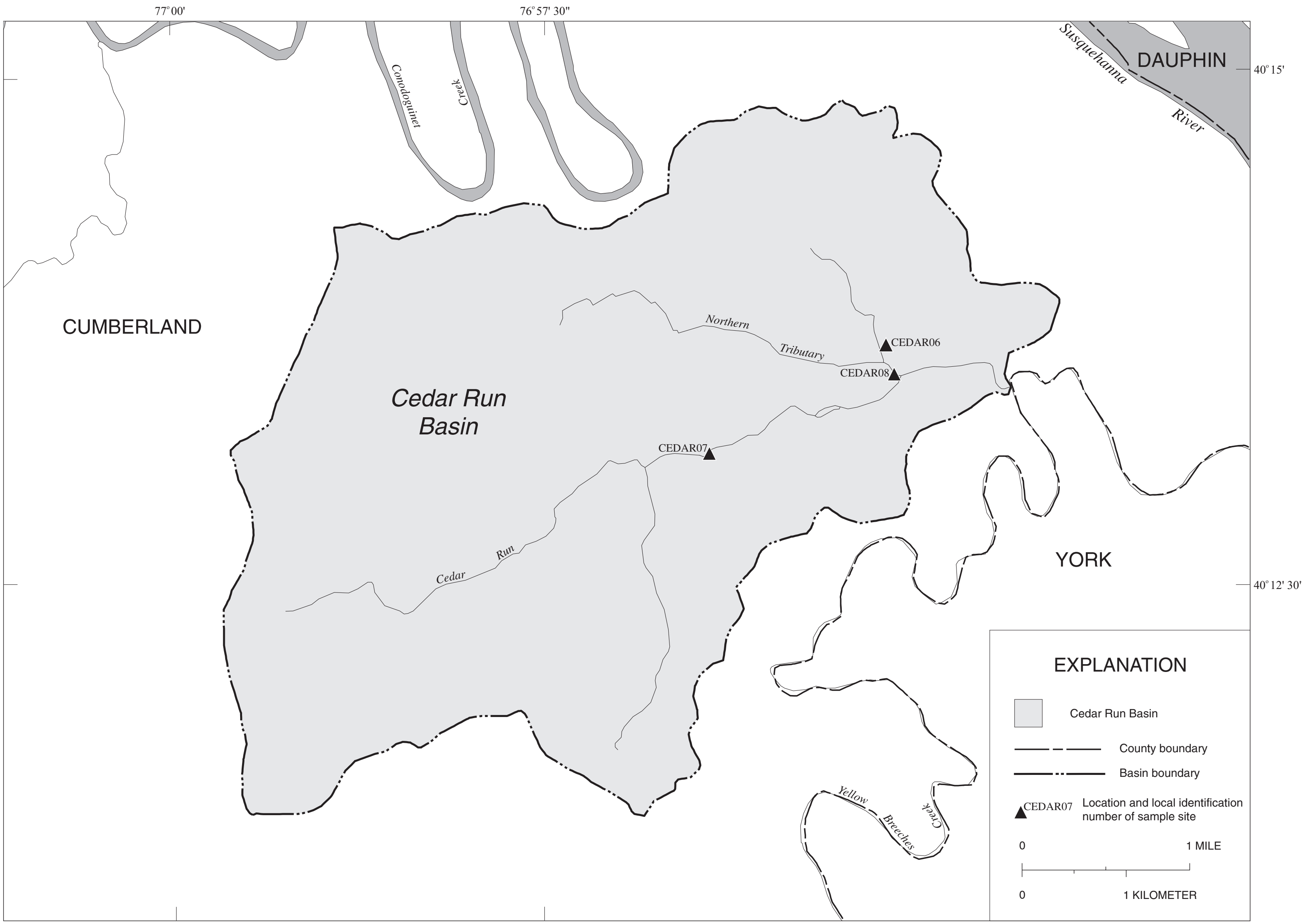

Figure A-9. Locations of sites sampled for the Cedar Run ecological synoptic study.

Table A-10. *Characteristics of sites and basins in the high-flux synoptic study #1*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
01540500	ODS08, BST01, 36, HFLX01, ESS13, TT01	Susquehanna River at Danville, Pa.	405729/763710	Montour	Mixed	Mixed	Mixed	11,200	Chesapeake Bay
01553500	ODS09, 37, HFLX02, TT02 BST02, ESS15	West Branch Susquehanna River at Lewisburg, Pa.	405805/765225	Northumberland	Mixed	Mixed	Mixed	6,840	Susquehanna River
01555000	HFLX03	Penns Creek at Penns Creek, Pa.	405200/770255	Union	Ridge & Valley (Appalachian Mountain)	Mixed	Mixed	306	Susquehanna River
01555400	ODS25, 20, HFLX04, EFS06, BST21	East Mahantango Creek at Klingerstown, Pa.	403948/764130	Schuylkill	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	44.7	Susquehanna River
01555500	ODS31, 26, HFLX05	East Mahantango Creek near Dalmatia, Pa.	403640/765444	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	162	Susquehanna River
01567000	HFLX06, BST08, ESS17, TT03	Juniata River at Newport, Pa.	402842/770746	Perry	Ridge & Valley (Appalachian Mountain)	Mixed	Mixed	3,340	Susquehanna River
01568000	HFLX07	Sherman Creek at Shermans Dale, Pa.	401924/771009	Perry	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Mixed	207	Susquehanna River
01570280	HFLX08, ESS35	Conodoguinet Creek at Enola, Pa.	401638/765700	Cumberland	Ridge & Valley (Great Valley)	Mixed	Mixed	502	Susquehanna River
01570500	ODS10, 38, HFLX09	Susquehanna River at Harrisburg, Pa.	401517/765311	Dauphin	Mixed	Mixed	Mixed	24,100	Chesapeake Bay
01571490	ODS04, 32, HFLX10, GVUR07, EFS02, CEDARFS	Cedar Run at Eberlys Mill, Pa.	401330/765424	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	12.6	Yellow Breeches Creek
01571500	HFLX11	Yellow Breeches Creek near Camp Hill, Pa.	401329/765354	Cumberland	Mixed	Mixed	Mixed	213	Susquehanna River
01573560	ODS11, 39, HFLX12	Swatara Creek near Hershey, Pa.	401754/764005	Dauphin	Mixed	Mixed	Mixed	483	Susquehanna River
01574000	HFLX13	West Conewago Creek near Manchester, Pa.	400456/764313	York	Piedmont	Siliciclastic	Mixed	512	Susquehanna River
01575585	HFLX14	Codorus Creek at Pleasureville, Pa.	400107/764136	York	Piedmont	Crystalline	Mixed	267	Susquehanna River

Table A-10. *Characteristics of sites and basins in the high-flux synoptic study #1—Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
01576000	ODS12, 40, HFLX15	Susquehanna River at Marietta, Pa.	400316/763152	Lancaster	Mixed	Mixed	Mixed	25,600	Chesapeake Bay
01576540	HFLX16, 10, PCAR11, MILLFS, EFS03, BST11, ODS47	Mill Creek at Eshelman Mill Road near Lyndon, Pa.	400036/761639	Lancaster	Piedmont	Carbonate	Agriculture	54.3	Conestoga River
01576754	ODS13, 41, HFLX17	Conestoga River at Conestoga, Pa.	395647/762205	Lancaster	Mixed	Mixed	Mixed	468	Susquehanna River
01576787	ODS14, 42, HFLX18	Pequea Creek at Martic Forge, Pa.	395421/761943	Lancaster	Mixed	Mixed	Mixed	148	Susquehanna River
01577500	ODS37, 03, HFLX19, PCRS06	Muddy Creek at Castle Fin, Pa.	394621/761858	York	Piedmont	Crystalline	Agriculture	133	Susquehanna River
01578310	HFLX20, 43, ODS15	Susquehanna River at Conowingo, Md.	393926/761031	Harford	Mixed	Mixed	Mixed	27,100	Chesapeake Bay

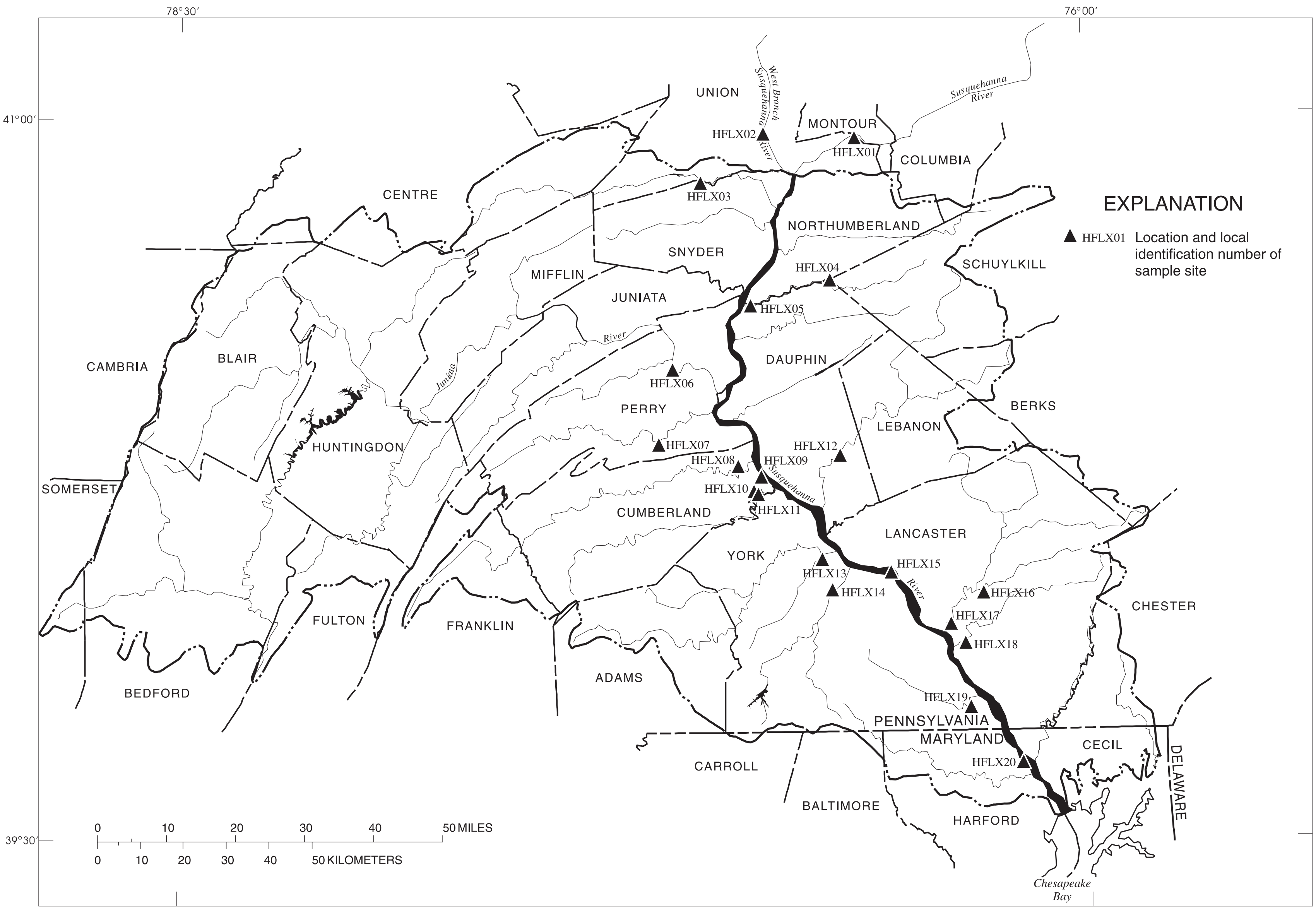

Figure A-10. Locations of sites sampled for the high-flux synoptic study #1.

Table A-11. *Characteristics of sites and basins in the high-flux synoptic study #2*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
01555000	HFLX03	Penns Creek at Penns Creek, Pa.	405200/770255	Union	Ridge & Valley (Appalachian Mountain)	Mixed	Mixed	306	Susquehanna River
01555400	ODS25, 20, HFLX04, EFS06, BST21	East Mahantango Creek at Klingerstown, Pa.	403948/764130	Schuylkill	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	44.7	Susquehanna River
01555500	ODS31, 26, HFLX05	East Mahantango Creek near Dalmatia, Pa.	403640/765444	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Agriculture	162	Susquehanna River
01567000	HFLX06, BST08, ESS17, TT03	Juniata River at Newport, Pa.	402842/770746	Perry	Ridge & Valley (Appalachian Mountain)	Mixed	Mixed	3,340	Susquehanna River
01568000	HFLX07	Sherman Creek at Shermans Dale, Pa.	401924/771009	Perry	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Mixed	207	Susquehanna River
01570500	ODS10, 38, HFLX09	Susquehanna River at Harrisburg, Pa.	401517/765311	Dauphin	Mixed	Mixed	Mixed	24,100	Chesapeake Bay

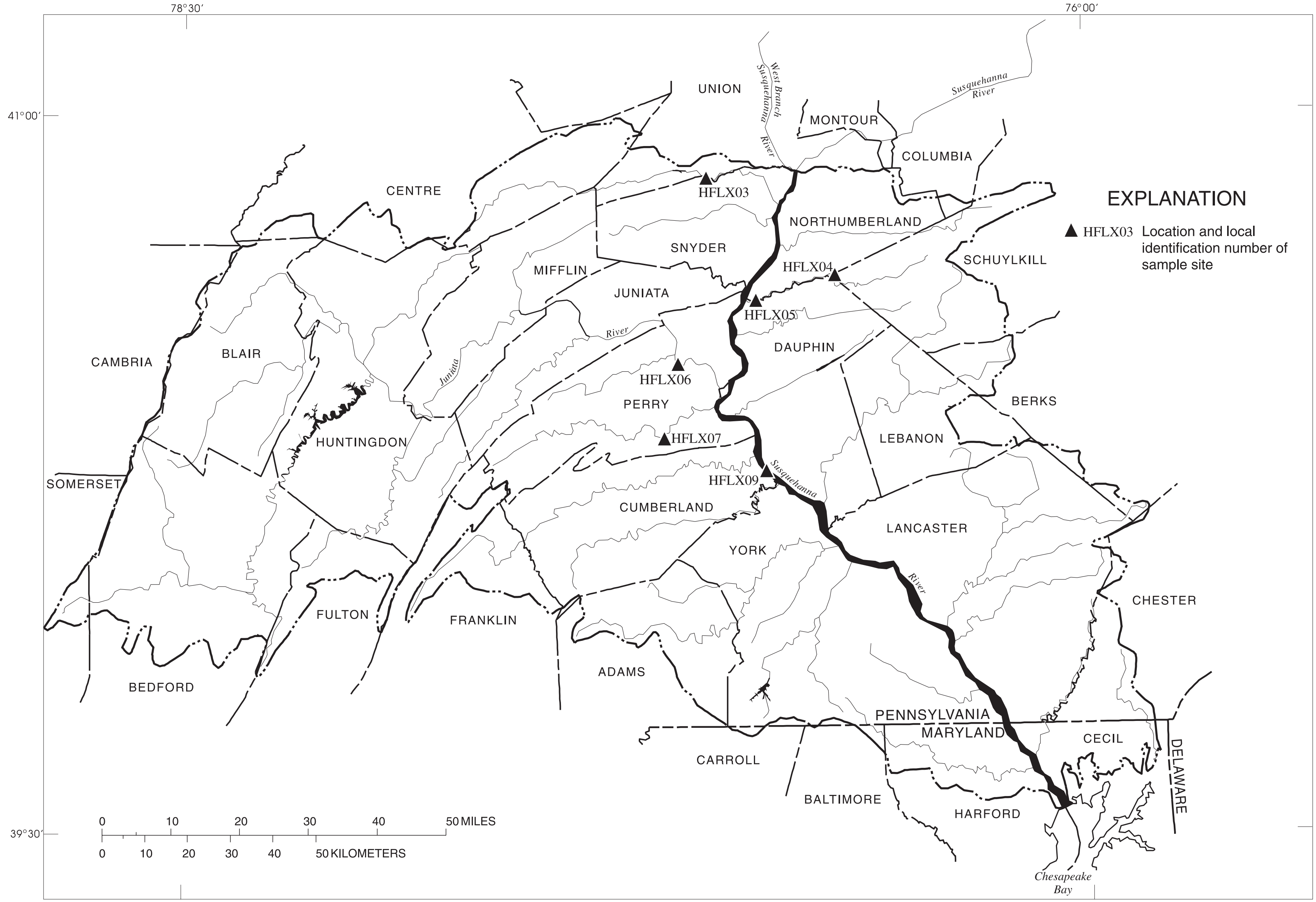

Figure A-11. Locations of sites sampled for the high-flux synoptic study #2.

Table A-12. *Characteristics of sites and basins in the Mahanoy Creek synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/longitude at sample site	County	Physiographic province (section)	Bedrock type	Land uses	Drainage area (square miles)	Next higher-order stream
404354076474001	MCS01	Mahanoy Creek near Dornsife, Pa.	404354/764740	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest, mining	120	Susquehanna River
404328076485701	MCS02	Mahanoy Creek at Kneass, Pa.	404328/764857	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest, mining	154	Susquehanna River
404334076501601	MCS03, ESS14	Mahanoy Creek near Herndon, Pa.	404334/765016	Northumberland	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest, mining	157	Susquehanna River

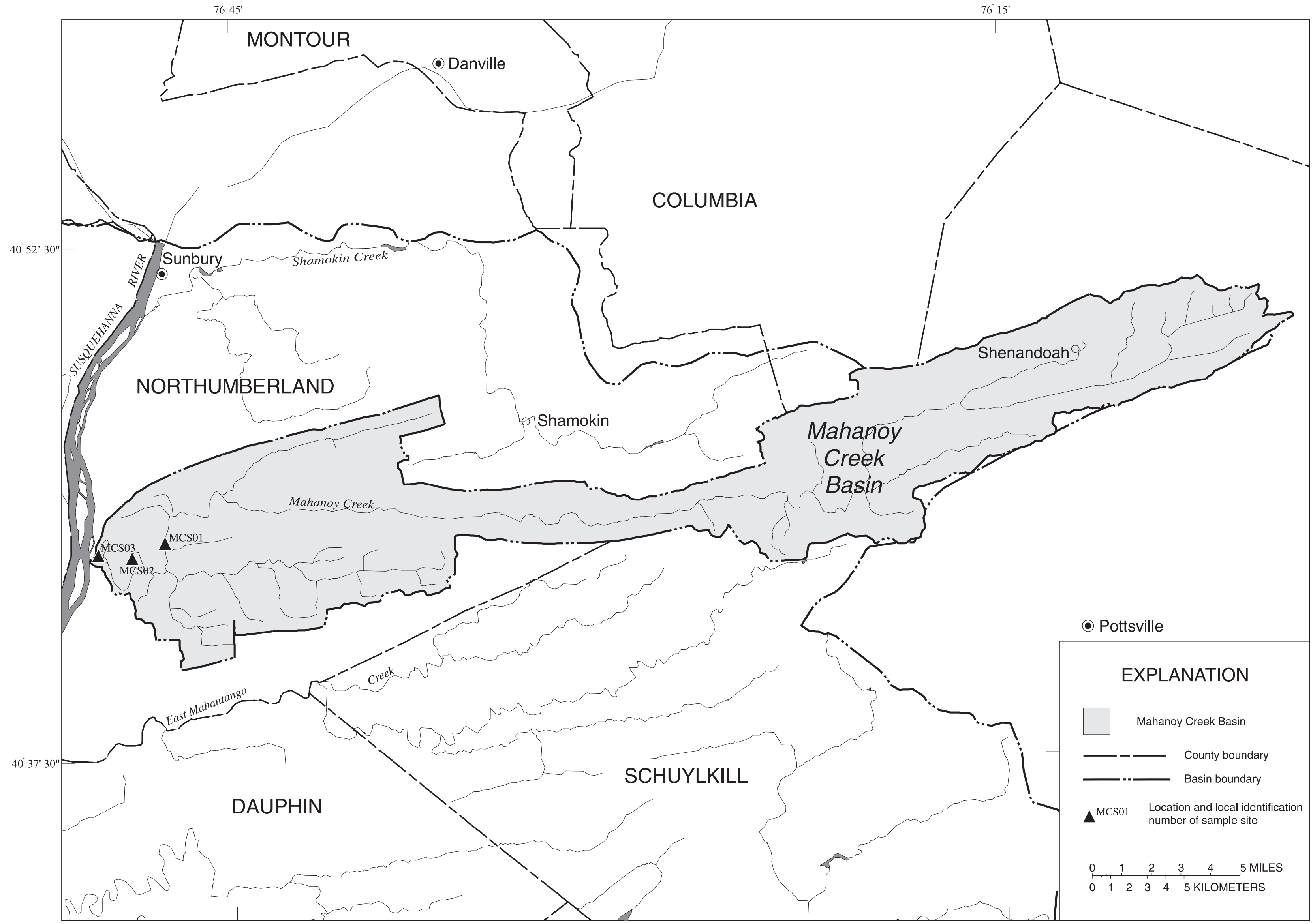

Figure A-12. Locations of sites sampled for the Mahanoy Creek synoptic study.

Table A-13. *Characteristics of sites and basins in the Bachman Run synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
401607076275401	BACH01	East Branch Bachman Run at Mount Gretna, Pa.	401607/762754	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Forest	0.04	Bachman Run
401635076290501	BACH02	East Branch Bachman Run at mouth at Fontana, Pa.	401635/762905	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	.81	Bachman Run
01573091	BACH03	Center Branch Bachman Run near Mount Gretna Heights, Pa.	401609/762855	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Forest	.30	Bachman Run
401632076290701	BACH04	Center Branch Bachman Run at mouth at Fontana, Pa.	401632/762907	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	.48	Bachman Run
01573092	BACH05	West Branch Bachman Run at Mount Wilson, Pa.	401608/762931	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Forest	.64	Bachman Run
401635076291701	BACH06	West Branch Bachman Run at mouth at Fontana, Pa.	401635/762917	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	1.31	Bachman Run
401704076293101	BACH07	Bachman Run at Fontana, Pa.	401704/762931	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	3.68	Quittapahilla Creek
401809076301901	BACH08	Bachman Run near Annville, Pa.	401809/763019	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	5.96	Quittapahilla Creek
01573095	GVAG09, BACHFS, BST19, EFS04, ODS46	Bachman Run at Annville, Pa.	401859/763058	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	7.72	Quittapahilla Creek

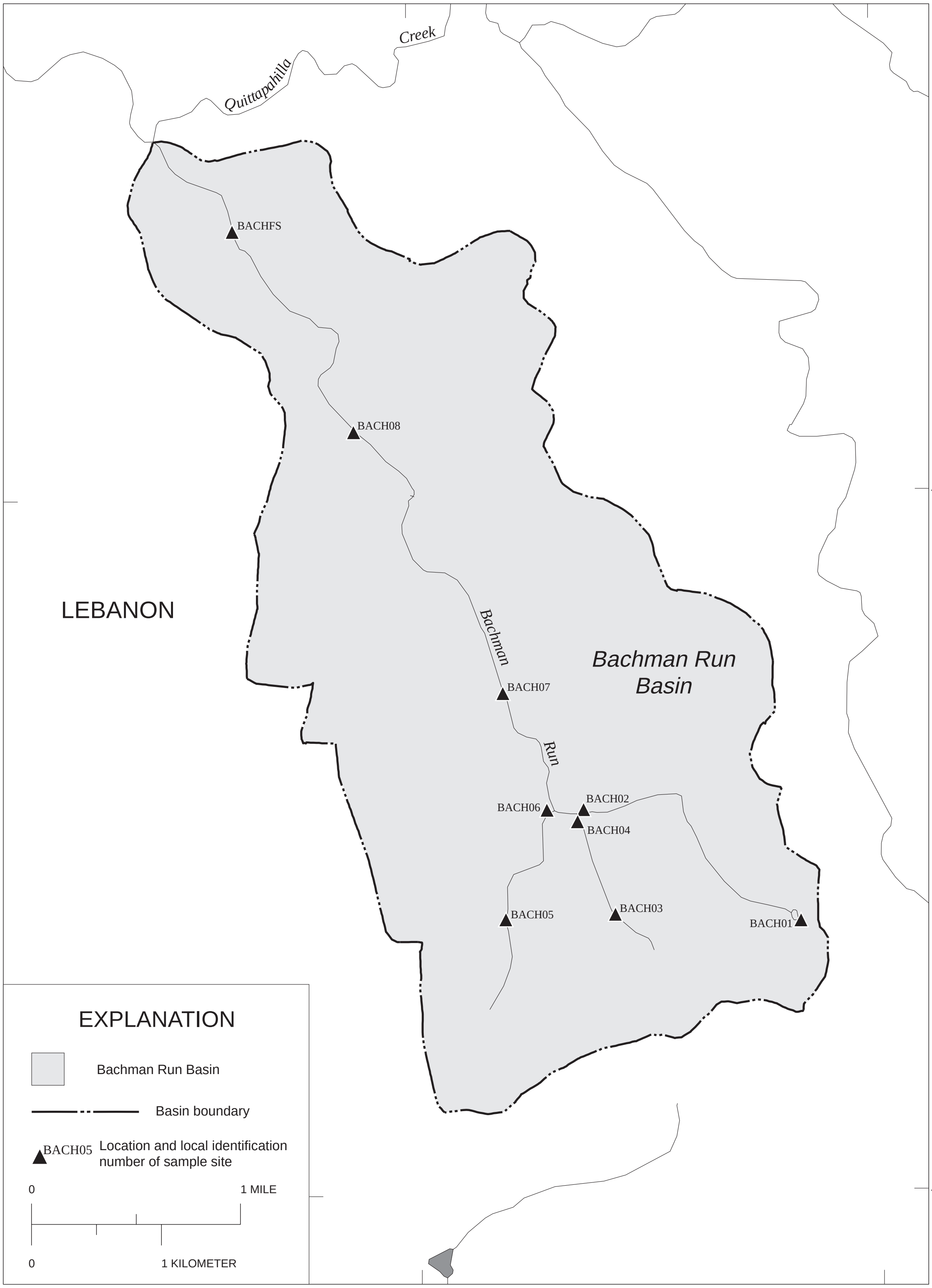

Figure A-13. Locations of sites sampled for the Bachman Run synoptic study.

Table A-14. *Characteristics of sites and basins in the Kishacoquillas Creek synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
403322077465301	KISH01	Kings Hollow at mouth near Allensville, Pa.	403322/774653	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	5.16	Kishacoquillas Creek
403434077453401	KISH02	Unnamed tributary to Kishacoquillas Creek at mouth at Menno, Pa.	403434/774534	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	1.92	Kishacoquillas Creek
403603077433301	KISH03	Kishacoquillas Creek above Little Kishacoquillas Creek at Belleville, Pa.	403603/774333	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	16.5	Juniata River
403611077442801	KISH04	Little Kishacoquillas Creek above Soft Run at Belleville, Pa.	403611/774428	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	6.41	Kishacoquillas Creek
403617077442801	KISH05	Soft Run at mouth at Belleville, Pa.	403617/774428	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	2.91	Little Kishacoquillas Creek
403607077432901	KISH06	Little Kishacoquillas Creek at mouth at Belleville, Pa.	403607/774329	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	13.1	Kishacoquillas Creek
403618077420101	KISH07	Kishacoquillas Creek below Little Kishacoquillas Creek at Union Mills, Pa.	403618/774201	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	33.1	Juniata River
403727077401901	KISH08	Frog Hollow near mouth at Alexander Springs, Pa.	403727/774019	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	7.42	Kishacoquillas Creek
403740077392801	KISH09	Kishacoquillas Creek at Kishacoquillas, Pa	403740/773928	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	44.8	Juniata River
403919077380001	KISH10	Coffee Run near mouth at Cedar Hill, Pa.	403919/773800	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	7.17	Kishacoquillas Creek
01564997	ACAR14, KISHFS, EFS05, BST20, ODS45	Kishacoquillas Creek at Lumber City, Pa.	403942/773601	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	57.4	Juniata River

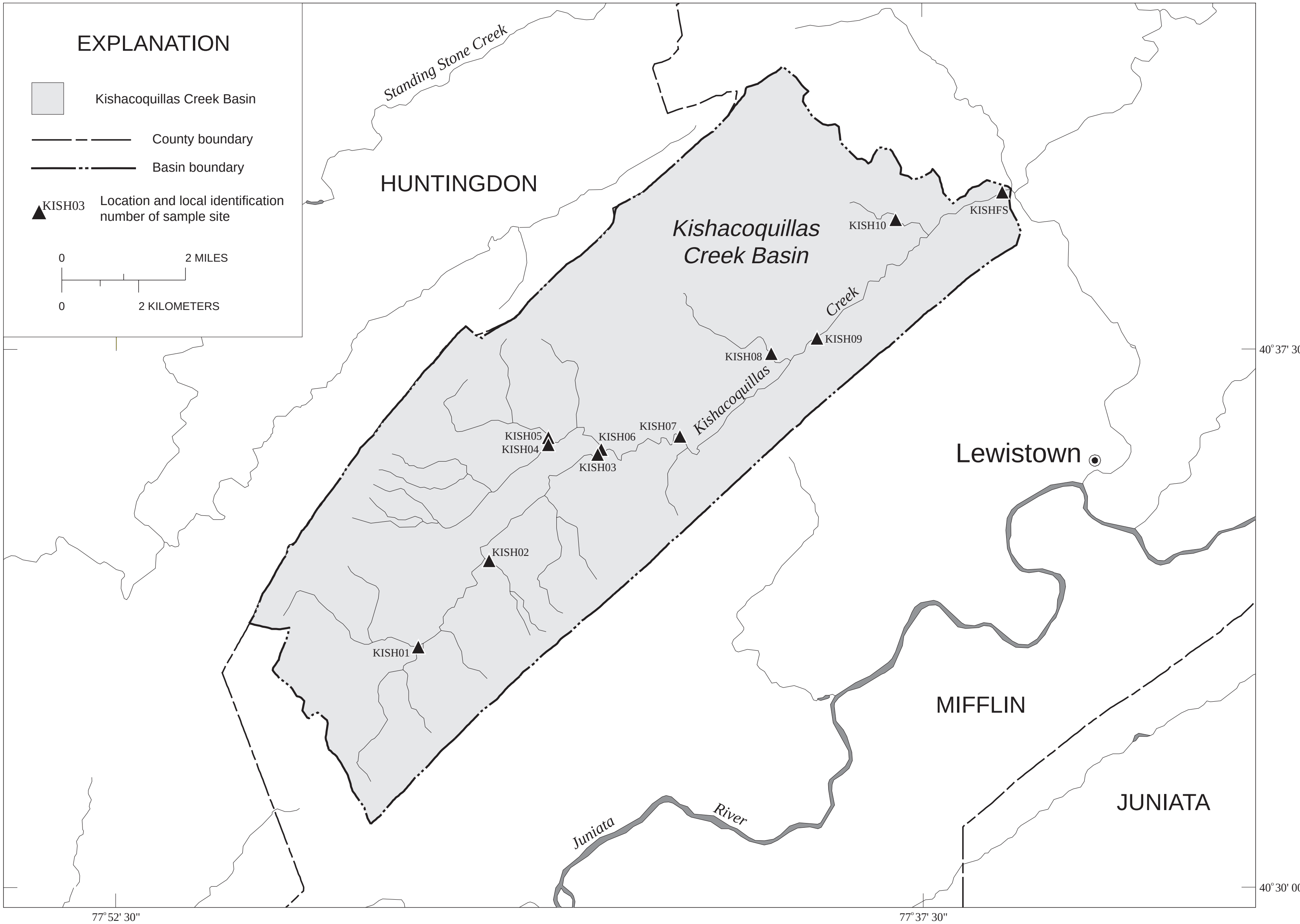

Figure A-14. Locations of sites sampled for the Kishacoquillas Creek synoptic study.

Table A-15. *Characteristics of sites and basins in the Muddy Creek synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
395112076335501	MUDD01	North Branch Muddy Creek above Pine Run at Felton, Pa.	395112/763355	York	Piedmont	Crystalline	Agriculture	10.8	Muddy Creek
395115076335101	MUDD02	Pine Run at mouth at Felton, Pa.	395115/763351	York	Piedmont	Crystalline	Agriculture	5.61	North Branch Muddy Creek
395032076320301	MUDD03	North Branch Muddy Creek above Carter Creek at Brogueville, Pa.	395032/763203	York	Piedmont	Crystalline	Agriculture	19.5	Muddy Creek
395034076315601	MUDD04	Carter Creek at mouth at Brogueville, Pa.	395034/763156	York	Piedmont	Crystalline	Forest	3.12	North Branch Muddy Creek
394921076320001	MUDD05	Rambo Run near mouth near Laurel, Pa.	394921/763200	York	Piedmont	Crystalline	Agriculture	10.2	North Branch Muddy Creek
394934076303701	MUDD06	Bear Branch at mouth at Laurel, Pa.	394934/763037	York	Piedmont	Crystalline	Agriculture	1.53	North Branch Muddy Creek
394828076283401	MUDD07	North Branch Muddy Creek at mouth at Muddy Creek Forks, Pa.	394828/762834	York	Piedmont	Crystalline	Agriculture	43.8	Muddy Creek
394413076314101	MUDD08	South Branch Muddy Creek above Leibs Creek near New Park, Pa.	394413/763141	York	Piedmont	Crystalline	Agriculture	.87	Muddy Creek
394506076320801	MUDD09	Leibs Creek near mouth at Draco, Pa.	394506/763208	York	Piedmont	Crystalline	Agriculture	8.17	South Branch Muddy Creek
394552076311001	MUDD10	Unnamed tributary to South Branch Muddy Creek at mouth at Grove Mill, Pa.	394552/763110	York	Piedmont	Crystalline	Agriculture	2.95	South Branch Muddy Creek
394644076295701	MUDD11	South Branch Muddy Creek above Alum Rock Run near Muddy Creek Forks, Pa.	394644/762957	York	Piedmont	Crystalline	Agriculture	17.6	Muddy Creek
394635076293501	MUDD12	Alum Rock Run at mouth near Muddy Creek Forks, Pa.	394635/762935	York	Piedmont	Crystalline	Agriculture	2.70	South Branch Muddy Creek
394736076285201	MUDD13	Unnamed tributary to South Branch Muddy Creek at mouth at Muddy Creek Forks, Pa.	394736/762852	York	Piedmont	Crystalline	Agriculture	1.68	South Branch Muddy Creek

Table A-15. *Characteristics of sites and basins in the Muddy Creek synoptic study—Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
394827076283601	MUDD14, ODS35, 01	South Branch Muddy Creek at mouth at Muddy Creek Forks, Pa.	394827/762836	York	Piedmont	Crystalline	Agriculture	28.1	Muddy Creek
01577300	MUDDFS, ODS36, PCRS05, BST22, EFS07, 02	Muddy Creek at Muddy Creek Forks, Pa.	394827/762834	York	Piedmont	Crystalline	Agriculture	71.9	Susquehanna River

Figure A-15. Locations of sites sampled for the Muddy Creek synoptic study.

Table A-16. *Characteristics of sites and basins in the Mill Creek synoptic study*
[--, not applicable.]

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
400527076011701	MILL01	Mill Creek above New Holland Reservoir at Cedar Lane, Pa.	400527/760117	Lancaster	Piedmont	Crystalline	Forest	0.57	Conestoga River
400551076032801	MILL02	Unnamed tributary to Mill Creek at New Holland, Pa.	400551/760328	Lancaster	Piedmont	Carbonate	Agriculture	1.80	Mill Creek
400450076052301	MILL04	Mill Creek above Groff Run near New Holland, Pa.	400450/760523	Lancaster	Piedmont	Carbonate	Agriculture	9.70	Conestoga River
400425076051001	MILL05	Groff Run near mouth near New Holland, Pa.	400425/760510	Lancaster	Piedmont	Carbonate	Agriculture	2.48	Mill Creek
400428076065401	MILL06	Unnamed tributary to Mill Creek nr New Holland, Pa.	400428/760654	Lancaster	Piedmont	Carbonate	Agriculture	.97	Mill Creek
400412076085601	MILL07	Unnamed tributary to Mill Creek near Bareville, Pa.	400412/760856	Lancaster	Piedmont	Carbonate	Agriculture	2.84	Mill Creek
400318076101401	MILL08	Mill Creek above Muddy Run near Bird-in-Hand, Pa.	400318/761014	Lancaster	Piedmont	Carbonate	Agriculture	20.8	Conestoga River
400259076092201	MILL09	Muddy Run at mouth near Bird-in-Hand, Pa.	400259/760922	Lancaster	Piedmont	Carbonate	Agriculture	8.09	Mill Creek
400339076110201	MILL10	Unnamed tributary to Mill Creek near Bird-in-Hand, Pa.	400339/761102	Lancaster	Piedmont	Carbonate	Agriculture	4.56	Mill Creek
400200076112801	MILL11	Unnamed tributary to Mill Creek at Smoketown, Pa	400200/761128	Lancaster	Piedmont	Carbonate	Agriculture	1.84	Mill Creek
400200076123201	MILL12	Mill Creek at Smoketown, Pa.	400200/761232	Lancaster	Piedmont	Carbonate	Agriculture	42.8	Conestoga River
400106076154301	MILL13	Mill Creek above Big Spring Run near Lyndon, Pa.	400106/761543	Lancaster	Piedmont	Carbonate	Agriculture	47.7	Conestoga River
400030076160801	MILL14	Big Spring Run at mouth near Lyndon, Pa.	400030/761608	Lancaster	Piedmont	Carbonate	Agriculture	5.80	Mill Creek

Table A-16. *Characteristics of sites and basins in the Mill Creek synoptic study—Continued*

[--, not applicable.]

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
01576540	MILLFS, 10, PDCAR11, HFLX16, EFS03, BST11, ODS47	Mill Creek at Eshelman Mill Road near Lyndon, Pa.	400036/761639	Lancaster	Piedmont	Carbonate	Agriculture	54.3	Conestoga River
Treated Wastewater Effluents									
400529076050102	MILL16	New Holland Borough Wastewater Treatment Plant	400529/760501	Lancaster	Piedmont	--	--	--	Mill Creek
400503076051402	MILL17	Tyson Poultry	400503/760514	Lancaster	Piedmont	--	--	--	Mill Creek
400440076112802	MILL18	Bristol Pipe	400440/761128	Lancaster	Piedmont	--	--	--	Unnamed tributary to Mill Creek (MILL10)
400521076103002	MILL19	C & D Batteries	400521/761030	Lancaster	Piedmont	--	--	--	Unnamed tributary to Mill Creek (MILL10)
400518076103502	MILL20	Dart Container Corporation	400518/761035	Lancaster	Piedmont	--	--	--	Unnamed tributary to Mill Creek (MILL10)

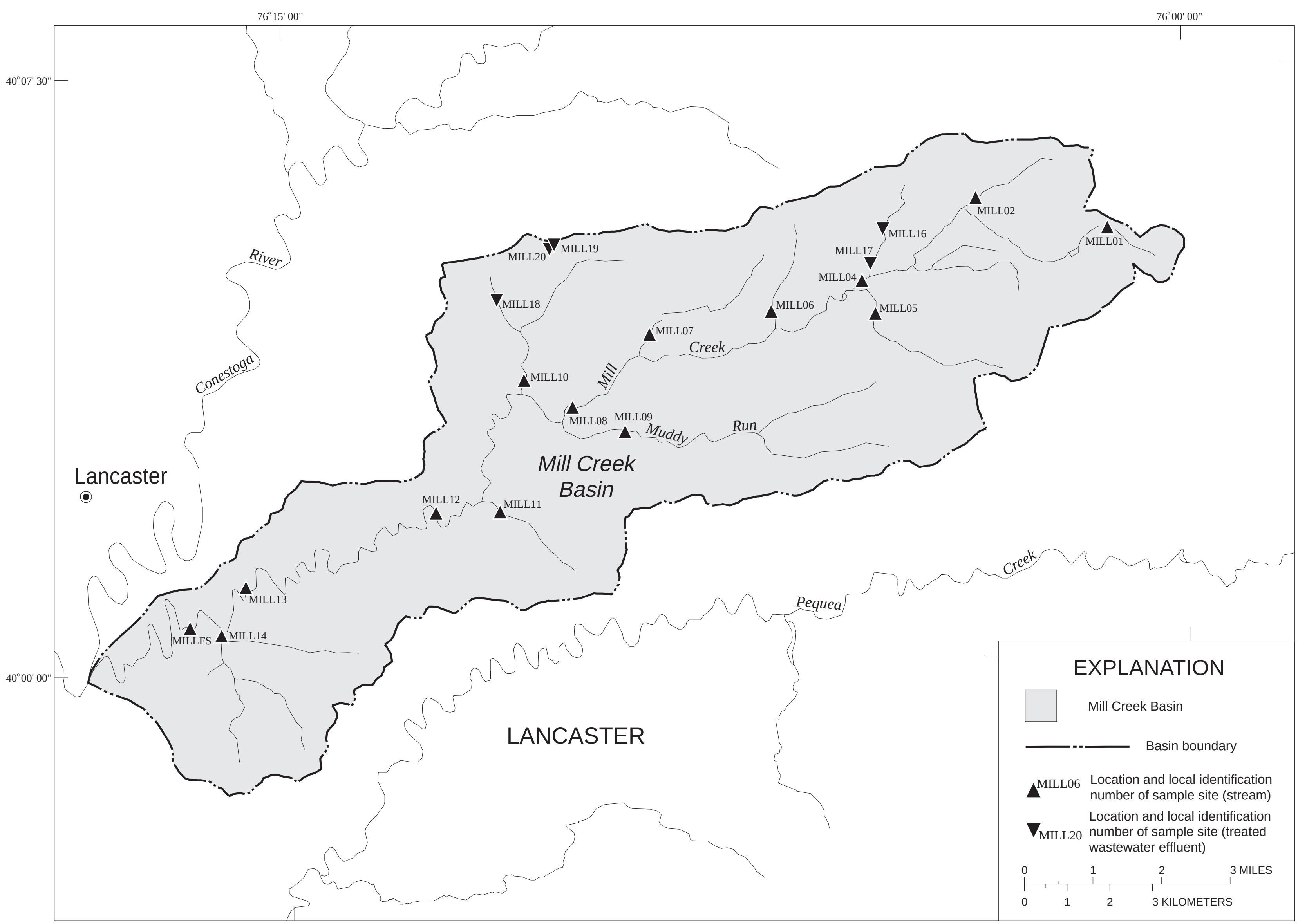

Figure A-16. Locations of sites sampled for the Mill Creek synoptic study.

Table A-17. *Characteristics of sites and basins in the Piedmont crystalline agricultural synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next high-order stream
394609076564801	PCRS01	Furnace Creek near Hanover, Pa.	394609/765648	York	Piedmont	Crystalline	Agriculture	2.08	West Branch Codorus Creek
394751076443601	PCRS02	Centerville Creek at Glen Rock, Pa.	394751/764436	York	Piedmont	Crystalline	Agriculture	14.3	South Branch Codorus Creek
395219076404401	PCRS03	East Branch Codorus Creek at Jacobus, Pa.	395219/764044	York	Piedmont	Crystalline	Agriculture	28.1	Codorus Creek
395751076305201	PCRS04	Cabin Creek at East Prospect, Pa.	395751/763052	York	Piedmont	Crystalline	Agriculture	13.4	Susquehanna River
01577300	ODS36, 02, PCRS05, MUDDFS, EFS07, BST22	Muddy Creek at Muddy Creek Forks, Pa.	394827/762834	York	Piedmont	Crystalline	Agriculture	71.9	Susquehanna River
01577500	ODS37, 03, HFLX19, PCRS06	Muddy Creek at Castle Fin, Pa.	394621/761858	York	Piedmont	Crystalline	Agriculture	133	Susquehanna River
394047076165201	PCRS07	Broad Creek at Macton, Md.	394047/761652	Harford	Piedmont	Crystalline	Agriculture	28.8	Susquehanna River
394201076112201	PCRS08	Conowingo Creek at Oakwood, Md.	394201/761122	Cecil	Piedmont	Crystalline	Agriculture	36.9	Susquehanna River
395048076011401	ODS40, 06, PCRS09, ESS25, BST13	East Branch Octoraro Creek near Kirkwood, Pa.	395048/760114	Lancaster	Piedmont	Crystalline	Agriculture	59.8	Octoraro Creek
01578350	PCRS10	Muddy Run at Cream, Pa.	394957/760015	Chester	Piedmont	Crystalline	Agriculture	13.4	Susquehanna River
01578440	ODS41, 07, PCRS11	West Branch Octoraro Creek at White Rock, Pa.	394929/760525	Lancaster	Piedmont	Crystalline	Agriculture	39.6	Octoraro Creek
01578475	PCRS12	Octoraro Creek near Richardsmere, Md.	394224/760656	Cecil	Piedmont	Crystalline	Agriculture	177	Susquehanna River
393932076084301	PCRS13	Basin Run at Rowlandsville, Md.	393932/760843	Cecil	Piedmont	Crystalline	Agriculture	11.2	Octoraro Creek
394220076351501	ODS43, PCRS14, ESS31, BST16, 09, TT05	Deer Creek at Gorsuch Mills, Md.	394220/763515	Baltimore	Piedmont	Crystalline	Agriculture	25.7	Susquehanna River
394030076264401	PCRS15	Deer Creek near Rocks, Md.	394030/762644	Harford	Piedmont	Crystalline	Agriculture	61.6	Susquehanna River
393723076095401	PCRS16	Deer Creek at mouth near Conowingo, Md.	393723/760954	Harford	Piedmont	Crystalline	Agriculture	169	Susquehanna River
394314075535001	PCRS17	Little Elk Creek near Blake, Md.	394314/755350	Cecil	Piedmont	Crystalline	Agriculture	13.2	Big Elk Creek

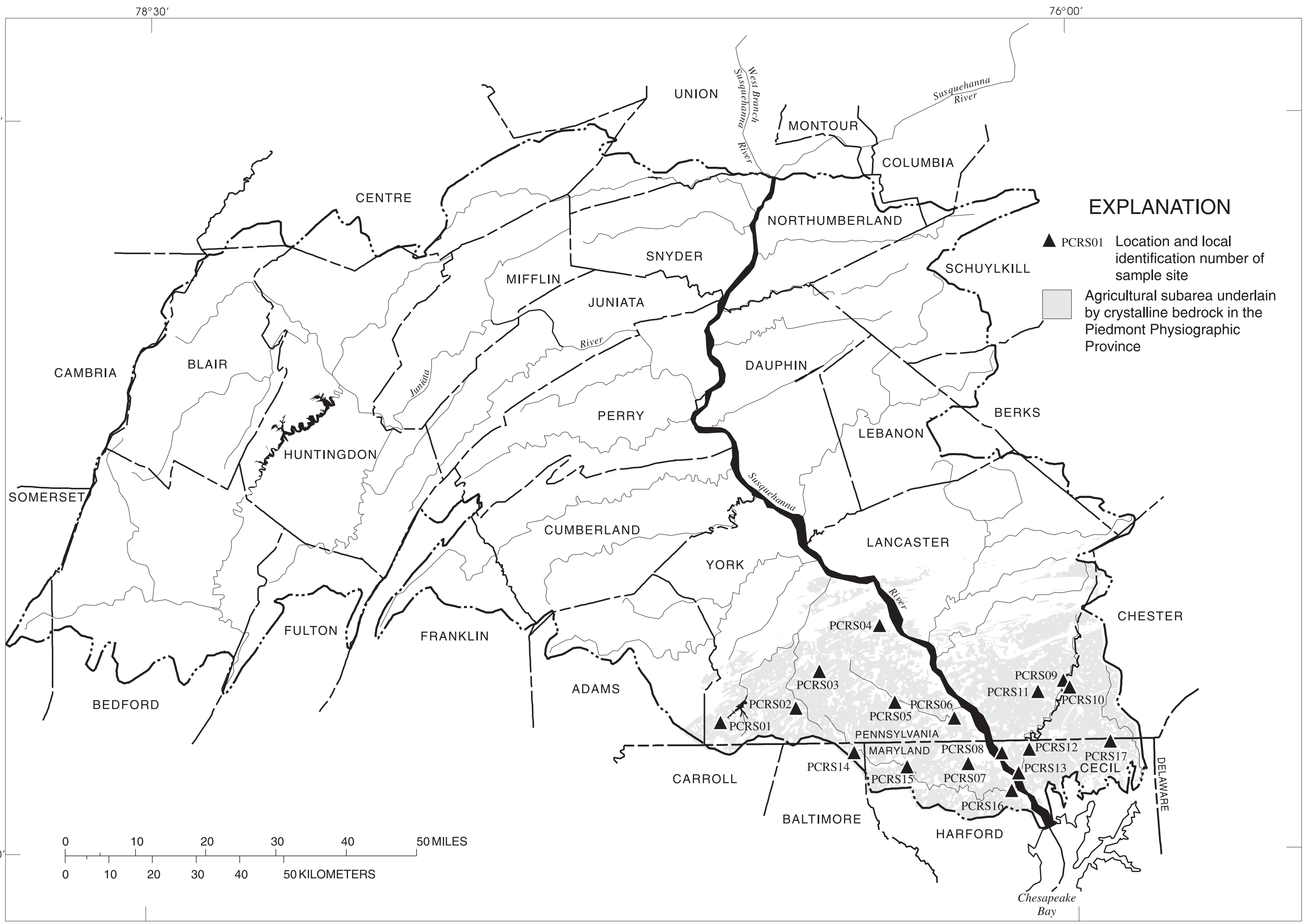

Figure A-17. Locations of sites sampled for the Piedmont crystalline agricultural synoptic study.

Table A-18. *Characteristics of sites and basins in the Piedmont carbonate agricultural synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
394839077025101	PCAR01	South Branch Conewago Creek at McSherrystown, Pa.	394839/770251	Adams	Piedmont	Carbonate	Agriculture	33.4	Conewago Creek
394757077014501	PCAR02	Plum Creek at McSherrystown, Pa.	394757/770145	Adams	Piedmont	Carbonate	Agriculture	7.08	South Branch Conewago Creek
395645076514701	PCAR03	Little Conewago Creek near West York, Pa.	395645/765147	York	Piedmont	Carbonate	Agriculture	7.11	Conewago Creek
400442076303201	PCAR04	Little Chickies Creek near Marietta, Pa.	400442/763032	Lancaster	Piedmont	Carbonate	Agriculture	43.6	Chickies Creek
400559076333101	PCAR05	Spring (SP LN-14) at Donegal Springs, Pa.	400559/763331	Lancaster	Piedmont	Carbonate	Agriculture	1.03	Donegal Creek
400447076320401	PCAR06	Donegal Creek at Marietta, Pa.	400447/763204	Lancaster	Piedmont	Carbonate	Agriculture	15.5	Chickies Creek
400038076332301	PCAR07	Kreutz Creek at Wrightsville, Pa.	400038/763323	York	Piedmont	Carbonate	Agriculture	30.5	Susquehanna River
395939076280001	PCAR08	Stamans Run at Washington Boro, Pa.	395939/762800	Lancaster	Piedmont	Carbonate	Agriculture	2.35	Susquehanna River
400805076102801	PCAR09	Conestoga River near Akron, Pa.	400805/761028	Lancaster	Piedmont	Carbonate	Agriculture	122	Susquehanna River
401038076143001	PCAR10	Middle Creek near Akron, Pa.	401038/761430	Lancaster	Piedmont	Carbonate	Agriculture	31.5	Cocalico Creek
01576540	HFLX16, 10, PCAR11, MILLFS, EFS03, BST11, ODS47	Mill Creek at Eshelman Mill Road near Lyndon, Pa.	400036/761639	Lancaster	Piedmont	Carbonate	Agriculture	54.3	Conestoga River
395745076213401	PCAR12	Stehman Run at Rockhill, Pa.	395745/762134	Lancaster	Piedmont	Carbonate	Agriculture	4.87	Conestoga River
400139076024401	PCAR13	Umbles Run at New Milltown, Pa.	400139/760244	Lancaster	Piedmont	Carbonate	Agriculture	8.21	Pequea Creek
395748076134701	PCAR14	Pequea Creek near Strasburg, Pa.	395748/761347	Lancaster	Piedmont	Carbonate	Agriculture	80.7	Susquehanna River
395749076132001	PCAR15	Walnut Run near Strasburg, Pa.	395749/761320	Lancaster	Piedmont	Carbonate	Agriculture	2.69	Pequea Creek
395619076133901	PCAR16, ESS22, BST12	Big Beaver Creek near Refton, Pa.	395619/761339	Lancaster	Piedmont	Carbonate	Agriculture	18.0	Pequea Creek

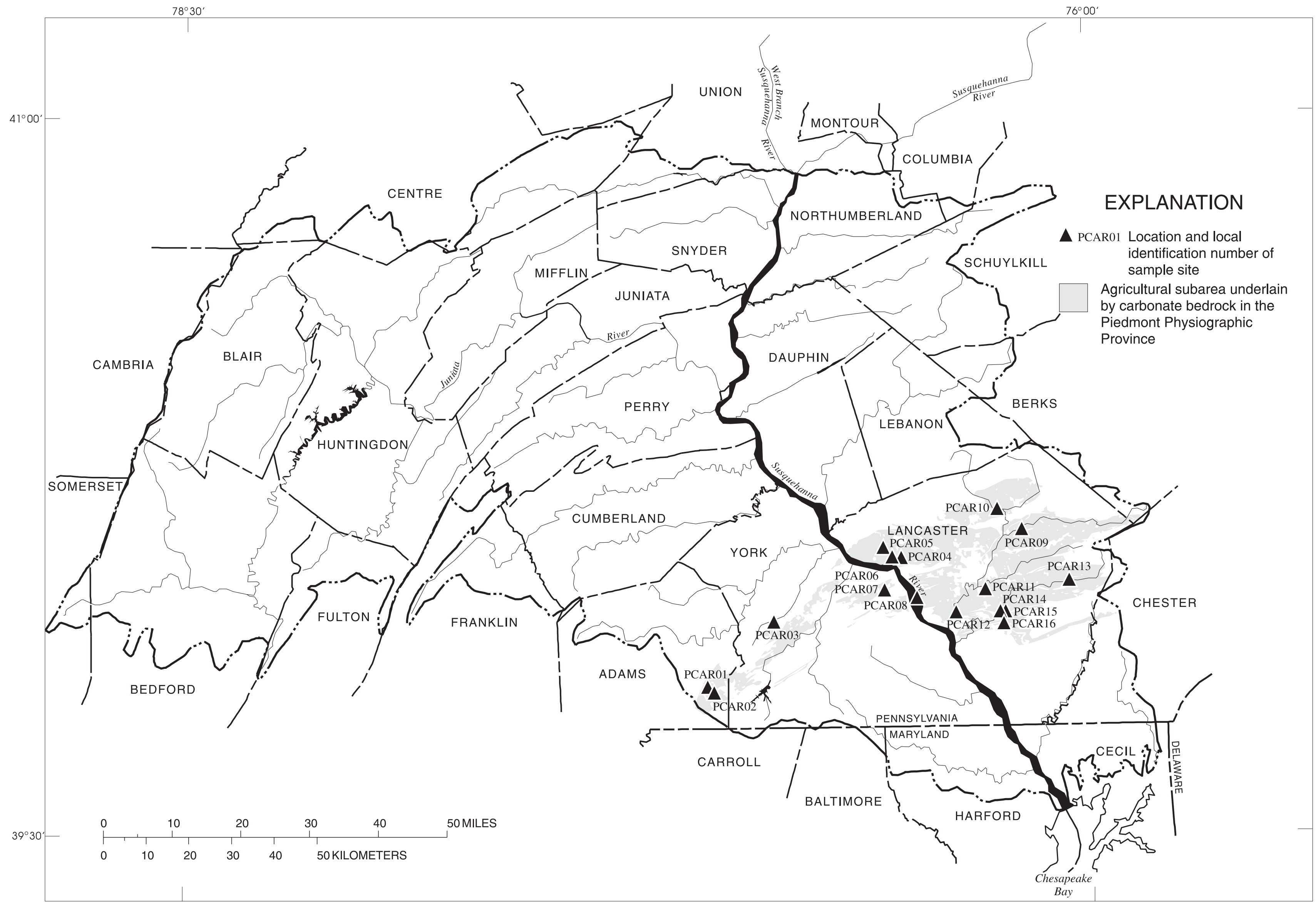

Figure A-18. Locations of sites sampled for the Piedmont carbonate agricultural synoptic study.

Table A-19. *Characteristics of sites and basins in the Appalachian Mountain siliciclastic forested synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
405330077115801	SILF01	Laurel Run at Laurelton, Pa.	405330/771158	Union	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	12.5	Penns Creek
403037078154801	SILF02	Canoe Creek near Canoe Creek, Pa.	403037/781548	Blair	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	11.0	Frankstown Branch Juniata River
403851077504201	SILF03	Laurel Run at McAlevys Fort, Pa.	403851/775042	Huntingdon	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	17.3	Standing Stone Creek
395639078384101	SILF04	Milligan Run at Buffalo Mills, Pa.	395639/783841	Bedford	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	7.62	Buffalo Run
01559795	SILF05, EFS01, ODS44	Bobs Creek near Pavia, Pa.	401621/783555	Bedford	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	16.7	Dunning Creek
401919078073901	SILF06	Great Trough Creek near Entriken, Pa.	401919/780739	Huntingdon	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	82.4	Raystown Branch Juniata River
402830077562001	SILF07	Sugar Grove Run near Mill Creek, Pa.	402830/775620	Huntingdon	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	3.06	Juniata River
400515078095101	SILF08	Laurel Fork at Wells Tannery, Pa.	400515/780951	Fulton	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	4.24	Sideling Hill Creek
401353077514801	SILF09	Blacklog Creek near Orbisonia, Pa.	401353/775148	Huntingdon	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	34.1	Aughwick Creek
403631077452601	SILF10	Soft Run at Rockville, Pa.	403631/774526	Mifflin	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	1.39	Little Kishacoquillas Creek
404256077291901	SILF11	Honey Creek near Locke Mills, Pa.	404256/772919	Mifflin	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	17.7	Kishacoquillas Creek
401258077465701	SILF12	Tuscarora Creek near Nossville, Pa.	401258/774657	Huntingdon	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	4.75	Juniata River
403344077271401	SILF13	Hammer Hollow near Walnut, Pa.	403344/772714	Juniata	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	1.36	East Licking Creek

Table A-19. *Characteristics of sites and basins in the Appalachian Mountain siliciclastic forested synoptic study—Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
403404077264001	SILF14	East Licking Creek near Mifflintown, Pa.	403404/772640	Juniata	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	33.5	Tuscarora Creek
402017077200401	SILF15	Laurel Run near Landisburg, Pa.	402017/772004	Perry	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	26.1	Sherman Creek
402325076521701	SILF16	Stony Creek near Dauphin, Pa.	402325/765217	Dauphin	Ridge & Valley (Appalachian Mountain)	Siliciclastic	Forest	30.1	Susquehanna River

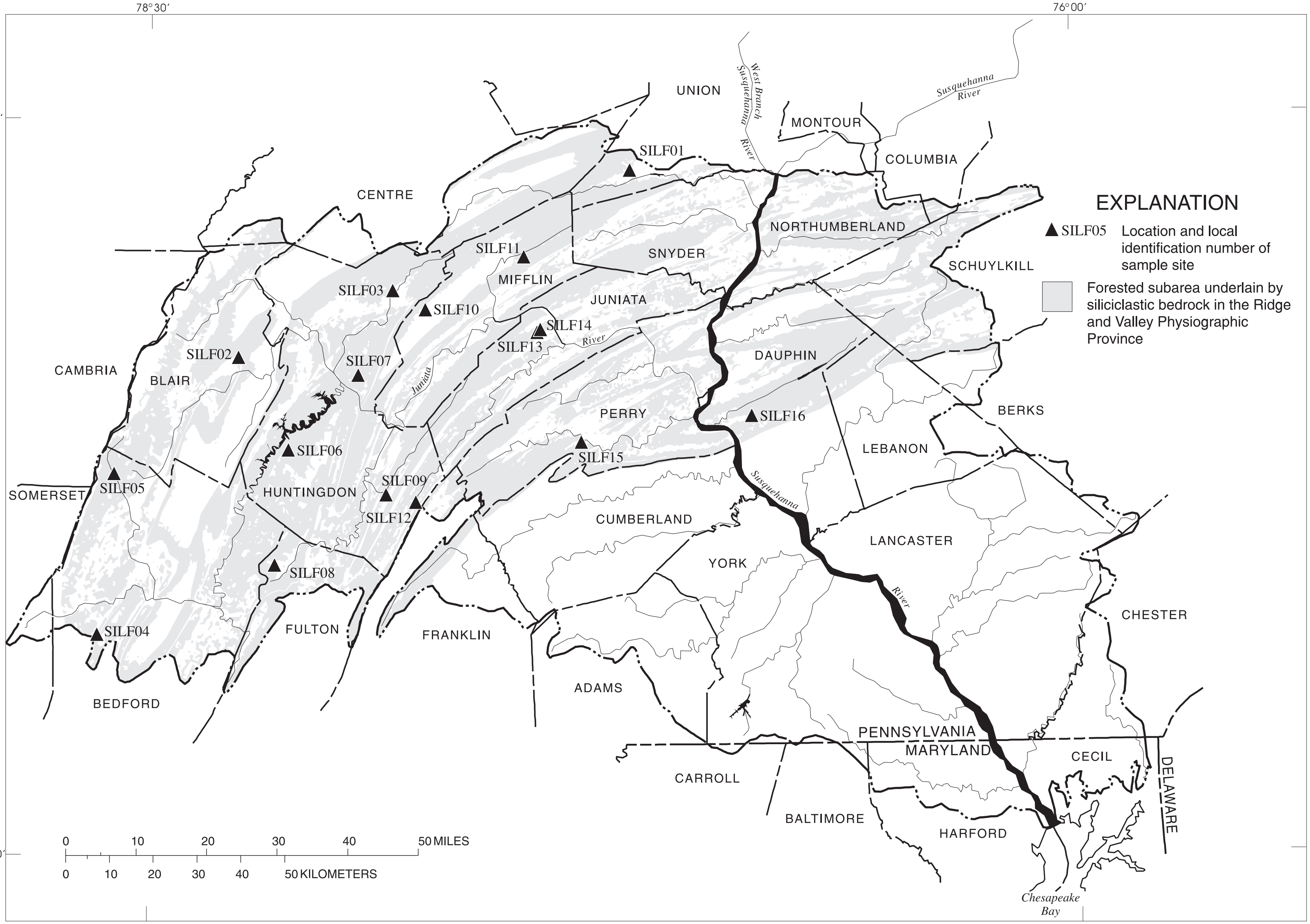

Figure A-19. Locations of sites sampled for the Appalachian Mountain siliciclastic forested synoptic study.

Table A-20. *Characteristics of sites and basins in the Appalachian Mountain carbonate agricultural synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
405121077342701	ACAR01, ESS05, BST03	Penns Creek at Spring Mills, Pa.	405121/773427	Centre	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	17.5	Susquehanna River
405505077284901	ACAR02	Elk Creek near Millheim, Pa.	405505/772849	Centre	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	42.2	Pine Creek
405323077233601	ACAR03	Unnamed tributary to Pine Creek near Aaronsburg, Pa.	405323/772336	Centre	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	5.43	Pine Creek
402115078235101	ACAR04	Plum Creek at Roaring Spring, Pa.	402115/782351	Blair	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	17.0	Halter Creek
402836078103601	ACAR05	Clover Creek near Williamsburg, Pa.	402836/781036	Blair	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	50.1	Frankstown Branch Juniata River
403123078103801	ACAR06	Roaring Run at Mount Etna, Pa.	403123/781038	Blair	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	2.70	Frankstown Branch Juniata River
403156078100701	ACAR07	Fox Run at Mount Etna, Pa.	403156/781007	Blair	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	2.57	Frankstown Branch Juniata River
404026078123201	ACAR08	Logan Spring Run near Tyrone, Pa.	404026/781232	Huntingdon	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	6.98	Little Juniata River
403845078135701	ACAR09	Elk Run near Tyrone, Pa.	403845/781357	Blair	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	4.43	Little Juniata River
404221077595501	ACAR10	Spruce Creek at Pennsylvania Furnace, Pa.	404221/775955	Huntingdon	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	7.67	Little Juniata River
403632078080901	ACAR11	Spruce Creek at Spruce Creek, Pa.	403632/780809	Huntingdon	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	109	Little Juniata River
400020078252201	ACAR12	Cove Creek at Everett, Pa.	400020/782522	Bedford	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	41.9	Raystown Branch Juniata River
401020078230401	ACAR13	Three Springs Run near Loysburg, Pa.	401020/782304	Bedford	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	9.68	Yellow Creek

Table A-20. *Characteristics of sites and basins in the Appalachian Mountain carbonate agricultural synoptic study*—*Continued*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
01564997	ACAR14, KISHFS, EFS05, BST20, ODS45	Kishacoquillas Creek at Lumber City, Pa.	403942/773601	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	57.4	Juniata River
01564996	ACAR15	Tea Creek at Reedsville, Pa.	403947/773551	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	10.9	Kishacoquillas Creek
403956077353401	ACAR16	Honey Creek at Reedsville, Pa.	403956/773534	Mifflin	Ridge & Valley (Appalachian Mountain)	Carbonate	Agriculture	93.5	Kishacoquillas Creek

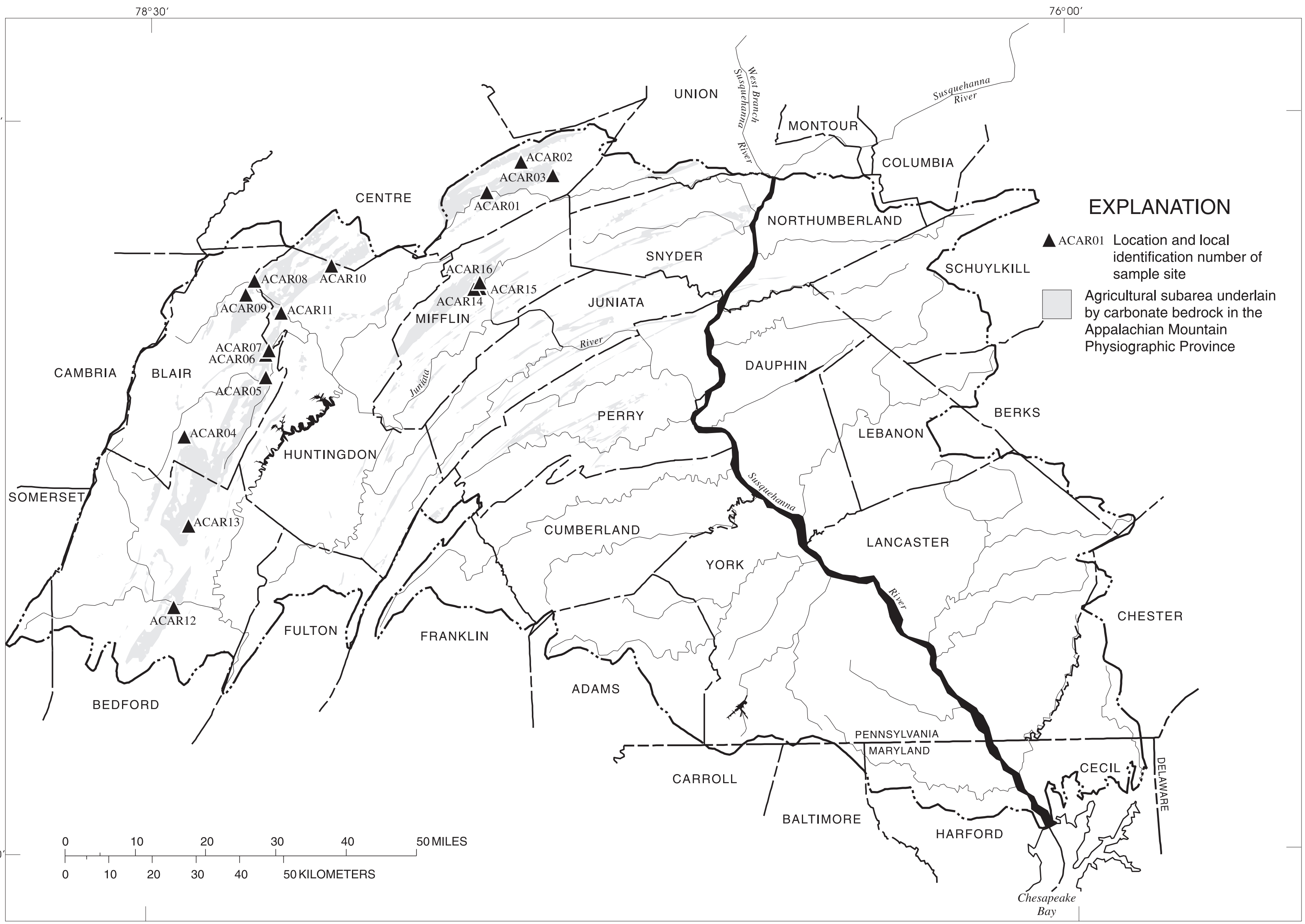

Figure A-20. Locations of sites sampled for the Appalachian Mountain carbonate agricultural synoptic study.

Table A-21. *Characteristics of sites and basins in the Great Valley carbonate agricultural synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
400207077353201	GVAG01	Rowe Run near Shippensburg, Pa.	400207/773532	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Agriculture	12.1	Muddy Run
400158077304401	GVAG02	Gum Run at Shippensburg, Pa.	400158/773044	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Agriculture	6.92	Middle Spring Creek
401214077182601	GVAG03	Mount Rock Spring at Plainfield, Pa.	401214/771826	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Agriculture	23.4	Conodoguinet Creek
401032077111001	GVAG04	Letort Spring Run at Carlisle, Pa.	401032/771110	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Agriculture	3.79	Conodoguinet Creek
401210077014601	GVAG05	Trindle Spring Run at Mechanicsburg, Pa.	401210/770146	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Agriculture	5.93	Conodoguinet Creek
401200076545301	GVAG06	Unnamed tributary to Yellow Breeches Creek near Shiremanstown, Pa.	401200/765453	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Agriculture	1.41	Yellow Breeches Creek
401926076270601	GVAG07	Snitz Creek at Lebanon, Pa.	401926/762706	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	11.3	Quittapahilla Creek
01573086	GVAG08	Beck Creek near Cleona, Pa.	401924/762900	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	7.83	Quittapahilla Creek
01573095	GVAG09, BACHFS, BST19, EFS04, ODS46	Bachman Run at Annville, Pa.	401859/763058	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	7.72	Quittapahilla Creek
401843076331201	GVAG10	Killinger Creek near Palmyra, Pa.	401843/763312	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Agriculture	10.04	Quittapahilla Creek

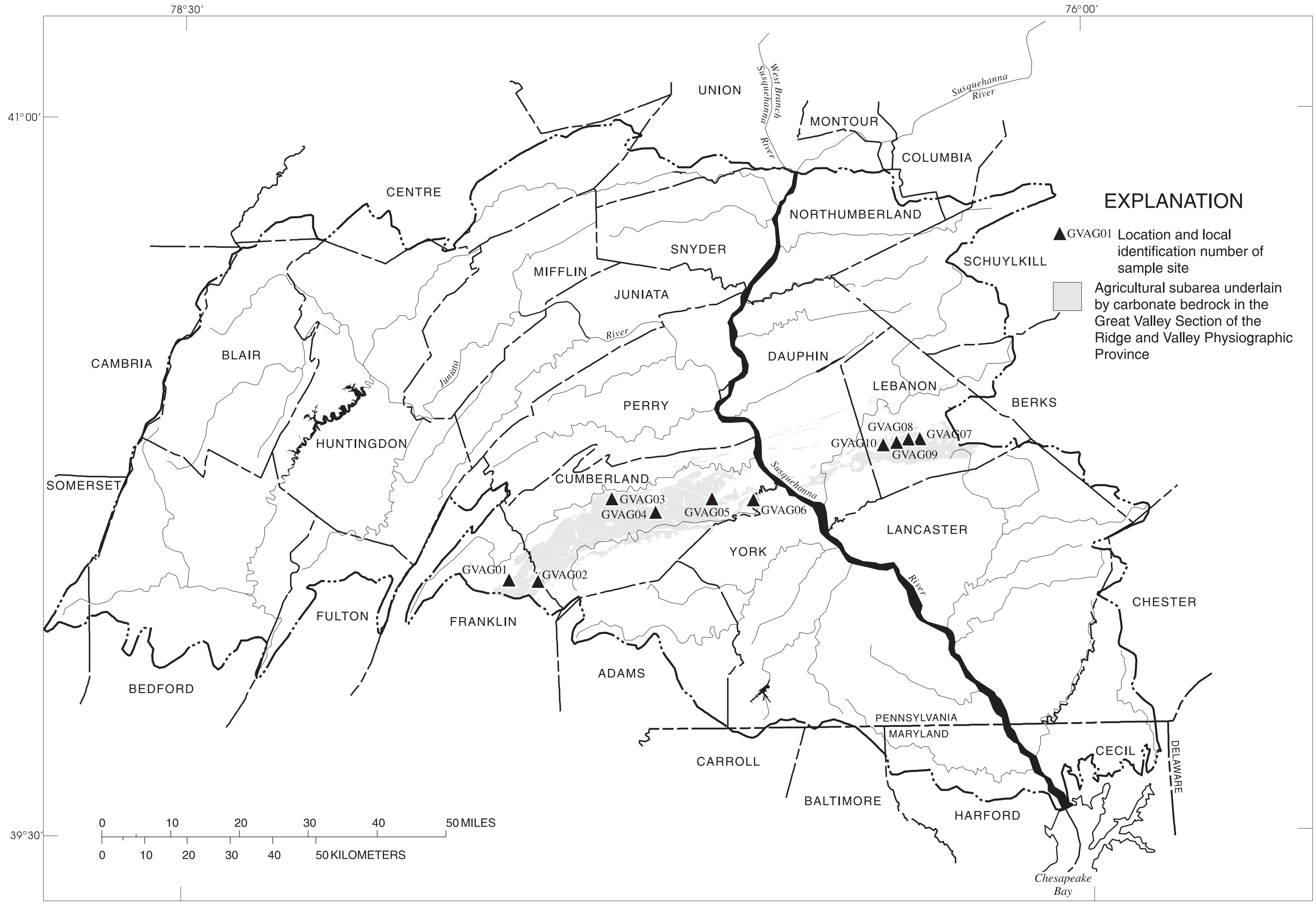

Figure A-21. Locations of sites sampled for the Great Valley carbonate agricultural synoptic study.

Table A-22. *Characteristics of sites and basins in the Great Valley urban synoptic study*

Site characteristics					Basin characteristics				
Site number	Local identifier(s)	Stream name and location	Latitude/ longitude at sample site	County	Physiographic province (section)	Bedrock type	Land use	Drainage area (square miles)	Next higher-order stream
400415077314401	GVUR01	Burd Run at Shippensburg, Pa.	400415/773144	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	19.7	Middle Spring Creek
400554077334801	GVUR02	Middle Spring Creek near Middle Spring, Pa.	400554/773348	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	45.2	Conodoguinet Creek
401045077233301	GVUR03	Big Spring Creek near Newville, Pa.	401045/772333	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	12.1	Conodoguinet Creek
01569800	GVUR04, 30, ODS02	Letort Spring Run near Carlisle, Pa.	401405/770823	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	21.8	Conodoguinet Creek
401505077002601	ODS03, 31, GVUR05	Trindle Spring Run at Hogestown, Pa.	401505/770026	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	17.8	Conodoguinet Creek
01571000	GVUR06, ESS09	Paxton Creek near Penbrook, Pa.	401830/765100	Dauphin	Ridge & Valley (Great Valley)	Mixed	Urban	11.4	Susquehanna River
01571490	ODS04, 32, HFLX10, GVUR07, EFS02, CEDARFS	Cedar Run at Eberlys Mill, Pa.	401330/765424	Cumberland	Ridge & Valley (Great Valley)	Carbonate	Urban	12.6	Yellow Breeches Creek
401258076514101	GVUR08	Unnamed tributary to Yellow Breeches Creek at New Cumberland, Pa.	401258/765141	York	Ridge & Valley (Great Valley)	Carbonate	Urban	2.90	Yellow Breeches Creek
402042076260801	GVUR09	Brandywine Creek at Lebanon, Pa.	402042/762608	Lebanon	Ridge & Valley (Great Valley)	Mixed	Urban	3.12	Quittapahilla Creek
402018076272901	ODS05, 33, GVUR10	Quittapahilla Creek near Cleona, Pa.	402018/762729	Lebanon	Ridge & Valley (Great Valley)	Carbonate	Urban	19.6	Swatara Creek
01573570	GVUR11	Spring Creek at Union Deposit, Pa.	401709/764047	Dauphin	Ridge & Valley (Great Valley)	Carbonate	Urban	24.0	Swatara Creek

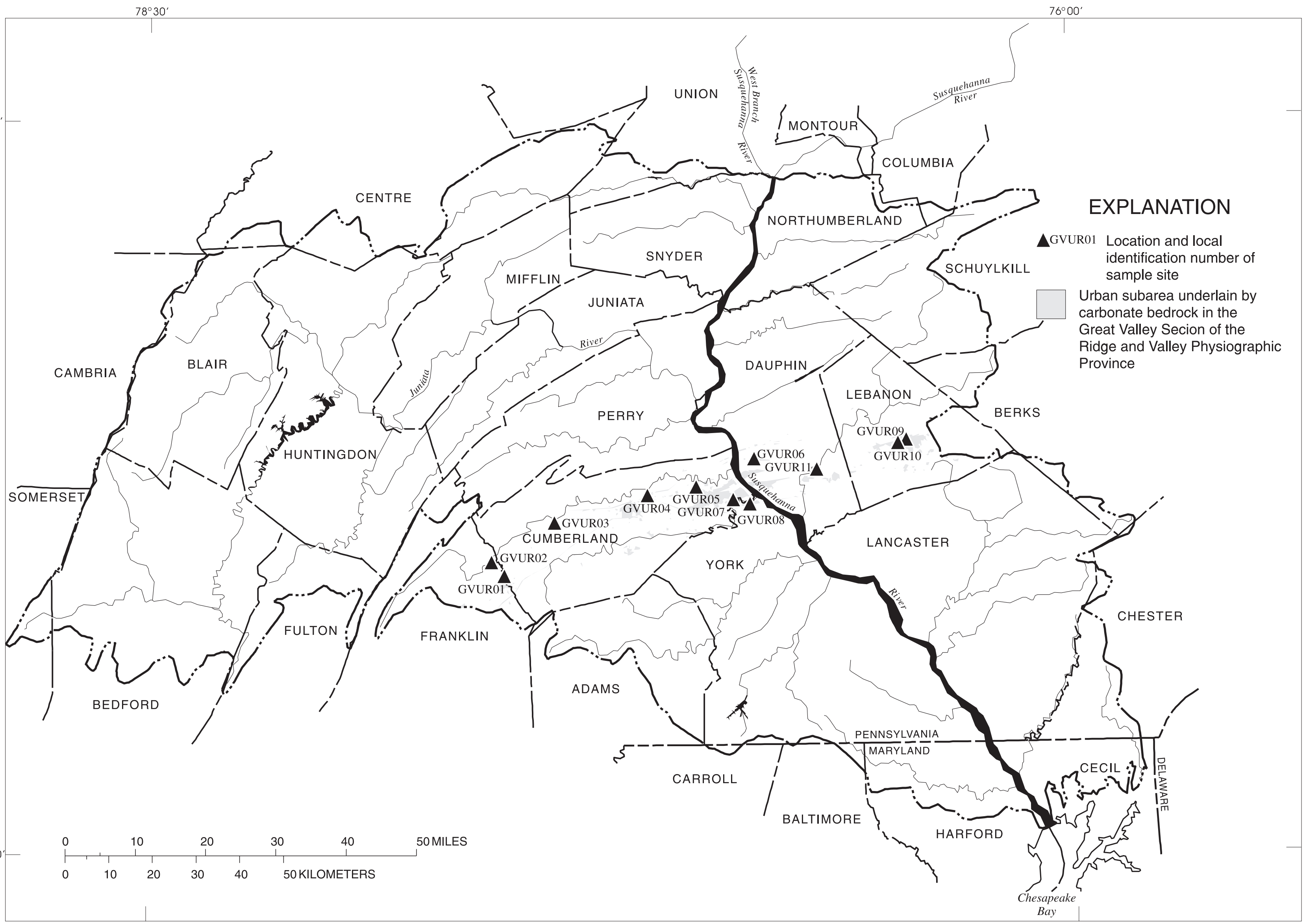

Figure A-22. Locations of sites sampled for the Great Valley urban synoptic study.

Table A-23. *Characteristics of sites in the Piedmont carbonate agricultural ground-water land-use study*

[Explanation of Aquifer Codes: 377LDGR, Ledger Formation; 377KZRS, Kinzers Formation; 367CNSG, Conestoga Formation; 371MLBC, Millbach Formation; 367EPLR, Epler Formation; 374ZKCR, Zooks Corner Formation; 371SZCK, Snitz Creek Formation; 367SNNG, Stonehenge Formation; 377VNTG, Vintage Formation.]

Site identifier	Local well number	Local identifier	County	Latitude/longitude	Altitude of land surface (feet)	Aquifer code	Well depth (feet)	Year of construction	Depth to bottom of casing (feet)	Lithology
394643077043101	AD653	C1	Adams	394643/0770431	600	377LDGR	150	1982	43	Limestone
395143076525201	YO1194	C2	York	395143/0765252	500	377KZRS	140	1983	41	Limestone
395346076502901	YO1195	C3	York	395346/0765029	500	377KZRS	160	1987	60	Limestone
400033076344901	YO1196	C4	York	400033/0763449	360	367CNSG	200	1977	42	Limestone
400629076365201	LN2005	C5	Lancaster	400629/0763652	390	371MLBC	100	1975	40	Limestone and dolomite
400722076231601	LN2006	C6	Lancaster	400722/0762316	400	367EPLR	125	1990	66	Limestone and dolomite
400623076242302	LN2007	C7	Lancaster	400623/0762423	410	374ZKCR	150	1989	20	Dolomite
400558076281201	LN2008	C8	Lancaster	400558/0762812	370	371MLBC	175	1991	102	Limestone and dolomite
400452076331601	LN2009	C9	Lancaster	400452/0763316	420	371SZCK	175	1987	61	Limestone and dolomite
400052076233701	LN2010	C10	Lancaster	400052/0762337	360	367CNSG	175	1990	60	Limestone
395825076264301	LN2011	C11	Lancaster	395825/0762643	390	367CNSG	200	1988	42	Limestone
395809076232501	LN2012	C12	Lancaster	395809/0762325	370	367CNSG	175	1992	63	Limestone
395841076210001	LN2013	C13	Lancaster	395841/0762100	380	367CNSG	150	1987	20	Limestone
400343076140701	LN2014	C14	Lancaster	400343/0761407	360	377LDGR	195	1977	41	Limestone
400655076203401	LN2015	C15	Lancaster	400655/0762034	370	367SNNG	150	1987	41	Limestone
401114076151601	LN2016	C16	Lancaster	401114/0761516	390	367EPLR	122	1986	55	Limestone and dolomite
401254076114701	LN2017	C17	Lancaster	401254/0761147	410	367EPLR	160	1992	42	Limestone and dolomite
400834076090701	LN2018	C18	Lancaster	400834/0760907	340	367SNNG	160	1986	60	Limestone
400711076113801	LN2019	C19	Lancaster	400711/0761138	340	367EPLR	200	1989	20	Limestone and dolomite
400308076121401	LN2031	C20	Lancaster	400308/0761214	420	374ZKCR	150	1986	102	Dolomite
395951076122301	LN2021	C21	Lancaster	395951/0761223	370	367CNSG	150	1989	41	Limestone
395756076153301	LN2022	C22	Lancaster	395756/0761533	370	377VNTG	75	1981	41	Dolomite
395952076074901	LN2023	C23	Lancaster	395952/0760749	410	367CNSG	175	1990	26	Limestone
400259076072501	LN2024	C24	Lancaster	400259/0760725	380	377KZRS	150	1987	20	Limestone
400137076085201	LN2025	C25	Lancaster	400137/0760852	400	377LDGR	200	1992	42	Limestone
400026076021901	LN2026	C26	Lancaster	400026/0760219	450	377VNTG	175	1984	41	Dolomite
400229076020301	LN2027	C27	Lancaster	400229/0760203	460	377LDGR	175	1986	102	Limestone
400434076085001	LN2028	C28	Lancaster	400434/0760850	390	377LDGR	200	1991	60	Dolomite
400724075593201	LN2029	C29	Lancaster	400724/0755932	490	377LDGR	140	1992	42	Limestone
400814075535401	LN2030	C30	Lancaster	400814/0755354	535	377VNTG	97	1991	60	Dolomite

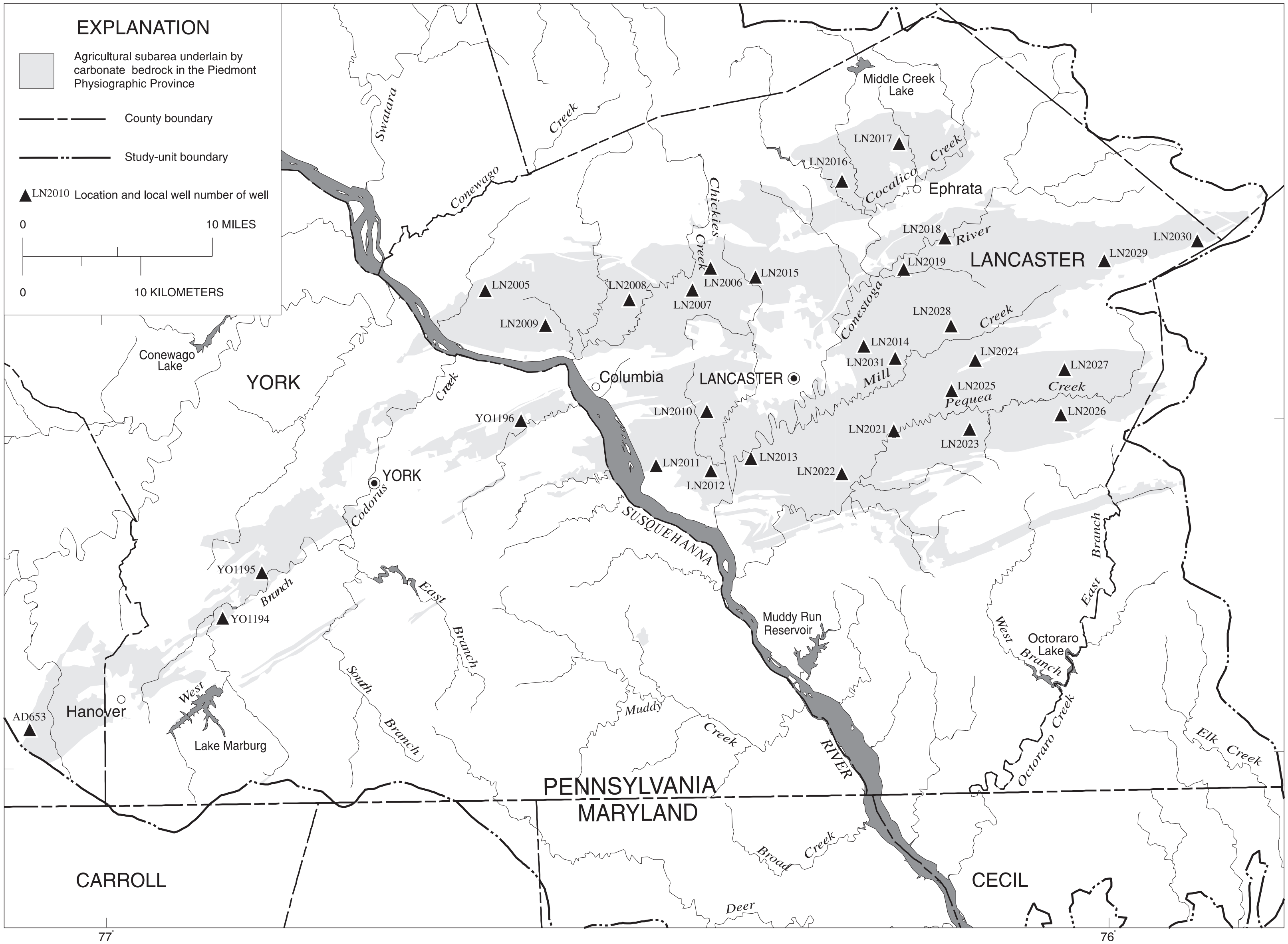

Figure A-23. Locations of sites sampled for the Piedmont carbonate agricultural ground-water land-use study.

Table A-24. *Characteristics of sites in the Appalachian Mountain carbonate agricultural ground-water land-use study*

[Explanation of Aquifer Codes: 367BLFN, Bellefonte Formation; 367BFAX, Bellefonte and Axemann Formations; 367NNLK, Nittany and Stonehenge (Larke) Formations; 364CBSN, Coburn and Nealmont Formations; 371GBRG, Gatesburg Formation; 364BSHL, Benner and Loysburg Formations; 364CSNL, Coburn and Loysburg Formations; 371MINS, Mines Member of Gatesburg Formation; 367AXMN, Axemann Formation; --, data not available.]

Site identifier	Local well number	Local identifier	County	Latitude/longitude	Altitude of land surface (feet)	Aquifer code	Well depth (feet)	Year of construction	Depth to bottom of casing (feet)	Lithology
400317078233501	BD325	A11	Bedford	400317/0782335	1150	367BLFN	243	1978	21	Limestone
401303078214401	BD410	A4	Bedford	401303/0782144	1345	367BFAX	150	1978	136	Limestone
395705078280901	BD530	A2	Bedford	395705/0782809	1220	367BLFN	100	1983	28	Dolomite
395605078291501	BD648	A1	Bedford	395605/0782915	1330	367NNLK	105	1984	31	Limestone and dolomite
400910078231501	BD649	A3	Bedford	400910/0782315	1270	364CBSN	179	1992	105	Limestone
401617078253401	BL629	A5	Blair	401617/0782534	1440	371GBRG	145	1993	42	Limestone and dolomite
401901078222501	BL630	A6	Blair	401901/0782225	1410	367BFAX	195	1978	45	Limestone and dolomite
403438078154901	BL631	A7	Blair	403438/0781549	1090	364CSNL	210	1978	111	Dolomite
402056078182701	BL632	A8	Blair	402056/0781827	1350	367BFAX	100	1986	25	Limestone and dolomite
401738078171801	BL633	A9	Blair	401738/0781718	1370	367BFAX	80	1986	25	Limestone and dolomite
401525078213801	BL634	A10	Blair	401525/0782138	1370	367NNLK	170	1990	84	Limestone and dolomite
402033078153501	BL625	A12	Blair	402033/0781535	1250	367BFAX	70	1982	21	Limestone and dolomite
402623078113401	BL636	A13	Blair	402623/0781134	1050	367BFAX	205	1985	88	Limestone and dolomite
403029078114101	BL637	A14	Blair	403029/0781141	1050	367NNLK	226	1987	218	Limestone and dolomite
404446078045101	CE546	A18	Centre	404446/0780451	1315	367BFAX	100	--	21	Limestone and dolomite
404927077392501	CE667	A17	Centre	404927/0773925	1290	367BLFN	200	1994	160	Limestone and dolomite
404450078004101	CE669	A19	Centre	404450/0780041	1250	367NNLK	180	1977	155	Limestone
405111077364201	CE670	A26	Centre	405111/0773642	1210	364CSNL	210	1973	100	Limestone
405229077380801	CE671	A27	Centre	405229/0773808	1220	364CSNL	200	1994	80	Limestone and dolomite
405253077301501	CE672	A28	Centre	405253/0773015	1190	364CSNL	200	1988	125	Limestone and dolomite
405327077271201	CE673	A29	Centre	405327/0772712	1170	364CSNL	190	1989	40	Limestone
405537077301301	CE674	A30	Centre	405537/0773013	1310	364CSNL	151	1981	81	Limestone
404116078113801	HU407	A16	Huntingdon	404116/0781138	1130	364CSNL	181	1985	20	Limestone and dolomite
403604078094601	HU421	A15	Huntingdon	403604/0780946	990	371MINS	65	1985	22	Dolomite
404142078012101	HU422	A20	Huntingdon	404142/0780121	1130	371MINS	125	1994	100	Dolomite
403706077432801	MF401	A21	Mifflin	403706/0774328	850	367BLFN	120	1991	40	Limestone and dolomite
403148077492901	MF402	A22	Mifflin	403148/0774929	990	364CBSN	102	1979	60	Dolomite
403702077413101	MF403	A23	Mifflin	403702/0774131	830	367AXMN	175	1990	63	Limestone and dolomite
403955077373301	MF404	A24	Mifflin	403955/0773733	830	367BLFN	200	1990	63	Limestone
404328077325501	MF405	A25	Mifflin	404328/0773255	850	364CSNL	147	1968	154	Limestone

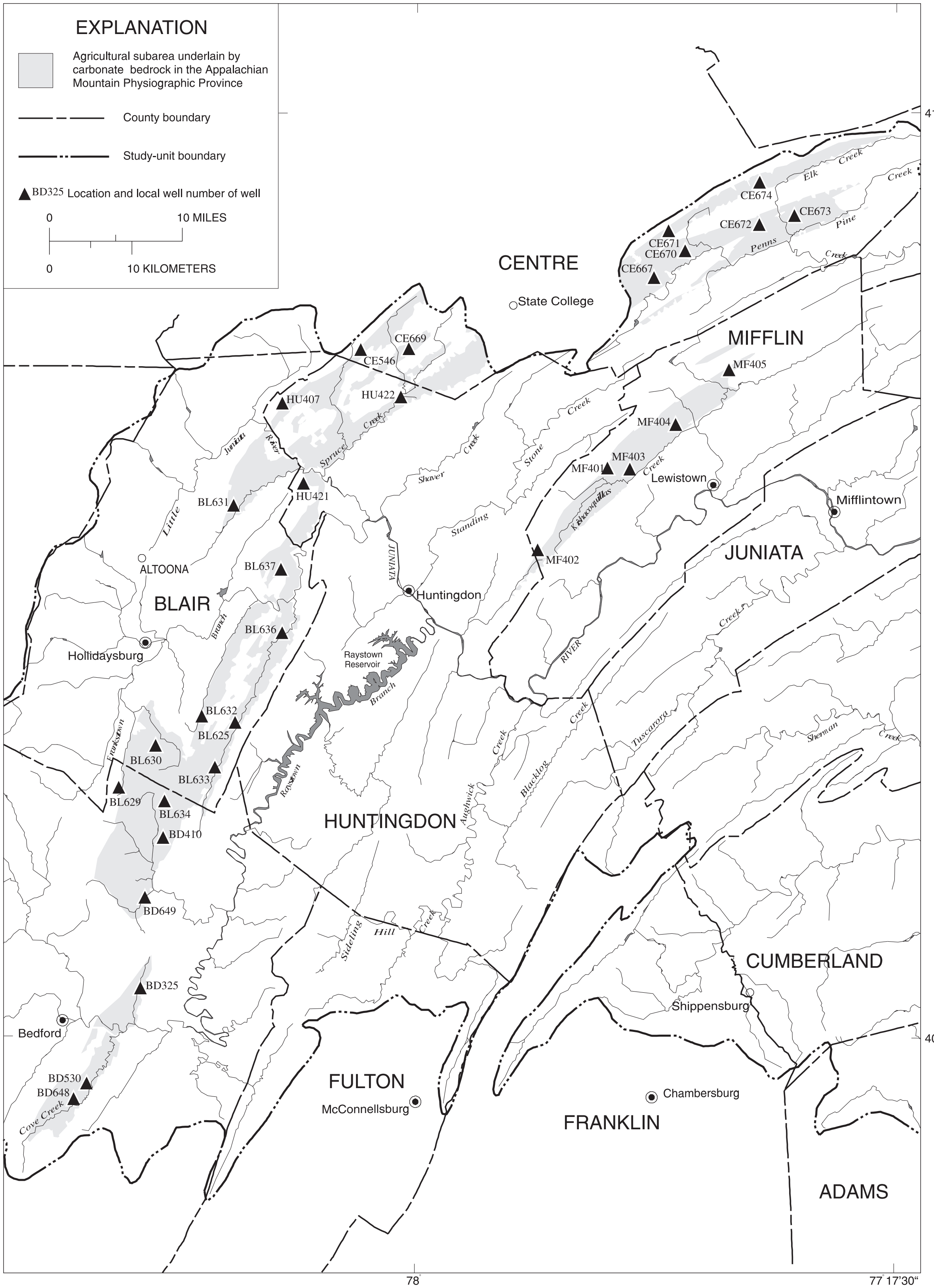

Figure A-24. Locations of sites sampled for the Appalachian Mountain carbonate agricultural ground-water land-use study.

Table A-25. *Characteristics of sites in the Great Valley carbonate agricultural ground-water land-use study*
[Explanation of Aquifer Codes: 371SNNG, Stonehenge Formation; 367RCKR, Rockdale Run Formation; 371ELBK, Elbrook Formation; 371RCLD, Richland Formation; 371SDGV, Shady Grove Formation; 364STPL, St. Paul Formation; 377TMSN, Tomstown Formation; 371ZLGR, Zullinger Formation; 364ONLN, Ontelaunee Formation; 367EPLR, Epler Formation; 374BSPG, Buffalo Springs Formation.]

Site identifier	Local well number	Local identifier	County	Latitude/longitude	Altitude of land surface (feet)	Aquifer code	Well depth (feet)	Year of construction	Depth to bottom of casing (feet)	Lithology
395946077344101	FR812	G1	Franklin	395946/0773441	740	367SNNG	200	1991	38	Dolomite
400117077343901	FR813	G2	Franklin	400117/0773439	710	367RCKR	98	1975	20	Limestone and dolomite
400252077272101	CU907	G3	Cumberland	400252/0772721	790	371ELBK	129	1988	120	Dolomite
400514077274501	CU908	G4	Cumberland	400514/0772745	650	371SDGV	182	1991	120	Limestone
400604077293001	CU909	G5	Cumberland	400604/0772930	600	367RCKR	145	1979	20	Limestone and dolomite
400746077262201	CU910	G6	Cumberland	400746/0772622	590	364STPL	198	1992	126	Limestone and dolomite
401125077195801	CU911	G7	Cumberland	401125/0771958	490	367RCKR	176	1981	108	Limestone and dolomite
400853077230101	CU912	G8	Cumberland	400853/0772301	600	367RCKR	162	1991	120	Limestone and dolomite
400754077195201	CU913	G9	Cumberland	400754/0771952	630	371ELBK	162	1990	60	Dolomite
400515077205501	CU914	G10	Cumberland	400515/0772055	700	377TMSN	147	1985	145	Dolomite
400649077255201	CU927	G11	Cumberland	400649/0772552	655	371ZLGR	290	1974	108	Limestone and dolomite
400905077152101	CU915	G12	Cumberland	400905/0771521	600	371ZLGR	160	1979	143	Limestone and dolomite
400835077171701	CU916	G13	Cumberland	400835/0771717	625	371ZLGR	123	1980	89	Limestone and dolomite
400835077134401	CU917	G14	Cumberland	400835/0771344	585	371ELBK	200	1989	60	Dolomite
400937077094201	CU926	G15	Cumberland	400937/0770942	520	371ELBK	100	1988	70	Dolomite
401136077152701	CU918	G16	Cumberland	401136/0771527	480	367RCKR	203	1993	179	Limestone and dolomite
400942077041201	CU919	G17	Cumberland	400942/0770412	524	371ELBK	165	1987	102	Dolomite
401400077023701	CU920	G18	Cumberland	401400/0770237	410	364STPL	102	1987	40	Limestone and dolomite
401242077055001	CU921	G19	Cumberland	401242/0770550	445	364STPL	62	1975	47	Limestone and dolomite
400946077015601	CU922	G20	Cumberland	400946/0770156	490	371ELBK	120	1980	106	Dolomite
401011077061401	CU923	G21	Cumberland	401011/0770614	550	371ELBK	225	1989	80	Dolomite
400738077085201	CU924	G22	Cumberland	400738/0770852	550	377TMSN	125	1979	89	Dolomite
401445076440801	DA841	G23	Dauphin	401445/0764408	370	364ONLN	180	1978	40	Limestone and dolomite
401639076360801	LB1161	G24	Lebanon	401639/0763608	470	367SNNG	175	1981	85	Dolomite
401945076214101	LB1162	G25	Lebanon	401945/0762141	543	371RCLD	220	1975	54	Limestone and dolomite
401732076323901	LB1163	G26	Lebanon	401732/0763239	479	367SNNG	100	1995	40	Dolomite
401750076274601	LB1164	G27	Lebanon	401750/0762746	504	371RCLD	150	1988	73	Limestone and dolomite
401916076292201	LB1165	G28	Lebanon	401916/0762922	480	367EPLR	115	1975	61	Limestone and dolomite
401808076233801	LB1166	G29	Lebanon	401808/0762338	530	374BSPG	87	1987	82	Limestone and dolomite
401713076221901	LB1167	G30	Lebanon	401713/0762219	620	374BSPG	158	1988	100	Limestone and dolomite

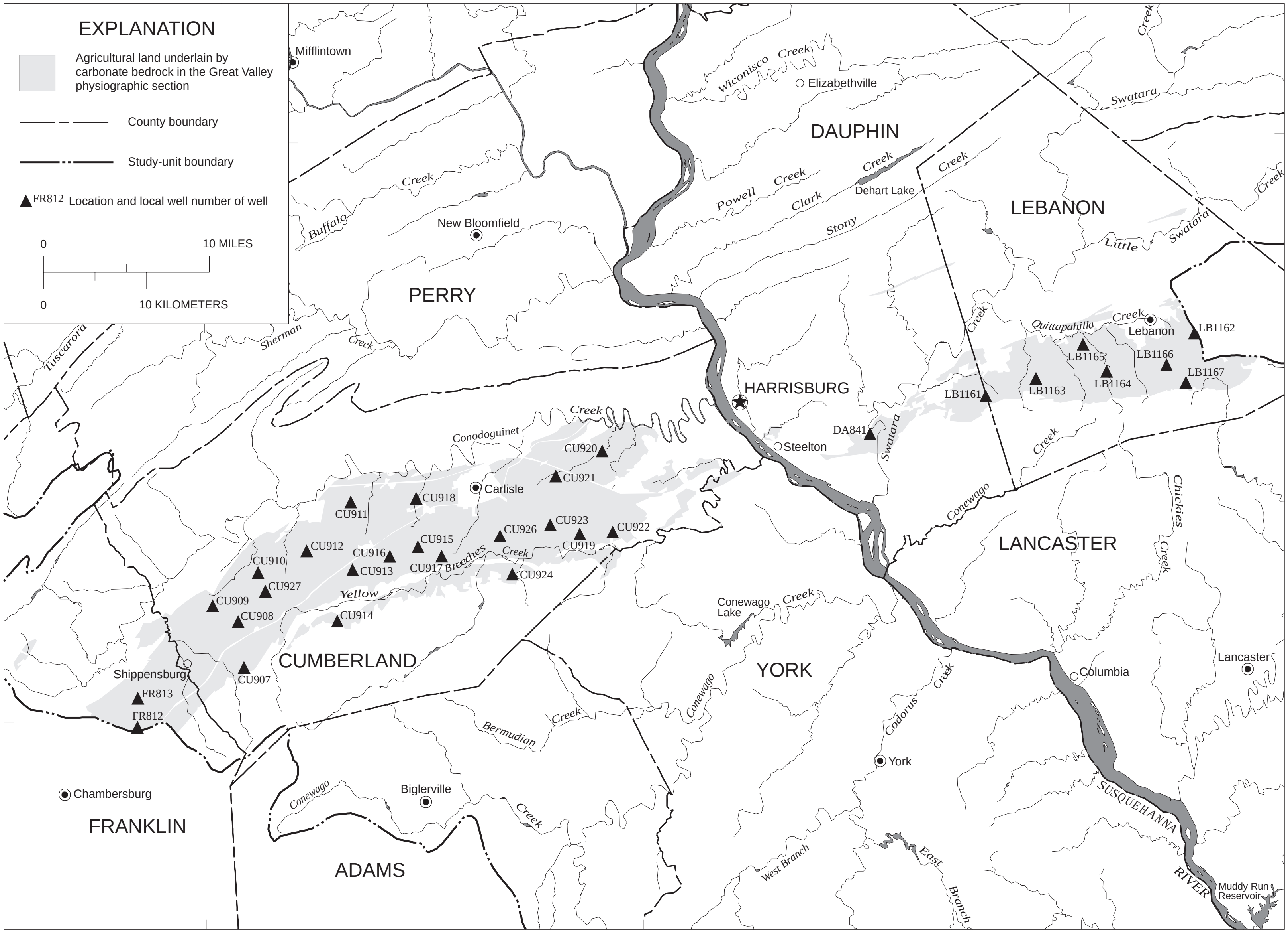

Figure A-25. Locations of sites sampled for the Great Valley carbonate agricultural ground-water land-use study.

Table A-26. *Characteristics of sites in the Great Valley carbonate urban ground-water land-use study*
[Explanation of Aquifer Codes: 367RCKR, Rockdale Run Formation; 361MRBGN, Martinsburg Formation, Basal Limestone; 367PBGS, Pinesburg Station Dolomite; 364STPL, St. Paul Formation; 371SDGV, Shady Grove Formation; 367 EPLR, Epler Formation; 364ONLN, Ontelaunee Formation; --, data not available.]

Site identifier	Local well number	Local identifier	County	Latitude/longitude	Altitude of land surface (feet)	Aquifer code	Well depth (feet)	Year of construction	Depth to bottom of casing (feet)	Lithology
401259077003601	CU278	U9	Cumberland	401259/0770036	429	367RCKR	116	1963	106	Limestone and dolomite
401546076543801	CU285	U5	Cumberland	401546/0765438	405	361MRBGN	69	1995[1]	49	Limestone
400330077313001	CU675	U1	Cumberland	400330/0773130	670	367RCKR	150	1972	24	Limestone and dolomite
401248076571701	CU898	U8	Cumberland	401248/0765715	390	367RCKR	30	1994[2]	30	Limestone
401345076555801	CU899	U7	Cumberland	401345/0765556	400	367PBGS	42	1994[2]	20	Limestone
401359076553301	CU901	U10	Cumberland	401359/0765533	400	367RCKR	46	1994[2]	30	Limestone
401341076584001	CU902	U6	Cumberland	401341/0765840	420	367RCKR	41.1	1994[2]	40	Limestone
401211077124701	CU903	U2	Cumberland	401211/0771247	480	364STPL	170	1981	42	Limestone and dolomite
401159077095101	CU904	U3	Cumberland	401159/0770951	480	371SDGV	200	1987	100	Limestone and dolomite
401224077014901	CU905	U4	Cumberland	401224/0770149	430	367RCKR	125	1976	108	Limestone and dolomite
401440076531901	CU906	U11	Cumberland	401440/0765319	400	367PBGS	175	1981	40	Limestone and dolomite
401602076530301	DA487	U13	Dauphin	401602/0765303	350	361MRBGN	150	1966	--	Limestone
401646076384801	DA839	U19	Dauphin	401646/0763848	400	367EPLR	50	1982	33	Limestone and dolomite
401605076411601	DA840	U20	Dauphin	401605/0764116	360	367EPLR	40	1975	30	Limestone and dolomite
401511076490501	DA842	U12	Dauphin	401511/0764905	400	364STPL	61.5	1986	61	Limestone and dolomite
402045076244801	LB1156	U14	Lebanon	402045/0762340	490	364ONLN	225	1989	41	Limestone and dolomite
402002076244801	LB1157	U15	Lebanon	402002/0762448	480	367EPLR	100	1989	29	Limestone and dolomite
402029076254801	LB1158	U16	Lebanon	402029/0762548	470	364ONLN	149	1981	36	Limestone and dolomite
402000076295301	LB1159	U17	Lebanon	402000/0762953	420	364ONLN	49	1995[1]	30	Limestone and dolomite
401856076345101	LB1160	U18	Lebanon	401856/0763451	440	367EPLR	180	1980	95	Limestone and dolomite

[1] Well was reconstructed for the purposes of this study in 1995.
[2] Well was drilled for the purposes of this study in 1994.

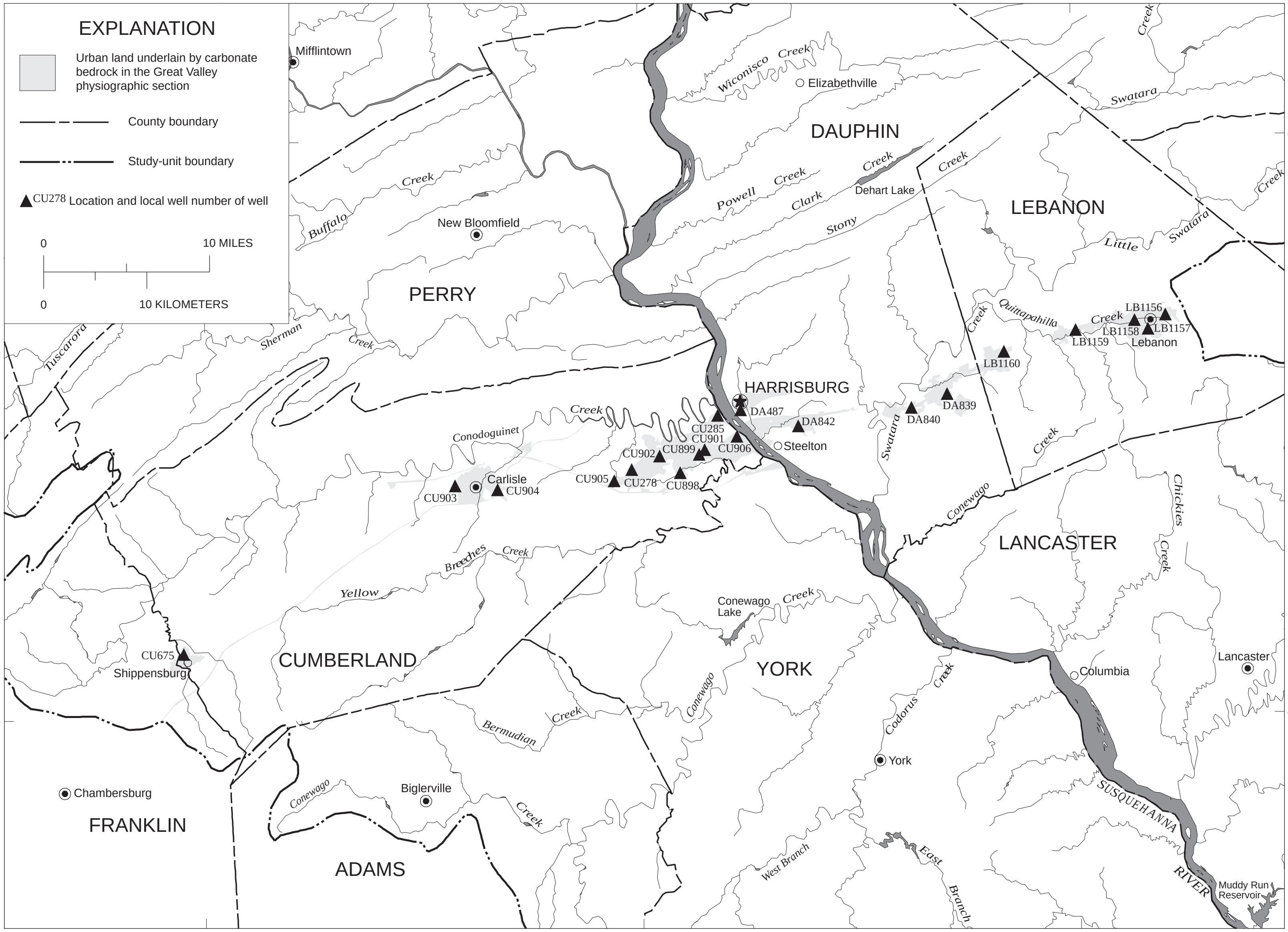

Figure A-26. Locations of sites sampled for the Great Valley carbonate urban ground-water land-use study.

Table A-27. *Characteristics of sites in the Piedmont crystalline ground-water subunit survey*

[Explanation of Aquifer Codes: 300WSCK, Wissahickon Formation (Oligoclase Mica Schist); 300PRCK, Peters Creek Schist; 300WSCKA, Wissahickon Formation (Albite-Chlorite Schist); 377CCKS, Chickies Formation; 300WSCKV, Wissahickon Formation (Metavolcanics); 300MRBG, Marburg Schist of Wissahickon Formation; 377HRPR, Harpers Formation; 377ANTM, Antietam Formation; 000GRGS, Granitic Gneiss; --, data not available.]

Site identifier	Local well number	Local identifier	County	Latitude/longitude	Altitude of land surface (feet)	Aquifer code	Well depth (feet)	Year of construction	Depth to bottom of casing (feet)	Lithology	Land use/cover
394426075533501	CH4931	P25	Chester	394426/0755335	410	300WSCK	132	1992	59	Schist	Agriculture
394606076002001	CH4932	P26	Chester	394606/0760020	500	300WSCK	143	1981	52	Schist	Agriculture
394759075560301	CH4933	P27	Chester	394759/0755603	480	300WSCK	157	1976	87	Schist	Agriculture
395335075563501	CH4934	P29	Chester	395335/0755635	510	300PRCK	135	1991	73	Schist	Agriculture
395349076204401	LN2049	P16	Lancaster	395349/0762044	300	300WSCKA	186	1980	75	Schist	Forest
395752076045001	LN2050	P17	Lancaster	395752/0760450	760	000GRGS	130	1979	20	Granite and/or gneiss	Agriculture
395440076150301	LN2051	P18	Lancaster	395440/0761503	620	300WSCKA	200	--	20	Schist	Forest
395003076110001	LN2052	P19	Lancaster	395003/0761100	580	300WSCKA	180	1990	60	Schist	Agriculture
394550076100001	LN2053	P20	Lancaster	394550/0761000	320	300PRCK	63	1979	43	Schist	Agriculture
395230076014801	LN2054	P28	Lancaster	395230/0760148	430	300PRCK	105	1982	60	Schist	Agriculture
400432076011901	LN2055	P30	Lancaster	400432/0760119	1000	377CCKS	180	1992	84	Quartzite	Forest
394515076470101	YO1197	P1	York	394515/0764701	810	300WSCKV	140	1993	72	Metamorphic (undifferentiated)	Agriculture
394745076524801	YO1198	P2	York	394714/0765256	730	300MRBG	125	1990	21	Schist	Agriculture
394816076463001	YO1199	P3	York	394816/0764630	790	300MRBG	175	1978	21	Schist	Agriculture
395210076560401	YO1200	P4	York	395210/0765604	920	377CCKS	150	1988	27	Quartzite	Forest
395404076404401	YO1201	P5	York	395404/0764044	770	377HRPR	170	1979	63	Slate	Mixed suburban and agriculture
400230076410201	YO1202	P6	York	400230/0764102	600	377ANTM	140	1975	26	Quartzite	Agriculture
395812076340001	YO1203	P7	York	395812/0763400	500	377ANTM	100	1985	77	Quartzite	Agriculture
395320076334001	YO1204	P8	York	395320/0763340	900	300WSCK	200	1986	45	Schist	Forest
395017076313501	YO1205	P9	York	395017/0763135	600	300WSCKA	200	1991	25	Schist	Forest
394721076390101	YO1206	P10	York	394721/0763901	970	300WSCKA	140	1985	40	Schist	Agriculture
394343076361301	YO1207	P11	York	394343/0763613	730	300WSCKA	200	1984	42	Schist	Agriculture
394637076260501	YO1208	P14	York	394637/0762605	640	300WSCKA	200	1991	80	Schist	Agriculture
395204076262101	YO1209	P15	York	395204/0762621	740	300WSCKA	175	1993	52	Schist	Agriculture
393828076294501	HA104	P12	Harford (Md.)	393828/0762945	500	300WSCKA	175	1976	71	Schist	Agriculture
394240076263501	HA12	P13	Harford (Md.)	394240/0762635	610	300WSCKA	150	1980	26	Schist	Agriculture
394209076164301	HA15	P21	Harford (Md.)	394209/0761643	280	300PRCK	100	1992	68	Schist	Forest
393504076133601	HA39	P22	Harford (Md.)	393504/0761336	300	300WSCK	125	1982	40	Schist	Agriculture
394038076061701	CE85	P23	Cecil (Md.)	394038/0760617	400	300WSCK	115	1976	38	Schist	Agriculture
394127075583101	CE67	P24	Cecil (Md.)	394121/0755831	420	300WSCK	107	1988	82	Schist	Agriculture

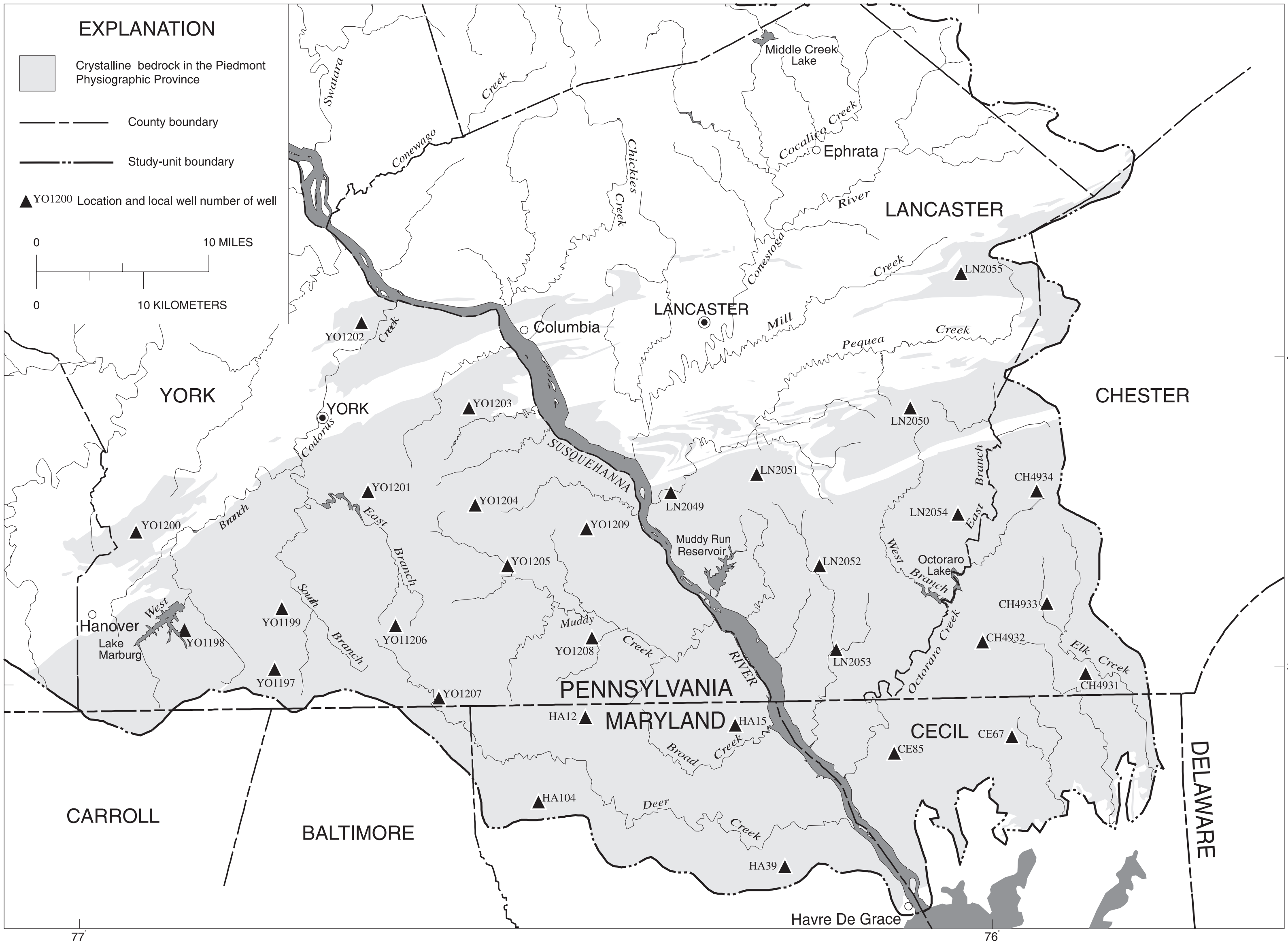

Figure A-27. Locations of sites sampled for the Piedmont crystalline ground-water subunit survey.

Table A-28. *Characteristics of sites in the Appalachian Mountain siliciclastic ground-water subunit survey*

[Explanation of Aquifer Codes: 331MSSPU, Mississippian, upper; 341TMRK, Trimmer's Rock Formation; 341SMCK, Sherman Creek Member of Catskill Formation; 341BVMR, Beaverdam Run Member of Catskill Formation; 341IRVL, Irish Valley Member of Catskill Formation; 341SMLR, Sawmill Run Member of Catskill Formation; 344HMLN, Hamilton Group; 341HRRL, Harrell Shale; 344SMRG, Sherman Ridge Member Mahantango Formation; --, data not available.]

Site identifier	Local well number	Local identifier	County	Latitude/longitude	Altitude of land surface (feet)	Aquifer code	Well depth (feet)	Year of construction	Depth to bottom of casing (feet)	Lithology	Land use/cover
402444076542501	DA830	S1	Dauphin	402444/0765425	640	331MSSPU	160	1983	68	Sandstone and shale	Forest
402955076533301	DA832	S4	Dauphin	402955/0765333	610	341TMRK	80	1990	43	Sandstone and shale	Agriculture
402652076524001	DA833	S5	Dauphin	402652/0765240	590	341SMCK	200	1987	40	Sandstone and shale	Agriculture
403131076514401	DA834	S6	Dauphin	403131/0765144	780	341SMCK	200	1979	40	Sandstone and shale	Forest
403613076475801	DA835	S7	Dauphin	403613/0764758	695	331MSSPU	150	1991	--	Sandstone and shale	Agriculture
403418076523501	DA836	S8	Dauphin	403418/0765235	670	331MSSPU	120	1989	37	Sandstone and shale	Agriculture
403745076433201	DA837	S10	Dauphin	403745/0764332	730	331MSSPU	200	1981	41	Sandstone and shale	Agriculture
403045076313101	LB1155	S2	Lebanon	403045/0763131	660	341SMCK	96	1986	40	Sandstone and shale	Forest
403533076135101	SC613	S3	Schuylkill	403533/0761351	820	341BVMR	200	1991	63	Sandstone	Agriculture
403913076275501	SC614	S13	Schuylkill	403913/0762755	880	331MSSPU	120	1987	40	Sandstone and shale	Agriculture
404152076315401	SC615	S11	Schuylkill	404152/0763154	830	341IRVL	180	1989	82	Sandstone and shale	Agriculture
403745076510901	NU520	S9	Northumberland	403745/0765109	530	341SMLR	155	1988	62	Sandstone and shale	Agriculture
404255076384001	NU524	S12	Northumberland	404255/0763840	810	341IRVL	205	1975	102	Sandstone and shale	Agriculture
404623076483601	NU522	S14	Northumberland	404623/0764836	630	341IRVL	201	1986	40	Sandstone and shale	Agriculture
404922076435201	NU523	S15	Northumberland	404922/0764352	630	344HMLN	100	1989	34	Shale	Agriculture
402000077013701	PE676	S16	Perry	402000/0770137	610	341SMCK	120	1983	38	Sandstone	Forest
402259077085401	PE677	S17	Perry	402259/0770854	650	344SMRG	165	1988	100	Shale	Forest
402123077022701	PE678	S18	Perry	402123/0770227	475	331MSSPU	140	1976	45	Sandstone and shale	Agriculture
402429077054601	PE679	S19	Perry	402429/0770546	695	341TMRK	200	1991	75	Sandstone and shale	Agriculture
402830076595501	PE680	S20	Perry	402830/0765955	660	344SMRG	200	1985	84	Shale	Forest

Table A-28. *Characteristics of sites in the Appalachian Mountain siliciclastic ground-water subunit survey—Continued*

[Explanation of Aquifer Codes: 331MSSPU, Mississippian, upper; 341TMRK, Trimmer's Rock Formation; 341SMCK, Sherman Creek Member of Catskill Formation; 341BVMR, Beaverdam Run Member of Catskill Formation; 341IRVL, Irish Valley Member of Catskill Formation; 341SMLR, Sawmill Run Member of Catskill Formation; 344HMLN, Hamilton Group; 341HRRL, Harrell Shale; 344SMRG, Sherman Ridge Member Mahantango Formation; --, data not available.]

Site identifier	Local well number	Local identifier	County	Latitude/longitude	Altitude of land surface (feet)	Aquifer code	Well depth (feet)	Year of construction	Depth to bottom of casing (feet)	Lithology	Land use/cover
402819077104701	PE681	S21	Perry	402819/0771047	635	341SMCK	100	1984	31	Sandstone and shale	Agriculture
402405077213001	PE682	S22	Perry	402405/0772130	825	344SMRG	140	1992	42	Sandstone and shale	Forest
403417077031301	PE683	S23	Perry	403417/0770313	680	341TMRK	173	1986	40	Sandstone and shale	Agriculture
403628077144601	JU369	S24	Juniata	403628/0771446	625	344SMRG	125	1989	56	Sandstone and shale	Agriculture
403640077045901	JU370	S25	Juniata	403640/0770459	620	341HRRL	150	1993	40	Sandstone and shale	Agriculture
404057077004901	SN245	S26	Snyder	404057/0770049	740	341IRVL	100	1974	41	Sandstone and shale	Agriculture
404059076545801	SN246	S27	Snyder	404059/0765458	610	341IRVL	200	1992	55	Sandstone and shale	Agriculture
405037076561101	SN247	S28	Snyder	405037/0765611	670	341IRVL	199	1991	41	Sandstone and shale	Agriculture
404435077182801	SN249	S30	Snyder	404435/0771828	780	341TMRK	114	1987	30	Sandstone and shale	Agriculture

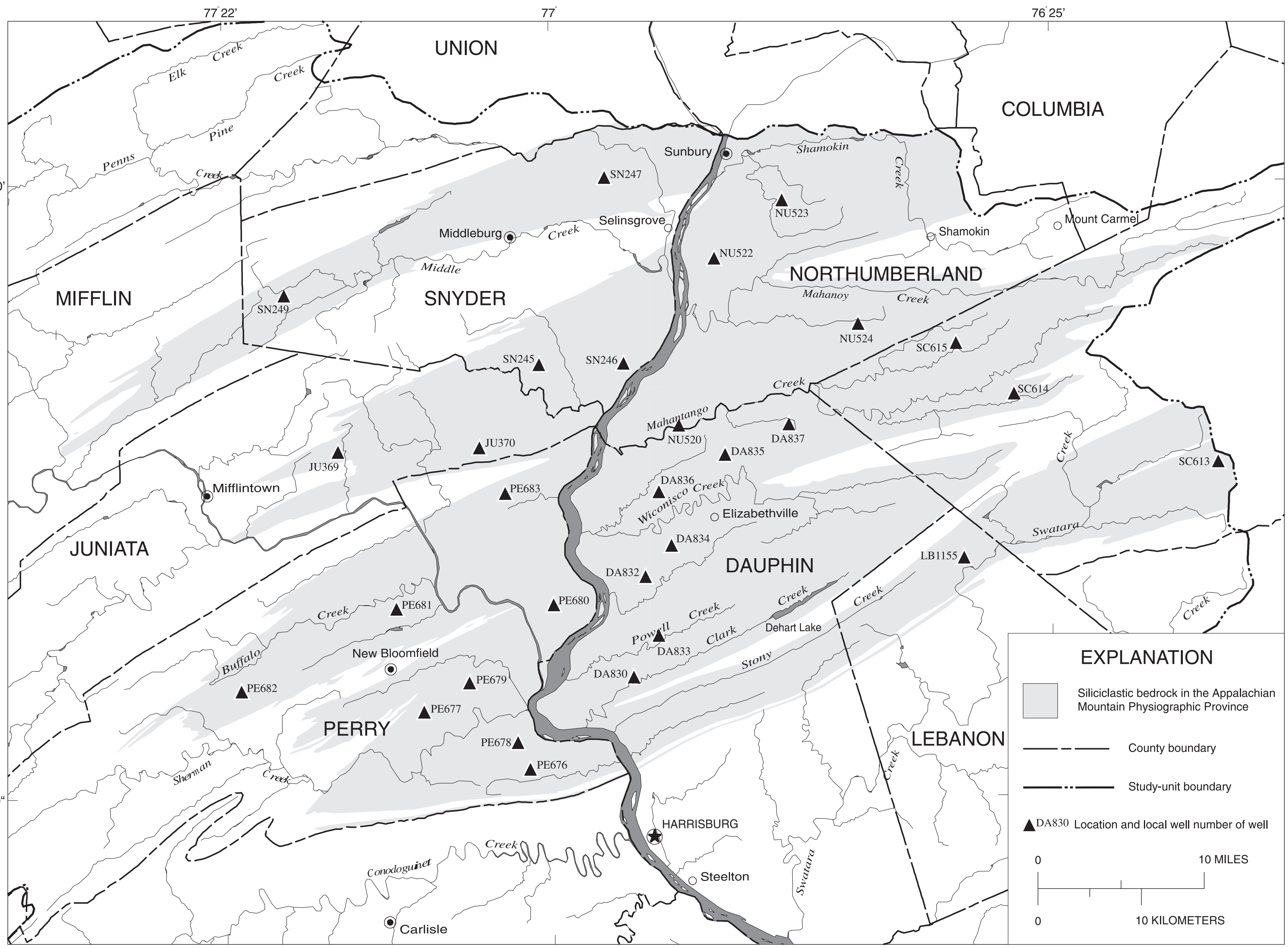

Figure A-28. Locations of sites sampled for the Appalachian Mountain siliciclastic ground-water subunit survey.

APPENDIX B - ANALYTICAL GROUPINGS OF WATER-QUALITY CHARACTERISTICS

[Unless otherwise noted, all analyses performed by USGS National Water-Quality Laboratory, Arvada, Colo.; Parameter code is a 5-digit number used in the U.S. Geological Survey computerized data system WATSTORE, to uniquely identify a specific constituent.]

Table B-1. *Analytical grouping of organochlorine pesticide compounds in biological samples*

[µg/kg, micrograms per kilogram; N.A., not applicable.]

Compound name (common name)	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Aldrin	49353	Gas chromatography	5.0	µg/kg
Chlordane, cis-	49380	Gas chromatography	5.0	µg/kg
Chlordane, trans-	49379	Gas chromatography	5.0	µg/kg
DCPA (Dacthal)	49378	Gas chromatography	5.0	µg/kg
DDT, o,p'-	49377	Gas chromatography	5.0	µg/kg
DDT, p,p'-	49376	Gas chromatography	5.0	µg/kg
DDD, p,p'-	49375	Gas chromatography	5.0	µg/kg
DDD, o,p'-	49374	Gas chromatography	5.0	µg/kg
DDE, o,p'-	49373	Gas chromatography	5.0	µg/kg
DDE, p,p'-	49372	Gas chromatography	5.0	µg/kg
Dieldrin (Cygon)	49371	Gas chromatography	5.0	µg/kg
Endrin	49370	Gas chromatography	5.0	µg/kg
Heptachlor	49369	Gas chromatography	5.0	µg/kg
Heptachlor Epoxide	49368	Gas chromatography	5.0	µg/kg
Hexachlorobenzene	49367	Gas chromatography	5.0	µg/kg
HCH, alpha-	49366	Gas chromatography	5.0	µg/kg
HCH, beta-	49365	Gas chromatography	5.0	µg/kg
HCH, delta-	49364	Gas chromatography	5.0	µg/kg
HCH, gamma- (Lindane)	49363	Gas chromatography	5.0	µg/kg
Methoxychlor, o,p'- (Dual)	49362	Gas chromatography	5.0	µg/kg
Methoxychlor, p,p'-	49361	Gas chromatography	5.0	µg/kg
Mirex	49360	Gas chromatography	5.0	µg/kg
Nonachlor, cis-	49359	Gas chromatography	5.0	µg/kg
Nonachlor, trans-	49358	Gas chromatography	5.0	µg/kg
Oxychlordane	49357	Gas chromatography	5.0	µg/kg
Pentachloroanisole	49356	Gas chromatography	5.0	µg/kg
Polychlorinated biphenyls, total	49354	Gas chromatography	50.0	µg/kg
Toxaphene	49355	Gas chromatography	200.0	µg/kg
Lipid content	49289	Calculated	N.A.	percent

Table B-2. *Analytical grouping of trace elements in biological samples*

[µg/g, micrograms per gram; N.A., not applicable.]

Constituent name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Aluminum	49237	Inductively coupled plasma atomic emission spectrometry	1.0	µg/g (dry)
Barium	49238	Inductively coupled plasma atomic emission spectrometry	.1	µg/g (dry)
Boron	49239	Inductively coupled plasma atomic emission spectrometry	.2	µg/g (dry)
Chromium	49240	Inductively coupled plasma atomic emission spectrometry	.5	µg/g (dry)
Copper	49241	Inductively coupled plasma atomic emission spectrometry	.5	µg/g (dry)
Iron	49242	Inductively coupled plasma atomic emission spectrometry	1.0	µg/g (dry)
Manganese	49243	Inductively coupled plasma atomic emission spectrometry	.1	µg/g (dry)
Strontium	49244	Inductively coupled plasma atomic emission spectrometry	.1	µg/g (dry)
Zinc	49245	Inductively coupled plasma atomic emission spectrometry	.5	µg/g (dry)
Antimony	49246	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Arsenic	49247	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Beryllium	49248	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Cadmium	49249	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Cobalt	49250	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Lead	49251	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Molybdenum	49252	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Nickel	49253	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Selenium	49254	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Silver	49255	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Uranium	49257	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Vanadium	49465	Inductively coupled plasma mass spectrometry	.1	µg/g (dry)
Mercury	49258	Cold vapor atomic absorption spectrometry	.1	µg/g (dry)
Water content	49273	Calculated	N.A.	percent

Table B-3. *Analytical grouping of combined biomass and chlorophyll in biological samples*

[g/m^2, grams per square meter; mg/m^2, milligrams per square meter.]

Constituent name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Biomass, ash weight	00572	Ashing	0.001	g/m^2
Biomass, dry weight	00573	Drying	.001	g/m^2
Chlorophyll a	70957	High-pressure liquid chromatography	.1	mg/m^2
Chlorophyll b	70958	High-pressure liquid chromatography	.1	mg/m^2

Table B-4. *Analytical grouping of trace elements in bed sediments*

[Analysis performed by USGS Branch of Geochemistry Laboratory, Denver, Colo.; µg/g, micrograms per gram; limit of detection is the lowest concentration that can be determined to be statistically different from a blank (Arbogast, 1990).]

Constituent name	Parameter code	Analytical method	Limit of detection	Reporting unit
Aluminum	34790	Inductively coupled plasma	0.05	percent
Calcium	43830	Inductively coupled plasma	.05	percent
Iron	34880	Inductively coupled plasma	.05	percent
Potassium	34940	Inductively coupled plasma	.05	percent
Magnesium	34900	Inductively coupled plasma	.005	percent
Sodium	34960	Inductively coupled plasma	.005	percent
Phosphorus	34935	Inductively coupled plasma	.005	percent
Titanium	49274	Inductively coupled plasma	.005	percent
Gold	34870	Inductively coupled plasma	8.0	µg/g
Barium	34850	Inductively coupled plasma	1.0	µg/g
Beryllium	34810	Inductively coupled plasma	1.0	µg/g
Bismuth	34816	Inductively coupled plasma	1.0	µg/g
Cerium	34835	Inductively coupled plasma	4.0	µg/g
Cobalt	34845	Inductively coupled plasma	1.0	µg/g
Chromium	34840	Inductively coupled plasma	1.0	µg/g
Copper	34850	Inductively coupled plasma	1.0	µg/g
Europium	34855	Inductively coupled plasma	2.0	µg/g
Gallium	34860	Inductively coupled plasma	4.0	µg/g
Holmium	34875	Inductively coupled plasma	4.0	µg/g
Lanthanum	34855	Inductively coupled plasma	2.0	µg/g
Lithium	34895	Inductively coupled plasma	2.0	µg/g
Manganese	34905	Inductively coupled plasma	4.0	µg/g
Molybdenum	34915	Inductively coupled plasma	2.0	µg/g
Niobium	34930	Inductively coupled plasma	4.0	µg/g
Neodymium	34920	Inductively coupled plasma	4.0	µg/g
Nickel	34925	Inductively coupled plasma	2.0	µg/g
Lead	34890	Inductively coupled plasma	4.0	µg/g
Scandium	34945	Inductively coupled plasma	2.0	µg/g
Tin	34985	Inductively coupled plasma	1.0	µg/g
Strontium	34965	Inductively coupled plasma	2.0	µg/g
Tantalum	34975	Inductively coupled plasma	4.0	µg/g
Thorium	34980	Inductively coupled plasma	4.0	µg/g
Vanadium	35005	Inductively coupled plasma	2.0	µg/g
Yttrium	35010	Inductively coupled plasma	2.0	µg/g
Ytterbium	35015	Inductively coupled plasma	1.0	µg/g
Zinc	35020	Inductively coupled plasma	4.0	µg/g
Silver	34955	Grafite furnace atomic adsorption	.1	µg/g
Cadmium	34825	Grafite furnace atomic adsorption	.1	µg/g
Mercury	34910	Graphite furnace atomic adsorption	.02	µg/g
Arsenic	34800	Hydride analysis	.1	µg/g
Antimony	34795	Hydride analysis	.1	µg/g
Selenium	34950	Hydride analysis	.1	µg/g
Uranium	35000	Delayed neutron activation analysis	.05	µg/g
Thorium	34980	Delayed neutron activation analysis	1.0	µg/g
Sulfur	34970	Infared analysis	.05	percent

Table B-4. *Analytical grouping of trace elements in bed sediments—Continued*

Constituent name	Parameter code	Analytical method	Limit of detection	Reporting unit
Carbon, carbonate	49266	Coulometric titration	0.01	percent
Carbon, organic	49267	Difference	.01	percent
Carbon, total	49269	Combustion, infared analysis	.01	percent

Table B-5. *Analytical grouping of carbon in bed sediments*

[g/kg, grams per kilogram.]

Constituent name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Carbon, carbonate	49270	Coulometric titration	0.1	g/kg dry
Carbon, organic	49271	Difference (between parameter 49272 and 49270)	.1	g/kg dry
Carbon, total	49272	Resistance furnace, infared absorption	.1	g/kg dry

Table B-6. *Analytical grouping of bed- and suspended-sediment characteristics*

[Analysis performed by USGS Pennsylvania District Sediment Laboratory, Lemoyne, Pa.; mm, millimeters; mg/L, milligrams per liter; µm, microns.]

Parameter name	Parameter code	Analytical method	Estimated reporting limit	Reporting unit
Particle size finer than 2.00 mm in bed sediment	80169	Dry sieving	0.1	percent
Particle size finer than 63 µm in bed sediment	80164	Dry sieving	.1	percent
Particle size finer than 4 µm in bed sediment	80157	Pipet analysis or hydrometer	.01	percent
Suspended sediment concentration	80154	Filtration	1.0	mg/L
Particle size finer than 0.062 mm in suspended sediment	70331	Wet sieving	.1	percent

Table B-7. *Analytical grouping of organochlorine pesticide compounds in bed sediments*

[μg/kg, micrograms per kilogram.]

Compound name (common name)	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Aldrin	49319	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Chlordane, cis-	49320	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Chlordane, trans-	49321	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Chloroneb	49322	Gas chromatography/mass spectrometry	5.0	μg/kg (dry)
DCPA (Dacthal)	49324	Gas chromatography/mass spectrometry	5.0	μg/kg (dry)
DDD, o,p'-	49325	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
DDD, p,p'-	49326	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
DDE, o,p'-	49327	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
DDE, p,p'-	49328	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
DDT, o,p'-	49329	Gas chromatography/mass spectrometry	2.0	μg/kg (dry)
DDT, p,p'-	49330	Gas chromatography/mass spectrometry	2.0	μg/kg (dry)
Dieldrin (Panoram D-31)	49331	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Endosulfan I	49332	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Endrin	49335	Gas chromatography/mass spectrometry	2.0	μg/kg (dry)
HCH, alpha-	49338	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
HCH, beta-	49339	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
HCH, gamma- (Lindane)	49345	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Heptachlor	49341	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Heptachlor epoxide	49342	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Hexachlorobenzene	49343	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Isodrin	49344	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Methoxychlor, o,p'- (Dual)	49347	Gas chromatography/mass spectrometry	5.0	μg/kg (dry)
Methoxychlor, p,p'-	49346	Gas chromatography/mass spectrometry	5.0	μg/kg (dry)
Mirex	49348	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Nonachlor, cis-	49316	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Nonachlor, trans-	49317	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Oxychlordane	49318	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Polychlorinated biphenyls, total	49459	Gas chromatography/mass spectrometry	50.0	μg/kg (dry)
Pentachloroanisole	49460	Gas chromatography/mass spectrometry	1.0	μg/kg (dry)
Permethrin, cis- (Ambush)	49349	Gas chromatography/mass spectrometry	5.0	μg/kg (dry)
Permethrin, trans-	49350	Gas chromatography/mass spectrometry	5.0	μg/kg (dry)
Toxaphene	49351	Gas chromatography/mass spectrometry	200.0	μg/kg (dry)

Table B-8. *Analytical grouping of base-neutral-acid semivolatile organic compounds in bed sediments*

[µg/kg, micrograms per kilogram.]

Compound name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Acenaphthylene	49428	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Acenaphthene	49429	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Acridine	49430	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Amine, n-Nitroso-Di-n-Propyl-	49431	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Amine, n-Nitroso-Diphenyl-	49433	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Anthracene	49434	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Anthracene, 2-Methyl-	49435	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benz[a]anthracene	49436	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Dibenzo[a,h]anthracene	49461	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Anthraquinone	49437	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Azobenzene	49443	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzene, 1,2-Dichloro-	49439	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzene, 1,3-Dichloro-	49441	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzene, 1,4-Dichloro-	49442	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzene, 1,2,4-Trichloro-	49438	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzene, Nitro-	49444	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzene, Hexachloro-	49343	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzene, Pentachloronitro-	49446	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Butadiene, Hexachloro-	49448	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
9H-Carbazol	49449	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Chrysene	49450	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
p-Cresol	49451	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Dibenzothiophene	49452	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Ethane, Hexachloro-	49453	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Ether, 4-Bromophenyl-phenyl-	49454	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Ether, 4-Chlorophenyl-phenyl-	49455	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Ether, bis(2-Chloroethyl)-	49456	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Ether, bis(2-Chloroisopropyl)	49457	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Fluoranthene	49466	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzo[b]fluoranthene	49458	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzo[k]fluoranthene	49397	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
9H-Fluorene, 1-Methyl-	49398	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
9H-Fluorene	49399	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Isophorone	49400	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Methane, bis(2-Chloroethoxy)-	49401	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Naphthalene	49402	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Naphthalene, 2-Chloro-	49407	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Naphthalene, 1,2-Dimethyl-	49403	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Naphthalene, 1,6-Dimethyl-	49404	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Naphthalene, 2,6-Dimethyl-	49406	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Naphthalene, 2-Ethyl-	49490	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Naphthalene, 2,3,6-Trimethyl-	49405	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Pentachloroanisol	49460	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Pentadiene, Hexachlorocyclo-	49489	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzo[g,h,i]perylene	49408	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenanthrene	49409	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenanthrene, 1-Methyl-	49410	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenanthrene, 4,5-Methylene-	49411	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)

Table B-8. *Analytical grouping of base-neutral-acid semivolatile organic compounds in bed sediments—Continued*

[µg/kg, micrograms per kilogram.]

Compound name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Phenanthridine	49393	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol	49413	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 2-Chloro-	49467	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 2.4-Dichloro-	49417	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 3,5-Dimethyl-	49421	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 2,4-Dinitro-	49418	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 4,6-Dinitro-2-methyl-	49419	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 4-Chloro-3-Methyl-	49422	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, C8-Alkyl-	49424	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 2-Nitro-	49420	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 4-Nitro-	49423	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, Pentachloro-	49425	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 2,3,5,6-Tetramethyl-	49414	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 2,4,6-Trichloro-	49415	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phenol, 2,4,6-Trimethyl-	49416	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phthalate, Butylbenzyl-	49427	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phthalate, Di-n-Butyl-	49381	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phthalate, Di-n-Octyl-	49382	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phthalate, Diethyl-	49383	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Phthalate, Dimethyl-	49384	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Pyrene	49387	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Pyrene, 1-Methyl-	49388	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzo(a)pyrene	49389	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Indeno[1,2,3-c,d]pyrene	49390	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
2,2'-Biquinoline	49391	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Quinoline	49392	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Benzo[c]quinoline	49468	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Isoquinoline	49394	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Toluene, 2,4-Dinitro-	49395	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)
Toluene, 2,6-Dinitro-	49396	Gas chromatography/mass spectrometry	50.0	µg/kg (dry)

Table B-9. *Field measurements of physical and chemical properties of water*

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25° Celsius; mg/L, milligrams per liter; $CaCO_3$, calcium carbonate.]

Constituent name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
pH	00400	Electrometric, glass electrode	0.1	pH units
Specific conductance	00095	Electrometric, Wheatstone bridge	1.0	µS/cm
Alkalinity as $CaCO_3$ [1]	39036	Filtered fixed-endpoint electrometric titration	1.0	mg/L
Bicarbonate as CaCO3 [1]	29804	Calculated from parameter code 39036	1.0	mg/L
Carbonate as CaCO3 [1]	29807	Calculated from parameter code 39036	1.0	mg/L
Dissolved oxygen	00300	Cathode/electrometric, membrane electrode	.1	mg/L
Oxygen saturation	00301	Calculated	.1	percent
Temperature	00010	Electrometric, thermistor	-2.0	˚C
Alkalinity as $CaCO_3$ [2]	00419	Unfiltered incremental titration	1.0	mg/L
Alkalinity [2]	00410	Unfiltered fixed-endpoint titration	1.0	mg/L
Carbonate as CO_3 [2]	00447	Calculated from parameter code 00419	1.0	mg/L
Carbonate [2]	00445	Calculated from parameter code 00410	1.0	mg/L
Bicarbonate as HCO_3 [2]	00450	Calculated from parameter code 00419	1.0	mg/L
Bicarbonate [2]	00440	Calculated from parameter code 00410	1.0	mg/L

[1] Surface water only.
[2] Ground water only.

Table B-10. *Analytical grouping of major inorganic constituents in water*

[ROE, residue on evaporation; $CaCO_3$, calcium carbonate; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25° Celsius; µg/L, micrograms per liter; °C, degrees Celsius.]

Constituent name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Chloride, dissolved	00940	Inductively coupled plasma spectrometry	0.1	mg/L
ROE dissolved @ 180°C	70300	Gravimetric analysis	1	mg/L
Potassium, dissolved	00935	Atomic absorption spectrometry	.1	mg/L
pH, laboratory	00403	Electrometric	.1	units
Specific Conductance, laboratory	90095	Electrometric	1	µS/cm
Alkalinity, as $CaCO_3$, laboratory	90410	Fixed-endpoint electrometric titration	1	mg/L
Iron, dissolved	01046	Inductively coupled plasma spectrometry	3	µg/L
Manganese, dissolved	01056	Inductively coupled plasma spectrometry	1	µg/L
Calcium, dissolved	00915	Inductively coupled plasma spectrometry	.02	mg/L
Magnesium, dissolved	00925	Inductively coupled plasma spectrometry	.01	mg/L
Silica, dissolved	00955	Inductively coupled plasma spectrometry	.01	mg/L
Sodium, dissolved	00930	Inductively coupled plasma spectrometry	.2	mg/L
Sulfate, dissolved	00945	Ion-exchange chromatography	.1	mg/L
Fluoride, dissolved	00950	Ion-selective electrode	.1	mg/L
Bromide, dissolved	71870	Automated-segmented flow, colorimetric	.01	mg/L
Strontium, dissolved	01080	Atomic absorption spectrometry	10	µg/L

Table B-11. *Analytical grouping of nutrients in water*

[N, nitrogen; P, phosphorus; Ortho-P, orthophosphate; NO_2, nitrite; NO_3, nitrate; NH_4, ammonia; mg/L, milligrams per liter.]

Nutrient name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Nitrogen, Nitrite, as N, dissolved	00613	Diazotization, automated-segmented flow, colorimetric	0.01	mg/L
Phosphorus, Ortho-P, as P, dissolved	00671	Phosphomolybdate, automated-segmented flow, colorimetric	.01	mg/L
Nitrogen, NO_3 +NO_2, as N, dissolved	00631	Diazotization, automated-segmented flow, colorimetric	.05	mg/L
Nitrogen, Ammonia, as N, dissolved	00608	Salicylate-hypochlorite, automated-segmented flow, colorimetric	.01	mg/L
Phosphorus, as P, dissolved	00666	Phosphomolybdate, automated-segmented flow, colorimetric	.01	mg/L
Nitrogen, NH_4 +Organic, as N, dissolved	00623	Salicylate-hypochlorite, automated-segmented flow, colorimetric	.20	mg/L
Nitrogen, NH_4 +Organic, as N, total [1]	00625	Salicylate-hypochlorite, automated-segmented flow, colorimetric	.20	mg/L
Phosphorus, as P, total	00665	Phosphomolybdate, automated-segmented flow, colorimetric	.01	mg/L

[1] Surface water only.

Table B-12. *Analytical grouping of pesticides in filtered water analyzed by gas chromatography/mass spectrometry*

[Method detection limit per 40 CFR 136, Appendix B (U.S. Environmental Protection Agency, 1991b); µg/L, micrograms per liter.]

Compound name (common name)	Parameter code	Analytical method	Method detection limit	Reporting unit
Alachlor (Lasso)	46342	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	0.002	µg/L
Desethyl-Atrazine [1]	04040	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L
Atrazine (AAtrex)	39632	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.001	µg/L
Methyl-Azinphos (Guthion) [1]	82686	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.001	µg/L
Benfluralin (Benefin, Balan, Bonalin)	82673	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L
Butylate (Genate Plus, Sutan+)	04028	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L
Carbaryl (Sevin) [1,2]	82680	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.003	µg/L
Carbofuran (Furadan) [1,2]	82674	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.003	µg/L
Chlorpyrifos (Dursban)	38933	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.004	µg/L
Cyanazine (Bladex)	04041	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.004	µg/L
DCPA (Dacthal) [2]	82682	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L
p,p-DDE	34653	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.006	µg/L
Diazinon (Knox-Out)	39572	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L
Dieldrin (Panoram D-31)	39381	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.001	µg/L
Diethylanaline	82660	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.003	µg/L
Dimethoate [3] (Cygon)	82662	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.004	µg/L
Disulfoton (Di-Syston)	82677	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.017	µg/L
EPTC (Eptam)	82668	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L
Ethalfluralin (Sonalin)	82663	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.004	µg/L
Ethoprop (Mocap, Ethoprophos)	82672	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.003	µg/L
Fonofos	04095	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.003	µg/L
alpha-HCH	34253	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L
gamma-HCH (Lindane)	39341	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.004	µg/L
Linuron (Lorox, Linex) [2]	82666	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L
Malathion (Cythion)	39532	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.005	µg/L
Metolachlor (Dual)	39415	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L

Table B-12. *Analytical grouping of pesticides in filtered water analyzed by gas chromatography/mass spectrometry—Continued*

Compound name (common name)	Parameter code	Analytical method	Method detection limit	Reporting unit
Metribuzin (Lexone, Sencor)	82630	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	0.004	µg/L
Molinate (Ordram)	82671	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.004	µg/L
Napropamide (Devrinol)	82684	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.003	µg/L
Parathion (Parathion)	39542	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.004	µg/L
Methyl-Parathion (Penncap-M)	82667	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.006	µg/L
Pebulate (Tillam)	82669	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.004	µg/L
Pendimethalin (Prowl)	82683	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.004	µg/L
cis-Permethrin (Ambush)	82687	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.005	µg/L
Phorate (Thimet)	82664	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L
Prometon (Pramitol)	82676	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.018	µg/L
Pronamide (Kerb, Propyzamid)	04037	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.003	µg/L
Propachlor (Ramrod)	04024	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.007	µg/L
Propanil (Stampede)	82679	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.004	µg/L
Propargite (Omite, alkyl sulfite)	82685	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.013	µg/L
Simazine (Aquazine, Princep)	04035	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.005	µg/L
Tebuthiuron (Spike)	82670	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.010	µg/L
Terbacil (Sinbar) [1]	82665	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.007	µg/L
Terbufos (Counter)	82675	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.013	µg/L
Thiobencarb (Bolero)	82681	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L
Triallate (Avadex BW, FarGo)	82678	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.001	µg/L
Trifluralin (Treflan)	82661	Extracted on C-18 solid-phase extraction cartridge and analyzed by gas chromatography/mass spectrometric detector	.002	µg/L

[1] Analysis for this compound produces poor results. Values reported are estimates.
[2] Compound also analyzed by high pressure liquid chromatography (Table B-13).
[3] Compound dropped from analytical grouping in November 1994 due to poor performance.

Table B-13. *Analytical grouping of pesticides in filtered water analyzed by high-performance liquid chromatography*

[Method detection limit per 40 CFR 136, Appendix B (U.S. Environmental Protection Agency, 1991b); µg/L, micrograms per liter.]

Compound name (common name)	Parameter code	Analytical method	Method detection limit	Reporting unit
2,4,5-T, mono-acid- (Weedar)	39742	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	0.035	µg/L
2,4-D, mono-acid- (Dacamine)	39732	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
2,4-DB, mono-acid- (Butyrac)	38746	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Acifluorfen (Scepter, Blazer)	49315	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Aldicarb (Temik)	49312	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.016	µg/L
Aldicarb Sulfone (Standak)	49313	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.016	µg/L
Aldicarb Sulfoxide	49314	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.021	µg/L
Bentazon (Basagran)	38711	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.014	µg/L
Bromacil (Hyvar)	04029	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Bromoxynil (Buctril)	49311	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Carbaryl (Sevin) [1]	49310	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.08	µg/L
Carbofuran [1] (Furadan)	49309	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.028	µg/L
Carbofuran, 3-Hydroxy-	49308	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.014	µg/L
Chloramben (Amiben)	49307	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.011	µg/L
Chlorothalonil (Daconil)	49306	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Clopyralid (Stinger, Lontrel))	49305	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.050	µg/L
DCPA (Dacthal) [1]	49304	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.017	µg/L

Table B-13. *Analytical grouping of pesticides in filtered water analyzed by high-performance liquid chromatography—Continued*

[Method detection limit per 40 CFR 136, Appendix B (U.S. Environmental Protection Agency, 1991b); µg/L, micrograms per liter.]

Compound name (common name)	Parameter code	Analytical method	Method detection limit	Reporting unit
Dicamba, mono-acid- (Banvel)	38442	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	0.035	µg/L
Dichlobenil (Casoron)	49303	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.020	µg/L
Dichlorprop, mono-acid (Weedone)	49302	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.032	µg/L
Dinoseb (DNBP, Premerge)	49301	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Diuron (Karmex)	49300	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.020	µg/L
DNOC (Elgotol)	49299	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Esfenvalerate (Asana XL)	49298	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.019	µg/L
Fenuron	49297	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.013	µg/L
Fluometuron (Cotoran)	38811	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Linuron (Lorox, Linex) [1]	38478	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.018	µg/L
MCPA, mono-acid- (Weedar, Chiptox))	38482	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.050	µg/L
MCPB, mono-acid- (Thistrol)	38487	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Methiocarb (Mesurol)	38501	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.026	µg/L
Methomyl (Lannade)	49296	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.017	µg/L
1-Naphthol	49295	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.007	µg/L
Neburon	49294	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.015	µg/L
Norflurazon (Zorial)	49293	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.024	µg/L

Table B-13. *Analytical grouping of pesticides in filtered water analyzed by high-performance liquid chromatography—Continued*

[Method detection limit per 40 CFR 136, Appendix B (U.S. Environmental Protection Agency, 1991b); µg/L, micrograms per liter.]

Compound name (common name)	Parameter code	Analytical method	Method detection limit	Reporting unit
Oryzalin (Surflan)	49292	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	0.019	µg/L
Oxamyl (Vydate)	38866	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.018	µg/L
Picloram, mono-acid- (Tordon)	49291	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.050	µg/L
Propham (IPC, Chem-Hoe)	49236	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Propoxur (Baygon)	38538	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Silvex, mono-acid- (2,4,5-TP)	39762	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.035	µg/L
Triclopyr, mono-acid- (Turflon)	49235	Extracted on Carbopak B solid-phase extraction cartridge and analyzed by high-pressure liquid chromatography - diode array detection	.050	µg/L

[1] Compound also analyzed by gas chromatography/mass spectrometry (Table B-12).

Table B-14. *Analytical grouping of triazine herbicides in filtered water*

[Analyses performed by USGS Organic Geochemistry Research Laboratory, Lawrence, Kans.; µg/L, micrograms per liter.]

Constituent name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Triazines, as Atrazine, Total	34575	Immunoassay	0.1	µg/L

Table B-15. *Analytical grouping of dissolved trace elements in water*

[mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microseimens per centimeter at 25° Celsius.]

Name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
pH, determined in laboratory	00403	Electrometric, glass electrode	1	pH units
Specific conductance, determined in laboratory	90095	Electrometric, Wheatstone bridge	1	µS/cm
Barium	01005	Inductively coupled plasma	1	µg/L
Cobalt	01035	Inductively coupled plasma	3	µg/L
Iron	01046	Inductively coupled plasma	3	µg/L
Lead	01049	Inductively coupled plasma	1	µg/L
Manganese	01056	Inductively coupled plasma	1	µg/L
Molybdenum	01060	Inductively coupled plasma	1	µg/L
Strontium	01080	Inductively coupled plasma	.5	µg/L
Vanadium	01085	Inductively coupled plasma	6	µg/L
Beryllium	01010	Inductively coupled plasma	.5	µg/L
Copper	01040	Inductively coupled plasma	1	µg/L
Calcium	00915	Inductively coupled plasma	.02	mg/L
Magnesium	00925	Inductively coupled plasma	.01	mg/L
Lithium	01130	Inductively coupled plasma	4	µg/L
Silica	00955	Inductively coupled plasma	.01	mg/L
Zinc	01090	Inductively coupled plasma	3	µg/L
Cadmium	01025	Inductively coupled plasma	1	µg/L
Sodium	00930	Inductively coupled plasma	.2	mg/L
Nickel	01065	Inductively coupled plasma	1	µg/L
Chromium	01030	Inductively coupled plasma	5	µg/L
Silver	01075	Inductively coupled plasma	1	µg/L

Table B-16. *Analytical grouping of total recoverable trace elements in water*

[mg/L, milligrams per liter; µg/L, micrograms per liter.]

Element name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Barium	01007	Atomic absorption, spectrometric direct	100	µg/L
Beryllium	01012	Atomic absorption, spectrometric direct	1	µg/L
Cadmium	01027	Graphite furnace atomic absorption	1	µg/L
Chromium	01034	Graphite furnace atomic absorption	1	µg/L
Cobalt	01037	Graphite furnace atomic absorption	.2	µg/L
Copper	01042	Graphite furnace atomic absorption	1	µg/L
Iron	01045	Graphite furnace atomic absorption	1	µg/L
Lead	01051	Graphite furnace atomic absorption	1	µg/L
Manganese	01055	Atomic absorption, spectrometric direct	1	µg/L
Molybdenum	01062	Atomic absorption, spectrometric direct	1	µg/L
Nickel	01067	Graphite furnace atomic absorption	1	µg/L
Silver	01077	Graphite furnace atomic absorption	1	µg/L
Strontium	01082	Atomic absorption, spectrometric direct	1	µg/L
Zinc	01092	Atomic absorption, spectrometric direct	1	µg/L
Lithium	01132	Atomic absorption, spectrometric direct	1	µg/L
Calcium	00916	Atomic absorption, spectrometric direct	.1	mg/L
Magnesium	00927	Atomic absorption, spectrometric direct	.1	mg/L
Sodium	00929	Atomic absorption, spectrometric direct	.1	mg/L

Table B-17. *Analytical grouping of volatile organic compounds in water*

[μg/L, micrograms per liter.]

Compound name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Benzene	34030	Gas chromatography, mass spectrometry	0.2	μg/L
1,2,3-Trichlorobenzene	77613	Gas chromatography, mass spectrometry	.2	μg/L
1,2,4-Trichlorobenzene	34551	Gas chromatography, mass spectrometry	.2	μg/L
1,2,4-Trimethylbenzene	77222	Gas chromatography, mass spectrometry	.2	μg/L
1,2-Dichlorobenzene	34536	Gas chromatography, mass spectrometry	.2	μg/L
1,3,5-Trimethylbenzene	77226	Gas chromatography, mass spectrometry	.2	μg/L
1,3-Dichlorobenzene	34566	Gas chromatography, mass spectrometry	.2	μg/L
1,4-Dichlorobenzene	34571	Gas chromatography, mass spectrometry	.2	μg/L
2-Chlorotoluene	77275	Gas chromatography, mass spectrometry	.2	μg/L
4-Chlorotoluene	77277	Gas chromatography, mass spectrometry	.2	μg/L
Isopropylbenzene	77223	Gas chromatography, mass spectrometry	.2	μg/L
Bromobenzene	81555	Gas chromatography, mass spectrometry	.2	μg/L
Chlorobenzene	34301	Gas chromatography, mass spectrometry	.2	μg/L
Dimethylbenzene	81551	Gas chromatography, mass spectrometry	.2	μg/L
Ethylbenzene	34371	Gas chromatography, mass spectrometry	.2	μg/L
p-Isopropyltoluene	77356	Gas chromatography, mass spectrometry	.2	μg/L
Methylbenzene	34010	Gas chromatography, mass spectrometry	.2	μg/L
n-Butylbenzene	77342	Gas chromatography, mass spectrometry	.2	μg/L
n-Propylbenzene	77224	Gas chromatography, mass spectrometry	.2	μg/L
sec-Butylbenzene	77350	Gas chromatography, mass spectrometry	.2	μg/L
tert-Butylbenzene	77353	Gas chromatography, mass spectrometry	.2	μg/L
1,1,1,2-Tetrachloroethane	77562	Gas chromatography, mass spectrometry	.2	μg/L
1,1,1-Trichloroethane	34506	Gas chromatography, mass spectrometry	.2	μg/L
1,1,2,2-Tetrachloroethane	34516	Gas chromatography, mass spectrometry	.2	μg/L
1,1,2-Trichloroethane	34511	Gas chromatography, mass spectrometry	.2	μg/L
1,1-Dichloroethane	34496	Gas chromatography, mass spectrometry	.2	μg/L
1,2-Dibromoethane	77651	Gas chromatography, mass spectrometry	.2	μg/L
1,2-Dichloroethane	32103	Gas chromatography, mass spectrometry	.2	μg/L
Chloroethane	34311	Gas chromatography, mass spectrometry	.2	μg/L
1,1,2-Trichloro-1,2,2-trifluoroethane	77652	Gas chromatography, mass spectrometry	.2	μg/L
1,1-Dichloroethene	34501	Gas chromatography, mass spectrometry	.2	μg/L
Chloroethene	39175	Gas chromatography, mass spectrometry	.2	μg/L
cis-1,2-Dichloroethene	77093	Gas chromatography, mass spectrometry	.2	μg/L
Tetrachloroethene	34475	Gas chromatography, mass spectrometry	.2	μg/L
trans-1,2-Dichloroethene	34546	Gas chromatography, mass spectrometry	.2	μg/L
Trichloroethene	39180	Gas chromatography, mass spectrometry	.2	μg/L
Hexachlorobutadiene	39702	Gas chromatography, mass spectrometry	.2	μg/L
Bromomethane	34413	Gas chromatography, mass spectrometry	.2	μg/L
Bromochloromethane	77297	Gas chromatography, mass spectrometry	.2	μg/L
Bromodichloromethane	32101	Gas chromatography, mass spectrometry	.2	μg/L
Chloromethane	34418	Gas chromatography, mass spectrometry	.2	μg/L
Dibromomethane	30217	Gas chromatography, mass spectrometry	.2	μg/L
Chlorodibromomethane	32105	Gas chromatography, mass spectrometry	.2	μg/L
Dichloromethane	34423	Gas chromatography, mass spectrometry	.2	μg/L
Dichlorodifluoromethane	34668	Gas chromatography, mass spectrometry	.2	μg/L
Tetrachloromethane	32102	Gas chromatography, mass spectrometry	.2	μg/L
Tribromomethane	32104	Gas chromatography, mass spectrometry	.2	μg/L

Table B-17. *Analytical grouping of volatile organic compounds in water—Continued*

[μg/L, micrograms per liter.]

Compound name	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Trichloromethane	32106	Gas chromatography, mass spectrometry	0.2	μg/L
Trichlorofluoromethane	34488	Gas chromatography, mass spectrometry	.2	μg/L
Methyl *tert*-butyl ether	78032	Gas chromatography, mass spectrometry	.2	μg/L
Naphthalene	34696	Gas chromatography, mass spectrometry	.2	μg/L
1,2,3-Trichloropropane	77443	Gas chromatography, mass spectrometry	.2	μg/L
1,2-Dibromo-3-chloropropane	82625	Gas chromatography, mass spectrometry	1.0	μg/L
1,2-Dichloropropane	34541	Gas chromatography, mass spectrometry	.2	μg/L
1,3-Dichloropropane	77173	Gas chromatography, mass spectrometry	.2	μg/L
2,2-Dichloropropane	77170	Gas chromatography, mass spectrometry	.2	μg/L
1,1-Dichloropropene	77168	Gas chromatography, mass spectrometry	.2	μg/L
cis-1,3-Dichloropropene	34704	Gas chromatography, mass spectrometry	.2	μg/L
trans-1,3-Dichloropropene	34699	Gas chromatography, mass spectrometry	.2	μg/L
Styrene	77128	Gas chromatography, mass spectrometry	.2	μg/L

Table B-18. *Miscellaneous ground-water-quality analytes*

[Analyses performed by USGS National Water-Quality Laboratory, Arvada, Colo., or USGS Pennsylvania District Laboratory, Lemoyne, Pa.; --, no data; mg/L, milligrams per liter; μg/L, micrograms per liter; °C, degrees Celsius; mL, milliliters; pCi/L, picoCuries per liter.]

Analyte name (abbreviation/acronym)	Parameter code	Analytical method	Minimum reporting level	Reporting unit
Methylene Blue Active Substances (MBAS)	38260	Spectrophotometry	0.01	mg/L
Dissolved Organic Carbon (DOC)	00681	Ultraviolet promoted persulfate oxidation and infared spectrometry	.1	mg/L
Coliform, total	31501	24-hour incubation, 35°C, m-Endo media	1	colonies per 100 mL
Coliform, fecal	31625	24-hour incubation, 44.5°C, m-Fc media	1	colonies per 100 mL
Streptococci, fecal	31673	48-hour incubation, 35°C, KF media	1	colonies per 100 mL
Escherichia coli	31633	4-hour confirmation test, 35°C, NA-MUG media	1	colonies per 100 mL
Uranium, natural, as U, dissolved	22703	Fluorometry [1]	1.0	μg/L
Uranium, natural, 2 sigma, dissolved	75900	Fluorometry [1]	--	μg/L
Uranium, natural, as U, dissolved	22703	Laser phosphorescence [2]	.4	μg/L
Uranium, natural, 2 sigma, dissolved	75900	Laser phosphorescence [2]	--	μg/L
Radon 222, total	82303	Liquid scintillation	24+	pCi/L
Radon 222, 2 sigma	76002	Liquid scintillation	--	pCi/L
Tritium, total	07000	Electrolytic enrichment, liquid scintillation	1.0	pCi/L
Tritium, 2 sigma, total	75985	Electrolytic enrichment, liquid scintillation	--	pCi/L
H-2/H-1 stable isotope ratio	82082	Isotope ratio mass spectrometry	--	per mil
O-18/O-16 stable isotope ratio	82085	Isotope ratio mass spectrometry	--	per mil

[1] 1993.
[2] 1994 and 1995.

Table B-19. *Habitat characteristics*

[Unless otherwise noted, characteristic applies to entire stream reach.]

Characteristic	Reporting unit(s)	Notes
Reach conditions	Text	Description of general conditions of stream reach
Geomorphic channel unit length(s)	Meters	Recorded for each pool, riffle, and run greater than 50 percent of channel width
Reach length	Meters	Measured at thalweg along reach
Stream type	Descriptive keyword	Keyword selected from predefined list
Channel width	Meters	Measured at each of four to six transects within stream reach
Bank width	Meters	Measured at each of four to six transects within stream reach
Flood-plain width	Meters	Measured at each of four to six transects within stream reach
Depth of stream	Feet and centimeters	Measured at three points along each transect
Stream-flow velocity	Feet/second and centimeters/second	Measured with meter appropriate for depth and velocity conditions at three points along each transect
Bed substrate	Code(s)	Code(s) selected from predefined list
Embeddedness	Code (percentage)	Code selected from predefined list
Canopy angle	Degrees	Value between 0 and 180 degrees
Stream aspect	Degrees	Value between 0 and 360 degrees
Habitat features	Code(s)/percentage(s)	Code(s) selected from predefined list
Bar/shelf/island width	Meters	Measured for each bar, shelf, or island within stream reach
Bank angle	Degrees	Measured for both left and right banks at each transect
Bank height	Meters	Measured for both left and right banks at each transect
Bank vegetation stability	Code	Code selected from predefined list; recorded for both left and right banks at each transect
Bank shape	Code	Code selected from predefined list; recorded for both left and right banks at each transect
Bank erosion	Code(s)	Code(s) selected from predefined list; recorded for both left and right banks at each transect
Bank substrate	Code(s)	Code(s) selected from predefined list; recorded for both left and right banks at each transect
Bank woody vegetation	List	Recorded for both left and right banks at each transect
Aquatic and riparian vegetation species	List, rank (5 most dominant)	Recorded for both left and right banks at each transect
Comments	Text	Other pertinent ancillary information concerning habitat assessment of stream reach at each transect