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Data Compilation and Assessment for Water Resources in Pennsylvania State Forest and Park Lands

Data Series 327

U.S. Department of the Interior
U.S. Geological Survey

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Conversion Factors and Datums

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
	Area	
square mile (mi^2)	259.0	hectare (ha)
	Volume	
gallon (gal)	3.785	liter (L)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8×°C)+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8$$

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

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

Data Compilation and Assessment for Water Resources in Pennsylvania State Forest and Park Lands

By Daniel G. Galeone

Abstract

As a result of a cooperative study between the U.S. Geological Survey and the Pennsylvania Department of Conservation and Natural Resources (PaDCNR), available electronic data were compiled for Pennsylvania state lands (state forests and parks) to allow PaDCNR to initially determine if data exist to make an objective evaluation of water resources for specific basins. The data compiled included water-quantity and water-quality data and sample locations for benthic macroinvertebrates within state-owned lands (including a 100-meter buffer around each land parcel) in Pennsylvania. In addition, internet links or contacts for geographic information system coverages pertinent to water-resources studies also were compiled. Water-quantity and water-quality data primarily available through January 2007 were compiled and summarized for site types that included streams, lakes, ground-water wells, springs, and precipitation. Data were categorized relative to 35 watershed boundaries defined by the Pennsylvania Department of Environmental Protection for resource-management purposes.

The primary sources of continuous water-quantity data for Pennsylvania state lands were the U.S. Geological Survey (USGS) and the National Weather Service (NWS). The USGS has streamflow data for 93 surface-water sites located in state lands; 38 of these sites have continuous-recording data available. As of January 2007, 22 of these 38 streamflow-gaging stations were active; the majority of active gaging stations have over 40 years of continuous record. The USGS database also contains continuous ground-water elevation data for 32 wells in Pennsylvania state lands, 18 of which were active as of January 2007. Sixty-eight active precipitation stations (primarily from the NWS network) are located in state lands.

The four sources of available water-quality data for Pennsylvania state lands were the USGS, U.S. Environmental Protection Agency, Pennsylvania Department of Environmental Protection (PaDEP), and the Susquehanna River Basin Commission. The water-quality data, which were primarily collected after 1970, were summarized by categorizing the analytical data for each site into major groups (for example, trace metals, pesticides, major ions, etc.) for each type (streams, lakes, ground-water wells, and springs) of data compiled. The number of samples and number of detections for each analyte within each group also were summarized. A total of 410 stream sites and 205 ground-water wells in state lands had water-quality data from the available data sets, and these sites were well-distributed across the state. A total of 107 lakes and 47 springs in state lands had water-quality data from the available data sets, but these data types were not well-distributed across the state; the majority of water-quality data for lakes was in the western or eastern sections of the state and water-quality data for springs was primarily located in the central part of the Lower Susquehanna River Valley. The most common types of water-quality data collected were major ions, trace elements, and nutrients. Physical parameters, such as water temperature, stream discharge, or water level, typically were collected for most water-quality samples.

Given the large database available from PaDEP for benthic macroinvertebrates, along with some data from other agencies, there is very good distribution of benthic-macroinvertebrate data for state lands. Benthic macroinvertebrate samples were collected at 1,077 locations in state lands from 1973 to 2006. Most (980 samples) of the benthic-macroinvertebrate samples were collected by PaDEP as part of the state assessment of stream conditions required by the Clean Water Act.

Data compiled in this report can be used for various water-resource issues, such as basin-wide water-budget analysis, studies of ecological or instream flow, or water-quality assessments. The determination of an annual water budget in selected basins is best supported by the available data. Much different and more extensive data are required for an ecological-flow study or water-quality assessment. The compilation and summary of data in this report allow for a quick initial determination of available data and whether more data may be required for the particular task at hand within a specific basin. Methods of data estimation for basins that are lacking certain types of water-quantity data also are presented. Data estimation is of primary importance for streamflow data in ungaged basins.

Introduction

The management of water resources within or near state forests and parks is an important issue for the Bureaus of Forestry and State Parks within the Pennsylvania Department of Conservation and Natural Resources (PaDCNR). Data on water quantity and water quality and instream biological data are needed to assist these bureaus in making informed water-resource-management decisions. Because of increasing demands for potable water in many areas near state forest (fig. 1) and park (fig. 2) lands, PaDCNR needs to assess the availability of water resources and the quality of water within Pennsylvania state forest and park lands. Developing a water budget is typically a first step in determining whether a sufficient supply of water is available in a specific basin. Water quality tied to the water budget helps to determine if the available water is adequate for the designated uses, such as recreation or consumption. Benthic-macroinvertebrate data can also be a very useful tool in assessing water resources, and this is one tool currently used by the Pennsylvania Department of Environmental Protection (PaDEP) to assess the quality of waters across the state.

The quantity and quality of available water are important; however, maintaining instream flow to support or enhance existing aquatic communities is equally important. Presently, information regarding instream-flow needs or ecological flows is not available for many areas of Pennsylvania state forest and park holdings. A growing need of many regulatory and conservation agencies within Pennsylvania is the establishment of ecological flows. Ecological flows or instream-flow needs are the amount of surface water in streams needed to support aquatic communities. The Susquehanna River Basin Commission (SRBC) has developed a Pennsylvania Instream Flow Incremental Method (IFIM) model that can be applied to cold-water fisheries of less than 100 mi^2 with reproducing trout populations (Denslinger and others, 1998). This method can only be applied to specific areas (Ridge and Valley Limestone and Freestone, Unglaciated Plateau, and Piedmont Upland) of the state. At this time, no other models or methodologies have been developed to address ecological-flow requirements in other parts of the state or for other species except brook trout. Currently, PaDEP as part of the State Water Plan Update 2008 has established the 7-day 10-year low flow (Q7,10) streamflow statistic as an initial criteria or surrogate for instream-flow needs to identify potential conflict areas between water usage and aquatic communities across the entire state except for areas where the SRBC IFIM model applies (Pennsylvania Department of Environmental Protection, 2006). The Q7,10 is defined as the discharge at the 10-year recurrence interval taken from a frequency curve of annual values of the lowest mean discharge for 7 consecutive days (U.S. Geological Survey, 2007). The establishment of a single streamflow statistic is antiquated and more appropriate criteria are currently being developed (such as the work done by Denslinger and others (1998)). However, at this time, it is not known what methodology will be established to assess ecological flows for the state of Pennsylvania. Therefore, the compilation of all possible electronic data on water quantity and quality is prudent at this time until methods are established.

The U.S. Geological Survey (USGS) in cooperation with the PaDCNR Bureau of Topographic and Geologic Survey (PaTGS) performed a data-needs compilation to identify critical and supporting data that will allow an objective evaluation of water resources for basins within state forest and park land holdings. For water quantity, the compilation determined the availability and adequacy of meteorological, hydrologic, and geographic data needed to provide the results of an annual mass-balance basin water budget. An annual basin-wide water budget describes inputs to the basin (precipitation and imported water), outputs of water from the basin (streamflow, exported water, leakage, consumed water, and evapotranspiration), and changes in ground-water and surface-water storage (Sloto and Buxton, 2005). Water-quality data are also compiled from available electronic sources to characterize the water quality of streams, lakes, ground-water wells, and springs in state forest and park lands. Benthic-macroinvertebrate sample locations also were compiled from available electronic sources to provide a spatial representation of the data available.

Purpose and Scope

This report compiles, summarizes, and presents electronically available (from state and federal agencies) water-quantity and water-quality data and sample locations for benthic macroinvertebrates for state forest and park lands (including 100-meter buffers around each land parcel) in Pennsylvania and provides internet links to geographic information system coverages pertinent for water-resources studies. All available water-quantity data through January 2007 were compiled and summarized for stream, ground-water well, and precipitation stations in or adjacent to state lands so that overlapping time periods for different types of data could be determined. The adequacy of a stream-gaging station in representing the state land where the station was located was also determined by reviewing drainage area boundaries and land use. All available water-quality data primarily collected through January 2007 were compiled and summarized for streams, lakes, ground-water wells, and springs in or adjacent to state lands. Water-quality data were available from four different agencies and data were grouped by the type of water-quality analyses (examples include trace elements, major ions, and nutrients). The number of samples and number of detections for each analyte within each group also were summarized in appendixes that were compiled for each agency and data type (streams, lakes, ground-water wells, and springs). The adequacy in the distribution of water-quantity and water-quality data in state lands across the state was summarized in tables according to the 35 water-resource management watersheds defined by PaDEP.

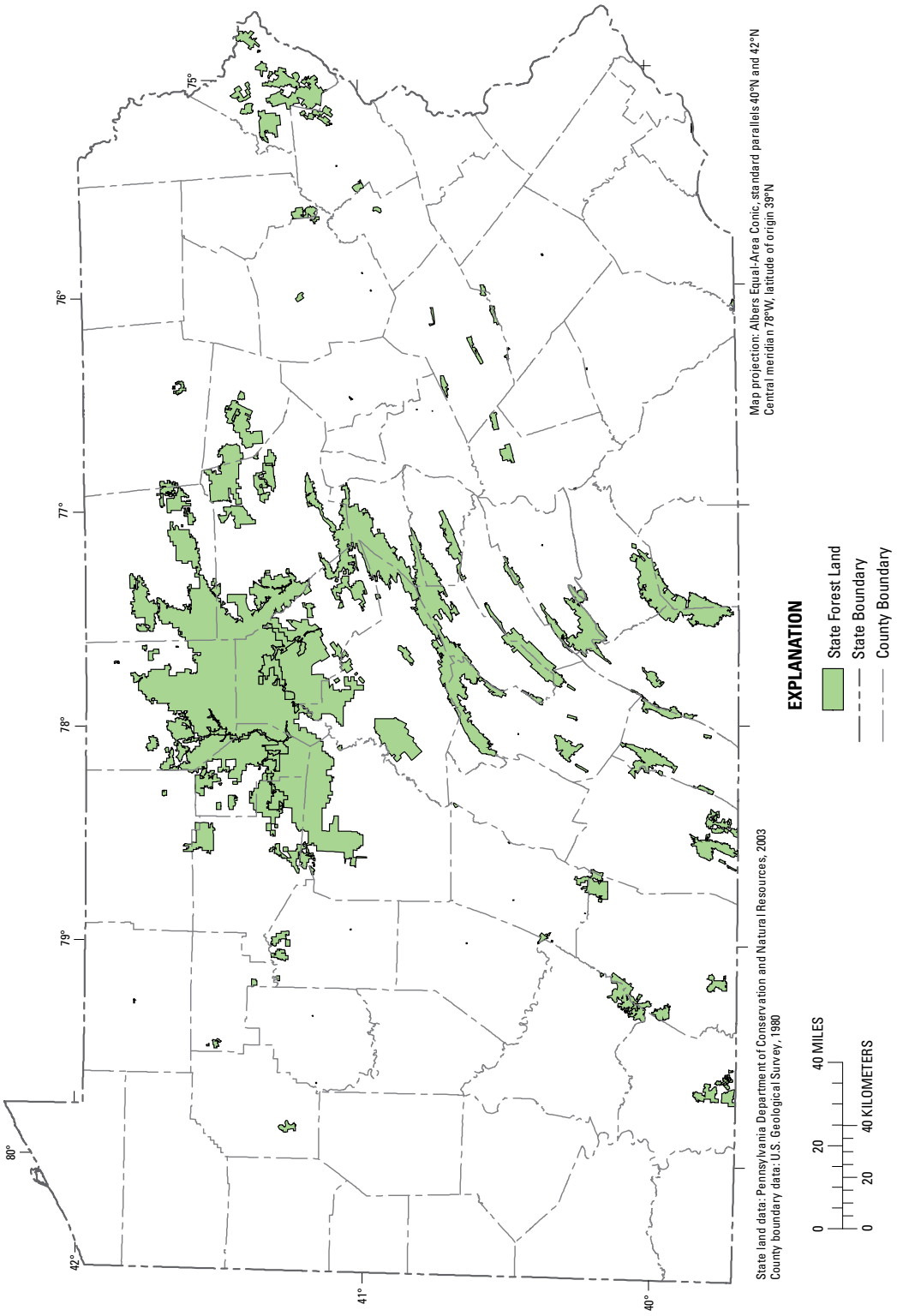

Figure 1. Location of state forest lands (100-meter buffers included) in Pennsylvania.

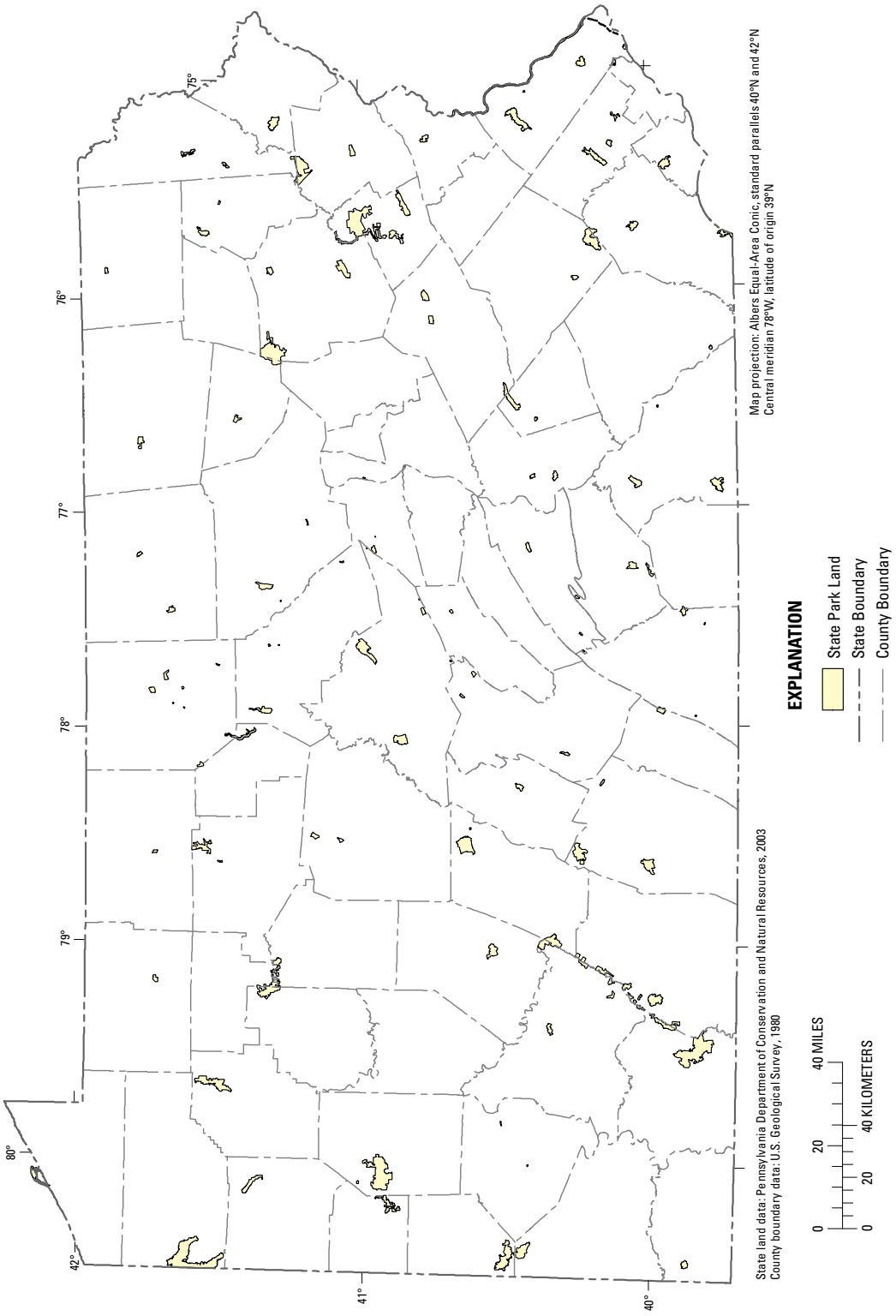

Figure 2. Location of state park lands (100-meter buffers included) in Pennsylvania.

Water Resources

The general equation for an annual mass-balance basin water budget (Sloto and Buxton, 2005) is:

Precipitation + Imported water = Streamflow + (Change in ground-water or soil-water storage) + Ground-water leakage + (Surface- and ground-water export) + Consumptive use + Evapotranspiration (ET) (1)

On the basis of the above equation, the variables necessary to develop water budgets for specific drainage basins include streamflow, precipitation, human population, consumptive uses in the basin (such as water for animals, crop irrigation), water imported into the basin, and ground-water storage. For an annual mass-balance basin water budget, the equation typically is solved for evapotranspiration (ET); therefore, ET does not have to be estimated. Also, the change in soil-water storage is usually set to zero because the annual budgets start and end at the same time of year, and the change is assumed to be zero.

Estimates for human populations can be acquired from the U.S. Census Bureau. These numbers can then be converted to a consumptive use per person. Currently, PaDEP assumes one person consumes 80 gal per person per day (David Sayers, Delaware River Basin Commission, written commun., 2007). PaDEP also provides estimates for consumptive uses for industrial and commercial settings. PaDEP also maintains a water-use database for the entire state that would provide information on imports and exports of water out of the basin.

Precipitation stations within the study basin are not critical in developing a water budget given the present-day availability of estimated amounts of precipitation derived from radar; however, the cost of processing radar-derived estimates or interpolating precipitation from stations outside of the basin can be a problem. Changes in ground-water storage can be estimated on the basis of changes in ground-water elevations (water levels in wells). Documenting changes in ground-water levels to estimate changes in ground-water storage terms can be very site specific. It may be very difficult to estimate changes in ground-water storage without monitoring wells within the study basin in question. Unless a detailed study is conducted, it is assumed that ground-water leakage is zero.

Streamflow data are difficult to estimate without a stream-gaging station in a specific basin, so identifying locations of continuous-recording stream-gaging stations in any particular drainage basin is one of the first steps in any water-budget study. Techniques that will be discussed later can be used to generate hydrographs for ungaged streams using reference (index) stations in other basins. The streamflow component of the mass-balance equation can be separated into base-flow and surface-runoff components using a hydrograph separation model such as HYSEP (Sloto and Crouse, 1996). Hydrograph separation allows for an estimate of the ground-water contribution to streamflow and also can be used for estimating recharge rates of precipitation into the ground-water system (Sloto and Crouse, 1996).

Ecological instream-flow requirements are a new concept based on determining how hydrologic alteration affects ecological assemblages that exist in the stream system. Hydrologic alteration takes place when the magnitude, frequency, and within-year variability of streamflow are affected (Kiesling, 2003). Changes in streamflow variability are determined using a series of hydrologic attributes, such as the frequency and duration of high- and low-flow pulses or medians of monthly water conditions (Kiesling, 2003). (See Kiesling (2003) for other factors.) In general, instream-flow analysis requires statistical compilations of continuous-record and partial-record hydrologic data in gaged basins, surface-runoff modeling to simulate the unavailable hydrologic data in ungaged basins, meteorological data, and selected basin-characteristic data.

An ecological-flow model to assess instream-flow requirements was developed by SRBC for native brook trout streams in noncarbonate terrain in Pennsylvania (Denslinger and others, 1998). Because the method only applies to streams draining less than 100 mi^2 with reproducing trout populations, the SRBC model can only be applied to a limited percentage of the streams in state forest and park lands. The hydrologic statistical parameters used to characterize different study stream reaches for this method include (1) median monthly flows (e.g., the median flow for a selected period only for the month of January); (2) annual mean and median flows; (3) annual and seasonal flow duration; and (4) a time series of median monthly flows (e.g., the median flow for each month in a selected year) (Denslinger and others, 1998). These types of parameters are also discussed as part of the **l**imits **o**f **h**ydrologic **a**lteration (LOHA) approach presented by the Nature Conservancy (The Nature Conservancy, written commun., 2007). In this approach, to apply regional results to an ungaged stream, gaged data were used in ungaged areas if the gaged and ungaged basins were underlain by similar geology. The evaluation species for this method was brook trout, and this method can not be transferred to other species. For each stream of concern, the species of most importance is selected and its instream-flow needs are determined. For each species of any one system, the instream-flow needs could be quite different, so target species help to clarify or focus the effort. Also, even for one species, the different life stages may dictate different flow requirements. For the SRBC method, they noted that redd (gravel deposit in stream where fish lay eggs) development in one part of year, or fry, may have different flow requirements than adults.

Other work is being done to develop methodology for determining instream-flow requirements for the entire state of Pennsylvania. The current impetus to establish statewide instream-flow requirements stems from the use of Q7,10 in order to establish some sort of flow protection level for instream biota (Denslinger and others, 1998). The problem with using a long-term statistic like Q7,10 is that it does not address the temporary effects of withdrawals on stream habitat

and, subsequently, stream biota. The basis of work by Kennen (Jonathan Kennen, U.S. Geological Survey, written commun., 2005) requires continuous-record streamflow data to compute many of the important variables relative to instream-flow requirements. Kennen notes that two of the most important hydrologic variables affecting stream biota are the number of storms producing runoff and the flashiness of the stream (as determined by the ratio of 25-percent to 75-percent exceedance flows).

Methods for estimating streamflow for ungaged basins are necessary because most stream reaches are not gaged. Hydrographs for streams in ungaged basins can be estimated from gaged basins if minimum data requirements are met. Those requirements include geology, topography, slope, land cover, and a daily time series of precipitation. One accepted approach to translate gaged data to an ungaged basin is the QPPQ method, which takes a streamflow (Q) record from a gaged basin, outputs a frequency duration curve (P) for that station, translates that to a frequency duration curve (P) for the ungaged basin, then outputs a streamflow (Q) for the ungaged basin (Waldron and Archfield, 2006).

Approaches to assess instream-flow requirements for future scenarios in a basin are more difficult to determine if ground-water withdrawals are an integral part of the consumptive water use in a basin. In this case, methods that combine the surface-water and ground-water components of a basin may be required to get an adequate idea of water quantity in a basin. For basins such as this, conceptual models that integrate ground-water and surface-water interactions are implemented, and one such model is a ground-water/surface-water flow (GSFLOW) model. GSFLOW is a model developed by the USGS that couples the Precipitation Runoff Modeling System (PRMS) with the Modular Ground-Water Flow Model (MODFLOW). The coupling is made via a new soil-moisture zone module in PRMS and a new unsaturated-zone flow package in MODFLOW. GSFLOW simulates spatial- and time-varying recharge on the basis of daily energy and mass balances among precipitation, solar radiation, heat, evapotranspiration, runoff, infiltration, and storage in the snowpack and soil zone, and percolation and storage through the unsaturated zone (Stephen Markstrom, U.S. Geological Survey, written commun., 2007).

Any compilation of data for a watershed should include a water-quality component because the potability of the water supply dictates the potential use of water in the basin, the potential for exporting water out of the basin as a drinking-water supply, and the adequacy of the chemical composition of the water for stream biota. Presently, methods developed by Denslinger and others (1998) to assess ecological flows do not incorporate water-quality data; however, future methods developed for ecological assessments may include a water-quality component because adequate flow regimes do not necessarily indicate adequate conditions for biota if contaminants in the stream cause stress and subsequent population declines.

Across the state of Pennsylvania, rivers and streams are assessed by PaDEP to determine if a water body is meeting a particular stream designation. PaDEP determines if a stream segment should be included on an impaired stream list (303(d) list) on the basis of the benthic-macroinvertebrate communities identified within that particular stream segment. The criteria for impairment vary depending on the physiographic setting (for example, limestone streams have different criteria than sandstone streams). Benthic-macroinvertebrate data and the biological indices derived from the communities are a useful tool in determining stream health. However, these communities are dynamic and can easily be changed as a result of flood events, major droughts, mining activity, timber harvest (and subsequent sediment loading to streams), and land development; therefore, benthic-macroinvertebrate data can be used to get a general sense of the stream health at some point in the past.

Data Compilation

The compilation of data for state lands included a compilation of all existing electronic water-quantity, water-quality, and benthic-macroinvertebrate data from various sources: the USGS, PaDEP, U.S. Environmental Protection Agency (USEPA), NWS, SRBC, and the Pennsylvania Fish and Boat Commission (PaFBC). Using a geographic information system (GIS), point coverages of site locations from the different data sources were overlayed on state forest and park polygon coverages. A 100-m buffer encompassed each state park or forest polygon, and any sites that were within the state forest or park lands or within the 100-m buffered locations were identified. For this report, if a site is said to be within a state forest or park, the site is either inside the forest or park or within the 100-m buffer around that particular forest and (or) park. For brevity, forest or park land and the associated 100-meter buffer will hereafter be referred to as state lands. The sites also were categorized relative to watershed boundaries (defined as PABASIDs hereafter) used by PaDEP for resource management (see fig. 3 for watershed boundaries and table 1 for watershed names). The total amount of state land within each PABASID was determined so that the number of sites per unit area of state land could be determined for each PABASID.

Water Quantity

Readily available water-quantity data for Pennsylvania state lands were available from three sources: USGS, NWS, and the Pennsylvania Emergency Management Agency (PEMA). The USGS has a National Water Information System (NWIS) that stores all data collected by the Water Resources Discipline offices of the USGS. NWIS contains information for all active and discontinued sites that have been inventoried by the USGS. Any site inventoried can have water-quantity and (or) water-quality data associated with it, and, if so, these data can be retrieved from NWIS. Water-quantity data are available from the USGS for surface-water, ground-water,

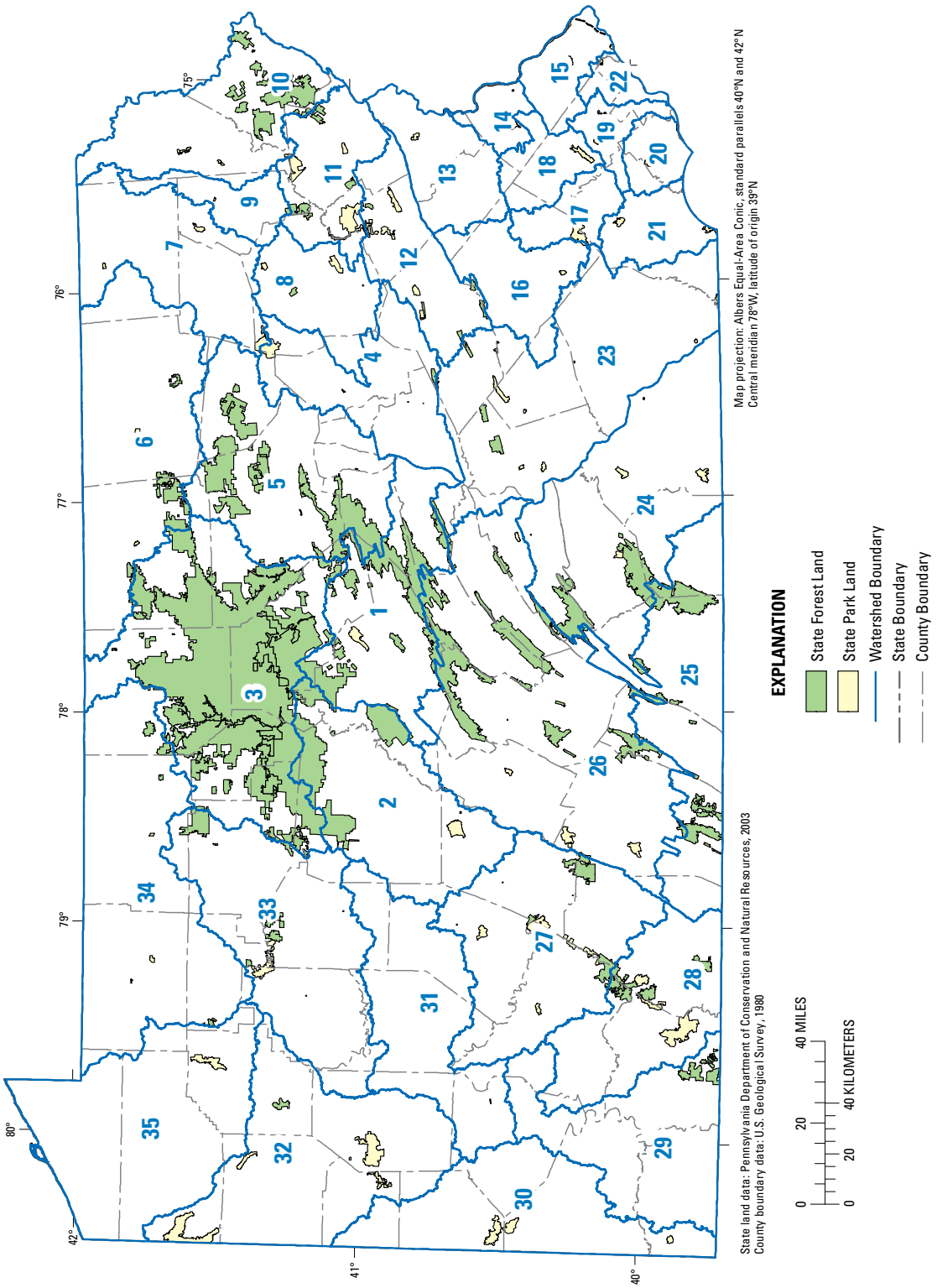

Figure 3. Boundaries of the 35 resource-management watersheds used by the Pennsylvania Department of Environmental Protection.

Table 1. The 35 resource-management watersheds used by the Pennsylvania Department of Environmental Protection.

{mi², square miles]

Basin identification number	Basin name	Major drainage basin	State lands	
			Forest (mi²)	Park (mi²)
1	Central Penn	Susquehanna River Basin	257	9.91
2	Upper West Branch	Susquehanna River Basin	250	16.4
3	Susquehannock/Genessee	Susquehanna River Basin	1,540	15.9
4	Lower North Branch Susquehanna	Susquehanna River Basin	3.13	12.1
5	Big Bend	Susquehanna River Basin	322	2.43
6	Bradford/Tioga	Susquehanna River Basin	54.3	2.69
7	Upper Susquehanna	Susquehanna River Basin	0	10.7
8	Wyoming Valley	Susquehanna River Basin	1.97	7.12
9	Lackawanna	Susquehanna River Basin	1.78	.22
10	Upper Delaware	Delaware River Basin	121	7.37
11	Brodhead/Toby/Tunk	Delaware River Basin	20.0	37.7
12	Upper Schuylkill/Middle Lehigh	Delaware River Basin	9.60	16.3
13	Lower Lehigh	Delaware River Basin	0	1.65
14	Delaware River/Tohickon Creek	Delaware River Basin	0	12.0
15	Delaware Common Tributaries/Neshaminy	Delaware River Basin	0	7.93
16	Middle Schuylkill	Delaware River Basin	.11	1.91
17	French/Manatawny	Delaware River Basin	0	9.79
18	Perkiomen Creek	Delaware River Basin	0	5.17
19	Lower Schuylkill (Wissahickon Creek)	Delaware River Basin	0	1.75
20	Ridley/Darby/Chester/Crum Creeks	Delaware River Basin	.15	4.08
21	Christina /Elk/North East /Brandywine	Delaware River Basin	0	4.64
22	Pennypack/Tacony	Delaware River Basin	0	.47
23	Lower Susquehanna East	Delaware River Basin	24.6	8.05
24	Lower Susquehanna West	Potomac River Basin	131	12.2
25	Potomac	Potomac River Basin	136	1.94
26	Juniata	Susquehanna River Basin	315	20.6
27	Kiski-Conemaugh	Ohio River Basin	43.4	23.5
28	Youghioheny	Ohio River Basin	40.8	44.1
29	Monongahela	Ohio River Basin	25.0	.04
30	Ohio	Ohio River Basin	0	20.2
31	Allegheny	Ohio River Basin	0	.05
32	Moraine	Ohio River Basin	4.98	66.8
33	Middle Allegheny	Ohio River Basin	46.8	19.0
34	Upper Allegheny	Ohio River Basin	17.8	1.72
35	Lake Erie/French & Oil Creek	Ohio River Basin	.03	13.2

and precipitation sites. Location and names of active NWS precipitation stations were obtained in a GIS data layer from the NWS. The GIS coverage acquired from NWS also contained site information for a network of precipitation stations maintained cooperatively between NWS and PEMA. PEMA maintains these cooperative sites across the state as part of a flash-flood warning system known as the Integrated Flood Observing and Warning System (IFLOWS).

Site locations and data for all water-quantity sites were summarized by PABASID so that each available data source and available data with overlapping collection periods could be easily identified. Continuous-recording stream-gaging stations in state lands that were available from USGS NWIS were analyzed to determine how representative the station was for the state lands in which it was located. This was done by first determining how much of the station drainage area (DA) was within state lands and further analysis was done to determine land use in the station DA relative to state lands in that same DA.

Streamflow

Existing data that quantifies streamflow were mostly available from the USGS NWIS database. This includes streamflow data collected either continuously at a set recording interval, typically 15 minutes (these sites will hereafter be referred to as "continuous" sites for any type of data collected), or streamflow that was measured using standard measurement techniques but only at discrete points in time (these sites will hereafter be referred to as "partial" sites) for sites in state lands. Any continuous and partial streamflow sites that were within the USGS NWIS database as of January 10, 2007, were retrieved. The data were then grouped depending on whether or not the site was active; date ranges for available data were then determined, and, if the site was not continuous, the number of streamflow measurements conducted at the site was determined.

Ground Water

Ground-water-level data were available only from the USGS NWIS database. All active (as of Jan. 10, 2007) and discontinued continuous ground-water sites in state lands were retrieved from the NWIS database. For any ground-water sites in state lands, the time range of available data was retrieved from NWIS. For most ground-water wells in NWIS, physical characteristics typically include topographic setting, well depth, casing length, depth to bedrock, depth of water-bearing zones, water level, and driller-reported yield. Because some wells can have as many as 300-400 characteristics associated with them, a table of all the physical characteristics for each well is not included in this report. These data are available in USGS NWIS.

Precipitation

Locations of continuous precipitation stations in state lands were retrieved from the NWS and the USGS. The GIS data received from NWS included site information for four different station types (including the IFLOWS network maintained cooperatively by PEMA). The three types of stations that are accessible on a real-time basis are Geostationary Operational Environmental Satellites (GOES), Limited Automated Remote Center (LARC), and IFLOWS. The fourth precipitation station type is from the NWS cooperative program (COOP sites). Data from COOP sites are not available real time, but at some time after the observers have entered their data. Only daily precipitation values are available from the COOP sites. Data from GOES and LARC sites are available from the date that the site was established. Data from IFLOWS sites in Pennsylvania, accessible at *http://www.afws.net/states/pa/pa.htm*, are only available since 2004 from the web site, but additional data can be retrieved by contacting PEMA. All USGS precipitation stations are GOES stations that are all available on a real-time basis. Real-time data from precipitation stations are the most common form of precipitation data used to develop annual water budgets and for simple modeling approaches.

Water Quality

Water-quality data were available from USGS, SRBC, PaDEP, and USEPA. Some sites were included in more than one database. All water-quality constituents associated with the sites were retrieved and categorized according to the type of analysis (table 2). Examples of some types of data are major ions (such as calcium, magnesium, potassium), nutrients, trace elements (such as arsenic, lead, selenium), bedload and suspended sediment for streams, and alkalinity/acidity parameters. Also, some data sources included data on concentrations of certain constituents in fish tissue, and these data were retrieved for both streams and lakes. Water-quality data from USGS were retrieved from the USGS NWIS system. Most water-quality data retrieved from USGS and SRBC were collected by those agencies. Data retrieved from PaDEP could have been collected by PaDEP but also could have been collected by USGS, SRBC, or the Delaware River Basin Commission (DRBC). PaDEP maintains an internal electronic database for all data collected as part of their water-quality network (WQN). Sites in the WQN are either streams or lakes. PaDEP also had other internal electronic databases where ground-water-quality data were stored. The ground-water-quality databases available from PaDEP were from the north-central and south-central regional PaDEP offices. PaDEP also maintains a ground-water-quality database for the Pennsylvania Drinking Water System (PADWIS). Two databases were retrieved from USEPA, Legacy STORET (LEGACY) and Modernized STORET (MODERN). Data within the USEPA STORET system were primarily collected by other agencies

Table 2. Groupings used for the summarization of water-quality data.

Group abbreviation	Description	Selected examples
acid/alk	Acidity (pH) and alkalinity constituents	
bed-sed	Bed sediments	
bio	Biological constituents	Biological oxygen demand, chlorophyll *a*
bsed-bio	Bed sediments and associated biological constituents	
bsed-hrb	Bed sediments and associated herbicides	
bsed-ins	Bed sediments and associated insecticides	
bsed-mjr	Bed sediments and associated major ions	
bsed-nuts	Bed sediments and associated nutrients	
bsed-rare	Bed sediments and associated rare earth elements	
bsed-trc	Bed sediments and associated trace elements	
bsed-voc	Bed sediments and associated volatile organic compounds	
bsed-wst	Bed sediments and associated waste compounds	
fish	Fish-tissue concentrations	
fungi	Fungicides	Carboxin, dichlorprop
herb	Herbicides	Atrazine, metolachlor
insect	Insecticides	Endosulfan, chlordane
ionic	Ionic strength constituents	Specific conductance, total dissolved solids
major	Major ions	Calcium, sulfate
micro	Microbiological constituents	Fecal streptococci, total coliform
nuts	Nutrients	Nitrate, phosphorus
phys	Physical constituents	Temperature, streamflow
rads	Radiological constituents	Radon-222, potassium-40
rare	Rare earth elements	Cerium, erbium
susp-sed	Suspended sediment	
ssed-bio	Suspended sediments and associated biological constituents	
ssed-ins	Suspended sediments and associated insecticides	
ssed-mjr	Suspended sediments and associated major ions	
ssed-nuts	Suspended sediments and associated nutrients	
ssed-trc	Suspended sediments and associated trace elements	
ssed-voc	Suspended sediments and associated volatile organic compounds	
ssed-wst	Suspended sediments and associated waste compounds	
trace	Trace constituents	Arsenic, lead
voc	Volatile organic compounds	Benzene, toluene

such as USGS, PaDEP, SRBC, and DRBC. Any data collected by DRBC were only available electronically through retrieval of USEPA STORET or PaDEP data.

Primarily, only water-quality data collected after 1970 were incorporated into this summary report because of changes in analytical methods. The only water-quality database from which data prior to 1970 were retrieved was the LEGACY database from USEPA. For the USEPA LEGACY database, there were so few samples for any one site that samples collected prior to 1970 were included within this summary report. The USGS NWIS system has a substantial amount of data collected prior to 1970, but because of concerns with changes in analytical methods, these data were not retrieved. Data prior to 1970 from PaDEP and SRBC were not available.

Water-quality data for streams, lakes, ground-water wells, and springs was compiled into separate appendixes and the original water-quality data were summarized according to the water-quality types listed in table 2. The number of available samples was totaled for each site by type and the number of detections for each of those samples also was reported. This was done for each data source (USGS NWIS, LEGACY, MODERN, PaDEP, and SRBC) and data type (streams, lakes, ground-water wells, and springs) in separate appendixes. Redundant sites between data sets were noted in each appendix.

In addition, water-quality data for each data type were summarized in tables that combine all the data from the different sources. Data for redundant sites were removed so that no one sample (and its associated analytes) was counted into the summary table more than once. These summary tables were compiled by PABASID.

Available Data

Water-quality data for streams and lakes for Pennsylvania state lands were available from USGS, USEPA (LEGACY and MODERN), PaDEP, and SRBC. MODERN did not contain any lake data for state lands. Water-quality data for ground-water wells and springs for state lands were primarily available from USGS and USEPA (primarily LEGACY), but a few wells were available from PaDEP and SRBC. For some USGS NWIS stream and ground-water-well samples, data retrieved also included values for physical characteristics, such as water level, stream discharge, well depth, and well elevation.

Benthic Macroinvertebrates

Two forms of benthic-macroinvertebrate data were compiled, data associated with the water-quality databases and data compiled by agencies for sites specifically sampled for benthic macroinvertebrates. National water-quality databases such as USEPA LEGACY and MODERN and USGS NWIS have numerical parameter codes for input of benthic-macroinvertebrate communities (to either the family or genus level). Locations of sites with any benthic-macroinvertebrate data in these national databases were retrieved. Locations for benthic-macroinvertebrate samples available from other agencies also were compiled. Data were compiled from four sources: USGS, PaDEP, SRBC, and PaFBC.

Benthic-macroinvertebrate sample locations from each data source were compiled in separate appendixes that listed site identifier, latitude, longitude, PABASID, and name of state land associated with location. Benthic-macroinvertebrate sample locations were summarized for all the different sources in a summary table according to PABASID.

Geographic Information Systems Coverages

The locations of GIS coverages of physical basin characteristics were compiled. The physical basin characteristics (such as land cover, point-source discharges, population density, soil type, etc.) compiled were only those applicable to conducting a water-budget or ecological assessment (instream-flow) study. The sources and links to the data are compiled in this report, but the coverages will not be presented in map format for this report. The primary sources of data included USGS, PaDCNR, NWS, the Natural Resource Conservation Service (NRCS), and the Pennsylvania Spatial Data Access (PASDA) web site.

Data Assessment

The water-quantity and water-quality data compiled are summarized according to the basin designations by PaDEP (table 1 and fig. 3). Criteria are established to determine if the water-quantity data are sufficient for use in developing an annual water budget. Water-quality data, grouped into major water-quality categories, are summarized by PaDEP basin (PABASID) for each major site type (streams, lakes, ground-water wells, and springs).

Water Quantity

The predominant form of water-quantity data available for state lands in Pennsylvania was streamflow, including continuous and partial streamflow stations. Similar to streamflow stations, available data for continuous precipitation and ground-water elevations were also relatively well-distributed across state lands. Locations of continuous and partial streamflow stations and continuous ground-water wells in state lands were retrieved from the USGS NWIS database; the majority of locations for precipitation stations were available from NWS station locations.

Streamflow

Thirty-eight USGS continuous streamflow-gaging stations, some of which have been discontinued, were in state lands (appendix 1 and fig. 4). As of January 2007, 22 of these streamflow stations were active, with 7 of the 22 continuous sites located in PABASID #3 (Susquehannock/Genessee). This is somewhat expected because PABASID #3 has about 1,550 mi^2 of state land, which is over 1,000 mi^2 more than any other PABASID (table 1). The period of record (POR) for continuous-record stations varies from a few months to as much as 75 years for Oil Creek at Rouseville in Venango County. The majority of active streamflow stations have over 40 years of continuous record. Active continuous USGS streamflow-gaging stations are lacking in the middle part of the Ridge and Valley Physiographic Province (PABASID #1 and #26 (the north east section of #26)), specifically from Perry County north to Centre County.

Further analysis of the 38 continuous stations in state lands was conducted in order to determine how representative (status) the drainage area of each station was relative to the state land in which the station was located (table 3). In the table, status is equivalent to representation. The primary criteria to determine status was intersected or common land area between the station DA and the state land within that DA:

1. If the DA of the stream-gaging station included less than 30 percent state land, the station was determined not to be representative (status equals 'no' in table 3) of the state land;

2. If the DA of the stream-gaging station contained between 30 and 90 percent state land, land-use comparisons between the station DA and the state land were conducted. Land use was categorized into six groups (residential, city (commercial, industrial, and transportation), forest, mining, wetlands, and agriculture). If all land-use categories between the station DA and the state land were within 10 percent, the station was determined to be representative;

3. If the DA of the stream-gaging station contained 90 percent or greater state land, the station was determined to be representative.

Using the above criteria, 11 of the 38 continuous stream-gaging stations were determined to be representative of the state lands in which they were located (table 3). The two stations in PABASID #5 are not active (see appendix 1). Five of the active stations that are representative of state lands based on the criteria are located in PABASID #3. Three of the representative stations in other PABASIDs were installed by USGS for PaDCNR specifically for reasons of quantifying streamflows in state lands. These stations are Little Bushkill Run at Edgemere in PABASID #10, Mountain Creek near Pine Grove Furnace in PABASID #24, and Linn Run at Linn Run State Park near Rector in PABASID #27.

Continuous stream-gaging stations deemed not representative of the state land where they are located (in table 3) does not necessarily mean that the stations could not be used to represent the state land, but further analysis would be required to verify their use. For example, the areas of the station DA outside the state land would have to be studied in order to determine if point-source discharges occurred. Also, if the station DA outside the state lands included more residential or city land use, then that station may not be appropriate; however, similar land uses between the station DA and state lands (even if the intersected land is less than 30 percent) may make that station appropriate for use in a water-budget study for that particular state-land parcel.

Besides the 38 continuous streamflow sites in state lands, there were an additional 56 streamflow sites where streamflow was measured at least 1 time (appendix 1 and fig. 5). Some of these 56 sites were originally established by the USGS between 1970 and the mid-1990s to be included within low-flow networks established across Pennsylvania. Twenty-one of these low-flow sites were in state lands, with 9 to 40 streamflow measurements made at any of these low-flow sites. Commonly, measurements at the low-flow sites are related to data from a continuous station in order to produce daily streamflow values for the low-flow site. Therefore, the usefulness of these low-flow sites is dependent on proximity to a continuous station of similar drainage area and physiography. Typically, a continuous station can be used as an index station for a partial (low flow) site if the index station drains 1/3 to 3 times the drainage area of the partial site (Edward H. Koerkle, U.S. Geological Survey, oral commun., 2007).

In addition to the streamflow sites that were part of past low-flow networks, an additional 37 partial USGS surface-water sites are in state lands (fig. 5). Anywhere from 1 to 120 streamflow measurements were made at these other partial sites. Although it has not been determined which of these other partial sites could be related to an index station, there is no apparent reason why any of them could not be used as a low-flow station if a continuous index station does exist.

Ground water

The USGS NWIS database contains 32 wells that have continuous water-quantity (water-level altitude) data and are located in state lands (appendix 2 and fig. 6). Eighteen of the 32 wells were actively recording data as of January 2007, and these 18 active wells were located in 15 of the 35 basins defined by PaDEP, indicating that the active wells are fairly well-distributed across the state. Seven of 32 wells have less than 1 year of continuous data, but the majority of wells have record lengths exceeding 22 years (appendix 2). For all these wells, physical attributes such as topographic setting, well and casing depth, depth to bedrock, and depth to any water-bearing zones are available from the USGS NWIS database. In addition to continuous wells, there are many ground-water wells in the USGS NWIS database that, similar to streamflow sites, have one or more instantaneous ground-water level mea-

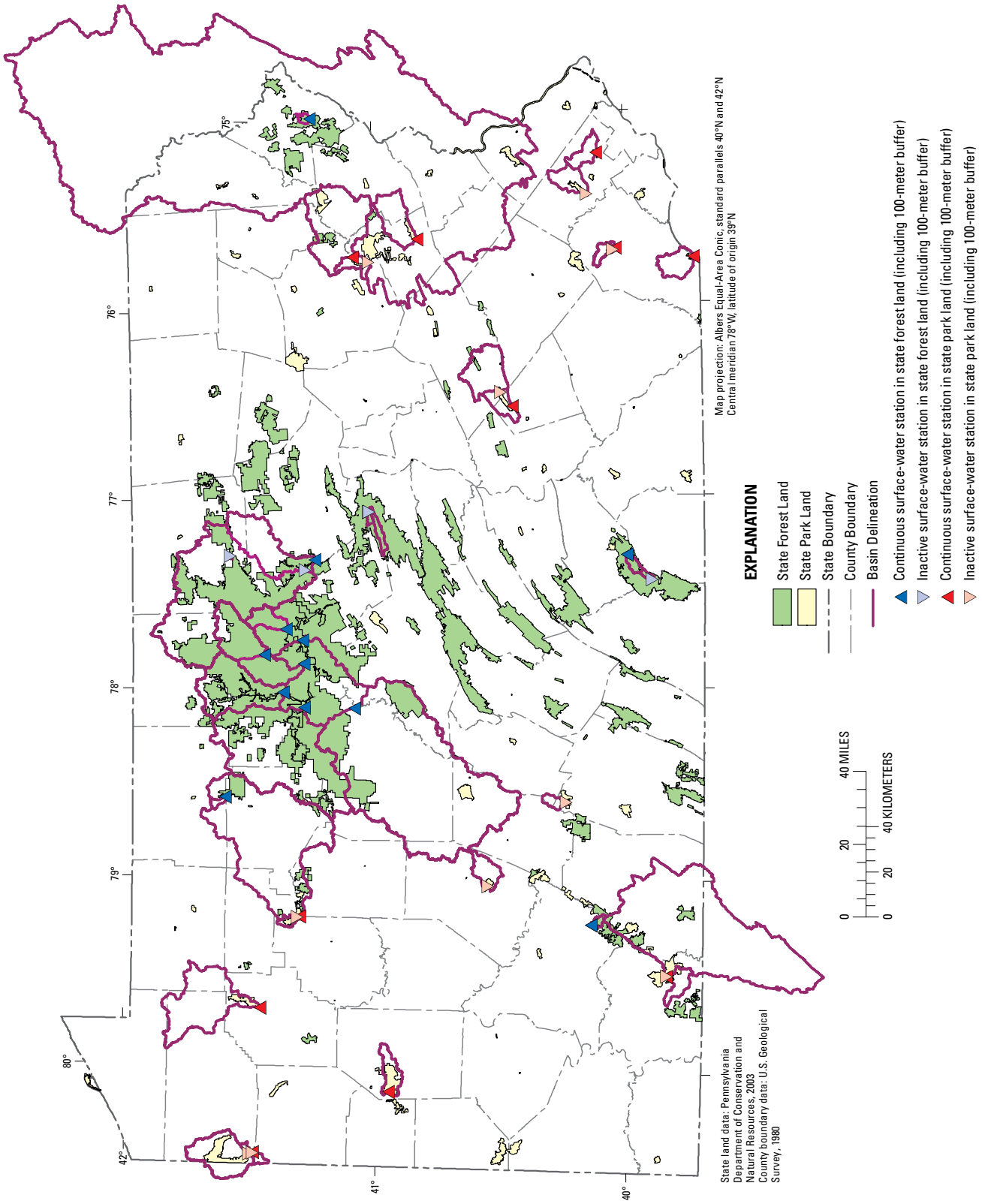

Figure 4. Location of continuous-record U.S. Geological Survey streamflow-gaging stations (and basin delineations) with water-quantity data in Pennsylvania state forest and park lands (100-meter buffers included).

Table 3. List of continuous stream-gaging stations in state forest and park lands (100-meter buffers included), amount of common area with state lands, and determination if stream station is representative of state lands.

[DA, drainage area of stream-gaging station; mi^2, square miles; Inter, intersected area of stream-gaging station drainage area with state-owned land; NA, not applicable]

Site identifier	Site name	Latitude	Longitude	DA (mi^2)	Intersected area (mi^2)	Inter/DA	Basin identification number	Status[1]	reason for 'no'
01439590	Little Bush Kill at Edgemere, Pa.	411531	745945	7.27	5.43	0.75	10	yes	NA
01447800	Lehigh River below Francis E. Walter Reservoir near White Haven Pa.	410617	754357	290	21.4	.07	11	no	insufficient overlap
01448000	Lehigh River at Tannery, Pa.	410225	754542	322	23.0	.07	11	no	insufficient overlap
01449800	Pohopoco Creek below Beltzville Dam near Parryville, Pa.	405044	753846	96.4	5.97	.06	12	no	insufficient overlap
01473120	Skippack Creek near Collegeville, Pa.	400952	752601	53.7	4.61	.09	18	no	insufficient overlap
01473900	Wissahickon Creek at Fort Washington, Pa.	400726	751313	40.8	.16	.00	19	no	insufficient overlap
01478245	White Clay Creek near Strickersville, Pa.	394451	754615	59.2	1.33	.02	21	no	insufficient overlap
01480680	Marsh Creek near Lyndell, Pa.	400358	754338	17.8	1.21	.07	21	no	insufficient overlap
01480685	Marsh Creek near Downingtown, Pa.	400319	754300	20.3	2.17	.11	21	no	insufficient overlap
01542500	West Branch Susquehanna River at Karthaus, Pa.	410703	780633	1,462	198	.14	2	no	insufficient overlap
01543500	Sinnemahoning Creek at Sinnemahoning, Pa.	411902	780612	685	291	.42	3	yes	NA
01544000	First Fork Sinnemahoning Creek near Sinnemahoning, Pa.	412406	780128	245	185	.75	3	yes	NA
01544500	Kettle Creek at Cross Fork, Pa.	412833	774934	136	112	.82	3	yes	NA
01545000	Kettle Creek near Westport, Pa.	411910	775227	233	208	.89	3	yes	NA
01545500	West Branch Susquehanna River at Renovo, Pa.	411928	774503	2,975	1110	.37	3	no	land use difference
01545600	Young Womans Creek near Renovo, Pa.	412322	774128	46.2	46.0	1.00	3	yes	NA
01548422	Rattler Run near Morris, Pa.	413636	771809	.32	.05	.16	3	no	insufficient overlap
01549000	Pine Creek near Waterville, Pa.	411845	772245	750	376	.50	3	no	land use difference
01549700	Pine Creek below Little Pine Creek near Waterville, Pa.	411625	771928	944	411	.44	3	no	land use difference
01553120	White Deer Creek above Sand Spring Run near White Deer, Pa.	410317	770431	17.8	17.7	.99	5	yes	NA
01553130	Sand Spring Run near White Deer, Pa.	410331	770437	4.9	4.93	1.00	5	yes	NA
01559795	Bobs Creek near Pavia, Pa.	401621	783555	16.6	1.14	.07	26	no	insufficient overlap
01571184	Mountain Creek near Pine Grove Furnace, Pa.	400151	771832	13.9	13.1	.94	24	yes	NA
01572030	Swatara Creek near Suedberg, Pa.	403129	762724	124	3.64	.03	23	no	insufficient overlap
01572190	Swatara Creek near Inwood, Pa.	402845	763152	167	8.52	.05	23	no	insufficient overlap

Table 3. List of continuous stream-gaging stations in state forest and park lands (100-meter buffers included), amount of common area with state lands, and determination if stream station is representative of state lands. —Continued

[DA, drainage area of stream-gaging station; mi^2, square miles; Inter, intersected area of stream-gaging station drainage area with state-owned land; NA, not applicable]

Site identifier	Site name	Latitude	Longitude	DA (mi^2)	Intersected area (mi^2)	Inter/DA	Basin identi-fication number	Status[1]	reason for 'no'
01614090	Conococheague Creek near Fayetteville, Pa.	395548	772623	5.1	4.13	0.82	25	yes	NA
03020500	Oil Creek at Rouseville, Pa.	412854	794144	300	9.95	.03	35	no	insufficient overlap
03026500	Sevenmile Run near Rasselas, Pa.	413752	783437	8.0	.17	.02	33	no	insufficient overlap
03029400	Toms Run at Cooksburg, Pa.	412016	791250	12.6	6.25	.50	33	no	land use difference
03029500	Clarion River at Cooksburg, Pa.	411950	791233	807	56.1	.07	33	no	insufficient overlap
03042250	Yellow Creek near Penn Run, Pa.	403447	790217	50.4	3.46	.07	27	no	insufficient overlap
03044810	Linn Run at Linn Run State Park near Rector, Pa.	401008	791402	8.0	6.83	.85	27	yes	NA
03081500	Youghiogheny River at Ohiopyle, Pa.	395157	792941	1,062	48.5	.05	28	no	insufficient overlap
03081600	Big Meadow Run at Ohiopyle, Pa.	395151	792943	36	5.24	.15	28	no	insufficient overlap
03100000	Shenango River near Turnersville, Pa.	413045	802815	152	30.7	.20	32	no	insufficient overlap
03101000	Sugar Run at Pymatuning Dam, Pa.	412950	802755	9.3	.01	0	32	no	insufficient overlap
03101500	Shenango River at Pymatuning Dam, Pa.	412953	802737	167	31.7	.19	32	no	insufficient overlap
03106300	Muddy Creek near Portersville, Pa.	405747	800731	51.2	23.9	.47	32	no	land use difference

[1]Status of yes indicates that the stream gage is representative of the state-owned land. The criteria for 'yes' or 'no' status:Inter/DA greater than 0.90, status is 'yes';For Inter/DA between 0.30 and 0.90: Land use[2] analyzed: If land use between stream drainage area and state land within that drainage area was within 10 percent for each of the six land-use categories, then the status for the stream gage is 'yes'; otherwise, status is 'no'.For Inter/DA less than 0.30, status is 'no'.

[2] Land use was categorized into six land uses: Reseidential, city (commercial, industrial, and transportation), forest, mining, wetlands, and agriculture.

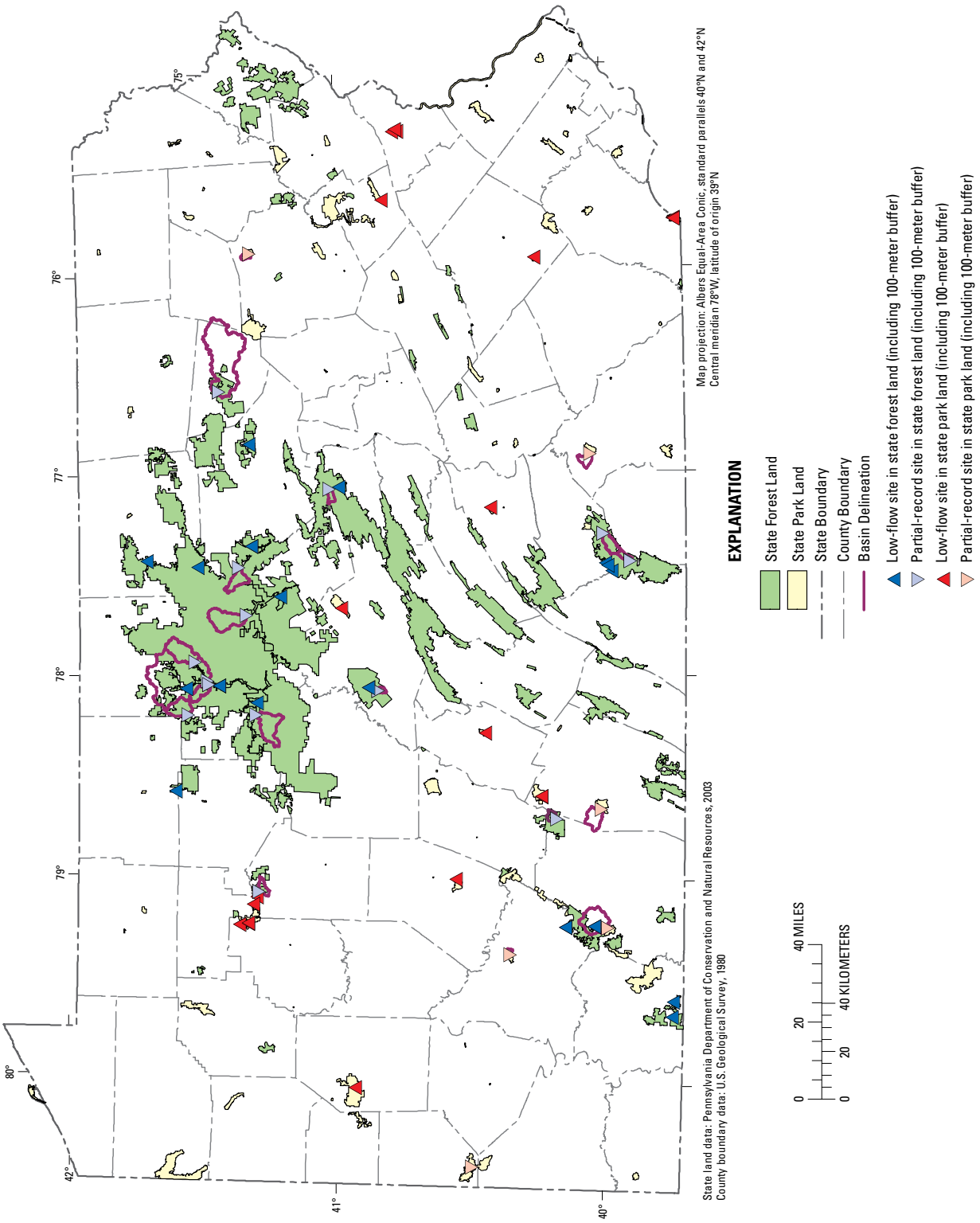

Figure 5. Location of partial-record U.S. Geological Survey surface-water sites (and basin delineations for low-flow network sites) with water-quantity data in Pennsylvania state forest and park lands (100-meter buffers included).

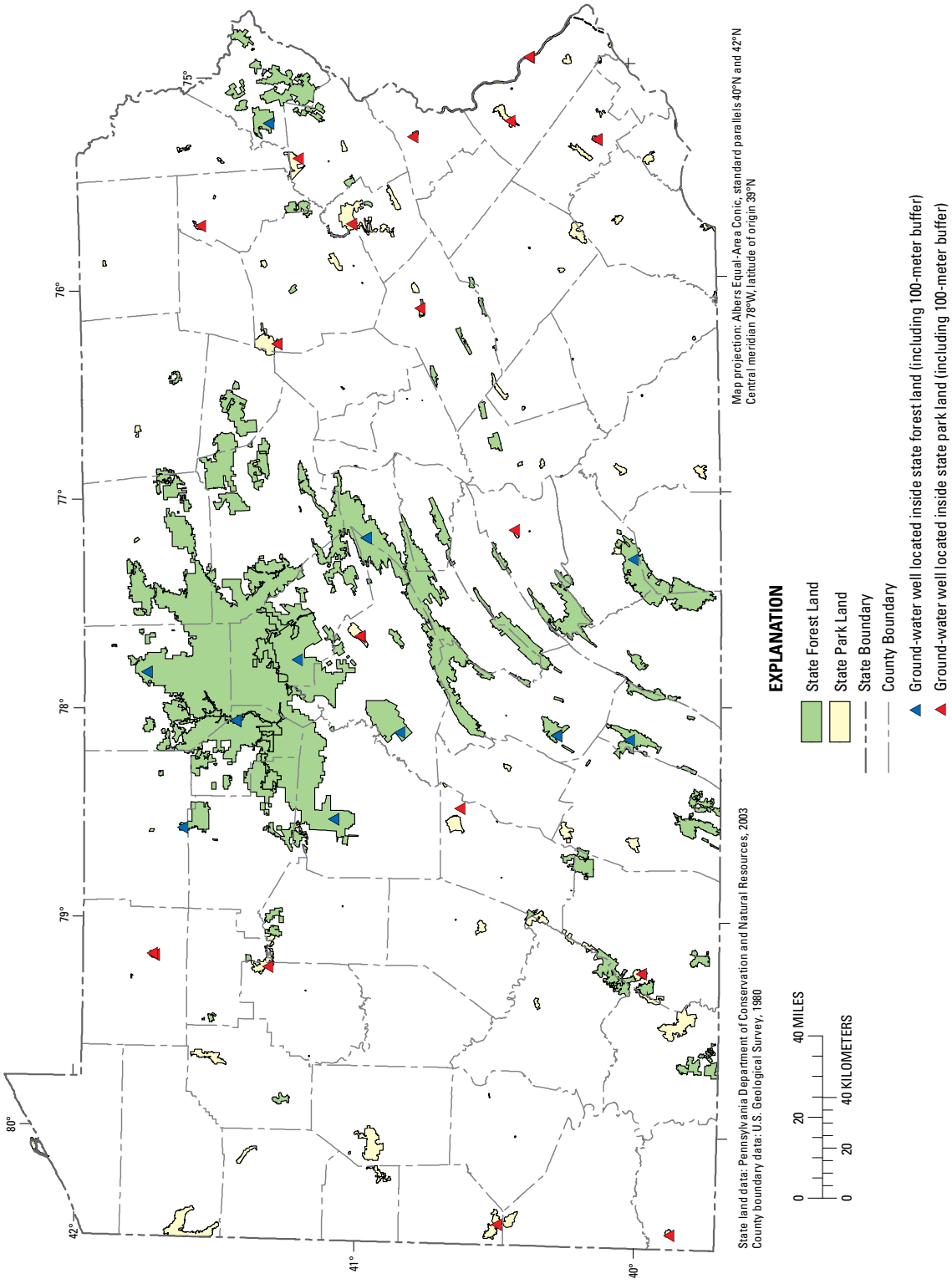

Figure 6. Location of U.S. Geological Survey ground-water sites with water-quantity data in state forest and park lands (100-meter buffers included) of Pennsylvania.

surements. Data from these wells were not retrieved for this assessment but are available for review.

Precipitation

Many of the precipitation stations in state-owned lands are from the NWS station network. Thirty-seven active precipitation stations from the NWS network were located in state lands, including 14 GOES, 13 COOP, and 10 LARC stations. For flash-flood forecasting purposes, PEMA has established 21 IFLOWS precipitation stations in state-owned lands. An additional 10 GOES precipitation stations from the USGS network were located in state lands (appendix 3 and fig. 7). The 68 precipitation stations on state lands from the NWS, PEMA (IFLOWS), and USGS networks are distributed across 18 PABASIDs, with PABASID #3 (Susquehannock/Genessee) having the most stations (24), followed by #5 (Big Bend) and #26 (Juniata), which both had 10 stations.

There may be instances where a specific drainage basin in state lands does not have adequate precipitation station coverage for daily estimates, as would be required for any water budget or surface-water modeling exercise. This especially may occur in mountainous terrain where orographic effects on precipitation amounts could occur. **Nex**t Generation **Rad**ar (NEXRAD) uses the raw radar data and estimates time-series precipitation totals. An improvement of NEXRAD data is multisensor precipitation estimates (MPE), meaning that the raw radar estimates are modified on the basis of real-time data from the network of precipitation stations. Another modification of raw radar data is a program called the Gridded **P**arameter-Elevation **R**egressions on **I**ndependent **S**lopes **M**odel (PRISM), which also considers elevation gradients (Jeton and others, 2006). These radar composite methods can be used to estimate the total amount of precipitation that falls over any given area. MPE or PRISM can be used to generate time-series data of daily precipitation values for a specific area. NEXRAD data are comprised of the actual reflectivity data from the NWS radar network, so MPE values are good estimates of spatial variability, but processing time is costly. One of the methods for using NEXRAD data to determine spatial distributions of precipitation is given by Hay and others (2000). It is also possible to use PRISM, which would be a better methodology if the elevation gradient in the basin was relatively steep. PRISM was used to determine daily rates of precipitation for the entire state of Nevada (Jeton and others, 2006). A package such as GSFLOW can incorporate daily precipitation data compiled using radar composite methods.

Water-Budget Summary

Confidence in the estimates of a water budget increase with the use of measured or simulated continuous data for that particular study basin. Some of the necessary components of an annual water budget include streamflow, ground-water altitude, and precipitation data (see equation 1). Other required data include water use and estimates for ET. Assuming that water-use data and estimates for ET are available or can be derived, water-quantity data available for each PABASID was summarized to assess the ability to conduct a water-budget study within that basin using an active or recently active gaging-station network (table 4). Seven of the 35 PABASIDs have a currently active gaging-station network with streamflow, ground-water altitude, and precipitation stations, with one PABASID (#26, Juniata) having a network of overlapping data from 1993 into 2001. For many PABASIDs, one or two types of data are available. Within the appropriate appendixes of this report, locations (latitude, longitudes, PABASID, and state-land name) of each station are given, and available POR are given. Even though data for different types of water-quantity stations may not overlap for a specific PABASID, data from many of the sites, including partial-record stream-gaging sites, may be very useful to a water-budget or other water-resource study for state lands in that specific PABASID.

If the analysis for continuous stream-gaging stations (table 3) is applied to the summary presented in table 4, then only three PABASIDs (#3, #10, and #24) would have appropriate data to conduct a water-budget summary using an active gaging-station network with stream, ground-water, and precipitation data available. These would be very restrictive criteria; therefore, all the possible continuous stream-gaging stations were included in table 4. This does point out one problem with assuming that PABASIDs listed in table 4 with overlapping POR can automatically be used for a water-budget study in that PABASID for state lands. The use of data from any stations listed in this report would depend on the specific basin to be studied in a particular PABASID. Once a study basin is selected, comparisons can be made to the data available within that PABASID to determine which stations may be appropriate for use. Also, ground-water altitudes and precipitation totals can be greatly impacted by localized conditions, so the location of a ground-water well with altitude data in a PABASID may not be useful for a specific basin in state land. Full use of available data can not be determined until a study basin is defined.

However, on the basis of the spatial coverage of USGS continuous surface-water stations and the USGS low-flow networks, most ungaged stream reaches in state lands could be tied to an index station and an adequate representation of the hydrograph for the ungaged stream could be produced using existing methodologies such as the QPPQ method (Waldron and Archfield, 2006).

Also, given the availability of NEXRAD spatial data and the present coverage of precipitation stations in state lands of Pennsylvania, quantifying the amount of precipitation over any area of concern is possible. This is assuming that resources are available to either process NEXRAD data or to use an interpolation method that includes all pertinent precipitation stations over a given radius from a central point of interest.

The primary challenge in conducting a water-budget study for a specific basin may be the availability of adequate ground-water data. Even though a ground-water well may

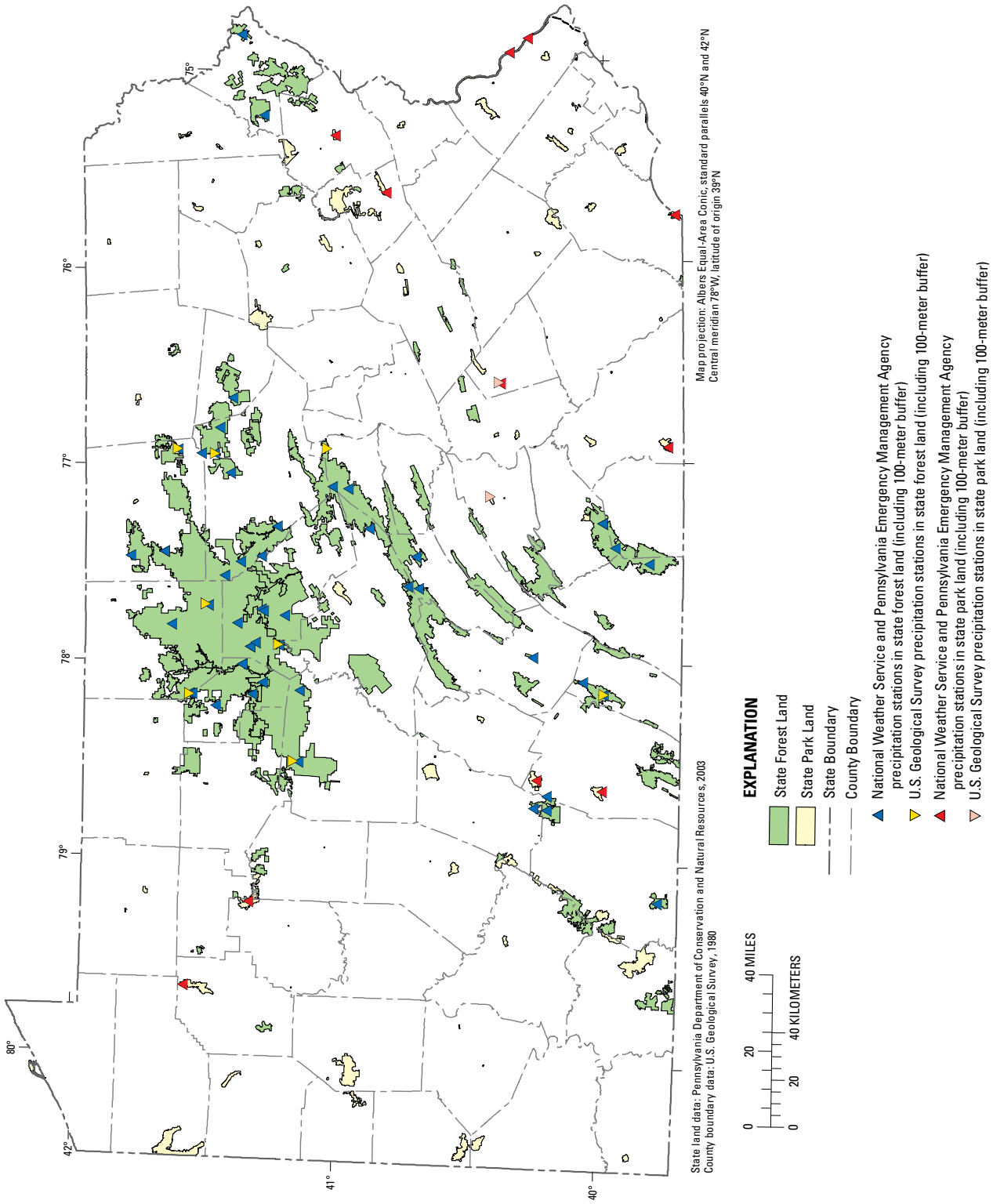

Figure 7. Location of active National Weather Service, Pennsylvania Emergency Management Agency, and U.S. Geological Survey precipitation stations in Pennsylvania state forest and park lands (100-meter buffers included).

Table 4. Summary of surface-water, ground-water, and precipitation stations where water-quality data were collected in Pennsylvanaia state forest and park lands (100-meter buffers included).

[mi², square miles; #sites, number of sites; POR, period of record; min/max DA, minimum and maximum drainage area in square miles; NA, not applicable]

Basin identification number	Basin name	State land area (mi²)	Streamflow[1]		
			#sites	POR	min/max DA
1	Central Penn	267	0	NA	NA
2	Upper West Branch	266	1	3/1/1940 - active	1,462 - 1,462
3	Susquehannock/Genessee	1,560	9	10/1/1907 - active	0.32 - 2,975
4	Lower North Branch Susquehanna	15.2	0	NA	NA
5	Big Bend	324	2	1/1/1968 - 3/31/1981	5 - 18
6	Bradford/Tioga	57.0	0	NA	NA
7	Upper Susquehanna	10.7	0	NA	NA
8	Wyoming Valley	9.09	0	NA	NA
9	Lackawanna	2.00	0	NA	NA
10	Upper Delaware	128	1	11/4/2005 - active	7 - 7
11	Brodhead/Toby/Tunk	57.7	2	10/1/1916 - active	290 - 322
12	Upper Schuylkill/Middle Lehigh	25.9	1	8/1/1967 - active	96 - 96
13	Lower Lehigh	1.65	0	NA	NA
14	Delaware River/Tohickon Creek	12.0	0	NA	NA
15	Delaware Common Tributaries/Neshaminy	7.93	0	NA	NA
16	Middle Schuylkill	2.02	0	NA	NA
17	French/Manatawny	9.79	0	NA	NA
18	Perkiomen Creek	5.17	1	5/1/1966 - 9/30/1994	54 -54
19	Lower Schuylkill (Wissahickon Creek)	1.75	1	9/1/1961 - active	41 - 41
20	Ridley/Darby/Chester/Crum Creeks	4.23	0	NA	NA
21	Christina /Elk/North East /Brandywine	4.64	3	8/1/1960 - 9/30/1969 & 6/1/1973 - active	18 - 59
22	Pennypack/Tacony	.47	0	NA	NA
23	Lower Susquehanna East	32.6	2	12/21/1984 - 9/30/1987 & 10/1/1988 - active	124 - 167
24	Lower Susquehanna West	143	1	11/5/2005 - active	14 - 14
25	Potomac	138	1	9/1/1960 - 3/31/1981	5 - 5
26	Juniata	336	1	6/1/1993 - 6/21/2001	17 - 17
27	Kiski-Conemaugh	66.9	1	10/1/1963 - 9/30/1967	50 - 50
28	Youghioheny	84.9	2	2/2/1988 - 11/15/1988 & 10/1/2002 - active	36 - 1062
29	Monongahela	25.0	0	NA	NA
30	Ohio	20.2	0	NA	NA
31	Allegheny	.05	0	NA	NA
32	Moraine	71.8	4	2/1/1912 - 9/30/1922 & 3/1/1934 - active	9 - 167
33	Middle Allegheny	65.8	3	10/1/1938 - present	8 - 807
34	Upper Allegheny	19.5	0	NA	NA
35	Lake Erie/French & Oil Creek	13.2	1	10/1/1932 - active	300 - 300

[1]Partial-record stations were not included.

Table 4. Summary of surface-water, ground-water, and precipitation stations where water-quality data were collected in Pennsylvanaia state forest and park lands (100-meter buffers included).—Continued

[mi^2, square miles; #sites, number of sites; POR, period of record; min/max DA, minimum and maximum drainage area in square miles]

Basin identification number	Ground water		Precipitation		Common dates
	#sites	POR	#sites	begin date	
1	2	8/9/1950 - active	3	1984	NA
2	3	11/17/1984 - 10/23/1985 & 7/19/1995 - 11/26/1995 & 9/18/2001 - active	1	8/29/2003	8/29/2003 - present
3	2	10/11/1967 - active	24	10/1/1962	10/11/1967 - present
4	2	7/28/1919 - 7/14/1994 & 11/23/1994 - active	0	NA	NA
5	1	10/10/1967 - active	10	1983	No overlap
6	0	NA	2	4/1/1975	NA
7	1	9/21/2001 - active	0	NA	NA
8	0	NA	0	NA	NA
9	0	NA	0	NA	NA
10	1	9/20/2001 - active	2	10/1/1980	11/4/2005 - present
11	2	10/19/1967 - active	1	1984	1984 - present
12	1	7/1/1975 - active	1	2/1/1971	7/1/1975 - present
13	1	5/3/2001 - active	0	NA	NA
14	1	11/22/1967 - active	0	NA	NA
15	1	3/25/1992 - 1/10/1993	2	1/1/1936	NA
16	0	NA	0	NA	NA
17	0	NA	0	NA	NA
18	0	NA	0	NA	NA
19	1	9/13/1956 - 11/15/2006	0	NA	NA
20	0	NA	0	NA	NA
21	0	NA	1	1996	NA
22	0	NA	0	NA	NA
23	0	NA	2	1987	NA
24	1	6/20/1951 - active	2	8/25/1970	11/5/2005 - present
25	0	NA	2	11/1/1973	NA
26	3	7/7/1940 - active	10	3/1/1975	6/1/1993 - 6/21/2001
27	0	NA	2	3/1/1985	NA
28	2	4/17/1937 - 9/30/2004 & 1/11/2006 - 11/29/2006	1	5/28/2003	5/28/2003 - 9/30/2004 & 1/11/2006 - 11/29/2006
29	0	NA	0	NA	NA
30	2	11/8/1967 - active	0	NA	NA
31	0	NA	0	NA	NA
32	0	NA	0	NA	NA
33	2	1/1/1970 - active	1	3/1/1977	3/1/1977 - present
34	3	10/14/1987 - 10/22/1987 & 10/14/1988 - 10/22/1988	0	NA	NA
35	0	NA	1	1985	NA

be located in a PABASID in which a study is conducted, it may be difficult to transfer those data to another basin unless lithology and precipitation are similar. Again, this is a difficult question to answer without discussing a specific basin.

Water Quality

The numerical parameter codes retrieved from all the water-quality databases, a description of the parameter codes, and the water-quality group for each parameter code is presented in appendix 4. For the USEPA MODERN and SRBC water-quality data sets, parameter codes were not included with the data; however, the constituents in these databases were also retrieved from other databases (such as USGS NWIS and USEPA LEGACY), therefore, the parameter code list in appendix 4 is complete.

Data retrieved from each water-quality data set are summarized in separate appendixes for each data set. Except for the USEPA MODERN data set, all other data retrieved had remark codes (such as "<") associated with the results. These remark codes were used to summarize the number of detections. For example, if a site had 50 analyses for trace constituents and only 20 of the analytes were detected, then the appendix would list 50 trace-constituent samples for that site with only 20 detections. For the USEPA MODERN data set, threshold values were used to summarize the data. Thresholds for each constituent were set and any values equal to this were identified as "not exceeding the threshold value." Threshold values were set by reviewing data in MODERN and making an assumption on the basis of the "most common" value in the database that the most common value was the method detection limit (MDL). For example, for dissolved arsenic, 4 micrograms per liter was the "most common" number, and many samples had this value. Thus, this value was set as the threshold and the assumed MDL. Thresholds had to be set for each constituent on the basis of this approach for the MODERN data set. The one potential problem with this method is that the data in MODERN came from many different sources, and it is possible that detection levels were different for the same constituent; nevertheless, each constituent in MODERN was reviewed to set a reasonable threshold value.

Streams

The majority of stream water-quality data retrieved for state lands was available from USGS NWIS and USEPA LEGACY data sets. From USGS NWIS, 151 sites with water-quality data for streams were retrieved (fig. 8 and appendix 5). A total of 2,586 records (observations) were retrieved for these sites. A total of about 510 constituents were associated with these records. The greatest number of samples (362) for any one site was collected at Young Woman's Creek near Renovo in Sproul State Forest (station number 01545600). A wide range of constituents were sampled at this site, but the major finding is that for 269 trace-elements samples collected at the site, only 2 constituents were detected over the 35 years (1970 through 2005) when samples were collected.

It should also be noted that continuous water-quality data are also available for 16 continuous-recording stream sites within state lands (appendix 1). The parameters collected at some of these 16 sites include pH, water temperature, specific conductance, dissolved oxygen, and suspended sediment. These data were collected sporadically from 1967 through 2006.

The USEPA LEGACY data set contained 154 stream sites with water-quality data that were in Pennsylvania state lands (fig. 9 and appendix 6). Sites identified in the LEGACY database as acid mine drainage (AMD) (five sites) and waste (wastewater treatment outflows) (three sites) were also included (appendix 6). Although 1 site in Forest County (4CLA10049) had more samples (362) than any other stream site retrieved from LEGACY, the majority of sites with more than 250 samples (see appendix 6) from this database were WQN site samples entered into LEGACY by PaDEP. The LEGACY data set was transmitted to the USGS as compressed files by county. All the data for any one site were used for the summary given in appendix 6. That is, data prior to 1970 were not deleted from the database. The earliest data retrieved from LEGACY was 1950 (for six sites). Only about 10 percent of the sites have any data prior to 1970.

From the USEPA MODERN data set, the total number of stream sites retrieved for state lands was 52 (fig. 10 and appendix 7). Sixteen of the sites retrieved from MODERN were sites established by DRBC and 14 other sites were part of the PaDEP WQN. The dates for all stream samples retrieved from MODERN ranged from 1992 through 2004. Most samples in MODERN were collected during or after 1999. Samples in MODERN collected prior to 1999 are samples also in the LEGACY database that had the proper quality-assurance documentation to allow the data to be stored in MODERN.

Ninety-nine sites sampled by SRBC were in state lands (appendix 8 and fig. 11). Sites from SRBC were all within the Susquehanna River Basin, and most sites were in the north-central part of Pennsylvania, primarily in Moshannon, Elk, Sproul, Susquehannock, and Tiadaghton State Forests. The sample dates for these SRBC data ranged from 1994 into mid-2006. Except for one site, all sites have less than 10 samples. Generally, sites were sampled for major ions, acidity/alkalinity, and trace constituents (appendix 8).

Data for 16 stream sites were retrieved from the PaDEP WQN database (fig. 12 and appendix 9). Some of these water-quality data also were available in either LEGACY or MODERN. Appendix 9 contains footnotes associated with sites that have data in these other data sets. MODERN did not have any data for the WQN sites beyond 2004. Data obtained from PaDEP for WQN sites ranged from November 1998 through March 2007, with 38 to 77 samples collected at each of the 16 sites. Similar to the WQN data compiled from USEPA STORET, this data set from PaDEP also contained constituents for major ions and trace elements, along with fish-tissue concentration data.

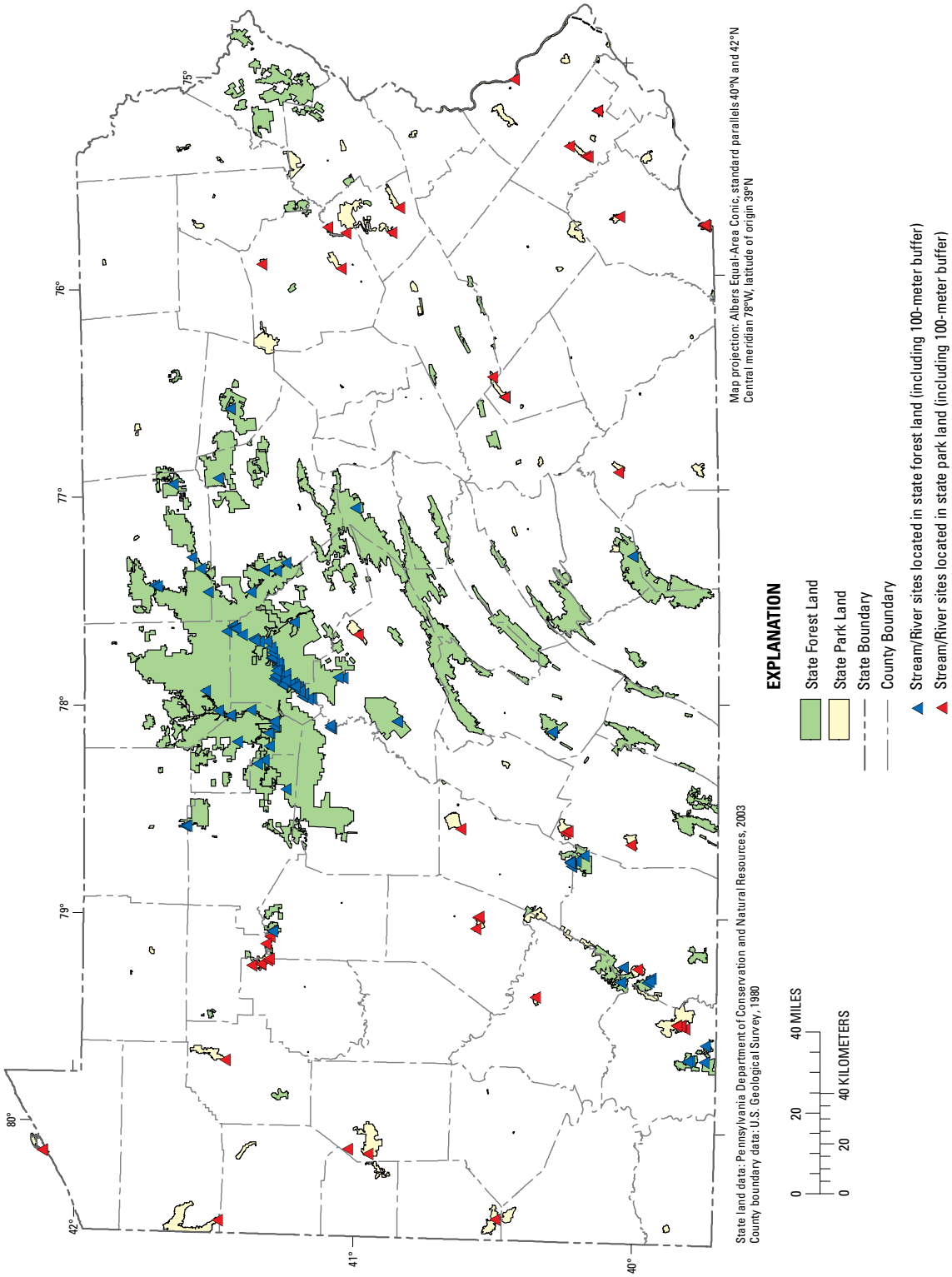

Figure 8. Location of U.S. Geological Survey stream sites with water-quality data in Pennsylvania state forest and park lands (100-meter buffers included).

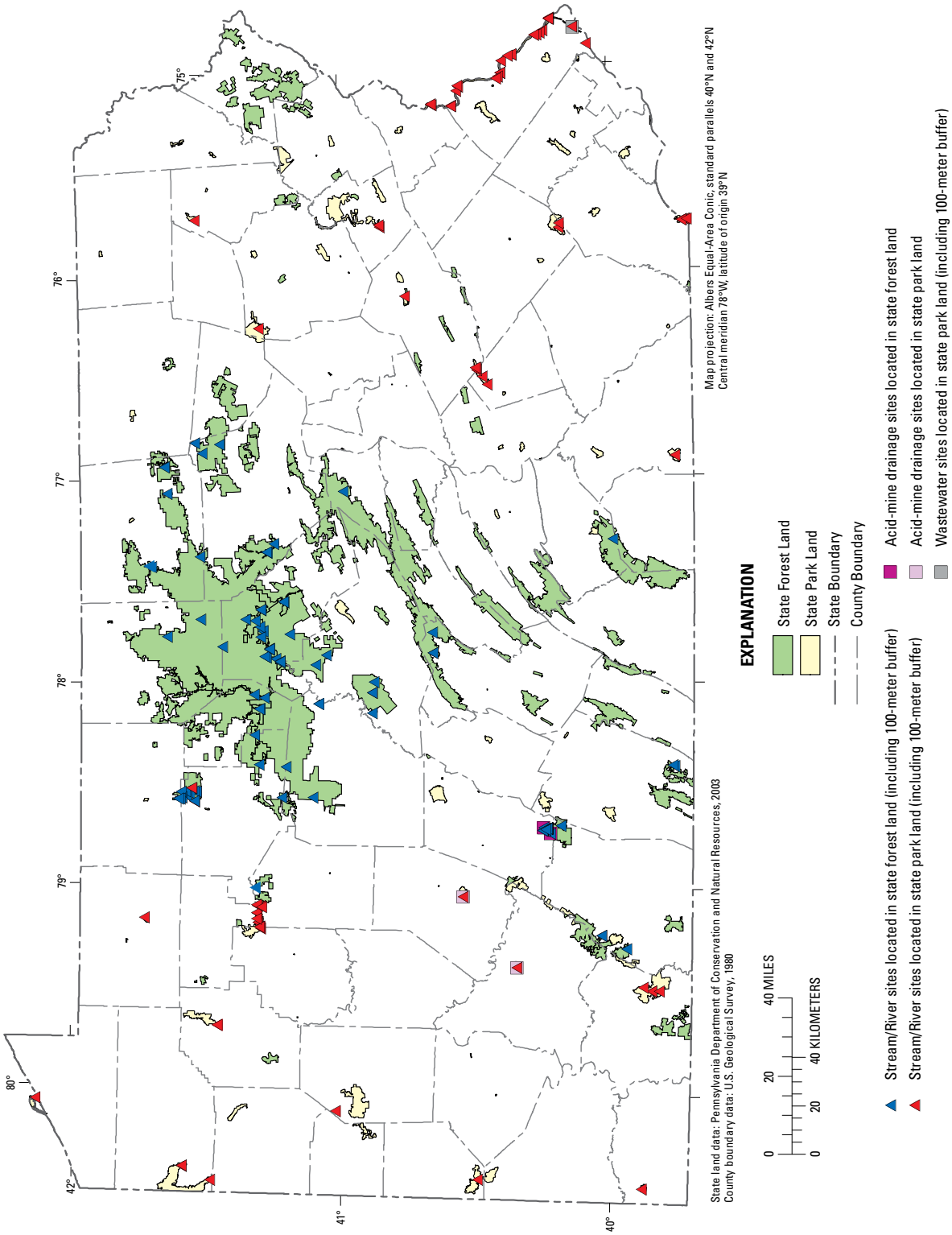

Figure 9. Location of stream and acid-mine drainage sites with water-quality data retrieved from the U.S. Environmental Protection Agency Legacy STORET database for state forest and park lands (100-meter buffers included) in Pennsylvania.

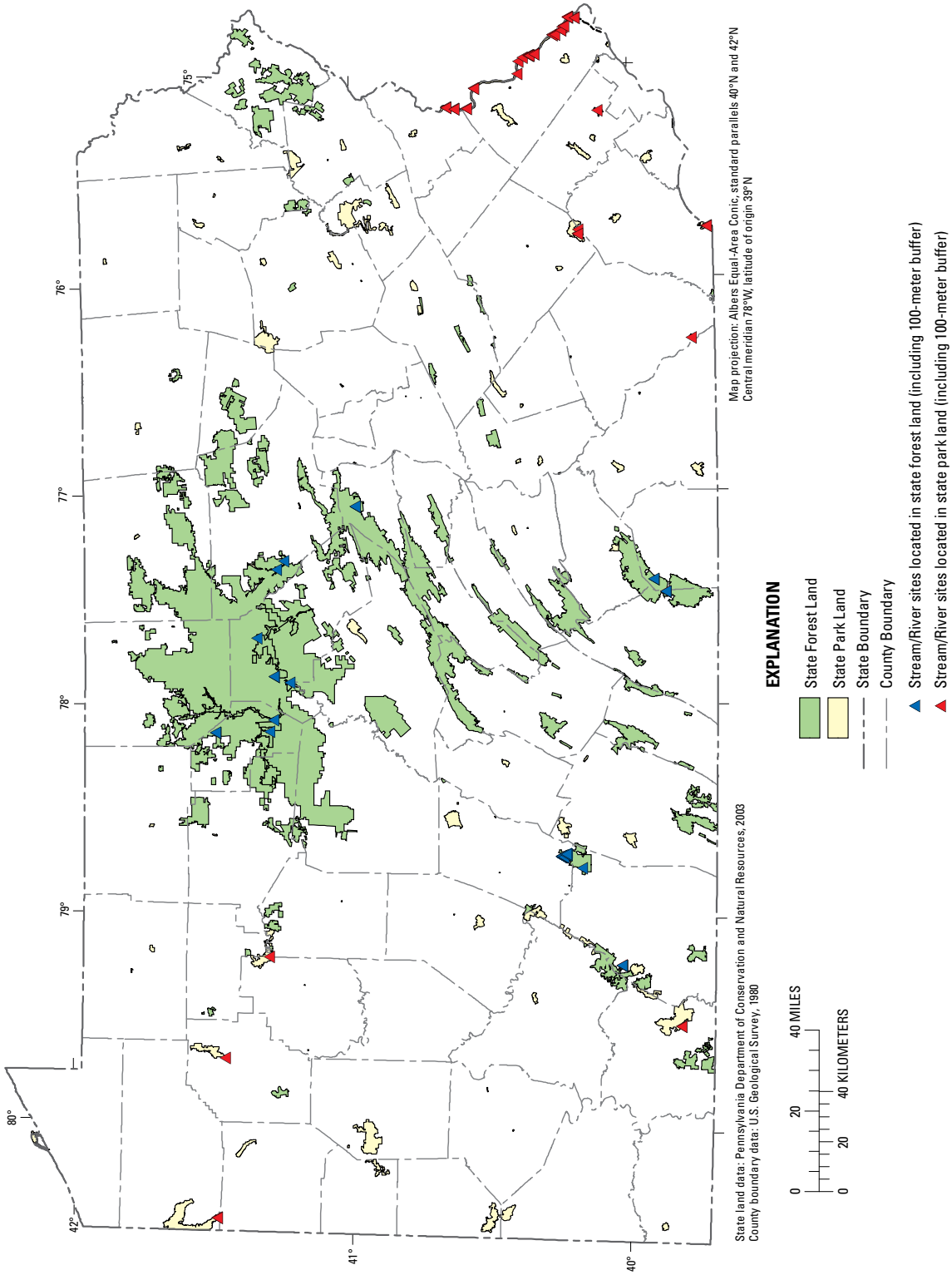

Figure 10. Location of stream sites with water-quality data retrieved from the U.S. Environmental Protection Agency Modernized STORET database for state forest and park lands (100-meter buffers included) in Pennsylvania.

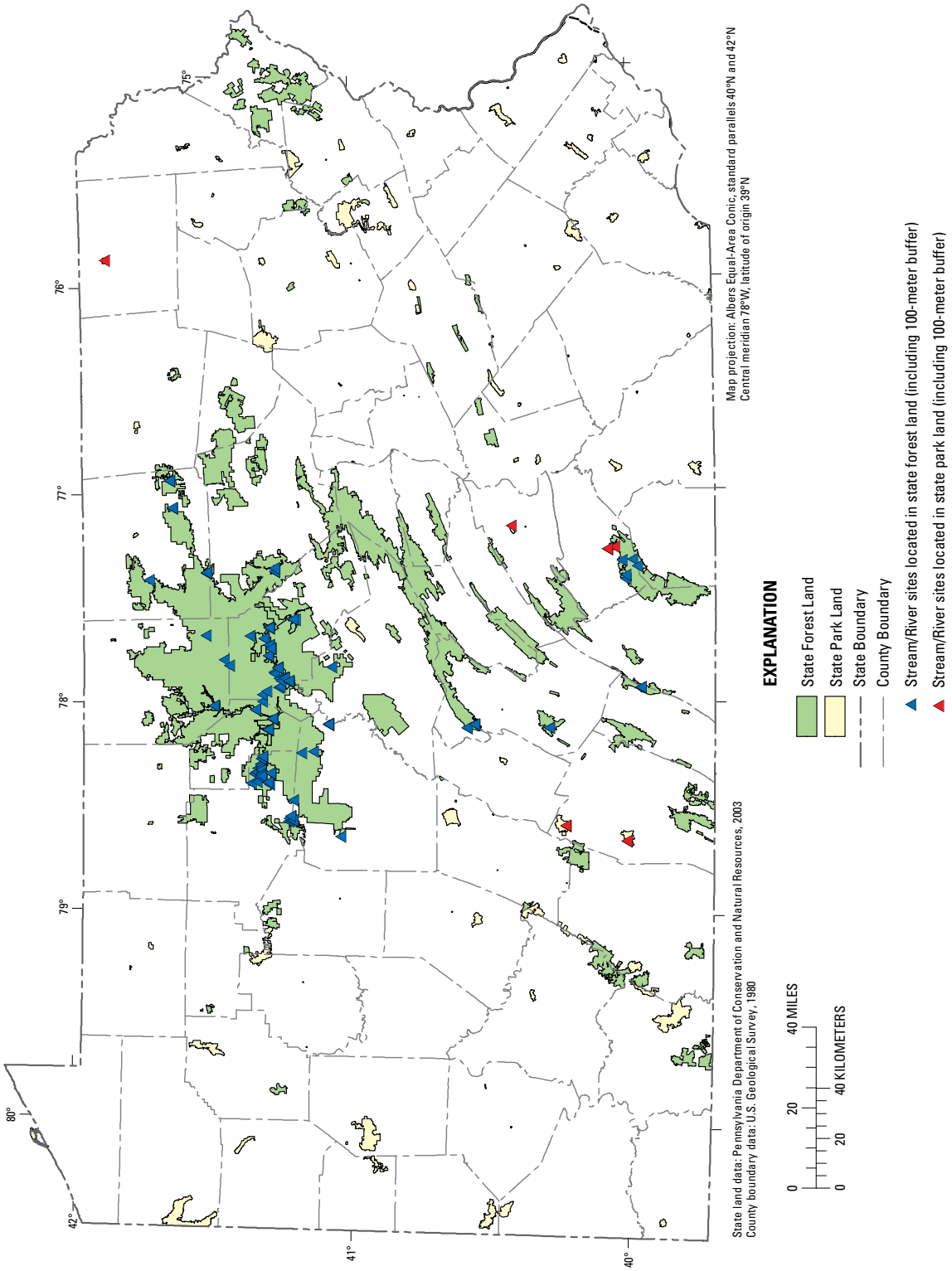

Figure 11. Location of stream sites with water-quality data retrieved from the Susquehanna River Basin Commission for state forest lands (100-meter buffers included) in Pennsylvania.

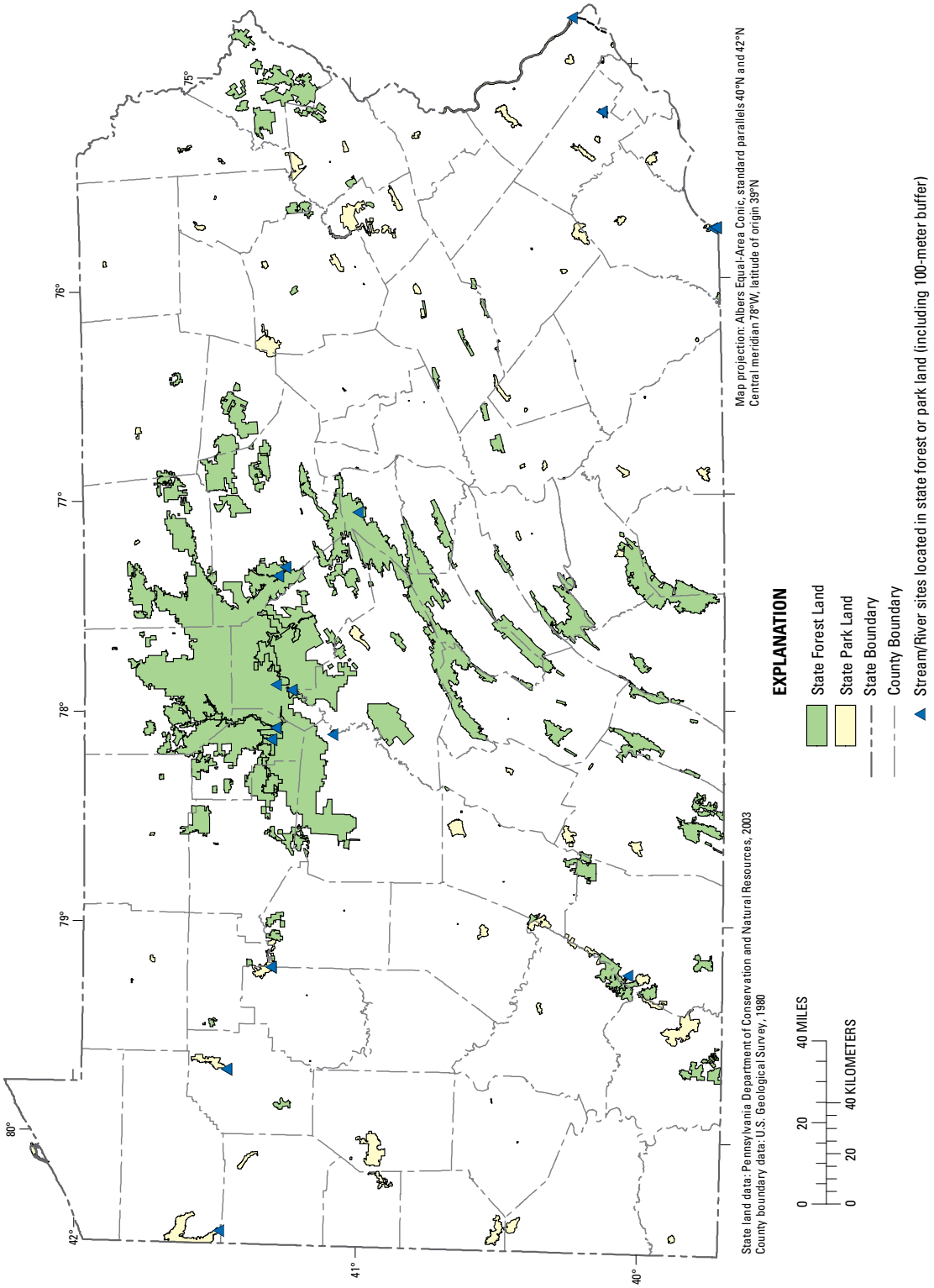

Figure 12. Location of stream sites with water-quality data in Pennsylvania state forest and park lands (100-meter buffers included) that are part of the Water Quality Network of the Pennsylvania Department of Environmental Protection.

A total of 410 stream sites in state lands had water-quality data available from the data sets compiled (table 5). The PABASID with the most sites was #3 (Susquehannock/Genessee) with 165 sites, followed by #33 (Middle Allegheny) with 35 sites and #27 (Kiski-Conemaugh) with 32 sites. PABASID #3 has the most state land (about 1,550 mi^2) of any PABASID (no other PABASID has more than about 320 mi^2 of state land), so the highest number of stream sites is expected. PABASID #5 (Big Bend) has the smallest number of sites per unit area of state land, with only six stream sites over 320 mi^2 of state land.

The common types of water-quality data collected for stream sites in state lands were major ions with over 40,000 analyses at 347 sites, followed by about 35,000 analyses each for trace constituents, nutrients, and physical parameters (table 5). Almost 300 sites had data available on suspended-sediment concentrations. Bed sediments were also sampled at about 35 sites. Samples from 17 of these sites were located in PABASID #3 (Susquehannock/Genessee) and were analyzed for trace metals associated with bed sediments. Thirty-one stream sites had data available for concentrations of constituents in fish tissue.

Lakes

Water-quality data for lakes in state lands were retrieved from USGS NWIS, USEPA LEGACY, and PaDEP. A total of 53 sites were retrieved from USGS NWIS (fig. 13 and appendix 10). Only 8 of the 53 sites in this database had data collected after the year 2000. Data for most of these lake sites were collected in the 1970s. Nutrients and major ions were the predominant types of water-quality data. The majority of sites had only 1 sample collected, but 1 site (Howard Dam in Bald Eagle State Park) had 21 samples.

Fifty-eight lake sites in state lands were retrieved from the USEPA LEGACY database (fig. 14 and appendix 11). Twenty-five of the 58 sites (43 percent) are in Crawford, Elk, or Erie Counties, in the northwest part of the state. The sites with the most samples (3 sites each had over 180 samples) were in Elk County. For the 58 sites, only 1 site had any data collected prior to 1970; sample dates for the other sites ranged from 1970 through 1996. The predominant types of water-quality data collected were analyses for nutrients and measurements of acidity/alkalinity.

Data for five lake sites were retrieved from the PaDEP WQN database (fig. 15 and appendix 12). Data for these five lakes also were in the USEPA LEGACY database but only data collected before 1996. The additional PaDEP data provided a total of 12 discrete samples for all 5 sites ranging in date from July 1999 to September 2004. The five sites were within state park boundaries and none of the five sites were located in state forest land. Major ions, trace elements, and fish-tissue concentrations were the predominant types of water-quality data available.

A total of 107 lake sites in state lands had water-quality data available from the data sets compiled (table 6). The PABASID with the most sites was #32 (Moraine) in the northwest part of the state with 15 sites, followed by #10 (Upper Delaware) with 11 sites and #33 (Middle Allegheny) with 10 sites.

The most common types of water-quality data collected for lake sites in state lands were nutrients and acidity/alkalinity parameters with over 4,000 analyses for each at 93 of the lake sites (table 6). Suspended-sediment data were collected at 93 sites and bed-sediment data at about 40 sites. Some form of biological data was available for 88 sites, with 20 sites having data on concentrations of constituents in fish tissue.

Ground-Water Wells and Springs

Water-quality data for ground-water wells and springs in state lands were retrieved from the USGS NWIS, USEPA LEGACY and MODERN, PaDEP, and SRBC databases. Data for 73 ground-water wells (appendix 13) and 11 springs (appendix 14) were retrieved from USGS NWIS (fig. 16). The wells are well-distributed across the state, but not many samples were collected at any one location. The number of samples collected at each site ranged from 1 to 22. The wells with the most samples were in Bucks County in Benjamin Rush State Park, located along the Delaware River. The PABASIDs with the most ground-water wells in state lands were the Juniata Basin (#26) with nine wells, followed by Delaware River (#15 and #10) and Lower Schuykill Basins (#19). Nutrients and major ions were the predominant types of water-quality data collected for the wells from NWIS. Sample dates ranged from 1970 to 2001. For springs, only one to two samples were collected at any site; nine springs had data only collected in the 1970s, and the other two springs had data only for the 1980s. Major ions were the predominant type of water-quality data available for springs. The LEGACY database contained additional water-quality data for 10 of the wells (appendix 15) and 6 of the springs (appendix 16) retrieved from USGS NWIS.

The USEPA LEGACY database contained 133 wells (fig. 17 and appendix 15) and 42 springs (fig. 18 and appendix 16) with water-quality data for state lands. The sample dates for wells ranged from 1933 to 1998. The wells from USEPA LEGACY were well-distributed across the state. Only 3 of the 133 wells had more than 10 samples collected; the majority of wells had 1 to 3 samples. Nutrients, major ions, and physical characteristics were the predominant types of water-quality data for wells. For springs with water-quality data in LEGACY, three of the springs in Forbes State Forest had samples collected as early as 1945; however, for all other springs, the earliest sample date in LEGACY was 1967. All springs except 1 had less than 10 samples collected. Major ions and trace elements were the predominant types of water-quality data for springs in LEGACY.

Water-quality data for nine additional wells were retrieved from the PaDEP and SRBC databases (appendix 17). All of these wells were in state forest land except for one (fig. 19), and most are public-supply wells. One to 5 samples

Table 5. Water-quality summary for stream sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.

Basin identification number	Basin name	Total sites	Acidity (pH) and alkalinity parameters		Bed sediment parameters		Bed sediment and associated biological parameters		Bed sediment and associated insecticide parameters	
			Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	Central Penn	6	6	88	0	0	2	4	0	0
2	Upper West Branch	26	25	804	0	0	0	0	0	0
3	Susquehannock/Genessee	165	164	12,657	1	5	16	32	3	74
4	Lower North Branch Susquehanna	0	0	0	0	0	0	0	0	0
5	Big Bend	6	6	359	0	0	1	2	0	0
6	Bradford/Tioga	6	6	42	0	0	1	2	0	0
7	Upper Susquehanna	3	3	34	0	0	0	0	0	0
8	Wyoming Valley	2	2	20	0	0	0	0	0	0
9	Lackawanna	0	0	0	0	0	0	0	0	0
10	Upper Delaware	0	0	0	0	0	0	0	0	0
11	Brodhead/Toby/Tunk	2	1	11	0	0	0	0	0	0
12	Upper Schuylkill/Middle Lehigh	5	4	400	0	0	0	0	0	0
13	Lower Lehigh	0	0	0	0	0	0	0	0	0
14	Delaware River/Tohickon Creek	14	10	291	0	0	0	0	1	16
15	Delaware Common Tributaries/Neshaminy	24	20	1,131	0	0	0	0	0	0
16	Middle Schuylkill	0	0	0	0	0	0	0	0	0
17	French/Manatawny	2	2	4	0	0	0	0	0	0
18	Perkiomen Creek	3	3	93	0	0	2	4	2	9
19	Lower Schuylkill (Wissahickon Creek)	2	2	181	0	0	1	2	1	1
20	Ridley/Darby/Chester/Crum Creeks	0	0	0	0	0	0	0	0	0
21	Christina /Elk/North East /Brandywine	9	7	1,514	0	0	0	0	0	0
22	Pennypack/Tacony	0	0	0	0	0	0	0	0	0
23	Lower Susquehanna East	7	7	167	0	0	0	0	0	0
24	Lower Susquehanna West	11	10	552	0	0	0	0	0	0
25	Potomac	3	3	17	0	0	0	0	0	0
26	Juniata	13	13	550	1	77	0	0	0	0
27	Kiski-Conemaugh	32	26	212	1	3	2	4	1	5
28	Youghioheny	15	14	1,114	0	0	1	1	0	0
29	Monongahela	5	5	243	0	0	1	1	0	0
30	Ohio	3	2	415	0	0	0	0	0	0
31	Allegheny	0	0	0	0	0	0	0	0	0
32	Moraine	5	5	1,412	0	0	1	2	0	0
33	Middle Allegheny	35	35	3,775	0	0	3	6	0	0
34	Upper Allegheny	1	1	7	0	0	0	0	0	0
35	Lake Erie/French & Oil Creek	5	4	1,092	0	0	0	0	1	19
Total		410	386	27,185	3	85	31	60	9	124

Table 5. Water-quality summary for stream sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Bed sediment and associated major ion parameters		Bed sediment and associated nutrient parameters		Bed sediment and associated rare earth element parameters		Bed sediment and associated trace element parameters		Bed sediment and associated volatile organic compound parameters		Bed sediment and associated wastewater compound parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	2	4	0	0	0	0	2	14	0	0	0	0
2	1	2	0	0	0	0	1	6	0	0	0	0
3	17	51	1	4	0	0	17	139	3	5	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	1	2	0	0	0	0	1	7	0	0	0	0
6	1	3	0	0	0	0	1	7	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	1	9	1	15	1	4
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	1	1	0	0	0	0	2	21	2	2	0	0
19	1	1	1	2	0	0	1	5	1	1	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0
27	2	4	0	0	0	0	2	8	1	1	0	0
28	1	9	1	1	1	8	1	28	0	0	0	0
29	0	0	0	0	1	8	1	28	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	1	3	0	0	0	0	1	7	0	0	0	0
33	3	8	0	0	0	0	3	27	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0
35	1	2	0	0	0	0	1	9	1	39	1	4
Total	32	90	3	7	2	16	35	315	9	63	2	8

Table 5. Water-quality summary for stream sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Biological parameters		Fish tissue parameters		Fungicide parameters		Herbicide parameters		Insecticide parameters		Ionic strength parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	5	10	0	0	0	0	0	0	0	0	6	50
2	6	83	0	0	0	0	0	0	0	0	21	432
3	79	1,891	10	908	1	1	1	3	1	22	162	9,339
4	0	0	0	0	0	0	0	0	0	0	0	0
5	5	81	1	67	0	0	0	0	0	0	6	247
6	3	3	0	0	0	0	0	0	0	0	6	17
7	3	12	0	0	0	0	0	0	0	0	3	16
8	2	2	0	0	0	0	0	0	0	0	2	17
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	1	9
12	4	42	0	0	0	0	0	0	0	0	4	255
13	0	0	0	0	0	0	0	0	0	0	0	0
14	6	58	4	247	0	0	0	0	0	0	8	184
15	7	303	2	297	0	0	0	0	0	0	17	1,153
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	2	5
18	1	6	0	0	0	0	0	0	1	1	3	75
19	2	36	0	0	0	0	0	0	0	0	2	184
20	0	0	0	0	0	0	0	0	0	0	0	0
21	6	748	6	313	1	91	1	705	2	2,212	7	1,556
22	0	0	0	0	0	0	0	0	0	0	0	0
23	2	171	0	0	0	0	0	0	0	0	7	65
24	3	129	1	64	1	1	1	2	1	22	10	379
25	3	38	0	0	0	0	0	0	0	0	3	13
26	11	114	0	0	0	0	2	753	2	512	12	291
27	2	3	0	0	0	0	0	0	0	0	26	154
28	5	167	0	0	0	0	0	0	0	0	14	622
29	1	45	0	0	0	0	0	0	0	0	5	180
30	3	141	2	97	0	0	0	0	0	0	2	338
31	0	0	0	0	0	0	0	0	0	0	0	0
32	2	213	1	99	0	0	0	0	0	0	5	1,296
33	4	234	2	128	0	0	0	0	0	0	34	2,039
34	0	0	0	0	0	0	0	0	0	0	1	5
35	1	242	2	144	1	1	0	0	0	0	4	1001
Total	166	4,772	31	2,364	4	94	5	1,463	7	2,769	373	19,922

Table 5. Water-quality summary for stream sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Major ion parameters		Microbiological parameters		Nutrient parameters		Physical parameters		Radiological parameters		Rare earth element parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	6	171	3	9	5	38	6	100	0	0	0	0
2	25	938	1	61	7	761	25	907	1	54	0	0
3	163	22,933	47	1,588	97	16,664	164	15,331	7	575	1	33
4	0	0	0	0	0	0	0	0	0	0	0	0
5	6	943	2	48	5	402	6	410	0	0	0	0
6	4	50	2	2	3	17	6	26	0	0	0	0
7	2	42	0	0	3	59	3	55	0	0	0	0
8	2	36	0	0	2	13	1	16	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	1	10	1	2	1	77	2	40	0	0	0	0
12	4	571	1	76	4	387	5	437	1	56	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	3	174	8	72	4	266	13	643	1	60	0	0
15	7	1,497	18	337	14	2,027	20	2,409	1	68	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	2	12	2	5	2	7	1	3	0	0	0	0
18	1	182	0	0	2	50	3	299	0	0	0	0
19	2	306	0	0	2	419	2	187	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	7	2,642	5	241	7	3,453	9	2,046	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	7	355	1	33	7	728	6	142	0	0	0	0
24	10	1,326	1	65	10	762	3	577	0	0	0	0
25	3	49	0	0	3	76	3	43	0	0	0	0
26	13	996	2	34	12	804	13	601	1	16	0	0
27	26	442	1	1	7	44	26	146	0	0	1	50
28	14	2,312	2	101	9	858	15	927	1	50	0	0
29	5	724	1	23	2	159	5	211	0	0	0	0
30	2	792	1	64	2	803	3	555	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	5	2,354	3	126	5	2,306	5	2,212	0	0	0	0
33	25	2,792	5	72	18	2,310	35	3,492	1	56	0	0
34	1	18	0	0	1	3	1	9	0	0	0	0
35	1	1,190	3	318	2	1,313	5	2,302	1	53	0	0
Total	347	43,857	110	3,278	236	34,806	386	34,126	15	988	2	83

Table 5. Water-quality summary for stream sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Suspended sediment parameters		Suspended sediment and associated biological parameters		Suspended sediment and associated insecticide parameters		Suspended sediment and associated major ion parameters		Suspended sediment and associated nutrient parameters		Suspended sediment and associated trace element parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	6	59	0	0	0	0	2	12	0	0	0	0
2	6	382	0	0	0	0	1	25	0	0	0	0
3	138	8,221	1	2	2	3	17	198	1	11	3	35
4	0	0	0	0	0	0	0	0	0	0	0	0
5	6	169	0	0	0	0	1	6	0	0	0	0
6	4	31	0	0	0	0	1	8	0	0	0	0
7	3	26	0	0	0	0	0	0	0	0	0	0
8	2	5	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	2	5	0	0	0	0	0	0	0	0	0	0
12	4	242	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	3	146	0	0	1	3	0	0	0	0	0	0
15	7	748	0	0	1	1	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	2	3	0	0	0	0	0	0	0	0	0	0
18	1	243	0	0	0	0	0	0	0	0	1	55
19	2	120	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	6	1,081	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	7	232	0	0	0	0	0	0	0	0	0	0
24	3	210	0	0	0	0	0	0	0	0	0	0
25	3	9	0	0	0	0	0	0	0	0	0	0
26	12	480	1	20	0	0	0	0	0	0	0	0
27	26	98	0	0	0	0	2	12	0	0	2	2
28	13	566	0	0	0	0	0	0	0	0	0	0
29	5	212	0	0	0	0	0	0	0	0	0	0
30	2	211	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	5	994	0	0	0	0	1	13	0	0	0	0
33	22	1,599	0	0	0	0	3	25	0	0	0	0
34	1	3	0	0	0	0	0	0	0	0	0	0
35	4	842	0	0	0	0	1	20	0	0	0	0
Total	295	16,937	2	22	4	7	29	319	1	11	6	92

Table 5. Water-quality summary for stream sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Suspended sediment and associated volatile organic compound parameters		Suspended sediment and associated wastewater compound parameters		Trace element parameters		Volatile organic compound parameters		Wastewater compound parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	0	0	0	0	5	12	0	0	0	0
2	0	0	0	0	20	430	0	0	0	0
3	0	0	0	0	139	16,230	6	52	3	54
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	4	902	1	61	1	40
6	0	0	0	0	3	3	0	0	0	0
7	0	0	0	0	2	4	0	0	0	0
8	0	0	0	0	1	13	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	1	7	0	0	0	0
12	0	0	0	0	4	163	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	1	2	1	1	1	29	1	3	1	2
15	0	0	0	0	1	1,404	2	82	1	7
16	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	2	13	0	0	0	0
18	0	0	0	0	1	51	0	0	0	0
19	0	0	0	0	2	298	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	6	3,983	1	118	2	3
22	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	6	285	1	12	0	0
24	0	0	0	0	9	2,116	2	85	2	69
25	0	0	0	0	2	4	0	0	0	0
26	0	0	0	0	11	229	1	13	0	0
27	0	0	0	0	24	365	0	0	0	0
28	0	0	0	0	12	1,187	1	59	2	41
29	0	0	0	0	5	426	1	24	0	0
30	0	0	0	0	1	2,221	1	6	1	67
31	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	3	1,441	1	98	1	1
33	0	0	0	0	17	1,985	0	0	0	0
34	0	0	0	0	1	23	0	0	0	0
35	1	3	1	1	1	1,265	2	96	0	0
Total	2	5	2	2	284	35,089	21	709	14	284

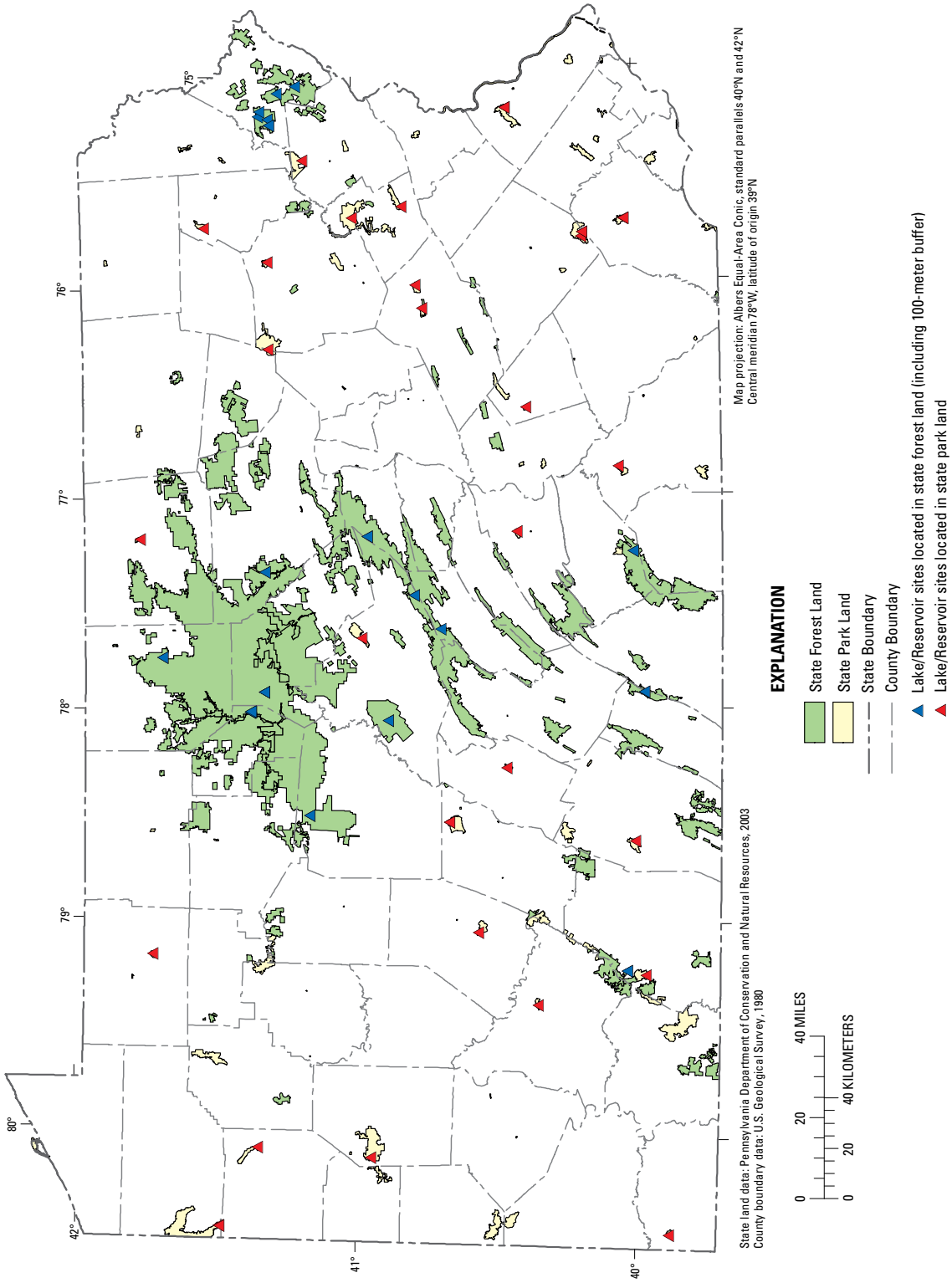

Figure 13. Location of lake sites with water-quality data in state forest and park lands (100-meter buffers included) in Pennsylvania retrieved from the U.S. Geological Survey database.

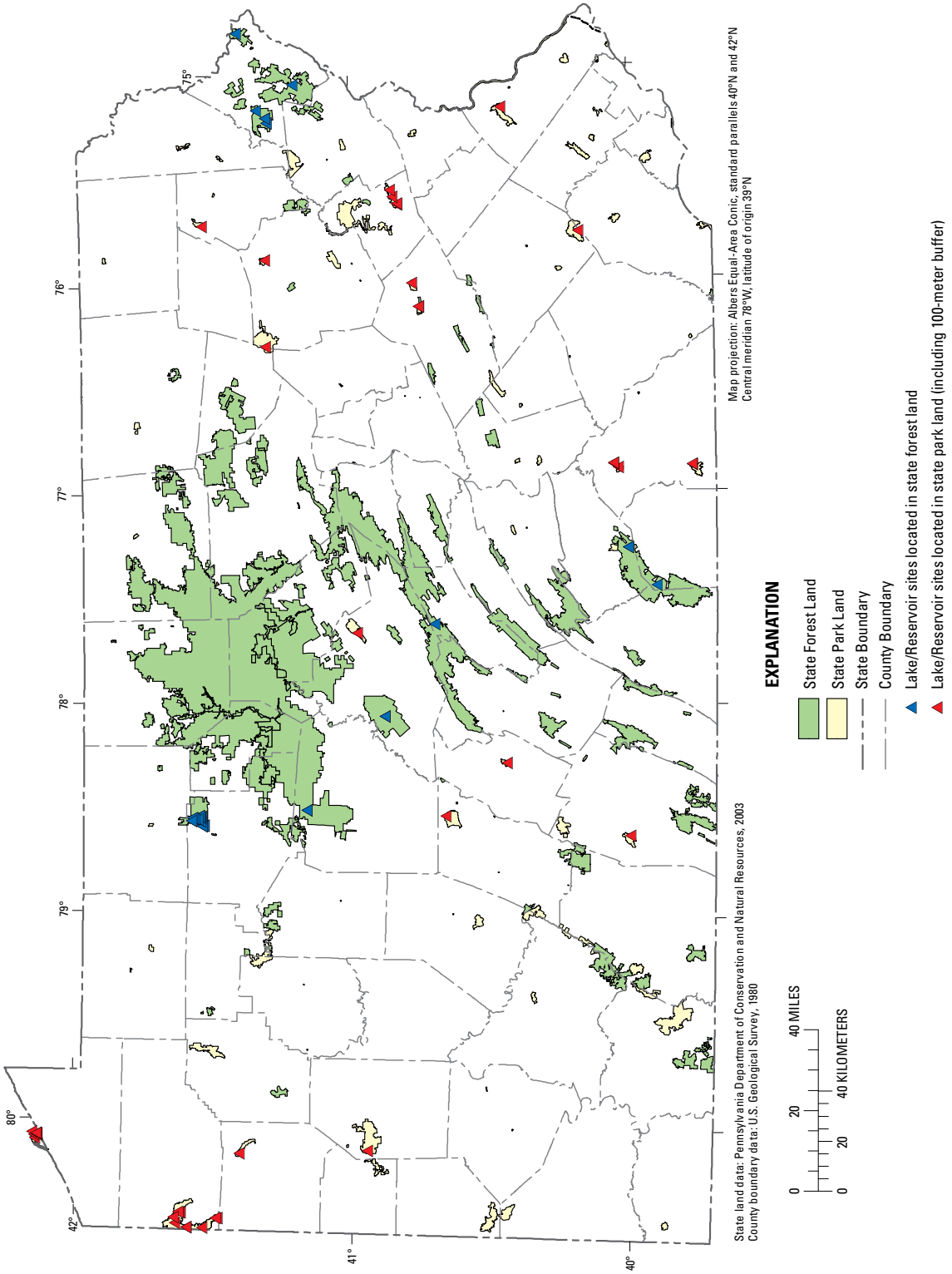

Figure 14. Location of lake sites with water-quality data retrieved from the U.S. Environmental Protection Agency Legacy STORET database for state forest and park lands (100-meter buffers included) in Pennsylvania.

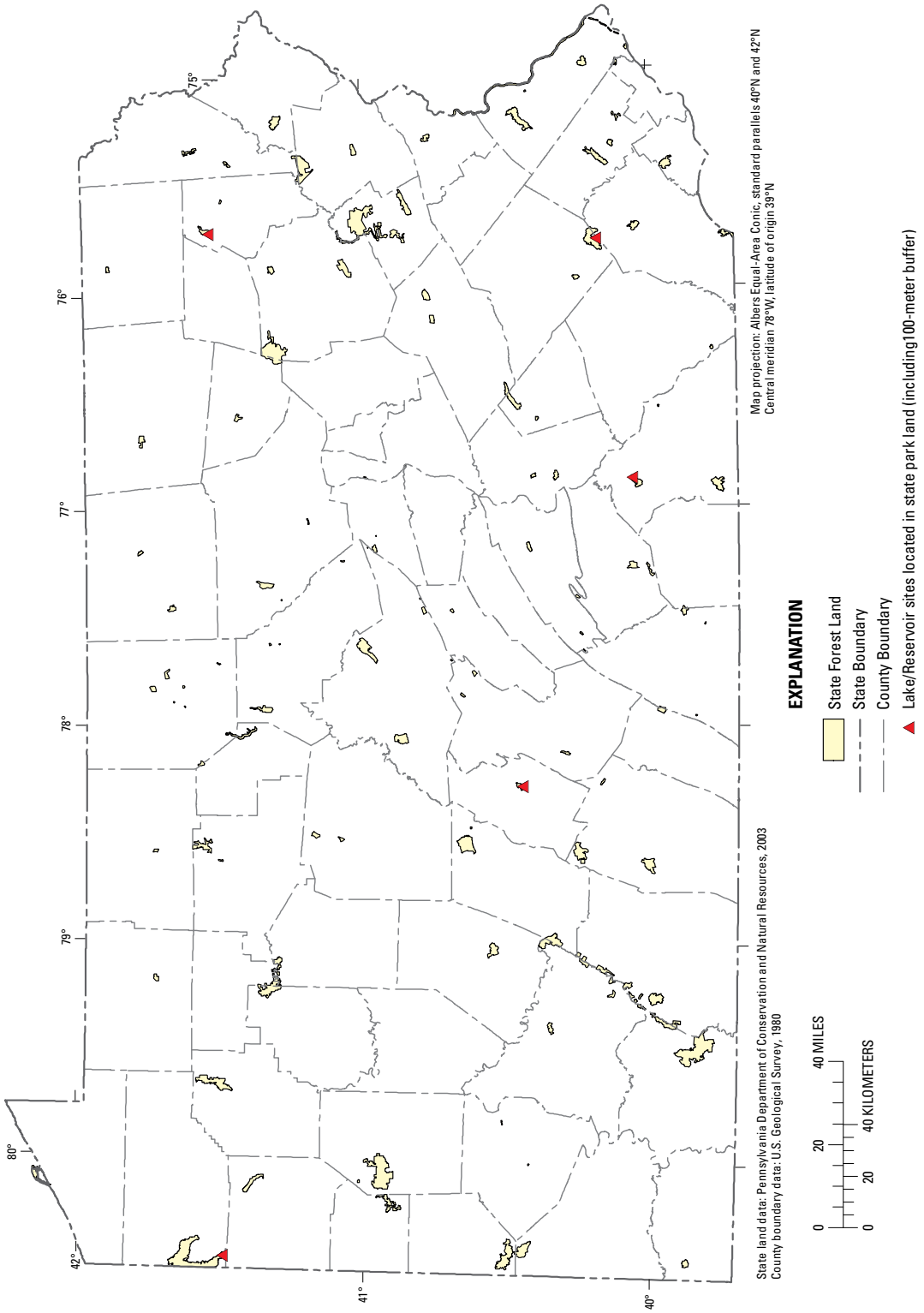

Figure 15. Location of lake sites with water-quality data in Pennsylvania state park lands (100-meter buffers included) that are part of the Water Quality Network of the Pennsylvania Department of Environmental Protection.

Table 6. Water-quality summary for lake sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.

Basin identification number	Basin name	Total sites	Acidity (pH) and alkalinity parameters		Bed sediment parameters		Bed sediment and associated herbicide parameters		Bed sediment and associated insecticide parameters	
			Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	Central Penn	3	3	59	0	0	0	0	1	2
2	Upper West Branch	5	4	27	1	3	0	0	2	5
3	Susquehannock/Genessee	8	7	50	3	9	1	3	2	18
4	Lower North Branch Susquehanna	2	1	4	1	3	0	0	1	2
5	Big Bend	1	1	4	0	0	0	0	1	4
6	Bradford/Tioga	1	1	4	1	3	1	1	1	2
7	Upper Susquehanna	2	2	7	1	3	1	2	1	4
8	Wyoming Valley	2	2	16	1	3	0	0	1	5
9	Lackawanna	0	0	0	0	0	0	0	0	0
10	Upper Delaware	11	10	30	6	17	1	1	6	13
11	Brodhead/Toby/Tunk	2	2	8	2	6	0	0	2	9
12	Upper Schuylkill/Middle Lehigh	8	7	44	3	9	1	1	3	13
13	Lower Lehigh	0	0	0	0	0	0	0	0	0
14	Delaware River/Tohickon Creek	3	2	13	0	0	0	0	0	0
15	Delaware Common Tributaries/Neshaminy	0	0	0	0	0	0	0	0	0
16	Middle Schuylkill	0	0	0	0	0	0	0	0	0
17	French/Manatawny	4	4	28	1	3	0	0	2	8
18	Perkiomen Creek	0	0	0	0	0	0	0	0	0
19	Lower Schuylkill (Wissahickon Creek)	0	0	0	0	0	0	0	0	0
20	Ridley/Darby/Chester/Crum Creeks	0	0	0	0	0	0	0	0	0
21	Christina /Elk/North East /Brandywine	2	2	12	0	0	0	0	0	0
22	Pennypack/Tacony	0	0	0	0	0	0	0	0	0
23	Lower Susquehanna East	1	1	4	1	3	1	1	1	5
24	Lower Susquehanna West	7	7	53	2	6	1	1	2	10
25	Potomac	1	1	12	0	0	0	0	0	0
26	Juniata	7	7	52	3	9	1	1	4	17
27	Kiski-Conemaugh	2	2	8	0	0	0	0	1	2
28	Youghioheny	2	2	8	0	0	0	0	2	8
29	Monongahela	0	0	0	0	0	0	0	0	0
30	Ohio	1	1	4	0	0	0	0	0	0
31	Allegheny	0	0	0	0	0	0	0	0	0
32	Moraine	15	11	153	2	5	0	0	4	8
33	Middle Allegheny	10	10	3,369	0	0	0	0	0	0
34	Upper Allegheny	1	1	4	1	3	0	0	1	3
35	Lake Erie/French & Oil Creek	6	2	90	0	0	0	0	0	0
Total		107	93	4,063	29	85	8	11	38	138

Table 6. Water-quality summary for lake sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Bed sediment and associated major ion parameters		Bed sediment and associated nutrient parameters		Bed sediment and associated trace element parameters		Bed sediment and associated volatile organic compound parameters		Biological parameters		Fish tissue parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	0	0	0	0	0	0	0	0	2	4	0	0
2	0	0	0	0	0	0	0	0	5	24	2	20
3	0	0	0	0	0	0	5	5	8	23	1	3
4	0	0	0	0	0	0	1	1	2	2	1	14
5	0	0	0	0	0	0	1	1	1	2	0	0
6	0	0	0	0	0	0	0	0	1	2	0	0
7	0	0	0	0	0	0	1	1	1	2	1	34
8	0	0	0	0	0	0	1	1	2	13	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	3	3	10	11	1	3
11	0	0	0	0	0	0	1	1	2	3	0	0
12	0	0	0	0	0	0	2	2	8	32	3	55
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	3	6	1	32
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	2	2	4	15	1	3
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	2	5	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	1	1	1	2	0	0
24	0	0	0	0	0	0	2	2	7	28	1	33
25	0	0	0	0	0	0	0	0	1	7	0	0
26	0	0	0	0	0	0	4	4	6	29	0	0
27	0	0	0	0	0	0	1	1	2	4	0	0
28	0	0	0	0	0	0	2	2	2	3	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	1	1	1	2	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	11	33	5	143
33	0	0	0	0	0	0	0	0	2	81	1	1
34	0	0	0	0	0	0	0	0	1	2	0	0
35	2	6	2	2	2	16	0	0	3	84	2	87
Total	2	6	2	2	2	16	28	28	88	419	20	428

Table 6. Water-quality summary for lake sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Fungicide parameters		Herbicide parameters		Insecticide parameters		Ionic strength parameters		Major ion parameters		Microbiological parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	0	0	0	0	0	0	3	46	2	199	0	0
2	0	0	0	0	0	0	4	28	4	78	1	1
3	0	0	0	0	0	0	7	45	7	151	0	0
4	0	0	0	0	0	0	1	3	1	12	0	0
5	0	0	0	0	0	0	1	3	1	12	0	0
6	0	0	0	0	0	0	1	3	1	11	0	0
7	0	0	0	0	0	0	2	6	2	19	1	3
8	0	0	0	0	0	0	2	15	2	49	1	7
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	10	22	10	113	0	0
11	0	0	0	0	0	0	2	6	2	24	0	0
12	0	0	0	0	0	0	7	36	4	78	1	10
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	2	12	2	39	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	4	24	4	73	1	1
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	2	11	2	38	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	1	3	1	11	0	0
24	0	0	0	0	0	0	7	46	5	101	0	0
25	0	0	0	0	0	0	1	12	1	28	0	0
26	0	0	0	0	0	0	7	47	7	149	0	0
27	0	0	0	0	0	0	2	5	2	23	0	0
28	0	0	0	0	0	0	2	4	2	21	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	1	3	1	13	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	11	85	7	166	1	4
33	1	3	1	2	1	21	10	1,549	7	910	0	0
34	0	0	0	0	0	0	1	3	1	12	0	0
35	0	0	0	0	0	0	2	52	2	140	2	132
Total	1	3	1	2	1	21	93	2,069	80	2,470	8	158

Table 6. Water-quality summary for lake sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Nutrient parameters		Physical parameters		Radiological parameters		Suspended sediment parameters		Suspended sediment and associated volatile organic compound parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	3	140	3	30	0	0	3	44	0	0
2	4	64	5	39	0	0	4	12	0	0
3	7	78	8	83	0	0	7	28	0	0
4	1	10	2	5	0	0	1	3	0	0
5	1	4	1	2	0	0	1	3	0	0
6	1	6	1	3	0	0	1	3	0	0
7	2	16	2	6	0	0	2	4	0	0
8	2	39	2	24	0	0	2	8	0	0
9	0	0	0	0	0	0	0	0	0	0
10	10	63	11	40	0	0	10	22	0	0
11	2	16	2	6	0	0	2	6	0	0
12	7	118	8	82	0	0	7	24	0	0
13	0	0	0	0	0	0	0	0	0	0
14	2	25	2	22	0	0	2	7	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	4	54	4	34	0	0	4	12	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
21	2	26	2	10	0	0	2	7	0	0
22	0	0	0	0	0	0	0	0	0	0
23	1	5	1	3	0	0	1	3	0	0
24	7	109	7	83	0	0	7	21	0	0
25	1	21	1	18	0	0	1	4	0	0
26	7	86	7	75	0	0	7	26	0	0
27	2	30	2	9	0	0	2	6	0	0
28	2	28	2	3	0	0	2	7	0	0
29	0	0	0	0	0	0	0	0	0	0
30	1	12	1	1	0	0	1	3	0	0
31	0	0	0	0	0	0	0	0	0	0
32	11	259	13	168	1	50	11	64	0	0
33	8	2,872	10	2,190	0	0	10	1,040	0	0
34	1	7	1	2	0	0	1	3	0	0
35	4	270	6	214	0	0	2	116	2	2
Total	93	4,358	104	3,152	1	50	93	1,476	2	2

Table 6. Water-quality summary for lake sites in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Trace element parameters		Volatile organic compound parameters		Wastewater compound parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	2	180	0	0	0	0
2	4	67	0	0	0	0
3	7	109	0	0	0	0
4	1	3	0	0	0	0
5	1	2	0	0	0	0
6	1	1	0	0	0	0
7	2	10	0	0	0	0
8	2	44	0	0	0	0
9	0	0	0	0	0	0
10	10	13	0	0	0	0
11	2	6	0	0	0	0
12	3	52	0	0	0	0
13	0	0	0	0	0	0
14	2	31	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	4	56	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	1	29	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	5	89	0	0	0	0
25	1	32	0	0	0	0
26	6	111	1	1	0	0
27	2	14	0	0	0	0
28	2	4	0	0	0	0
29	0	0	0	0	0	0
30	1	2	0	0	0	0
31	0	0	0	0	0	0
32	7	122	0	0	0	0
33	6	718	1	95	1	8
34	1	2	0	0	0	0
35	1	154	1	33	1	1
Total	74	1,851	3	129	2	9

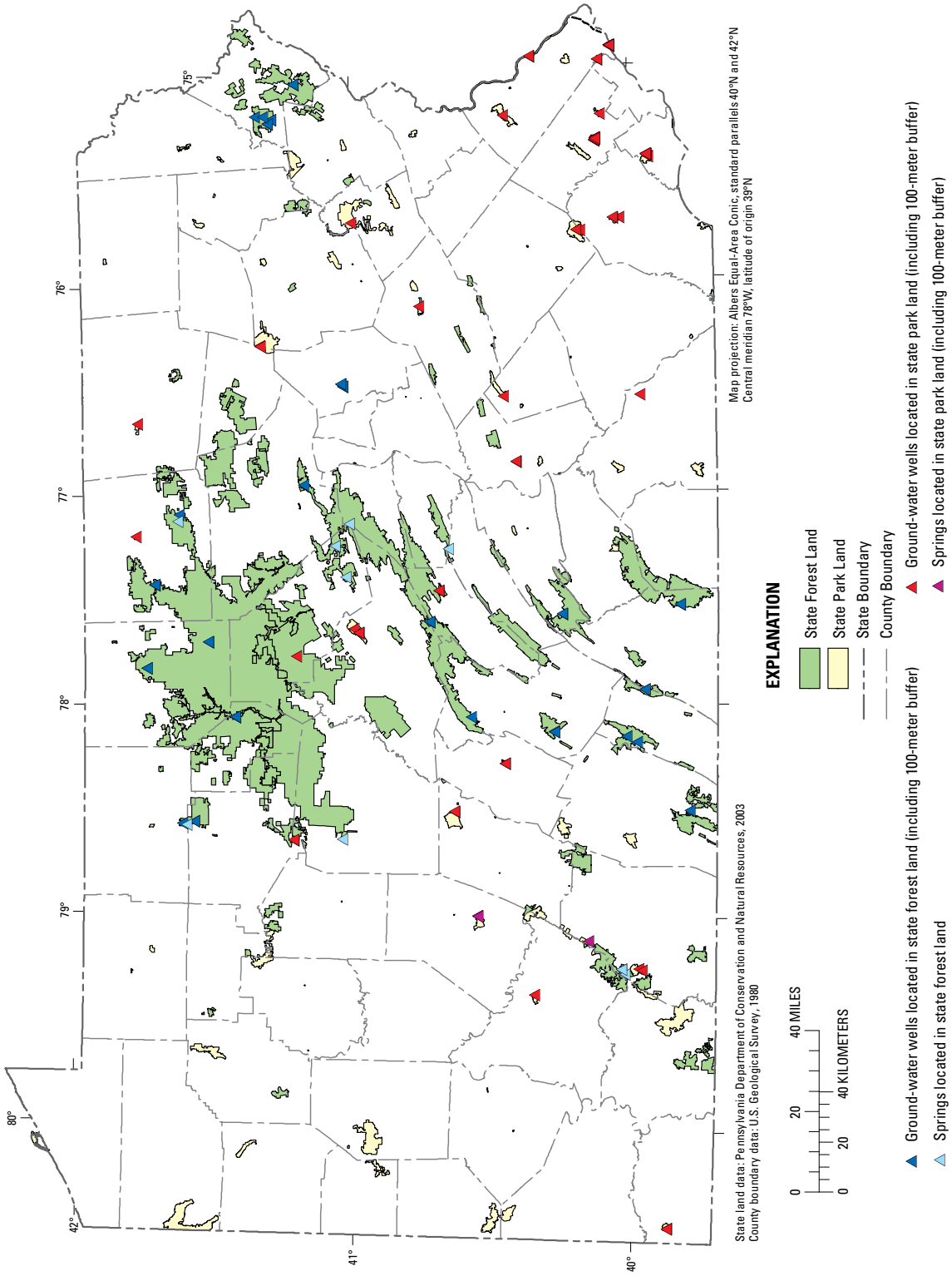

Figure 16. Location of ground-water wells and springs with water-quality data in state forest and park lands (100-meter buffers included) in Pennsylvania retrieved from the U.S. Geological Survey database.

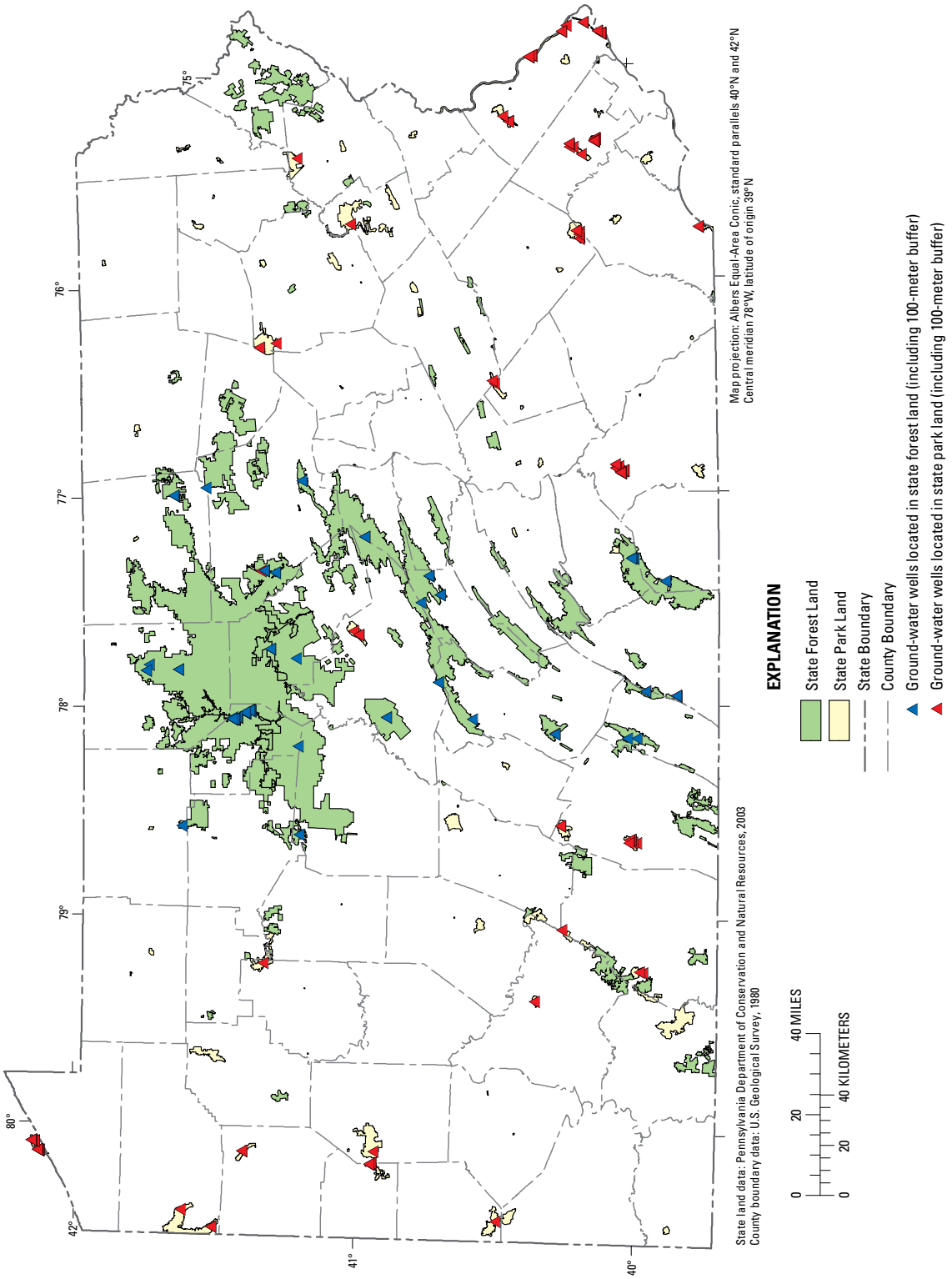

Figure 17. Location of ground-water wells with water-quality retrieved from U.S. Environmental Protection Agency Legacy STORET database for state forest and park lands (100-meter buffers included) in Pennsylvania.

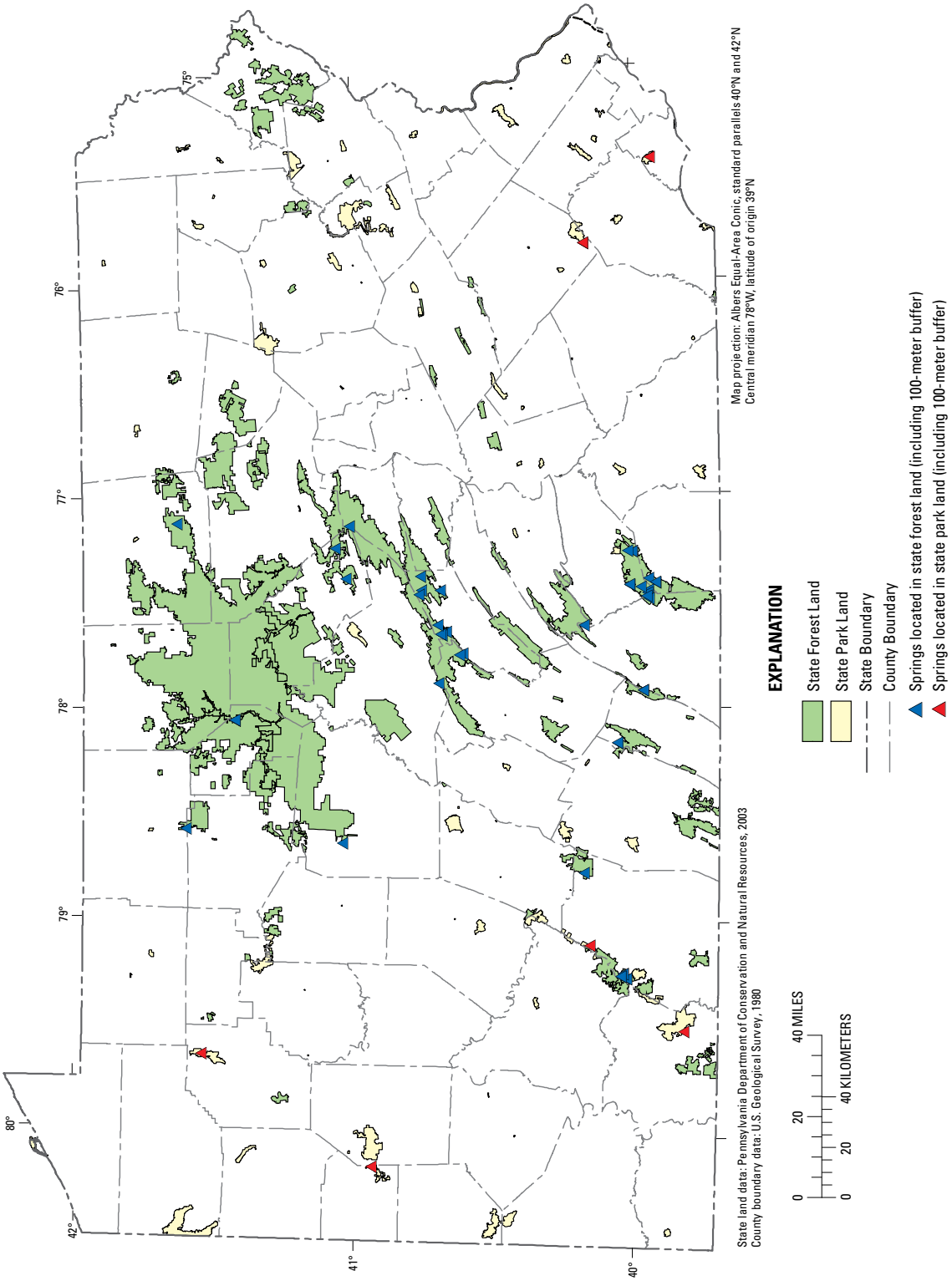

Figure 18. Location of springs with water-quality data retrieved from U.S. Environmental Protection Agency Legacy STORET database for state forest and park lands (100-meter buffers included) in Pennsylvania.

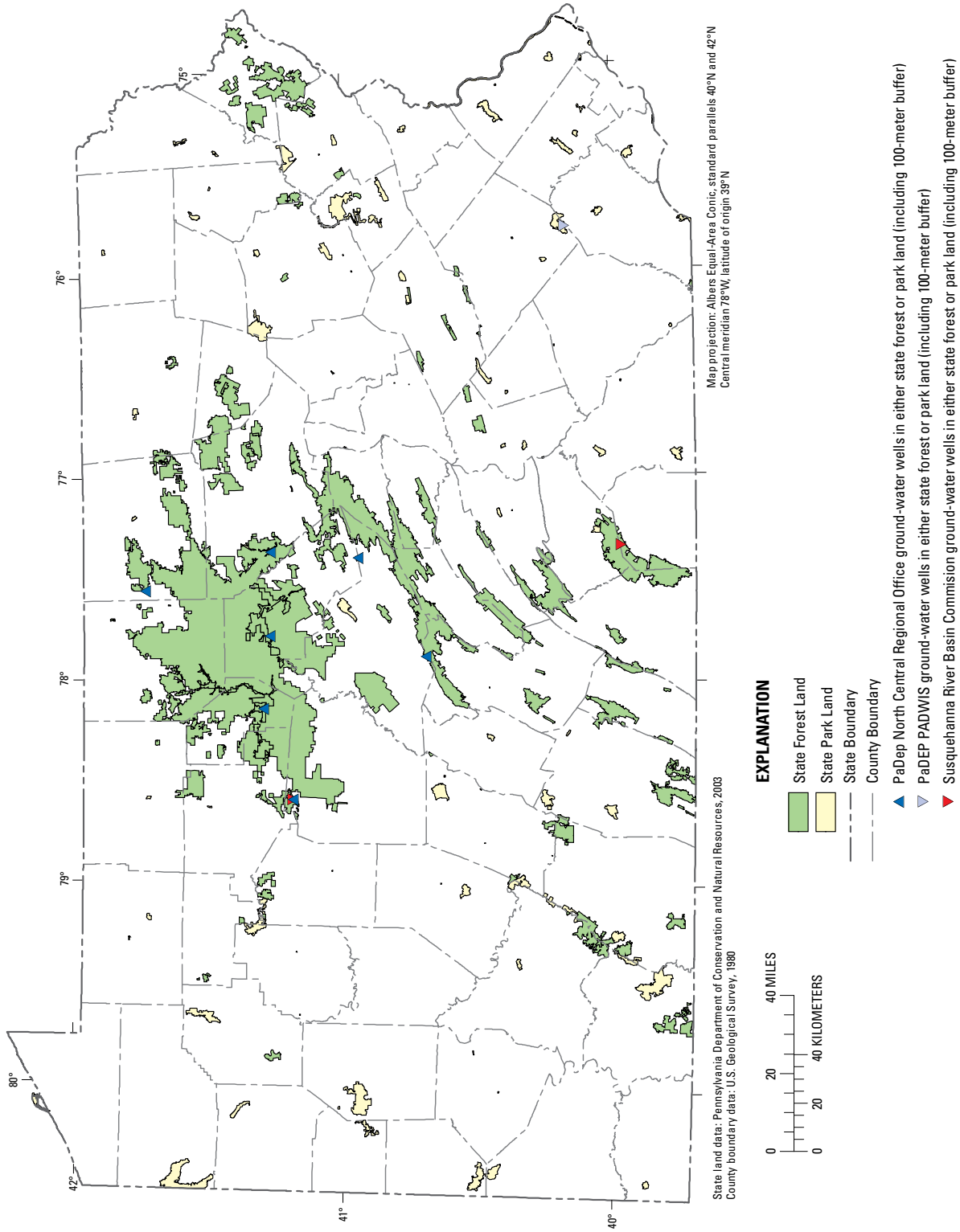

Figure 19. Location of ground-water wells with water-quality data retrieved from the Susquehanna River Basin Commission and the Pennsylvania Department of Environmental Protection databases for state forest and park lands (100-meter buffers included) in Pennsylvania.

were collected at any 1 well, and very little water-quality data were available for any of these wells; however, the 1 SRBC well in Clearfield County was sampled for volatile organic compounds (VOC), with 12 detections for 22 VOC analyses. Data for these nine wells were collected from 1993 to 2005.

A total of 205 wells (table 7) and 47 springs (table 8) in state lands had water-quality data available from the data sets compiled. The PABASID with data available for the most ground-water wells was #3 (Susquehannock/Genessee) followed by the Juniata Basin (#26); however, wells with water-quality data were very well-distributed in state lands across the state. Water-quality data for springs were not that well-distributed. There was a lack of water-quality data available for springs in PABASID #3, with only one site in state lands. The large majority of the springs with water-quality data were located in the central part of the state in PABASIDs #24 (Lower Susquehanna West with 9 springs) and #26 (Juniata with 12 springs). The uneven spatial coverage of springs may be a result of the naturally occurring uneven distribution of springs.

The most common types of water-quality data collected for wells in state lands were primarily major ions with almost 3,400 analyses, followed by nutrients and physical parameters with both over 2,000 analyses. Trace-element data were available for 92 sites and VOCs for 13 sites (table 7).

The predominant types of water quality collected for springs in state lands were major ions (748 analyses at all 47 sites) and trace elements (566 analyses at 37 sites). Acidity/alkalinity, nutrients, ionic strength, and physical parameters were available at almost all spring sites (table 8).

Summary

Water-quality data were compiled for streams, lakes, ground-water wells, and springs located in state lands and adjacent 100-meter buffers for data available primarily through January 2007. The majority of water-quality data compiled were for streams (410 sites), followed by ground-water wells and springs (205 and 47 sites, respectively), and lakes (107 sites). Data for stream sites and ground-water wells in state lands were well-distributed across the state; however, data for lakes and springs were more widely scattered, which may be a result of site availability. The most common types of water-quality data collected were major ions, trace elements, and nutrients. Some physical parameters, such as water temperature, stream discharge, or water level typically were collected for most water-quality samples.

Some of these sites are currently under a sampling schedule by some agency, such as the stream and lake sites that are part of PaDEP WQN. Therefore, additional water-quality data beyond these presented in this report are likely available for some sites. The original data that went into the water-quality summaries for this report are currently being stored at the USGS Office in New Cumberland, Pa., and are available as database format (dbf) files.

Benthic Macroinvertebrates

Benthic-macroinvertebrate sampling locations in state lands were retrieved from USGS NWIS, USEPA LEGACY and MODERN, SRBC, PaDEP, and the PaFBC. Benthic-macroinvertebrate sampling locations from USGS were either retrieved from the USGS NWIS (which has parameter codes for entry of counts for specific benthic-macroinvertebrate fauna) or sites were identified externally (Robin Brightbill, U.S. Geological Survey, oral commun., 2007) (appendix 18). From USGS NWIS, all benthic-macroinvertebrate samples were collected in 1979, and there were a total of 29 observations at 26 locations (appendix 18). An additional five benthic-macroinvertebrate sampling sites were external from NWIS (fig. 20 and appendix 18).

Benthic-macroinvertebrate sampling locations were also retrieved from USEPA LEGACY and MODERN (fig. 21 and appendix 19). Ten benthic-macroinvertebrate sites were retrieved from STORET, eight from LEGACY and two from MODERN. The eight sites from legacy STORET also were PaDEP WQN sites. The benthic-macroinvertebrate sites in MODERN (in Clinton and Cameron Counties) were not in LEGACY. Benthic-macroinvertebrate samples in LEGACY were collected in either 1973 or 1974; the two sites in MODERN were sampled in 2004.

Benthic-macroinvertebrate sampling locations were retrieved from SRBC for some of the same locations for which SRBC collected water-quality data. Fifty-five benthic-macroinvertebrate sampling locations (with 89 total samples) were retrieved from SRBC (fig. 22 and appendix 20). The benthic-macroinvertebrate samples from SRBC were collected from the mid-1990s to the mid-2000s with 52 of the samples collected in PABASID #3 (Susquehannock/Genessee).

The largest number of benthic-macroinvertebrate sample locations retrieved from any one source was from a PaDEP internal database that has a list of all the sites sampled across the state for the purpose of determining whether streams are impaired. The PaDEP internal database had a total of 980 benthic-macroinvertebrate samples collected in state lands (fig. 23 and appendix 21). These benthic-macroinvertebrate sampling sites generally covered the entire state, and sample dates ranged from 1991 to 2006. Approximately 30 percent (321 samples) were collected in PABASID #3 (Susquehannock/Genessee). The only three PABASIDs where PaDEP did not collect samples in state lands were #9 (Lackawanna), #16 (Middle Schuylkill), and #31 (Allegheny), but these PABASIDs have very limited amounts of state lands (see table 1).

PFBC collected benthic-macroinvertebrate samples across Pennsylvania from 1977 through 2001. The site information data retrieved electronically from PFBC contained 14 widely-scattered locations in state lands (fig. 24 and appendix 22).

Table 7. Water-quality summary for ground-water wells in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.

Basin identification number	Basin name	Total sites	Acidity (pH) and alkalinity parameters		Biological parameters		Fungicide parameters		Herbicide parameters	
			Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	Central Penn	7	7	70	0	0	0	0	0	0
2	Upper West Branch	2	2	7	0	0	0	0	0	0
3	Susquehannock/Genessee	32	32	96	4	15	0	0	0	0
4	Lower North Branch Susquehanna	7	7	81	0	0	0	0	0	0
5	Big Bend	4	4	10	0	0	0	0	0	0
6	Bradford/Tioga	4	4	18	1	4	0	0	0	0
7	Upper Susquehanna	0	0	0	0	0	0	0	0	0
8	Wyoming Valley	0	0	0	0	0	0	0	0	0
9	Lackawanna	0	0	0	0	0	0	0	0	0
10	Upper Delaware	6	6	26	6	6	0	0	0	0
11	Brodhead/Toby/Tunk	3	3	14	0	0	0	0	0	0
12	Upper Schuylkill/Middle Lehigh	1	1	10	1	1	1	5	1	76
13	Lower Lehigh	0	0	0	0	0	0	0	0	0
14	Delaware River/Tohickon Creek	4	4	11	0	0	0	0	0	0
15	Delaware Common Tributaries/Neshaminy	17	17	513	8	110	0	0	0	0
16	Middle Schuylkill	0	0	0	0	0	0	0	0	0
17	French/Manatawny	6	5	18	3	5	0	0	0	0
18	Perkiomen Creek	4	4	18	4	9	0	0	0	0
19	Lower Schuylkill (Wissahickon Creek)	16	15	56	3	5	1	1	1	29
20	Ridley/Darby/Chester/Crum Creeks	5	5	24	0	0	0	0	0	0
21	Christina /Elk/North East /Brandywine	3	3	34	3	4	1	2	1	28
22	Pennypack/Tacony	1	1	4	1	1	0	0	0	0
23	Lower Susquehanna East	4	4	7	1	1	0	0	0	0
24	Lower Susquehanna West	17	16	35	4	6	0	0	0	0
25	Potomac	3	3	14	2	3	1	1	1	55
26	Juniata	22	21	67	3	4	0	0	0	0
27	Kiski-Conemaugh	3	3	11	0	0	0	0	0	0
28	Youghioheny	3	3	39	1	1	0	0	0	0
29	Monongahela	0	0	0	0	0	0	0	0	0
30	Ohio	3	6	34	2	2	0	0	0	0
31	Allegheny	0	0	0	0	0	0	0	0	0
32	Moraine	7	4	10	5	7	0	0	0	0
33	Middle Allegheny	5	5	33	0	0	0	0	0	0
34	Upper Allegheny	0	0	0	0	0	0	0	0	0
35	Lake Erie/French & Oil Creek	16	16	140	16	48	0	0	0	0
Total		205	201	1,400	68	232	4	9	4	188

Table 7. Water-quality summary for ground-water wells in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Insecticide parameters		Ionic strength parameters		Major ion parameters		Microbiological parameters		Nutrient parameters		Physical parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	0	0	7	51	5	218	0	0	5	123	5	78
2	0	0	1	2	1	11	0	0	1	5	2	4
3	0	0	28	97	28	304	0	0	25	72	27	239
4	0	0	7	110	7	338	0	0	7	46	7	123
5	0	0	4	6	4	27	0	0	4	15	4	25
6	0	0	4	12	4	77	0	0	4	37	4	23
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	6	19	6	72	0	0	6	37	6	22
11	0	0	3	15	3	51	0	0	3	14	3	33
12	1	33	1	7	1	26	1	2	1	17	1	17
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	4	7	4	30	0	0	4	10	4	29
15	0	0	17	375	17	726	0	0	17	1,131	17	638
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	5	15	5	69	1	5	4	19	5	40
18	0	0	4	18	4	80			4	33	4	17
19	1	19	15	36	15	147	0	0	14	71	16	132
20	0	0	5	15	4	18	1	7	1	3	5	27
21	1	34	3	24	3	83	0	0	3	58	3	35
22	0	0	1	4	1	13	0	0	1	10	1	6
23	0	0	4	7	4	30	1	1	4	8	4	14
24	0	0	16	37	15	145	1	7	15	37	16	112
25	1	32	3	10	3	46	0	0	3	25	3	14
26	0	0	20	50	21	210	3	18	17	75	22	132
27	0	0	3	5	3	18	0	0	2	12	3	14
28	0	0	3	20	3	129	0	0	3	55	3	50
29	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	6	18	6	78	0	0	6	14	6	50
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	3	8	6	38	2	2	5	18	4	6
33	0	0	5	25	5	109	0	0	3	21	5	48
34	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	16	128	16	288	0	0	16	280	16	92
Total	4	118	194	1,121	194	3,381	10	42	178	2,246	196	2,020

Table 7. Water-quality summary for ground-water wells in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Radiological parameters		Rare earth element parameters		Suspended sediment parameters		Suspended sediment and associated major ion parameters		Suspended sediment and associated nutrient parameters		Trace element parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	0	0	0	0	5	48	0	0	0	0	1	179
2	0	0	0	0	1	3	0	0	0	0	1	4
3	0	0	0	0	23	53	0	0	0	0	14	53
4	2	2	0	0	7	46	0	0	0	0	1	1
5	0	0	0	0	4	7	0	0	0	0	1	9
6	0	0	0	0	4	11	0	0	0	0	4	92
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	2	2	0	0	6	12	0	0	0	0	1	6
11	0	0	0	0	3	10	0	0	0	0	1	2
12	1	12	1	1	1	7	0	0	0	0	1	21
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	4	5	0	0	0	0	0	0
15	0	0	0	0	17	150	4	5	0	0	9	503
16	0	0	0	0	0	0	0	0	0	0	0	0
17	1	5	1	1	5	15	0	0	0	0	3	33
18	0	0	0	0	4	17	3	64	0	0	0	0
19	2	17	2	2	14	40	0	0	0	0	12	113
20	0	0	0	0	1	3	0	0	0	0	1	2
21	1	2	1	1	3	19	0	0	1	1	3	40
22	0	0	0	0	1	3	0	0	0	0	1	11
23	1	3	0	0	3	5	0	0	0	0	2	6
24	0	0	0	0	14	21	0	0	0	0	13	65
25	1	5	1	1	3	10	0	0	0	0	2	24
26	2	13	0	0	19	38	0	0	0	0	11	51
27	0	0	0	0	3	5	0	0	0	0	0	0
28	0	0	0	0	3	22	0	0	0	0	3	121
29	0	0	0	0	0	0	0	0	0	0	0	0
30	2	2	0	0	6	16	4	6	0	0	2	14
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	4	8	0	0	0	0	3	26
33	0	0	0	0	4	25	0	0	0	0	2	41
34	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	16	96	0	0	0	0	0	0
Total	15	63	6	6	178	695	11	75	1	1	92	1,417

Table 7. Water-quality summary for ground-water wells in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Volatile organic compound parameters		Wastewater compound parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses
1	0	0	0	0
2	0	0	0	0
3	1	22	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	1	83	1	1
13	0	0	0	0
14	0	0	0	0
15	6	136	0	0
16	0	0	0	0
17	0	0	1	1
18	0	0	0	0
19	1	83	0	0
20	1	28	0	0
21	2	102	0	0
22	1	10	0	0
23	0	0	1	1
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
Total	13	464	3	3

Table 8. Water-quality summary for springs in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.

Basin identification number	Basin name	Total sites	Acidity (pH) and alkalinity parameters		Biological parameters		Ionic strength parameters		Major ion parameters	
			Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	Central Penn	3	3	17	1	1	3	9	3	41
2	Upper West Branch	1	1	4	0	0	1	4	1	14
3	Susquehannock/Genessee	1	1	4	0	0	1	6	1	19
4	Lower North Branch Susquehanna	0	0	0	0	0	0	0	0	0
5	Big Bend	1	1	4	0	0	1	3	1	14
6	Bradford/Tioga	1	1	4	0	0	1	2	1	5
7	Upper Susquehanna	0	0	0	0	0	0	0	0	0
8	Wyoming Valley	0	0	0	0	0	0	0	0	0
9	Lackawanna	0	0	0	0	0	0	0	0	0
10	Upper Delaware	0	0	0	0	0	0	0	0	0
11	Brodhead/Toby/Tunk	0	0	0	0	0	0	0	0	0
12	Upper Schuylkill/Middle Lehigh	0	0	0	0	0	0	0	0	0
13	Lower Lehigh	0	0	0	0	0	0	0	0	0
14	Delaware River/Tohickon Creek	0	0	0	0	0	0	0	0	0
15	Delaware Common Tributaries/Neshaminy	0	0	0	0	0	0	0	0	0
16	Middle Schuylkill	1	0	0	0	0	0	0	1	7
17	French/Manatawny	0	0	0	0	0	0	0	0	0
18	Perkiomen Creek	0	0	0	0	0	0	0	0	0
19	Lower Schuylkill (Wissahickon Creek)	0	0	0	0	0	0	0	0	0
20	Ridley/Darby/Chester/Crum Creeks	1	1	20	1	10	1	20	1	90
21	Christina /Elk/North East /Brandywine	0	0	0	0	0	0	0	0	0
22	Pennypack/Tacony	0	0	0	0	0	0	0	0	0
23	Lower Susquehanna East	0	0	0	0	0	0	0	0	0
24	Lower Susquehanna West	9	9	32	9	17	9	34	9	141
25	Potomac	3	3	10	2	4	3	9	3	40
26	Juniata	12	12	42	9	18	11	38	12	176
27	Kiski-Conemaugh	4	4	15	0	0	4	9	4	29
28	Youghioheny	6	6	28	5	6	6	20	6	65
29	Monongahela	0	0	0	0	0	0	0	0	0
30	Ohio	0	0	0	0	0	0	0	0	0
31	Allegheny	0	0	0	0	0	0	0	0	0
32	Moraine	1	1	8	1	1	1	12	1	32
33	Middle Allegheny	2	2	12	1	1	2	12	2	43
34	Upper Allegheny	0	0	0	0	0	0	0	0	0
35	Lake Erie/French & Oil Creek	1	1	8	1	1	1	12	1	32
Total		47	46	208	30	59	45	190	47	748

Table 8. Water-quality summary for springs in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.—Continued

Basin identification number	Microbiological parameters		Nutrient parameters		Physical parameters		Rare earth element parameters		Suspended sediment parameters		Suspended sediment and associated trace element parameters		Trace element parameters	
	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses	Number of sites	Number of analyses
1	0	0	3	21	3	18	0	0	3	10	0	0	2	24
2	0	0	1	7	1	3	0	0	1	3	0	0	1	16
3	0	0	1	2	1	4	0	0	1	3	0	0	1	3
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	1	6	1	2	0	0	1	2	0	0	1	15
6	0	0	1	5	1	2	0	0	1	1	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	1	2	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	1	40	1	3	0	0	1	20	0	0	1	80
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	9	68	9	30	0	0	9	34	0	0	9	136
25	0	0	2	16	3	8	1	2	2	8	0	0	3	34
26	1	4	12	83	12	42	0	0	12	41	0	0	10	147
27	0	0	4	15	4	10	1	2	3	5	1	1	2	13
28	0	0	5	28	6	40	0	0	3	5	0	0	3	17
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	1	19	1	5	0	0	1	6	0	0	1	36
33	0	0	1	8	2	9	0	0	2	7	0	0	2	17
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	1	17	1	4	0	0	1	8	0	0	1	28
Total	1	4	44	337	46	180	2	4	41	153	1	1	37	566

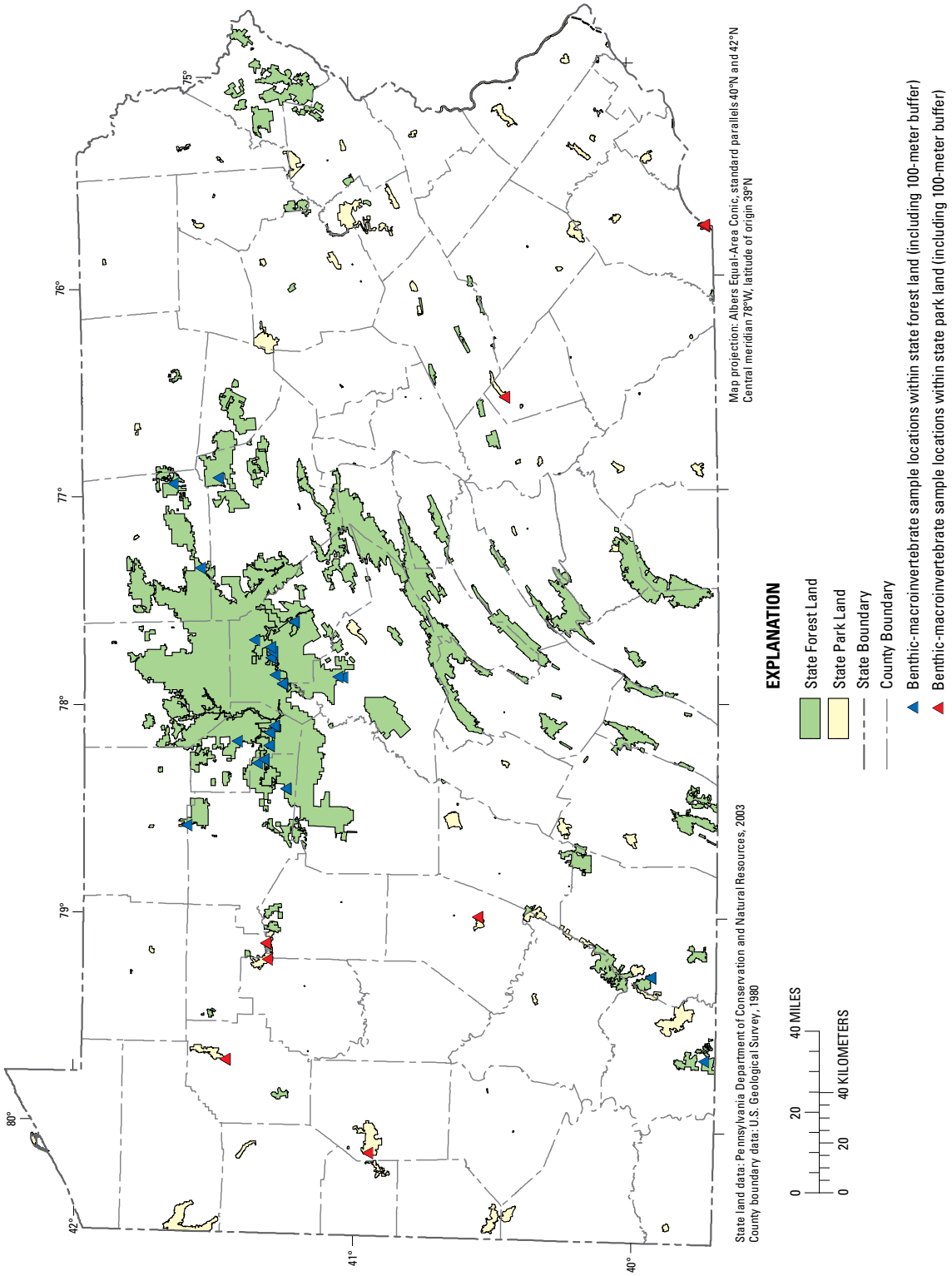

Figure 20. Benthic-macroinvertebrate sample locations retrieved from U.S. Geological Survey database for state forest and park lands (100-meter buffers included) in Pennsylvania.

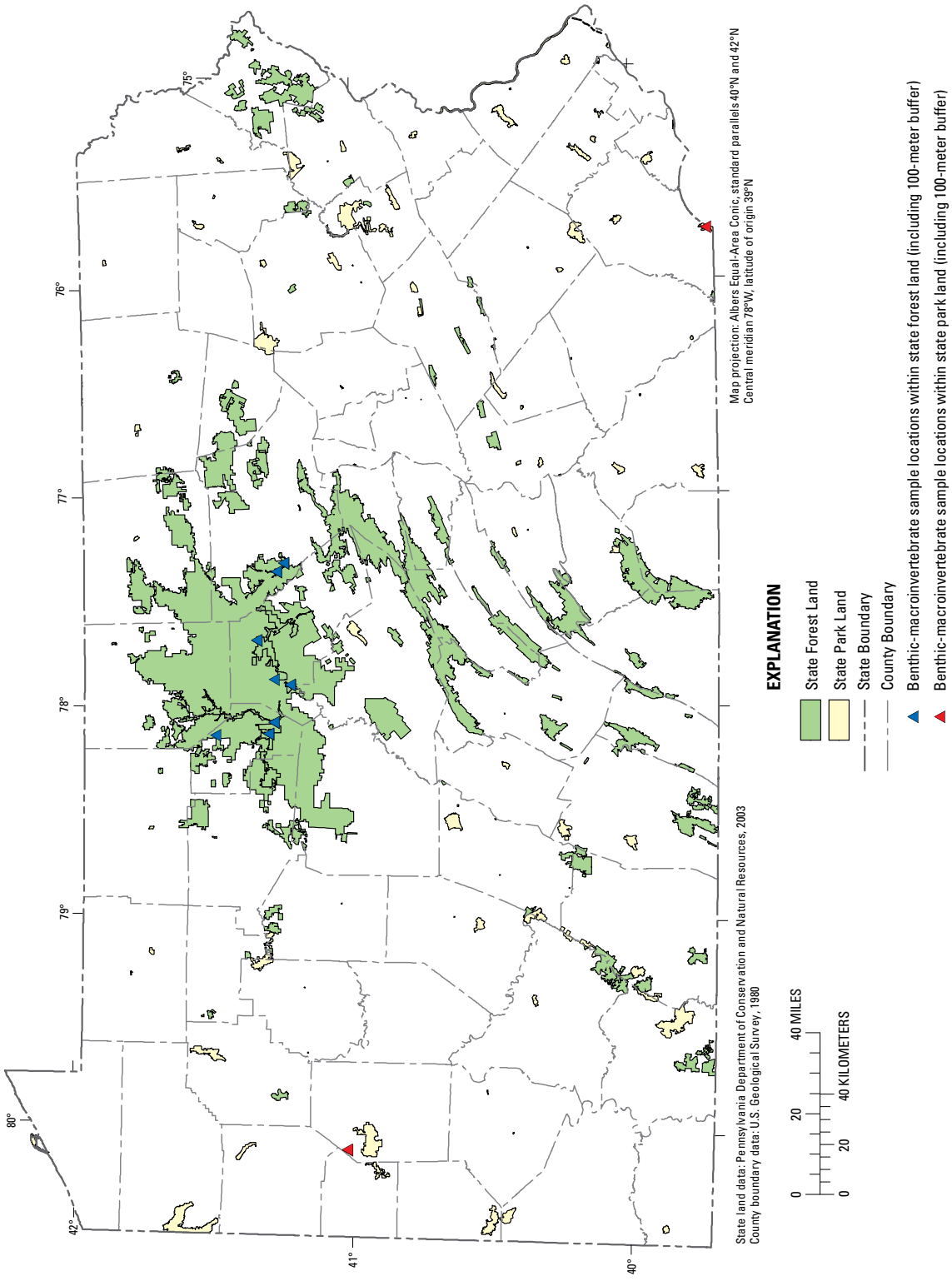

Figure 21. Benthic-macroinvertebrate sample locations retrieved from U.S. Environmental Protection Agency Legacy and Modernized STORET databases for state forest and park lands (100-meter buffers included) in Pennsylvania.

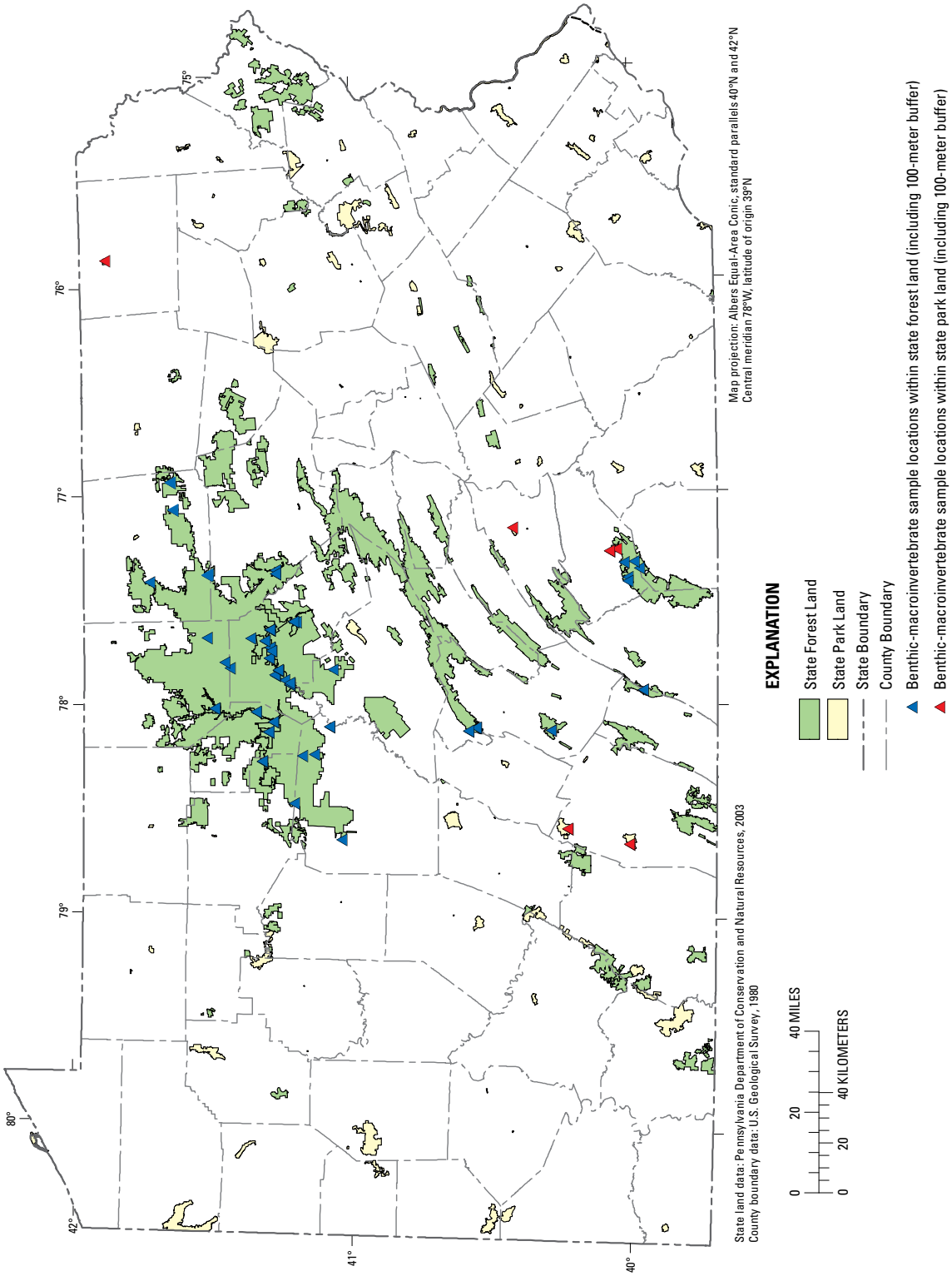

Figure 22. Benthic-macroinvertebrate sample locations retrieved from the Susquehanna River Basin Commission database for state forest and park lands (100-meter buffers included) in Pennsylvania.

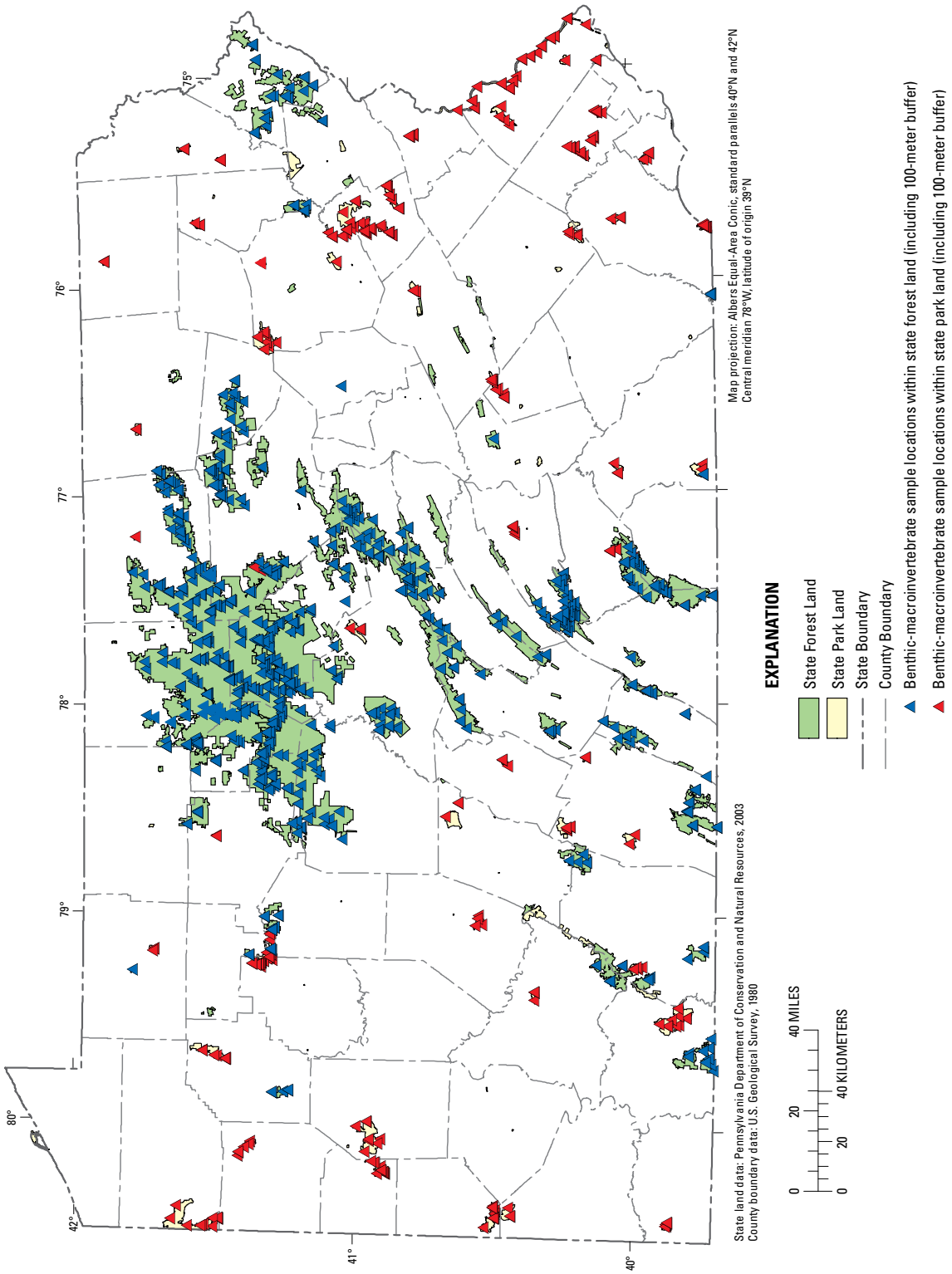

Figure 23. Benthic-macroinvertebrate sample locations retrieved from the Pennsylvania Department of Environmental Protection database for state forest and park lands (100-meter buffers included) in Pennsylvania.

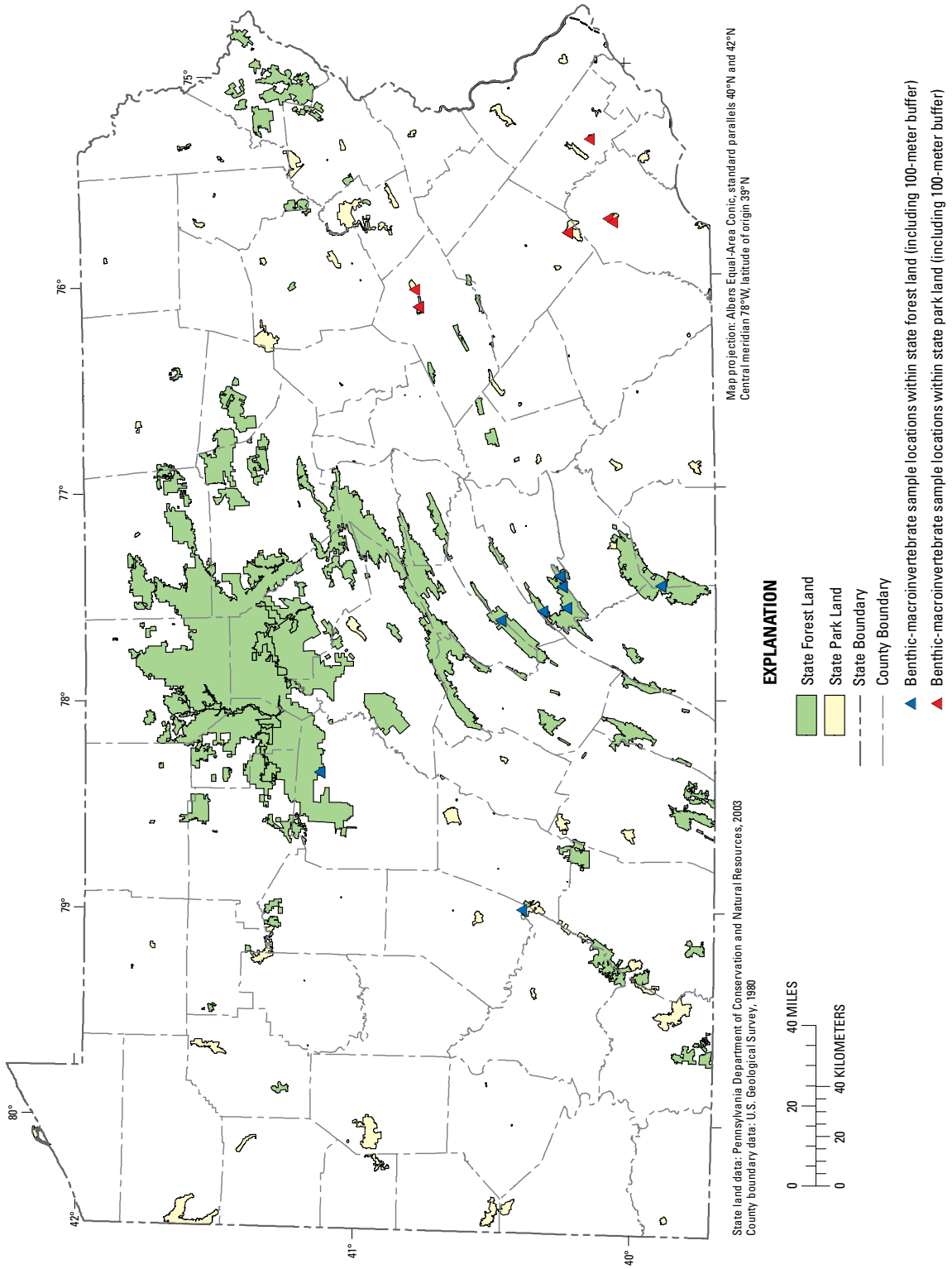

Figure 24. Benthic-macroinvertebrate sample locations obtained from the Pennsylvania Fish and Boat Commission for Pennsylvania state forest and park lands (100-meter buffers included).

Summary

Given the large database available from PaDEP for benthic macroinvertebrates, along with the other data from the other agencies (USGS, SRBC, USEPA, and PaFBC), there is very good distribution of benthic-macroinvertebrate population data for state lands. A total of 1,077 benthic-macroinvertebrate samples were collected statewide with 391 samples collected in PABASID #3 (Susquehannock/Genessee) (table 9). The only other PABASIDs with more than 70 benthic-macroinvertebrate samples were #24 (Lower Susquehanna West with 81 samples), #26 (Juniata with 78 samples), and #5 (Big Bend with 73 samples). No benthic-macroinvertebrate samples were available in PABASIDs #9 (Lackawanna), #16 (Middle Schuykill), and #31 (Allegheny), but each of these PABASIDs has no more than 2 mi^2 of state lands, with #31 having only 0.05 mi^2, the lowest of all PABASIDs (table 1).

As with the water-quality data, the benthic-macroinvertebrate data were compiled in early 2007, and it is likely that additional data are available for state lands, especially because PaDEP is continually assessing waters across the state to determine if impairment has occurred or improved. However, it is unclear how useful benthic-macroinvertebrate data may be in the context of any ecological-flow assessment because its value would be determined by the type of flow assessment. Ancillary data typically collected with benthic-macroinvertebrate samples such as stream habitat characteristics also could be useful, and these data may be available from the collecting agency.

Geographic Information System Coverages

Depending on the methodology to develop a water budget or assess instream-flow needs, a number of different GIS coverages are required. Coverages that may be pertinent in assessing water availability and the ecological implications are listed in table 10. Presently, data accessed at the link to the USGS DEM (digital elevation model) website can be used to generate elevation contours (see link in table 10); however, the state of Pennsylvania is currently funding a program to generate LiDAR (light detection and ranging) data for the entire state. These data will be available at the PASDA site once the project is complete. LiDAR data are expected to give better resolution elevation data than the DEM data currently available; however, processing costs of LiDAR data may outweigh the benefits associated with using LiDAR data.

Three links for drainage-basin delineations are given in table 10. One source, StreamStats (*http://water.usgs.gov/osw/streamstats/pennsylvania.html*), can be used to delineate the drainage area for any point in any stream in the state of Pennsylvania. This may be very advantageous for PaDCNR as points of interest in state forests and parks are identified. StreamStats can provide a relatively quick basin delineation that would help to identify the area of the basin of interest. Once delineated, a shape file of the basin can be saved in StreamStats and can be used to identify any existing sites with water quantity and quality data for that area.

Site-specific data on channel characteristics (such as wetted width, average water depth, etc.) and the biological fauna will be necessary in order to develop instream-flow needs for specific species. The required methodology to look at just one species was presented by Denslinger and others (1998) for brook trout. This methodology is very field intensive, even if the stream reach is continuously gaged. If the reach is not gaged, then, initially, using index stations to mimic stream hydrographs would be required. Following that step, the procedure by Denslinger for brook trout could be applied after the hydrograph (daily values for stream discharge) for the study reach has been estimated.

The physical attributes in table 10 are a general list of some of the physical attributes that may be pertinent for water-resource management and decision making; however, other GIS coverages could be necessary, especially for studies that are focused on ecological-flow requirements. One example would be tree cover along a riparian zone, which could be used to indirectly determine the amount of incoming solar radiation reaching the stream channel.

Summary And Conclusions

Electronically available data were compiled for Pennsylvania state lands (state forests and parks) for the Pennsylvania Department of Conservation and Natural Resources so that the agency could initially determine if data exist to make an objective evaluation of water resources for specific basins within state lands. Although many data are available, the required data for a specific analyses will be dictated by the type of evaluation. An annual water-budget determination would require much different data than an ecological-flow or a water-quality assessment. Therefore, in this report, various types of electronic data were retrieved, including water quantity, water quality, benthic-macroinvertebrate sample locations, and geographic information systems coverages. The compilation and summary of data in this report allow for quick determination of available data and whether more data may be required for the particular task at hand.

The water-quantity, water-quality, and benthic-macroinvertebrate sample location data compiled were well-distributed across the state; however, selected areas of interest in state lands may not have adequate data for a specific task, such as developing a water budget. Data-estimation techniques can be used to generate some of the necessary streamflow and precipitation data for a water-budget study if measured data for a specific area are not adequate. Data-estimation techniques are discussed in this report. For other tasks, such as an ecological-flow or water-quality assessment, data provided in this report provide an initial source of information. The available data described in this report would not be sufficient for a specific basin-wide water-quality or ecological-flow assessment. Determination of annual water budgets in selected basins is the task best supported by the data currently available.

Table 9. Summary of benthic-macroinvertebrate samples in Pennsylvania state forest and park lands (100-meter buffers included) retrieved from all available electronic databases.

Basin identification number	Basin name	Number of samples
1	Central Penn	45
2	Upper West Branch	51
3	Susquehannock/Genessee	391
4	Lower North Branch Susquehanna	6
5	Big Bend	73
6	Bradford/Tioga	27
7	Upper Susquehanna	14
8	Wyoming Valley	10
9	Lackawanna	0
10	Upper Delaware	24
11	Brodhead/Toby/Tunk	22
12	Upper Schuylkill/Middle Lehigh	24
13	Lower Lehigh	5
14	Delaware River/Tohickon Creek	12
15	Delaware Common Tributaries/Neshaminy	11
16	Middle Schuylkill	0
17	French/Manatawny	4
18	Perkiomen Creek	9
19	Lower Schuylkill (Wissahickon Creek)	8
20	Ridley/Darby/Chester/Crum Creeks	3
21	Christina /Elk/North East /Brandywine	9
22	Pennypack/Tacony	1
23	Lower Susquehanna East	12
24	Lower Susquehanna West	66
25	Potomac	26
26	Juniata	65
27	Kiski-Conemaugh	12
28	Youghioheny	24
29	Monongahela	9
30	Ohio	17
31	Allegheny	0
32	Moraine	38
33	Middle Allegheny	43
34	Upper Allegheny	9
35	Lake Erie/French & Oil Creek	7
Total		1,077

Table 10. List of geographic information system (GIS) coverages with potential applications for development of water budgets and ecological-flow assessments.

[NA, not applicable]

Coverage	Description	Source	Date Verified
Dams/impoundments	Dams are not included in hydrography coverage	ftp://www.pasda.psu.edu/pub/pasda/pafish/Dams_RunofRiver.zip	8/14/2007
DEM (Digital elevation model)	Topography and elevation	*http://ned.usgs.gov*	8/14/2007
Digital ortho quarter quads	Topographic maps	*http://www.pasda.psu.edu/access/doq99list.cgi*	8/31/2007
Digital ortho quarter quads	Topographic maps	*http://www.pasda.psu.edu/access/doqlist.cgi*	8/14/2007
Drainage basins	Areal delineations - any size watershed	*http://water.usgs.gov/osw/streamstats/pennsylvania.html*	9/5/2007
Drainage basins	Areal delineations - any size watershed	ftp://www.pasda.psu.edu/pub/pasda/watersheds/	8/14/2007
Drainage basins	Areal delineations - small watersheds	*http://pa.water.usgs.gov/pa_digit.v2.html*	8/14/2007
Faults	Geologic faults identified	*http://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspx#entirestate*	8/14/2007
Floodplains	100-year floodplains	ftp://www.pasda.psu.edu/pub/pasda/floodpln/floodpln.zip	8/14/2007
Geology and physiography	Physiographic provinces and underlying geology	*http://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspx#entirestate*	8/14/2007
Hydrography	Water bodies	*http://nhd.usgs.gov*	8/14/2007
Impervious surface	Typically includes just roads, not parking lots	*http://www.mrlc.gov/mrlc2k_nlcd.asp*	8/14/2007
Land use/cover	National Land Cover Data, 1993	*http://landcover.usgs.gov/show_data.php?code=PA&state=Pennsylvania*	8/14/2007
Land use/cover	National Land Cover Data, 2001	http://gisdata.usgs.net/website/MRLC/viewer.php	8/31/2007
Land use/cover	Mosaicked	*ftp://www.pasda.psu.edu/pub/pasda/nlcd/*	8/14/2007
Land use/cover	Land cover	http://www.mrlc.gov/mrlc2k_nlcd.asp	8/14/2007
Mines and quarries	Location of mines and quarries	PaDEP and USGS databases & spatial data	NA
Point sources	Industrial/commercial dischargers, treatment plants	http://www.epa.gov/enviro/geo_data.html	8/31/2007
Population density	1990 census block info. (U.S. Census Bureau)	http://www.census.gov/geo/www/cob/bdy_files.html	8/14/2007
Potential evapotranspiration	Annual average (1:1,000,000 scale data)	Global GIS Database: Digital Atlas of North America (USGS, DDS-62-F)	NA
Potential evapotranspiration	Annual average (glaciated regions only)	*http://water.usgs.gov/GIS/metadata/usgswrd/XML/ofr96395_eva.xml*	8/14/2007
Weather data	Precipitation and temperature (maximum, minimum, and mean)	*http://www.ocs.oregonstate.edu/index.html*	8/31/2007
Precipitation	Annual average (glaciated regions only)	*http://water.usgs.gov/GIS/metadata/usgswrd/XML/ofr96395_pre.xml*	8/14/2007

Table 10. List of geographic information system (GIS) coverages with potential applications for development of water budgets and ecological-flow assessments.—Continued

[NA, not applicable]

Coverage	Description	Source	Date Verified
Public water supplies	Withdrawals, interconnections, and discharges for public supply, commercial, industrial, mining, thermoelectric, hydroelectric, and agricultural categories	*http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Act220/default.htm*	8/14/2007
Soil	Various coverages such as porosity, depths, etc.	*http://www.soilinfo.psu.edu/index.cgi?soil_data&index.html*	8/14/2007
Soil grouping (hydrologic)	Soil Survey Geographic database: data by county	*http://soildatamart.nrcs.usda.gov/County.aspx?State=PA*	8/14/2007
Soil grouping (hydrologic)	County data	ftp://www.pasda.psu.edu/pub/pasda/soils/	8/14/2007
Soil grouping (hydrologic)	Soil Survey Geographic database	*http://soildatamart.nrcs.usda.gov/SSURGOMetadata.aspx*	8/14/2007
Springs	Spring locations	PA Ground Water Information System, version 3.0, CD-ROM, 9/17/1999	NA
Stream classification	Stream use (example, cold-water fishery)	*http://www.pacode.com/secure/data/025/chapter93/chap93toc.html*	8/14/2007
Streams	Class A designations	ftp://www.pasda.psu.edu/pub/pasda/pafish/ClassA_Streams.zip	8/14/2007
Water imports/exports	Withdrawals, discharges, and imports to basin	*http://www.state.nj.us/drbc* (Delaware River Basin)	8/14/2007
Water imports/exports	Withdrawals, discharges, and imports to basin	*http://www.srbc.net* (Susquehanna River Basin)	8/14/2007
Water type	Source- surface or ground	USGS database	NA
Wetlands	National wetland inventory	*http://wetlandsfws.er.usgs.gov/NWI/download.html*	8/14/2007

References Cited

Denslinger, T.L., Gast, W.A., Hauenstein, J.J., Heicher, D.W., Henriksen, D.R., Jackson, D.R., Lazorchick, G.J., McSparran, J.E., Stoe, T.W., and Young, L.M., 1998, Instream flow studies Pennsylvania and Maryland: Susquehanna River Basin Commission Publication 191, May 1998, 293 p.

Hay, L.E., Wilby, R.L., and Leavesley, G.H., 2000, A comparison of delta change and downscaled GCM scenarios for three mountainous basins in the United States: Journal of the American Water Resources Association, v. 36, no. 2, p. 387-397.

Jeton, A.E., Watkins, S.A., Lopes, T.J., and Huntington, J., 2006, Evaluation of precipitation estimates from PRISM for the 1961-90 and 1971-2000 data sets, Nevada: U.S. Geological Survey Scientific Investigations Report 2005-5291, 25 p.

Kiesling, R.L., 2003, Applying indicators of hydrologic alteration to Texas streams–Overview of methods with examples from the Trinity River Basin: U.S. Geological Survey Fact Sheet 128-03, 6 p.

Pennsylvania Department of Environmental Protection, 2006, Guidelines for identification of critical water planning areas: Document 392-2130-014, 17 p.

Sloto, R.A, and Buxton, D.E., 2005, Water budgets for selected watersheds in the Delaware River Basin, Eastern Pennsylvania and Western New Jersey: U.S. Geological Survey Scientific Investigations Report 2005-5113, 37 p.

Sloto, R.A., and Crouse, M.Y., 1996, HYSEP: A computer program for streamflow hydrograph separation and analysis: U.S. Geological Survey Water-Resources Investigations Report 96-4040, 46 p.

U.S. Geological Survey, Water resources glossaries—Water resources data: accessed Dec. 4, 2007, at *http://water.usgs.gov/glossaries.html*

Waldron, M.C., and Archfield, S.A., 2006, Factors affecting firm yield and the estimation of firm yield for selected streamflow-dominated drinking-water-supply reservoirs in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2006-5044, 39 p.

Appendixes

Appendix 1. List of all U.S. Geological Survey surface-water sites with water-quantity and continuous water-quality data for state forest and park lands in Pennsylvania

Appendix 2. List of all U.S. Geological Survey ground-water wells with water-quantity (water-level elevation) data for state forest and park lands in Pennsylvania

Appendix 3. List of active National Weather Service and U.S. Geological Survey precipitation stations in state forest and park lands in Pennsylvania

Appendix 4. List of parameter codes, parameter descriptions, and the water-quality group designated for each parameter

Appendix 5. Water-quality data summary for stream sites in state forest and park lands in Pennsylvania retrieved from the U.S. Geological Survey database

Appendix 6. Water-quality data summary for stream, acid mine drainage, and wastewater sites in Pennsylvania state forest and park lands retrieved from the U.S. Environmental Protection Agency Legacy STORET database

Appendix 7. Water-quality data summary for stream sites and springs in Pennsylvania state forest and park lands retrieved from the U.S. Environmental Protection Agency Modernized STORET database

Appendix 8. Water-quality data summary for stream sites in state forest and park lands in Pennsylvania retrieved from the Susquehanna River Basin Commission database

Appendix 9. Water-quality data summary for Pennsylvania Department of Environmental Protection water-quality network stream sites in state forest and park lands in Pennsylvania

Appendix 10. Water-quality data summary for lake sites in state forest and park lands in Pennsylvania retrieved from the U.S. Geological Survey database

Appendix 11. Water-quality data summary for lake sites in Pennsylvania state forest and park lands retrieved from the U.S. Environmental Protection Agency Legacy STORET database

Appendix 12. Water-quality data summary for Pennsylvania Department Environmental Protection water-quality network lake sites in state park land in Pennsylvania

Appendix 13. Water-quality data summary for ground-water wells located in Pennsylvania state forest and park lands retrieved from the U.S. Geological Survey database

Appendix 14. Water-quality data summary for springs located in Pennsylvania state forest and park lands retrieved from the U.S. Geological Survey database

Appendix 15. Water-quality data summary for ground-water wells in Pennsylvania state forest and park lands retrieved from the U.S. Environmental Protection Agency Legacy STORET database

Appendix 16. Water-quality data summary for springs in Pennsylvania state forest and park lands retrieved from the U.S. Environmental Protection Agency Legacy STORET database

Appendix 17. Water-quality data summary for ground-water wells in Pennsylvania state forest and park lands retrieved from the Pennsylvania Department of Environmental Protection and the Susquehanna River Basin Commission databases

Appendix 18. Benthic-macroinvertebrate sample locations for state forest and park lands in Pennsylvania retrieved from the U.S. Geological Survey database

Appendix 19. Benthic-macroinvertebrate sample locations and dates retrieved from the U.S. Environmental Protection Agency Legacy and Modernized STORET databases for state forest and park lands in Pennsylvania

Appendix 20. Locations of benthic-macroinvertebrate samples collected by the Susquehanna River Basin Commission in state forest and park lands in Pennsylvania

Appendix 21. Benthic-macroinvertebrate sample locations in state forest and park lands in Pennsylvania retrieved from the Pennsylvania Department of Environmental Protection database

Appendix 22. Benthic-macroinvertebrate sample dates and locations obtained from the Pennsylvania Fish and Boat Commission for state forest and park lands in Pennsylvania