

# **Ground-Water-Quality Data in Pennsylvania— A Compilation of Computerized [Electronic] Databases, 1979-2004**

By Dennis J. Low and Douglas C. Chichester

In cooperation with the Pennsylvania Department of Environmental Protection

Data Series 150

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# Contents

Abstract .....	1
Introduction .....	1
Purpose and Scope .....	2
Data-Compilation Methods .....	2
Data Sources .....	5
Mandatory Latitude and Longitude in Data Files .....	8
Assigning a Geolithology to Wells .....	8
Clean-up of Data Records and Bulk Processing .....	8
Categories of Analytes .....	8
Analyte Group Abbreviations and Descriptions .....	9
Formats, Naming Conventions, and Abbreviations Used in Data Files .....	10
Maps and Tables Summarizing the Ground-Water-Quality Data .....	10
Statewide Summary Map .....	10
Summary Maps for 35 Watersheds .....	10
Summary Maps for Nitrate Nitrogen Concentrations in Ground Water for 35 Watersheds .....	10
Summary Tables by Source Agency .....	10
Summary .....	15
Acknowledgments .....	15
Selected References .....	15
Appendix—Files of Comments, Data, and Map Images by Source .....	20
Borough of Carroll Valley .....	20
Chester County Health Department .....	20
Pennsylvania Department of Environmental Protection Ambient and Fixed Station Network .....	20
Montgomery County Health Department .....	20
Pennsylvania Drinking Water Information System .....	21
Pennsylvania Department of Agriculture .....	21
Susquehanna River Basin Commission .....	21
U.S. Geological Survey—Pennsylvania Water Science Center .....	21
Pennsylvania Geology .....	21
Pennsylvania Well Locations .....	22
Pennsylvania Watersheds .....	22
Pennsylvania Watersheds and Nitrate Ranges .....	22
Pennsylvania Watersheds 17 and 18 Geology and Nitrate Ranges .....	22

## Figures

1. The 67 counties in Pennsylvania and boundaries of the 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management .....	3
2. Dominant aquifer and boundaries of the 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management .....	4
3. Glacial outwash or “ice” aquifers and boundaries of the 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management .....	6
4. Well locations with ground-water-quality data compiled from eight source agencies representing the period 1979-2004 for Pennsylvania .....	11
5. Well locations of water-quality data compiled from two source agencies for Watershed Number 35, Lake Erie/French & Oil Creek, northwestern Pennsylvania .....	12
6. Ranges of concentration for nitrate nitrogen in ground water for Watershed Number 24, southcentral Pennsylvania .....	13

## Tables

1. The 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management .....	2
2. The 13 dominant aquifer and rock-type categories used for this data compilation with abbreviations .....	5
3. Data sources and reason(s) for data collection .....	7
4. Summary table of Susquehanna River Basin Commission ground-water-quality studies by major river basins in Pennsylvania .....	14

# Conversion Factors, Datums, and Abbreviations

## Inch/Pound to SI

<b>Multiply</b>	<b>By</b>	<b>To obtain</b>
	<b>Length</b>	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	<b>Area</b>	
square mile (mi <sup>2</sup> )	2.590	square kilometer (km <sup>2</sup> )
	<b>Flow rate</b>	
gallon per day (gal/d)	0.003785	cubic meter per day
	<b>Radioactivity</b>	
picocurie per liter (pCi/L)	0.037	becquerel per liter
	<b>Temperature</b>	
degree Fahrenheit (°F)	°C=5/9 (°F-32)	degree Celsius

Horizontal coordinate information is referenced to either the North American Datum (NAD 1927) or the North American Datum of 1983 (NAD 83).

### Water-Quality Units

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as mass (milligrams) of solute per unit volume (liter) of water. One-thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million. Bacterial concentrations are reported in units of colonies per 100 milliliters (col/100 mL). Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C). Turbidity is reported in nephelometric turbidity units (NTU).

### Radioactivity Units

A commonly used unit of measure for radioactivity is the picocurie. One Curie is the activity of one gram of radium-226, which is equal to  $3.7 \times 10^{10}$  atomic disintegrations per second; a picocurie is  $10^{-12}$  Curies, which is about equal to 2.2 atomic disintegrations per minute. Activity refers to the decay of a radioactive substance, which is measured by the number of particles emitted by a radionuclide per unit of time. The rate of decay is proportional to the number of atoms of a radioactive substance present, and inversely proportional to its half life, which is the time necessary for the substance to lose half its radioactivity. Activity is defined as being equal to  $n \times I$ , where  $n$  is the number of atoms of a radionuclide and  $I$  is the decay constant. The decay constant,  $I$ , is equal to the natural logarithm of 2 divided by the half-life of the radionuclide.



# Ground-Water-Quality Data in Pennsylvania—A Compilation of Computerized [Electronic] Databases, 1979-2004

By Dennis J. Low and Douglas C. Chichester

## Abstract

This study, by the U.S. Geological Survey (USGS) in cooperation with the Pennsylvania Department of Environmental Protection (PADEP), provides a compilation of ground-water-quality data for a 25-year period (January 1, 1979, through August 11, 2004) based on water samples from wells. The data are from eight source agencies—Borough of Carroll Valley, Chester County Health Department, Pennsylvania Department of Environmental Protection-Ambient and Fixed Station Network, Montgomery County Health Department, Pennsylvania Drinking Water Information System, Pennsylvania Department of Agriculture, Susquehanna River Basin Commission, and the U.S. Geological Survey. The ground-water-quality data from the different source agencies varied in type and number of analyses; however, the analyses are represented by 12 major analyte groups: biological (bacteria and viruses), fungicides, herbicides, insecticides, major ions, minor ions (including trace elements), nutrients (dominantly nitrate and nitrite as nitrogen), pesticides, radiochemicals (dominantly radon or radium), volatile organic compounds, wastewater compounds, and water characteristics (dominantly field pH, field specific conductance, and hardness).

A summary map shows the areal distribution of wells with ground-water-quality data statewide and by major watersheds and source agency. Maps of 35 watersheds within Pennsylvania are used to display the areal distribution of water-quality information. Additional maps emphasize the areal distribution with respect to 13 major geolithologic units in Pennsylvania and concentration ranges of nitrate (as nitrogen). Summary data tables by source agency provide information on the number of wells and samples collected for each of the 35 watersheds and analyte groups.

The number of wells sampled for ground-water-quality data varies considerably across Pennsylvania. Of the 8,012 wells sampled, the greatest concentration of wells are in the southeast (Berks, Bucks, Chester, Delaware, Lancaster, Montgomery, and Philadelphia Counties), in the vicinity of Pittsburgh, and in the northwest (Erie County). The number of wells sampled is relatively sparse in south-central (Adams, Cambria,

Cumberland, and Franklin Counties), central (Centre, Indiana, and Snyder Counties), and north-central (Bradford, Potter, and Tioga Counties) Pennsylvania. Little to no data are available for approximately one-third of the state. Water characteristics and nutrients were the most frequently sampled major analyte groups; approximately 21,000 samples were collected for each group. Major and minor ions were the next most-frequently sampled major analyte groups; approximately 17,000 and 12,000 samples were collected, respectively. For the remaining eight major analyte groups, the number of samples collected ranged from a low of 307 samples (wastewater compounds) to a high of approximately 3,000 samples (biological).

The number of samples that exceeded a maximum contaminant level (MCL) or secondary maximum contaminant level (SMCL) by major analyte group also varied. Of the 2,988 samples in the biological analyte group, 53 percent had water that exceeded an MCL. Almost 2,500 samples were collected and analyzed for volatile organic compounds; 14 percent exceeded an MCL. Other major analyte groups that frequently exceeded MCLs or SMCLs included major ions (17,465 samples and a 33.9 percent exceedence), minor ions (11,905 samples and a 17.1 percent exceedence), and water characteristics (21,183 samples and a 20.3 percent exceedence). Samples collected and analyzed for fungicides, herbicides, insecticides, and pesticides (4,062 samples), radiochemicals (1,628 samples), wastewater-compounds (307 samples), and nutrients (20,822 samples) had the lowest exceedences of 0.3, 8.4, 0.0, and 8.8 percent, respectively.

## Introduction

Ground-water-quality data have been collected in Pennsylvania for more than 100 years. Unfortunately, most data are confined to paper copies, and it is prohibitively expensive to compile the data. However, with the advent of computers and increased storage capacities, most recent (since about 1980) data now reside in electronic databases making access less expensive. By compiling the electronic data from local, state, and Federal agencies, it may be possible to identify areas where (1) data are sparse and further studies of ground-water quality

## 2 Ground-Water-Quality in Pennsylvania

may be needed, and (2) ground water contains analytes of concern at elevated concentrations.

In 2001, the Pennsylvania Department of Environmental Protection (PADEP) re-oriented its resource management and planning strategy to a watershed, as opposed to political boundary, approach. With this watershed-focused approach, PADEP established 35 watershed teams (fig. 1 and table 1) to address 17 indicators of environmental improvement at a watershed scale.

Pennsylvania is a physiographically and geologically diverse state. Over 200 different geologic formations or members are recognized by the Pennsylvania Topographic and Geologic Survey (PAGS). For this study, geologic formations were consolidated into 13 major aquifer categories based on dominant rock type or geolithologies (table 2). Even with this simplified categorization, however, geology extends beyond watershed and political boundaries (fig 2).

### Purpose and Scope

This report provides geologic, hydrologic, and geographic information regarding electronically available ground-water-quality data in the Commonwealth of Pennsylvania on watershed and statewide scales from January 1, 1979, through August 11, 2004. This report presents ground-water-quality data from eight local, state, or Federal source agencies in a standard electronic format. The geographic distribution of the data also are presented in a standard electronic format, most commonly by watershed. Ancillary information, including local well numbers, and major geolithologic units are included by well for each source agency. More detailed information, specifically the aquifer sampled and the original scientific or data report in which the water-quality data were released, is provided for individual wells sampled as part of various U.S. Geological Survey (USGS) studies or investigations.

Nitrate nitrogen was identified as an analyte of interest to better evaluate the potential of an electronic database for visually displaying ground-water-quality data. Nitrate nitrogen was selected because (1) it is widespread in Pennsylvania, (2) it is commonly analyzed for, and (3) it has a maximum contaminant level (MCL). As a result, maps were generated summarizing nitrate nitrogen concentrations by watershed and geology.

### Data-Compilation Methods

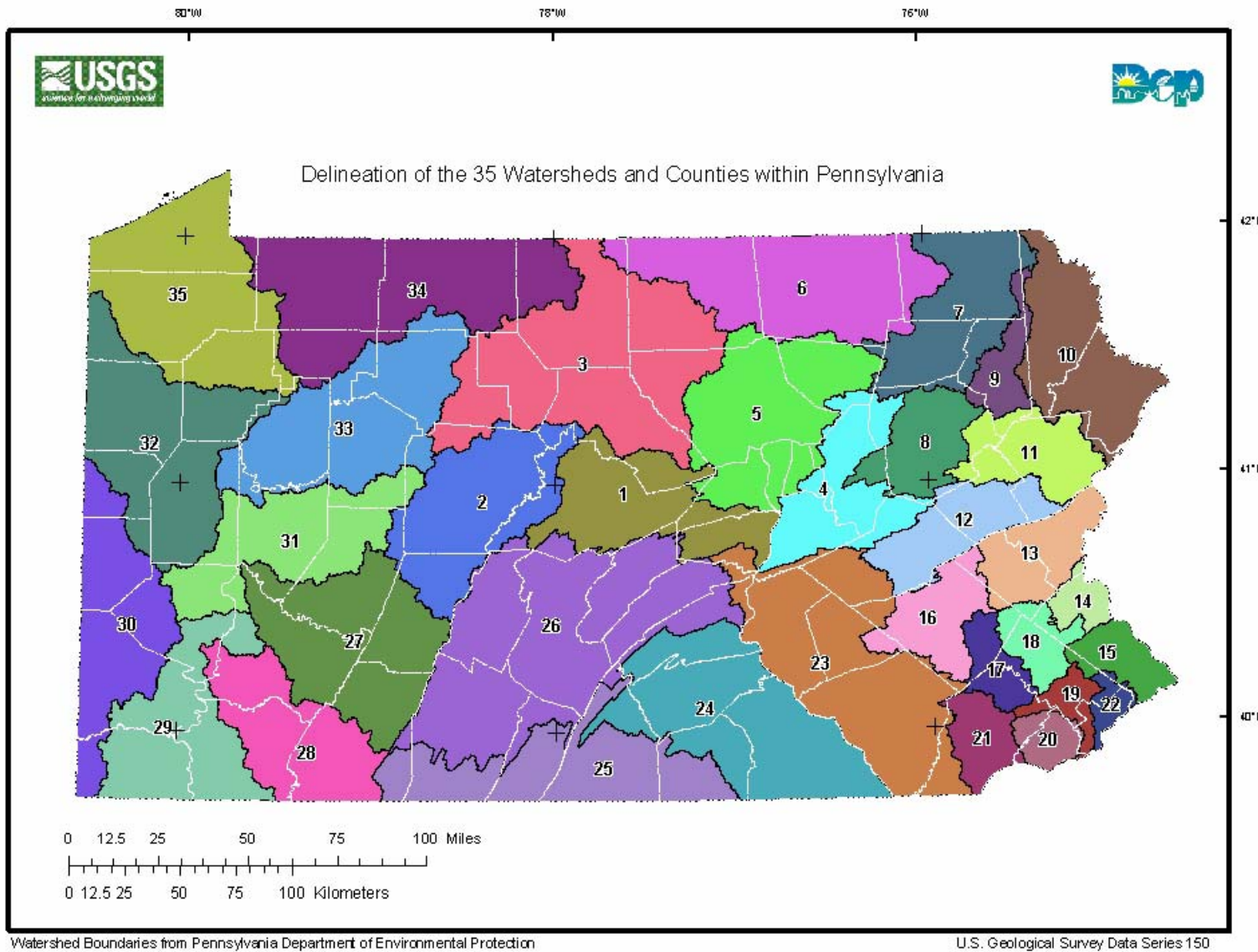
The compiled ground-water-quality data varies by (1) number of constituents, (2) frequency of sample collection, (3) source agency, and (4) geographic distribution. For example, the Borough of Carroll Valley collects water-quality data on bacteria and nutrients from selected wells within the Borough once every 10 years. The PADEP Ambient and Fixed Station Network (FSN) collects water-quality data (major ions, minor ions, trace elements, and nutrients) from across the state at individual wells. The frequency of this collection varies from one time only to multiple samples spread out over a period of years.

Although the USGS collects ground-water-quality samples across the state, the geographic distribution may vary from several wells at a field research site to major river basins. A specific contaminant of concern such as arsenic may lead to a geographic distribution relating to land use or other factors. Geographic distribution of data collection also may be restricted to specific geologic formations and members.

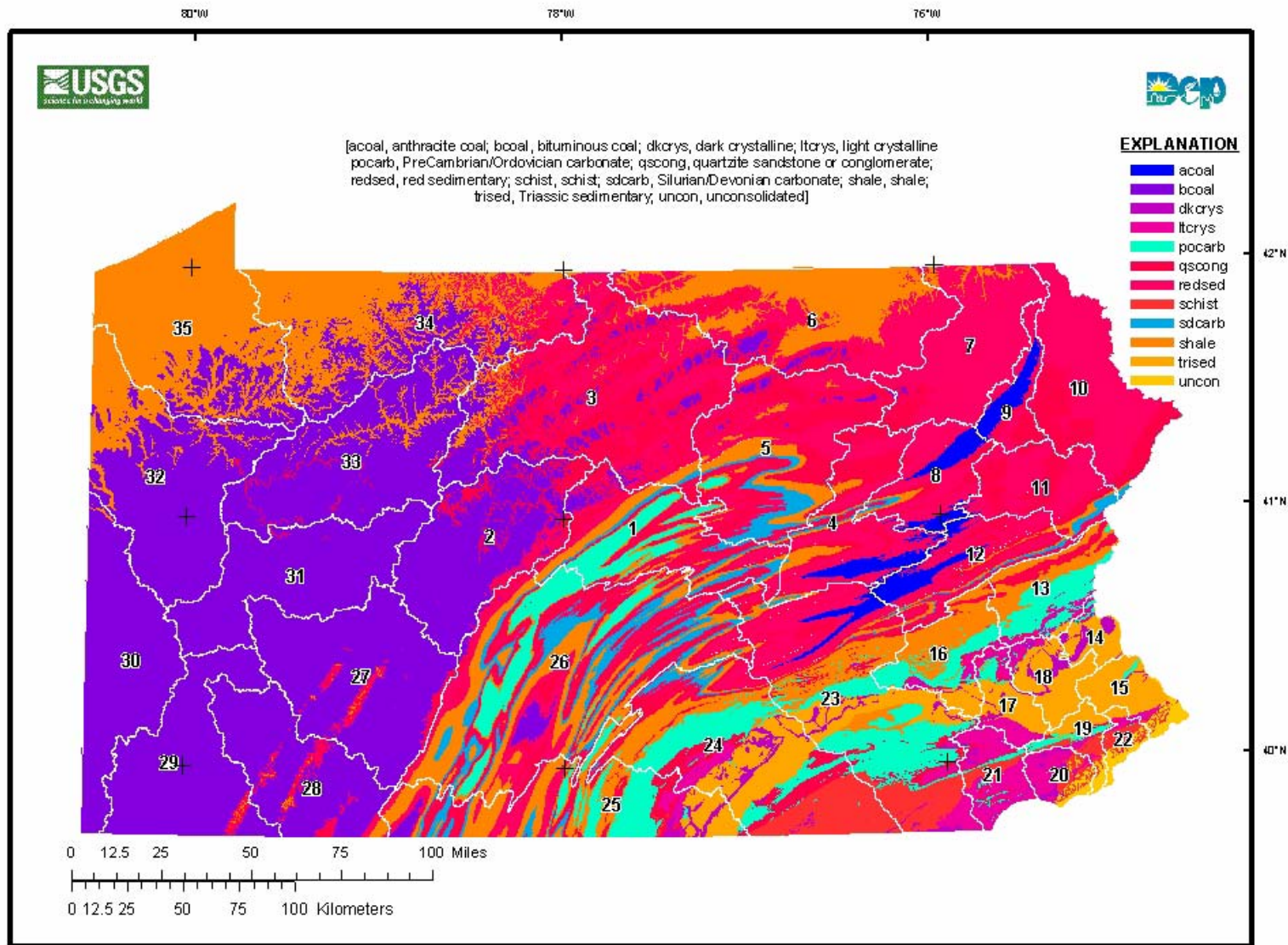
**Table 1.** The 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management.

Watershed number	Watershed name
1	Central Penn
2	Upper West Branch
3	Susquehannock/Genessee
4	Lower North Branch Susquehanna
5	Big Bend
6	Bradford/Tioga
7	Upper Susquehanna
8	Wyoming Valley
9	Lackawanna
10	Upper Delaware
11	Brodhead/Toby/Tunk
12	Upper Schuylkill/Middle Lehigh
13	Lower Lehigh
14	Delaware River/Tohickon Creek
15	Delaware Common Tributaries/Neshaminy
16	Middle Schuylkill
17	French/Manatawny
18	Perkiomen Creek
19	Wissahickon Creek/Schuylkill River
20	Darby/Chester/Ridley/Crum Creeks
21	Christina River/Elk/North East River/ Brandywine Creek/White Clay
22	Pennypack/Tacony
23	Lower Susquehanna East
24	Lower Susquehanna West
25	Potomac
26	Juniata
27	Kiski-Conemaugh
28	Youghiogheny
29	Monongahela
30	Ohio
31	Allegheny
32	Moraine
33	Middle Allegheny
34	Upper Allegheny
35	Lake Erie/French & Oil Creek





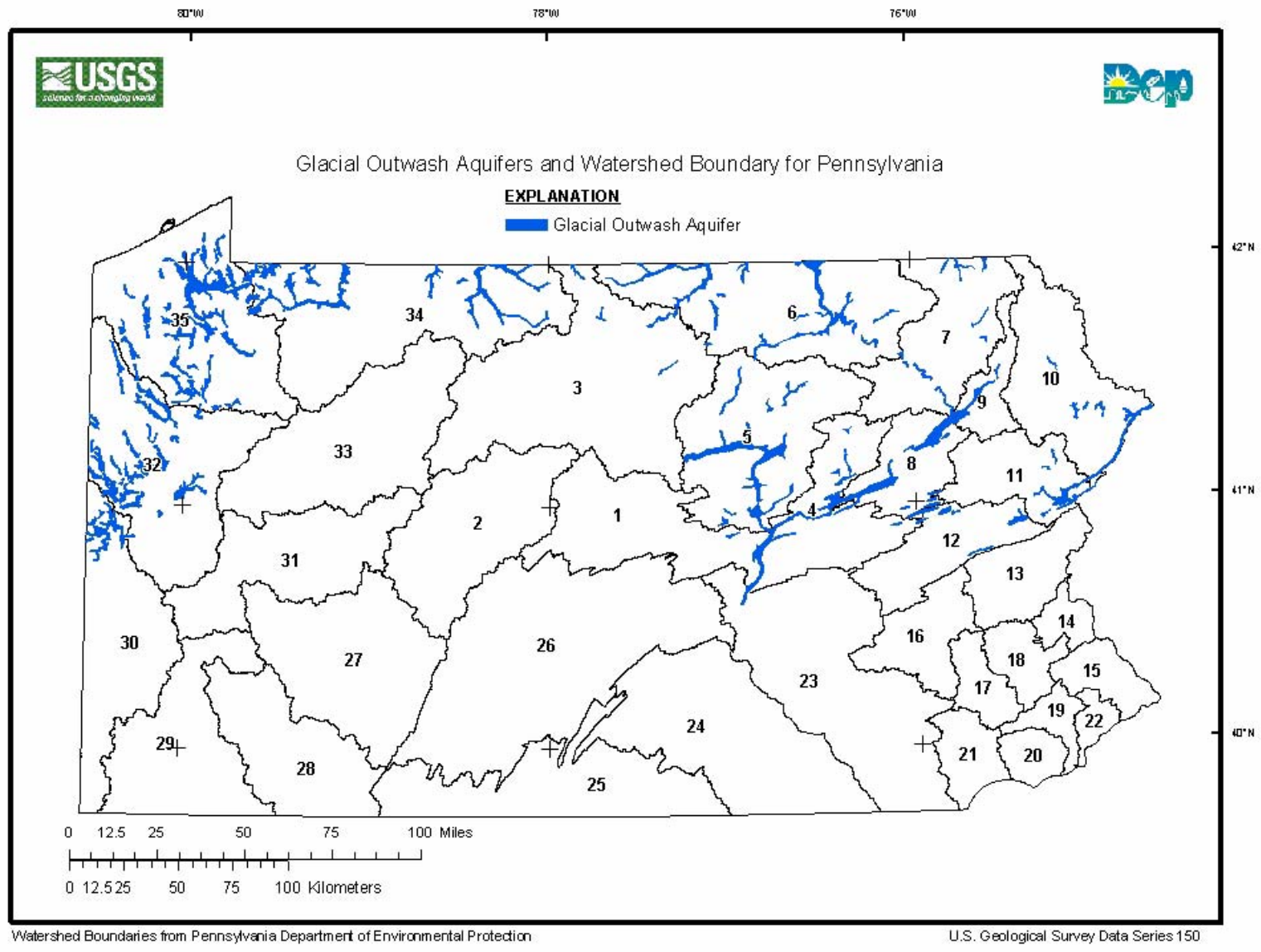
**Figure 1.** The 67 counties in Pennsylvania and boundaries of the 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management (see table 1 for watershed names). (modified from Pennsylvania Department of Environmental Protection, 2005)



**Figure 2.** Dominant aquifer (excludes Glacial outwash or “ice”) and boundaries of the 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management.

**Table 2.** The 13 dominant aquifer and rock-type categories used for this data compilation with abbreviations.

Dominant aquifer	Geo-Abbreviation	Dominant rock type.
Anthracite coal	acoal	Anthracite coal bearing
Bituminous coal	bcoal	Bituminous coal bearing
Dark crystalline	dkcrys	Intrusive crystalline rocks that are dark in color (for example, diabase)
Light crystalline	lkcrys	Intrusive crystalline rocks that are light in color (for example, granite)
PreCambrian/Ordovician carbonates	pocarb	Precambrian- through Ordovician-age limestones and dolomites (with or without minor siliciclastics)
Quartzite, sandstone, or conglomerate	qscong	Quartz rich, dominantly sedimentary rocks (for example, Tuscarora Formation)
Red sedimentary	redsed	Rocks that are dominantly red in color, excludes Triassic age sediments (for example, Catskill Formation)
Schist	schist	A strongly foliated crystalline rock, formed by dynamic metamorphism, that have a dominant cleavage plane due to well developed parallelism of the minerals (for example, Marburg Schist)
Silurian/Devonian carbonates	sdcarb	Silurian- through Devonian-age limestones and dolomites (with or without minor siliciclastics)
Shale	shale	Dark, fine-grained, sedimentary rocks (for example, Hamilton Group)
Triassic sedimentary	trised	Sedimentary rocks that are Triassic in age (for example, Gettysburg Formation)
Unconsolidated	uncon	Gravels, sands, and clays along the Delaware River (for example, Trenton Gravel)
Glacial outwash	ice	Dominantly sand and gravel that were deposited by glaciers or associated fluvial action (for example, outwash)



Watershed Boundaries from Pennsylvania Department of Environmental Protection

U.S. Geological Survey Data Series 150

**Figure 3.** Glacial outwash or "ice" aquifers and boundaries of the 35 watersheds used by Pennsylvania Department of Environmental Protection to subdivide Pennsylvania for resource management. (modified from Sevon and Braun, 2000)







## Analyte Group Abbreviations and Descriptions

- **Micro**—Bacteria, viruses, and other micro-organisms group. Total coliform and fecal coliform are the most common bacteria analyzed. Enteric and coliphage are the most common viruses analyzed. Clostridium and enterococci are some of the other micro-organisms analyzed.
  - Source agency—CV: Total and fecal bacteria; 124 samples.
  - Source agency—MCHD: Total, fecal, and *Escherichia coli* (*E. coli*) bacteria; 971 samples.
  - Source agency—PADWIS: Total, fecal, and *E. coli* bacteria; 360 samples.
  - Source agency—PennAg: Total and *E. coli* bacteria; 269 samples.
  - Source agency—USGS: 11 methods or organisms including viruses; 1,264 samples.
- **Field**—Water characteristics group. pH and specific conductance are the most common analytes.
  - Source agency—CCDH: Turbidity and pH; 833 samples.
  - Source agency—FSN: lab pH, lab alkalinity, and total hardness; 10,590 samples.
  - Source agency—MCHD: pH; 971 samples.
  - Source agency—SRBC: 4 parameters or analytes; 681 samples.
  - Source agency—USGS: 16 parameters or analytes; 8,132 samples.
- **Fungus**—Fungicide group. Chlorothalonil and cis-1,3-Dichloropropane are the most common analytes.
  - Source agency—USGS: 10 analytes (including filtered and unfiltered); 1,196 samples.
- **Herb**—Herbicide group. Atrazine, Alachlor, and Cyanazine are among the most common analytes.
  - Source agency—USGS: 107 analytes (including filtered and unfiltered); 1,319 samples.
- **Insec**—Insecticide group. Carbaryl, Dieldrin, and Lindane are among the most common analytes.
  - Source agency—USGS: 87 analytes (including filtered and unfiltered); 1,280 samples.
- **Major**—Major cations and anions group. Chloride, calcium, and iron are among the most common analytes.
  - Source agency—FSN: 11 analytes; 10,591 samples.
  - Source agency—MCHD: 4 analytes; 971 samples.
  - Source agency—SRBC: 8 analytes; 724 samples.
  - Source agency—USGS: 31 analytes (including filtered and unfiltered); 5,175 samples.
- **Minors**—Minor cations, anions, and trace elements group. Aluminum, arsenic, and lead are common analytes.
  - Source agency—FSN: 8 analytes (trace elements); 7,675 samples.
  - Source agency—MCHD: 4 analytes (trace elements); 75 samples.
  - Source agency—PADWIS: 12 analytes; 36 samples.
  - Source agency—SRBC: 6 analytes (trace elements); 706 samples.
  - Source agency—USGS: 41 analytes (including filtered and unfiltered); 3,413 samples.
- **Nuts**—Nutrient group. Nitrate, nitrite, and total organic carbon are among the most common analytes.
  - Source agency—CV: Nitrate; 124 samples.
  - Source agency—CCDH: Nitrate; 849 samples.
  - Source agency—FSN: 5 analytes; 10,594 samples.
  - Source agency—MCHD: Nitrate; 971 samples.
  - Source agency—PennAg: Nitrate, nitrite; 269 samples.
  - Source agency—SRBC: Nitrate, orthophosphate, and total organic carbon; 707 samples.
  - Source agency—USGS: 27 analytes (including filtered and unfiltered); 7,315 samples.
- **Pest**—Pesticide group. Atrazine, Cyanazine, and Simazine are among the most common analytes.
  - Source agency—PADWIS: Carbofuran, and 2,4-D; 2 samples.
  - Source agency—PennAg: 10 analytes; 273 samples.
- **Radio**—Radiochemicals (radionuclides) group. Radon-222 and uranium are the most common analytes.
  - Source agency—PADWIS: 6 analytes; 19 samples.
  - Source agency—USGS: 16 analytes (including filtered and unfiltered); 1,609 samples.
- **Voa**—Volatile organic compounds group. Benzene, toluene, styrene, and xylenes are among the most common analytes.
  - Source agency—MCHD: 25 analytes; 971 samples.
  - Source agency—PADWIS: 27 analytes; 183 samples.
  - Source agency—USGS: 104 analytes (including filtered and unfiltered); 1,280 samples.
- **Waste**—Wastewater and pharmaceuticals group. Methylene blue active substance and caffeine are among the most common analytes.
  - Source agency—MCHD: Trihalomethanes; 5 samples.
  - Source agency—USGS: 54 analytes (including filtered and unfiltered); 304 samples.

### Formats, Naming Conventions, and Abbreviations Used in Data Files

The data format is Microsoft Excel 2003 (Excel); supporting documents are in Portable Document Format (PDF). Each folder is identified by the source agency. For example, the folder titled MCHD contains files compiled from the Montgomery County Health Department. Within each folder are a series of files. Each file is organized by analyte group. For example, the Excel file titled MCHD.Voa.xls contains the water-quality data for volatile organic compounds collected by the Montgomery County Health Department. Also included in this file are ancillary data such as local well number, site identifier (site ID), latitude, longitude, and geolithologic unit. Information regarding an exceedence of a USEPA MCL or SMCL is presented in an adjacent column and cell. Analyte results for MCHD and CCDH also contain numeric qualifiers. Data files from the USGS also contain analyte remark codes such as less than, estimated, and missing, as well as information on the study for which the samples were collected. The USGS data files also contain a seven or eight length alphanumeric code that details a specific geologic formation or unit.

**MCHD.Comments.Micro.pdf** is a PDF file that provides supporting information on the water-quality measurements (in this case about bacteria and viruses), including analytes, definitions, and USEPA contaminant levels on samples collected by or for the Montgomery County Health Department.

USGS.CrossReferenceNumbers is an Excel table that presents the abbreviated author and report citation for the scientific or data report in which the data were originally published. This allows the interested reader a means to locate the study and determine the purpose for which the data were collected. It is an aid in locating the complete citation listed in the Selected References, which also lists the abbreviated report citation in bold. USGS.MicroReport is an Excel file that lists the abbreviated citations for bacteria and virus studies and includes local well numbers, site IDs, latitudes, longitudes, watersheds, geolithologic units, and geologic formations.

### Maps and Tables Summarizing the Ground Water-Quality Data

The maps generated for this study (accessed through hyperlinks in the Appendix) are PDF images. The 35 images titled Basin1\_Wells through Basin35\_Wells show the distribution of wells with available water-quality data by watershed and source agency. The 35 images titled Basin1\_QWNO3 through Basin35\_QWNO3 show the distribution of nitrate data (NO3) by watershed and source agency. The 12 images pre-fixed by “Statewide” show the distribution of wells with water-quality data by source agency.

Summary tables (accessed through hyperlinks in the Appendix) are included within each source-agency file. For example, SRBC.Summary.pdf (table 4) presents information on the number of (1) wells sampled by major river basin, (2) wells sampled by watershed, (3) samples collected by analyte group, and (4) samples that exceeded USEPA contaminant levels.

### Statewide Summary Map

Figure 4 shows the distribution of the 8,012 wells from the eight source agencies. The greatest concentration of wells with water-quality data are in watersheds 17, 18, 21, and 23 of southeastern Pennsylvania (Chester, Lancaster, and Montgomery Counties). The part of watershed 35 that has been extensively sampled is Erie County. About half of the watersheds in Pennsylvania have fewer than 100 wells with water-quality data; watershed 9 contains no ground-water-quality data.

### Summary Maps for 35 Watersheds

Figure 5 shows the distribution by county and watershed from the PDF image Basin35\_Wells. Almost all 246 wells sampled for ground-water-quality data in watershed 35 were the result of USGS studies specifically related to Erie County. Similar images for all 35 watersheds can be viewed through the hyperlinks in the Appendix.

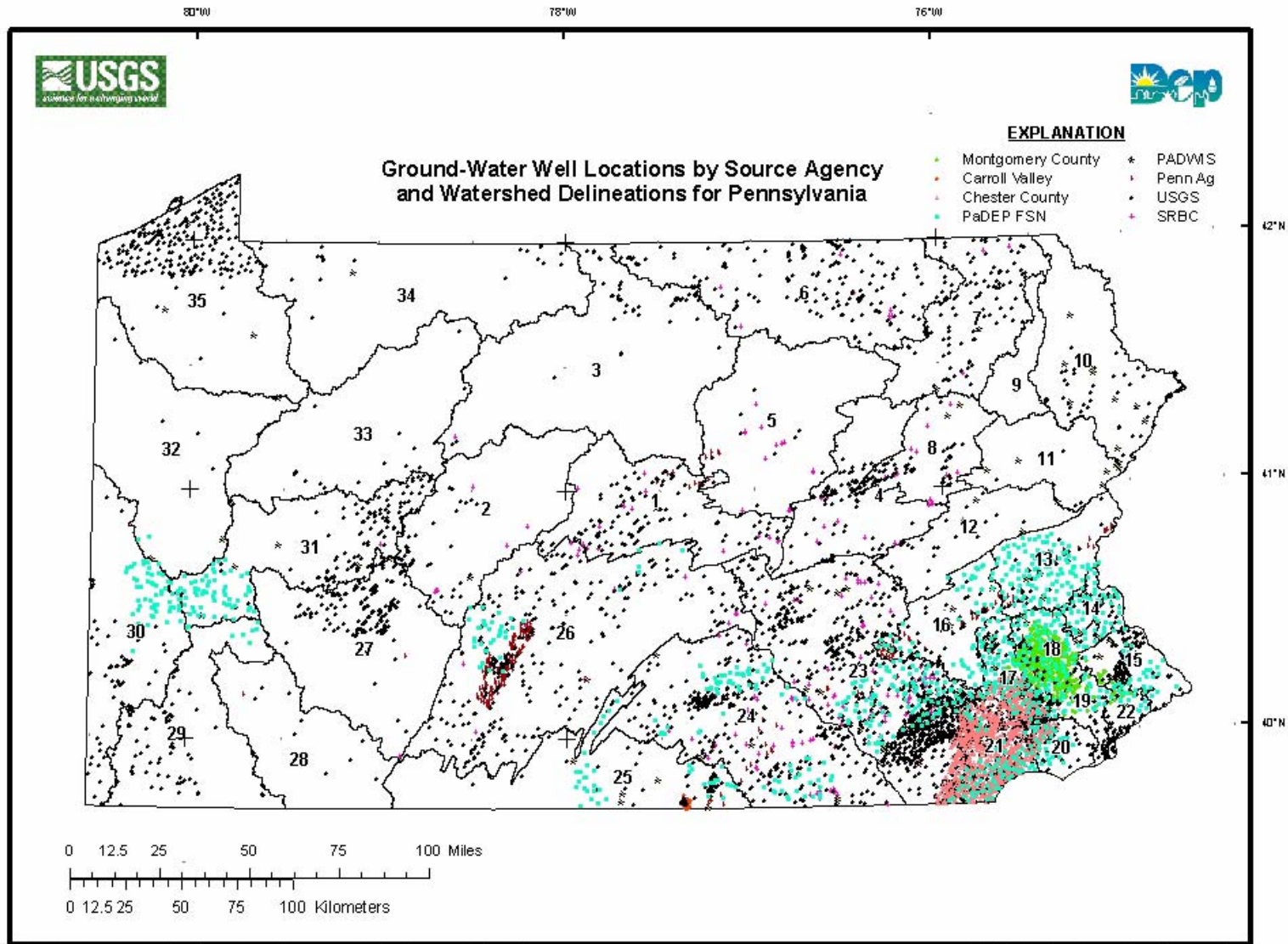
### Summary Maps for Nitrate Nitrogen Concentrations in Ground Water for 35 Watersheds

Figure 6 shows the distribution of 461 wells by county in watershed 24 (from the PDF image Basin24\_QWNO3). Of the 565 nutrient samples collected and analyzed, 31 samples (5.5 percent) exceeded the USEPA MCL of 10.0 mg/L for nitrate. Results were averaged for wells that were sampled more than once. About 50 percent of the wells visited and sampled are the result of USGS studies. Similar images for all 35 watersheds can be viewed through the hyperlinks in the Appendix.

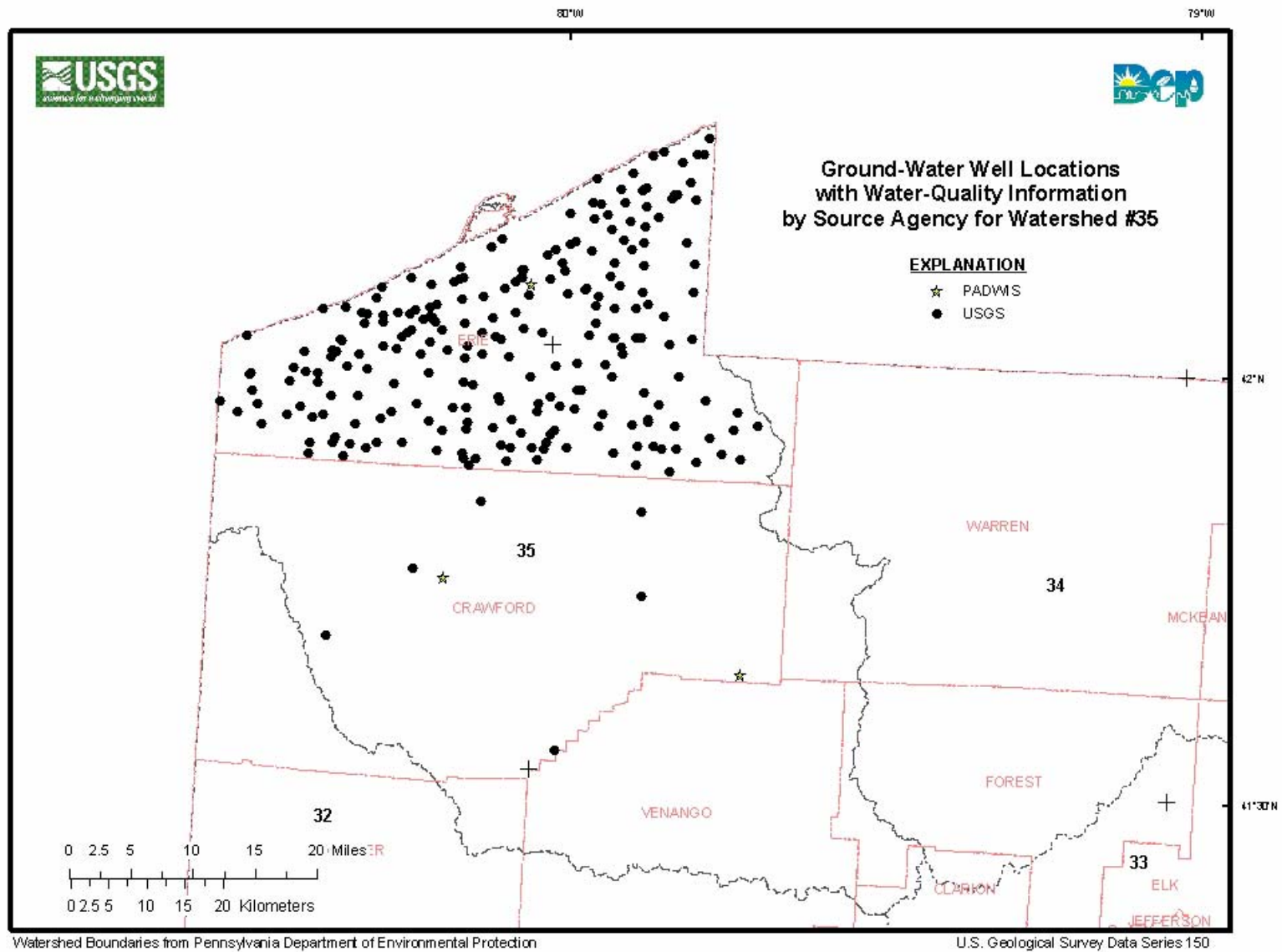
### Summary Tables by Source Agency

Table 4 is a summary of the ground-water-quality data collected by the SRBC and contained within the various Excel data spreadsheet files listed for the SRBC in the Appendix. Similar summary files for the other source agencies also are available through hyperlinks in the Appendix. Each summary table presents information on the number of wells sampled, the number of samples collected, the number of exceedences for USEPA MCL and SMCL analytes. The summary data are organized by PADEP watershed and major analyte group.





**Figure 4.** Well locations with ground-water-quality data compiled from eight source agencies representing the period 1979-2004 for Pennsylvania.



**Figure 5.** Well locations of water-quality data compiled from two source agencies (Pennsylvania Drinking Water Information System and U.S. Geological Survey) for Watershed Number 35, Lake Erie/French & Oil Creek, northwestern Pennsylvania.

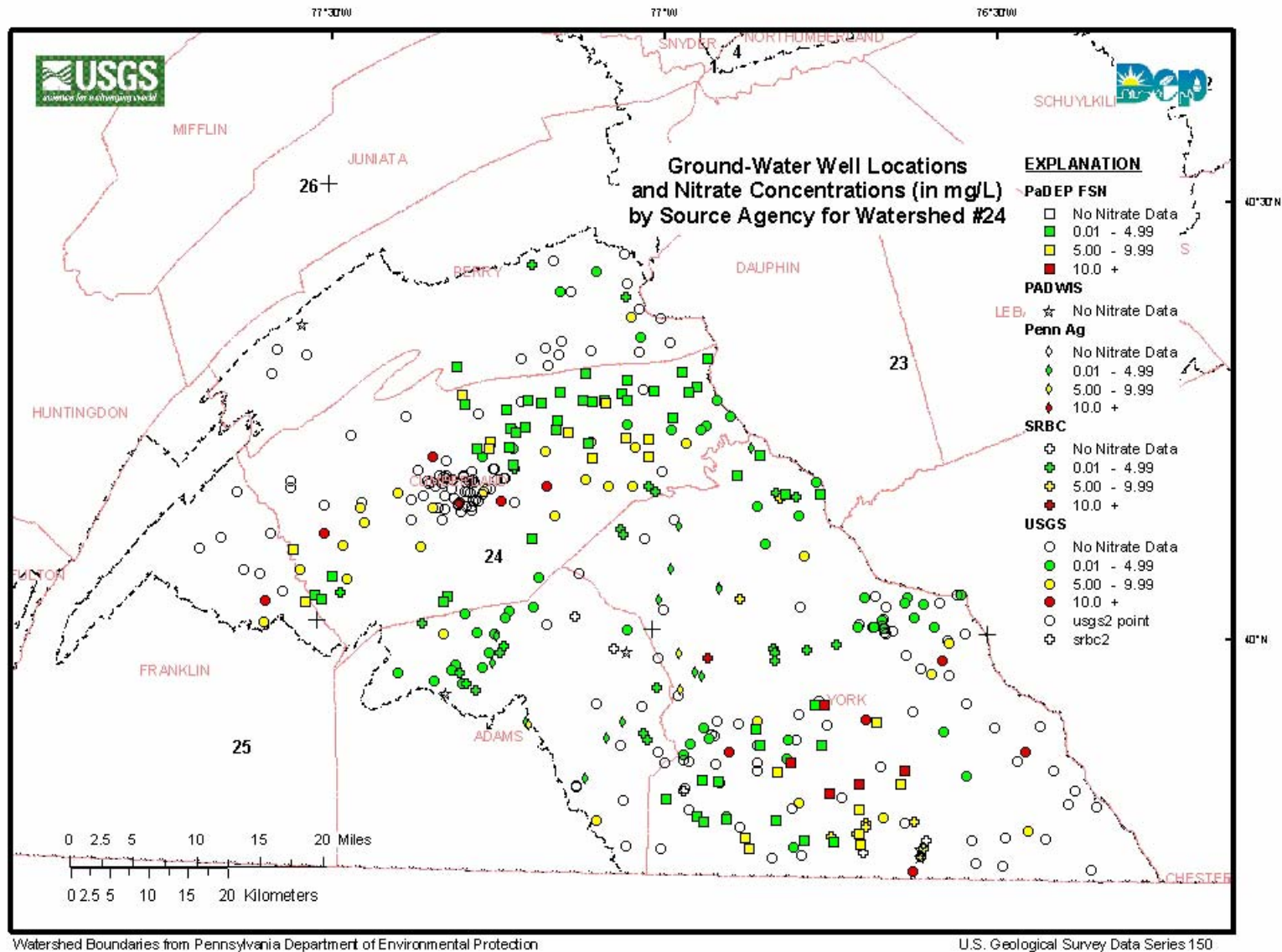


Figure 6. Ranges of concentration for nitrate nitrogen in ground water for Watershed Number 24, southcentral Pennsylvania.

## 14 Ground-Water-Quality in Pennsylvania

**Table 4.** Summary table of Susquehanna River Basin Commission (SRBC) ground-water-quality studies by major river basins in Pennsylvania.

[2/ 0, number of samples collected/number of samples that exceeded a U.S. Environmental Protection Agency Maximum or Secondary Maximum Contaminant Level]

Pennsylvania Department of Environmental Protection watershed	Wells	Major ions		Minor and trace elements		Nutrients		Water characteristics (field measurements)	
Ohio and St. Lawrence River Basins									
31	1	2/	0	2/	0	2/	0	2/	0
Delaware River Basin									
12	6	13/	4	14/	4	13/	0	13/	8
Lower Susquehanna River Basin									
23	123	289/	73	278/	27	236/	34	267/	27
24	61	147/	14	145/	22	138/	3	144/	23
26	18	40/	3	39/	6	31/	3	33/	2
Upper Susquehanna River Basin									
1	23	39/	9	38/	5	36/	0	37/	1
2	10	35/	15	35/	5	28/	0	33/	7
3	1	2/	0	3/	0	2/	0	2/	0
4	14	21/	12	21/	5	21/	0	21/	7
5	24	44/	12	41/	3	41/	0	43/	10
6	17	33/	23	32/	8	28/	0	31/	0
7	3	7/	0	6/	1	7/	0	6/	1
8	28	52/	22	52/	7	49/	1	49/	17

## Summary

This study, by the U.S. Geological Survey (USGS) in cooperation with the Pennsylvania Department of Environmental Protection (PADEP) Bureau of Watershed Management, provides detailed ground-water-quality data from January 1, 1979, to August 11, 2004, on 8,612 wells for 35 watersheds throughout Pennsylvania. Eight source agencies—Borough of Carroll Valley (CV), Chester County Health Department (CCDH), Pennsylvania Department of Environmental Protection-Ambient and Fixed Station Network (FSN), Montgomery County Health Department (MCHD), Pennsylvania Drinking Water Information System (PADWIS), Pennsylvania Department of Agriculture (PennAg), Susquehanna River Basin Commission (SRBC), and USGS provided the data in various electronic formats that were suitable for editing and compiling. The resulting ground-water-quality data were divided, by source agency, into 12 analyte groups—micro-organisms, major ions, minor ions and trace elements, nutrients, pesticides (USGS pesticide data were further subdivided into fungicides, herbicides, and insecticides), radiochemicals, volatile organic compounds, wastewater compounds, and water characteristics.

For each source agency, Microsoft Excel files and Portable Document Format files were created. The Excel files (for example, CV.Micro.xls) contain the edited ground-water-quality data, whereas the PDF files (for example, SRBC.Summary.pdf) contain a summary of the results by watershed and analyte group. As a result of the large number of independent studies conducted by the USGS, additional Excel files were created. These Excel files (for example, USGS.MicroReport.xls) contain an abbreviated reference to the original citation listed in Selected References. This allows the interested reader a means to locate the study and determine the purpose for which the ground-water-quality data were collected.

A series of PDF images were created to show the 35 watersheds within Pennsylvania, the 13 geolithologic units that were used to represent the complex geology of Pennsylvania, and the distribution of 8,612 wells with ground-water-quality data. An additional 35 images were created to show the distribution of the 8,612 wells by watershed, another 35 were images created to show the distribution and range of nitrate (as nitrogen) concentrations in the 35 watersheds.

## Acknowledgments

Joseph J. Lee, Jr. and Patrick Bowling of the Pennsylvania Department of Environmental Protection Bureau of Watershed Management provided technical assistance and review of the report along with Dennis W. Risser, Kim L. Otto, and Kevin J. Breen from the USGS.

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Bolded abbreviations in parentheses at the end of a citation are used in USGS.MicroReport.xls and other similar named Excel files to identify where the water-quality data have been previously published and/or the basis for the collection of the sample.

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## Appendix—Files of Comments, Data, and Map Images by Source

[“Click” on filename in lists below to link to the file]

### Borough of Carroll Valley

#### Comment Files

Portable Document Format  
CV.Comments.Micro.pdf  
CV.Comments.Nuts.pdf  
CV.Summary.pdf

#### Data Spreadsheet Files

Microsoft Excel Format  
CV.Micro.xls  
CV.Nuts.xls

#### Map Image Files

Portable Document Format  
Statewide\_WellsCarrollValley.pdf

### Chester County Health Department

#### Comment Files

Portable Document Format  
CCDH.Comments.Field.pdf  
CCDH.Comments.Nuts.pdf  
CCDH.Summary.pdf

#### Data Spreadsheet Files

Microsoft Excel Format  
CCDH.Field.xls  
CCDH.Nuts.xls

#### Map Image Files

Portable Document Format  
Statewide\_WellsChesterCo.pdf

### Pennsylvania Department of Environmental Protection Ambient and Fixed Station Network

#### Comment Files

Portable Document Format  
FSN.Comments.Field.pdf  
FSN.Comments.Major.pdf  
FSN.Comments.Minor.pdf  
FSN.Comments.Nuts.pdf  
FSN.Summary.pdf

#### Data Spreadsheet Files

Microsoft Excel Format  
FSN.Field.xls  
FSN.Major.xls  
FSN.Minor.xls  
FSN.Nuts.xls

#### Map Image Files

Portable Document Format  
Statewide\_WellsPaDEPFNS.pdf

### Montgomery County Health Department

#### Comment Files

Portable Document Format  
MCHD.Comments.Micro.pdf  
MCHD.Comments.Field.pdf  
MCHD.Comments.Major.pdf  
MCHD.Comments.Minor.pdf  
MCHD.Comments.Nuts.pdf  
MCHD.Comments.Voa.pdf  
MCHD.Comments.Waste.pdf  
MCHD.Summary.pdf

#### Data Spreadsheet Files

Microsoft Excel Format  
MCHD.Micro.xls  
MCHD.Field.xls  
MCHD.Major.xls  
MCHD.Minor.xls  
MCHD.Nuts.xls  
MCHD.Voa.xls  
MCHD.Waste.xls

#### Map Image Files

Portable Document Format  
Statewide\_WellsMontgomeryCo.pdf

## Pennsylvania Drinking Water Information System

### Comment Files

#### Portable Document Format

PADWIS.Comments.Micro.pdf  
 PADWIS.Comments.Minor.pdf  
 PADWIS.Comments.Pest.pdf  
 PADWIS.Comments.Radio.pdf  
 PADWIS.Comments.Voa.pdf  
 PADWIS.Summary.pdf

### Data Spreadsheet Files

#### Microsoft Excel Format

PADWIS.Micro.xls  
 PADWIS.Minor.xls  
 PADWIS.Pest.xls  
 PADWIS.Radio.xls  
 PADWIS.Voa.xls

### Map Image Files

#### Portable Document Format

Statewide\_WellsPADWIS.pdf

## Pennsylvania Department of Agriculture

### Comment Files

#### Portable Document Format

PennAg.Comments.Micro.pdf  
 PennAg.Comments.Nuts.pdf  
 PennAg.Comments.Pest.pdf  
 PennAg.Summary.pdf

### Data Spreadsheet Files

#### Microsoft Excel Format

PennAg.Micro.xls  
 PennAg.Nuts.xls  
 PennAg.Pest.xls

### Map Image Files

#### Portable Document Format

Statewide\_WellsPennAg.pdf

## Susquehanna River Basin Commission

### Comment Files

#### Portable Document Format

SRBC.Comments.Field.pdf  
 SRBC.Comments.Major.pdf  
 SRBC.Comments.Minor.pdf  
 SRBC.Comments.Nuts.pdf  
 SRBC.Summary.pdf

### Data Spreadsheet Files

#### Microsoft Excel Format

SRBC.Field.xls  
 SRBC.Major.xls  
 SRBC.Minor.xls  
 SRBC.Nuts.xls

### Map Image Files

#### Portable Document Format

Statewide\_WellsSRBC.pdf

## U.S. Geological Survey—Pennsylvania Water Science Center

### Comment Files

#### Portable Document Format

USGS.Comments.Micro.pdf  
 USGS.Comments.Field.pdf  
 USGS.Comments.Fungus.pdf  
 USGS.Comments.Herb.pdf  
 USGS.Comments.Insec.pdf  
 USGS.Comments.Major.pdf  
 USGS.Comments.Minor.pdf  
 USGS.Comments.Nuts.pdf  
 USGS.Comments.Radio.pdf  
 USGS.Comments.Voa.pdf  
 USGS.Comments.Waste.pdf  
 USGS.Summary.pdf

### Data Spreadsheet Files

#### Microsoft Excel Format

USGS.Micro.xls      USGS.MicroReport.xls  
 USGS.Field.xls      USGS.FieldReport.xls  
 USGS.Fungus.xls      USGS.FungusReport.xls  
 USGS.Herb.xls      USGS.HerbReport.xls  
 USGS.Insec.xls      USGS.InsecReport.xls  
 USGS.Major.xls      USGS.MajorReport.xls  
 USGS.Minor.xls      USGS.MinorReport.xls  
 USGS.Nuts.xls      USGS.NutsReport.xls  
 USGS.Radio.xls      USGS.RadioReport.xls  
 USGS.Voa.xls      USGS.VoaReport.xls  
 USGS.Waste.xls      USGS.WasteReport.xls  
 USGS.CrossReference Numbers.xls

### Map Image Files

#### Portable Document Format

Statewide\_WellsUSGS.pdf

## Pennsylvania Geology

### Map Image Files

#### Portable Document Format

Statewide\_Geology.pdf  
 Statewide\_SurficialGeology.pdf

## 22 Ground-Water-Quality in Pennsylvania

### Pennsylvania Well Locations

#### Map Image Files

Portable Document Format

Statewide\_Wells2.pdf

### Pennsylvania Watersheds

#### Map Image Files

Portable Document Format

Statewide\_Watershed.pdf

Basin1\_Wells.pdf

Basin2\_Wells.pdf

Basin3\_Wells.pdf

Basin4\_Wells.pdf

Basin5\_Wells.pdf

Basin6\_Wells.pdf

Basin7\_Wells.pdf

Basin8\_Wells.pdf

Basin9\_Wells.pdf

Basin10\_Wells.pdf

Basin11\_Wells.pdf

Basin12\_Wells.pdf

Basin13\_Wells.pdf

Basin14\_Wells.pdf

Basin15\_Wells.pdf

Basin16\_Wells.pdf

Basin17\_Wells.pdf

Basin18\_Wells.pdf

Basin19\_Wells.pdf

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Basin26\_Wells.pdf

Basin27\_Wells.pdf

Basin28\_Wells.pdf

Basin29\_Wells.pdf

Basin30\_Wells.pdf

Basin31\_Wells.pdf

Basin32\_Wells.pdf

Basin33\_Wells.pdf

Basin34\_Wells.pdf

Basin35\_Wells.pdf

### Pennsylvania Watersheds and Nitrate Ranges

#### Map Image Files

Portable Document Format

Basin1\_QWNO3.pdf

Basin2\_QWNO3.pdf

Basin3\_QWNO3.pdf

Basin4\_QWNO3.pdf

Basin5\_QWNO3.pdf

Basin6\_QWNO3.pdf

Basin7\_QWNO3.pdf

Basin8\_QWNO3.pdf

Basin9\_QWNO3.pdf

Basin10\_QWNO3.pdf

Basin11\_QWNO3.pdf

Basin12\_QWNO3.pdf

Basin13\_QWNO3.pdf

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Basin26\_QWNO3.pdf

Basin27\_QWNO3.pdf

Basin28\_QWNO3.pdf

Basin29\_QWNO3.pdf

Basin30\_QWNO3.pdf

Basin31\_QWNO3.pdf

Basin32\_QWNO3.pdf

Basin33\_QWNO3.pdf

Basin34\_QWNO3.pdf

Basin35\_QWNO3.pdf

### Pennsylvania Watersheds 17 and 18 Geology and Nitrate Ranges

#### Map Image Files

Portable Document Format

Basin17\_QWNO3GEO.pdf