GEOGRAPHIC INFORMATION SYSTEM DATA SETS OF HYDROGEOLOGIC CONDITIONS IN PEQUEA AND MILL CREEK WATERSHEDS, PENNSYLVANIA: PART II—HYDROGEOLOGIC INTERPRETATIONS

by Dennis J. Low, Douglas C. Chichester, and Stephen J. Char

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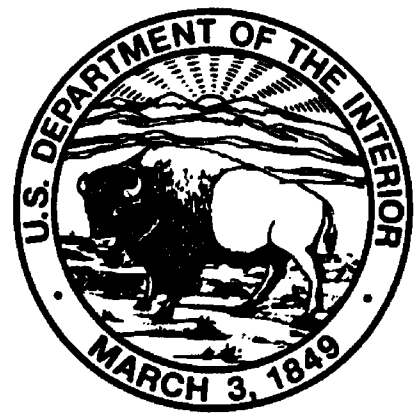

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CONTENTS

ILLUSTRATION

TABLE

CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
	Area	
square mile (mi^2)	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.

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ABSTRACT

This report describes Geographic Information System data sets of ground-water levels, unsaturated-zone thickness, and regolith thickness in the Pequea and Mill Creek watersheds, a 210-square-mile area in Lancaster and Chester Counties, Pa. The data sets, which represent 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 bedrock geology, sinkholes and closed depressions, and spring and well locations attributed with hydrogeologic and water-quality data, which do not contain hydrogeologic interpretations, are described along with associated basic data in a companion report. The U.S. Environmental Protection Agency proposes to use these interpretive and noninterpretive 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 (PaDER), 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, ground-water levels. Data sets of ground-water levels, unsaturated-zone thickness, and regolith thickness were developed by the use of ARC/INFO[1] software. This report describes the data sets that incorporate hydrogeologic interpretations. Associated data sets of bedrock geology, sinkholes and closed depressions, and attributed spring and well locations, which do not contain hydrogeologic interpretations, are described along with associated basic data in a companion report (Dugas and others, 1995). The U.S. Environmental Protection Agency proposes to use these interpretive and noninterpretive 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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[1] 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 ground-water levels, unsaturated-zone thickness, and regolith thickness in the Pequea and Mill Creek watersheds. The report identifies sources of data and methods used to develop the data sets. The report also presents a general discussion of the effects of unsaturated-zone thickness and regolith thickness on ground-water vulnerability to contamination.

Study Area

The study area consists of the Pequea and Mill Creek watersheds, which together comprise 210 mi^2 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 the 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 the successful completion of the project on 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.

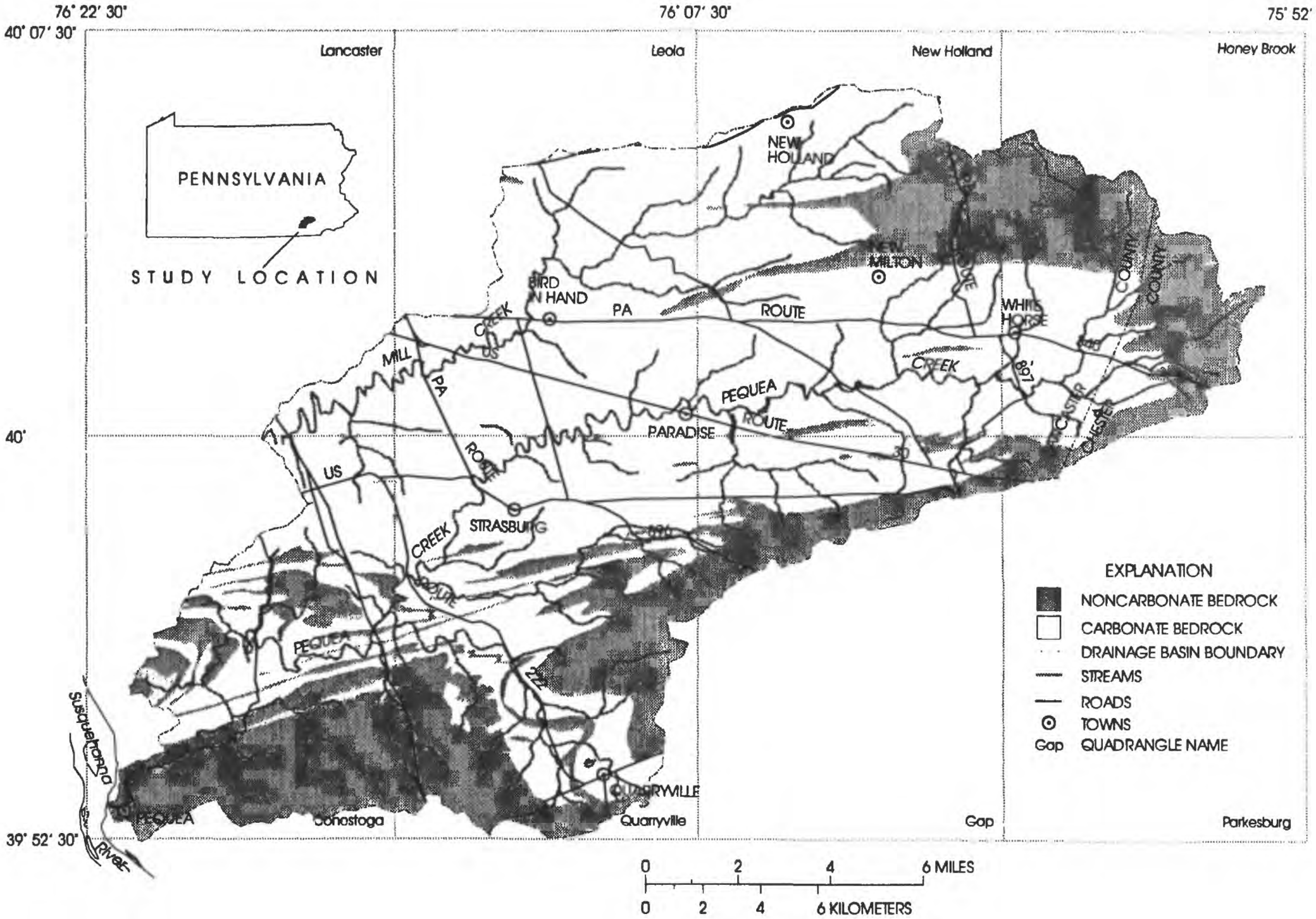

Figure 1.—Location of Pequea and Mill Creek watersheds, topographic quadrangle boundaries and names, and extent of carbonate and noncarbonate bedrock.

GEOGRAPHIC INFORMATION SYSTEM DATA SETS

During 1990-93, GIS data sets of ground-water levels, unsaturated-zone thickness, and regolith thickness were developed by the use of ARC/INFO software. Sources of data and methods used to develop these 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.

Ground-Water Levels

The GIS data set, watercont (table 1), is a digital representation of ground-water levels in the Pequea and Mill Creek watersheds for May and October 1991 and has line and polygon features. For each quadrangle within the study area, contours of water-level elevations were manually drawn on a mylar sheet underlain by a 1:24,000 scale, 7.5-minute paper topographic quadrangle map. Ground-water levels were measured synoptically during May and October 1991 in 166 wells and stream-level elevations provided primary control points. Each contour was drawn at an interval of 40 ft. The quadrangle mylars were electronically scanned to create a digital data set, which, after correcting any scanning or digitizing errors, was projected into the Albers (meters) coordinate system. The eight data sets were appended into a single data set and the line and polygon features were attributed by referencing the data-set features to associated features on the source maps. Because the wells are finished at various depths and in various geologic formations, the water levels measured do not necessarily represent hydraulic heads in a single, uniform ground-water flow system.

Unsaturated-Zone Thickness

Thickness of the unsaturated zone, or the vertical interval between the land surface and the upper surface of the ground-water reservoir, is an important factor that affects potential for ground-water contamination by surface sources. This interval represents the thickness of unsaturated material through which water and accompanying contaminants must travel before reaching the ground-water reservoir. The hydraulic and physical characteristics of the unsaturated zone partly determine the contact time of water with the surrounding soil and rock matrix. Generally, potential for contamination decreases as unsaturated-zone thickness increases because of greater contact times and greater opportunity for physical, chemical, and biological attenuation of contaminants.

The GIS data set, unsatzn, is a digital representation of unsaturated-zone thickness contours in the Pequea and Mill Creek watersheds for May 1991 and has line and polygon features. For each quadrangle within the study area, contours of unsaturated-zone thickness were developed by superimposing the mylar source map of water-level elevations on its associated 1:24,000-scale, 7.5-minute paper topographic quadrangle map, computing the numerical difference between the water-level and land-surface elevations at points of contour intersection, and manually contouring the resultant point values of unsaturated-zone thickness on a mylar sheet. Each contour was drawn at an interval of 40 ft. Ground-water levels measured synoptically during May 1991 in 75 wells and stream-level and associated land-surface elevations from the topographic maps provided primary control for the contouring process. The contours of unsaturated-zone thickness for each quadrangle mylar were manually digitized to create a digital data set, which, after correcting any digitizing errors, was projected into the Albers (meters) coordinate system. The eight data sets were appended into a single data set and the line and polygon features were attributed by referencing the data-set features to their associated features on the source maps. Although the measured water levels do not necessarily represent the water table, they provide the best available estimate of the elevation of the upper surface of the ground-water reservoir.

Table 1. Type of feature, attribute data, data source, and digitizing methods used for interpretive Geographic Information System data sets

[F&M, Franklin and Marshall College; PaDER, Pennsylvania Department of Environmental Resources; USGS, U.S. Geological Survey]

Data set	Feature	Attribute data	Original source	Digitizing method
watercont	line polygon	Water level elevation (welev)	USGS[1]	Scanned from mylar sheets on which contour lines were manually drawn
unsatzn	line polygon	Unsaturated zone thickness(uszn) Unsaturated zone thickness (uszn)	USGS[1]	Digitized from mylar sheets on which contour lines were manually drawn
bedrock_pt	point	Depth to bedrock (depth) Type of feature (type)	USGS[2] PaDER[3] F&M[4]	Digitized from paper maps
bedrock_arc	line	Depth to bedrock (depth) Type of feature (type)	USGS[2] PaDER[3] F&M[4]	Digitized from paper maps
bedrock_exp	line polygon	Depth to bedrock (depth) Type of feature (type)	USGS[2] PaDER[3] F&M[4]	Digitized from paper maps on which interpolated contour lines were manually drawn
bedrock_cont	line polygon	Bedrock contour at 20 foot depth	USGS[2] PaDER[3] F&M[4]	Digitized from paper maps on which interpolated contour lines were manually drawn

[1] Performed by USGS personnel (USGS 1:24,000 7.5-minute topographic quadrangle map).

[2] Exposed bedrock locations identified and verified by USGS personnel.

[3] Exposed bedrock locations identified by Pennsylvania Topographic and Geological Survey personnel.

[4] Exposed bedrock location identified by senior geology students at Franklin and Marshall College, Lancaster, Pa.

Regolith Thickness

Regolith (including transported material and weathered rock) thickness, the vertical interval between the land surface and the upper surface of fresh (unweathered) rock, is an important factor that affects potential for ground-water contamination by surface sources. Because regolith is a product of physical- and chemical-weathering processes, it commonly contains a relatively large proportion of clay minerals. The surfaces of these minerals are potential sites for various sorption processes including adsorption, the process by which solute adheres to solid surfaces; cation exchange, the process by which positively charged ions are attracted to a region near a negatively charged clay-mineral surface and held there by electrostatic forces; and anion exchange, the process by which negatively charged ions are attracted to a region near positively charged edges of clay minerals. Sorption processes are important because they can result in removal of contaminant solute from solution. Generally, potential for contamination decreases as regolith thickness increases because of greater availability of sorption sites and greater opportunity for physical, chemical, and biological attenuation of contaminants.

The GIS data sets of regolith thickness (bedrock_pt, bedrock_arc, bedrock_exp, and bedrock_cont) are digital representations of bedrock outcrops and regolith-thickness data. The data sets bedrock_pt, bedrock_arc, and bedrock_exp were developed by compiling, analyzing, and interpreting locational and well-construction data from the USGS Ground-Water Site Inventory (GWSI) data base, the Pennsylvania Topographic and Geologic Water-Well Inventory (WWI) data base, water-well completion reports filed by well drillers, borehole-geophysical logs, bedrock exposures, and seismic-refraction surveys. Locational data for bedrock exposures also were obtained from unpublished geologic maps developed by senior geology students at Franklin and Marshall College in Lancaster, Pa., and field work conducted by PaDER. For each quadrangle within the study area, the locations of water wells and bedrock exposures were field verified and manually plotted on the appropriate 1:24,000-scale, 7.5-minute paper topographic quadrangle map. Bedrock exposures with mapped dimensions measuring less than 1/8-in. in length and width were considered to be point features, with mapped dimensions measuring greater than 1/8-in. in length and less than 1/8-in. in width were considered to be line features, and with mapped dimensions measuring greater than 1/8-in. in length and width were considered to be polygon features.

Regolith-thickness contours of 20 ft were manually drawn on the topographic quadrangle maps by use of the depth-to-bedrock data for each well as the primary control. The locational data on bedrock exposures and inactive quarries and data on depth to bedrock obtained by seismic-refraction surveys conducted by the USGS during August 1993 at 13 localities in the watershed supplemented the well-construction data. The point, line, and polygon features were manually digitized from the paper topographic-quadrangle maps by use of the UTM 18 projection. For each feature type (point, line, and polygon), the eight data sets were appended creating a single data set, which was then projected into the Albers (meters) coordinate system. The point data set, bedrock_pt, includes locational and depth-to-bedrock data for 207 wells from GWSI, 1,213 wells from WWI, and 604 wells from well drillers' cards, and locational data for 784 bedrock exposures and 47 inactive quarries. The line data set, bedrock_arc, includes locational data for 817 bedrock exposures and contours of regolith thickness of 20 ft. The polygon data set, bedrock_exp, includes locational data for 72 bedrock exposures. The polygon data set, bedrock_cont, includes polygons of regolith-thickness contours and was developed by reselecting features attributed as contour lines from the line data set, bedrock_arc, and building polygon topology.

SUMMARY

This report describes Geographic Information System data sets of ground-water levels, unsaturated-zone thickness, and regolith thickness in the Pequea and Mill Creek watersheds. These watersheds comprise 210 square miles in Lancaster and Chester Counties, Pa., and are situated 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. The data set of ground-water levels during May and October 1991 was developed by manually plotting well locations and associated ground-water levels, manually contouring the water levels using an interval of 40 ft, and electronically scanning the contours of ground-water levels to create a digital data file. The data set of unsaturated-zone thickness during May 1991 was developed by superimposing the contour map of contemporaneous ground-water levels on the contour map of land-surface elevation, computing the numerical difference between these values at points of contour intersection, manually contouring the resultant point values of unsaturated-zone thickness using an interval of 40 ft, and manually digitizing the contours of unsaturated-zone thickness. The data sets of regolith thickness were developed by compiling, analyzing, and interpreting information from water-well data bases and completion reports, borehole-geophysical logs, bedrock exposures, and seismic-refraction surveys; manually plotting and contouring the thickness values; and manually digitizing locations of water wells, bedrock exposures, and the contours of regolith thickness. 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.

REFERENCES CITED

Dugas, D.L., Char, S.J., and Baumbach, G.E., 1995, Geographic Information System data sets of hydrogeologic conditions in Pequea and Mill Creek watersheds, Pennsylvania: Part I—Basic data: U.S. Geological Survey Open-File Report 95-113, 8 p.

Environmental Systems Research Institute, Inc., 1992, Understanding GIS—The ARC/INFO method: Redlands, California, 10 sect., 5 app., variously paged.