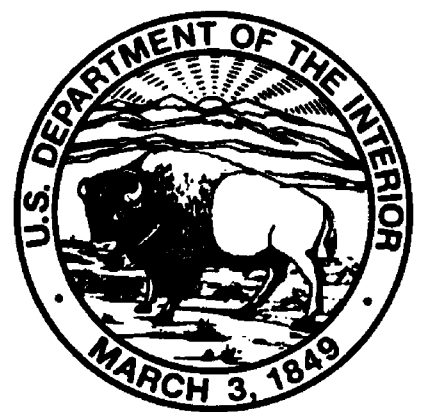


**GEOGRAPHIC INFORMATION SYSTEM DATA SETS  
OF HYDROGEOLOGIC CONDITIONS  
IN PEQUEA AND MILL CREEK WATERSHEDS, PENNSYLVANIA:  
PART I—BASIC DATA**

*by Diana L. Dugas, Stephen J. Char, and Gary E. Baumbach*

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**PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES,  
BUREAU OF WATER QUALITY MANAGEMENT**

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## CONVERSION FACTORS AND ABBREVIATIONS

<u>Multiply</u>		<u>By</u>		<u>To obtain</u>
			Length	
foot (ft)		0.3048		meter
			Area	
square mile (mi <sup>2</sup> )		2.590		square kilometer

**Sea level:** In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

# GEOGRAPHIC INFORMATION SYSTEM DATA SETS OF HYDROGEOLOGIC CONDITION IN PEQUEA AND MILL CREEK WATERSHEDS, PENNSYLVANIA: PART I—BASIC DATA

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## ABSTRACT

This report describes basic data used to develop Geographic Information System data sets of bedrock geology, sinkholes and closed depressions, and spring and well locations attributed with hydrogeologic and water-quality data in the Pequea and Mill Creek watersheds, a 210-square-mile area in Lancaster and Chester Counties, Pa. The data sets, which do not contain hydrogeologic interpretations, were developed by the use of ARC/INFO software during 1990-93 by the U.S. Geological Survey, in cooperation with the Pennsylvania Department of Environmental Resources. Associated data sets of ground-water levels, unsaturated-zone thickness, and regolith thickness incorporate hydrogeologic interpretations and are described along with associated basic data in a companion report. The U.S. Environmental Protection Agency proposes to use these noninterpretive and interpretive data sets, and those from other sources, to aid in the assessment of ground-water vulnerability to pesticides in the Pequea and Mill Creek watersheds.

## INTRODUCTION

During 1990-93, the U.S. Geological Survey (USGS), Water Resources Division, in cooperation with the Pennsylvania Department of Environmental Resources, developed Geographic Information System (GIS) data sets of selected hydrogeologic conditions in the Pequea and Mill Creek watersheds in Lancaster and Chester Counties, Pa. As used in this report, a data set is a set of thematically-associated data considered as a unit (Environmental Systems Research Institute, Inc., 1992). A data set contains spatial and tabular information in a digital format and may include polygon, line, and point features. A data set usually represents a single theme, for example, bedrock geology. Data sets of bedrock geology, sinkholes and closed depressions, and spring and well locations attributed with hydrogeologic and water-quality data were developed by the use of ARC/INFO<sup>1</sup> software. Related hydrogeologic data attributes include specific yield and hydraulic conductivity, and related water-quality data attributes collected during May and October 1991 include water temperature, specific conductance, dissolved oxygen, pH, alkalinity, and total phosphorus. This report describes the data sets that do not contain hydrogeologic interpretations. Associated data sets of ground-water levels, unsaturated-zone thickness, and regolith thickness incorporate hydrogeologic interpretations and are described along with the attribute data in a companion report (Low and others, 1995). The U.S. Environmental Protection Agency proposes to use these data sets, and those developed by other agencies, to aid in the assessment of ground-water vulnerability to pesticides in the Pequea and Mill Creek watersheds.

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<sup>1</sup> Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

## Purpose and Scope

This report describes GIS data sets of bedrock geology, sinkholes and closed depressions, and spring and well locations with related hydrogeologic and water-quality data, collected or compiled during 1990-93, for the Pequea and Mill Creek watersheds. The report presents a general discussion of the effects of bedrock geology and sinkholes and closed depressions on ground-water vulnerability to contamination. The report also identifies sources of data and methods used to develop the data sets.

## Study Area

The study area consists of the Pequea and Mill Creek watersheds, which together comprise 210 mi<sup>2</sup> in Lancaster and Chester Counties in south-central Pennsylvania (fig. 1). The area is covered by the Lancaster, Leola, New Holland, Honey Brook, Parkesburg, Gap, Quarryville, and Conestoga 7.5-minute topographic quadrangle maps published by USGS.

The study area is in the Piedmont Lowland and Upland Sections of the Piedmont Physiographic Province. The Piedmont Lowland Section is typically underlain by carbonate rocks that form broad valleys separated by low hills. Karstic terrane is common in the Piedmont Lowland Section. The Piedmont Upland Section is generally underlain by noncarbonate rocks that form broad, gently rolling hills and valleys. Land-surface elevations in the study area range from 169 ft above sea level at Lake Aldred on the Susquehanna River to 1,107 ft above sea level at Welsh Mountain near New Holland.

The Pequea and Mill Creek watersheds are predominantly rural, and agriculture is the major land use. The watersheds do not contain any large industrial or municipal centers. Production of corn and small grains and maintenance of pastures are the principal agricultural activities. Farmsteads and pastures are usually concentrated near streams. Most farmers maintain a herd of dairy cattle, and milk is a major local commodity.

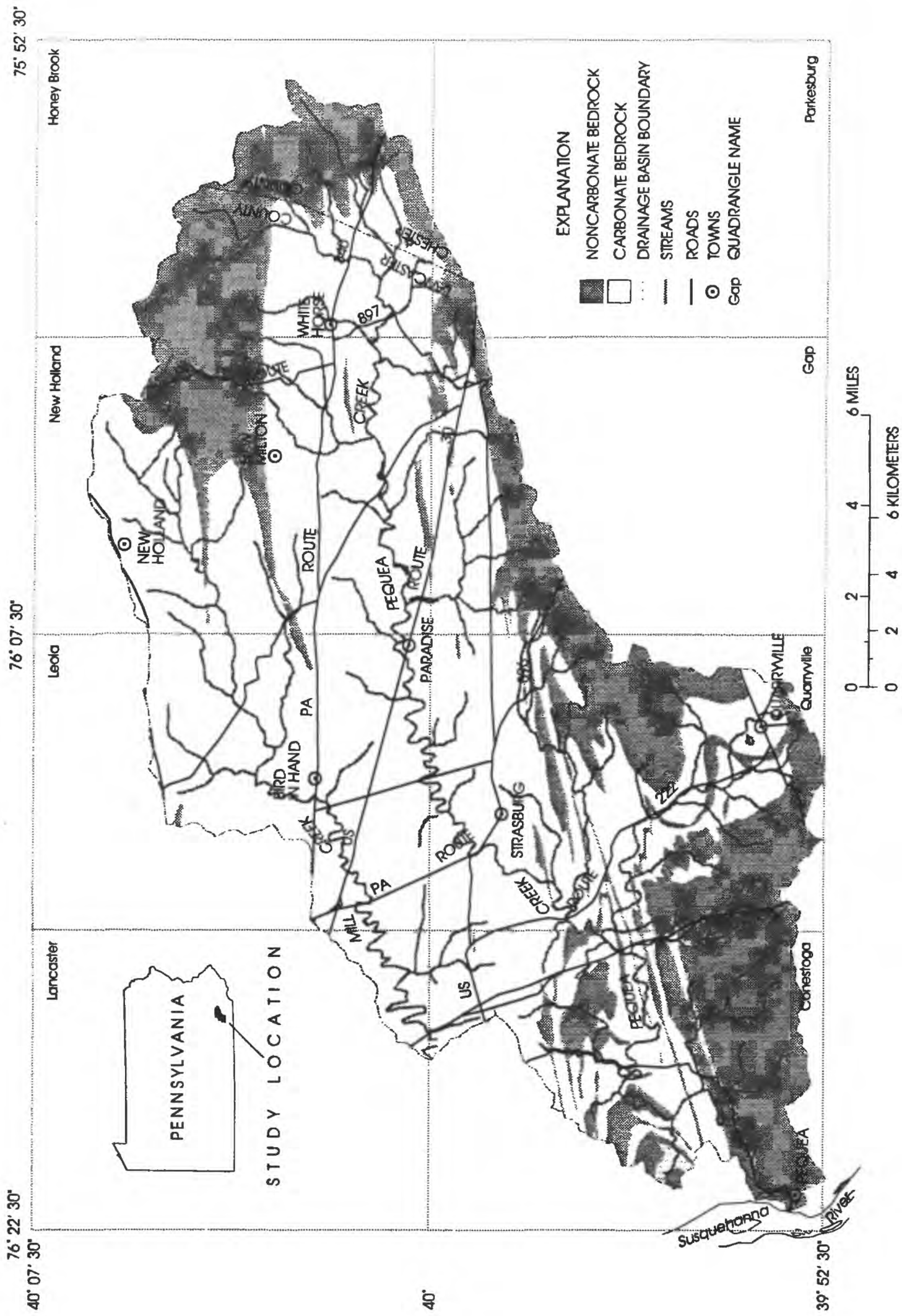
## Geologic Setting

The Pequea and Mill Creek watersheds are underlain by carbonate and noncarbonate rocks of Cambrian, Ordovician, and Triassic age (fig. 1). Carbonate rocks, composed primarily of limestone and dolomite, underlie about two-thirds of the study area. Topographic relief in areas underlain by carbonate rocks is low. Noncarbonate metamorphic rocks underlie about one-third of the study area, mainly along the southern and eastern margins. Topographic relief in areas underlain by noncarbonate rocks is moderate. Locally, noncarbonate igneous rocks, in the form of Triassic-age dikes, are present in the eastern part of the study area.

Rocks in the Pequea and Mill Creek watersheds have undergone several phases of deformation resulting from tectonic stresses. These stresses have produced intense folding and faulting throughout the study area. Folding and faulting can result in zones of concentrated fractures that act as preferential pathways for ground-water flow.

## Acknowledgments

The authors acknowledge the assistance and information provided by various agencies, organizations, and individuals whose efforts enabled successful completion of the project upon which this report is based. The U.S. Environmental Protection Agency provided incentive and overall coordination for the project. The Pennsylvania Department of Environmental Resources actively participated in the design of the project, furnished essential data, and, through the USGS Federal-State Cooperative Water-Resources Program, provided financial support for the project. Many well owners and several well drillers furnished essential information and permitted measurement of water levels and collection of water samples from wells.



**Figure 1.**—Location of Pequea and Mill Creek watersheds, topographic quadrangle boundaries and names, and extent of carbonate and noncarbonate bedrock.



## GEOGRAPHIC INFORMATION SYSTEM DATA SETS

During 1990-93, GIS data sets of bedrock geology, sinkholes and closed depressions, and spring and well locations attributed with hydrogeologic and water-quality data were developed by the use of ARC/INFO software. Sources of data and methods used to develop the data sets are discussed in subsequent sections of this report. A summary of features, attributes, data sources, and digitizing methods for the data sets is shown in table 1. The actual data sets and accompanying documentation are contained in a computerized data base maintained by the USGS office in Lemoyne, Pa.

### Bedrock Geology

Bedrock geology is an important factor that affects potential for contaminant movement from the land surface to the ground-water reservoir. Bedrock types that favor rapid infiltration of recharge water and accompanying contaminants inherently provide less protection against ground-water contamination than types that favor gradual percolation or inhibit percolation entirely. In the Pequea and Mill Creek watersheds, noncarbonate rocks generally provide greater protection against ground-water contamination than carbonate rocks. The level of protection, however, depends partly on the degree of fracturing in the bedrock and the mineralogical composition and thickness of regolith (including transported material and weathered rock) overlying the bedrock.

The GIS data set of bedrock geology (geology) consists of linear features for fault traces or contacts (exclusive of Triassic-age dikes) and polygonal features for carbonate- and noncarbonate-lithology identification and geologic-formation names (table 1). The data set was developed by manually plotting geologic features on 1:24,000-scale USGS 7.5-minute topographic quadrangle maps, digitizing the features, joining the data sets for each quadrangle together by edgematching, and projecting the resulting data set into the Albers (meters) coordinate system. Carbonate and noncarbonate lithologies were interpreted from the geologic-formation names. The geologic-source maps were prepared originally by the Pennsylvania Department of Environmental Resources, Bureau of Topographic and Geologic Survey, for use in a statewide geologic map (Berg and others, 1980). Copies of the original source maps at a reduced scale are presented in Berg and Dodge (1981). Because non-USGS source materials were used to develop the data set of bedrock geology, the USGS cannot guarantee that these materials conform to National Map Accuracy Standards.

### Sinkholes and Closed Depressions

Sinkholes—depressions in the land surface connected to subsurface passages or caverns—are features that provide a direct pathway for contaminant movement from the land surface to the ground-water reservoir. Carbonate rocks containing sinkholes and large, interconnected solution channels and fractures are particularly susceptible to ground-water contamination from surface sources. Closed depressions—indentations in the land surface with no direct outlet to the subsurface—are features that increase potential for contaminant movement to the subsurface by detention and infiltration of surface water and accompanying contaminants. Closed depressions can develop into sinkholes through the processes of dissolution and caving.

The GIS data set of sinkholes and closed depressions (snkdepr) is a set of points representing locations of these features in the Pequea and Mill Creek watersheds in Lancaster County (table 1). The data set was developed by manually digitizing the point locations of sinkholes and closed depressions from 1:24,000-scale mylar source maps for each 7.5-minute topographic quadrangle. The data sets for each quadrangle were joined together by edgematching. The resulting data set was projected into the Albers (meters) coordinate system. The original source maps were prepared by the Pennsylvania Department of Environmental Resources, Bureau of Topographic and Geologic Survey, for publication in a report describing sinkholes and karst-related features in Lancaster County (Kochanov, 1989). Because non-USGS source materials were used to develop the data set of sinkholes and closed depressions, the USGS cannot guarantee these materials conform to National Map Accuracy Standards.



**Table 1. Type of feature, attribute data, relational environment, original data source, and digitizing method used for Geographic Information System data sets**

Data set	Feature	Attribute data	Related name	Related file	Related items	Original source	Digitizing method
geology	line	Indicator of fault feature (fault)	geohydr1	geology.geoh	frmn	PaDER <sup>1</sup>	Digitized from mylar and paper manuscript maps
	polygon	Formation code (frmn) carbonate lithology indicator (carb)	frmndefs	geology.frmn	frmn		
snkdepr	point	Indicator of sinkhole or closed depression (snk)				PaDER <sup>2</sup>	Digitized from mylar manuscript maps
gws	point	Site identification number (sid) Station name or local number (sname) Latitude (slat) Longitude (slong) Type of ground-water site (sgwtyp) Gage or land-surface datum (sdatum) Well depth (swdept) Date of construction (cdcodt) Method of construction (cdcome) Type of finish (cdcofi) Depth of bottom of casing interval (cdcsbt) Aquifer code (saqufr) Owner's name (mgdonm) Site identification number (siteid) Description of measuring point (cdmprm)	qw_rel sc_rel zn_rel wl_rel wtyp_rel nut_rel pst1_rel pst2_rel qwfld_rel	gws1.qw gws1.sc gws1.zn gws1.w1 gws1.pat gws1.nut gws1.pst1 gws1.pst2 gws1.qwfld	sid sid sid sid sid sid sid sid sid	USGS <sup>3</sup>	Converted from ASCII format into ARC/INFO format by use of CREATEPOINT.AML

<sup>1</sup> Berg and others, 1980; Berg and Dodge, 1981.

<sup>2</sup> Kochanov, 1989.

<sup>3</sup> U.S. Geological Survey Ground-Water Site Inventory data base.

## Spring and Well Locations

The GIS data set of spring and well locations (gws) is a set of points representing locations of these features in the Pequea and Mill Creek watersheds (table 1). The data set was developed by retrieving geographic coordinates and other associated information from the USGS Ground-Water Site Inventory (GWSI) data base (Babcock and others, 1992), creating a formatted ASCII file for springs and wells located within the Pequea and Mill Creek watersheds. A point data set was generated from the ASCII file by the use of createpoint.aml, an ARC/INFO macro level program developed by the USGS. The data set contains records for 398 wells and 19 springs; the data have been field-checked and verified to within one second of latitude and longitude by the USGS.

## Ground-Water Quality

Related ARC/INFO files are associated with the spring and well locations data set by the site identification number (sid, table 1). These files contain data on parameter codes (gws.qw), field measurements (gws.qwfld), pesticide and nutrient concentrations (gws.pst1, gws.pst2, and gws.nut), specific capacities (gws.sc), water-bearing zones (gws.zn), and water levels (gws.wl). Water-quality samples along with field and water-level measurements were collected during May and October 1991 at selected ground-water sites within the Pequea and Mill Creek watersheds. Field measurements include water temperature, specific conductance, dissolved oxygen, pH, and alkalinity. Laboratory measurements include total nitrate (table 2), total phosphorus, orthophosphorus, and triazine herbicides (table 2). Figure 2 shows the location of all sites sampled for water-quality analyses. The water-quality data result from chemical analyses of samples collected from springs and wells during the indicated months. Water samples were collected and analyzed in accordance with established USGS protocols and the Quality Assurance Project Plan. Field and chemical data were reported by Durlin and Schaffstall (1993).

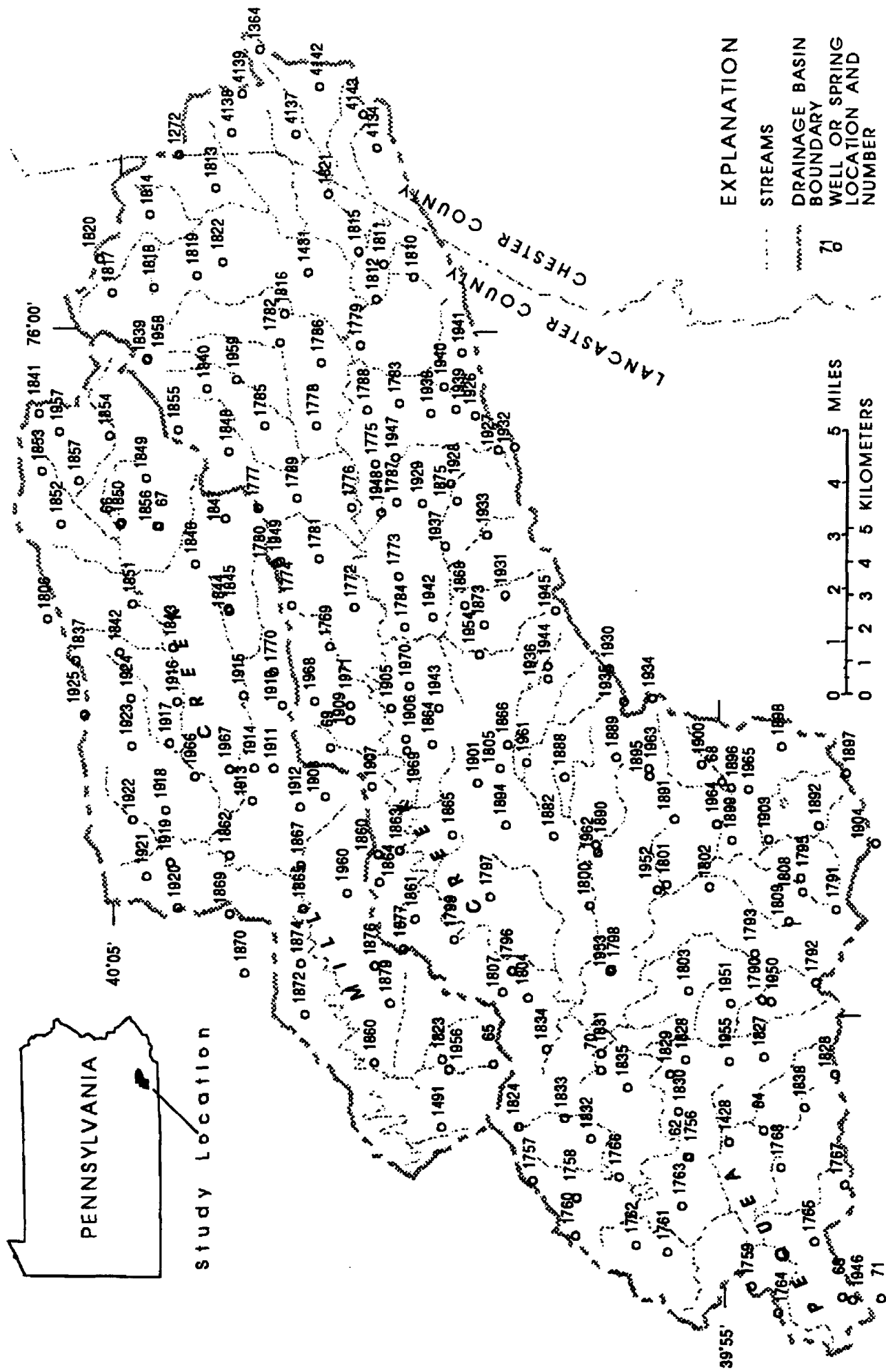
**Table 2.** Summary of chemical analyses of nitrate and herbicide concentrations in water from wells and springs in the Pequea and Mill Creek watersheds during May and October 1991

[Concentrations are in micrograms per liter unless otherwise noted; mg/L, milligram per liter; MCL, maximum contaminant level; --, no data]

Constituent	Minimum reporting level <sup>1</sup>	MCL <sup>2</sup>	Springs						Wells					
			May 1991			October 1991			May 1991			October 1991		
			Total number of samples	Below minimum reporting level	Above MCL	Total number of samples	Below minimum reporting level	Above MCL	Total number of samples	Below minimum reporting level	Above MCL	Total number of samples	Below minimum reporting level	Above MCL
Nitrogen, nitrate, total, mg/L as N	0.04	10	8	0	4	10	0	3	185	4	92	176	3	90
Alachlor, dissolved	.05	2	1	1	0	1	1	0	19	18	1	7	17	0
Ametryn, dissolved	.05	--	1	1	0	1	1	0	19	19	0	17	17	0
Atrazine, dissolved	.05	3	1	0	0	1	0	0	19	12	0	17	10	0
Cyanazine, dissolved	.2	--	1	1	0	1	1	0	19	19	0	17	17	0
Deethylatrazine, dissolved	.05	--	1	0	--	1	0	--	19	5	--	17	3	--
Deisopropylatrazine, dissolved	.05	--	1	1	0	1	0	--	19	16	--	17	13	--
Metolachlor, dissolved	.05	--	1	1	0	1	1	0	19	17	--	17	15	--
Metribuzin, dissolved	.05	--	1	1	0	1	1	0	19	19	0	17	17	0
Propazine, dissolved	.05	--	1	1	0	1	1	0	19	18	--	17	17	0
Prometon, dissolved	.05	--	1	0	--	1	0	--	19	16	--	17	13	--
Prometryn, dissolved	.05	--	1	1	0	1	1	0	19	19	0	17	17	0
Simazine, dissolved	.05	4	1	0	0	1	1	0	19	17	0	17	12	0
Triazine, screen (ELISA), dissolved (µg/L as atrazine)	.1	--	8	3	--	10	4	--	180	94	--	173	82	--

<sup>1</sup> Minimum reporting level is the smallest measured concentration of a constituent that may be reliably reported using an given analytical method.

<sup>2</sup> U.S. Environmental Protection Agency, 1993.



**Figure 2.**—Location of water-quality sampling sites and associated site identification number for the Pequea and Mill Creek watersheds.

## SUMMARY

This report describes basic data used to develop Geographic Information System data sets of bedrock geology, sinkholes and closed depressions, and spring and well locations with related hydrogeologic and water-quality data for the Pequea and Mill Creek watersheds. These watersheds comprise 210 mi<sup>2</sup> in Lancaster and Chester Counties, Pa., and are located in the Piedmont Lowland and Upland Sections of the Piedmont Physiographic Province. About two-thirds of the study area is underlain by carbonate rocks and the remaining one-third is underlain by noncarbonate metamorphic and igneous rocks. Data sets of bedrock geology and sinkholes and closed depressions were developed from 1:24,000-scale source maps prepared originally by the Pennsylvania Department of Environmental Resources, Bureau of Topographic and Geologic Survey. The data set of spring and well locations was developed from verified information from the USGS data base. The U.S. Environmental Protection Agency proposes to use these data sets and those from other sources to aid in the assessment of ground-water vulnerability to pesticides in the Pequea and Mill Creek watersheds.

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