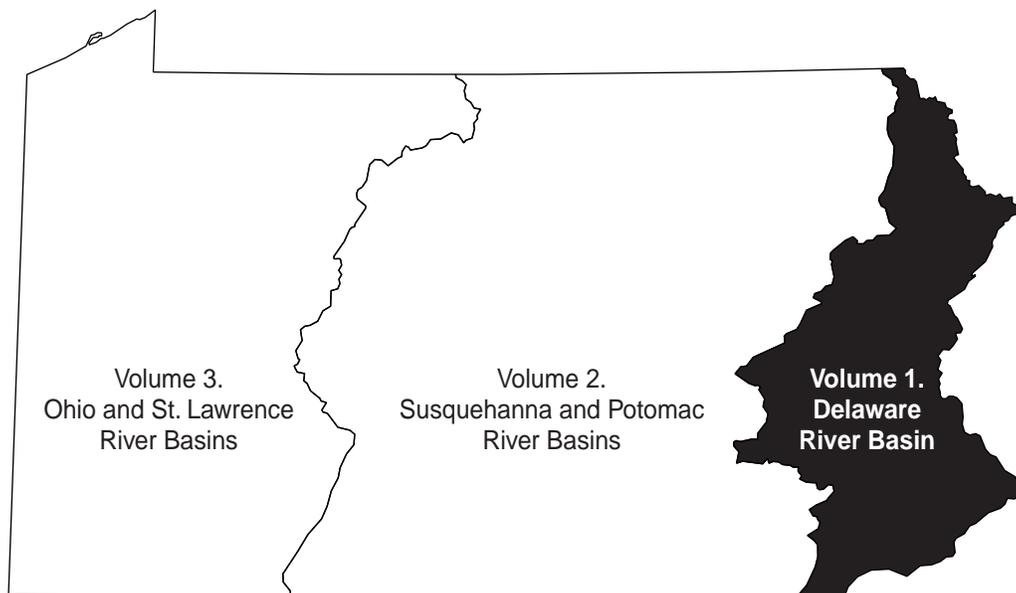


# Water Resources Data Pennsylvania Water Year 2005

## Volume 1. Delaware River Basin

By R.R. Durlin, W.P. Schaffstall, and M.R. Beaver

Water-Data Report PA-05-1



Prepared in cooperation with the Pennsylvania Department of Environmental Protection, the Philadelphia District of the U.S. Army Corps of Engineers, the Chester County Water Resources Authority, and with other State, municipal, and Federal agencies.



U.S. DEPARTMENT OF THE INTERIOR  
DIRK KEMPTHORNE, *SECRETARY*

U.S. GEOLOGICAL SURVEY  
Mark Myers, *Director*

For additional information write to:  
Director, USGS Pennsylvania Water Science Center  
215 Limekiln Road  
New Cumberland, Pennsylvania 17070

2006

## PREFACE

This volume of the annual hydrologic data report of Pennsylvania is one of a series of annual reports that document hydrologic data gathered from the U.S. Geological Survey's surface- and ground-water data-collection networks in each State, Puerto Rico, and the Trust Territories. These records of streamflow, ground-water levels, and quality of water provide the hydrologic information needed by State, local, and Federal agencies, and the private sector for developing and managing our Nation's land and water resources. Hydrologic data for Pennsylvania are contained in 3 volumes.

- Volume 1. Delaware River Basin
- Volume 2. Susquehanna and Potomac River Basins
- Volume 3. Ohio and St. Lawrence River Basins

Volume 1 was prepared in cooperation with the Commonwealth of Pennsylvania and other agencies under the general supervision of Patricia L. Lietman, Director, USGS Pennsylvania Water Science Center ; Robert A. Hainly, Assistant Director for Hydrologic Surveillance and Data Management; Mark R. Beaver, Chief of the Hydrologic Surveillance Program, New Cumberland, William P. Schaffstall (retired), and Randall R. Durlin, Chief, Williamsport Office. It is the product of a team effort by dedicated personnel of the U.S. Geological Survey who collected, compiled, analyzed, verified, and organized these data, and who typed, edited, and assembled the report. In addition to the authors, who had primary responsibility for assuring that the information contained herein is accurate, complete, and adheres to Geological Survey policy and established guidelines, the following individuals contributed significantly to the collection, processing, and tabulation of these data:

J. K. Bender	J. D. Hollenbach	A. G. Reif
K. E. Brayton	T. R. Hunt	J. D. Riggle
R. T. Campbell	J. V. Irvin	J. J. Rote
P. J. Cinotto	M. E. Jones	A. J. Ruddy
C. A. Cravotta	C. A. Loper	L. A. Senior
E. Egger	C. Neill	R. A. Sloto
D. R. Galeone	D. L. O'Brien	S. P. Sorber
M. C. Gyves	L. E. Olson	S. J. Ward

# REPORT DOCUMENTATION PAGE

*Form Approved*  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY <i>(Leave blank)</i>		2. REPORT DATE September 2006	3. REPORT TYPE AND DATES COVERED Annual Oct. 1, 2004 to Sept. 30, 2005	
4. TITLE AND SUBTITLE Water Resources Data for Pennsylvania Water Year 2005 Volume 1, Delaware River Basin			5. FUNDING NUMBERS	
6. AUTHOR(S) Randall R. Durlin, William P. Schaffstall, and Mark R. Beaver				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Geological Survey Pennsylvania Water Science Center 215 Limekiln Road New Cumberland, PA 17070			8. PERFORMING ORGANIZATION REPORT NUMBER USGS-WDR-PA-05-1	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Geological Survey Pennsylvania Water Science Center 215 Limekiln Road New Cumberland, PA 17070			10. SPONSORING / MONITORING AGENCY REPORT NUMBER USGS-WDR-PA-05-1	
11. SUPPLEMENTARY NOTES Prepared in cooperation with the Commonwealth of Pennsylvania and with other agencies.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT  No restrictions on distribution. This report may be purchased from: National Technical Information Service, Springfield, Virginia 22161			12b. DISTRIBUTION CODE	
13. ABSTRACT <i>(Maximum 200 words)</i> Water resources data for the 2005 water year for Pennsylvania consist of records of discharge and water quality of streams; contents and elevations of lakes and reservoirs; and water levels and water quality of ground-water wells. This report, Volume 1 contains (1) discharge records for 75 continuous-record streamflow-gaging stations, 5 partial-record stations, 41 special-study and miscellaneous streamflow sites; (2) elevation and contents records for 13 lakes and reservoirs, and water-quality records for 5 lakes and reservoirs; (3) water-quality records for 24 gaging stations and 10 ungaged streamsites; (4) water-quality records for 73 special-study stations; (5) water-level records for 52 network observation wells; and (6) water-quality analyses of ground water from 42 ground-water wells. Site locations are shown in figures 6-19. Additional water data collected at various sites not involved in the systematic data-collection program are also presented. These data together with the data in Volumes 2 and 3, represent that part of the National Water Data System operated by the U.S. Geological Survey and cooperating State, local, and Federal agencies in Pennsylvania.				
14. SUBJECT TERMS *Pennsylvania, *Hydrologic data, *Ground water, *Surface water, *Water quality, Gaging stations, Streamflow, Flow rates, Lakes, Reservoirs, Chemical analysis, Sediments, Water temperature, Water analysis, Water levels, Water wells, Data collection sites			15. NUMBER OF PAGES 575	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

# CONTENTS

	<b>Page</b>
Preface .....	iii
List of surface-water stations, in downstream order, for which records are published in this volume .....	viii
List of ground-water wells, by county, for which records are published in this volume .....	xi
List of discontinued continuous-record surface-water discharge stations .....	xiii
List of discontinued continuous-record surface-water-quality stations .....	xvi
USGS Pennsylvania Water Science Center office locations and addresses .....	xx
Introduction .....	1
Cooperation .....	1
Summary of hydrologic conditions .....	3
Surface water .....	3
Precipitation and streamflow .....	3
Water quality .....	6
Ground water .....	8
References .....	8
Special networks and programs .....	10
Explanation of the records .....	11
Station identification numbers .....	11
Downstream-order system .....	11
Latitude-longitude system .....	11
Explanation of stage- and water-discharge records .....	12
Data collection and computation .....	12
Data presentation .....	13
Station manuscript .....	13
Peak discharge greater than base discharge .....	14
Data table of daily mean values .....	14
Statistics of monthly mean data .....	14
Summary statistics .....	14
Identifying estimated daily discharge .....	15
Accuracy of field data and computed results .....	16
Other data records available .....	16
Explanation of water-quality records .....	16
Collection and examination of data .....	16
Water analysis .....	16
Records of surface-water quality .....	17
Classification of records .....	17
Accuracy of the records .....	17
Arrangement of records .....	17
On-site measurements and sample collection .....	17
Water temperature .....	18
Sediment .....	18
Laboratory measurements .....	18
Data presentation .....	18
Remark codes .....	19
Water-quality-control data .....	19
Blank samples .....	20
Reference samples .....	20
Replicate samples .....	20
Spike samples .....	20
Explanation of ground-water-level records .....	21
Site identification numbers .....	21
Data collection and computation .....	21
Data presentation .....	21
Water-level tables .....	22
Hydrographs .....	22

## CONTENTS--Continued

	<b>Page</b>
Ground-water-quality data .....	22
Data collection and computation .....	22
Laboratory measurements .....	22
Access to USGS Water Data .....	22
Definition of terms .....	23
Techniques of Water-Resources Investigations of the U.S. Geological Survey .....	36
Special Notes, Remark Codes, and Selected Constituent Definitions .....	48
Station records, surface water	
Continuous water-discharge and water-quality station records .....	50
Discharge at partial-record stations and miscellaneous sites	
Crest-stage partial-record stations .....	378
Miscellaneous sites .....	380
Hydrogeology of the Pocono Creek Basin, Monroe County, discharge-measurement sites .....	382
Analyses of samples collected at special-study sites	
Pennsylvania water-quality network .....	386
Stream conditions of Chester County biological monitoring network .....	434
Acid mine drainage projects in the upper Schuylkill River basin .....	452
Special Notes, Remark Codes, and Selected Constituent Definitions .....	486
Station records, ground water	
Water-level .....	488
Ground-water data collected at special-study sites	
Chester County ground-water-quality monitoring program .....	522
Ground water pesticides network project .....	534
Delaware River Basin NAWQA project .....	543
Hydrogeology of the Pocono Creek Basin, Monroe County .....	557
Index .....	569

### **ILLUSTRATIONS**

Figure 1.--Comparison of monthly precipitation in the Delaware River Basin at Pleasant Mount and Allentown, Pa. during the 2005 water year with mean monthly precipitation for the period 1971 through 2000 .....	4
2.--Comparison of streamflow at two long-term streamflow-gaging stations during the 2005 water year with the median monthly and annual mean streamflow for the period 1971 through 2000 .....	5
3.--Monthly mean specific conductance measured in the Delaware River at Reedy Island Jetty, Delaware for the 2005 water year and the mean monthly specific conductance for the period 1965 through 2004 .....	7
4.--Relation between 2005 seasonal mean ground-water levels and long-term mean ground-water levels .....	9
5.--System for numbering wells and miscellaneous sites .....	11
6.--Location of continuous-record data-collection stations in the upper Delaware River Basin .....	41
7.--Location of continuous-record observation wells in the upper Delaware River Basin .....	42
8.--Location of continuous-record data-collection stations in the lower Delaware River Basin .....	43
9.--Location of continuous-record observation wells in the lower Delaware River Basin .....	44
10.--Location of partial-record data-collection stations in the upper Delaware River Basin .....	45
11.--Location of partial-record data-collection stations in the lower Delaware River Basin .....	46
12.--Daily mean water-quality monitor values recorded at 01463500 Delaware River at Trenton, water year 2005 .....	179
13.--Location of discharge-measurement sites, Pocono Creek Basin, Monroe County, Pennsylvania .....	382
14.--Biological sampling locations and major drainage basin divides in Chester County .....	435
15.--Location of stream and ground-water sampling sites for the Chester County ground-water monitoring program, summer 2005 .....	522
16.--Location of the Hot-Spot Trend Network well, in the Delaware River basin, sampled as part of the Ground Water Pesticides Network project .....	535
17.--Locations of ground-water wells and a spring sampled in August 2005 as part of the Ground Water Pesticides Network project .....	535
18.--Location of Delaware River Basin National Water-Quality Assessment Program low-intensity phase ground-water sampling sites in the Clastic Bedrock within the Triassic Lowlands Section of the Piedmont Physiographic Province .....	544
19.--Location of wells where water levels were measured, Pocono Creek Basin, Monroe County, Pennsylvania .....	557

**CONTENTS**--Continued

	<b>Page</b>
<b><u>TABLES</u></b>	
Table 1. List of stream sites sampled as part of the Pennsylvania water-quality network .....	387
2. List of lakes sampled as part of the Pennsylvania water-quality network .....	388
3. Stream conditions of Chester County biological monitoring network station list.....	434
4. Acid mine drainage project station list .....	452

**SURFACE-WATER STATIONS, IN DOWNSTREAM ORDER, FOR WHICH RECORDS ARE PUBLISHED IN THIS VOLUME**

[Letters after station name designate type of data: (d) discharge, (c) chemical, (sc) specific conductance, (t) water temperature, (do) dissolved oxygen, (%) dissolved oxygen, % saturation, (b) biological, (turb) turbidity, (e) elevation, gage heights, or contents.]

**NORTH ATLANTIC SLOPE BASINS**

	<b>Station number</b>	<b>Page</b>
<b>DELAWARE RIVER BASIN</b>		
West Branch Delaware River at Hancock, N.Y. ....	<sup>a</sup> 01427000	
Delaware River at Callicoon, N.Y. ....	<sup>a</sup> 01427510	
Delaware River above Lackawaxen River near Barryville, N.Y. ....	<sup>a</sup> 01428500	
<b>LACKAWAXEN RIVER BASIN</b>		
West Branch Lackawaxen River near Aldenville (d) .....	01428750	50
West Branch Lackawaxen River at Prompton (d) .....	01429000	52
Dyberry Creek near Honesdale (d) .....	01429500	54
Lackawaxen River near Honesdale (d) .....	01430000	56
Lackawaxen River at Hawley (d) .....	01431500	58
Wallenpaupack Creek:		
Wallenpaupack Creek at Wilsonville (d) .....	01432000	60
Lakes and Reservoirs in Lackawaxen River basin (e) .....		62
Delaware River at Barryville, N.Y. ....	<sup>a</sup> 01432160	
Delaware River at Pond Eddy, N.Y. ....	<sup>a</sup> 01432805	
Delaware River at Port Jervis, N.Y. ....	<sup>a</sup> 01434000	
Delaware River at Montague, N.J. (d,c,b) .....	01438500	64
<b>BUSH KILL BASIN</b>		
Bush Kill at Shoemakers (d,c,b) .....	01439500	68
<b>BRODHEAD CREEK BASIN</b>		
Brodhead Creek near Analomink (d) .....	01440400	74
Paradise Creek:		
Swiftwater Creek at Swiftwater (d) .....	01440485	76
McMichael Creek:		
Pocono Creek above Wigwam Run near Stroudsburg (d) .....	01441495	78
Brodhead Creek at Minisink Hills (d,c,b) .....	01442500	80
Delaware River at Portland (c,b) .....	01443000	84
Delaware River at Belvidere, N.J. (d) .....	01446500	86
<b>LEHIGH RIVER BASIN</b>		
Lehigh River at Stoddartsville (d,c,b) .....	01447500	88
Tobyhanna Creek:		
Tunkhannock Creek near Long Pond (d) .....	01447680	94
Tobyhanna Creek near Blakeslee (d,c,b) .....	01447720	96
Lehigh River below Francis E. Walter Reservoir near White Haven (d) .....	01447800	102
Lehigh River at Leighton (d) .....	01449000	104
Pohopoco Creek at Kresgeville (d) .....	01449360	106
Pohopoco Creek below Beltzville Lake near Parryville (d) .....	01449800	108
Aquashicola Creek at Palmerton (d) .....	01450500	110
Lehigh River at Walnutport (d) .....	01451000	112
Little Lehigh Creek near Allentown (d) .....	01451500	114
Little Lehigh Creek at Tenth Street Bridge at Allentown (d) .....	01451650	116
Jordan Creek near Schnecksville (d) .....	01451800	118
Jordan Creek at Allentown (d) .....	01452000	120
Monocacy Creek at Bethlehem (d) .....	01452500	122

<sup>a</sup> Beginning with the 2005 water year, data for those stations operated by the USGS New York Water Science Center will no longer be published in the Pennsylvania Water Data Report. Those data can be obtained by contacting the Director (518-285-5600; email - dc\_ny@usgs.gov) of the USGS New York Water Science Center, 425 Jordan Road, Troy, NY 12180-8349.

## SURFACE-WATER STATIONS, IN DOWNSTREAM ORDER, FOR WHICH RECORDS ARE PUBLISHED IN THIS VOLUME

**NORTH ATLANTIC SLOPE BASINS**--Continued

	<b>Station number</b>	<b>Page</b>
<b>DELAWARE RIVER BASIN</b> --Continued		
<b>LEHIGH RIVER BASIN</b> --Continued		
Lehigh River at Bethlehem (d) .....	01453000	124
Lehigh River at Glendon (d,c,b) .....	01454700	126
Lehigh River at Easton (sc,pH,t,do) .....	01454720	130
Lakes and Reservoirs in Lehigh River Basin (e) .....		138
Delaware River at Riegelsville, N.J. (c,b) .....	01457500	140
<b>TOHICKON CREEK BASIN</b>		
Nockamixon Reservoir near Ottsville (e) .....	01459350	142
Tohickon Creek near Pipersville (d) .....	01459500	143
Delaware River near Point Pleasant (sc,pH,t,do) .....	01460200	145
Delaware River at Lumberville, N.J. (c,b) .....	01461000	150
Delaware River at Trenton, N.J. (d,c,b,sc,pH,t,do,% ,turb) .....	01463500	152
<b>NESHAMINY CREEK BASIN</b>		
North Branch Neshaminy Creek below Lake Galena near New Britain (d) .....	01464645	182
North Branch Neshaminy Creek at Chalfont (d) .....	01464720	184
Neshaminy Creek near Rushland (d) .....	01464750	186
Little Neshaminy Creek at Valley Road near Neshaminy (d) .....	01464907	188
Neshaminy Creek near Langhorne (d,c,b) .....	01465500	190
<b>POQUESSING CREEK BASIN</b>		
Poquessing Creek at Grant Avenue, Philadelphia (d) .....	01465798	194
<b>PENNYPACK CREEK BASIN</b>		
Pennypack Creek at Lower Rhawn Street Bridge, Philadelphia (d) .....	01467048	196
<b>FRANKFORD CREEK BASIN</b>		
Frankford Creek at Castor Avenue, Philadelphia (d) .....	01467087	198
Delaware River at Benjamin Franklin Bridge at Philadelphia (sc,pH,t,do) .....	01467200	200
<b>SCHUYLKILL RIVER BASIN</b>		
Schuylkill River at Landingville (d) .....	01468500	208
Little Schuylkill River at Tamaqua (d) .....	01469500	210
Schuylkill River at Berne (d,c,b) .....	01470500	212
Tulpehocken Creek near Bernville (d) .....	01470779	218
Spring Creek:		
Furnace Creek at Robesonia (d) .....	01470853	220
Tulpehocken Creek at Blue Marsh damsite near Reading (d) .....	01470960	222
Tulpehocken Creek near Reading (d,c,b) .....	01471000	224
Schuylkill River at Reading (d) .....	01471510	230
Manatawny Creek near Spangsville (d) .....	01471875	232
Schuylkill River at Pottstown (d,c,b) .....	01472000	234
Schuylkill River at Vincent Dam at Linfield (t,do) .....	01472104	238
French Creek near Phoenixville (d,c,b) .....	01472157	242
Perkiomen Creek at East Greenville (d) .....	01472198	248
West Branch Perkiomen Creek at Hillegass (d) .....	01472199	250
East Branch Perkiomen Creek near Dublin (d) .....	01472620	252
East Branch Perkiomen Creek near Schwenksville (d) .....	01472810	254
Perkiomen Creek at Graterford (d) .....	01473000	256
Valley Creek at Pennsylvania Turnpike Bridge near Valley Forge (d,c,b) .....	01473169	258
Schuylkill River at Norristown (d) .....	01473500	264
Wissahickon Creek at Fort Washington (d,c,b) .....	01473900	266
Wissahickon Creek at mouth, Philadelphia (d,c,b) .....	01474000	270
Schuylkill River at Philadelphia (d) .....	01474500	274
Lakes and Reservoirs in Schuylkill River Basin (e) .....		276
Delaware River at Fort Mifflin at Philadelphia (sc,t) .....	01474703	278

## SURFACE-WATER STATIONS, IN DOWNSTREAM ORDER, FOR WHICH RECORDS ARE PUBLISHED IN THIS VOLUME

**NORTH ATLANTIC SLOPE BASINS**--Continued

	<b>Station number</b>	<b>Page</b>
<b>DELAWARE RIVER BASIN</b> --Continued		
<b>DARBY CREEK BASIN</b>		
Cobbs Creek at U.S. Highway No. 1 at Philadelphia (d).....	01475530	280
<b>CRUM CREEK BASIN</b>		
Crum Creek near Newtown Square (d,c,b) .....	01475850	283
<b>RIDLEY CREEK BASIN</b>		
Ridley Creek at Media (d) .....	01476480	288
<b>CHESTER CREEK BASIN</b>		
Chester Creek near Chester (d) .....	01477000	290
Delaware River at Chester (sc,pH,t,do) .....	01477050	292
<b>CHRISTINA RIVER BASIN</b>		
White Clay Creek:		
White Clay Creek near Strickersville (d,c,b) .....	01478245	300
Red Clay Creek near Kennett Square (d,c,b) .....	01479820	304
Brandywine Creek:		
West Branch Brandywine Creek near Honey Brook (d,c,b).....	01480300	309
Birch Run near Wagontown (d,c,b,t) .....	01480400	314
West Branch Brandywine Creek at Coatesville (d,t).....	01480500	321
West Branch Brandywine Creek at Modena (d,c,b,sc,pH,t,do) .....	01480617	325
Broad Run at Northbrook (d) .....	01480638	337
East Branch:		
Marsh Creek near Glenmoore (d) .....	01480675	340
Marsh Creek near Downingtown (d) .....	01480685	342
East Branch Brandywine Creek near Downingtown (d) .....	01480700	344
East Branch Brandywine Creek below Downingtown (d,c,b,sc,pH,t,do) .....	01480870	346
Brandywine Creek at Chadds Ford (d,c,b,sc,pH,t,do) .....	01481000	358
Lakes and Reservoirs in Christina River Basin (e) .....		369
Delaware River at Reedy Island Jetty, DE (sc,pH,t,do) .....	01482800	370
<hr/>		
Discharge at partial-record stations and miscellaneous sites		
Crest-stage partial-record stations .....		378
Miscellaneous sites .....		380
Hydrogeology of the Pocono Creek Basin, Monroe County, discharge-measurement sites .....		382
Analysis of samples collected at special-study sites		
Pennsylvania water-quality network.....		386
Stream conditions of Chester County biological monitoring network .....		434
Acid mine drainage projects in the upper Schuylkill River basin .....		452

**GROUND-WATER WELLS, BY COUNTY, FOR WHICH RECORDS ARE PUBLISHED IN THIS VOLUME**

[Letters after local well number designate type of data: (l) water level.]

**GROUND-WATER RECORDS**

	<b>Page</b>
<b>BERKS COUNTY</b>	
Well 402615075530501 Local number BE 623 (l) .....	488
<b>BUCKS COUNTY</b>	
Well 402643075150501 Local number BK 929 (l) .....	489
Well 401157075032001 Local number BK 1020 (l) .....	490
<b>CARBON COUNTY</b>	
Well 410123075425401 Local number CB 104 (l) .....	491
<b>CHESTER COUNTY</b>	
Well 400650075514001 Local number CH 2 (l) .....	493
Well 395450075485401 Local number CH 10 (l) .....	492
Well 395717075392301 Local number CH 12 (l) .....	493
Well 394846075444901 Local number CH 38 (l) .....	493
Well 400400075314401 Local number CH 89 (l) .....	494
Well 400453075255601 Local number CH 210 (l) .....	494
Well 394457075581601 Local number CH 254 (l) .....	494
Well 395701075561601 Local number CH 1201 (l) .....	495
Well 400412075404301 Local number CH 1229 (l) .....	495
Well 400645075411501 Local number CH 1247 (l) .....	495
Well 395540075332601 Local number CH 1387 (l) .....	496
Well 400956075391501 Local number CH 1571 (l) .....	496
Well 394757075432101 Local number CH 1921 (l) .....	496
Well 400242075484301 Local number CH 2273 (l) .....	497
Well 400325075332501 Local number CH 2313 (l) .....	497
Well 400847075414701 Local number CH 2328 (l) .....	497
Well 400133075450001 Local number CH 2456 (l) .....	498
Well 400039075335201 Local number CH 2457 (l) .....	498
Well 400456075320301 Local number CH 2561 (l) .....	498
Well 395225075422001 Local number CH 2584 (l) .....	499
Well 394624075444001 Local number CH 2663 (l) .....	499
Well 400358075311301 Local number CH 3289 (l) .....	499
Well 395141075525401 Local number CH 5422 (l) .....	500
Well 401405075400301 Local number CH 6513 (l) .....	500
Well 395201075363001 Local number CH 6516 (l) .....	500
Well 400247075532401 Local number CH 6517 (l) .....	501
Well 394903075581901 Local number CH 6518 (l) .....	501
Well 395634075442601 Local number CH 6519 (l) .....	501
<b>DELAWARE COUNTY</b>	
Well 395512075293701 Local number DE 723 (l) .....	502
<b>LEBANON COUNTY</b>	
Well 402207076180801 Local number LB 372 (l) .....	503
<b>LEHIGH COUNTY</b>	
Well 403429075392401 Local number LE 644 (l) .....	504
<b>MONROE COUNTY</b>	
Well 411223075234901 Local number MO 190 (l) .....	505

**GROUND-WATER WELLS, BY COUNTY, FOR WHICH RECORDS ARE PUBLISHED IN THIS VOLUME**

**GROUND WATER RECORDS**--Continued

	<b>Page</b>
<b>MONTGOMERY COUNTY</b>	
Well 401415075175101 Local number MG 68 (l) .....	506
Well 401338075162801 Local number MG 72 (l) .....	507
Well 400808075210401 Local number MG 225 (l) .....	508
Well 401733075171401 Local number MG 917 (l) .....	509
Well 401314075171401 Local number MG 1145 (l) .....	510
Well 401318075171101 Local number MG 1146 (l) .....	511
Well 401322075171201 Local number MG 1147 (l) .....	512
Well 401324075171601 Local number MG 1148 (l) .....	513
Well 401321075171701 Local number MG 1149 (l) .....	514
Well 401323075171201 Local number MG 1842 (l) .....	515
<b>NORTHAMPTON COUNTY</b>	
Well 404745075184001 Local number NP 820 (l) .....	516
<b>PHILADELPHIA COUNTY</b>	
Well 395342075102101 Local number PH 12 (l) .....	517
<b>PIKE COUNTY</b>	
Well 410940074583401 Local number PI 200 (l) .....	518
Well 411833075133601 Local number PI 522 (l) .....	519
<b>SCHUYLKILL COUNTY</b>	
Well 404708076070701 Local number SC 296 (l) .....	520
<b>WAYNE COUNTY</b>	
Well 414333075153201 Local number WN 64 (l) .....	521
 <b><u>GROUND-WATER DATA COLLECTED AT SPECIAL-STUDY SITES</u></b>	
Chester County ground-water-quality monitoring program .....	522
Ground Water Pesticides Network project .....	534
Delaware River Basin NAWQA project .....	543
Hydrogeology of the Pocono Creek Basin, Monroe County .....	557

The following continuous-record surface-water discharge stations (listed by downstream order) have been discontinued. Daily streamflow records were collected and published for the period of record shown for each station. Discontinued stations with less than 3 years of record have not been included. Information regarding these stations may be obtained from the USGS Pennsylvania Water Science Center office at the address given on the back of the title page of this report.

**DISCONTINUED CONTINUOUS-RECORD SURFACE-WATER DISCHARGE STATIONS**

Station name	Station number	Drainage area (mi <sup>2</sup> )	Period of record (water years)
DELAWARE RIVER BASIN			
North Branch Calkins Creek near Damascus	01427650	7.02	1965-73
Lackawaxen River at West Hawley	01430500	206	1922-37
Middle Creek near Hawley	01431000	78.4	1945-59
Stevens Creek near Sterling	01431620	0.68	1992-94
Ariel Creek near Ledgesdale	01431673	15.6	1992-94
Unnamed tributary to Purdy Creek near Lakeville	01431683	0.34	1992-94
Purdy Creek at Lakeville	01431685	8.18	1992-94
Shohola Creek near Shohola	01432500	83.6	1920-28
Delaware River below Tocks Island Damsite, near Delaware Water Gap	01440200	3,850	1964-96
McMichaels Creek at Stroudsburg	01441000	65.3	1912-37
Pocono Creek near Stroudsburg	01441500	41.0	1912-19
Lehigh River at Tannery	01448000	322	1919-58
Martins Creek near East Bangor	01446600	10.4	1962-77
Delaware River at Easton	01446700	4,636	1967-77
Dilldown Creek near Long Pond	01448500	2.39	1949-96
Wild Creek at Hatchery	01449500	16.8	1941-78
Pohopoco Creek near Parryville	01450000	109	1941-69
Little Lehigh Creek near East Texas	01451420	51.2	1987-94
East Branch Monocacy Creek near Bath	01452300	5.35	1963-68
Saucon Creek at Lanark	01453500	12.1	1948-53
South Branch Saucon Creek at Friedensville	01454000	10.3	1948-53
Saucon Creek at Friedensville	01454500	26.6	1948-53
Cooks Creek at Durham Furnace	01457790	29.4	1991-93
Tinicum Creek near Ottsville	01458900	14.7	1991-93
Tohickon Creek at Point Pleasant	01460000	107	1884-98, 1901-12
Paunacussing Creek at Carversville	01460800	6.49	1991-93

**DISCONTINUED CONTINUOUS-RECORD SURFACE-WATER DISCHARGE STATIONS**—Continued

Station name	Station number	Drainage area (mi <sup>2</sup> )	Period of record (water years)
Pine Run at Chalfont	01464710	11.6	1990-92
Cooks Run at New Britain	01464741	3.08	1985-89
Neshaminy Creek near Rushland	01464750	91.0	1987-92
Little Neshaminy Cr. at Walton Road near Jacksonville	01464984	40.1	1986-92
Neshaminy Creek at Rushland	01465000	134	1885-1912, 32-33
Mill Creek near Wycombe	01465050	14.0	1990-93
Poquessing Creek at Trevoise Road, Philadelphia	01465780	13.2	1965-70
Walton Run at Philadelphia	01465785	2.17	1965-77
Byberry Creek at Chalfont Road, Philadelphia	01465790	5.34	1966-77
Byberry Creek at Grant Avenue, Philadelphia	01465795	7.13	1965-70
Pennypack Creek at Pine Road, Philadelphia	01467042	37.9	1965-80
Pennypack Creek below Verree Road, Philadelphia	01467045	42.8	1965-70
Wooden Bridge Run at Philadelphia	01467050	3.35	1966-80
Tacony Creek near Jenkintown	01467083	5.25	1973-78
Rock Creek above Curtis Arboretum near Philadelphia	01467084	1.15	1972-78
Jenkintown Creek at Elkins Park	01467085	1.17	1974-78
Tacony Creek above Adams Avenue, Philadelphia	01467086	16.7	1966-86
Frankford Creek at Torresdale Avenue, Philadelphia	01467089	33.8	1967-80
Schuylkill River at Pottsville	01467500	53.4	1944-69
Little Schuylkill River at Drehersville	01470000	122	1948-50, 1964-65
Maiden Creek tributary at Lenhartsville	01470720	7.46	1966-79
Maiden Creek at Virginville	01470756	159	1973-94
Manatawny Creek near Pottstown	01471980	85.5	1974-2004
Pickering Creek near Chester Springs	01472174	5.98	1967-82
Perkiomen Creek near Frederick	01472500	152	1885-1912
Skippack Creek near Collegeville	01473120	53.7	1966-94
Schuylkill River at Norristown	01473500	1,760	1928-32
Wissahickon Creek at Bells Mill Road, Philadelphia	01473950	53.6	1966-70, 1974-81
Wissahickon Creek at Livezey Lane, Philadelphia	01473980	59.2	1967-70
Schuylkill River above Passayunk Ave. at Philadelphia	01474505	1,900	1979-93

**DISCONTINUED CONTINUOUS-RECORD SURFACE-WATER DISCHARGE STATIONS**—Continued

Station name	Station number	Drainage area (mi <sup>2</sup> )	Period of record (water years)
Darby Creek at Waterloo Mills near Devon	01475300	5.1	1972-97
Darby Creek near Darby	01475510	37.4	1964-90
Cobbs Creek below Indian Creek near Upper Darby	01475540	10.6	1965-73
Naylor Creek at West Chester Pike near Philadelphia	01475545	1.10	1974-78
Cobbs Creek at Darby	01475550	22.0	1964-90
Crum Creek at Woodlyn	01476000	33.3	1932-37
Ridley Creek at Moylan	01476500	31.9	1932-54
Marsh Creek near Lyndell	01480680	17.8	1961-69
East Branch Brandywine Creek at Downingtown	01480800	81.6	1958-68
Valley Creek at Ravine Road near Downingtown	01480887	14.5	1990-97

The following continuous-record water-quality stations (listed by downstream order) have been discontinued. Daily records were collected and published for the period shown for each constituent. Discontinued stations with less than 3 years of record, or stations with data collection less than daily, have not been included. If a station had one constituent with 3 or more years of record, all constituents having daily values will be listed for that station regardless of the length of record. Information regarding these stations may be obtained from the USGS Pennsylvania Water Science Center office at the address given on the back of the title page of this report.

The following abbreviations are used in this table: --- (not determined); SC (specific conductance); pH; Temp (water temperature); DO (dissolved oxygen); Sed (sediment concentration and discharge); Biol (biological).

#### DISCONTINUED CONTINUOUS-RECORD SURFACE-WATER-QUALITY STATIONS

Station name	Station number	Drainage area (mi <sup>2</sup> )	Type of Record	Period of record (water years)
DELAWARE RIVER BASIN				
Delaware Bay at Ship John Shoal Light, N.J.	01412350	---	SC, Temp	1968-86
Delaware River at Lordville, N.Y.	01427207	1,590	Temp	1968-71, 1973-96
Delaware River at Narrowsburg, N.Y.	01427740	2,023	SC, pH	1948-51
West Branch Lackawaxen River near Aldenville	01428750	40.6	Temp	1988-2004
West Branch Lackawaxen River at Prompton	01429000	59.7	Temp	1987-2004
Delaware River at Port Jervis, N.Y.	01434000	3,070	Temp	1957-60, 1973-94
Delaware River at Montague, N.J.	01438500	3,480	Temp SC, pH	1956-57 1956-73
Delaware River at Dingmans Ferry	01439000	3,542	Temp, SC, pH	1950-53
Delaware River near East Stroudsburg	01440090	3,830	SC, DO, Temp pH	1966-78 1972-78
Delaware River at Dunnfield, N.J.	01442750	4,150	Sed	1964-75
Delaware River near Richmond	01444800	4,378	Temp SC	1944-47, 1962-63 1962-63
Delaware River at Easton	01446700	4,636	SC, DO, Temp, pH	1967-77
Lehigh River at Stoddartsville	01447500	91.7	Temp	1981-2004
Tobychanna Creek near Blakeslee	01447720	118	Temp	1980-2004
Lehigh River below Francis E. Walter Reservoir near White Haven	01447800	290	Temp	1988-2004
Pohopoco Creek at Kresgeville	01449360	49.9	Temp	1969-2004
Pohopoco Creek below Beltzville Lake near Parryville	01449800	96.4	Temp	1969-2004
Lehigh River at Walnutport	01451000	889	Sed	1948-53
Jordan Creek near Schnecksville	01451800	53.0	Sed	1967-69

## DISCONTINUED CONTINUOUS-RECORD SURFACE-WATER-QUALITY STATIONS—Continued

Station name	Station number	Drainage area (mi <sup>2</sup> )	Type of Record	Period of record (water years)
Jordan Creek at Allentown	01452000	75.8	Sed	1967-69
Lehigh River at Bethlehem	01453000	1,279	SC, pH	1906-07, 1956-72
Delaware River at Burlington-Bristol Bridge	01464600	7,163	Temp DO SC, pH	1954-75, 1979-80 1961-75, 1978-80 1967-75, 1978-80
Neshaminy Creek near Langhorne	01465500	210	Sed	1956-58, 1965-69
Poquessing Creek at Trevoise Road, Philadelphia	01465770	5.08	Sed	1965-69
Poquessing Creek above Byberry Creek, Philadelphia	01465780	13.2	Sed	1965-70
Walton Run at Philadelphia	01465785	2.17	Sed	1965-68
Byberry Creek at Chalfont Road, Philadelphia	01465790	5.34	Sed	1966-68, 1970
Byberry Creek at Grant Avenue, Philadelphia	01465795	7.13	Sed	1965-70
Poquessing Creek at Grant Avenue, Philadelphia	01465798	21.4	Sed	1965-70
Delaware River at Torresdale Intake, Philadelphia	01467030	7,781	Temp DO SC pH	1956-57, 1960-81 1961-81 1963-81 1968-81
Pennypack Creek at Pine Road, Philadelphia	01467042	37.9	Sed	1965-69
Pennypack Creek below Verree Road, Philadelphia	01467045	42.8	Sed	1965-69
Wooden Bridge Run at Philadelphia	01467049	3.35	Sed	1965-70
Delaware River at Palmyra, N.J.	01467060	7,850	Sed	1962-64
Tacony Creek at County Line, Philadelphia	01467084	16.2	Sed	1966-69
Frankford Creek at Torresdale Avenue, Philadelphia	01467088	33.8	Sed	1966-70
Delaware River at Lehigh Avenue, Philadelphia	01467100	7,935	SC, DO, Temp, pH	1949-68
Delaware River at Wharton Street, Philadelphia	01467300	7,998	Temp, SC, pH, DO	1949-68
Delaware River at League Island, Philadelphia	01467400	8,072	SC, DO, Temp, pH	1949-68
Schuylkill River at Port Carbon	01467470	27.1	SC, pH, Sed	1949-51, 1963
Schuylkill River at Pottsville	01467500	53.4	SC, pH Sed	1948-51, 1963-66 1963-66
West Branch Schuylkill River at Cressona	01467950	52.5	Sed	1963-66

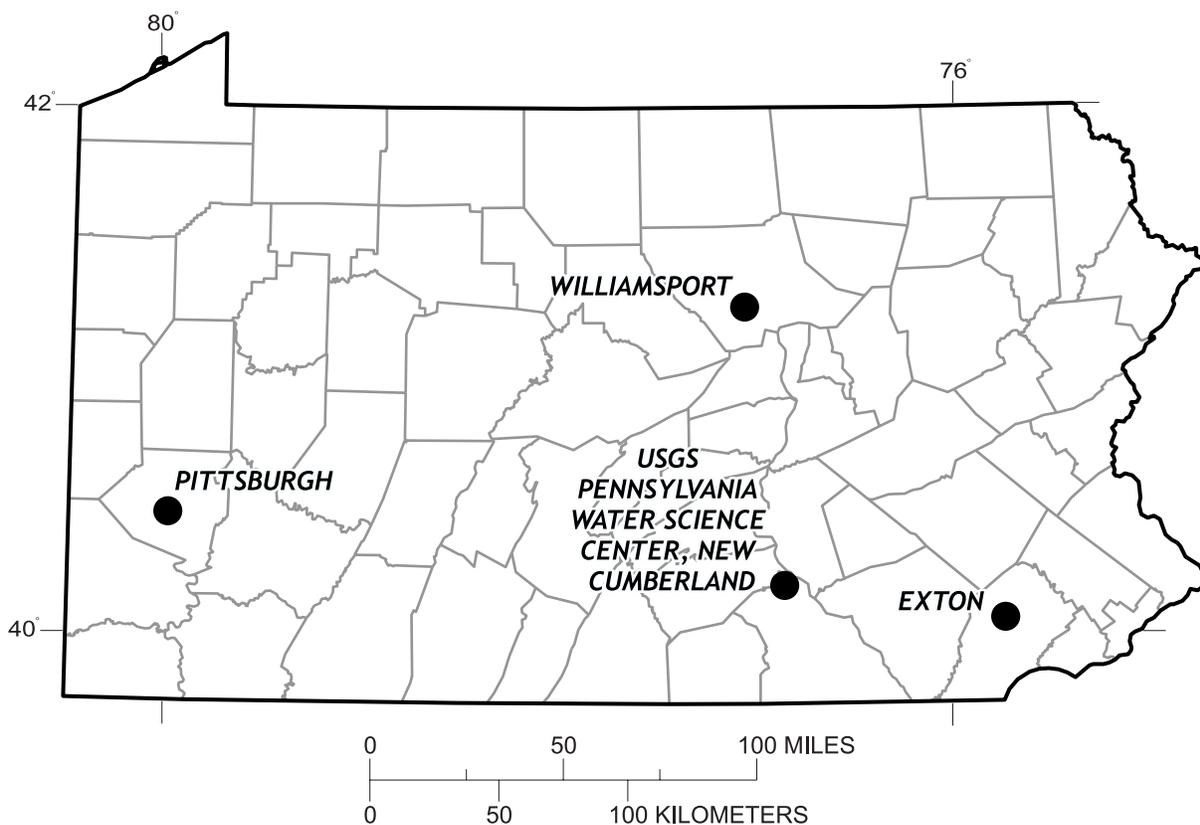
## DISCONTINUED CONTINUOUS-RECORD SURFACE-WATER-QUALITY STATIONS—Continued

Station name	Station number	Drainage area (mi <sup>2</sup> )	Type of Record	Period of record (water years)
Schuylkill River at Landingville	01468500	133	SC, pH, Temp Sed	1947-53 1947-53, 1963-65
Schuylkill River at Auburn	01469000	160	Sed, SC, pH	1947-51, 1963-65
Little Schuylkill River at South Tamaqua	01469700	65.7	SC, pH Sed	1948-51, 1963 1950-53, 1963
Little Schuylkill River at Drehersville	01470000	122	SC, pH, Temp, Sed	1947-51, 1963-65
Schuylkill River at Berne	01470500	355	Temp  SC, pH Sed	1948-53, 1957-81 1963-81 1947-81
Maiden Creek tributary at Lenhartsville	01470720	7.46	Sed	1963-65
Maiden Creek near East Berkley	01470760	192	Sed	1963-65
Tulpehocken Creek near Bernville	01470779	66.5	Temp	1978-2004
Tulpehocken Creek at Blue Marsh Damsite near Reading	01470960	175	Temp	1969-2004
Tulpehocken Creek near Reading	01471000	211	Sed	1963-65
Schuylkill River at Pottstown	01472000	1,147	Temp  Sed, pH SC	1944-51, 1956, 1963-66 1948-51, 1963-66 1948-51, 1963-66, 1985-89
Pigeon Creek near Bucktown	01472054	4.20	Biol	1970-83
Pigeon Creek at Porters Mill	01472065	6.97	Biol	1970-83
Stony Run at Spring City	01472110	4.07	Biol	1970-83
Schuylkill River at Black Rock Dam at Mont Clare	01472119	---	SC, DO	1986-90
French Creek at Trythall	01472126	5.06	Biol	1971-83
French Creek near Knauertown	01472129	11.7	Biol	1970-83
Pickering Creek near Chester Springs	01472174	5.98	Sed	1967-69
Perkiomen Creek at Graterford	01473000	279	SC, pH, Temp  Sed	1946-51, 1948-53 1963-66
Schuylkill River at Norristown Dam at Bridgeport	01473499	---	SC, DO	1985-90

## DISCONTINUED CONTINUOUS-RECORD SURFACE-WATER-QUALITY STATIONS—Continued

Station name	Station number	Drainage area (mi <sup>2</sup> )	Type of Record	Period of record (water years)
Schuylkill River at Plymouth Dam	01473675	---	SC, DO	1985-90
Schuylkill River at Flat Rock Dam at West Manayunk	01473780	---	SC, DO	1985-90
Schuylkill River at Manayunk	01473800	893	SC, pH Sed Temp	1947-70 1947-86 1956-70
Wissahickon Creek at Fort Washington	01473900	40.8	Sed	1963-69
Wissahickon Creek at Bells Mill Road, Philadelphia	01473950	53.6	Sed	1966-69
Wissahickon Creek at Livezey Lane, Philadelphia	01473980	59.2	Sed	1966-69
Wissahickon Creek at mouth, Philadelphia	01474000	64.0	Sed	1966-69
Darby Creek near Darby	01475510	37.4	Sed	1965-69
Cobbs Creek at US Highway 1 near Philadelphia	01475530	4.78	Sed	1965-70
Cobbs Creek below Indian Creek near Upper Darby	01475540	9.65	Sed	1965-69
Cobbs Creek at Darby	01475550	22.0	Sed	1965-69
Crum Creek near Paoli	01475830	6.16	Biol	1970-83
Delaware River at Eddystone	01476200	10,190	SC, DO, Temp, pH	1949-68
Delaware River at Marcus Hook	01477200	10,370	SC, DO, Temp, pH	1949-77
West Branch Brandywine Creek near Honey Brook	01480300	18.7	Sed	1965-66, 1968
East Branch Brandywine Creek near Struble Dam	01480647	4.36	Biol	1972-82
Marsh Creek near Lyndell	01480680	17.8	Temp Sed	1965-66 1965-66, 1968
Marsh Creek near Downingtown	01480695	20.3	Temp	1973-87
Brandywine Creek at Chadds Ford	01481000	287	Sed	1963-70
Delaware River at Delaware Memorial Bridge, Del.	01482100	11,030	Temp DO SC pH	1956-81 1962-81 1963-81 1968-81

# USGS PENNSYLVANIA WATER SCIENCE CENTER LOCATIONS AND ADDRESSES



**USGS Pennsylvania  
Water Science Center:  
U.S. Geological Survey**  
Yellow Breeches Office Center  
215 Limekiln Road  
New Cumberland, PA 17070  
(717) 730-6900  
FAX (717) 730-6997

**USGS Pennsylvania  
Water Science Center  
Williamsport Office:  
U. S. Geological Survey**  
439 Hepburn Street  
Williamsport, PA 17701  
(570) 323-7127  
FAX (570) 323-2137

**USGS Pennsylvania  
Water Science Center  
Pittsburgh Office:  
U.S. Geological Survey**  
1000 Church Hill Road  
Pittsburgh, PA 15205  
(412) 490-3800  
FAX (412) 490-3828

**USGS Pennsylvania  
Water Science Center  
Exton Office:  
U.S. Geological Survey**  
770 Pennsylvania Drive  
Suite 116  
Exton, PA 19341  
(610) 321-2434

## **INTRODUCTION**

The USGS Pennsylvania Water Science Center, in cooperation with State, municipal, and Federal agencies, collects a large amount of data pertaining to the water resources of Pennsylvania each water year. These data, accumulated during many water years, constitute a valuable data base for developing an improved understanding of the water resources of the State. To make these data readily available to interested parties outside the Geological Survey, these data are published annually in this report series entitled "Water Resources Data - Pennsylvania, Volumes 1, 2, and 3." Volume 1 contains data for the Delaware River Basin; Volume 2, the Susquehanna and Potomac River Basins; and Volume 3, the Ohio and St. Lawrence River Basins.

This report, Volume 1, contains: (1) discharge records for 75 continuous-record streamflow-gaging stations, 5 partial-record stations, 41 special study and miscellaneous streamflow sites; (2) elevation and contents records for 13 lakes and reservoirs, and water quality records for 5 lakes and reservoirs; (3) water-quality records for 24 gaging stations and 10 ungaged streamsites; (4) water-quality records for 73 special-study stations; (5) water-level records for 52 network observation wells; and (6) water-quality analyses of ground water from 42 ground-water wells. Additional water data collected at various sites not involved in the systematic data-collection program may also be presented.

Publications similar to this report are published annually by the Geological Survey for all States. For the purpose of archiving, these official reports have an identification number consisting of the two-letter State abbreviation, the last two digits of the water year, and the volume number. For example, this volume is identified as "U.S. Geological Survey Water-Data Report PA-05-1." These water data reports, beginning with the 1971 water year, are for sale as paper copy or microfiche by the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

The annual series of Water Data Reports for Pennsylvania began with the 1961 water-year report and contained only data relating to quantities of surface water. With the 1964 water year, a companion report (part 2) was introduced that contained only data relating to water quality. Beginning with the 1975 water year the report was changed to its present format of three volumes (by river basin), with each volume containing data on quantities of surface water, quality of surface and ground water, and ground-water levels.

Prior to the introduction of this series and for several years concurrent with it, water-resources data for Pennsylvania were published in U.S. Geological Survey Water-Supply Papers. Data on stream discharge and stage, and on lake or reservoir contents and stage, through September 1960, were published annually under the title "Surface-Water Supply of the United States," which was released in numbered parts as determined by natural drainage basins. For the 1961-70 water years, these data were published in two 5-year reports. Data prior to 1961 are included in two reports: "Compilation of Records of Surface Waters of the United States through 1950," and "Compilation of Records of Surface Waters of the United States, October 1950 to September 1960." Data for Pennsylvania are published in Parts 1, 3, and 4. Data on chemical quality, temperature, and suspended sediment for the 1941-70 water years were published annually under the title "Quality of Surface Waters of the United States," and ground-water levels for the 1935-74 water years were published under the title "Ground-Water Levels in the United States." The above mentioned Water-Supply Papers may be consulted in the libraries of the principal cities of the United States and may be purchased from the U.S. Geological Survey, Information Services, Box 25286, Denver, CO 80225.

Information for ordering specific reports may be obtained from the USGS Pennsylvania Water Science Center at the address given on the back of the title page or by phoning the Scientific and Technical Products Section, at (717) 730-6940. Information on the availability of unpublished data or statistical analyses may be obtained from the USGS Pennsylvania Water Science Center Information Specialist by telephone at (717) 730-6916 or by FAX at (717) 730-6997.

## **COOPERATION**

The U.S. Geological Survey (USGS) and organizations of the Commonwealth of Pennsylvania have had cooperative agreements for the systematic collection of surface-water records during the periods 1919-21 and 1931 to date, water-quality records from 1944 to date, and ground-water records from 1925 to date. Organizations that supplied data are acknowledged in station manuscripts. Organizations that assisted in collecting data for this report through cooperative agreements with the USGS are listed below.

The Commonwealth of Pennsylvania,  
Department of Environmental Protection, Kathleen A. McGinty, Secretary through the following:  
Office of Water Management, Cathleen C. Myers, Deputy Secretary;  
    Bureau of Water Standards and Facility Regulation, Frederick A. Marrocco, Director;  
    Bureau of Watershed Management, Stuart I. Gansell, Director;  
    Bureau of Waterways Engineering, Michael D. Conway, Director

Bucks County Commissioners, Charles H. Martin, Chairman;  
Chester County Health Department, David Jackson, Executive Director;  
Chester County Water Resources Authority, Janet L. Bowers, Executive Director;  
City of Allentown, Roy Afflerbach, Mayor;  
City of Bethlehem, John B. Callahan, Mayor;

**COOPERATION--Continued**

City of Philadelphia, Water Department, Kumar Kishinchand, Water Commissioner;  
City of Wilmington, Delaware, James M. Baker, Mayor;  
Delaware County Solid Waste Authority, Joseph W. Vasturia, Chief Executive Officer;  
Delaware Geological Survey, John Talley, Director;  
Delaware River Basin Commission, Carol R. Collier, Executive Director;  
Hazelton City Authority, Water Department, Randy J. Cahalan, Operation Manager;  
Monroe County Conservation District, Craig Todd, District Manager;  
North Penn Water Authority, Anthony J. Bellitto, Jr., Executive Director;  
North Wales Water Authority, Peter. S. Lukens, Executive Director.

Federal Energy Regulatory Commission Licensee:  
PPL Electric Utilities Corporation.

The following Federal agency assisted in the data-collection program by providing funds or services: Corps of Engineers, U.S. Army, Philadelphia District, the U.S. Environmental Protection Agency, Region III, and the National Park Service.

The following organizations aided in collecting records: Palmer Water Company, Aqua Pennsylvania Water Company, Borough of Tamaqua, Womelsdorf-Robeson Joint Water Authority, Forest Park Water Company, and the City of Coatesville.

## SUMMARY OF HYDROLOGIC CONDITIONS

### Surface Water

The Delaware River Basin extends from the confluence of the river's East and West branch headwaters at Hancock, New York, located in the Catskill Mountains, southward 330 miles to the mouth of the Delaware Bay. In addition to Pennsylvania, the Delaware River drains parts of the states of New York, New Jersey, Delaware, and Maryland. The river is fed by 216 tributaries, the largest being the Schuylkill and Lehigh Rivers in Pennsylvania. Of the 13,539-mi<sup>2</sup> (square mile) drainage basin, 6,422 mi<sup>2</sup> (50.3 percent of the basin's total area) are within the Commonwealth of Pennsylvania (Delaware River Basin Commission, 2005).

### **Precipitation and Streamflow**

Precipitation for the 2005 water year was slightly below normal and streamflows, on average, slightly above normal. Data from 28 selected National Oceanic and Atmospheric Administration climatological sites, located within 3 climatological regions in the Delaware River basin in Pennsylvania, indicate the annual total precipitation for the Delaware River basin in Pennsylvania averaged 42.6 inches. This average is about 90 percent of the 1971-2000 basinwide average of 47.0 inches.

For the period October to December average basinwide precipitation was about normal with an average surplus of 0.20 inches. Precipitation totals averaged about 1.3 inches above normal from January to March. During April, May, and June precipitation averaged about 2.3 inches below normal throughout the basin. Basinwide precipitation during July, August, and September averaged about 3.8 inches below normal. The greatest surplus basinwide, with an average of 1.9 inches above normal, occurred in April. The greatest deficit basinwide, with an average of 3.2 inches below normal, occurred in September. Precipitation for the water year was about 4.6 inches below the 1971-2000 basinwide average. The precipitation data are from the National Oceanic and Atmospheric Administration (Northeast Region Climate Center) and National Weather Service records.

Monthly precipitation at two index stations in the Delaware River basin were used as indicator sites within the basin. The 2005 water year monthly precipitation was compared with the 1971-2000 mean monthly precipitation recorded at Pleasant Mount and Allentown, Pennsylvania (fig. 1). The indicator sites show normal to above-normal precipitation at both sites for November through April. The greatest surplus at the Allentown site occurred in April and at Pleasant Mount occurred in January. The greatest deficit at the indicator sites, with an average of 3.1 inches below normal, occurred in May.

Streamflow varied seasonably throughout the basin and generally reflected the precipitation patterns within the basin unless the stream was regulated. Following a continuing pattern defined by the above-normal precipitation that fell in the basin during the 2004 water year, the mean annual streamflow for unregulated Delaware River basin streams during the 2005 water year was slightly above normal. (Normal streamflows are defined as streamflows between the 25th and 75th percentiles of the streamflows measured during the period 1971-2000.)

The Delaware River Basin and its tributaries experienced flooding as a result of two early spring rainstorms. The first was on March 28-29 and a second on April 2-3. This rainfall combined with snowmelt resulted in flooding on the main stem of the Delaware River that exceeded the peaks caused by Tropical Storm Ivan in September 2004. At many streamflow sites along the main stem, the peaks exceeded the August 1955 flood.

Using 39 unregulated sites with greater than 15 years of record, no new record high annual mean streamflows were recorded during the water year. Using those same 39 sites, new record instantaneous maximums were recorded at two sites as a result of the April flooding.

Two U.S. Geological Survey streamflow-gaging stations within the basin were selected as indicators of basinwide streamflow conditions. Figure 2 compares the 2005 water year monthly and annual mean streamflows with the median of the monthly and annual mean streamflows for 1971 through 2000 at the indicator sites. The 2005 water year annual mean streamflow of the Bush Kill at Shoemakers in the upper Delaware River basin was 111 percent of the 1971-2000 median of the mean annual streamflows. The mean annual streamflow of the Schuylkill River at Pottstown in the lower Delaware River basin was 116 percent of the 1971-2000 median of the mean annual streamflows.

Monthly streamflows were above normal in the Bush Kill for October, December, January, and April (fig. 2). Monthly streamflows were above normal in the Schuylkill River at Pottstown during October through January and April. The remaining months had normal streamflows, except for May, June, August, and September when streamflows were below normal (fig. 2).

There were no drought declarations affecting the Delaware River basin during the 2005 water year. All 67 Pennsylvania counties remained in a normal status for the entire water year.

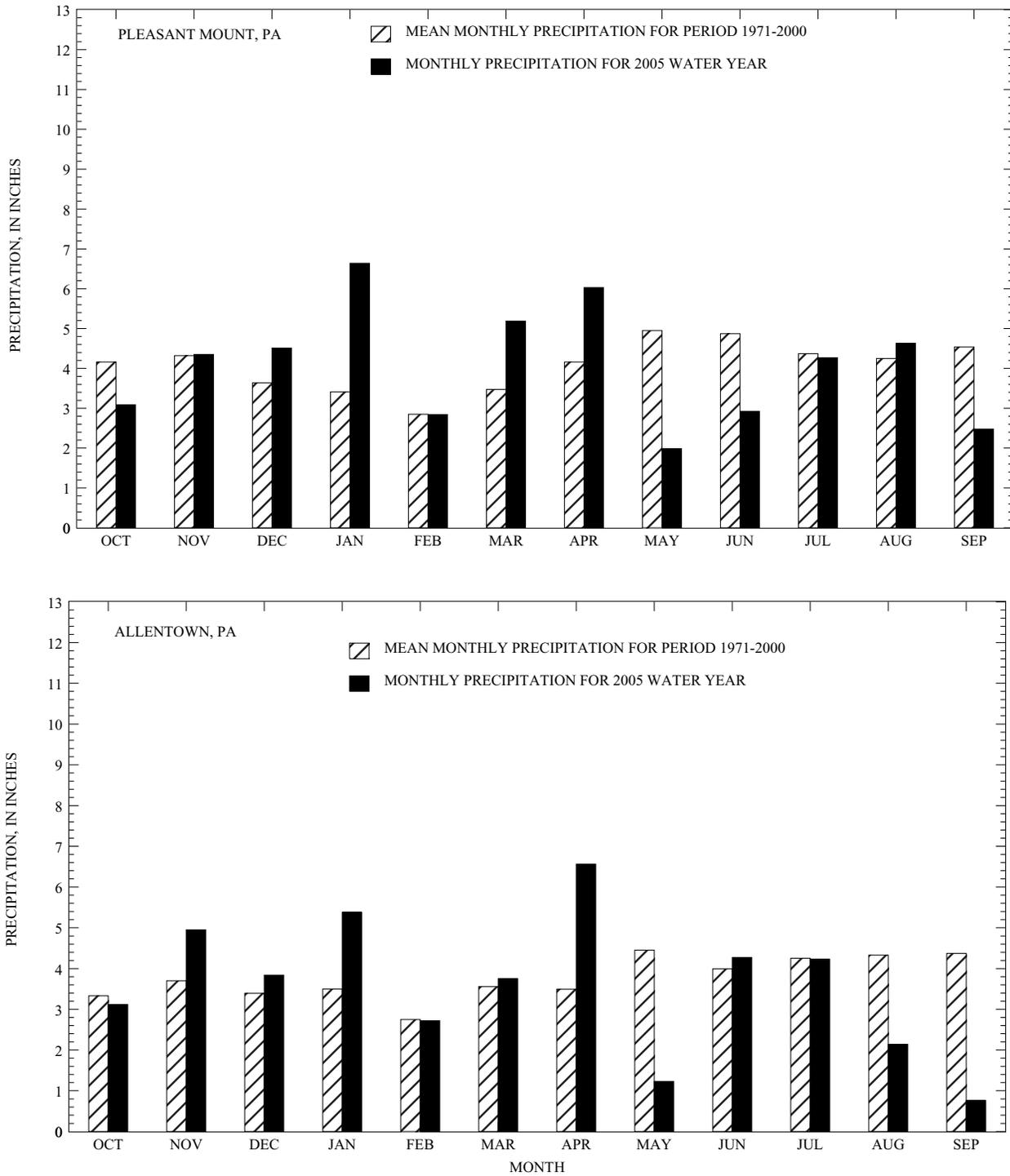


Figure 1.--Comparison of monthly precipitation in the Delaware River Basin at Pleasant Mount and Allentown, Pa. during the 2005 water year with mean monthly precipitation for the period 1971 through 2000.

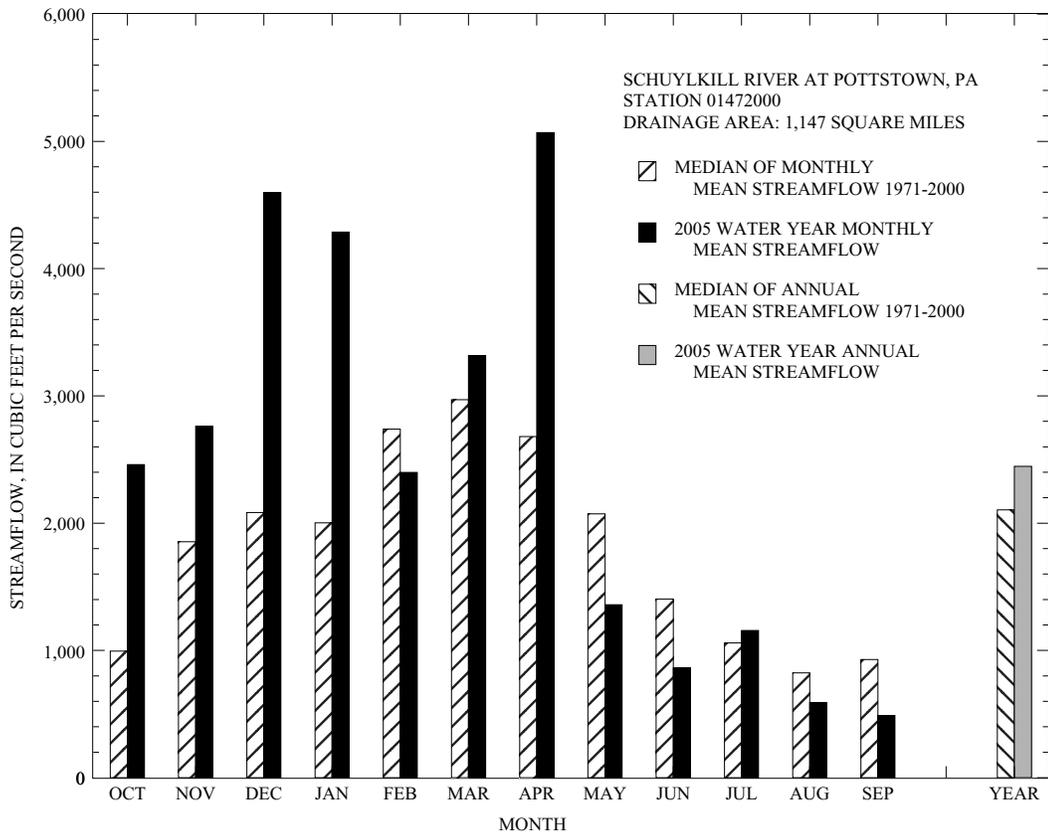
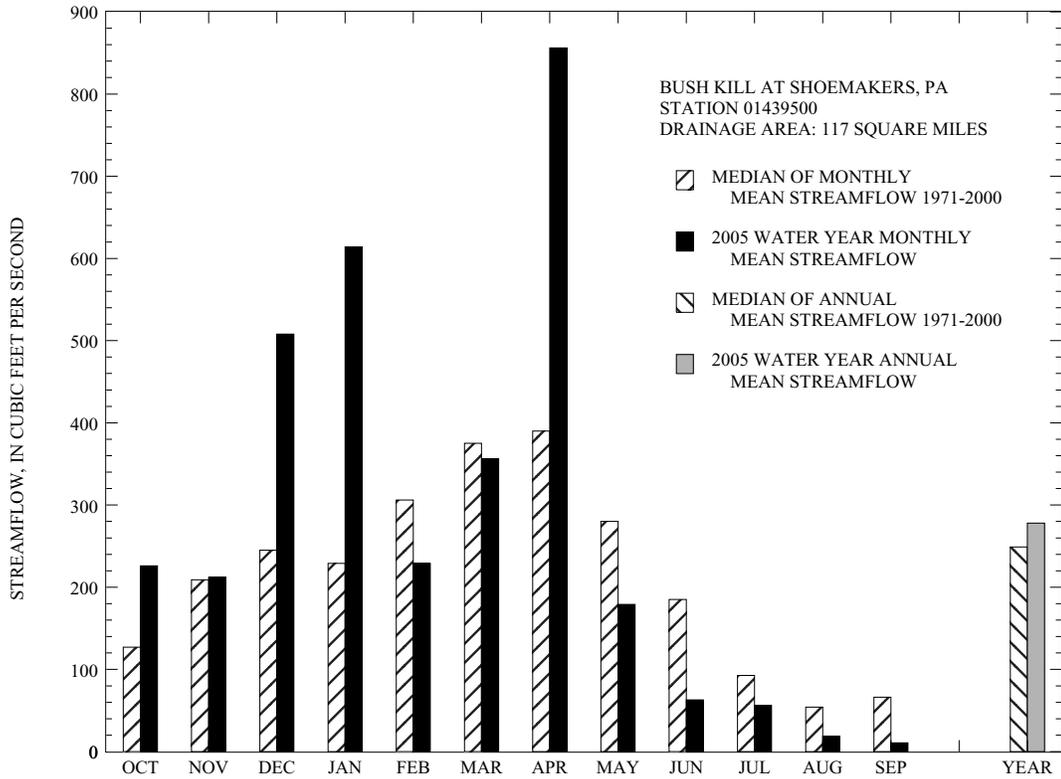


Figure 2.--Comparison of streamflow at two long-term streamflow-gaging stations during the 2005 water year with the median monthly and annual mean streamflow for the period 1971 through 2000.

### **Reservoirs**

Total combined capacity of the major reservoirs in the Delaware River basin within Pennsylvania is 659,390 acre-feet. Total combined drainage areas into these reservoirs is about 1,130 square miles or 18 percent of the total Delaware River basin drainage area within the Commonwealth of Pennsylvania. Combined storage in 13 major reservoirs in the Delaware River basin within Pennsylvania decreased slightly from 272,300 acre-feet (41.3 percent of total combined capacity) on September 30, 2004 to 246,179 acre-feet (37.3 percent of total combined capacity) on September 30, 2005. This decrease in water storage in the basin for the year is a reflection of the above-normal storage conditions in effect in October 2004 as a result of high streamflows in September 2004. About two-thirds of the combined reservoir storage decrease was the result of the increase in usable storage now in effect at Lake Wallenpaupack (station 01431700).

### **Water Quality**

As part of an ongoing program, the USGS maintains a network of continuous-record water-quality monitoring sites along the Delaware River and its tributaries. Water temperature, dissolved oxygen, pH, and specific conductance are monitored at most sites from April through November. A primary concern to water-resource managers of the Lower Delaware River Basin is the upstream migration of saline water from the Delaware Bay. The salinity and dissolved-solid content in the water are indirectly measured by specific conductance.

Water quality of the Delaware Estuary was monitored between Trenton, N.J., and Reedy Island Jetty, Delaware. Streamflow is a vital factor that influences the water quality of the estuary. Increased streamflow usually results in better water quality by limiting salt-water intrusion and diluting the concentration of dissolved minerals, both of which contribute to a lower specific conductance and chloride level. Increased freshwater streamflow also aids in maintaining lower water temperature during warm weather and in supporting higher dissolved-oxygen levels.

In general, streamflow for the Delaware River continued the trend begun in 2004 and was above normal going into the 2005 water year. The annual mean streamflow as recorded at Delaware River at Trenton, N.J., was 132 percent of the period of record mean annual streamflow. The highest sustained streamflows occurred in early April as a direct result of two early spring rainstorms, the first on March 28-29 and a second on April 2-3. This rain combined with snowmelt to cause major flooding in the basin. The highest momentary streamflows (peaks) occurred on April 4. (For additional streamflow information refer to Delaware River at Trenton, N.J., station 01463500, pages 152-180). Higher than normal sustained streamflows in the Delaware River generally continued through April. Beginning with May and continuing through September streamflows began to drop and by the end of September were nearing record lows. As a reflection of these streamflows, the monthly mean specific conductance at the U.S. Geological Survey water-quality monitoring station on the Delaware River at Reedy Island Jetty, Delaware, was lowest in April and highest in September. Generally higher than normal flows through April, resulted in the monthly mean conductance at Reedy Island for the months of October through January and the month of April to be 47 percent, 77 percent, 27 percent, 55 percent and 56 percent, respectively, of the normal mean monthly conductance for those months for the 40-year period of record.

Figure 3 compares the 2005 water year monthly mean specific conductance with the mean monthly values for the period 1965 through 2004. The mean monthly values of specific conductance were lower than the mean for the period of record for October through January and April. Higher streamflows early in the water year kept the migration of saline water, (commonly known as "The Salt Line") at or downstream of River Mile 72, a location about 4 miles upstream of the Delaware Memorial Bridge, into early summer. During the summer months and continuing into late September, the salt line continued to migrate upstream. The furthestmost upstream location for the 2005 water year was River Mile 86, which occurred September 29 and 30, during a sustained low-flow period. The instantaneous maximum conductance was recorded at Reedy Island on September 28. For perspective, the most upstream point of the Salt Line ever recorded (River Mile 102) occurred during the drought of the mid 1960's (Delaware River Basin Commission, 2004). Specific conductance data, along with other water-quality data from the Delaware River at Reedy Island Jetty, Del., can be found on pages 370-377.

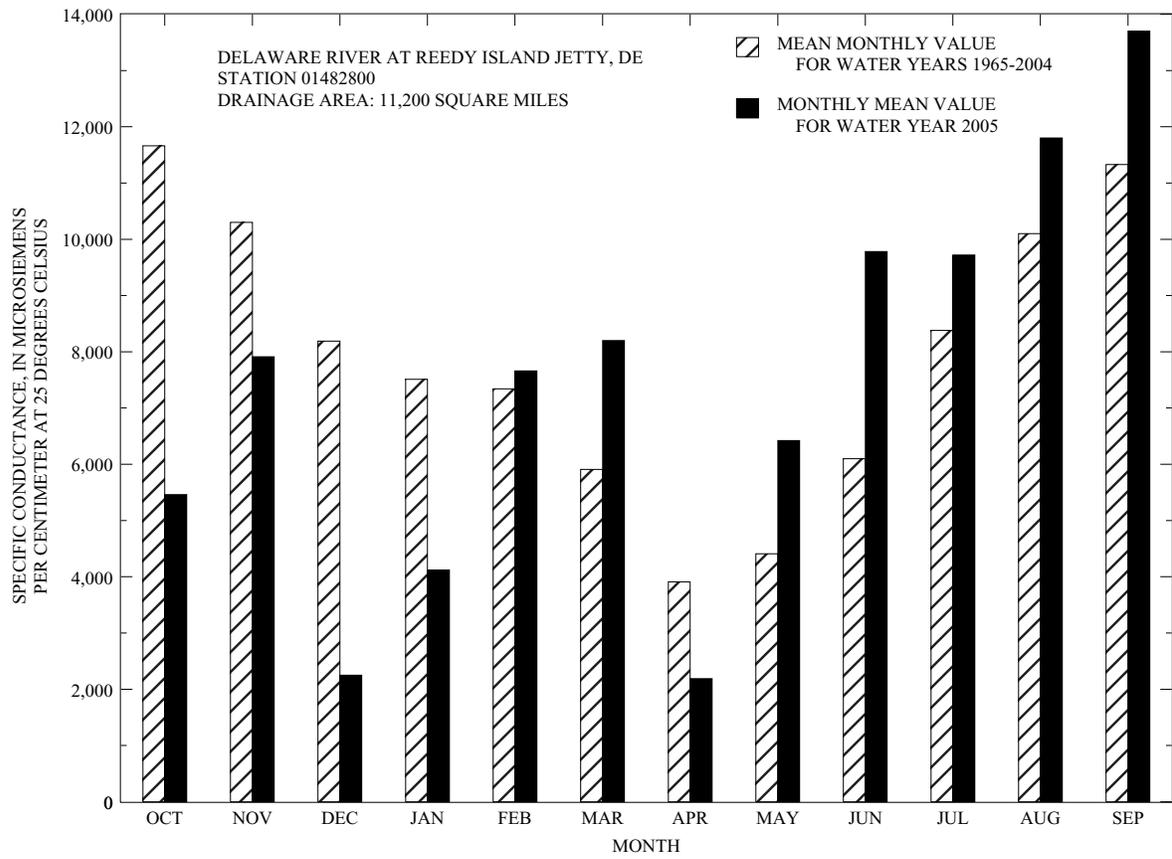


Figure 3.--Monthly mean specific conductance measured in the Delaware River at Reedy Island Jetty, Delaware for the 2005 water year and the mean monthly specific conductance for the period 1965 through 2004.

### **Ground Water**

With some lag time, seasonal ground-water levels during the year generally reflect seasonal precipitation variations. A comparison of the monthly precipitation variation received in the Delaware River basin in the 2005 water year (fig. 1) and recorded ground-water levels shows that this scenario was the case for this year. Ground-water levels by the end of September 2004 were generally above to much-above normal within the basin (Durlin and Schaffstall, 2005). Water levels in all 15 observation wells in the basin began the water year at normal to much-above-normal conditions. A comparison between seasonal ground-water levels for the 2005 water year and long-term seasonal ground-water levels is shown in figure 4.

During the fall season, in spite of slightly below-normal precipitation, ground-water levels continued to remain above to much-above normal at 13 of 15 indicator sites within the basin. By the end of the winter season, only 10 of 15 indicator wells were above to much-above-normal levels. By the end of the spring season, only 6 of 15 wells remained above to much-above normal, with 4 of 15 wells returning to normal levels. This is a reflection of below normal precipitation during May and June, combined with the onset of the growing season. The ground-water levels showed a response to the continuing precipitation deficit in the summer months. By the end of the summer season, ground-water levels, in the observation wells, gradually decreased to normal or below normal categories at 11 of 15 indicator wells. At five of the observation wells, those located in Montgomery County (MG225 and MG917), Bucks County (BK929), Chester County (CH10), and Northampton County (NP820), new high water levels were recorded in April. None of the indicator wells had a new record low during the 2005 water year.

### **References**

- Delaware River Basin Commission, 2005, Delaware River Basin Selected Flow and Storage Data, accessed April 19, 2006, at URL [<http://www.state.nj.us/drbc/data.htm>].
- Durlin, R. R., and Schaffstall, W. P., 2005, Water Resources Data, Pennsylvania, water year 2003: U.S. Geological Survey Water-Data Report PA-04-1, 651 p.
- U.S. Department of Commerce, 2004-05, Climatological data for Pennsylvania, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Northeast Regional Climate Center, accessed April 19, 2006, at URL [<http://www.ncdc.noaa.gov/oa/ncdc.html>].
- Pennsylvania Department of Environmental Protection, 2006, Drought News Room, accessed April 19, 2006, at URL [<http://www.dep.state.pa.us/dep/subject/hotopics/drought/news.htm>].

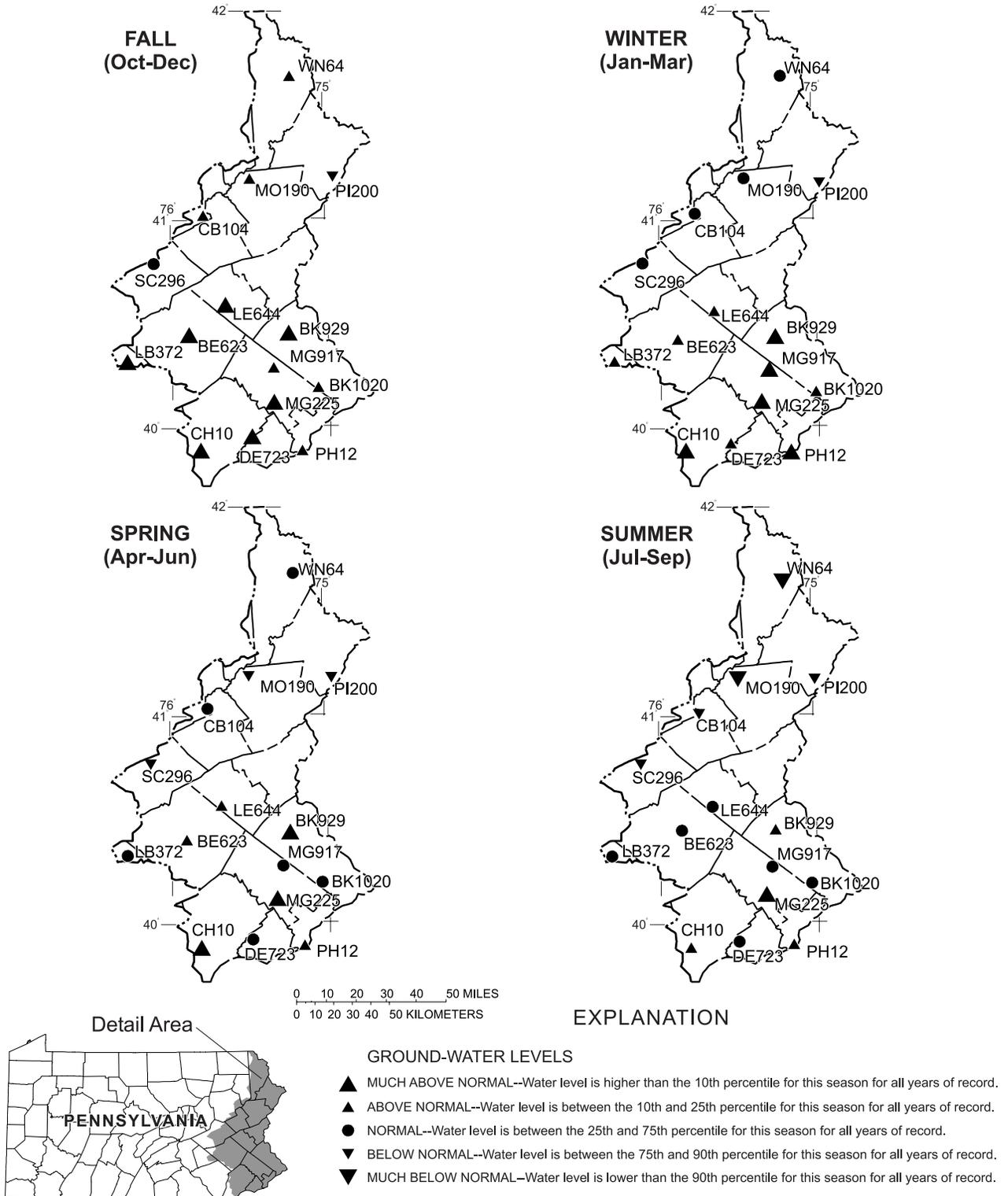


Figure 4.--Relation between 2005 seasonal mean ground-water levels and long-term mean ground-water levels [Seasonal percentile values were determined by ranking the average monthly water levels for each month in the season from highest to lowest for all years of record and averaging the ranks for the three months. A water level that is higher than the seasonal 10th percentile value would be expected to occur only once in a ten-year period. Conversely, a water level that is lower than the seasonal 90th percentile value also would be expected to occur only once during a ten-year period.]

### SPECIAL NETWORKS AND PROGRAMS

The **Hydrologic Bench-Mark Network** is a network of 61 sites in small drainage basins in 39 States that was established in 1963 to provide consistent streamflow data representative of undeveloped watersheds nationwide, and from which data could be analyzed on a continuing basis for use in comparison and contrast with conditions observed in basins more obviously affected by human activities. At selected sites, water-quality information is being gathered on major ions and nutrients, primarily to assess the effects of acid deposition on stream chemistry. Additional information on the Hydrologic Benchmark Program may be accessed from <http://ny.cf.er.usgs.gov/hbn/>.

The **National Stream-Quality Accounting Network** (NASQAN) is a network of sites used to monitor the water quality of large rivers within the Nation's largest river basins. From 1995 through 1999, a network of approximately 40 stations was operated in the Mississippi, Columbia, Colorado, and Rio Grande River basins. For the period 2000 through 2004, sampling was reduced to a few index stations on the Colorado and Columbia Rivers so that a network of five stations could be implemented on the Yukon River. Samples are collected with sufficient frequency that the flux of a wide range of constituents can be estimated. The objective of NASQAN is to characterize the water quality of these large rivers by measuring concentration and mass transport of a wide range of dissolved and suspended constituents, including nutrients, major ions, dissolved and sediment-bound heavy metals, common pesticides, and inorganic and organic forms of carbon. This information will be used (1) to describe the long-term trends and changes in concentration and transport of these constituents; (2) to test findings of the National Water-Quality Assessment (NAWQA) Program; (3) to characterize processes unique to large-river systems such as storage and re-mobilization of sediments and associated contaminants; and (4) to refine existing estimates of off-continent transport of water, sediment, and chemicals for assessing human effects on the world's oceans and for determining global cycles of carbon, nutrients, and other chemicals. Additional information about the NASQAN Program can be found at [<http://water.usgs.gov/nasqan/>].

The **National Atmospheric Deposition Program/National Trends Network** (NADP/NTN) is a network of monitoring sites that provides continuous measurement and assessment of the chemical constituents in precipitation throughout the United States. As the lead Federal agency, the USGS works together with over 100 organizations to provide a long-term, spatial and temporal record of atmospheric deposition generated from this network of 250 precipitation-chemistry monitoring sites. The USGS supports 74 of these 250 sites. This long-term, nationally consistent monitoring program, coupled with ecosystem research, provides critical information toward a national scorecard to evaluate the effectiveness of ongoing and future regulations intended to reduce atmospheric emissions and subsequent impacts to the Nation's land and water resources. Reports and other information on the NADP/NTN Program, as well as data from the individual sites, may be accessed from <http://bqs.usgs.gov/acidrain/>.

The **USGS National Water-Quality Assessment Program** (NAWQA) is a long-term program with goals to describe the status and trends of water-quality conditions for a large, representative part of the Nation's ground- and surface-water resources; to provide an improved understanding of the primary natural and human factors affecting these observed conditions and trends; and to provide information that supports development and evaluation of management, regulatory, and monitoring decisions by other agencies.

Assessment activities are being conducted in 42 study units (major watersheds and aquifer systems) that represent a wide range of environmental settings nationwide and that account for a large percentage of the Nation's water use. A wide array of chemical constituents is measured in ground water, surface water, streambed sediments, and fish tissues. The coordinated application of comparative hydrologic studies at a wide range of spatial and temporal scales will provide information for water-resources managers to use in making decisions and a foundation for aggregation and comparison of findings to address water-quality issues of regional and national interest.

Communication and coordination between USGS personnel and other local, State, and Federal interests are critical components of the NAWQA Program. Each study unit has a local liaison committee consisting of representatives from key Federal, State, and local water-resources agencies, Indian nations, and universities in the study unit. Liaison committees typically meet semiannually to discuss their information needs, monitoring plans and progress, desired information products, and opportunities for collaboration among the agencies. Additional information about the NAWQA Program may be accessed from <http://water.usgs.gov/nawqa/>.

The **USGS National Streamflow Information Program** (NSIP) is a long-term program with goals to provide framework streamflow data across the Nation. Included in the program are creation of a permanent Federally funded streamflow network, research on the nature of streamflow, regional assessments of streamflow data and databases, and upgrades in the streamflow information delivery systems. Additional information about NSIP may be accessed from <http://water.usgs.gov/nsip/>.

## EXPLANATION OF THE RECORDS

The surface-water and ground-water records in this report are for the 2005 water year that began October 1, 2004, and ended September 30, 2005. A calendar of the water year is provided on the inside of the front cover. The records contain streamflow data, stage and content data for lakes and reservoirs, water-quality and ecological data for streamflow stations, ground-water-level data, and water-quality data for ground-water wells. The location of these stations and wells are shown in figures 6-10 and 14-18. The following sections of the introductory text are presented to provide users with a more detailed explanation of how these hydrologic data published in this report were collected, analyzed, computed, and arranged for presentation.

### Station Identification Numbers

Each data station in this report, whether a streamsite or a well, is assigned a unique identification number. This number is unique in that it applies specifically to a given station and to no other. The number usually is assigned when a station is first established and is retained for that station indefinitely. The systems used by the U.S. Geological Survey to assign identification numbers for surface-water stations and for ground-water well sites differ, but both are based on geographic location. The "downstream order" system is used for regular surface-water stations and the "latitude-longitude" system is used for wells and, in Pennsylvania, for some miscellaneous surface-water sites where only random water-quality samples or discharge measurements are made.

#### Downstream-order system

Since October 1, 1950, the order of listing hydrologic-station records in Survey reports is in a downstream direction along the main stream. All stations on a tributary entering upstream from a main-stream station are listed before that station. A station on a tributary that enters between two main-stream stations is listed between them. A similar order is followed in listing stations on first rank, second rank, and other ranks of tributaries. The rank of any tributary on which a station is situated with respect to the stream to which it is immediately tributary is indicated by an indentation in a list of stations in the front of the report. Each indentation represents one rank. This downstream-order system of indentation shows which stations are on tributaries between any two stations and the rank of the tributary on which each station is situated.

The station-identification number is assigned in downstream order. In assigning station numbers, no distinction is made between partial-record and continuous-record stations; therefore, the station number for a partial-record station indicates downstream-order position in a list made up of both types of stations. Gaps are left in the series of numbers to allow for new stations that may be established; hence, the numbers are not consecutive. A station number can be from 8 to 15 digits in length and normally appears to the left of the station name. For example, an 8-digit number for a station such as 01470500, includes a 2-digit part number "01" plus a 6-digit downstream-order number "470500." The part number designates major river basins; for example, part "01" is the North Atlantic Slope Basin.

#### Latitude-longitude system

The identification numbers for wells and miscellaneous surface-water sites are assigned based on the grid system of latitude and longitude. The system provides the geographic location of the well or miscellaneous site and a unique number for each site. The number consists of 15 digits. The first six digits denote the degrees, minutes, and seconds of latitude, the next seven digits denote the degrees, minutes, and seconds of longitude, and the last two digits (assigned sequentially) identify the wells or other sites within a 1-second grid (fig. 5).

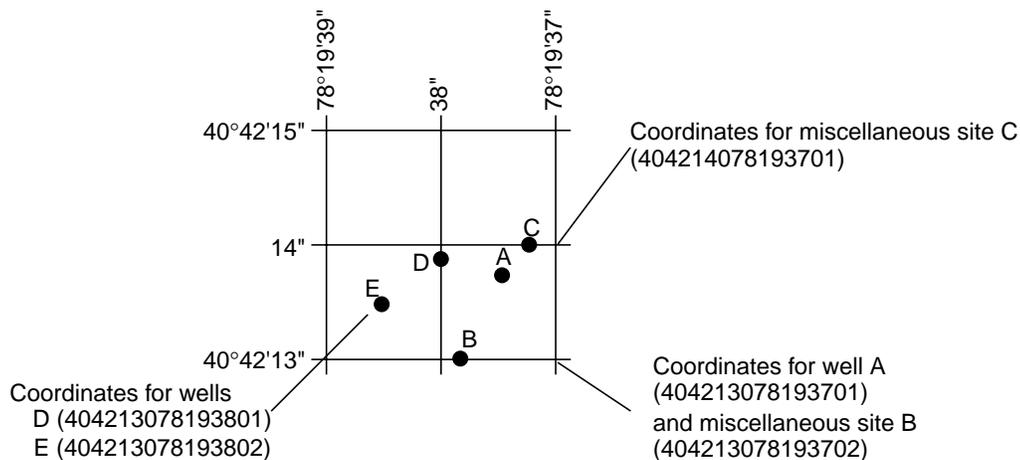


Figure 5.--System for numbering wells and miscellaneous sites (latitude and longitude).

A local well number is also assigned to the wells and consists of a 2-letter abbreviation of the county in which the well is located and a sequential number assigned at the time the well was scheduled.

## EXPLANATION OF STAGE- AND WATER-DISCHARGE RECORDS

### Data Collection and Computation

The base data collected at gaging stations (fig. 6-13) consist of records of stage and measurements of discharge of streams or canals, and stage, surface area, and volume of lakes or reservoirs. In addition, observations of factors affecting the stage-discharge relation or the stage-capacity relation, weather records, and other information are used to supplement base data in determining the daily flow or volume of water in storage. Records of stage are obtained from a water-stage recorder that is either downloaded electronically in the field to a laptop computer or similar device or is transmitted using telemetry such as GOES satellite, land-line or cellular-phone modems, or by radio transmission. Measurements of discharge are made with a current meter or acoustic Doppler current profiler, using the general methods adopted by the USGS. These methods are described in standard textbooks, USGS Water-Supply Paper 2175, and the Techniques of Water-Resources Investigations of the United States Geological Survey (TWRIs), Book 3, Chapters A1 through A19 and Book 8, Chapters A2 and B2, which may be accessed from <http://water.usgs.gov/pubs/twri/>. The methods are consistent with the American Society for Testing and Materials (ASTM) standards and generally follow the standards of the International Organization for Standardization (ISO).

For stream-gaging stations, discharge-rating tables for any stage are prepared from stage-discharge curves. If extensions to the rating curves are necessary to express discharge greater than measured, the extensions are made on the basis of indirect measurements of peak discharge (such as slope-area or contracted-opening measurements, or computation of flow over dams and weirs), step-backwater techniques, velocity-area studies, and logarithmic plotting. The daily mean discharge is computed from gage heights and rating tables, then the monthly and yearly mean discharges are computed from the daily values. If the stage-discharge relation is subject to change because of frequent or continual change in the physical features of the stream channel, the daily mean discharge is computed by the shifting-control method in which correction factors that are based on individual discharge measurements and notes by engineers and observers are used when applying the gage heights to the rating tables. If the stage-discharge relation for a station is temporarily changed by the presence of aquatic growth or debris on the controlling section, the daily mean discharge is computed by the shifting-control method.

The stage-discharge relation at some stream-gaging stations is affected by backwater from reservoirs, tributary streams, or other sources. Such an occurrence necessitates the use of the slope method in which the slope or fall in a reach of the stream is a factor in computing discharge. The slope or fall is obtained by means of an auxiliary gage at some distance from the base gage.

An index velocity is measured using ultrasonic or acoustic instruments at some stream-gaging stations, and this index velocity is used to calculate an average velocity for the flow in the stream. This average velocity along with a stage-area relation is then used to calculate average discharge.

At some stations, the stage-discharge relation is affected by changing stage. At these stations, the rate of change in stage is used as a factor in computing discharge.

At some stream-gaging stations in the northern United States, the stage-discharge relation is affected by ice in the winter; therefore, computation of the discharge in the usual manner is impossible. Discharge for periods of ice effect is computed on the basis of gage-height record and occasional winter-discharge measurements. Consideration is given to the available information on temperature and precipitation, notes by gage observers and hydrologists, and comparable records of discharge from other stations in the same or nearby basins.

For a lake or reservoir station, capacity tables giving the volume or contents for any stage are prepared from stage-area relation curves defined by surveys. The application of the stage to the capacity table gives the contents, from which the daily, monthly, or yearly changes are computed.

If the stage-capacity curve is subject to changes because of deposition of sediment in the reservoir, periodic resurveys of the reservoir are necessary to define new stage-capacity curves. During the period between reservoir surveys, the computed contents may be increasingly in error due to the gradual accumulation of sediment.

For some stream-gaging stations, periods of time occur when no gage-height record is obtained or the recorded gage height is faulty and cannot be used to compute daily discharge or contents. Such a situation can happen when the recorder stops or otherwise fails to operate properly, the intakes are plugged, the float is frozen in the well, or for various other reasons. For such periods, the daily discharges are estimated on the basis of recorded range in stage, prior and subsequent records, discharge measurements, weather records, and comparison with records from other stations in the same or nearby basins. Likewise, lake or reservoir volumes may be estimated on the basis of operator's log, prior and subsequent records, inflow-outflow studies, and other information.

### Data Presentation

The records published for each continuous-record surface-water discharge station (stream-gaging station) consist of five parts; (1) the station manuscript or description; (2) the data table of daily mean values for the current water year with summary data; (3) a tabular statistical summary of monthly mean flow data for a designated period, by water year; (4) a summary statistics table that includes statistical data of annual, daily, and instantaneous flows as well as data pertaining to annual runoff, 7-day low-flow minimums, and flow duration; and (5) a hydrograph of discharge.

#### Station manuscript

The manuscript provides, under various headings, descriptive information, such as station location; period of record; historical extremes outside the period of record; record accuracy; and other remarks pertinent to station operation and regulation. The following information, as appropriate, is provided with each continuous record of discharge or lake content. Comments follow that clarify information presented under the various headings of the station description.

**LOCATION.**--Location information is obtained from the most accurate maps available. The location of the gaging station with respect to the cultural and physical features in the vicinity and with respect to the reference place mentioned in the station name is given. River mileages, given for only a few stations, were determined by methods given in "River Mileage Measurement," Bulletin 14, Revision of October 1968, prepared by the Water Resources Council or were provided by the U.S. Army Corps of Engineers.

**DRAINAGE AREA.**--Drainage areas are measured using the most accurate maps available. Because the type of maps available varies from one drainage basin to another, the accuracy of drainage areas likewise varies. Drainage areas are updated as better maps become available.

**PERIOD OF RECORD.**--This term indicates the time period for which records have been published for the station or for an equivalent station. An equivalent station is one that was in operation at a time that the present station was not and whose location was such that its streamflow reasonably can be considered equivalent to the streamflow at the present station.

**REVISED RECORDS.**--If a critical error in published records is discovered, a revision is included in the first report published following discovery of the error.

**GAGE.**--The type of gage in current use, the datum of the current gage referred to a standard datum, and a condensed history of the types, locations, and datums of previous gages are given under this heading.

**REMARKS.**--All periods of estimated daily discharge either will be identified by date in this paragraph of the station description for water-discharge stations or flagged in the daily discharge table. (See section titled Identifying Estimated Daily Discharge.) Information is presented relative to the accuracy of the records, to special methods of computation, and to conditions that affect natural flow at the station. In addition, information may be presented pertaining to average discharge data for the period of record; to extremes data for the period of record and the current year; and possibly, to other pertinent items. For reservoir stations, information is given on the dam forming the reservoir, the capacity, the outlet works and spillway, and the purpose and use of the reservoir.

**COOPERATION.**--Records provided by a cooperating organization or obtained for the U.S. Geological Survey by a cooperating organization are identified here.

**EXTREMES OUTSIDE PERIOD OF RECORD.**—Information here documents major floods or unusually low flows that occurred outside the stated period of record. The information may or may not have been obtained by the USGS.

**PEAK DISCHARGES FOR CURRENT YEAR.**--Peaks given here are similar to those found in the summary statistics table, except the peak discharge listing may include secondary peaks. For stations meeting certain criteria, all peak discharges and stages occurring during the water year and greater than a selected base discharge (see Definition of Terms) are presented under this heading. The peaks greater than the base discharge, excluding the highest one, are referred to as secondary peaks. Peak discharges are not published for streams for which the peaks are subject to substantial control by man. The time of occurrence for peaks is expressed in 24-hour local standard time. For example, 12:30 a.m. is 0030, and 1:30 p.m. is 1330.

**REVISIONS.**—Records are revised if errors in published records are discovered. Appropriate updates are made in the USGS distributed data system, NWIS, and subsequently to its Web-based national data system, NWISWeb (<http://water.usgs.gov/nwis/nwis>). Users are encouraged to obtain all required data from NWIS or NWISWeb to ensure that they have the most recent data updates. Updates to NWISWeb are made on an annual basis.

Although rare, occasionally the records of a discontinued gaging station may need revision. Because no current or, possibly, future station manuscript would be published for these stations to document the revision in a REVISED RECORDS entry, users of data for these stations who obtained the record from previously published data reports may wish to contact the USGS Pennsylvania Water Science Center (address given on the back of the title page of this report) to determine if the published records were revised after the station was discontinued. If, however, the data for a discontinued station were obtained by computer retrieval, the data would be current. Any published revision of data is always accompanied by revision of the corresponding data in computer storage.

Manuscript information for lake or reservoir stations differs from that for stream stations in the nature of the REMARKS and in the inclusion of a stage-capacity table when daily volumes are given.

#### **Peak discharge greater than base discharge**

Tables of peak discharge above base discharge are included for some stations where secondary instantaneous peak discharge data are used in flood-frequency studies of highway and bridge design, flood-control structures, and other flood-related projects. The base discharge value is selected so an average of three peaks a year will be reported. This base discharge value has a recurrence interval of approximately 1.1 years or a 91-percent chance of exceedence in any 1 year.

#### **Data table of daily mean values**

The daily table of discharge records for stream-gaging stations gives mean discharge for each day of the water year. In the monthly summary for the table, the line headed "TOTAL" gives the sum of the daily figures for each month; the line headed "MEAN" gives the arithmetic average flow in cubic feet per second for the month; and the lines headed "MAX" and "MIN" give the maximum and minimum daily mean discharges, respectively, for each month. Discharge for the month also is usually expressed in cubic feet per second per square mile (line headed "CFSM"); or in inches (line headed "IN."). Values for cubic feet per second per square mile and runoff in inches may be omitted if there is extensive regulation or diversion or if the drainage area includes large noncontributing areas. At some stations, monthly and (or) yearly observed discharges are adjusted for reservoir storage or diversion, or diversion data or reservoir volumes are given. These values are identified by a symbol and corresponding footnote.

#### **Statistics of monthly mean data**

A tabular summary of the mean (line headed MEAN), maximum (MAX), and minimum (MIN) of monthly mean flows for each month for a designated period is provided below the mean values table. The water years of the first occurrence of the maximum and minimum monthly flows are provided immediately below those values. The designated period will be expressed as "FOR WATER YEARS \_\_\_\_-\_\_\_\_, BY WATER YEAR (WY)," and will list the first and last water years of the range of years selected from the PERIOD OF RECORD paragraph in the station manuscript. The designated period will consist of all of the station record within the specified water years, including complete months of record for partial water years, and may coincide with the period of record for the station. The water years for which the statistics are computed are consecutive, unless a break in the station record is indicated in the manuscript.

#### **Summary statistics**

A table titled "SUMMARY STATISTICS" follows the statistics of monthly mean data tabulation. This table consists of four columns, with the first column containing the line headings of the statistics being reported. The table provides a statistical summary of yearly, daily, and instantaneous flows, not only for the current water year but also for the previous calendar year and for a designated period, as appropriate. The designated period selected, "WATER YEARS \_\_\_\_-\_\_\_\_," will consist of all of the station record within the specified water years, including complete months of record for partial water years, and may coincide with the period of record for the station. The water years for which the statistics are computed are consecutive, unless a break in the station record is indicated in the manuscript. All of the calculations for the statistical characteristics designated ANNUAL (see line headings below), except for the "ANNUAL 7-DAY MINIMUM" statistic, are calculated for the designated period using complete water years. The other statistical characteristics may be calculated using partial water years.

The date or water year, as appropriate, of the first occurrence of each statistic reporting extreme values of discharge is provided adjacent to the statistic. Repeated occurrences may be noted in the REMARKS paragraph of the manuscript or in footnotes. Because the designated period may not be the same as the station period of record published in the manuscript, occasionally the dates of occurrence listed for the daily and instantaneous extremes may not be within the selected water years listed in the heading. When the dates of occurrence do not fall within the selected water years listed in the heading, it will be noted in the REMARKS paragraph or in footnotes. Selected streamflow duration-curve statistics and runoff data also are given. Runoff data may be omitted if extensive regulation or diversion of flow is in effect in the drainage basin.

The following summary statistics data are provided with each continuous record of discharge. Comments that follow clarify information presented under the various line headings of the SUMMARY STATISTICS table.

ANNUAL TOTAL.--The sum of the daily mean values of discharge for the year.

ANNUAL MEAN.--The arithmetic mean for the individual daily mean discharges for the year noted or for the designated period.

HIGHEST ANNUAL MEAN.--The maximum annual mean discharge occurring for the designated period.

LOWEST ANNUAL MEAN.--The minimum annual mean discharge occurring for the designated period.

HIGHEST DAILY MEAN.--The maximum daily mean discharge for the year or for the designated period.

LOWEST DAILY MEAN.--The minimum daily mean discharge for the year or for the designated period.

ANNUAL 7-DAY MINIMUM.--The lowest mean discharge for 7 consecutive days for a calendar year or a water year. Note that most low-flow frequency analyses of annual 7-day minimum flows use a climatic year (April 1-March 31). The date shown in the summary statistics table is the initial date of the 7-day period. This value should not be confused with the 7-day 10-year low-flow statistic.

MAXIMUM PEAK FLOW.--The maximum instantaneous peak discharge occurring for the water year or designated period. Occasionally the maximum flow for a year may occur at midnight at the beginning or end of the year, on a recession from or rise toward a higher peak in the adjoining year. In this case, the maximum peak flow is given in the table and the maximum flow may be reported in a footnote or in the REMARKS paragraph in the manuscript.

MAXIMUM PEAK STAGE.--The maximum instantaneous peak stage occurring for the water year or designated period. Occasionally the maximum stage for a year may occur at midnight at the beginning or end of the year, on a recession from or rise toward a higher peak in the adjoining year. In this case, the maximum peak stage is given in the table and the maximum stage may be reported in the REMARKS paragraph in the manuscript or in a footnote. If the dates of occurrence of the maximum peak stage and maximum peak flow are different, the REMARKS paragraph in the manuscript or a footnote may be used to provide further information.

INSTANTANEOUS LOW FLOW.--The minimum instantaneous discharge occurring for the water year or for the designated period.

ANNUAL RUNOFF.--Indicates the total quantity of water in runoff for a drainage area for the year. Data reports may use any of the following units of measurement in presenting annual runoff data:

Acre-foot (AC-FT) is the quantity of water required to cover 1 acre to a depth of 1 foot and is equal to 43,560 cubic feet or about 326,000 gallons or 1,233 cubic meters.

Cubic feet per square mile (CFSM) is the average number of cubic feet of water flowing per second from each square mile of area drained, assuming the runoff is distributed uniformly in time and area.

Inches (IN) indicates the depth to which the drainage area would be covered if all of the runoff for a given time period were uniformly distributed on it.

10 PERCENT EXCEEDS.--The discharge that has been exceeded 10 percent of the time for the designated period.

50 PERCENT EXCEEDS.--The discharge that has been exceeded 50 percent of the time for the designated period.

90 PERCENT EXCEEDS.--The discharge that has been exceeded 90 percent of the time for the designated period.

Data collected at partial-record stations follow the information for continuous-record sites. Data for partial-record discharge stations are presented in two tables. The first table lists annual maximum stage and discharge at crest-stage stations, and the second table lists discharge measurements at low-flow partial-record stations. The tables of partial-record stations are followed by a listing of discharge measurements made at sites other than continuous-record or partial-record stations. These measurements are often made in times of drought or flood to give better areal coverage to those events. Those measurements and others collected for some special reason are called measurements at miscellaneous sites.

#### **Identifying Estimated Daily Discharge**

Estimated daily-discharge values published in the water-discharge tables of annual State data reports are identified. This identification is shown either by flagging individual daily values with the letter "e" and noting in a table footnote, "*e-Estimated*," or by listing the dates of the estimated record in the REMARKS paragraph of the station description.

### Accuracy of Field Data and Computed Results

The accuracy of streamflow data depends primarily on (1) the stability of the stage-discharge relation or, if the control is unstable, the frequency of discharge measurements, and (2) the accuracy of observations of stage, measurements of discharge, and interpretations of records.

The degree of accuracy of the records is stated in the REMARKS in the station description. "*Excellent*" indicates that about 95 percent of the daily discharges are within 5 percent of the true value; "*good*," within 10 percent; and "*fair*," within 15 percent. "*Poor*" indicates that daily discharges have less than "*fair*" accuracy. Different accuracies may be attributed to different parts of a given record.

Values of daily mean discharge in this report are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft<sup>3</sup>/s; to the nearest tenths between 1.0 and 10 ft<sup>3</sup>/s; to whole numbers between 10 and 1,000 ft<sup>3</sup>/s; and to three significant figures above 1,000 ft<sup>3</sup>/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharge values listed for partial-record stations.

Discharge at many stations, as indicated by the monthly mean, may not reflect natural runoff due to the effects of diversion, consumption, regulation by storage, increase or decrease in evaporation due to artificial causes, or to other factors. For such stations, figures of cubic feet per second per square mile and of runoff, in inches, are not published unless satisfactory adjustments can be made for diversions, for changes in contents of reservoirs, or for other changes incident to use and control. Evaporation from a reservoir is not included in the adjustments for changes in reservoir contents, unless it is so stated. Even at those stations where adjustments are made, large errors in computed runoff may occur if adjustments or losses are large in comparison with the observed discharge.

### Other Data Records Available

Information of a more detailed nature than that published for most of the stream-gaging stations such as observations of water temperature, discharge measurements, gage-height records, and rating tables is available from the USGS Pennsylvania Water Science Center. Also, most stream-gaging station records are available in computer-usable form and many statistical analyses have been made.

Information on the availability of unpublished data or statistical analyses may be obtained from the USGS Pennsylvania Water Science Center (see address that is shown on the back of the title page of this report).

## EXPLANATION OF WATER-QUALITY RECORDS

### Collection and Examination of Data

Surface-water samples for analysis usually are collected at or near stream-gaging stations. The quality-of-water records are given immediately following the discharge records at these stations.

The descriptive heading for water-quality records gives the period of record for all water-quality data; the period of daily record for parameters that are measured on a daily basis (specific conductance, water temperature, sediment discharge, and so forth); extremes for the current year; and general remarks.

For ground-water records, no descriptive statements are given; however, the well number, depth of well, sampling date, or other pertinent data are given in the table containing the chemical analyses of the ground water.

### Water Analysis

Most of the methods used for collecting and analyzing water samples are described in the TWRIs, which may be accessed from <http://water.usgs.gov/pubs/twri/>.

One sample can define adequately the water quality at a given time if the mixture of solutes throughout the stream cross section is homogeneous. However, the concentration of solutes at different locations in the cross section may vary widely with different rates of water discharge, depending on the source of material and the turbulence and mixing of the stream. Some streams must be sampled at several verticals to obtain a representative sample needed for an accurate mean concentration and for use in calculating load.

Chemical-quality data published in this report are considered to be the most representative values available for the stations listed. The values reported represent water-quality conditions at the time of sampling as much as possible, consistent with available sampling techniques and methods of analysis. In the rare case where an apparent inconsistency exists between a reported pH value and the relative abundance of carbon dioxide species (carbonate and bicarbonate), the inconsistency is the result of a slight uptake of carbon dioxide from the air by the sample between measurement of pH in the field and determination of carbonate and bicarbonate in the laboratory.

For chemical-quality stations equipped with digital monitors, the records consist of daily maximum and minimum values (and sometimes mean or median values) for each constituent measured and are based on 15-minute or 1-hour intervals of recorded data beginning at 0000 hours and ending at 2400 hours for the day of record.

### Records of Surface-Water Quality

Records of surface-water quality ordinarily are obtained at or near stream-gaging stations because discharge data are useful in the interpretation of surface-water quality. Records of surface-water quality in this report involve a variety of types of data and measurement frequencies.

#### Classification of records

Water-quality data for surface-water sites are grouped into one of three classifications. A *continuous-record station* is a site where data are collected on a regularly scheduled basis. Frequency may be one or more times daily, weekly, monthly, or quarterly. A *partial-record station* is a site where limited water-quality data are collected systematically over a period of years. Frequency of sampling is usually less than quarterly. A *miscellaneous sampling site* is a location other than a continuous- or partial-record station, where samples are collected to give better areal coverage to define water-quality conditions in the river basin.

A careful distinction needs to be made between *continuous records* as used in this report and *continuous recordings* that refer to a continuous graph or a series of discrete values recorded at short intervals. Some records of water quality, such as temperature and specific conductance, may be obtained through continuous recordings; however, because of costs, most data are obtained only monthly or less frequently. Locations of stations for which records on the quality of surface water appear in this report are shown in figures 6-10 and 14-18.

#### Accuracy of the records

One of four accuracy classifications is applied for measured physical properties at continuous-record stations on a scale ranging from poor to excellent. The accuracy rating is based on data values recorded before any shifts or corrections are made. Additional consideration also is given to the amount of publishable record and to the amount of data that have been corrected or shifted.

#### Rating classifications for continuous water-quality records

[≤, less than or equal to; ±, plus or minus value shown; °C, degree Celsius; >, greater than; %, percent; mg/L, milligram per liter; pH unit, standard pH unit]

Measured field parameter	Ratings of accuracy (Based on combined fouling and calibration drift corrections applied to the record)			
	Excellent	Good	Fair	Poor
Water temperature	≤ ±0.2 °C	> ±0.2 - 0.5 °C	> ±0.5 - 0.8 °C	> ±0.8 °C
Specific conductance	≤ ±3%	> ±3 - 10%	> ±10 - 15%	> ±15%
Dissolved oxygen	≤ ±0.3 mg/L or ≤ ±5%, whichever is greater	> ±0.3 - 0.5 mg/L or ≤ ±5% - 10%, whichever is greater	> ±0.5 - 0.8 mg/L or ≤ ±10% - 15%, which- ever is greater	> ±0.8 mg/L or ≤ ±15%, whichever is greater
pH	≤ ±0.2 unit	> ±0.2 - 0.5 unit	> ±0.5 - 0.8 unit	> ±0.8 unit
Turbidity	≤ ±0.5 turbidity units or ≤ ±5%, whichever is greater	> ±0.5 - 1.0 turbidity units or > ±5 - 10%, whichever is greater	> ±1.0 - 15% turbidity units or > ±10 - 15%, whichever is greater	> ±1.5 turbidity units or > ±15%, whichever is greater

#### Arrangement of records

Water-quality records collected at a surface-water daily record station are published immediately following that record, regardless of the frequency of sample collection. Station number and name are the same for both records. Where a surface-water daily record station is not available or where the water quality differs significantly from that at the nearby surface-water station, the continuing water-quality record is published with its own station number and name in the regular downstream-order sequence. Water-quality data for partial-record stations and for miscellaneous sampling sites appear in separate tables following the table of discharge measurements at miscellaneous sites.

#### Onsite measurements and sample collection

In obtaining water-quality data, a major concern is assuring that the data obtained represent the naturally occurring quality of the water. To ensure this, certain measurements, such as water temperature, pH, and dissolved oxygen, must be made onsite when the samples are collected. To assure that measurements made in the laboratory also represent the naturally occurring water, carefully prescribed procedures must be followed in collecting the samples, in treating the samples to prevent changes in quality pending analysis, and in shipping the samples to the laboratory. Procedures for onsite measurements and for collecting, treating, and shipping samples are given in TWRIs Book 1, Chapter D2; Book 3, Chapters A1, A3, and A4; and Book 9, Chapters A1-A9. Most of the

methods used for collecting and analyzing water samples are described in the TWRIs, which may be accessed from <http://water.usgs.gov/pubs/twri/>. Also, detailed information on collecting, treating, and shipping samples can be obtained from the USGS Pennsylvania Water Science Center (see address that is shown on the back of title page in this report).

### **Water temperature**

Water temperatures are measured at most of the water-quality stations. In addition, water temperatures are taken at the time of discharge measurements for water-discharge stations. For stations where water temperatures are taken manually once or twice daily, the water temperatures are taken at about the same time each day. Large streams have a small diurnal temperature change; shallow streams may have a daily range of several degrees and may follow closely the changes in air temperature. Some streams may be affected by waste-heat discharges.

At stations where recording instruments are used, maximum, minimum, and mean temperatures for each day are published. Water temperatures measured at the time of water-discharge measurements are on file in the USGS Pennsylvania Water Science Center.

### **Sediment**

Suspended-sediment concentrations are determined from samples collected by using depth-integrating samplers. Samples usually are obtained at several verticals in the cross section, or a single sample may be obtained at a fixed point and a coefficient applied to determine the mean concentration in the cross section.

During periods of rapidly changing flow or rapidly changing concentration, samples may be collected more frequently (twice daily or, in some instances, hourly). The published sediment discharges for days of rapidly changing flow or concentration are computed by the subdivided-day method (time-discharge weighted average). Therefore, for those days when the published sediment discharge value differs from the value computed as the product of discharge times mean concentration times 0.0027, the reader can assume that the sediment discharge for that day was computed by the subdivided-day method. For periods when no samples were collected, daily discharges of suspended sediment were estimated on the basis of water discharge, sediment concentrations observed immediately before and after the periods, and suspended-sediment loads for other periods of similar discharge.

At other stations, suspended-sediment samples are collected periodically at many verticals in the stream cross section. Although data collected periodically may represent conditions only at the time of observation, such data are useful in establishing seasonal relations between quality and streamflow and in predicting long-term sediment-discharge characteristics of the stream.

In addition to the records of suspended-sediment discharge, records of the periodic measurements of the particle-size distribution of the suspended sediment and bed material are included for some stations.

### **Laboratory measurements**

Samples for biochemical oxygen demand (BOD) and indicator bacteria are analyzed locally. All other samples are analyzed in the USGS laboratory in Lakewood, Colorado, unless otherwise noted. Methods used in analyzing sediment samples and computing sediment records are given in TWRI, Book 5, Chapter C1. Methods used by the USGS laboratories are given in the TWRIs, Book 1, Chapter D2; Book 3, Chapter C2; and Book 5, Chapters A1, A3, and A4. The TWRI publications may be accessed from <http://water.usgs.gov/pubs/twri/>. These methods are consistent with ASTM standards and generally follow ISO standards.

### **Data presentation**

For continuing-record stations, information pertinent to the history of station operation is provided in descriptive headings preceding the tabular data. These descriptive headings give details regarding location, drainage area, period of record, type of data available, instrumentation, general remarks, cooperation, and extremes for parameters currently measured daily. Tables of chemical, physical, biological, radiochemical data, and so forth, obtained at a frequency less than daily are presented first. Tables of "*daily values*" of specific conductance, pH, water temperature, dissolved oxygen, and suspended sediment then follow in sequence.

In the descriptive headings, if the location is identical to that of the streamflow-gaging station, neither the LOCATION nor the DRAINAGE AREA statements are repeated. The following information is provided with each continuous-record station. Comments that follow clarify information presented under the various headings of the station description.

LOCATION.--See Data Presentation information in the "Records of Stage and Water Discharge" section of this report (same comments apply).

DRAINAGE AREA.--See Data Presentation under "Records of Stage and Water Discharge" section of this report (same comments apply).

PERIOD OF RECORD.--This indicates the time periods for which published water-quality records for the station are available. The periods are shown separately for records of parameters measured daily or continuously and those measured less often than daily.

For those measured daily or continuously, periods of record are given for the parameters individually.

**INSTRUMENTATION.**--Information on instrumentation is given only if a water-quality monitor, temperature recorder, sediment pumping sampler, or other sampling device is in operation at a station.

**REMARKS.**--Remarks provide added information pertinent to the collection, analysis, or computation of the records.

**COOPERATION.**--Records provided by a cooperating organization or obtained for the Geological Survey by a cooperating organization are identified here.

**EXTREMES.**—Maximums and minimums are given only for parameters measured daily or more frequently. For parameters measured weekly or less frequently, true maximums or minimums may not have been obtained. Extremes, when given, are provided for both the period of record and for the current water year.

**REVISIONS.**—Records are revised if errors in published water-quality records are discovered. Appropriate updates are made in the USGS distributed data system, NWIS, and subsequently to its Web-based national data system, NWISWeb (<http://waterdata.usgs.gov/nwis>). Users of USGS water-quality data are encouraged to obtain all required data from NWIS or NWISWeb to ensure that they have the most recent updates. Updates to the NWISWeb are made on an annual basis.

The surface-water-quality records for partial-record stations and miscellaneous sampling sites are published in separate tables following the table of discharge measurements at miscellaneous sites. No descriptive statements are given for these records. Each station is published with its own station number and name in the regular downstream-order sequence.

The surface-water-quality records for partial-record stations and miscellaneous sampling sites are published in separate tables following the table of discharge measurements at miscellaneous sites. No descriptive statements are given for these records. Each station is published with its own station number and name in the regular downstream-order sequence.

### **Remark codes**

The following remark codes may appear with the water-quality data in this report:

<u>PRINTED OUTPUT</u>	<u>REMARK</u>
E,e	Value is estimated.
>	Actual value is known to be greater than the value shown.
<	Actual value is known to be less than the value shown.
M	Presence of material verified, but not quantified.
N	Presumptive evidence of presence of material.
U	Material specifically analyzed for, but not detected.
A	Value is an average.
V	Analyte was detected in both the environmental sample and the associated blanks.
S	Most probable value.

### **Water-Quality-Control Data**

The USGS National Water Quality Laboratory collects quality-control data on a continuing basis to evaluate selected analytical methods to determine long-term method detection levels (LT-MDLs) and laboratory reporting levels (LRLs). These values are re-evaluated each year on the basis of the most recent quality-control data and, consequently, may change from year to year.

This reporting procedure limits the occurrence of false positive error. Falsely reporting a concentration greater than the LT-MDL for a sample in which the analyte is not present is 1 percent or less. Application of the LRL limits the occurrence of false negative error. The chance of falsely reporting a nondetection for a sample in which the analyte is present at a concentration equal to or greater than the LRL is 1 percent or less.

Accordingly, concentrations are reported as less than LRL for samples in which the analyte either was not detected or did not pass identification. Analytes detected at concentrations between the LT-MDL and the LRL and that pass identification criteria are estimated. Estimated concentrations will be noted with a remark code of "E." These data should be used with the understanding that their uncertainty is greater than that of data reported without the E remark code.

Data generated from quality-control (QC) samples are a requisite for evaluating the quality of the sampling and processing techniques as well as data from the actual samples themselves. Without QC data, environmental sample data cannot be adequately

interpreted because the errors associated with the sample data are unknown. The various types of QC samples collected by this USGS Water Science Center are described in the following section. Procedures have been established for the storage of water-quality-control data within the USGS. These procedures allow for storage of all derived QC data and are identified so that they can be related to corresponding environmental samples. These data are not presented in this report but are available from the USGS Pennsylvania Water Science Center.

### **Blank samples**

Blank samples are collected and analyzed to ensure that environmental samples have not been contaminated in the overall data-collection process. The blank solution used to develop specific types of blank samples is a solution that is free of the analytes of interest. Any measured value in a blank sample for an analyte (a specific component measured in a chemical analysis) that was absent in the blank solution is believed to be due to contamination. Many types of blank samples are possible; each is designed to segregate a different part of the overall data-collection process. The types of blank samples collected by this USGS Water Science Center are:

**Field blank**--A blank solution that is subjected to all aspects of sample collection, field processing, preservation, transportation, and laboratory handling as an environmental sample.

**Trip blank**--A blank solution that is put in the same type of bottle used for an environmental sample and kept with the set of sample bottles before and after sample collection.

**Equipment blank**--A blank solution that is processed through all equipment used for collecting and processing an environmental sample (similar to a field blank but normally done in the more controlled conditions of the office).

**Sampler blank**--A blank solution that is poured or pumped through the same field sampler used for collecting an environmental sample.

**Filter blank**--A blank solution that is filtered in the same manner and through the same filter apparatus used for an environmental sample.

**Splitter blank**--A blank solution that is mixed and separated using a field sample splitter in the same manner and through the same apparatus used for an environmental sample.

**Preservation blank**--A blank solution that is treated with the same preservatives used for an environmental sample.

### **Reference samples**

Reference material is a solution or material prepared by a laboratory. The reference material composition is certified for one or more properties so that it can be used to assess a measurement method. Samples of reference material are submitted for analysis to ensure that an analytical method is accurate for the known properties of the reference material. Generally, the selected reference material properties are similar to the environmental sample properties.

### **Replicate samples**

Replicate samples are a set of environmental samples collected in a manner such that the samples are thought to be essentially identical in composition. Replicate is the general case for which a duplicate is the special case consisting of two samples. Replicate samples are collected and analyzed to establish the amount of variability in the data contributed by some part of the collection and analytical process. Many types of replicate samples are possible, each of which may yield slightly different results in a dynamic hydrologic setting, such as a flowing stream. The types of replicate samples collected in this USGS Water Science Center are:

**Concurrent samples**—A type of replicate sample in which the samples are collected simultaneously with two or more samplers or by using one sampler and alternating the collection of samples into two or more compositing containers.

**Sequential samples**—A type of replicate sample in which the samples are collected one after the other, typically over a short time.

**Split sample**—A type of replicate sample in which a sample is split into subsamples, each subsample contemporaneous in time and space.

### **Spike samples**

Spike samples are samples to which known quantities of a solution with one or more well-established analyte concentrations have been added. These samples are analyzed to determine the extent of matrix interference or degradation on the analyte concentration during sample processing and analysis.

## EXPLANATION OF GROUND-WATER-LEVEL RECORDS

Generally, only ground-water-level data from selected wells with continuous recorders from a basic network of observation wells are published in this report. This basic network contains observation wells located so that the most significant data are obtained from the fewest wells in the most important aquifers.

### Site Identification Numbers

Each well is identified by means of (1) a 15-digit number that is based on latitude and longitude and (2) a local number that is produced for local needs. (See "Numbering System for Wells and Miscellaneous Sites" in this report for a detailed explanation)

### Data Collection and Computation

Measurements are made in many types of wells, under varying conditions of access and at different temperatures; hence, neither the method of measurement nor the equipment can be standardized. At each observation well, however, the equipment and techniques used are those that will ensure that measurements at each well are consistent.

Most methods for collecting and analyzing water samples are described in the TWRI's referred to in the onsite Measurements and Sample Collection and the Laboratory Measurements sections in this report. In addition, TWRI Book 1, Chapter D2, describes guidelines for the collection and field analysis of ground-water samples for selected unstable constituents. Procedures for onsite measurements and for collecting, treating, and shipping samples are given in TWRI's Book 1, Chapter D2; Book 3, Chapters A1, A3, and A4; and Book 9, Chapters A1 through A9. The TWRI publications may be accessed from <http://water.usgs.gov/pubs/twri/>. The values in this report represent water-quality conditions at the time of sampling, as much as possible, and that are consistent with available sampling techniques and methods of analysis. These methods are consistent with ASTM standards and generally follow ISO standards. Trained personnel collected all samples. The wells sampled were pumped long enough to ensure that the water collected came directly from the aquifer and had not stood for a long time in the well casing where it would have been exposed to the atmosphere and to the material, possibly metal, comprising the casings.

Water-level measurements in this report are given in feet with reference to land-surface datum (lsd). Land-surface datum is a datum plane that is approximately at land surface at each well. If known, the elevation of the land-surface datum above sea level is given in the well description. The height of the measuring point (MP) above or below land-surface datum is given in each well description. Water levels in wells equipped with recording gages are reported daily.

Water levels are reported to as many significant figures as can be justified by the local conditions. For example, in a measurement of a depth of water of several hundred feet, the error in determining the absolute value of the total depth to water may be a few tenths of a foot, whereas the error in determining the net change of water level between successive measurements may be only a hundredth or a few hundredths of a foot. For lesser depths to water the accuracy is greater. Accordingly, most measurements are reported to a hundredth of a foot, but some are given only to a tenth of a foot or a larger unit.

### Data Presentation

Water-level data are presented in alphabetical order by county. The primary identification number for a given well is the 15-digit site identification number that appears in the upper left corner of the table. The secondary identification number is the local or county well number. Well locations are shown and each well is identified by its local well or county well number on a map in this report (fig. 7-9).

Each well record consists of three parts: the well description, the data table of water levels observed during the water year, and, for most wells, a hydrograph following the data table. Well descriptions are presented in the headings preceding the tabular data.

The following comments clarify information presented in these various headings.

**LOCATION.**—This paragraph follows the well-identification number and reports the hydrologic-unit number and a geographic point of reference. Latitudes and longitudes used in this report are reported as North American Datum of 1927 unless otherwise specified.

**AQUIFER.**--This entry designates by name and geologic age of the aquifer that the well taps.

**WELL CHARACTERISTICS.**--This entry describes the well in terms of depth, casing diameter and depth or screened interval, method of construction, use, and changes since construction.

**INSTRUMENTATION.**--This paragraph provides information on both the frequency of measurement and the collection method used, allowing the user to better evaluate the reported water-level extremes by knowing whether they are based on continuous, monthly, or some other frequency of measurement.

**DATUM.**--This entry describes both the measuring point and the land-surface elevation at the well. The altitude of the land-surface datum is described in feet above the altitude datum; it is reported with a precision depending on the method of determination. The measuring point is described physically (such as top of casing, top of instrument shelf, and so forth), and in relation to land surface (such as 1.3 ft above land-surface datum). The elevation of the land-surface datum is described in feet above National Geodetic Vertical Datum of 1929 (NGVD 29); it is reported with a precision depending on the method of determination.

**REMARKS.**—This entry describes factors that may affect the water level in a well or the measurement of the water level, when various methods of measurement were begun, and the network (climatic, terrane, local, or areal effects) or the special project to which the well belongs.

**PERIOD OF RECORD.**—This entry indicates the time period for which records are published for the well, the month and year at the start of publication of water-level records by the USGS, and the words “to current year” if the records are to be continued into the following year. Time periods for which water-level records are available, but are not published by the USGS, may be noted.

**EXTREMES FOR PERIOD OF RECORD.**—This entry contains the highest and lowest instantaneously recorded or measured water levels of the period of published record, with respect to land-surface datum or sea level, and the dates of occurrence.

### **Water-level tables**

A table of water levels follows the well description for each well. Water-level measurements in this report are given in feet with reference to either sea level or land-surface datum (lsd). Missing records are indicated by dashes in place of the water-level value.

For wells not equipped with recorders, water-level measurements were obtained periodically by steel or electric tape. Tables of periodic water-level measurements in these wells show the date of measurement and the measured water-level value.

### **Hydrographs**

Hydrographs are a graphic display of water-level fluctuations over a period of time. In this report, current water year and, when appropriate, period-of-record hydrographs are shown. Hydrographs that display recorder data show a solid line representing the maximum or mean water level recorded for each day. Missing data are indicated by a blank space or break in a hydrograph. Missing data may occur as a result of recorder malfunctions, battery failures, or mechanical problems related to the response of the recorder's float mechanism to water-level fluctuations in a well.

## **GROUND-WATER-QUALITY DATA**

### **Data Collection and Computation**

The ground-water-quality data in this report were obtained as a part of special studies in specific areas. Consequently, a number of chemical analyses are presented for some wells within a county but not for others. As a result, the records for this year, by themselves, do not provide a balanced view of ground-water quality statewide.

Most methods for collecting and analyzing water samples are described in the TWRI, which may be accessed from <http://water.usgs.gov/pubs/twri/>. Procedures for onsite measurements and for collecting, treating, and shipping samples are given in TWRI, Book 1, Chapter D2; Book 3, Chapter C2; and Book 5, Chapters A1, A3, and A4. Also, detailed information on collecting, treating, and shipping samples may be obtained from the USGS Pennsylvania Water Science Center (see address shown on back of title page in this report).

### **Laboratory Measurements**

Analysis for sulfide and measurement of alkalinity, pH, water temperature, specific conductance, and dissolved oxygen are performed onsite. All other sample analyses are performed at the USGS laboratory in Lakewood, Colorado, unless otherwise noted. Methods used by the USGS laboratory are given in TWRI, Book 1, Chapter D2; Book 3, Chapter C2; and Book 5, Chapters A1, A3, and A4, which may be accessed from <http://water.usgs.gov/pubs/twri/>.

## **ACCESS TO USGS WATER DATA**

The USGS provides near real-time stage and discharge data for many of the gaging stations equipped with the necessary telemetry and historic daily-mean and peak-flow discharge data for most current or discontinued gaging stations through the World Wide Web (WWW). These data may be accessed from <http://water.usgs.gov>.

Water-quality data and ground-water data also are available through the WWW. In addition, data can be provided in various machine-readable formats on various media. Information about the availability of specific types of data or products, and user charges, can be obtained locally from each USGS Water Science Center. (See address that is shown on the back of the title page of this report)

## DEFINITION OF TERMS

Specialized technical terms related to streamflow, water-quality, and other hydrologic data, as used in this report, are defined below. Terms such as algae, water level, and precipitation are used in their common everyday meanings, definitions of which are given in standard dictionaries. Not all terms defined in this alphabetical list apply to every State. See also table for converting English units to International System (SI) Units. Other glossaries that also define water-related terms are accessible from <http://water.usgs.gov/glossaries.html>.

**Acid neutralizing capacity (ANC)** is the equivalent sum of all bases or base-producing materials, solutes plus particulates, in an aqueous system that can be titrated with acid to an equivalence point. This term designates titration of an “unfiltered” sample (formerly reported as alkalinity).

**Acre-foot (AC-FT, acre-ft)** is a unit of volume, commonly used to measure quantities of water used or stored, equivalent to the volume of water required to cover 1 acre to a depth of 1 foot and equivalent to 43,560 cubic feet, 325,851 gallons, or 1,233 cubic meters. (See also “Annual runoff”)

**Adenosine triphosphate (ATP)** is an organic, phosphate-rich compound important in the transfer of energy in organisms. Its central role in living cells makes ATP an excellent indicator of the presence of living material in water. A measurement of ATP therefore provides a sensitive and rapid estimate of biomass. ATP is reported in micrograms per liter.

**Adjusted discharge** is discharge data that have been mathematically adjusted (for example, to remove the effects of a daily tide cycle or reservoir storage).

**Algal growth potential (AGP)** is the maximum algal dry weight biomass that can be produced in a natural water sample under standardized laboratory conditions. The growth potential is the algal biomass present at stationary phase and is expressed as milligrams dry weight of algae produced per liter of sample. (See also “Biomass” and “Dry weight”)

**Alkalinity** is the capacity of solutes in an aqueous system to neutralize acid. This term designates titration of a “filtered” sample.

**Annual runoff** is the total quantity of water that is discharged (“runs off”) from a drainage basin in a year. Data reports may present annual runoff data as volumes in acre-feet, as discharges per unit of drainage area in cubic feet per second per square mile, or as depths of water on the drainage basin in inches.

**Annual 7-day minimum** is the lowest mean value for any 7-consecutive-day period in a year. Annual 7-day minimum values are reported herein for the calendar year and the water year (October 1 through September 30). Most low-flow frequency analyses use a climatic year (April 1-March 31), which tends to prevent the low-flow period from being artificially split between adjacent years. The date shown in the summary statistics table is the initial date of the 7-day period. (This value should not be confused with the 7-day, 10-year low-flow statistic.)

**Aroclor** is the registered trademark for a group of poly-chlorinated biphenyls that were manufactured by the Monsanto Company prior to 1976. Aroclors are assigned specific 4-digit reference

numbers dependent upon molecular type and degree of substitution of the biphenyl ring hydrogen atoms by chlorine atoms. The first two digits of a numbered aroclor represent the molecular type, and the last two digits represent the percentage weight of the hydrogen-substituted chlorine.

**Artificial substrate** is a device that purposely is placed in a stream or lake for colonization of organisms. The artificial substrate simplifies the community structure by standardizing the substrate from which each sample is collected. Examples of artificial substrates are basket samplers (made of wire cages filled with clean streamside rocks) and multiplate samplers (made of hardboard) for benthic organism collection, and plexiglass strips for periphyton collection. (See also “Substrate”)

**Ash mass** is the mass or amount of residue present after the residue from a dry-mass determination has been ashed in a muffle furnace at a temperature of 500 °C for 1 hour. Ash mass of zooplankton and phytoplankton is expressed in grams per cubic meter ( $\text{g}/\text{m}^3$ ), and periphyton and benthic organisms in grams per square meter ( $\text{g}/\text{m}^2$ ). (See also “Biomass” and “Dry mass”)

**Aspect** is the direction toward which a slope faces with respect to the compass.

**Bacteria** are microscopic unicellular organisms, typically spherical, rodlike, or spiral and threadlike in shape, often clumped into colonies. Some bacteria cause disease, whereas others perform an essential role in nature in the recycling of materials; for example, by decomposing organic matter into a form available for reuse by plants.

**Bankfull stage**, as used in this report, is the stage at which a stream first overflows its natural banks formed by floods with 1- to 3-year recurrence intervals.

**Base discharge** (for peak discharge) is a discharge value, determined for selected stations, above which peak discharge data are published. The base discharge at each station is selected so that an average of about three peak flows per year will be published. (See also “Peak flow”)

**Base flow** is sustained flow of a stream in the absence of direct runoff. It includes natural and human-induced streamflows. Natural base flow is sustained largely by ground-water discharge.

**Bedload** is material in transport that primarily is supported by the streambed. In this report, bedload is considered to consist of particles in transit from the bed to the top of the bedload sampler nozzle (an elevation ranging from 0.25 to 0.5 foot). These particles are retained in the bedload sampler. A sample collected with

a pressure-differential bedload sampler also may contain a component of the suspended load.

**Bedload discharge (tons per day)** is the rate of sediment moving as bedload, reported as dry weight, that passes through a cross section in a given time. NOTE: Bedload discharge values in this report may include a component of the suspended-sediment discharge. A correction may be necessary when computing the total sediment discharge by summing the bedload discharge and the suspended-sediment discharge. (See also “Bedload,” “Dry weight,” “Sediment,” and “Suspended-sediment discharge”)

**Bed material** is the sediment mixture of which a stream-bed, lake, pond, reservoir, or estuary bottom is composed. (See also “Bedload” and “Sediment”)

**Benthic organisms** are the group of organisms inhabiting the bottom of an aquatic environment. They include a number of types of organisms, such as bacteria, fungi, insect larvae and nymphs, snails, clams, and crayfish. They are useful as indicators of water quality.

**Biochemical oxygen demand (BOD)** is a measure of the quantity of dissolved oxygen, in milligrams per liter, necessary for the decomposition of organic matter by microorganisms, such as bacteria.

**Biomass** is the amount of living matter present at any given time, expressed as mass per unit area or volume of habitat.

**Biomass pigment ratio** is an indicator of the total proportion of periphyton that are autotrophic (plants). This also is called the Autotrophic Index.

**Blue-green algae** (Cyanophyta) are a group of phytoplankton and periphyton organisms with a blue pigment in addition to a green pigment called chlorophyll. Blue-green algae can cause nuisance water-quality conditions in lakes and slow-flowing rivers; however, they are found commonly in streams throughout the year. The abundance of blue-green algae in phytoplankton samples is expressed as the number of cells per milliliter (cells/mL) or biovolume in cubic micrometers per milliliter ( $\text{mm}^3/\text{mL}$ ). The abundance of blue-green algae in periphyton samples is given in cells per square centimeter (cells/ $\text{cm}^2$ ) or biovolume per square centimeter ( $\text{mm}^3/\text{cm}^2$ ). (See also “Phytoplankton” and “Periphyton”)

**Bottom material** (See “Bed material”)

**Bulk electrical conductivity** is the combined electrical conductivity of all material within a doughnut-shaped volume surrounding an induction probe. Bulk conductivity is affected by different physical and chemical properties of the material including the dissolved-solids content of the pore water, and the lithology and porosity of the rock.

**Canadian Geodetic Vertical Datum 1928** is a geodetic datum derived from a general adjustment of Canada’s first order level network in 1928.

**Cell volume** (biovolume) determination is one of several common methods used to estimate biomass of algae in aquatic systems. Cell members of algae are used frequently in aquatic surveys as

an indicator of algal production. However, cell numbers alone cannot represent true biomass because of considerable cell-size variation among the algal species. Cell volume ( $\mu\text{m}^3$ ) is determined by obtaining critical cell measurements or cell dimensions (for example, length, width, height, or radius) for 20 to 50 cells of each important species to obtain an average biovolume per cell. Cells are categorized according to the correspondence of their cellular shape to the nearest geometric solid or combinations of simple solids (for example, spheres, cones, or cylinders). Representative formulae used to compute biovolume are as follows:

$$\text{sphere } \frac{4}{3} \pi r^3 \quad \text{cone } \frac{1}{3} \pi r^2 h \quad \text{cylinder } \pi r^2 h.$$

$\pi$  ( $\pi$ ) is the ratio of the circumference to the diameter of a circle;  $\pi = 3.14159\dots$

From cell volume, total algal biomass expressed as biovolume ( $\mu\text{m}^3/\text{mL}$ ) is thus determined by multiplying the number of cells of a given species by its average cell volume and then summing these volumes for all species.

**Cells/volume** refers to the number of cells of any organism that is counted by using a microscope and grid or counting cell. Many planktonic organisms are multicelled and are counted according to the number of contained cells per sample volume, and generally are reported as cells or units per milliliter (mL) or liter (L).

**Cfs-day** (See “Cubic foot per second-day”)

**Channel bars**, as used in this report, are the lowest prominent geomorphic features higher than the channel bed.

**Chemical oxygen demand (COD)** is a measure of the chemically oxidizable material in the water and furnishes an approximation of the amount of organic and reducing material present. The determined value may correlate with BOD or with carbonaceous organic pollution from sewage or industrial wastes. [See also “Biochemical oxygen demand (BOD)”]

***Clostridium perfringens*** (*C. perfringens*) is a spore-forming bacterium that is common in the feces of human and other warm-blooded animals. Clostridial spores are being used experimentally as an indicator of past fecal contamination and the presence of microorganisms that are resistant to disinfection and environmental stresses. (See also “Bacteria”)

**Coliphages** are viruses that infect and replicate in coliform bacteria. They are indicative of sewage contamination of water and of the survival and transport of viruses in the environment.

**Color unit** is produced by 1 milligram per liter of platinum in the form of the chloroplatinate ion. Color is expressed in units of the platinum-cobalt scale.

**Confined aquifer** is a term used to describe an aquifer containing water between two relatively impermeable boundaries. The water level in a well tapping a confined aquifer stands above the top of the confined aquifer and can be higher or lower than the water table that may be present in the material above it. In some cases, the water level can rise above the ground surface, yielding a flowing well.

**Contents** is the volume of water in a reservoir or lake. Unless otherwise indicated, volume is computed on the basis of a level pool and does not include bank storage.

**Continuous-record station** is a site where data are collected with sufficient frequency to define daily mean values and variations within a day.

**Control** designates a feature in the channel that physically affects the water-surface elevation and thereby determines the stage-discharge relation at the gage. This feature may be a constriction of the channel, a bedrock outcrop, a gravel bar, an artificial structure, or a uniform cross section over a long reach of the channel.

**Control structure**, as used in this report, is a structure on a stream or canal that is used to regulate the flow or stage of the stream or to prevent the intrusion of saltwater.

**Cubic foot per second (CFS, ft<sup>3</sup>/s)** is the rate of discharge representing a volume of 1 cubic foot passing a given point in 1 second. It is equivalent to approximately 7.48 gallons per second or approximately 449 gallons per minute, or 0.02832 cubic meters per second. The term “second-foot” sometimes is used synonymously with “cubic foot per second” but is now obsolete.

**Cubic foot per second-day (CFS-DAY, Cfs-day, [(ft<sup>3</sup>/s)/d])** is the volume of water represented by a flow of 1 cubic foot per second for 24 hours. It is equivalent to 86,400 cubic feet, 1.98347 acre-feet, 646,317 gallons, or 2,446.6 cubic meters. The daily mean discharges reported in the daily value data tables numerically are equal to the daily volumes in cfs-days, and the totals also represent volumes in cfs-days.

**Cubic foot per second per square mile [CFSM, (ft<sup>3</sup>/s)/mi<sup>2</sup>]** is the average number of cubic feet of water flowing per second from each square mile of area drained, assuming the runoff is distributed uniformly in time and area. (See also “Annual runoff”)

**Daily mean suspended-sediment concentration** is the time-weighted mean concentration of suspended sediment passing a stream cross section during a 24-hour day. (See also “Sediment” and “Suspended-sediment concentration”)

**Daily record station** is a site where data are collected with sufficient frequency to develop a record of one or more data values per day. The frequency of data collection can range from continuous recording to data collection on a daily or near-daily basis.

**Data collection platform (DCP)** is an electronic instrument that collects, processes, and stores data from various sensors, and transmits the data by satellite data relay, line-of-sight radio, and/or landline telemetry.

**Data logger** is a microprocessor-based data acquisition system designed specifically to acquire, process, and store data. Data usually are downloaded from onsite data loggers for entry into office data systems.

**Datum** is a surface or point relative to which measurements of height and/or horizontal position are reported. A vertical datum is a horizontal surface used as the zero point for measurements of

gage height, stage, or elevation; a horizontal datum is a reference for positions given in terms of latitude-longitude, State Plane coordinates, or Universal Transverse Mercator (UTM) coordinates. (See also “Gage datum,” “Land-surface datum,” “National Geodetic Vertical Datum of 1929,” and “North American Vertical Datum of 1988”)

**Diatoms (*Bacillariophyta*)** are unicellular or colonial algae with a siliceous cell wall. The abundance of diatoms in phytoplankton samples is expressed as the number of cells per milliliter (cells/mL) or biovolume in cubic micrometers per milliliter (mm<sup>3</sup>/mL). The abundance of diatoms in periphyton samples is given in cells per square centimeter (cells/cm<sup>2</sup>) or biovolume per square centimeter (mm<sup>3</sup>/cm<sup>2</sup>). (See also “Phytoplankton” and “Periphyton”)

**Diel** is of or pertaining to a 24-hour period of time; a regular daily cycle.

**Discharge, or flow**, is the rate that matter passes through a cross section of a stream channel or other water body per unit of time. The term commonly refers to the volume of water (including, unless otherwise stated, any sediment or other constituents suspended or dissolved in the water) that passes a cross section in a stream channel, canal, pipeline, and so forth, within a given period of time (cubic feet per second). Discharge also can apply to the rate at which constituents, such as suspended sediment, bedload, and dissolved or suspended chemicals, pass through a cross section, in which cases the quantity is expressed as the mass of constituent that passes the cross section in a given period of time (tons per day).

**Dissolved** refers to that material in a representative water sample that passes through a 0.45-micrometer membrane filter. This is a convenient operational definition used by Federal and State agencies that collect water-quality data. Determinations of “dissolved” constituent concentrations are made on sample water that has been filtered.

**Dissolved oxygen (DO)** is the molecular oxygen (oxygen gas) dissolved in water. The concentration in water is a function of atmospheric pressure, temperature, and dissolved-solids concentration of the water. The ability of water to retain oxygen decreases with increasing temperature or dissolved-solids concentration. Photosynthesis and respiration by plants commonly cause diurnal variations in dissolved-oxygen concentration in water from some streams.

**Dissolved-solids concentration** in water is the quantity of dissolved material in a sample of water. It is determined either analytically by the “residue-on-evaporation” method, or mathematically by totaling the concentrations of individual constituents reported in a comprehensive chemical analysis. During the analytical determination, the bicarbonate (generally a major dissolved component of water) is converted to carbonate. In the mathematical calculation, the bicarbonate value, in milligrams per liter, is multiplied by 0.4917 to convert it to carbonate. Alternatively, alkalinity concentration (as mg/L CaCO<sub>3</sub>) can be converted to carbonate concentration by multiplying by 0.60.

**Diversity index (H)** (Shannon index) is a numerical expression of evenness of distribution of aquatic organisms. The formula for diversity index is:

$$\bar{d} = - \sum_{i=1}^s \frac{n_i}{n} \log_2 \frac{n_i}{n},$$

where  $n_i$  is the number of individuals per taxon,  $n$  is the total number of individuals, and  $s$  is the total number of taxa in the sample of the community. Index values range from zero, when all the organisms in the sample are the same, to some positive number, when some or all of the organisms in the sample are different.

**Drainage area** of a stream at a specific location is that area upstream from the location, measured in a horizontal plane, that has a common outlet at the site for its surface runoff from precipitation that normally drains by gravity into a stream. Drainage areas given herein include all closed basins, or noncontributing areas, within the area unless otherwise specified.

**Drainage basin** is a part of the Earth's surface that contains a drainage system with a common outlet for its surface runoff. (See "Drainage area")

**Dry mass** refers to the mass of residue present after drying in an oven at 105 °C, until the mass remains unchanged. This mass represents the total organic matter, ash and sediment, in the sample. Dry-mass values are expressed in the same units as ash mass. (See also "Ash mass," "Biomass," and "Wet mass")

**Dry weight** refers to the weight of animal tissue after it has been dried in an oven at 65°C until a constant weight is achieved. Dry weight represents total organic and inorganic matter in the tissue. (See also "Wet weight")

**Embeddedness** is the degree to which gravel-sized and larger particles are surrounded or enclosed by finer-sized particles. (See also "Substrate embeddedness class")

**Enterococcus bacteria** commonly are found in the feces of humans and other warmblooded animals. Although some strains are ubiquitous and not related to fecal pollution, the presence of enterococci in water is an indication of fecal pollution and the possible presence of enteric pathogens. Enterococcus bacteria are those bacteria that produce pink to red colonies with black or reddish-brown precipitate after incubation at 41°C on mE agar (nutrient medium for bacterial growth) and subsequent transfer to EIA medium. Enterococci include *Streptococcus faecalis*, *Streptococcus faecium*, *Streptococcus avium*, and their variants. (See also "Bacteria")

**EPT Index** is the total number of distinct taxa within the insect orders Ephemeroptera, Plecoptera, and Trichoptera. This index summarizes the taxa richness within the aquatic insects that generally are considered pollution sensitive; the index usually decreases with pollution.

**Escherichia coli** (*E. coli*) are bacteria present in the intestine and feces of warmblooded animals. *E. coli* are a member species of the fecal coliform group of indicator bacteria. In the laboratory, they are defined as those bacteria that produce yellow or yellow-brown colonies on a filter pad saturated with urea substrate broth after primary culturing for 22 to 24 hours at 44.5 °C on mTEC medium (nutrient medium for bacterial growth). Their concentra-

tions are expressed as number of colonies per 100 mL of sample. (See also "Bacteria")

**Estimated (E) value** of a concentration is reported when an analyte is detected and all criteria for a positive result are met. If the concentration is less than the method detection limit (MDL), an E code will be reported with the value. If the analyte is identified qualitatively as present, but the quantitative determination is substantially more uncertain, the National Water Quality Laboratory will identify the result with an E code even though the measured value is greater than the MDL. A value reported with an E code should be used with caution. When no analyte is detected in a sample, the default reporting value is the MDL preceded by a less than sign (<). For bacteriological data, concentrations are reported as estimated when results are based on non-ideal colony counts.

**Euglenoids** (*Euglenophyta*) are a group of algae that usually are free-swimming and rarely creeping. They have the ability to grow either photosynthetically in the light or heterotrophically in the dark. (See also "Phytoplankton")

**Extractable organic halides** (EOX) are organic compounds that contain halogen atoms such as chlorine. These organic compounds are semivolatile and extractable by ethyl acetate from air-dried streambed sediment. The ethyl acetate extract is combusted, and the concentration is determined by microcoulometric determination of the halides formed. The concentration is reported as micrograms of chlorine per gram of the dry weight of the streambed sediment.

**Fecal coliform bacteria** are present in the intestines or feces of warmblooded animals. They often are used as indicators of the sanitary quality of the water. In the laboratory, they are defined as all organisms that produce blue colonies within 24 hours when incubated at 44.5 °C plus or minus 0.2 °C on M-FC medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 mL of sample. (See also "Bacteria")

**Fecal streptococcal bacteria** are present in the intestines of warmblooded animals and are ubiquitous in the environment. They are characterized as gram-positive, cocci bacteria that are capable of growth in brain-heart infusion broth. In the laboratory, they are defined as all the organisms that produce red or pink colonies within 48 hours at 35 °C plus or minus 1.0 °C on KF-streptococcus medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 mL of sample. (See also "Bacteria")

**Filtered** pertains to constituents in a water sample passed through a filter of specified pore diameter, most commonly 0.45 micrometer or less for inorganic analytes and 0.7 micrometer for organic analytes.

**Filtered, recoverable** is the amount of a given constituent that is in solution after the part of a representative water-suspended sediment sample that has passed through a filter has been extracted. Complete recovery is not achieved by the extraction procedure and thus the analytical determination represents something less than 95 percent of the total constituent concentration in the sample. To achieve comparability of analytical data, equivalent

extraction procedures are required of all laboratories performing such analyses because different procedures are likely to produce different analytical results.

**Fire algae** (*Pyrrhophyta*) are free-swimming unicells characterized by a red pigment spot. (See also “Phytoplankton”)

**Flow-duration** percentiles are values on a scale of 100 that indicate the percentage of time for which a flow is exceeded. For example, the 90th percentile of river flow is the streamflow exceeded 90 percent of the time in the period of interest.

**Gage datum** is a horizontal surface used as a zero point for measurement of stage or gage height. This surface usually is located slightly below the lowest point of the stream bottom such that the gage height is usually slightly greater than the maximum depth of water. Because the gage datum is not an actual physical object, the datum is usually defined by specifying the elevations of permanent reference marks such as bridge abutments and survey monuments, and the gage is set to agree with the reference marks. Gage datum is a local datum that is maintained independently of any national geodetic datum. However, if the elevation of the gage datum relative to the national datum (North American Vertical Datum of 1988 or National Geodetic Vertical Datum of 1929) has been determined, then the gage readings can be converted to elevations above the national datum by adding the elevation of the gage datum to the gage reading.

**Gage height** (G.H.) is the water-surface elevation, in feet above the gage datum. If the water surface is below the gage datum, the gage height is negative. Gage height often is used interchangeably with the more general term “stage,” although gage height is more appropriate when used in reference to a reading on a gage.

**Gage values** are values that are recorded, transmitted, and/or computed from a gaging station. Gage values typically are collected at 5-, 15-, or 30-minute intervals.

**Gaging station** is a site on a stream, canal, lake, or reservoir where systematic observations of stage, discharge, or other hydrologic data are obtained.

**Gas chromatography/flame ionization detector** (GC/FID) is a laboratory analytical method used as a screening technique for semivolatile organic compounds that are extractable from water in methylene chloride.

**Geomorphic channel units**, as used in this report, are fluvial geomorphic descriptors of channel shape and stream velocity. Pools, riffles, and runs are types of geomorphic channel units considered for National Water-Quality Assessment (NAWQA) Program habitat sampling.

**Green algae** (*Chlorophyta*) are unicellular or colonial algae with chlorophyll pigments similar to those in terrestrial green plants. Some forms of green algae produce mats or floating “moss” in lakes. The abundance of green algae in phytoplankton samples is expressed as the number of cells per milliliter (cells/mL) or biovolume in cubic micrometers per milliliter ( $\text{mm}^3/\text{mL}$ ). The abundance of green algae in periphyton samples is given in cells per square centimeter (cells/ $\text{cm}^2$ ) or biovolume per square centimeter ( $\mu\text{m}^3/\text{cm}^2$ ). (See also “Phytoplankton” and “Periphyton”)

**Habitat**, as used in this report, includes all nonliving (physical) aspects of the aquatic ecosystem, although living components like aquatic macrophytes and riparian vegetation also are usually included. Measurements of habitat typically are made over a wider geographic scale than are measurements of species distribution.

**Habitat quality index** is the qualitative description (level 1) of instream habitat and riparian conditions surrounding the reach sampled. Scores range from 0 to 100 percent with higher scores indicative of desirable habitat conditions for aquatic life. Index only applicable to wadable streams.

**Hardness** of water is a physical-chemical characteristic that commonly is recognized by the increased quantity of soap required to produce lather. It is computed as the sum of equivalents of polyvalent cations (primarily calcium and magnesium) and is expressed as the equivalent concentration of calcium carbonate ( $\text{CaCO}_3$ ).

**High tide** is the maximum height reached by each rising tide. The high-high and low-high tides are the higher and lower of the two high tides, respectively, of each tidal day. See NOAA Web site: <http://www.csc.noaa.gov/text/glossary.html> (see “High water”)

**Hilsenhoff’s Biotic Index** (HBI) is an indicator of organic pollution that uses tolerance values to weight taxa abundances; usually increases with pollution. It is calculated as follows:

$$HBI = \frac{\sum(n)(a)}{N},$$

where n is the number of individuals of each taxon, a is the tolerance value of each taxon, and N is the total number of organisms in the sample.

**Horizontal datum** (See “Datum”)

**Hydrologic index stations** referred to in this report are continuous-record gaging stations that have been selected as representative of streamflow patterns for their respective regions. Station locations are shown on index maps.

**Hydrologic unit** is a geographic area representing part or all of a surface drainage basin or distinct hydrologic feature as defined by the former Office of Water Data Coordination and delineated on the State Hydrologic Unit Maps by the USGS. Each hydrologic unit is identified by an 8-digit number.

**Inch** (IN., in.), in reference to streamflow, as used in this report, refers to the depth to which the drainage area would be covered with water if all of the runoff for a given time period were distributed uniformly on it. (See also “Annual runoff”)

**Instantaneous discharge** is the discharge at a particular instant of time. (See also “Discharge”)

**International Boundary Commission Survey Datum** refers to a geodetic datum established at numerous monuments along the United States-Canada boundary by the International Boundary Commission.

**Island**, as used in this report, is a mid-channel bar that has permanent woody vegetation, is flooded once a year, on average, and remains stable except during large flood events.

**Laboratory reporting level (LRL)** generally is equal to twice the yearly determined long-term method detection level (LT-MDL). The LRL controls false negative error. The probability of falsely reporting a nondetection for a sample that contained an analyte at a concentration equal to or greater than the LRL is predicted to be less than or equal to 1 percent. The value of the LRL will be reported with a “less than” (<) remark code for samples in which the analyte was not detected. The National Water Quality Laboratory (NWQL) collects quality-control data from selected analytical methods on a continuing basis to determine LT-MDLs and to establish LRLs. These values are reevaluated annually on the basis of the most current quality-control data and, therefore, may change. The LRL replaces the term ‘non-detection value’ (NDV).

**Land-surface datum (lsd)** is a datum plane that is approximately at land surface at each ground-water observation well.

**Latent heat flux** (often used interchangeably with latent heat-flux density) is the amount of heat energy that converts water from liquid to vapor (evaporation) or from vapor to liquid (condensation) across a specified cross-sectional area per unit time. Usually expressed in watts per square meter.

**Light-attenuation coefficient**, also known as the extinction coefficient, is a measure of water clarity. Light is attenuated according to the Lambert-Beer equation:

$$I = I_0 e^{-\lambda L}$$

where  $I_0$  is the source light intensity,  $I$  is the light intensity at length  $L$  (in meters) from the source,  $\lambda$  is the light-attenuation coefficient, and  $e$  is the base of the natural logarithm. The light-attenuation coefficient is defined as

$$\lambda = -\frac{1}{L} \log_e \frac{I}{I_0}$$

**Lipid** is any one of a family of compounds that are insoluble in water and that make up one of the principal components of living cells. Lipids include fats, oils, waxes, and steroids. Many environmental contaminants such as organochlorine pesticides are lipophilic.

**Long-term method detection level (LT-MDL)** is a detection level derived by determining the standard deviation of a minimum of 24 method detection limit (MDL) spike-sample measurements over an extended period of time. LT-MDL data are collected on a continuous basis to assess year-to-year variations in the LT-MDL. The LT-MDL controls false positive error. The chance of falsely reporting a concentration at or greater than the LT-MDL for a sample that did not contain the analyte is predicted to be less than or equal to 1 percent.

**Low tide** is the minimum height reached by each falling tide. The high-low and low-low tides are the higher and lower of the two low tides, respectively, of each tidal day. See NOAA Website: <http://www.csc.noaa.gov/text/glossary.html> (see “Low water”)

**Macrophytes** are the macroscopic plants in the aquatic environment. The most common macrophytes are the rooted vascular plants that usually are arranged in zones in aquatic ecosystems and restricted in the area by the extent of illumination through the water and sediment deposition along the shoreline.

**Mean concentration of suspended sediment** (Daily mean suspended-sediment concentration) is the time-weighted concentration of suspended sediment passing a stream cross section during a given time period. (See also “Daily mean suspended-sediment concentration” and “Suspended-sediment concentration”)

**Mean discharge (MEAN)** is the arithmetic mean of individual daily mean discharges during a specific period. (See also “Discharge”)

**Mean high or low tide** is the average of all high or low tides, respectively, over a specific period.

**Mean sea level** is a local tidal datum. It is the arithmetic mean of hourly heights observed over the National Tidal Datum Epoch. Shorter series are specified in the name; for example, monthly mean sea level and yearly mean sea level. In order that they may be recovered when needed, such datums are referenced to fixed points known as benchmarks. (See also “Datum”)

**Measuring point (MP)** is an arbitrary permanent reference point from which the distance to water surface in a well is measured to obtain water level.

**Megahertz** is a unit of frequency. One megahertz equals one million cycles per second.

**Membrane filter** is a thin microporous material of specific pore size used to filter bacteria, algae, and other very small particles from water.

**Metamorphic stage** refers to the stage of development that an organism exhibits during its transformation from an immature form to an adult form. This developmental process exists for most insects, and the degree of difference from the immature stage to the adult form varies from relatively slight to pronounced, with many intermediates. Examples of metamorphic stages of insects are egg-larva-adult or egg-nymph-adult.

**Method code** is a one-character code that identifies the analytical or field method used to determine a value stored in the National Water Information System (NWIS).

**Method detection limit (MDL)** is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the analyte concentration is greater than zero. It is determined from the analysis of a sample in a given matrix containing the analyte. At the MDL concentration, the risk of a false positive is predicted to be less than or equal to 1 percent.

**Method of Cubatures** is a method of computing discharge in tidal estuaries based on the conservation of mass equation.

**Methylene blue active substances (MBAS)** indicate the presence of detergents (anionic surfactants). The determination depends on

the formation of a blue color when methylene blue dye reacts with synthetic anionic detergent compounds.

**Micrograms per gram** (UG/G,  $\mu\text{g/g}$ ) is a unit expressing the concentration of a chemical constituent as the mass (micrograms) of the element per unit mass (gram) of material analyzed.

**Micrograms per kilogram** (UG/KG,  $\mu\text{g/kg}$ ) is a unit expressing the concentration of a chemical constituent as the mass (micrograms) of the constituent per unit mass (kilogram) of the material analyzed. One microgram per kilogram is equivalent to 1 part per billion.

**Micrograms per liter** (UG/L,  $\mu\text{g/L}$ ) is a unit expressing the concentration of chemical constituents in water as mass (micrograms) of constituent per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. One microgram per liter is equivalent to 1 part per billion.

**Microsiemens per centimeter** (US/CM,  $\mu\text{S/cm}$ ) is a unit expressing the amount of electrical conductivity of a solution as measured between opposite faces of a centimeter cube of solution at a specified temperature. Siemens is the International System of Units nomenclature. It is synonymous with mhos and is the reciprocal of resistance in ohms.

**Milligrams per liter** (MG/L,  $\text{mg/L}$ ) is a unit for expressing the concentration of chemical constituents in water as the mass (milligrams) of constituent per unit volume (liter) of water. Concentration of suspended sediment also is expressed in milligrams per liter and is based on the mass of dry sediment per liter of water-sediment mixture.

**Minimum reporting level** (MRL) is the smallest measured concentration of a constituent that may be reliably reported by using a given analytical method.

**Miscellaneous site**, miscellaneous station, or miscellaneous sampling site is a site where streamflow, sediment, and/or water-quality data or water-quality or sediment samples are collected once, or more often on a random or discontinuous basis to provide better areal coverage for defining hydrologic and water-quality conditions over a broad area in a river basin.

**Most probable number** (MPN) is an index of the number of coliform bacteria that, more probably than any other number, would give the results shown by the laboratory examination; it is not an actual enumeration. MPN is determined from the distribution of gas-positive cultures among multiple inoculated tubes.

**Multiple-plate samplers** are artificial substrates of known surface area used for obtaining benthic invertebrate samples. They consist of a series of spaced, hardboard plates on an eyebolt.

**Nanograms per liter** (NG/L,  $\text{ng/L}$ ) is a unit expressing the concentration of chemical constituents in solution as mass (nanograms) of solute per unit volume (liter) of water. One million nanograms per liter is equivalent to 1 milligram per liter.

**National Geodetic Vertical Datum of 1929** (NGVD 29) is a fixed reference adopted as a standard geodetic datum for elevations determined by leveling. It formerly was called "Sea Level Datum

of 1929" or "mean sea level." Although the datum was derived from the mean sea level at 26 tide stations, it does not necessarily represent local mean sea level at any particular place. *See NOAA Web site: <http://www.ngs.noaa.gov/faq.shtml#WhatVD29VD88>* (See "North American Vertical Datum of 1988")

**Natural substrate** refers to any naturally occurring immersed or submersed solid surface, such as a rock or tree, upon which an organism lives. (See also "Substrate")

**Nekton** are the consumers in the aquatic environment and consist of large, free-swimming organisms that are capable of sustained, directed mobility.

**Nonfilterable** refers to the portion of the total residue retained by a filter.

**North American Datum of 1927** (NAD 27) is the horizontal control datum for the United States that was defined by a location and azimuth on the Clarke spheroid of 1866.

**North American Datum of 1983** (NAD 83) is the horizontal control datum for the United States, Canada, Mexico, and Central America that is based on the adjustment of 250,000 points including 600 satellite Doppler stations that constrain the system to a geocentric origin. NAD 83 has been officially adopted as the legal horizontal datum for the United States by the Federal government.

**North American Vertical Datum of 1988** (NAVD 88) is a fixed reference adopted as the official civilian vertical datum for elevations determined by Federal surveying and mapping activities in the United States. This datum was established in 1991 by minimum-constraint adjustment of the Canadian, Mexican, and United States first-order terrestrial leveling networks.

**Open or screened interval** is the length of unscreened opening or of well screen through which water enters a well, in feet below land surface.

**Organic carbon** (OC) is a measure of organic matter present in aqueous solution, suspension, or bottom sediment. May be reported as dissolved organic carbon (DOC), particulate organic carbon (POC), or total organic carbon (TOC).

**Organic mass or volatile mass** of a living substance is the difference between the dry mass and ash mass and represents the actual mass of the living matter. Organic mass is expressed in the same units as for ash mass and dry mass. (See also "Ash mass," "Biomass," and "Dry mass")

**Organism count/area** refers to the number of organisms collected and enumerated in a sample and adjusted to the number per area habitat, usually square meter ( $\text{m}^2$ ), acre, or hectare. Periphyton, benthic organisms, and macrophytes are expressed in these terms.

**Organism count/volume** refers to the number of organisms collected and enumerated in a sample and adjusted to the number per sample volume, usually milliliter (mL) or liter (L). Numbers of planktonic organisms can be expressed in these terms.

**Organochlorine compounds** are any chemicals that contain carbon and chlorine. Organochlorine compounds that are important in investigations of water, sediment, and biological quality include certain pesticides and industrial compounds.

**Parameter code** is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property.

**Partial-record station** is a site where discrete measurements of one or more hydrologic parameters are obtained over a period of time without continuous data being recorded or computed. A common example is a crest-stage gage partial-record station at which only peak stages and flows are recorded.

**Particle size** is the diameter, in millimeters (mm), of a particle determined by sieve or sedimentation methods. The sedimentation method uses the principle of Stokes Law to calculate sediment particle sizes. Sedimentation methods (pipet, bottom-withdrawal tube, visual-accumulation tube, sedigraph) determine fall diameter of particles in either distilled water (chemically dispersed) or in native water (the river water at the time and point of sampling).

**Particle-size classification**, as used in this report, agrees with the recommendation made by the American Geophysical Union Subcommittee on Sediment Terminology. The classification is as follows:

Classification	Size (mm)	Method of analysis
Clay	>0.00024 - 0.004	Sedimentation
Silt	>0.004 - 0.062	Sedimentation
Sand	>0.062 - 2.0	Sedimentation/sieve
Gravel	>2.0 - 64.0	Sieve
Cobble	>64 - 256	Manual measurement
Boulder	>256	Manual measurement

The particle-size distributions given in this report are not necessarily representative of all particles in transport in the stream. For the sedimentation method, most of the organic matter is removed, and the sample is subjected to mechanical and chemical dispersion before analysis in distilled water. Chemical dispersion is not used for native water analysis.

**Peak flow** (peak stage) is an instantaneous local maximum value in the continuous time series of streamflows or stages, preceded by a period of increasing values and followed by a period of decreasing values. Several peak values ordinarily occur in a year. The maximum peak value in a year is called the annual peak; peaks lower than the annual peak are called secondary peaks. Occasionally, the annual peak may not be the maximum value for the year; in such cases, the maximum value occurs at midnight at the beginning or end of the year, on the recession from or rise toward a higher peak in the adjoining year. If values are recorded at a discrete series of times, the peak recorded value may be taken as an approximation of the true peak, which may occur between the recording instants. If the values are recorded with finite precision, a sequence of equal recorded values may occur at the peak; in this case, the first value is taken as the peak.

**Percent composition or percent of total** is a unit for expressing the ratio of a particular part of a sample or population to the total sample or population, in terms of types, numbers, weight, mass, or volume.

**Percent shading** is a measure of the amount of sunlight potentially reaching the stream. A clinometer is used to measure left and right bank canopy angles. These values are added together, divided by 180, and multiplied by 100 to compute percentage of shade.

**Periodic-record station** is a site where stage, discharge, sediment, chemical, physical, or other hydrologic measurements are made one or more times during a year but at a frequency insufficient to develop a daily record.

**Periphyton** is the assemblage of microorganisms attached to and living upon submerged solid surfaces. Although primarily consisting of algae, they also include bacteria, fungi, protozoa, rotifers, and other small organisms. Periphyton are useful indicators of water quality.

**Pesticides** are chemical compounds used to control undesirable organisms. Major categories of pesticides include insecticides, miticides, fungicides, herbicides, and rodenticides.

**pH** of water is the negative logarithm of the hydrogen-ion activity. Solutions with pH less than 7.0 standard units are termed "acidic," and solutions with a pH greater than 7.0 are termed "basic." Solutions with a pH of 7.0 are neutral. The presence and concentration of many dissolved chemical constituents found in water are affected, in part, by the hydrogen-ion activity of water. Biological processes including growth, distribution of organisms, and toxicity of the water to organisms also are affected, in part, by the hydrogen-ion activity of water.

**Phytoplankton** is the plant part of the plankton. They usually are microscopic, and their movement is subject to the water currents. Phytoplankton growth is dependent upon solar radiation and nutrient substances. Because they are able to incorporate as well as release materials to the surrounding water, the phytoplankton have a profound effect upon the quality of the water. They are the primary food producers in the aquatic environment and commonly are known as algae. (See also "Plankton")

**Picocurie** (PC, pCi) is one-trillionth ( $1 \times 10^{-12}$ ) of the amount of radioactive nuclide represented by a curie (Ci). A curie is the quantity of radioactive nuclide that yields  $3.7 \times 10^{10}$  radioactive disintegrations per second (dps). A picocurie yields 0.037 dps, or 2.22 dpm (disintegrations per minute).

**Plankton** is the community of suspended, floating, or weakly swimming organisms that live in the open water of lakes and rivers. Concentrations are expressed as a number of cells per milliliter (cells/mL) of sample.

**Polychlorinated biphenyls** (PCBs) are industrial chemicals that are mixtures of chlorinated biphenyl compounds having various percentages of chlorine. They are similar in structure to organochlorine insecticides.

**Polychlorinated naphthalenes (PCNs)** are industrial chemicals that are mixtures of chlorinated naphthalene compounds. They have properties and applications similar to polychlorinated biphenyls (PCBs) and have been identified in commercial PCB preparations.

**Pool**, as used in this report, is a small part of a stream reach with little velocity, commonly with water deeper than surrounding areas.

**Primary productivity** is a measure of the rate at which new organic matter is formed and accumulated through photo-synthetic and chemosynthetic activity of producer organisms (chiefly, green plants). The rate of primary production is estimated by measuring the amount of oxygen released (oxygen method) or the amount of carbon assimilated (carbon method) by the plants.

**Primary productivity (carbon method)** is expressed as milligrams of carbon per area per unit time [ $\text{mg C}/(\text{m}^2/\text{time})$ ] for periphyton and macrophytes or per volume [ $\text{mg C}/(\text{m}^3/\text{time})$ ] for phytoplankton. The carbon method defines the amount of carbon dioxide consumed as measured by radioactive carbon (carbon-14). The carbon-14 method is of greater sensitivity than the oxygen light- and dark-bottle method and is preferred for use with unenriched water samples. Unit time may be either the hour or day, depending on the incubation period. (See also "Primary productivity")

**Primary productivity (oxygen method)** is expressed as milligrams of oxygen per area per unit time [ $\text{mg O}/(\text{m}^2/\text{time})$ ] for periphyton and macrophytes or per volume [ $\text{mg O}/(\text{m}^3/\text{time})$ ] for phytoplankton. The oxygen method defines production and respiration rates as estimated from changes in the measured dissolved-oxygen concentration. The oxygen light- and dark-bottle method is preferred if the rate of primary production is sufficient for accurate measurements to be made within 24 hours. Unit time may be either the hour or day, depending on the incubation period. (See also "Primary productivity")

**Radioisotopes** are isotopic forms of elements that exhibit radioactivity. Isotopes are varieties of a chemical element that differ in atomic weight but are very nearly alike in chemical properties. The difference arises because the atoms of the isotopic forms of an element differ in the number of neutrons in the nucleus; for example, ordinary chlorine is a mixture of isotopes having atomic weights of 35 and 37, and the natural mixture has an atomic weight of about 35.453. Many of the elements similarly exist as mixtures of isotopes, and a great many new isotopes have been produced in the operation of nuclear devices such as the cyclotron. There are 275 isotopes of the 81 stable elements, in addition to more than 800 radioactive isotopes.

**Reach**, as used in this report, is a length of stream that is chosen to represent a uniform set of physical, chemical, and biological conditions within a segment. It is the principal sampling unit for collecting physical, chemical, and biological data.

**Recoverable** is the amount of a given constituent that is in solution after a representative water sample has been extracted or digested. Complete recovery is not achieved by the extraction or digestion and thus the determination represents something less

than 95 percent of the constituent present in the sample. To achieve comparability of analytical data, equivalent extraction or digestion procedures are required of all laboratories performing such analyses because different procedures are likely to produce different analytical results. (See also "Bed material")

**Recurrence interval**, also referred to as return period, is the average time, usually expressed in years, between occurrences of hydrologic events of a specified type (such as exceedances of a specified high flow or nonexceedance of a specified low flow). The terms "return period" and "recurrence interval" do not imply regular cyclic occurrence. The actual times between occurrences vary randomly, with most of the times being less than the average and a few being substantially greater than the average. For example, the 100-year flood is the flow rate that is exceeded by the annual maximum peak flow at intervals whose average length is 100 years (that is, once in 100 years, on average); almost two-thirds of all exceedances of the 100-year flood occur less than 100 years after the previous exceedance, half occur less than 70 years after the previous exceedance, and about one-eighth occur more than 200 years after the previous exceedance. Similarly, the 7-day, 10-year low flow ( $7Q_{10}$ ) is the flow rate below which the annual minimum 7-day-mean flow dips at intervals whose average length is 10 years (that is, once in 10 years, on average); almost two-thirds of the nonexceedances of the  $7Q_{10}$  occur less than 10 years after the previous nonexceedance, half occur less than 7 years after, and about one-eighth occur more than 20 years after the previous nonexceedance. The recurrence interval for annual events is the reciprocal of the annual probability of occurrence. Thus, the 100-year flood has a 1-percent chance of being exceeded by the maximum peak flow in any year, and there is a 10-percent chance in any year that the annual minimum 7-day-mean flow will be less than the  $7Q_{10}$ .

**Replicate samples** are a group of samples collected in a manner such that the samples are thought to be essentially identical in composition.

**Return period** (See "Recurrence interval")

**Riffle**, as used in this report, is a shallow part of the stream where water flows swiftly over completely or partially submerged obstructions to produce surface agitation.

**River mileage** is the curvilinear distance, in miles, measured upstream from the mouth along the meandering path of a stream channel in accordance with Bulletin No. 14 (October 1968) of the Water Resources Council and typically is used to denote location along a river.

**Run**, as used in this report, is a relatively shallow part of a stream with moderate velocity and little or no surface turbulence.

**Runoff** is the quantity of water that is discharged ("runs off") from a drainage basin during a given time period. Runoff data may be presented as volumes in acre-feet, as mean discharges per unit of drainage area in cubic feet per second per square mile, or as depths of water on the drainage basin in inches. (See also "Annual runoff")

**Salinity** is the total quantity of dissolved salts, measured by weight in parts per thousand. Values in this report are calculated from

specific conductance and temperature. Seawater has an average salinity of about 35 parts per thousand (for additional information, refer to: Miller, R.L., Bradford, W.L., and Peters, N.E., 1988, Specific conductance: theoretical considerations and application to analytical quality control: U.S. Geological Survey Water-Supply Paper 2311, 16 p.)

**Sea level**, as used in this report, refers to one of the two commonly used national vertical datums (NGVD 1929 or NAVD 1988). See separate entries for definitions of these datums.

**Sediment** is solid material that originates mostly from disintegrated rocks; when transported by, suspended in, or deposited from water, it is referred to as “fluvial sediment.” Sediment includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics, and cause of the occurrence of sediment in streams are affected by environmental and land-use factors. Some major factors are topography, soil characteristics, land cover, and depth and intensity of precipitation.

**Sensible heat flux** (often used interchangeably with latent sensible heat-flux density) is the amount of heat energy that moves by turbulent transport through the air across a specified cross-sectional area per unit time and goes to heating (cooling) the air. Usually expressed in watts per square meter.

**Seven-day, 10-year low flow ( $7Q_{10}$ )** is the discharge below which the annual 7-day minimum flow falls in 1 year out of 10 on the long-term average. The recurrence interval of the  $7Q_{10}$  is 10 years; the chance that the annual 7-day minimum flow will be less than the  $7Q_{10}$  is 10 percent in any given year. (See also “Annual 7-day minimum” and “Recurrence interval”)

**Shelves**, as used in this report, are streambank features extending nearly horizontally from the flood plain to the lower limit of persistent woody vegetation.

**Sodium adsorption ratio (SAR)** is the expression of relative activity of sodium ions in exchange reactions within soil and is an index of sodium or alkali hazard to the soil. Sodium hazard in water is an index that can be used to evaluate the suitability of water for irrigating crops.

**Soil heat flux** (often used interchangeably with soil heat-flux density) is the amount of heat energy that moves by conduction across a specified cross-sectional area of soil per unit time and goes to heating (or cooling) the soil. Usually expressed in watts per square meter.

**Soil-water content** is the water lost from the soil upon drying to constant mass at 105 °C; expressed either as mass of water per unit mass of dry soil or as the volume of water per unit bulk volume of soil.

**Specific electrical conductance (conductivity)** is a measure of the capacity of water (or other media) to conduct an electrical current. It is expressed in microsiemens per centimeter at 25 °C. Specific electrical conductance is a function of the types and quantity of dissolved substances in water and can be used for approximating the dissolved-solids content of the water. Commonly, the con-

centration of dissolved solids (in milligrams per liter) is from 55 to 75 percent of the specific conductance (in microsiemens). This relation is not constant from stream to stream, and it may vary in the same source with changes in the composition of the water.

**Stable isotope ratio** (per MIL) is a unit expressing the ratio of the abundance of two radioactive isotopes. Isotope ratios are used in hydrologic studies to determine the age or source of specific water, to evaluate mixing of different water, as an aid in determining reaction rates, and other chemical or hydrologic processes.

**Stage** (See “Gage height”)

**Stage-discharge relation** is the relation between the water-surface elevation, termed stage (gage height), and the volume of water flowing in a channel per unit time.

**Streamflow** is the discharge that occurs in a natural channel. Although the term “discharge” can be applied to the flow of a canal, the word “streamflow” uniquely describes the discharge in a surface stream course. The term “streamflow” is more general than “runoff” as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

**Substrate** is the physical surface upon which an organism lives.

**Substrate embeddedness class** is a visual estimate of riffle streambed substrate larger than gravel that is surrounded or covered by fine sediment (<2 mm, sand or finer). Below are the class categories expressed as the percentage covered by fine sediment:

0	no gravel or larger substrate	3	26-50 percent
1	> 75 percent	4	5-25 percent
2	51-75 percent	5	< 5 percent

**Surface area** of a lake is that area (acres) encompassed by the boundary of the lake as shown on USGS topographic maps, or other available maps or photographs. Because surface area changes with lake stage, surface areas listed in this report represent those determined for the stage at the time the maps or photographs were obtained.

**Surficial bed material** is the upper surface (0.1 to 0.2 foot) of the bed material that is sampled using U.S. Series Bed-Material Samplers.

**Surrogate** is an analyte that behaves similarly to a target analyte, but that is highly unlikely to occur in a sample. A surrogate is added to a sample in known amounts before extraction and is measured with the same laboratory procedures used to measure the target analyte. Its purpose is to monitor method performance for an individual sample.

**Suspended** is the amount (concentration) of undissolved material in a water-sediment mixture. Most commonly refers to that material retained on a 0.45-micrometer filter.

**Suspended, recoverable** is the amount of a given constituent that is in solution after the part of a representative water-suspended sediment sample that is retained on a 0.45-micrometer filter has been extracted or digested. Complete recovery is not achieved by the

extraction or digestion procedures and thus the determination represents less than 95 percent of the constituent present in the sample. To achieve comparability of analytical data, equivalent extraction or digestion procedures are required of all laboratories performing such analyses because different procedures are likely to produce different analytical results. (See also “Suspended”)

**Suspended sediment** is sediment carried in suspension by the turbulent components of the fluid or by the Brownian movement (a law of physics). (See also “Sediment”)

**Suspended-sediment concentration** is the velocity-weighted concentration of suspended sediment in the sampled zone (from the water surface to a point approximately 0.3 foot above the bed) expressed as milligrams of dry sediment per liter of water-sediment mixture (mg/L). The analytical technique uses the mass of all of the sediment and the net weight of the water-sediment mixture in a sample to compute the suspended-sediment concentration. (See also “Sediment” and “Suspended sediment”)

**Suspended-sediment discharge** (tons/d) is the rate of sediment transport, as measured by dry mass or volume, that passes a cross section in a given time. It is calculated in units of tons per day as follows: concentration (mg/L) x discharge (ft<sup>3</sup>/s) x 0.0027. (See also “Sediment,” “Suspended sediment,” and “Suspended-sediment concentration”)

**Suspended-sediment load** is a general term that refers to a given characteristic of the material in suspension that passes a point during a specified period of time. The term needs to be qualified, such as “annual suspended-sediment load” or “sand-size suspended-sediment load,” and so on. It is not synonymous with either suspended-sediment discharge or concentration. (See also “Sediment”)

**Suspended solids, total residue at 105 °C concentration** is the concentration of inorganic and organic material retained on a filter, expressed as milligrams of dry material per liter of water (mg/L). An aliquot of the sample is used for this analysis.

**Suspended, total** is the total amount of a given constituent in the part of a water-sediment sample that is retained on a 0.45-micrometer membrane filter. This term is used only when the analytical procedure assures measurement of at least 95 percent of the constituent determined. Knowledge of the expected form of the constituent in the sample, as well as the analytical methodology used, is required to determine when the results should be reported as “suspended, total.” Determinations of “suspended, total” constituents are made either by directly analyzing portions of the suspended material collected on the filter or, more commonly, by difference, on the basis of determinations of (1) dissolved and (2) total concentrations of the constituent. (See also “Suspended”)

**Synoptic studies** are short-term investigations of specific water-quality conditions during selected seasonal or hydro-logic periods to provide improved spatial resolution for critical water-quality conditions. For the period and conditions sampled, they assess the spatial distribution of selected water-quality conditions in relation to causative factors, such as land use and contaminant sources.

**Taxa** (Species) richness is the number of species (taxa) present in a defined area or sampling unit.

**Taxonomy** is the division of biology concerned with the classification and naming of organisms. The classification of organisms is based upon a hierarchical scheme beginning with Kingdom and ending with Species at the base. The higher the classification level, the fewer features the organisms have in common. For example, the taxonomy of a particular mayfly, *Hexagenia limbata*, is the following:

Kingdom:	Animal
Phylum:	Arthropoda
Class:	Insecta
Order:	Ephemeroptera
Family:	Ephemeridae
Genus:	<i>Hexagenia</i>
Species:	<i>Hexagenia limbata</i>

**Thalweg** is the line formed by connecting points of minimum streambed elevation (deepest part of the channel).

**Thermograph** is an instrument that continuously records variations of temperature on a chart. The more general term “temperature recorder” is used in the table descriptions and refers to any instrument that records temperature whether on a chart, a tape, or any other medium.

**Time-weighted average** is computed by multiplying the number of days in the sampling period by the concentrations of individual constituents for the corresponding period and dividing the sum of the products by the total number of days. A time-weighted average represents the composition of water resulting from the mixing of flow proportionally to the duration of the concentration.

**Tons per acre-foot** (T/acre-ft) is the dry mass (tons) of a constituent per unit volume (acre-foot) of water. It is computed by multiplying the concentration of the constituent, in milligrams per liter, by 0.00136.

**Tons per day** (T/DAY, tons/d) is a common chemical or sediment discharge unit. It is the quantity of a substance in solution, in suspension, or as bedload that passes a stream section during a 24-hour period. It is equivalent to 2,000 pounds per day, or 0.9072 metric ton per day.

**Total** is the amount of a given constituent in a representative whole-water (unfiltered) sample, regardless of the constituent’s physical or chemical form. This term is used only when the analytical procedure assures measurement of at least 95 percent of the constituent present in both the dissolved and suspended phases of the sample. A knowledge of the expected form of the constituent in the sample, as well as the analytical methodology used, is required to judge when the results should be reported as “total.” (Note that the word “total” does double duty here, indicating both that the sample consists of a water-suspended sediment mixture and that the analytical method determined at least 95 percent of the constituent in the sample.)

**Total coliform bacteria** are a particular group of bacteria that are used as indicators of possible sewage pollution. This group includes coliforms that inhabit the intestine of warmblooded animals and those that inhabit soils. They are characterized as aerobic or facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 35 °C. In the laboratory, these bacteria are defined as all the organisms that produce colonies with a golden-green metallic sheen within 24 hours when incubated at 35 °C plus or minus 1.0 °C on M-Endo medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 milliliters of sample. (See also “Bacteria”)

**Total discharge** is the quantity of a given constituent, measured as dry mass or volume, that passes a stream cross section per unit of time. When referring to constituents other than water, this term needs to be qualified, such as “total sediment discharge,” “total chloride discharge,” and so on.

**Total in bottom material** is the amount of a given constituent in a representative sample of bottom material. This term is used only when the analytical procedure assures measurement of at least 95 percent of the constituent determined. A knowledge of the expected form of the constituent in the sample, as well as the analytical methodology used, is required to judge when the results should be reported as “total in bottom material.”

**Total length** (fish) is the straight-line distance from the anterior point of a fish specimen’s snout, with the mouth closed, to the posterior end of the caudal (tail) fin, with the lobes of the caudal fin squeezed together.

**Total load** refers to all of a constituent in transport. When referring to sediment, it includes suspended load plus bed load.

**Total organism count** is the number of organisms collected and enumerated in any particular sample. (See also “Organism count/volume”)

**Total recoverable** is the amount of a given constituent in a whole-water sample after a sample has been digested by a method (usually using a dilute acid solution) that results in dissolution of only readily soluble substances. Complete dissolution of all particulate matter is not achieved by the digestion treatment, and thus the determination represents something less than the “total” amount (that is, less than 95 percent) of the constituent present in the dissolved and suspended phases of the sample. To achieve comparability of analytical data for whole-water samples, equivalent digestion procedures are required of all laboratories performing such analyses because different digestion procedures may produce different analytical results.

**Total sediment discharge** is the mass of suspended-sediment plus bed-load transport, measured as dry weight, that passes a cross section in a given time. It is a rate and is reported as tons per day. (See also “Bedload,” “Bedload discharge,” “Sediment,” “Suspended sediment,” and “Suspended-sediment concentration”)

**Total sediment load** or **total load** is the sediment in transport as bedload and suspended-sediment load. The term may be qualified, such as “annual suspended-sediment load” or “sand-size suspended-sediment load,” and so on. It differs from total sedi-

ment discharge in that load refers to the material, whereas discharge refers to the quantity of material, expressed in units of mass per unit time. (See also “Sediment,” “Suspended-sediment load,” and “Total load”)

**Transect**, as used in this report, is a line across a stream perpendicular to the flow and along which measurements are taken, so that morphological and flow characteristics along the line are described from bank to bank. Unlike a cross section, no attempt is made to determine known elevation points along the line.

**Turbidity** is an expression of the optical properties of a liquid that causes light rays to be scattered and absorbed rather than transmitted in straight lines through water. Turbidity, which can make water appear cloudy or muddy, is caused by the presence of suspended and dissolved matter, such as clay, silt, finely divided organic matter, plankton and other microscopic organisms, organic acids, and dyes (ASTM International, 2003, D1889–00 Standard test method for turbidity of water, *in* ASTM International, Annual Book of ASTM Standards, Water and Environmental Technology, v. 11.01: West Conshohocken, Pennsylvania, 6 p.). The color of water, whether resulting from dissolved compounds or suspended particles, can affect a turbidity measurement. To ensure that USGS turbidity data can be understood and interpreted properly within the context of the instrument used and site conditions encountered, data from each instrument type are stored and reported in the National Water Information System (NWIS) using parameter codes and measurement reporting units that are specific to the instrument type, with specific instruments designated by the method code. The respective measurement units, many of which also are in use internationally, fall into two categories: (1) the designations NTU, NTRU, BU, AU, and NTMU signify the use of a broad spectrum incident light in the wavelength range of 400-680 nanometers (nm), but having different light detection configurations; (2) The designations FNU, FNRU, FBU, FAU, and FNMU generally signify an incident light in the range between 780-900 nm, also with varying light detection configurations. These reporting units are equivalent when measuring a calibration solution (for example, formazin or polymer beads), but their respective instruments may not produce equivalent results for environmental samples. Specific reporting units are as follows:

**NTU** (Nephelometric Turbidity Units): white or broadband [400-680 nm] light source, 90 degree detection angle, one detector.

**NTRU** (Nephelometric Turbidity Ratio Units): white or broadband [400-680 nm] light source, 90 degree detection angle, multiple detectors with ratio compensation.

**BU** (Backscatter Units): white or broadband [400-680 nm] light source, 30–15 degree detection angle (backscatter).

**AU** (Attenuation Units): white or broadband [400-680 nm] light source, 180 degree detection angle (attenuation).

**NTMU** (Nephelometric Turbidity Multibeam Units): white or broadband [400-680 nm] light source, multiple light sources, detectors at 90 degrees and possibly other angles to each beam.

**FNU** (Formazin Nephelometric Units): near infrared [780-900 nm] or monochrome light source, 90 degree detection angle, one detector.

***FNRU*** (Formazin Nephelometric Ratio Units): near infrared [780-900 nm] or monochrome light source, 90 degree detection angle, multiple detectors, ratio compensation.

***FBU*** (Formazin Backscatter Units): near infrared [780-900 nm] or monochrome light source, 30 15degree detection angle.

***FAU*** (Formazin Attenuation Units): near infrared [780-900 nm] light source, 180 degree detection angle.

***FNMU*** (Formazin Nephelometric Multibeam Units): near infrared [780-900 nm] or monochrome light source, multiple light sources, detectors at 90 degrees and possibly other angles to each beam.

For more information please see [http://water.usgs.gov/owq/FieldManual/Chapter6/6.7\\_contents.html](http://water.usgs.gov/owq/FieldManual/Chapter6/6.7_contents.html).

**Ultraviolet** (UV) absorbance (absorption) at 254 or 280 nanometers is a measure of the aggregate concentration of the mixture of UV absorbing organic materials dissolved in the analyzed water, such as lignin, tannin, humic substances, and various aromatic compounds. UV absorbance (absorption) at 254 or 280 nanometers is measured in UV absorption units per centimeter of path length of UV light through a sample.

**Unconfined aquifer** is an aquifer whose upper surface is a water table free to fluctuate under atmospheric pressure. (See “Water-table aquifer”)

**Unfiltered** pertains to the constituents in an unfiltered, representative water-suspended sediment sample.

**Unfiltered, recoverable** is the amount of a given constituent in a representative water-suspended sediment sample that has been extracted or digested. Complete recovery is not achieved by the extraction or digestion treatment and thus the determination represents less than 95 percent of the constituent present in the sample. To achieve comparability of analytical data, equivalent extraction or digestion procedures are required of all laboratories performing such analyses because different procedures are likely to produce different analytical results.

**Vertical datum** (See “Datum”)

**Volatile organic compounds** (VOCs) are organic compounds that can be isolated from the water phase of a sample by purging the water sample with inert gas, such as helium, and, subsequently, analyzed by gas chromatography. Many VOCs are human-made chemicals that are used and produced in the manufacture of paints, adhesives, petroleum products, pharmaceuticals, and refrigerants. They often are components of fuels, solvents, hydraulic fluids, paint thinners, and dry-cleaning agents commonly used in urban settings. VOC contamination of drinking-

water supplies is a human-health concern because many are toxic and are known or suspected human carcinogens.

**Water table** is that surface in a ground-water body at which the water pressure is equal to the atmospheric pressure.

**Water-table aquifer** is an unconfined aquifer within which the water table is found.

**Water year** in USGS reports dealing with surface-water supply is the 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 2002, is called the “2002 water year.”

**Watershed** (See “Drainage basin”)

**WDR** is used as an abbreviation for “Water-Data Report” in the REVISED RECORDS paragraph to refer to State annual hydrologic-data reports. (WRD was used as an abbreviation for “Water-Resources Data” in reports published prior to 1976.)

**Weighted average** is used in this report to indicate discharge-weighted average. It is computed by multiplying the discharge for a sampling period by the concentrations of individual constituents for the corresponding period and dividing the sum of the products by the sum of the discharges. A discharge-weighted average approximates the composition of water that would be found in a reservoir containing all the water passing a given location during the water year after thorough mixing in the reservoir.

**Wet mass** is the mass of living matter plus contained water. (See also “Biomass” and “Dry mass”)

**Wet weight** refers to the weight of animal tissue or other substance including its contained water. (See also “Dry weight”)

**WSP** is used as an acronym for “Water-Supply Paper” in reference to previously published reports.

**Zooplankton** is the animal part of the plankton. Zooplankton are capable of extensive movements within the water column and often are large enough to be seen with the unaided eye. Zooplankton are secondary consumers feeding upon bacteria, phytoplankton, and detritus. Because they are the grazers in the aquatic environment, the zooplankton are a vital part of the aquatic food web. The zooplankton community is dominated by small crustaceans and rotifers. (See also “Plankton”)

## Techniques of Water-Resources Investigations of the U.S. Geological Survey

The USGS publishes a series of manuals, the Techniques of Water-Resources Investigations, describing procedures for planning and conducting specialized work in water-resources investigations. The material is grouped under major subject headings called books and is further divided into sections and chapters. For example, section A of book 3 (Applications of Hydraulics) pertains to surface water. The chapter, the unit of publication, is limited to a narrow field of subject matter. This format permits flexibility in revision and publication as the need arises.

Reports in the Techniques of Water-Resources Investigations series, which are listed below, are online at <http://water.usgs.gov/pubs/twri/>. Printed copies are for sale by the USGS, Information Services, Box 25286, Federal Center, Denver, Colorado 80225 (authorized agent of the Superintendent of Documents, Government Printing Office), telephone 1-888-ASK-USGS. Please telephone 1-888-ASK-USGS for current prices, and refer to the title, book number, chapter number, and mention the "U.S. Geological Survey Techniques of Water-Resources Investigations." Products can then be ordered by telephone, or online at <http://www.usgs.gov/sales.html>, or by FAX to (303)236-469 of an order form available online at <http://mac.usgs.gov/isb/pubs/forms/>. Prepayment by major credit card or by a check or money order payable to the "U.S. Geological Survey" is required.

### Book 1. Collection of Water Data by Direct Measurement

#### Section D. Water Quality

1-D1. *Water temperature—Influential factors, field measurement, and data presentation*, by H.H. Stevens, Jr., J.F. Ficke, and G.F. Smoot: USGS–TWRI book 1, chap. D1. 1975. 65 p.

1-D2. *Guidelines for collection and field analysis of ground-water samples for selected unstable constituents*, by W.W. Wood: USGS–TWRI book 1, chap. D2. 1976. 24 p.

### Book 2. Collection of Environmental Data

#### Section D. Surface Geophysical Methods

2-D1. *Application of surface geophysics to ground-water investigations*, by A.A.R. Zohdy, G.P. Eaton, and D.R. Mabey: USGS–TWRI book 2, chap. D1. 1974. 116 p.

2-D2. *Application of seismic-refraction techniques to hydrologic studies*, by F.P. Haeni: USGS–TWRI book 2, chap. D2. 1988. 86 p.

#### Section E. Subsurface Geophysical Methods

2-E1. *Application of borehole geophysics to water-resources investigations*, by W.S. Keys and L.M. MacCary: USGS–TWRI book 2, chap. E1. 1971. 126 p.

2-E2. *Borehole geophysics applied to ground-water investigations*, by W.S. Keys: USGS–TWRI book 2, chap. E2. 1990. 150 p.

#### Section F. Drilling and Sampling Methods

2-F1. *Application of drilling, coring, and sampling techniques to test holes and wells*, by Eugene Shuter and W.E. Teasdale: USGS–TWRI book 2, chap. F1. 1989. 97 p.

## Book 3. Applications of Hydraulics

### Section A. Surface-Water Techniques

- 3–A1. *General field and office procedures for indirect discharge measurements*, by M.A. Benson and Tate Dalrymple: USGS–TWRI book 3, chap. A1. 1967. 30 p.
- 3–A2. *Measurement of peak discharge by the slope-area method*, by Tate Dalrymple and M.A. Benson: USGS–TWRI book 3, chap. A2. 1967. 12 p.
- 3–A3. *Measurement of peak discharge at culverts by indirect methods*, by G.L. Bodhaine: USGS–TWRI book 3, chap. A3. 1968. 60 p.
- 3–A4. *Measurement of peak discharge at width contractions by indirect methods*, by H.F. Matthai: USGS–TWRI book 3, chap. A4. 1967. 44 p.
- 3–A5. *Measurement of peak discharge at dams by indirect methods*, by Harry Hulsing: USGS–TWRI book 3, chap. A5. 1967. 29 p.
- 3–A6. *General procedure for gaging streams*, by R.W. Carter and Jacob Davidian: USGS–TWRI book 3, chap. A6. 1968. 13 p.
- 3–A7. *Stage measurement at gaging stations*, by T.J. Buchanan and W.P. Somers: USGS–TWRI book 3, chap. A7. 1968. 28 p.
- 3–A8. *Discharge measurements at gaging stations*, by T.J. Buchanan and W.P. Somers: USGS–TWRI book 3, chap. A8. 1969. 65 p.
- 3–A9. *Measurement of time of travel in streams by dye tracing*, by F.A. Kilpatrick and J.F. Wilson, Jr.: USGS–TWRI book 3, chap. A9. 1989. 27 p.
- 3–A10. *Discharge ratings at gaging stations*, by E.J. Kennedy: USGS–TWRI book 3, chap. A10. 1984. 59 p.
- 3–A11. *Measurement of discharge by the moving-boat method*, by G.F. Smoot and C.E. Novak: USGS–TWRI book 3, chap. A11. 1969. 22 p.
- 3–A12. *Fluorometric procedures for dye tracing*, Revised, by J.F. Wilson, Jr., E.D. Cobb, and F.A. Kilpatrick: USGS–TWRI book 3, chap. A12. 1986. 34 p.
- 3–A13. *Computation of continuous records of streamflow*, by E.J. Kennedy: USGS–TWRI book 3, chap. A13. 1983. 53 p.
- 3–A14. *Use of flumes in measuring discharge*, by F.A. Kilpatrick and V.R. Schneider: USGS–TWRI book 3, chap. A14. 1983. 46 p.
- 3–A15. *Computation of water-surface profiles in open channels*, by Jacob Davidian: USGS–TWRI book 3, chap. A15. 1984. 48 p.
- 3–A16. *Measurement of discharge using tracers*, by F.A. Kilpatrick and E.D. Cobb: USGS–TWRI book 3, chap. A16. 1985. 52 p.
- 3–A17. *Acoustic velocity meter systems*, by Antonius Laenen: USGS–TWRI book 3, chap. A17. 1985. 38 p.
- 3–A18. *Determination of stream reaeration coefficients by use of tracers*, by F.A. Kilpatrick, R.E. Rathbun, Nobuhiro Yotsukura, G.W. Parker, and L.L. DeLong: USGS–TWRI book 3, chap. A18. 1989. 52 p.
- 3–A19. *Levels at streamflow gaging stations*, by E.J. Kennedy: USGS–TWRI book 3, chap. A19. 1990. 31 p.
- 3–A20. *Simulation of soluble waste transport and buildup in surface waters using tracers*, by F.A. Kilpatrick: USGS–TWRI book 3, chap. A20. 1993. 38 p.
- 3–A21. *Stream-gaging cableways*, by C. Russell Wagner: USGS–TWRI book 3, chap. A21. 1995. 56 p.

### Section B. Ground-Water Techniques

- 3–B1. *Aquifer-test design, observation, and data analysis*, by R.W. Stallman: USGS–TWRI book 3, chap. B1. 1971. 26 p.
- 3–B2. *Introduction to ground-water hydraulics, a programed text for self-instruction*, by G.D. Bennett: USGS–TWRI book 3, chap. B2. 1976. 172 p.
- 3–B3. *Type curves for selected problems of flow to wells in confined aquifers*, by J.E. Reed: USGS–TWRI book 3, chap. B3. 1980. 106 p.
- 3–B4. *Regression modeling of ground-water flow*, by R.L. Cooley and R.L. Naff: USGS–TWRI book 3, chap. B4. 1990. 232 p.

- 3–B4. *Supplement 1. Regression modeling of ground-water flow—Modifications to the computer code for nonlinear regression solution of steady-state ground-water flow problems*, by R.L. Cooley: USGS–TWRI book 3, chap. B4. 1993. 8 p.
- 3–B5. *Definition of boundary and initial conditions in the analysis of saturated ground-water flow systems—An introduction*, by O.L. Franke, T.E. Reilly, and G.D. Bennett: USGS–TWRI book 3, chap. B5. 1987. 15 p.
- 3–B6. *The principle of superposition and its application in ground-water hydraulics*, by T.E. Reilly, O.L. Franke, and G.D. Bennett: USGS–TWRI book 3, chap. B6. 1987. 28 p.
- 3–B7. *Analytical solutions for one-, two-, and three-dimensional solute transport in ground-water systems with uniform flow*, by E.J. Wexler: USGS–TWRI book 3, chap. B7. 1992. 190 p.
- 3–B8. *System and boundary conceptualization in ground-water flow simulation*, by T.E. Reilly: USGS–TWRI book 3, chap. B8. 2001. 29 p.

## Section C. Sedimentation and Erosion Techniques

- 3–C1. *Fluvial sediment concepts*, by H.P. Guy: USGS–TWRI book 3, chap. C1. 1970. 55 p.
- 3–C2. *Field methods for measurement of fluvial sediment*, by T.K. Edwards and G.D. Glysson: USGS–TWRI book 3, chap. C2. 1999. 89 p.
- 3–C3. *Computation of fluvial-sediment discharge*, by George Porterfield: USGS–TWRI book 3, chap. C3. 1972. 66 p.

## Book 4. Hydrologic Analysis and Interpretation

### Section A. Statistical Analysis

- 4–A1. *Some statistical tools in hydrology*, by H.C. Riggs: USGS–TWRI book 4, chap. A1. 1968. 39 p.
- 4–A2. *Frequency curves*, by H.C. Riggs: USGS–TWRI book 4, chap. A2. 1968. 15 p.
- 4–A3. *Statistical methods in water resources*, by D.R. Helsel and R.M. Hirsch: USGS–TWRI book 4, chap. A3. 1991. Available only online at <http://water.usgs.gov/pubs/twri/twri4a3/>. (Accessed August 30, 2002.)

### Section B. Surface Water

- 4–B1. *Low-flow investigations*, by H.C. Riggs: USGS–TWRI book 4, chap. B1. 1972. 18 p.
- 4–B2. *Storage analyses for water supply*, by H.C. Riggs and C.H. Hardison: USGS–TWRI book 4, chap. B2. 1973. 20 p.
- 4–B3. *Regional analyses of streamflow characteristics*, by H.C. Riggs: USGS–TWRI book 4, chap. B3. 1973. 15 p.

### Section D. Interrelated Phases of the Hydrologic Cycle

- 4–D1. *Computation of rate and volume of stream depletion by wells*, by C.T. Jenkins: USGS–TWRI book 4, chap. D1. 1970. 17 p.

## Book 5. Laboratory Analysis

### Section A. Water Analysis

- 5–A1. *Methods for determination of inorganic substances in water and fluvial sediments*, by M.J. Fishman and L.C. Friedman, editors: USGS–TWRI book 5, chap. A1. 1989. 545 p.
- 5–A2. *Determination of minor elements in water by emission spectroscopy*, by P.R. Barnett and E.C. Mallory, Jr.: USGS–TWRI book 5, chap. A2. 1971. 31 p.
- 5–A3. *Methods for the determination of organic substances in water and fluvial sediments*, edited by R.L. Wershaw, M.J. Fishman, R.R. Grabbe, and L.E. Lowe: USGS–TWRI book 5, chap. A3. 1987. 80 p.

- 5–A4. *Methods for collection and analysis of aquatic biological and microbiological samples*, by L.J. Britton and P.E. Greeson, editors: USGS–TWRI book 5, chap. A4. 1989. 363 p.
- 5–A5. *Methods for determination of radioactive substances in water and fluvial sediments*, by L.L. Thatcher, V.J. Janzer, and K.W. Edwards: USGS–TWRI book 5, chap. A5. 1977. 95 p.
- 5–A6. *Quality assurance practices for the chemical and biological analyses of water and fluvial sediments*, by L.C. Friedman and D.E. Erdmann: USGS–TWRI book 5, chap. A6. 1982. 181 p.

## Section C. Sediment Analysis

- 5–C1. *Laboratory theory and methods for sediment analysis*, by H.P. Guy: USGS–TWRI book 5, chap. C1. 1969. 58 p.

## Book 6. Modeling Techniques

### Section A. Ground Water

- 6–A1. *A modular three-dimensional finite-difference ground-water flow model*, by M.G. McDonald and A.W. Harbaugh: USGS–TWRI book 6, chap. A1. 1988. 586 p.
- 6–A2. *Documentation of a computer program to simulate aquifer-system compaction using the modular finite-difference ground-water flow model*, by S.A. Leake and D.E. Prudic: USGS–TWRI book 6, chap. A2. 1991. 68 p.
- 6–A3. *A modular finite-element model (MODFE) for areal and axisymmetric ground-water-flow problems, Part 1: Model Description and User's Manual*, by L.J. Torak: USGS–TWRI book 6, chap. A3. 1993. 136 p.
- 6–A4. *A modular finite-element model (MODFE) for areal and axisymmetric ground-water-flow problems, Part 2: Derivation of finite-element equations and comparisons with analytical solutions*, by R.L. Cooley: USGS–TWRI book 6, chap. A4. 1992. 108 p.
- 6–A5. *A modular finite-element model (MODFE) for areal and axisymmetric ground-water-flow problems, Part 3: Design philosophy and programming details*, by L.J. Torak: USGS–TWRI book 6, chap. A5. 1993. 243 p.
- 6–A6. *A coupled surface-water and ground-water flow model (MODBRANCH) for simulation of stream-aquifer interaction*, by Eric D. Swain and Eliezer J. Wexler: USGS–TWRI book 6, chap. A6. 1996. 125 p.
- 6–A7. *User's guide to SEAWAT: A computer program for simulation of three-dimensional variable-density ground-water flow*, by Weixing Guo and Christian D. Langevin: USGS–TWRI book 6, chap. A7. 2002. 77 p.

## Book 7. Automated Data Processing and Computations

### Section C. Computer Programs

- 7–C1. *Finite difference model for aquifer simulation in two dimensions with results of numerical experiments*, by P.C. Trescott, G.F. Pinder, and S.P. Larson: USGS–TWRI book 7, chap. C1. 1976. 116 p.
- 7–C2. *Computer model of two-dimensional solute transport and dispersion in ground water*, by L.F. Konikow and J.D. Bredehoeft: USGS–TWRI book 7, chap. C2. 1978. 90 p.
- 7–C3. *A model for simulation of flow in singular and interconnected channels*, by R.W. Schaffranek, R.A. Baltzer, and D.E. Goldberg: USGS–TWRI book 7, chap. C3. 1981. 110 p.

## Book 8. Instrumentation

### Section A. Instruments for Measurement of Water Level

- 8–A1. *Methods of measuring water levels in deep wells*, by M.S. Garber and F.C. Koopman: USGS–TWRI book 8, chap. A1. 1968. 23 p.

8–A2. *Installation and service manual for U.S. Geological Survey manometers*, by J.D. Craig: USGS–TWRI book 8, chap. A2. 1983. 57 p.

## Section B. Instruments for Measurement of Discharge

8–B2. *Calibration and maintenance of vertical-axis type current meters*, by G.F. Smoot and C.E. Novak: USGS–TWRI book 8, chap. B2. 1968. 15 p.

## Book 9. Handbooks for Water-Resources Investigations

### Section A. National Field Manual for the Collection of Water-Quality Data

9–A1. *National field manual for the collection of water-quality data: Preparations for water sampling*, by F.D. Wilde, D.B. Radtke, Jacob Gibs, and R.T. Iwatsubo: USGS–TWRI book 9, chap. A1. 1998. 47 p.

9–A2. *National field manual for the collection of water-quality data: Selection of equipment for water sampling*, edited by F.D. Wilde, D.B. Radtke, Jacob Gibs, and R.T. Iwatsubo: USGS–TWRI book 9, chap. A2. 1998. 94 p.

9–A3. *National field manual for the collection of water-quality data: Cleaning of equipment for water sampling*, edited by F.D. Wilde, D.B. Radtke, Jacob Gibs, and R.T. Iwatsubo: USGS–TWRI book 9, chap. A3. 1998. 75 p.

9–A4. *National field manual for the collection of water-quality data: Collection of water samples*, edited by F.D. Wilde, D.B. Radtke, Jacob Gibs, and R.T. Iwatsubo: USGS–TWRI book 9, chap. A4. 1999. 156 p.

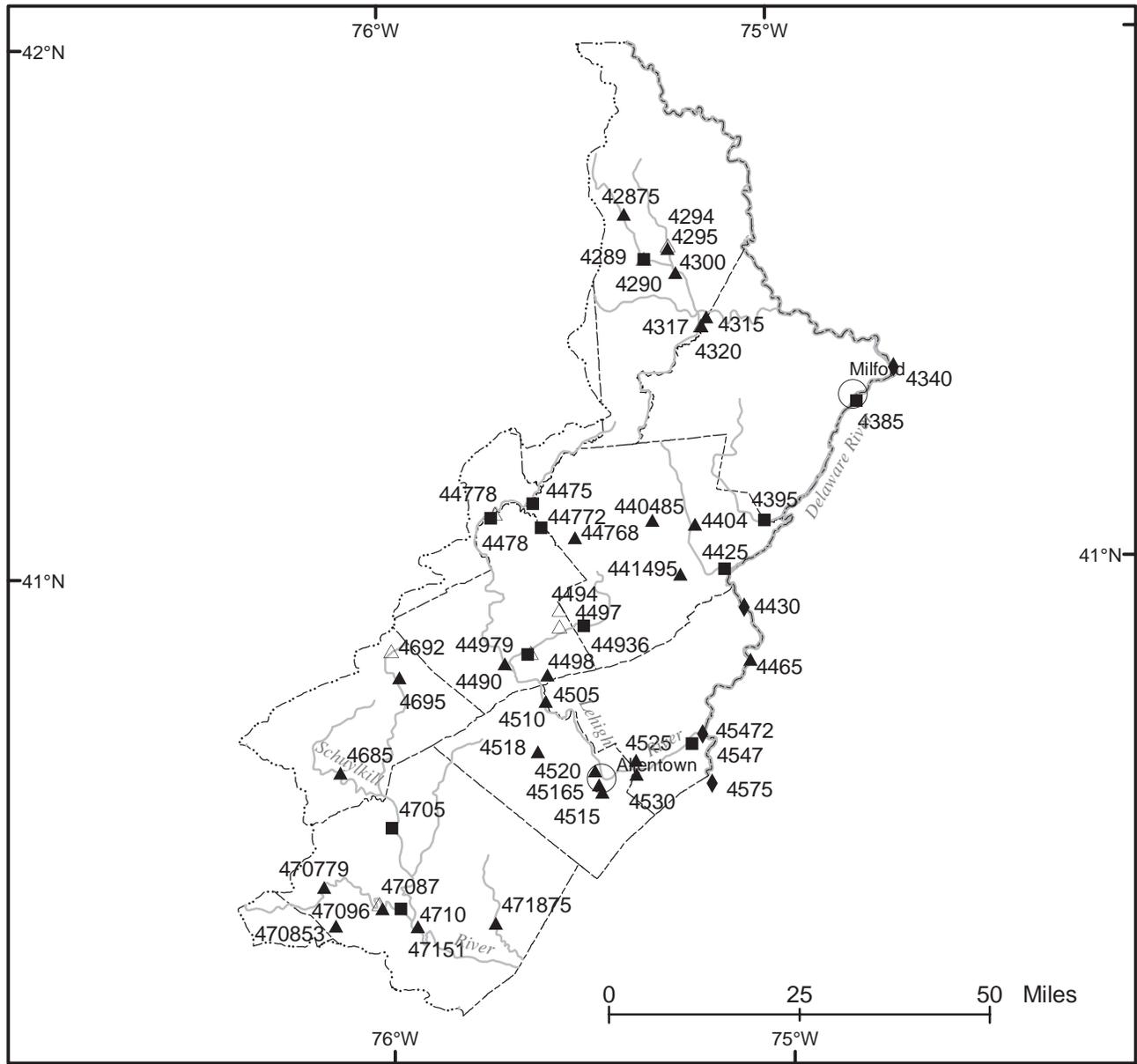
9–A5. *National field manual for the collection of water-quality data: Processing of water samples*, edited by F.D. Wilde, D.B. Radtke, Jacob Gibs, and R.T. Iwatsubo: USGS–TWRI book 9, chap. A5. 1999, 149 p.

9–A6. *National field manual for the collection of water-quality data: Field measurements*, edited by F.D. Wilde and D.B. Radtke: USGS–TWRI book 9, chap. A6. 1998. Variously paginated.

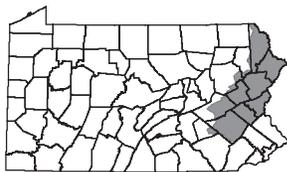
9–A7. *National field manual for the collection of water-quality data: Biological indicators*, edited by D.N. Myers and F.D. Wilde: USGS–TWRI book 9, chap. A7. 1997 and 1999. Variously paginated.

9–A8. *National field manual for the collection of water-quality data: Bottom-material samples*, by D.B. Radtke: USGS–TWRI book 9, chap. A8. 1998. 48 p.

9–A9. *National field manual for the collection of water-quality data: Safety in field activities*, by S.L. Lane and R.G. Fay: USGS–TWRI book 9, chap. A9. 1998. 60 p.



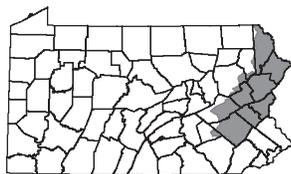
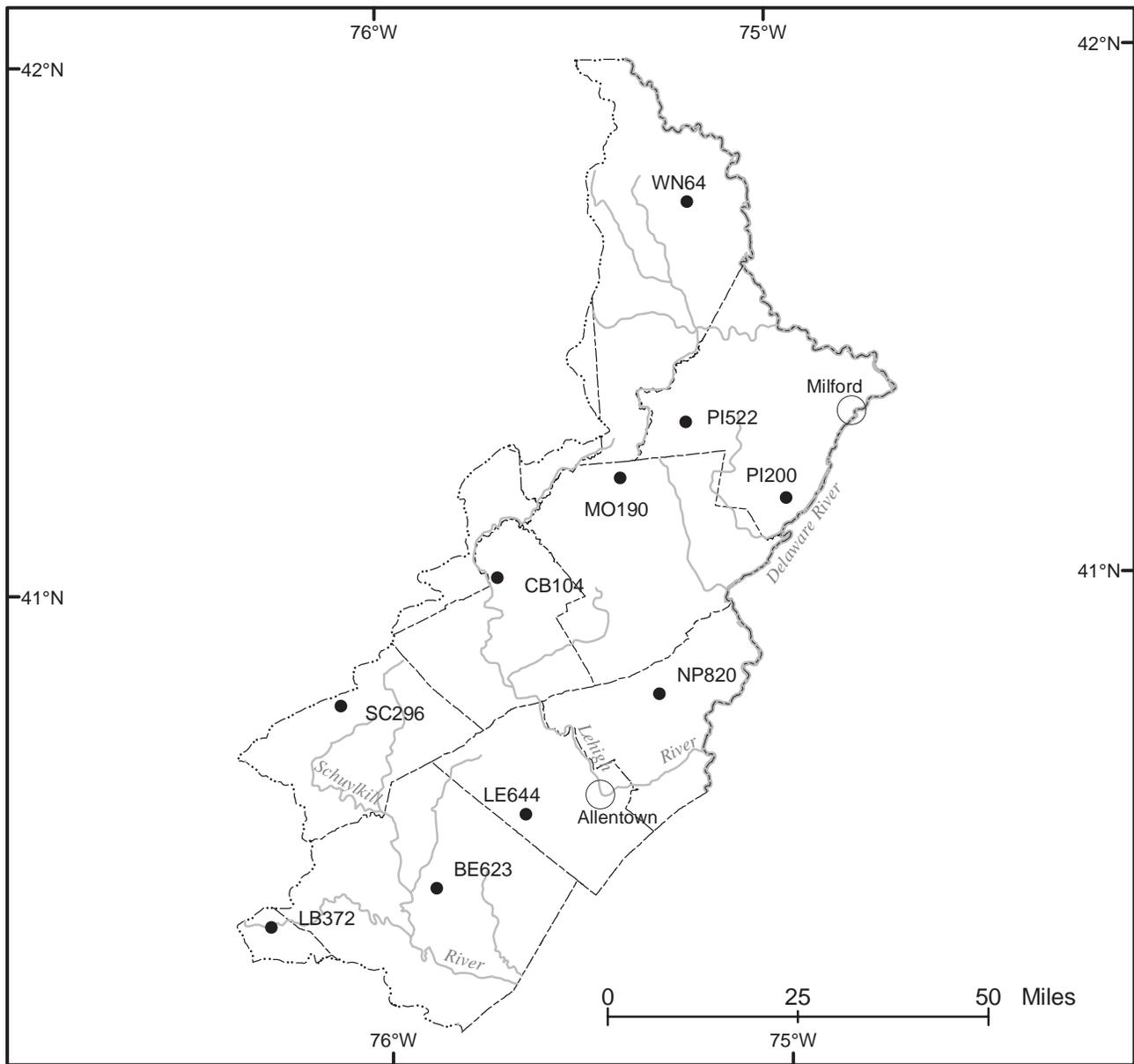
EXPLANATION



- ▲ Streamflow station
- △ Lake
- Water-quality station
- ◆ Streamflow and water-quality station

NOTE: Downstream station numbers are abbreviated; the first two digits (part number) and the last two digits (if zeros) are omitted (for example, station number 01470500 is shown as 4705, and station number 01471875 is shown as 471875).

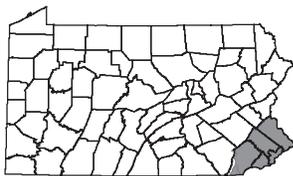
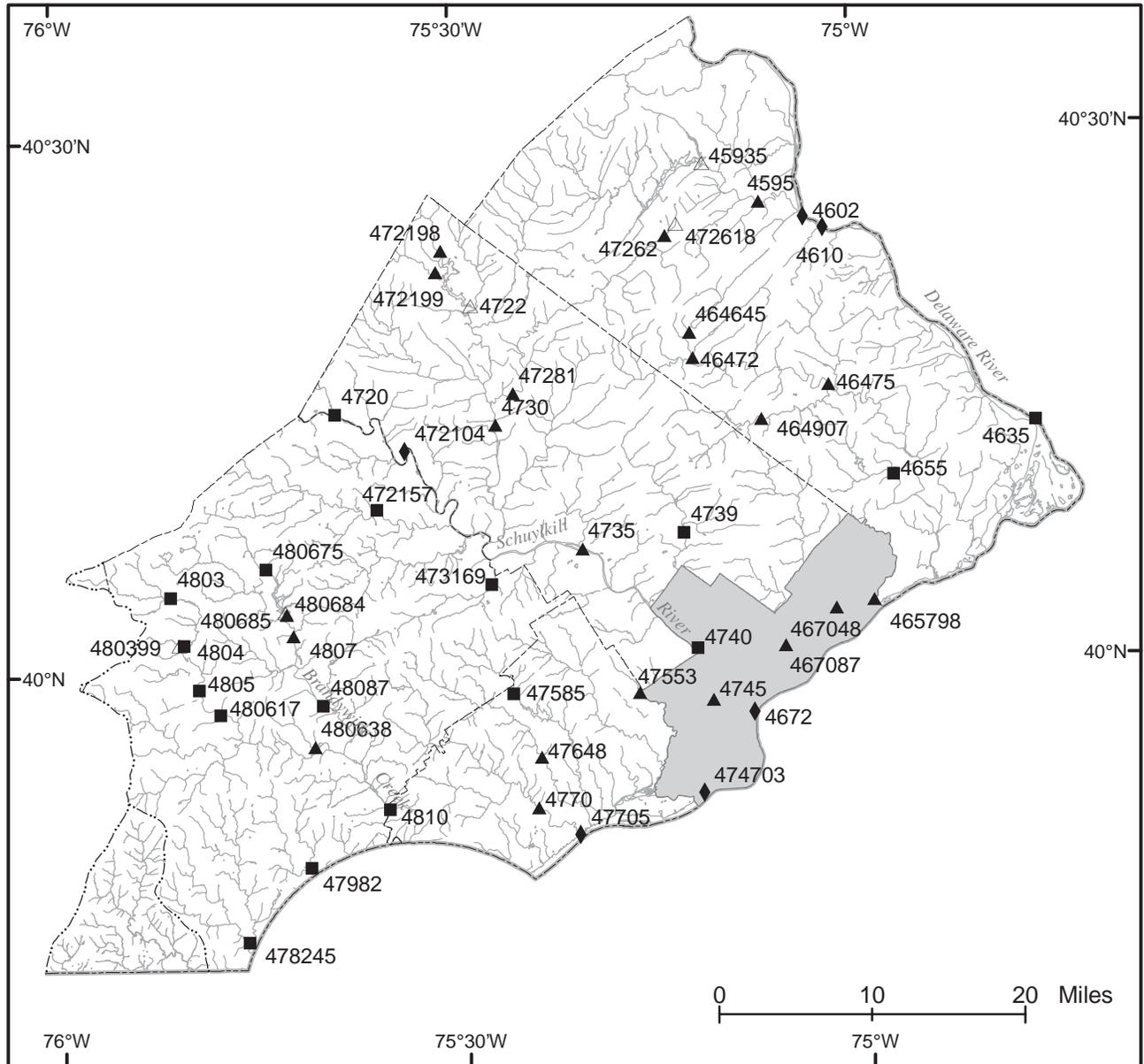
Figure 6.--Location of continuous-record data-collection stations in the upper Delaware River Basin.



EXPLANATION

- Observation well

Figure 7.--Location of continuous-record observation wells in the upper Delaware River Basin.

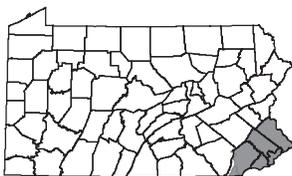
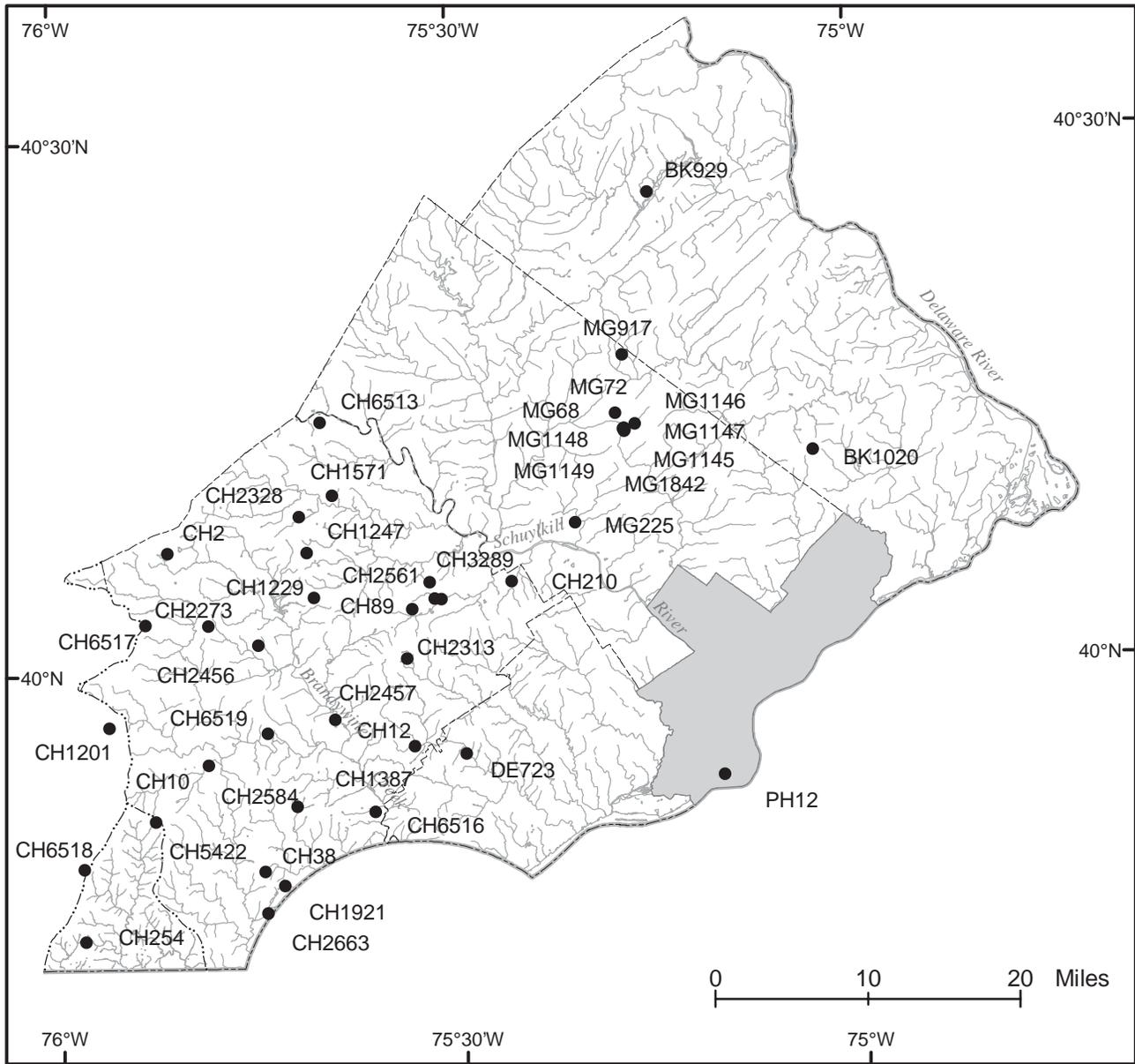


EXPLANATION

- ▲ Streamflow station
- △ Lake
- Water-quality station
- ◆ Streamflow and water-quality station

NOTE: Downstream station numbers are abbreviated; the first two digits (part number) and the last two digits (if zeros) are omitted (for example, station number 01465460 is shown as 46546).

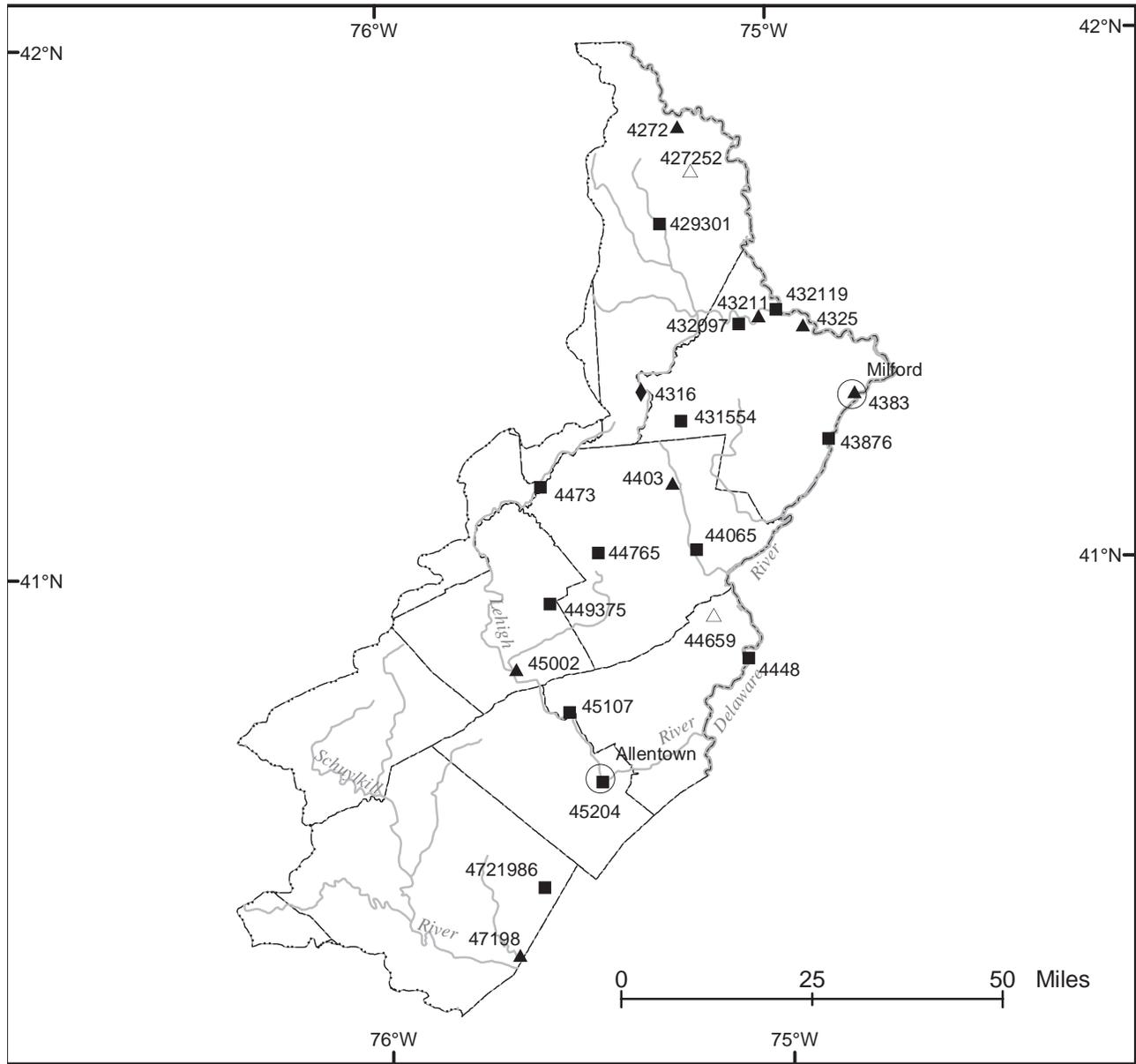
Figure 8.--Location of continuous-record data-collection stations in the lower Delaware River Basin.



EXPLANATION

- Observation well

Figure 9.--Location of continuous-record observation wells in the lower Delaware River Basin.



EXPLANATION

- ▲ Streamflow station
- △ Lake
- Water-quality station
- ◆ Streamflow and water-quality station

NOTE: Downstream station numbers are abbreviated; the first two digits (part number) and the last two digits (if zeros) are omitted (for example, station number 01438300 is shown as 4383, and station number 01451192 is shown as 451192).

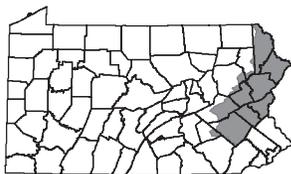
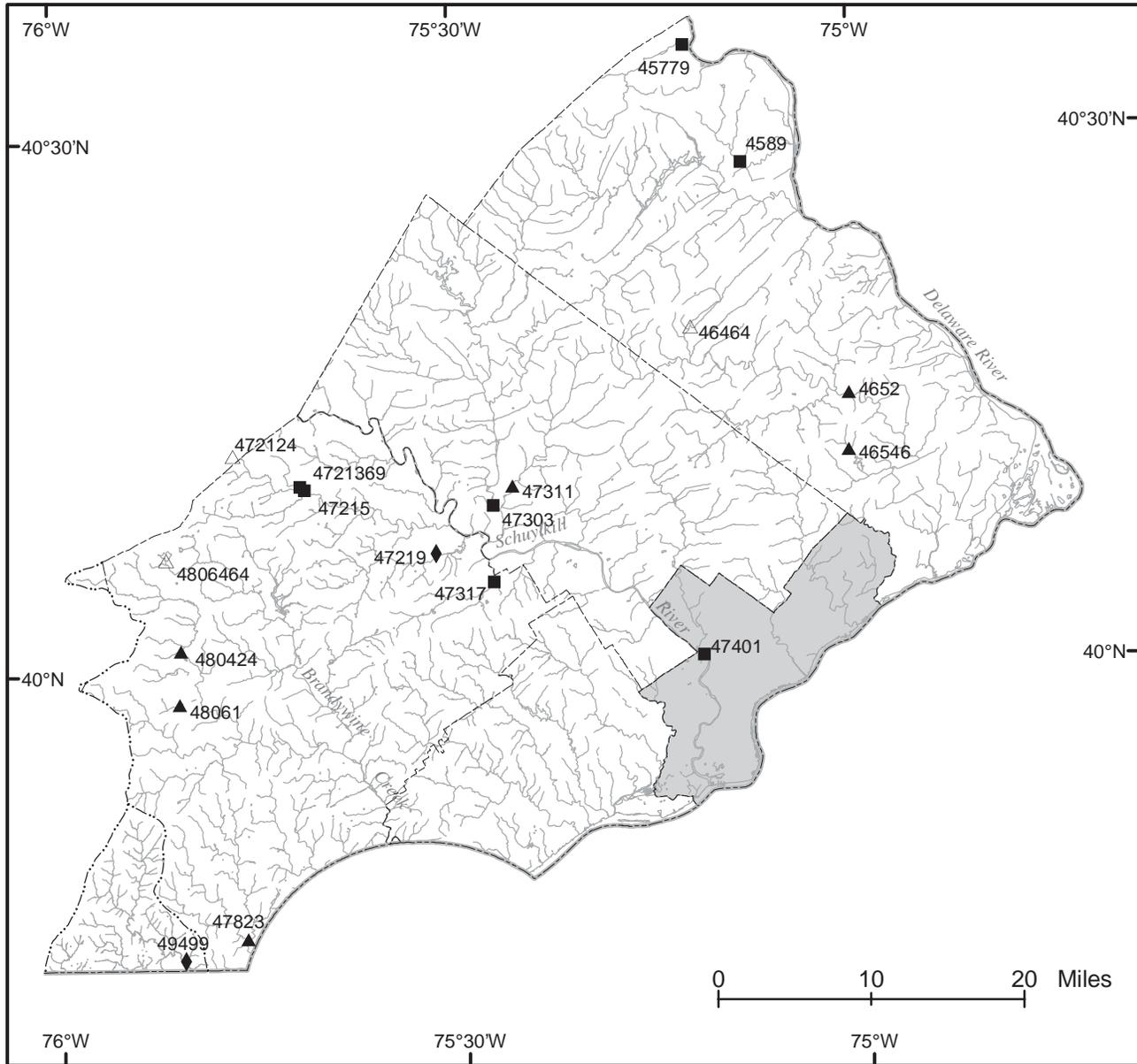


Figure 10.--Location of partial-record data-collection stations in the upper Delaware River Basin.



EXPLANATION

- ▲ Streamflow station
- △ Lake
- Water-quality station
- ◆ Streamflow and water-quality station

NOTE: Downstream station numbers are abbreviated; the first two digits (part number) and the last two digits (if zeros) are omitted (for example, station number 01465460 is shown as 46546).

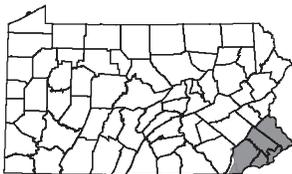


Figure 11.--Location of partial-record data-collection stations in the lower Delaware River Basin.



**SPECIAL NOTES, REMARK CODES, AND SELECTED CONSTITUENT DEFINITIONS**

\*\*\*\*\*

**NOTES**--Traditionally, dissolved trace-element concentrations have been reported at the microgram per liter( $\mu\text{G/L}$ ) level. Recent evidence, mostly from large rivers, indicates that actual dissolved-phase concentrations for a number of trace elements are within the range of 10's to 100's of nanograms per liter (ng/L). Data above the  $\mu\text{G/L}$  level should be viewed with caution. Such data may actually represent elevated environmental concentrations from natural or human causes; however, these data could reflect contamination introduced during sampling, processing, or analysis. To confidently produce dissolved trace-element data with insignificant contamination, the U.S. Geological Survey began using new trace-element protocols at some stations in water year 1994. Full implementation of the protocols took place during the 1995 water year.

--Sample handling procedures at all **National Trends Network** stations were changed substantially on January 11, 1994, in order to reduce contamination from the sample shipping container. The data for samples before and after that date are different and not directly comparable. A tabular summary of the differences based on a special intercomparison study, is available from the NADP/NTN Coordination Office, Colorado State University, Fort Collins, CO 80523 (Telephone: 303-491-5643).

--In March 1989 a bias was discovered in the turbidimetric method for sulfate analysis for those samples analyzed by the U.S. Geological Survey National Water-Quality Laboratory indicating that values below 75 mg/L have a median positive bias of 2 mg/L above the true value for the period between 1982 and 1989.

--**Methylene blue active substance (MBAS)** determinations made from January 1, 1970, through August 29, 1993, at the National Water Quality Laboratory in Denver (Analyzing Agency Code 80020) are positively biased. These data can be corrected on the basis of the following equation, if concentrations of dissolved nitrate plus nitrite, as nitrogen, and dissolved chloride, determined concurrently with the MBAS data are applied:

$$\text{MBASCOR} = \text{M} - 0.0088\text{N} - 0.00019\text{C}$$

where:

- MBASCOR = corrected MBAS concentration, in mg/L;
- M = reported MBAS concentration, in mg/L;
- N = dissolved nitrate plus nitrite, as nitrogen, in mg/L; and
- C = dissolved chloride concentration, in mg/L.

The detection limit of the new method is 0.02 mg/L, whereas the detection limit for the old method was 0.01 mg/L. A detection limit of 0.02 mg/L should be used with corrected MBAS data from January 1, 1970, through August 29, 1993.

\*\*\*\*\*

**Remark Codes**--The following remark codes may appear with the data tables in this report:

**PRINTED OUTPUT**

**REMARK**

E,e	Estimated value.
>	Actual value is known to be greater than the value shown.
<	Actual value is known to be less than the value shown.
M	Presence of material verified but not quantified.
K	Results based on colony count outside the acceptance range (non-ideal colony count).
L	Biological organism count less than 0.5 percent (organism may be observed rather than counted).
D	Biological organism count equal to or greater than 15 percent (dominant).
ND	Material specifically analyzed for but not detected.
V	Analyte was detected in both the environmental sample and the associated blanks.

\*\*\*\*\*

**EXPLANATION OF CODES USED TO DEFINE SAMPLE COLLECTION PROCEDURES (partial listing)**

**(71999) SAMPLE PURPOSE CODES:**

**(84164) SAMPLER TYPE: (partial list)**

- 10--Routine
- 15--NAWQA
- 20--NASQAN
- 30--Benchmark
- 50--GW Network

- 110--Sewage sampler
- 3011--US D-77
- 3035--DH-76 Trace metal sampler with teflon gasket and nozzle

**(82398) SAMPLE METHOD CODES:**

- 10--Equal width increment
- 20--Equal discharge increment
- 30--Single vertical
- 40--Multiple verticals
- 50--Point sample
- 70--Grab sample
- 120--Velocity integrated
- 4040--Submersible pump
- 8010--Other

- 3039--D-77 Trace metal
- 3040--D-77 Trace metal modified teflon bag sampler
- 3045--DH-81 with Teflon cap and nozzle
- 8010--Other (other than a defined sampler type)

**SPECIAL NOTES, REMARK CODES AND SELECTED CONSTITUENT DEFINITIONS--Continued****Explanation of selected abbreviations used in constituent definitions in water-quality tables:**

AC-FT	acre-feet
BOT MAT	bottom material (Unconsolidated material of which a streambed, lake, pond, reservoir, or estuary bottom is composed.)
COLS/100 ML	colonies per 100 milliliters
DIS	dissolved
FET	fixed end-point titration
FLD	field (Measurement determined at field site.)
F/S	feet per second
G/M	gallons per minute
G/SQM; MG/M2	grams or milligrams per square meter
IT	incremental titration
KF AGAR	nutrient medium for growth of fecal streptococcal bacteria
µG/L	micrograms per liter
µS/CM	microsiemens per centimeter
MG/L	milligrams per liter
MG/M2	milligrams per square meter
MM OF HG	millimeters of mercury
NONCARB	noncarbonate
NTU	nephelometric turbidity unit
PCI/L	picocuries per liter
REC	recoverable
TOT	total
T/DAY	tons per day
WH IT	whole water, incremental titration (Alkalinity, bicarbonate, and carbonate as determined by incremental titration of unfiltered water at the field site.)
2 SIGMA	Counting statistic that represents error in the reported radon, uranium, or tritium value caused by variations in sample counting, background radiation, volume of sample, and decay since sample was collected.
0.7µ GF	0.7 micron glass-fiber filter (Water filtered through a glass-fiber membrane filter with openings that are 0.7 microns in size.)

\*\*\*\*\*

**(00027) AGENCY COLLECTING SAMPLE CODES: (partial listing)**

1028 --U.S. Geological Survey

**(00028) AGENCY ANALYZING SAMPLE CODES: (partial listing)**

1028 --U.S. Geological Survey  
80020 --U.S. Geological Survey, National Water-Quality Laboratory, Denver, Colorado  
9813 --Pennsylvania Department of Environmental Protection  
83613 --USGS Water Science Center, Water-Quality Laboratory, Troy, New York

**MEDIUM CODES: (partial listing)**

9-- Surface water.  
6-- Ground water.  
R-- Quality-control sample. Surface water.  
S-- Quality-control sample. Ground water.  
Q-- Quality-control sample. Artificial.