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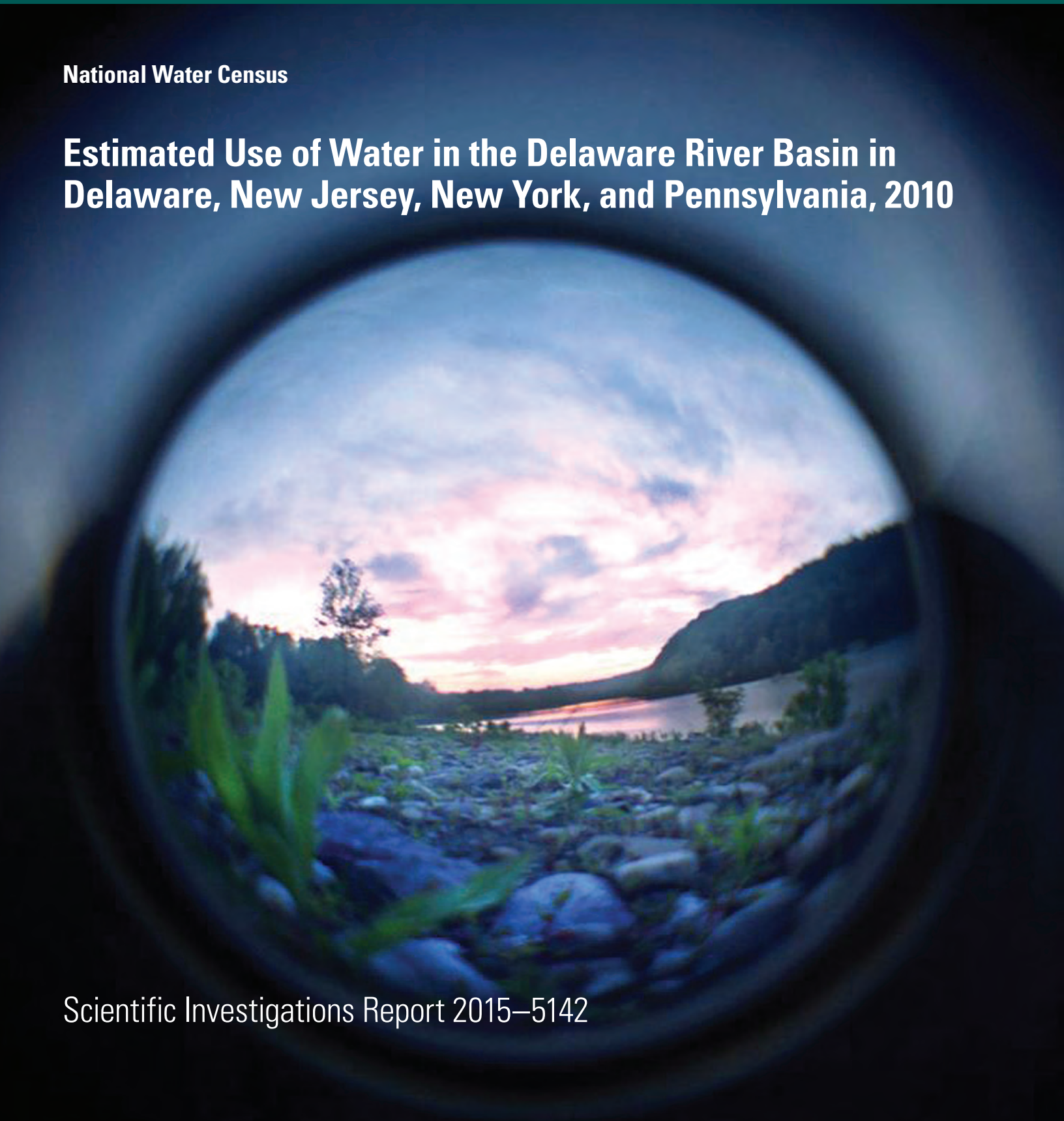
Estimated Use of Water in the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania, 2010



Scientific Investigations Report 2015–5142

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

Cover. Photograph of the Delaware River by Heather Siple (http://sipleart.com/).

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Conversion Factors and Datum

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	3.785	cubic decimeter (dm^3)
million gallons (Mgal)	3,785	cubic meters (m^3)
million gallons (Mgal)	3.07	acre-feet (acre-ft)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	325,851	gallons (gal)
acre-foot (acre-ft)	43,450	cubic feet (ft^3)
	Flow rate	
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)

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

Altitude, as used in this report, refers to distance above the vertical datum.

Acronyms

ASR	Aquifer Storage and Recovery
CDL	Cropland Data Layer
DRB	Delaware River Basin
DRBC	Delaware River Basin Commission
ECHO	Enforcement and Compliance History Online
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
HUC	Hydrologic Unit Code
NWIS	National Water Information System
NRCS	Natural Resources Conservation Service
SECURE	Science and Engineering to Comprehensively Understand and Responsibly Enhance
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WBD	Watershed Boundary Dataset

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Abstract

The Delaware River Basin (DRB) was selected as a Focus Area Study in 2011 by the U.S. Geological Survey (USGS) as part of the USGS National Water Census. The National Water Census is a USGS research program that focuses on national water availability and use and then develops new water accounting tools and assesses water availability at both the regional and national scales. One of the water management needs that the DRB study addressed, and that was identified by stakeholder groups from the DRB, was to improve the integration of state water use and water-supply data and to provide the compiled water use information to basin users. This water use information was also used in the hydrologic modeling and ecological components of the study.

Instream and offstream water use was calculated for 2010 for the DRB based on information received from Delaware, New Jersey, New York, and Pennsylvania. Water withdrawal, interbasin transfers, return flow, and hydroelectric power generation release data were compiled for 11 categories by hydrologic subregion, basin, subbasin, and subwatershed. Data availability varied by state. Site-specific data were used whenever possible to calculate public supply, irrigation (golf courses, nurseries, sod farms, and crops), aquaculture, self-supplied industrial, commercial, mining, thermoelectric, and hydroelectric power withdrawals. Where site-specific data were not available, primarily for crop irrigation, livestock, and domestic use, various techniques were used to estimate water withdrawals.

Total water withdrawals in the Delaware River Basin were calculated to be about 7,130 million gallons per day (Mgal/d) in 2010. Calculations of withdrawals by source indicate that freshwater withdrawals were about 4,130 Mgal/d (58 percent of the total) and the remaining 3,000 Mgal/d (42 percent) were from saline water. Total surface-water withdrawals were calculated to be 6,590 Mgal/d, or 92 percent of the total; about 54 percent (3,590 Mgal/d) of surface water withdrawn was freshwater. Total groundwater withdrawals were calculated to be 545 Mgal/d (8 percent of the total), all of which was freshwater. During 2010, calculated withdrawals by category, in decreasing order, were: thermoelectric power, 4,910 Mgal/d; public supply, 1,490 Mgal/d; self-supplied industrial, 350 Mgal/d; irrigation, 175 Mgal/d; self-supplied domestic, 117 Mgal/d; mining, 41.3 Mgal/d; aquaculture, 19.3 Mgal/d; livestock, 6.72 Mgal/d, and commercial, 5.89 Mgal/d. The amount of instream use for hydroelectric power generation purposes in 2010 was reported to be 273 Mgal/d for the Wallenpaupack Plant and 127 Mgal/d for the Mongaup River system.

Total return flows in the DRB were 2,960 Mgal/d in 2010. Although municipal wastewater-treatment plants accounted for 539 (97 percent) of the return-flow sites, they accounted for about 70 percent of the total return flows in the DRB. There was limited information on return flows from thermoelectric power.

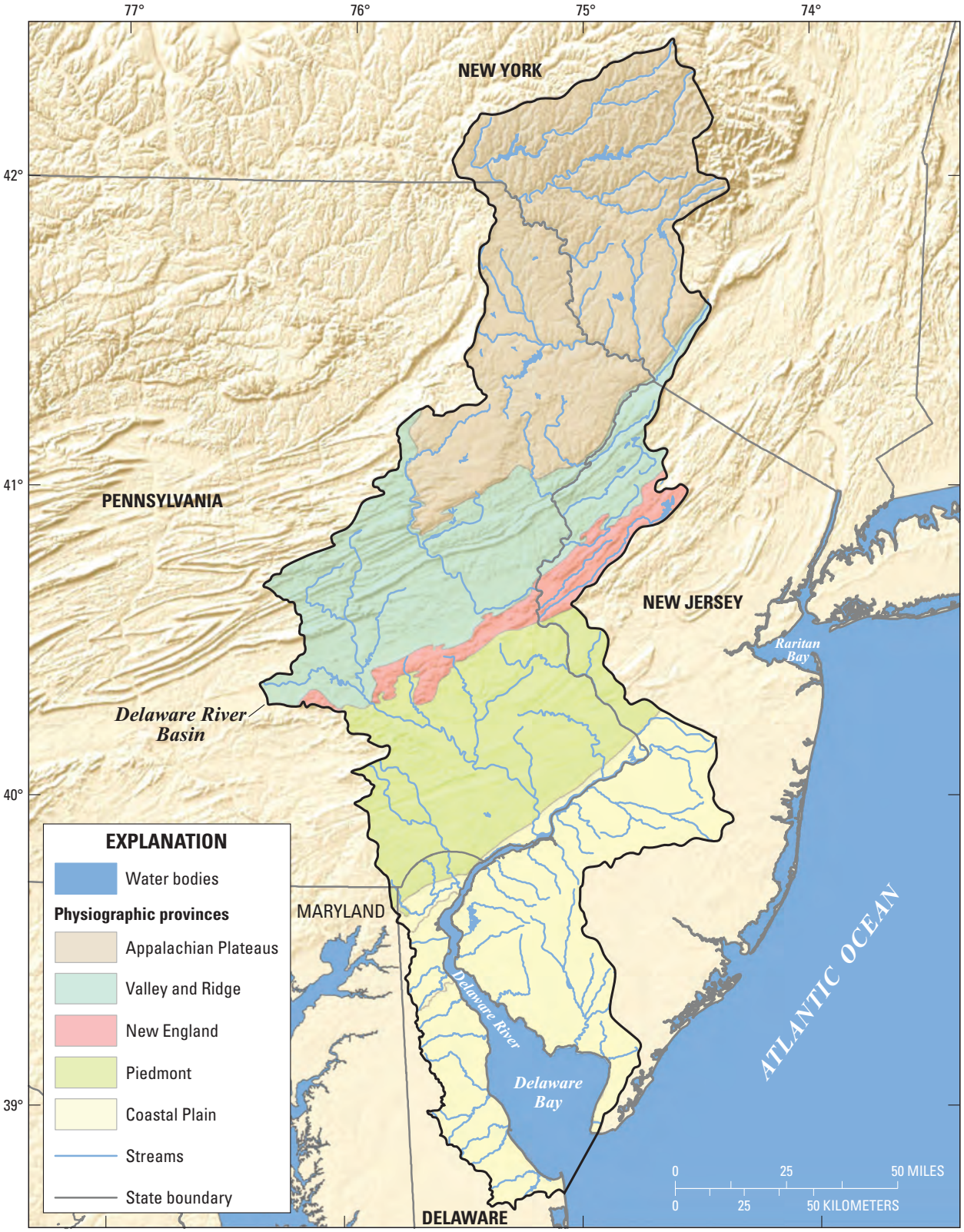
Introduction

The Delaware River Basin study area contains 13,539 square miles (mi^2), draining parts of Pennsylvania (6,422 mi^2 or 50.3 percent of the **basin's**[1] total land area); New Jersey (2,969 mi^2, 23.3 percent); New York (2,362 mi^2, 18.5 percent); Delaware (1,004 mi^2, 7.9 percent), and includes Delaware Bay (782 mi^2) (fig.1). In 2010, the population in the DRB was 8.2 million. The Appalachian Plateaus, Valley and Ridge, New England, Piedmont, and Coastal Plain are the major **physiographic provinces** in the DRB (Fischer and others, 2004; fig. 2, table 1). The northern provinces are relatively unpopulated. The Appalachian Plateaus Province contains 1,000- to 4,000-feet (ft)-high mountains that are mostly forested. The Valley and Ridge and New England Physiographic Provinces are composed of valleys with some urban and agricultural development, and mostly undeveloped 1,000-ft-high linear ridges. About 80 percent of the population in the basin lives in the southern half of the basin, which is composed of the rolling hills of the Piedmont Province, and the relatively flat Coastal Plain.

[1] Words and phrases introduced in **bold** are listed in the Glossary.

Shaded relief base from U.S. Geological Survey, National Map, 2014.
State boundaries from U.S. Geological Survey, 1983.
Water features from U.S. National Atlas, 2014.
Cities from U.S. Census, 2000.
Albers Equal-Area Conic Projection.

Figure 1. Major cities and other named locations in the Delaware River Basin.



Shaded relief base from U.S. Geological Survey, National Map, 2014.
State boundaries from U.S. Geological Survey, 1983.
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Albers Equal-Area Conic Projection.

Physiographic provinces modified from Parker and others, 1964.

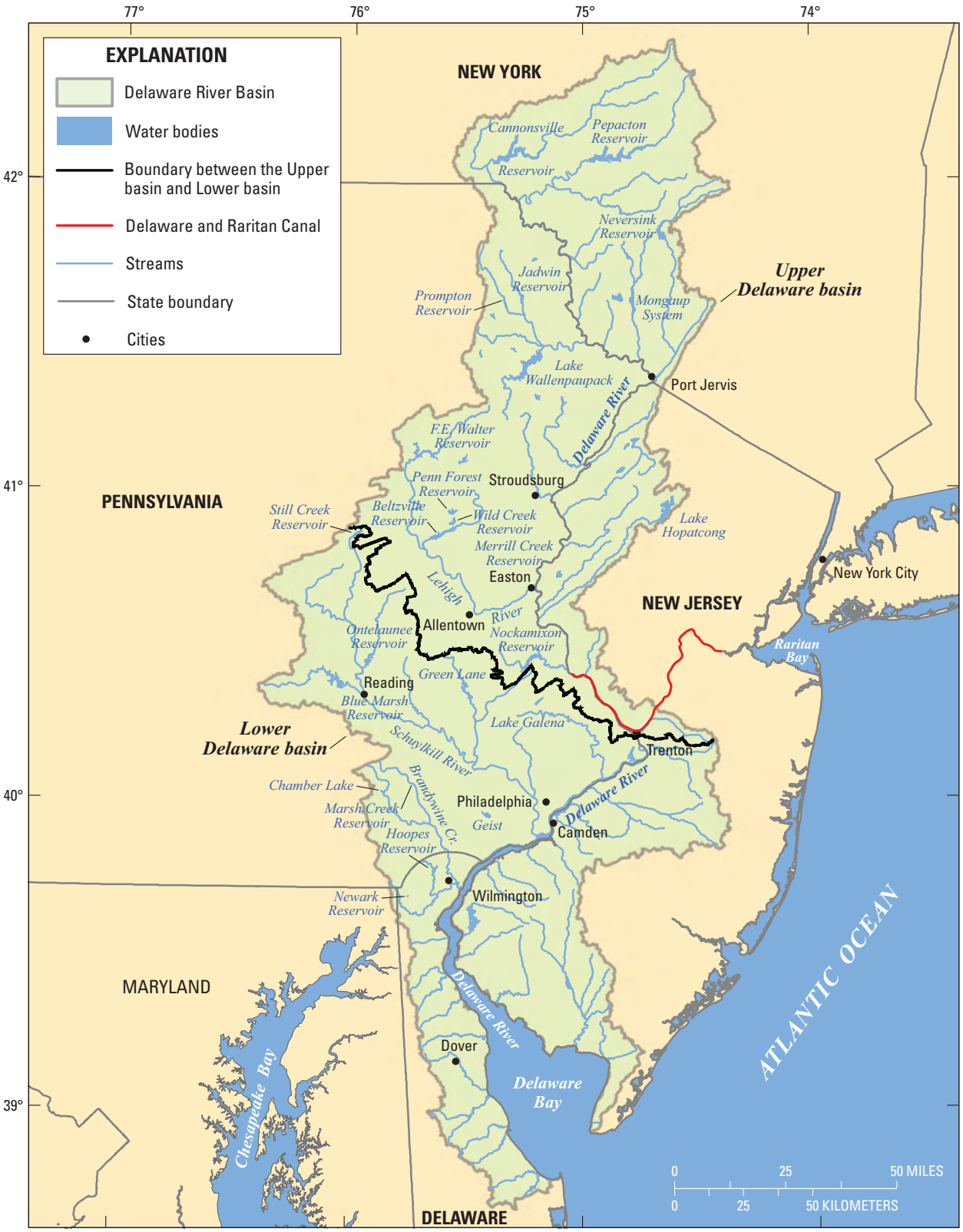
Figure 2. Physiographic provinces in the Delaware River Basin.

Table 1. Topography, geology, and land use of the physiographic provinces of the Delaware River Basin (Fischer and others, 2004; Vigil and others, 2000).

Physiographic province	Topography and geology	Hydrology	Predominant land use	Primary water use
Appalachian Plateaus	Elevations range from 1,000 to 4,000-feet-high. Uplands composed of gently folded sandstones, shales, and conglomerates.	Rivers have carved deep, narrow valleys through the rock. The glaciofluvial aquifer system is highly productive.	Forest covers approximately 85 percent of the land.	Hydroelectric power, drinking water for New York City, domestic wells, aesthetics, recreation.
Valley and Ridge	Topographic relief from ridgetop to valley bottom can exceed 1,200 feet. Consists primarily of sandstones and shales that have been folded into extensive ridges and valleys that trend southwest to northeast. An extensive sequence of carbonate rocks forms the southern boundary with the New England Province.	Major cities straddle either the Lehigh or Schuylkill River, and sit upon the Great Valley carbonate aquifer. Some domestic wells in the clastic rock aquifer. Highly productive glaciofluvial aquifer system.	Most of the developed land is along valley floors, and the ridges are primarily forested. Nearly one-third of the land is agricultural land.	Valley floors often contain extensive agricultural development. Self-supplied domestic groundwater is used in sparsely populated areas. Most public drinking water is surface water.
New England	Underlain by carbonate and crystalline rocks.	Highly productive glaciofluvial aquifer system.	Forest covers more than 60 percent, and nearly one-third is agricultural land.	Agricultural and self-supplied-domestic groundwater, municipal supply.
Piedmont	Lowland region of rolling hills and valleys with two distinct rock types. In the southwest Uplands Section, metamorphic and igneous rocks predominate, and small areas of carbonate rocks are present. In the northeast Lowlands section, sandstones and shales are the primary rock type, and diabase intrusions form resistant hills.	Rivers, estuary, and groundwater extensively used. Groundwater protected area is near Philadelphia. Underlain by the clastic rock aquifers.	Agricultural and urban development account for more than 50 percent of the land use. Much of the agricultural land is rapidly being converted to suburban housing.	Municipal and industrial water supply, agriculture, wastewater discharges, transportation corridor, and recreation. Most public drinking water is surface water.
Coastal Plain	An area of low relief southeast of the Delaware Estuary.	The sands and gravels store large quantities of water. Sediments are composed of slightly dipping layers of unconsolidated clay, silt, sand, and gravel that thicken and reach a depth of 6,000 feet to the southeast.	Agricultural land use is approximately 25 percent. Urban and industrial land use is approximately 22 percent centered around Camden, New Jersey.	Municipal, industrial, domestic, and agricultural supply.

Differences in topography, geology, and hydrology have mostly determined land-use patterns, and consequently, water availability and **water use** (table 1). Because of its relatively high topographic relief, the northern half of the basin is home to several large water-supply and hydroelectric reservoirs (fig. 3). Further south, in the Piedmont and Coastal Plain Provinces where most people live, **public supply** (also known as **municipal supply**) and **self-supplied domestic** water use are the highest uses (Fischer and others, 2004). Supplies in the Piedmont Province are mostly from surface-water sources, whereas most of the supply in the Coastal Plain Province comes from the highly productive aquifers. The drinking water supply in the Valley and Ridge Province is almost split equally between surface-water and groundwater sources. Many cities on major rivers, such as the Delaware, Lehigh, Schuylkill, and Brandywine, draw their drinking water directly from the river. Residents in sparsely populated areas of the basin rely on domestic wells as a source of drinking water.

Past interstate water conflicts have resulted in several court decisions, and the Delaware River Basin Commission (DRBC) was created in 1961 to help resolve disputes. As a result of Supreme Court decisions, three reservoirs in the upper basin can export up to 800 million gallons per day (Mgal/d) to New York City, and the Delaware and Raritan



State boundaries from U.S. Geological Survey, 1983.
Water features from U.S. National Atlas, 2014, and Delaware River Basin Commission, 2008.
Cities from U.S. Census, 2000.
Albers Equal-Area Conic Projection.

Figure 3. Major rivers, tributaries, and reservoirs in the Delaware River Basin.

Canal in central New Jersey can export up to 100 Mgal/d to northern New Jersey water purveyors (fig. 3). These exports supply over 8 million people outside the basin. Flow on the main-stem Delaware River is managed in accordance with the 1954 Supreme Court Decree that specifies a minimum flow requirement of 1,750 cubic feet per second (ft^3/s) at Montague, New Jersey. A 1983 Agreement among the Parties to the Decree established a minimum flow requirement of 3,000 ft^3/s at Trenton, New Jersey. More recently, a flexible flow management plan, negotiated by the DRBC, the States, and New York City, allows for modified releases from the upper basin reservoirs to address competing needs and uses that include: safe and reliable water supplies to serve the needs of more than 17 million people; water management during droughts; flood mitigation; protection of cold water fisheries; controlling salinity incursion in the estuary; and maintaining a diverse array of habitat needs in the main stem Delaware River, Estuary, and Bay (U.S. Geological Survey, 2014a).

Recent water-supply concerns that have emerged in the DRB include (1) the water needs of growing populations in the Pocono Mountains and selected **watersheds** surrounding the Delaware Bay, (2) proposed energy-production activities in groundwater-dependent watersheds, (3) the possibility of growth in the Thermoelectric and Irrigation sectors, and (4) the yet-unknown instream needs of aquatic ecosystems. Migration of the **salt line** into the upper estuary and its potential to increase sodium concentrations in public water-supply intakes is also a concern (Partnership for the Delaware Estuary, 2012). During the drought of record in the 1960s, the salt line was near river mile 102 and affected public supply wells in Camden, New Jersey and approached the nearby public supply intake for Philadelphia. In addition, recent concerns about excessive groundwater withdrawals to meet growing demands have resulted in regulatory action to remedy declining groundwater levels through conjunctive management of supplies in northern Delaware. Residents of the Appalachian Plateaus and Coastal Plain Provinces are particularly dependent on groundwater for public supply and self-supplied domestic use. In comparison, residents of the Valley and Ridge, Piedmont, and New England Provinces are more dependent on surface water for a large part of their drinking water. Residents in the most sparsely populated areas in the basin rely on domestic wells as a source of drinking water. In south-central New Jersey, reductions in aquifer withdrawals in a designated critical area (fig. 4) have been mandated in response to large drawdowns in the aquifer, and the DRBC has instituted additional groundwater permit requirements in southeastern Pennsylvania due to concerns about overuse.

Estimates of groundwater availability from the aquifers were determined by 10-digit watershed for the Delaware River Basin (Sloto and Buxton, 2006). Estimated 2-year, 5-year, 10-year, 25-year, and 50-year annual base-flow recurrence interval values for each watershed were considered to be the groundwater available for each watershed over a range of climatic conditions. The results showed that from 1997 to 2000, groundwater use ranged from 0 to 127 percent of available groundwater for the 50-year occurrence interval, which represents the drier years.

Recognizing these water availability and water use concerns, the U.S. Geological Survey's (USGS) National Water Census selected the DRB as a Focus Area Study in 2011 (Alley and others, 2013). The National Water Census is a USGS research program that focuses on national water availability and use and then develops new water accounting tools and assesses water availability at both the regional and national scales (U.S. Geological Survey, 2014b). Through the National Water Census, the USGS is integrating diverse research on water availability and use and enhancing the understanding of the connection between water quality and water availability. Research is designed to build decision-support capacity for water management agencies and other natural resource managers. The National Water Census is one of six major science directions identified by the USGS in its 2007 Science Plan (U.S. Geological Survey, 2007), called for in the SECURE (Science and Engineering to Comprehensively Understand and Responsibly Enhance) Water Act, and implemented through the Department of the Interior WaterSMART (Sustain and Manage America's Resources for Tomorrow) initiative (U.S. Geological Survey, 2014e).

The USGS Water Census Focus Area Study in the DRB will concentrate on providing information to stakeholders in the basin, and will contribute to science and water management needs in the basin. Among the needs identified by stakeholder groups that the study will address are: (1) improving the integration of state water use and water-supply data; (2) developing a basinwide surface-water hydrologic model capable of evaluating the impacts of land-use change, climate change, and changes in water demand; and (3) developing a scientific approach to defining relations between streamflow processes and the responses of aquatic organisms in tributary streams. Compiled water use information in this report will address the first need identified above by providing water use information to basin users. This water use information will also be used in the hydrologic modeling and ecological components of the study.

Purpose and Scope

This report presents instream and **offstream water use** estimates from 2010 for the DRB in Delaware, New Jersey, New York, and Pennsylvania (fig. 1). Estimates are not provided for the 8-mi^2 section of Maryland that is in the basin. **Site-specific** water withdrawal and **return flow** data from the four states were compiled, and **areal estimates** of non-reported uses were made. Estimates of **consumptive use** were not made. Water use data are **aggregated** to the DRB 4-digit **subregions**, 6-digit basins, 8-digit **subbasins**, and 12-digit **subwatersheds**. The 6-digit basin 020401 (Upper Delaware) is also referred to in this report as the Upper basin; 020402 (Lower Delaware) is referred to as the Lower basin. The boundary between the Upper basin and the Lower basin is shown in figure 1. The presentation of **instream water use** is limited to the release of water from the Wallenpaupack

(Pennsylvania) and Rio (New York) reservoirs for the production of **hydroelectric power**, and excludes releases of water from reservoirs to maintain water temperatures, flows for wildlife, and other downstream uses such as managing the location of the salt line and navigation.

The report contains a section on total water use in the basin along with other sections that present more detailed information on each water use category by basin and subbasin. The *Power Generation* section contains thermoelectric power and hydroelectric power uses; the *Drinking Water* section contains public supply and domestic uses; the *Industrial* section contains self-supplied **industrial**, **commercial**, and **mining** uses; and the *Agricultural* section contains **irrigation**, **livestock**, and **aquaculture** uses. Appendix 1 describes the Watershed Boundary Dataset (WBD) that defines the areal extent and the hydrologic classification of the basins, subbasins, watersheds, and subwatersheds in the DRB. Appendix 2 lists the subbasin, watershed, and subwatershed names and corresponding 8-digit, 10-digit, and 12-digit hydrologic unit codes. Appendix 3 summarizes water use by subbasin according to source of water and water use category. The 8-digit subbasin and 12-digit subwatershed data for all categories in this report may be downloaded from http://dx.doi.org/10.5066/F7TM787C.

The terms and units used in this report are similar to those used in previous USGS water use reports (MacKichan, 1951, 1957; MacKichan and Kammerer, 1961; Murray, 1968; Murray and Reeves, 1972, 1977; Solley and others, 1983, 1988, 1993, 1998; Hutson and others, 2004; Kenny and others, 2009) and are defined in the *Glossary* at the end of the report. Units of millions of gallons per day do not represent actual daily rates, but rather are used to express total amounts as an average daily rate for a period of 1 year. For example, irrigation water may be applied only during parts of the year and at variable rates; therefore, the actual rate of application at any given time during the growing season is different from the average daily rate based on 365 days in a year.

The water use data in this report are rounded to three significant figures. All values are rounded independently, so the sums of individual rounded numbers may not equal the totals. Percentage changes discussed in the text are calculated from the unrounded data and are expressed as integers. All population data are rounded to three significant figures. **Choropleths** by subbasin (8-digit hydrologic units) use similar ranges to facilitate comparison across sectors and categories. Choropleths by subwatershed (12-digit hydrologic units) use ranges that highlight variations among the subwatersheds. The minimum and maximum range values are adjusted to reflect actual estimates by category.

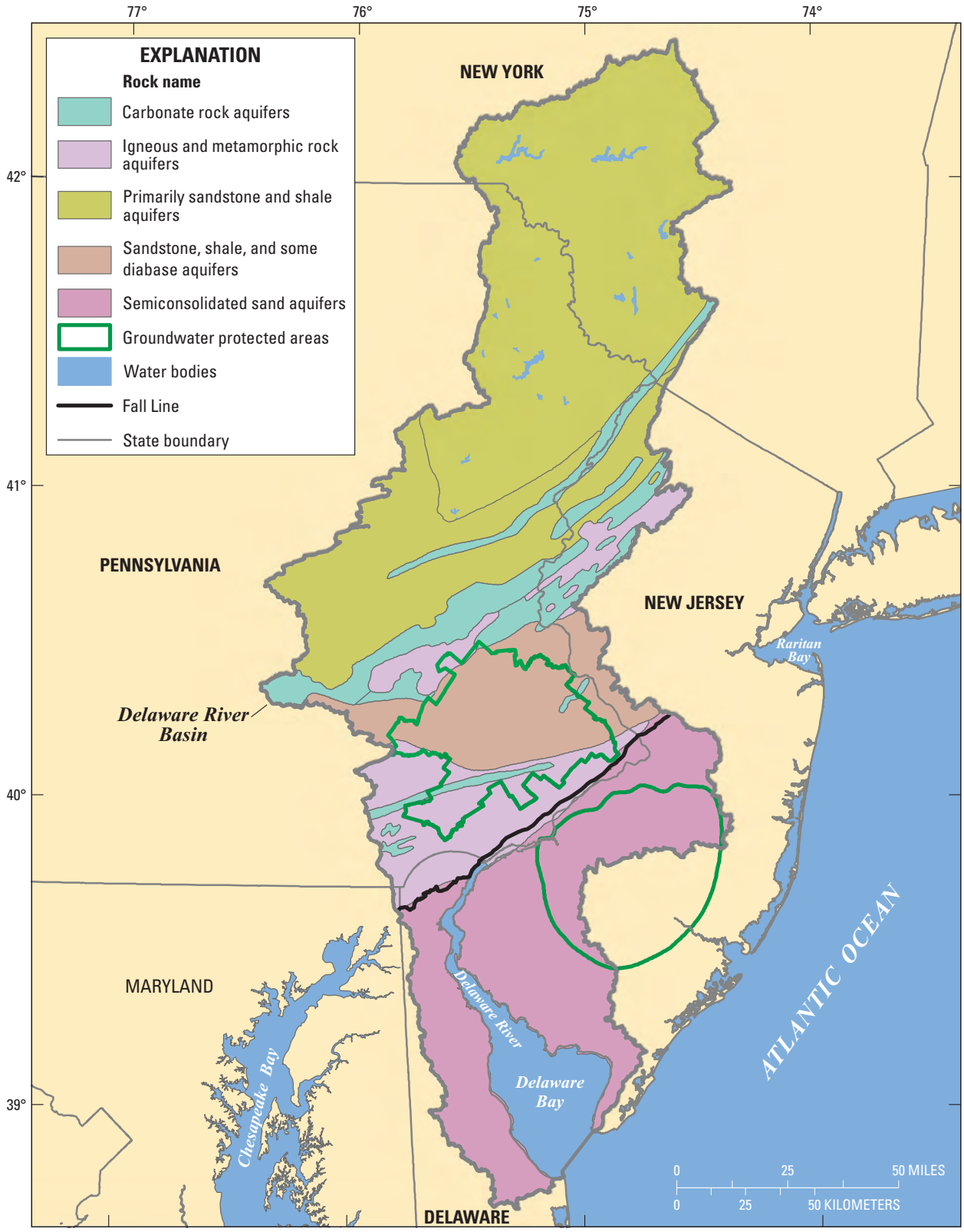
Water withdrawals in this report were compiled as **freshwater** or **saline**. Interbasin **water transfers** are limited to the major **interbasin transfers** of water from the Upper Delaware Basin to the Hudson Basin, from the Lower Delaware Basin through the Delaware-Raritan Canal to the Raritan Basin, and from the Susquehanna Basin to the Lower Delaware Basin. Public wastewater, industrial, thermoelectric, irrigation, and other return flows are reported by hydrologic subregion, basin, subbasin, and subwatershed.

Hydrologic Setting

The headwaters of the Delaware River (fig. 3) are in New York in the Catskill Mountains of the Appalachian Plateaus Physiographic Province. The Delaware River is formed at the confluence of the West Branch Delaware River and the East Branch Delaware River. From the confluence, the river flows 220 miles south to the Delaware Estuary, which extends from Trenton, New Jersey to the Delaware Bay. The river is fed by several principal tributaries—in New York, the Mongaup and Neversink Rivers and Callicoon Creek; in Pennsylvania, the Lackawaxen, Lehigh, and Schuylkill Rivers and Broadhead Creek; in New Jersey, the Musconetcong, Cooper, and Maurice Rivers and Rancocas Creek; and in Delaware, the Brandywine Creek-Christina River. The Delaware River is the longest undammed river east of the Mississippi River, but flow is regulated by large reservoirs that were constructed for water supply, power generation, flood control, and streamflow augmentation. Water releases are coordinated through the flexible flow management program. Approximately 1,500 smaller dams regulate tributary flow throughout the watershed (Partnership for the Delaware Estuary, 2012), many of which were built as mill dams, or for cutting ice in winter. Many of these small dams are now filled with sediment, and as a result have little effect on flow (Ronald Sloto, USGS, oral commun., June 16, 2014).

Precipitation in the DRB varies geographically, and from year to year. Average annual precipitation ranges from 50 inches (in.) in the higher elevation north to 42 in. in the south (Jenner and Lins, 1991). Average monthly precipitation varies little by season, but precipitation-producing mechanisms change with the season. In the winter, high rainfall is associated with storms moving parallel to the Atlantic Coast from the Gulf of Mexico, and in the summer, Bermuda highs circulate moist air into the area and create scattered convective showers. Occasionally tropical storms move into the area. The most important local influence is terrain. The orthography of the Catskill and Pocono Mountains can lead to great variability in precipitation characteristics over small areas.

The principal aquifers in the DRB north of the Coastal Plain are composed of carbonate, igneous metamorphic, and siliciclastic (including sandstone, shale, and slate) rock, whereas the Coastal Plain is a semiconsolidated sand aquifer (fig. 4). A glaciofluvial aquifer system (not a principal aquifer), composed of unconsolidated sands, silts, and clays, fills many of the valleys in the Appalachian Plateaus, Valley and Ridge, and New England Physiographic Provinces. Depending on the extent and thickness, the glacial aquifer can be highly productive in places. Carbonate aquifers are an important source of water in the Valley and Ridge and New England Provinces. Less extensive carbonate aquifers in the Piedmont and Appalachian Plateaus can also be locally important sources of water. Less productive siliciclastic rock aquifers underlie much of the Appalachian Plateaus, Valley and Ridge, and Piedmont Physiographic Provinces. The Coastal Plain aquifers are composed of thick sequences of unconsolidated sand



Aquifers from U.S. Geological Survey, 2003.
State boundaries from U.S. Geological Survey, 1983.
Water features from U.S. National Atlas, 2014.
Groundwater protected areas from Delaware River Basin Commission, 2014.
Fall Line from compilation of exisiting Delaware, Maryland, New Jersey, and Pennsylvania State geologic datasets, 2013.
Albers Equal-Area Conic Projection.

Figure 4. Principal aquifers and protected areas within the Delaware River Basin.

that are highly productive. A comparison of aquifer and well characteristics of the local formations show that the sands and gravels of the semiconsolidated stratum of the Coastal Plain have wells that may yield 1,000 gallons per minute (gal/min), and the wells may be deep as 2,000 ft (table 2).

Data Compilation, Sources of Information, and Methodology

State water use programs and the DRBC determine water reporting criteria for the water users within the Delaware River Basin (table 3). Reporting thresholds vary from state to state from 10,000 gallons per day (gal/d) to 100,000 gal/d, and may be different for protection areas within a state. Monthly, quarterly, and annually reported data from these entities were the primary source for the water withdrawal and return-flow estimates for the DRB.

The most recent water withdrawal data for the DRB were compiled by the DRBC using state agency data from 2003 and 2007 (Partnership for the Delaware Estuary, 2012). The data showed that water use varied regionally. Use in the Upper basin was 1,570 Mgal/d, and use in the Lower basin was 6,710 Mgal/d. Over 45 percent of the Upper basin use was for power generation (almost evenly split between hydroelectric and thermoelectric use), 42 percent was exported to New York or New Jersey, and most of the remainder was used for

Table 2. Principal aquifers and associated well characteristics within the Delaware River Basin.

Principal aquifer	Aquifer name and description	Well characteristics				Remarks
		Depth (feet)		Yield (gallons per minute)		
		Common range	May exceed	Common range	May exceed	
Clastic rock						
Sandstone aquifers	Piedmont clastic rocks	100–400	600	50–200	300	The rocks of this stratum are mostly shale, sandstone, and conglomerates. Groundwater flow is predominantly through fractures. Groundwater quality is affected by urban and agricultural land-use activities and the resource is heavily used for domestic and public water supply. A part of this area within the Delaware River Basin has been designated by the Delaware River Basin Commission as a "Groundwater protected area" to try and prevent overuse.
Sandstone and carbonate rock aquifers	Valley and Ridge clastic rocks	100–250	600	20–150	500	The rocks of this stratum are mostly shale, slate, and sandstone with some limestone. Groundwater flow is predominantly through fractures. Groundwater quality is affected by agricultural land-use activities and the resource is heavily used for domestic water supply.
Unconsolidated deposits						
Not a principal aquifer	Appalachian Plateaus and Valley and Ridge glaciofluvial valley-fill deposits	50–150	200	50–200	500	The deposits of this stratum are a heterogeneous assortment of bedded clay, silt, sand, and gravel. Groundwater flow is predominantly through the highly permeable and porous sand and gravel outwash deposits. Some of the coarser and thicker deposits are the most productive aquifers in the entire Delaware River Basin. The valley-fill deposits are heavily used for public and domestic water supply.
Semiconsolidated sand	Coastal Plain	80–175	200	100–500	750	The sands and gravels store large quantities of water. Sediments are composed of slightly dipping layers of unconsolidated clay, silt, sand, and gravel that thicken and reach a depth of 6,000 feet to the southeast.

Table 3. Water withdrawal reporting thresholds for the States of Delaware, New Jersey, New York, and Pennsylvania, and the Delaware River Basin Commission.

[DRB, Delaware River Basin; gal/d, gallons per day; Mgal/m, million gallons per month]

State agency or protected area	Reporting threshold (gallons per day)	Water source	Water withdrawal reporting criteria
Delaware			
Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Water, Water Supply Section, Water Allocation Branch	50,000	Surface water and groundwater	The 50,000 gal/d threshold applies to withdrawals on any one day. Public, industrial, and golf courses (commercial) facilities report monthly production annually for each well or intake. Irrigators report March through November.
New Jersey			
New Jersey Department of Environmental Protection, Bureau of Water Allocation & Well Permitting	100,000	Surface water and groundwater	A Water Allocation Permit is required for the diversion of groundwater or surface water in excess of 100,000 gal/d for a period of more than 30 days in a 365-consecutive-day period, for purposes other than agriculture, aquaculture or horticulture. This includes water diversions for public water supply, industrial processing and cooling, irrigation, sand and gravel operations, remediation, power generation, and other uses. The monthly average has to exceed 3.1 Mgal/month for any purpose.
	100,000	Surface water and groundwater	A Water Use Registration is required for any person with the capability to divert in excess of 100,000 gal/d of water, but who diverts less than this quantity.
New Jersey Highlands Preservation Area	50,000	Surface water and groundwater	If the monthly average exceeds 1.55 Mgal/m (30-day average), a water allocation permit is needed.
New York			
New York Department of Environmental Conservation (DEC), Division of Water, Bureau of Water Resource Management	100,000	Surface water and groundwater	Entities capable of withdrawing more than 100,000 gal/d for any purpose must report use data to DEC. Annual reports must include 12 months of data, the amount of water withdrawn, including the daily average for each month and the peak (maximum) day amount for each month.
	100,000	Surface water and groundwater	The law also requires statewide registration of existing agricultural withdrawals that are greater than 100,000 gal/d (30-day average) and major basin water diversions of greater than 1,000,000 gal/d.

drinking water. In the Lower basin, over 75 percent of the use was for thermoelectric use, with most of the remainder used for drinking water or industrial supply. Nearly 90 percent of potable use for residential and commercial purposes was through public water-supply systems; only 10 percent was from domestic wells.

Water withdrawal, interbasin transfers, return flow, and hydroelectric power release data were compiled for 11 water use categories by hydrologic subregion, basin, subbasin, and subwatershed (fig. 5). Data availability varied by state (table 4). Site-specific data were used whenever possible to estimate public supply, irrigation (golf courses, nurseries, sod farms, and crops), aquaculture, self-supplied industrial, commercial, mining, thermoelectric, and hydroelectric power withdrawals. Where site-specific data were not available, primarily for irrigation, livestock, and domestic use, various techniques, described below, were used.

Site-Specific Water Use Data

Site-specific data were compiled from a comprehensive list of facilities from respective National and state water agencies and the DRBC (table 4). Groundwater and surface-water withdrawal and **aquifer storage and recovery** records, and public-supplier **monthly operating reports** (MORs)

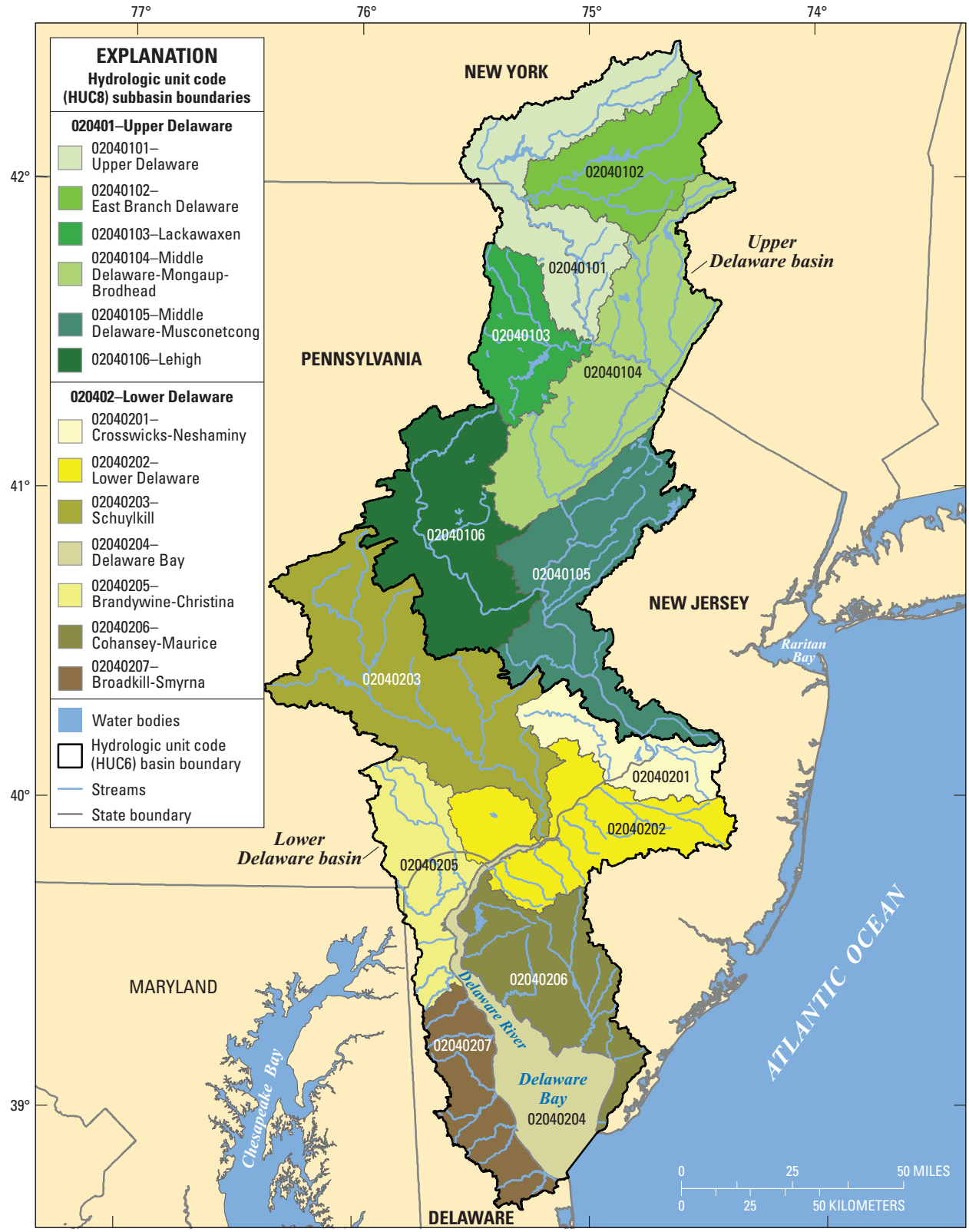
Table 3. Water withdrawal reporting thresholds for the States of Delaware, New Jersey, New York, and Pennsylvania, and the Delaware River Basin Commission.—Continued

[DRB, Delaware River Basin; gal/d, gallons per day; Mgal/m, million gallons per month]

State agency	Reporting threshold (gallons per day)	Water source	Water withdrawal reporting criteria
Pennsylvania			
Pennsylvania Department of Environmental Protection, Office of Water Management	10,000	Surface water and groundwater	All public suppliers and hydropower facilities must register their groundwater and surface-water sources and use. Any person (entity) whose total withdrawal from one or more points of withdrawal within a watershed operated as a system either concurrently or sequentially exceeds an average rate of 10,000 gallons per day in any 30-day period must register. Any person (entity) who receives through interconnection an average of 100,000 gallons a day in any 30-day period must also register.
Southeast (Pennsylvania) Groundwater Protected Area	10,000	Groundwater	An entity whose cumulative daily average withdrawal of groundwater from a well or group of wells operated as a system exceeds 10,000 gallons per day during any 30-day period shall meter or measure and record their withdrawals and report such withdrawals to the Pennsylvania Department of Environmental Protection. The following water uses and operations are exempt from the metering or measurement requirements of subsection A: agricultural irrigation; snowmaking; dewatering incidental to mining and quarrying; dewatering incidental to construction; and space heating or cooling uses that are exempt from permit requirements.
Delaware River Basin Commission	100,000	Surface water and groundwater	Each person, firm, corporation, or other entity whose cumulative daily average withdrawal(s) from the surface or groundwaters of the DRB from any surface-water intake, spring, or well, or any combination of surface-water intakes, springs, or wells operated as a system, exceeds 100,000 gallons per day during any 30-day period shall meter or measure and record their withdrawals and report such withdrawals to the designated agency (Delaware River Basin Compact, 32 P.S. §815.101 et seq., 1961. Project review triggered by withdrawals of 100,000 gal/d or more of groundwater or surface water.)

were the basis for the 2010 water withdrawal estimates. State water agencies and the U.S. Environmental Protection Agency (EPA) Enforcement and Compliance History Online (ECHO) database were the source for wastewater return flows. To ensure that the reported amounts were compiled for the geographical area in which a **water use transaction** occurred, the county, subbasin, and subwatershed locations of the water plants, surface-water intakes and outfalls, wells, or well fields were verified using the USGS WBD (U.S. Geological Survey and U.S. Department of Agriculture, National Resources Conservation Service, 2012) and Geographic Information System (GIS) techniques. Reported quarterly, monthly or annual water withdrawal and return-flow records for 6,385 unique sites (including six interbasin transfers) were reviewed for consistency, reasonableness, and completeness (fig. 6).

There were 5,614 withdrawal sites, 765 return-flow sites, and 6 interbasin transfer sites. Of the withdrawal sites, 42 percent (2,348 sites) were in the **Drinking Water sector**; 38 percent (2,128 sites) were in the **Agricultural sector**; 19 percent (1,078 sites) were in the **Industrial sector**; and the remaining 1 percent (60 sites) were in the **Power Generation sector**. Groundwater withdrawal sites accounted for 72 percent (4,580 sites) of the total number of sites, surface-water withdrawal sites accounted for 16 percent (1,034 sites), return-flow sites accounted for 12 percent (765 sites), and interbasin transfer sites accounted for less than 1 percent



State boundaries from U.S. Geological Survey, 1983.
HUC8 and HUC6 boundaries from U.S. Geological Survey, 1984.
Water features from U.S. National Atlas, 2014.
Albers Equal-Area Conic Projection.

Figure 5. Basins and subbasins in the Delaware River Basin.

Table 4. Summary of data sources by category and type of data, Delaware River Basin, 2010.

[DNREC, Delaware Department of Natural Resources and Environmental Control Division of Water, Water Supply Section, Water Allocation Branch; NJDEP, New Jersey Department of Environmental Protection Bureau of Water Allocation & Well Permitting; NYSDEC, New York State Department of Environmental Conservation, Division of Water, Bureau of Water Resource Management; PADEP, Pennsylvania Department of Environmental Protection, Office of Water Management; DRBC, Delaware River Basin Commission; USGS, U.S. Geological Survey (Diehl and others, 2013); EPA, U.S. Environmental Protection Agency; ODRM, Office of the Delaware River Master; USGS-NACP, USGS North Atlantic Coastal Plain model; USDA-NASS, U.S. Department of Agriculture-National Agricultural Statistics Service; USDA-CDL, U.S. Department of Agriculture-Cropland Data Layer]

Area	Data sources	Type of data
Site-specific data (Public Supply, Aquaculture, Industrial, Commercial, Mining)		
Delaware	DNREC Public supplier Monthly Operating Reports	Withdrawal
New Jersey	NJDEP	Withdrawal
New York	NYSDEC	Withdrawal
Pennsylvania	PADEP	Withdrawal
Thermoelectric		
Delaware	DNREC	Withdrawal
New Jersey	DRBC	Withdrawal
New York	USGS	Withdrawal
Pennsylvania	PADEP	Withdrawal
Irrigation and Livestock		
New Jersey	NJDEP	Withdrawal
Wastewater releases		
Delaware	EPA	Return flow
New Jersey	NJDEP	Return flow
New York	EPA	Return flow
Pennsylvania	EPA	Return flow
Hydroelectric power releases		
Delaware River Basin	ODRM	Releases
Areal estimates (Irrigation and Livestock)		
Delaware	USGS-NACP USDA-NASS USDA-CDL	Withdrawal
New York	USDA-NASS USDA-CDL	Withdrawal
Pennsylvania	USDA-NASS USDA-CDL	Withdrawal
Self-supplied domestic		
Delaware River Basin	USGS-NACP	Withdrawal

(6 sites). Site-specific water use for the aquaculture, commercial, hydroelectric power, industrial, irrigation (only New Jersey for crop irrigation; all states for golf course irrigation), mining, and thermoelectric power categories were summed by subregion, basin, subbasin, and subwatershed. Public supply required an additional accounting of water transfers to estimate water use as described in the following section. All site-specific data were assigned to hydrologic units based on site location information.

Public Supply

Public supply refers to water withdrawn by public and private water suppliers that provide water to at least 25 people or have a minimum of 15 connections. Public supply includes water delivered for domestic, commercial, industrial, other public use purposes, and system losses. Public supply numbers in this report do not differentiate between these uses. For this report, public supply and self-supplied domestic are referred

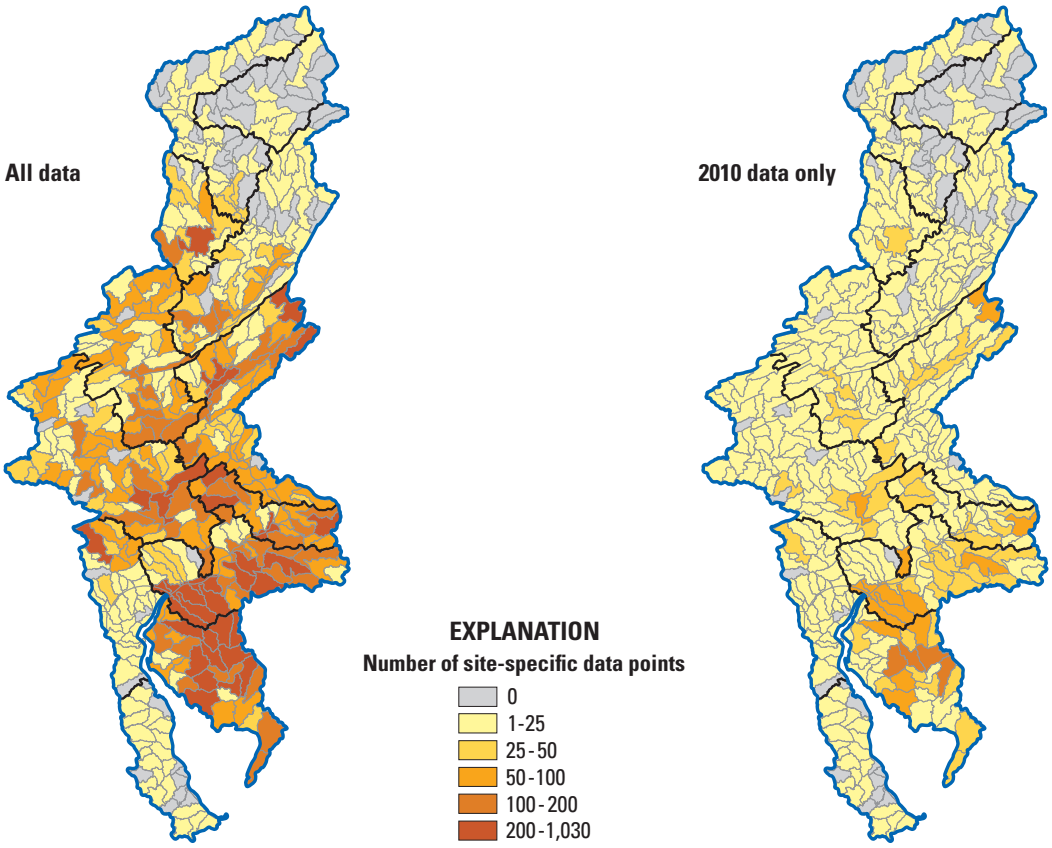
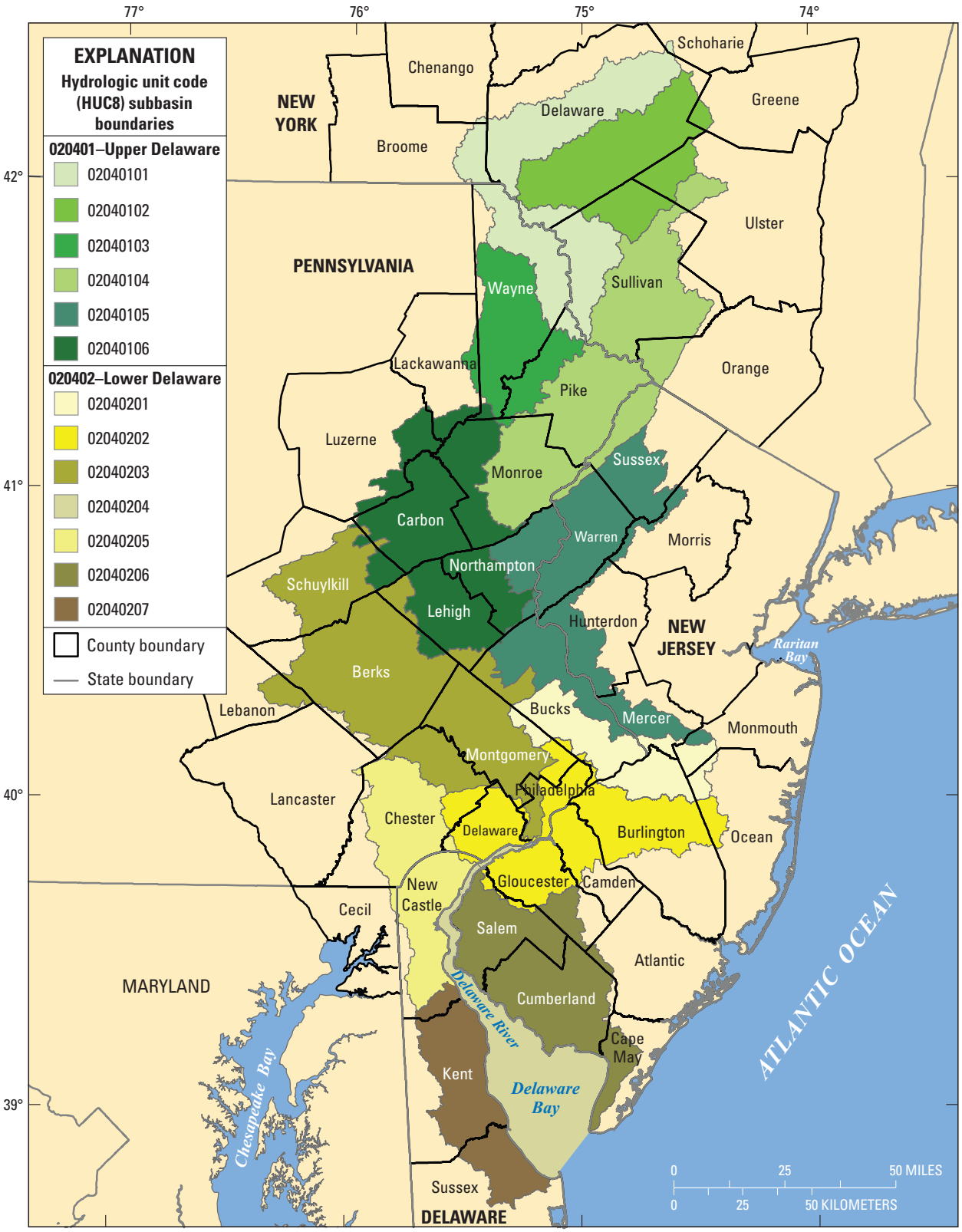


Figure 6. Number of site-specific data points by year range and subwatershed in the Delaware River Basin, 2010.

to together as potable water. For this report, the terms **public supply withdrawals**, public supply interbasin transfers (public supply transfers), and **public supply water use** each have a distinct meaning (although the terms water withdrawals and water use are commonly interchanged). A public supply withdrawal refers to water that is removed from a watershed for a beneficial purpose (offstream water use) and includes both within-basin uses and interbasin transfers; an interbasin transfer refers to water that moves into or out of the DRB; and public supply water use refers only to water used within the DRB.

Public suppliers in the DRB depend on reservoirs, surface-water intakes, single or multiple wells, and water-system interconnections to manage water supply and meet water demand. A large amount of water is transferred from the Cannonsville, Pepacton, and Neversink Reservoirs in the Upper DRB through a series of connecting tunnels and reservoirs to the Hudson River Basin. Nearly all of the water is delivered to New York City for public supply, although some is used as a water source for nearby communities in the Hudson River Basin. The maximum reservoir releases and transfers to New York City are controlled by a Supreme Court decree (U.S. Geological Survey, 2014a) and the daily releases are maintained by the Office of the Delaware River Master (U.S. Geological Survey, 2014c). Water is also transferred from the DRB to the Raritan River watershed for public supply use through the Delaware and Raritan Canal (D & R Canal). Transfers are monitored at the D & R Canal gage site at Port Mercer, New Jersey (U.S. Geological Survey, 2013). Water from the canal augments flows to either the Raritan or Millstone Rivers depending on low flow conditions to maintain minimum flow. There is a public supply transfer from the Susquehanna River Basin to the DRB through a piped distribution system into the Brandywine Creek-Christina subbasin in Pennsylvania. The transfer amounts are reported to the Pennsylvania Department of Environmental Protection.

To a lesser extent, some Burlington County and Camden County (New Jersey) (fig. 7) public supply systems periodically augmented the natural groundwater supply through **artificial aquifer recharge**. In 2010, excess water that had been stored in aquifers during wet periods or periods of low demand was recovered during dry periods or periods of high demand. Also, water stored in this manner can be withdrawn to be used later in months when an allocation limit is reached early in the month due to high demand. For this report, aquifer recovery numbers are reported as public supply withdrawals, and the storage values are reported as return flow.



State and County boundaries from U.S. Geological Survey, 1983.
HUC8 boundaries from U.S. Geological Survey, 1984.
Albers Equal-Area Conic Projection.

Figure 7. Counties in the Delaware River Basin.

Areal Estimates

Where site-specific data were not available it was necessary to develop areal estimates. Estimates of the total population and self-supplied domestic water use were developed for the entire DRB. Estimates of irrigation and livestock water use were made in states that did not have site-specific data. The different datasets and methods used to develop areal estimates, and techniques used to distribute these estimates across subbasins and subwatersheds, are described in the following sections. Areal estimates shown as a percentage of the total estimated withdrawals for each subwatershed are shown in figure 8, highlighting the impact of areal estimates in certain areas of the DRB.

Total Population

The 2010 estimates of total population were derived from 2010 census block-level data (U.S. Census Bureau, 2014). **Census block** population estimates were aggregated to the appropriate geographic unit based on the location of the centroid of the census block.

Self-Supplied Domestic Withdrawals

Domestic water use takes into account indoor and outdoor uses at residences. Self-supplied domestic water is usually withdrawn from a private source, such as a well. Although there may be some surface water used in the DRB for domestic supply, it is unlikely to be a significant quantity. For this reason, it was assumed for this report that only groundwater is used for domestic supply. Withdrawals were estimated basinwide as described below.

To develop current self-supplied domestic-use estimates for the DRB, information from the U.S. Census Bureau (USCB) was combined with information from the USGS National Water Information System (NWIS). USCB data used in this study include population and housing unit counts at the **block group** and block levels (the smallest geographical units available) from 1990, 2000, and 2010. The 1990 census included information at the block group level pertaining to the source of water supplied to housing units. This information was not collected in subsequent years. NWIS data used for this analysis were countywide estimates of total population served from a public supply source. These data are collected every 5 years, and data from 1990, 2000, and 2005 was used for this analysis.

For 1990, the total housing units within a block group, and the amount under public supply, were estimated so the percentage of housing units on public supply could be calculated for all block groups. For any given county, these block groups were then ranked and summed (from largest percentage to smallest), until the total population on public supply matched the NWIS estimate. The percentage of public supply housing units where the NWIS and USCB public supply totals most closely matched was then set as a cut-off value for each county. Any block group with a percentage of housing units above the cut-off value was considered fully public supply, whereas all those less than the cut-off value were considered to be self-supplied domestic.

Preliminary countywide estimates for 2000 and 2010 using the above technique did not always match NWIS values. Analysis of the data showed a trend for many counties where block groups with a high population total (and population density) were falling below the cut-off value, thus labelling them as domestic self-supply zones. In reality, they were likely to be publicly supplied. To address this issue, a 5-percent margin of error for population density (people per square mile) was applied to each county. The 95th percentile of population density was calculated for block groups that fall under the cut-off value, and a second condition was set in place. Block groups that were below the cut-off, but exceeded the 95th percentile of population density, were flipped from being characterized as domestic self-supply to public supply. Once this correction was applied, matches with NWIS county data were much improved.

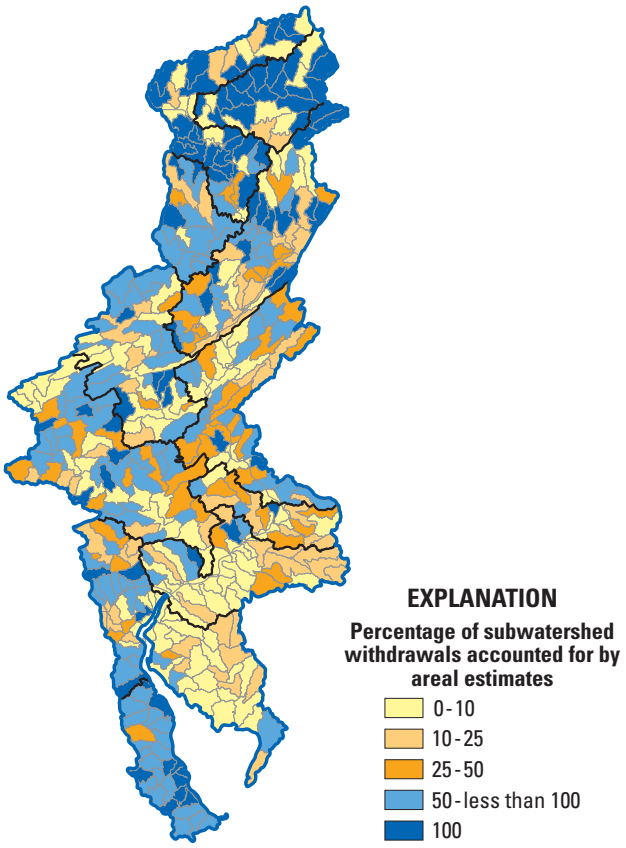


Figure 8. Percentage of subwatershed withdrawals accounted for by areal estimates in the Delaware River Basin, 2010.

The distribution of public supply and self-supplied populations by census block as determined through the above process is shown in figure 9. Results from this method were visually compared to existing data layers containing service area boundaries for public supply systems as a QA/QC check. This method of classifying census blocks was selected to be used for this study since it could be applied to other areas throughout the Nation where public supply system service area boundaries are not available.

Self-supplied populations in the DRB for 2000 and 2010 were estimated using the techniques described above. A coefficient of 75 gallons per person per day (the 2005 average self-supplied domestic per capita for the four states) (Kenny and others, 2009) was applied to the self-supplied population to estimate self-supplied domestic withdrawals. Centroids of the census blocks were matched to 8-digit subbasin and 12-digit subwatershed boundaries and summed using GIS to calculate water use in a watershed.

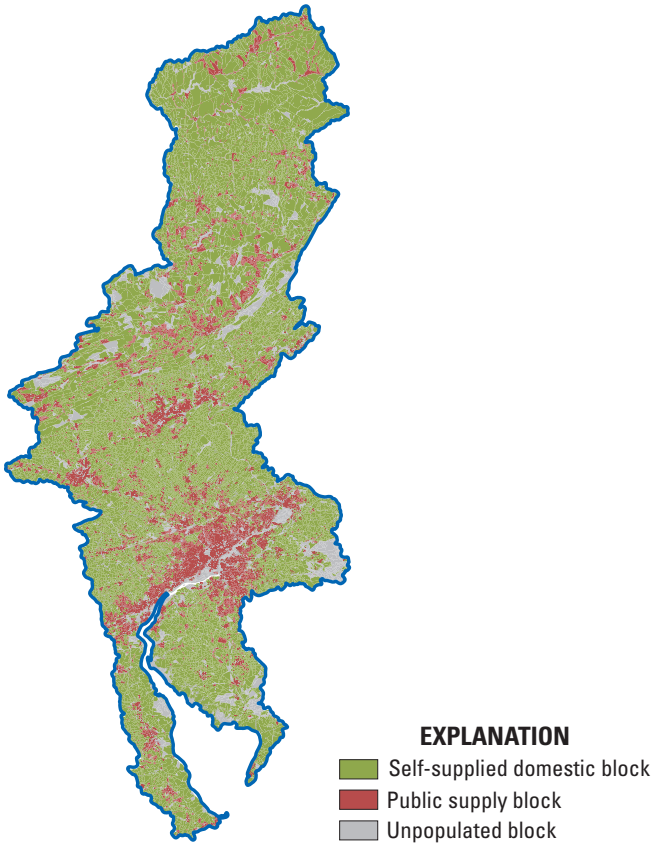


Figure 9. Distribution of public supply and self-supplied domestic census blocks in the Delaware River Basin, 2010.

Irrigation

Irrigation water use includes water that is applied by an irrigation system to sustain plant growth in all agricultural and horticultural practices. Golf course, park, nursery, turf farm, cemetery, and other self-supplied landscape-watering uses were also included. A mix of site-specific and areal estimates was used to estimate total irrigation in the DRB. Site-specific irrigation withdrawal data were available for golf courses, nurseries, and turf farms for all states. Site-specific data for crop irrigation was available for New Jersey. Areal irrigation estimates were made for Delaware, New York, and Pennsylvania by combining the 2010 NWIS county crop irrigation data (U.S Geological Survey, 2014c) for these three states with the 2010 U.S. Department of Agriculture (USDA) Cropland Data Layer (CDL) (U.S. Department of Agriculture, National Agricultural Statistics Service, 2010). For Delaware, a point dataset was available for center-pivot irrigation systems and was used to refine county crop irrigation estimates for that state.

To develop areal irrigation estimates, the 2010 NWIS county crop irrigation data were applied to selected CDL areas. Urban areas, water bodies and wetlands, forested areas, barren areas, pasture and grass, other hay, clover, and wildflowers were excluded as areas of potential irrigation in a county, and any remaining area was considered to be irrigated land. Total countywide irrigation withdrawals from NWIS by groundwater and surface water were distributed equally across the selected CDL crop types for that county. These values were then matched with 8-digit subbasin and 12-digit subwatershed boundaries using GIS and summed to calculate water use in a selected geographical area.

Livestock

Livestock water use is water associated with livestock watering, dairy operations, and other on-farm needs. Livestock includes dairy cows and heifers, beef cattle and calves, sheep and lambs, goats, hogs and pigs, horses, and poultry. Other livestock water uses include cooling of facilities for the animals and animal products such as milk, dairy sanitation and wash down of facilities, animal waste-disposal systems, and incidental water losses. Total livestock withdrawals relied on site-specific data for New Jersey, and areal estimates for the remaining states were made by combining the 2010 NWIS county estimates (U.S Geological Survey, 2014c; Lovelace, 2009) with the 2010 CDL data layers (U.S. Department of Agriculture, National Agricultural Statistics Service, 2010).

To develop areal livestock estimates, the 2010 NWIS county livestock use data were applied to selected CDL areas. Areas labeled as pasture, grass, or other hay were identified as areas of potential livestock watering and (or) livestock operations in a county. Total livestock withdrawals from NWIS by groundwater and surface water were then distributed equally across these identified areas. These values were then matched with 8-digit subbasin and 12-digit subwatershed boundaries using GIS and summed to calculate water use in a selected geographical area.

Water Use

Water can be withdrawn from rivers, reservoirs, and aquifers to meet offstream needs for public supply, self-supplied residential, irrigation, livestock, aquaculture, self-supplied industrial, commercial, mining, and **thermoelectric power generation** purposes. Water in river and reservoir systems can be used instream for hydroelectric power generation, navigation, recreation, maintaining minimum streamflows to support fish and wildlife habitat, and for wastewater assimilation. This report presents instream and offstream water use estimates from 2010 for the DRB in Delaware, New Jersey, New York, and Pennsylvania.

Total Water Withdrawals

Total water withdrawals in the DRB for 2010 were compiled for nine categories of use: public supply, self-supplied domestic, irrigation, livestock, aquaculture, industrial, commercial, mining, and thermoelectric power generation. Total subbasin populations and withdrawals by source for 2010 are listed in table 5. Total freshwater and saline-water withdrawals were calculated to be 7,130 Mgal/d, or 7,990 thousand acre-feet per year (acre-ft/yr). Freshwater withdrawals of 4,130 Mgal/d made up 58 percent of the total withdrawals, with 651 Mgal/d (9 percent of the total) being exported outside the basin to New York City (574 Mgal/d) and New Jersey (77.3 Mgal/d). Saline-water withdrawals were 3,000 Mgal/d (42 percent of the total), which were primarily brackish water from the Delaware Estuary used to cool thermoelectric powerplants. Total surface-water withdrawals were estimated to be 6,590 Mgal/d, or 92 percent of the total (fig. 10); about 54 percent (3,590 Mgal/d) of surface water withdrawn was freshwater. Total groundwater withdrawals were calculated to be about 8 percent of the total (545 Mgal/d), all of which was freshwater. The geographic distribution of total, surface-water, and groundwater withdrawals in the DRB is shown by subbasin in figure 11 and by subwatershed in figure 11a.

Withdrawals are generally highest in the southern half of the basin, where most of the population lives, but they can also be high in the north due to out-of-basin transfers. Withdrawals in New Jersey (3,930 Mgal/d) and Pennsylvania (2,120 Mgal/d) accounted for 85 percent of total withdrawals and were dominated by withdrawals for thermoelectric power generation. Withdrawals in New York (609 Mgal/d) and Delaware (475 Mgal/d) each accounted for less than 10 percent of total withdrawals. Ninety-four percent of the water withdrawals in New York are transferred out of the basin to supply New York City with drinking water.

The distribution of water withdrawals by category when withdrawals for thermoelectric power generation uses are not considered is shown in figure 10c. In this case, withdrawals for public supply uses within the DRB (840 Mgal/d) and transfers outside of the DRB (651 Mgal/d) account for 68 percent of the total. The distribution of water withdrawals by water use category and state (excluding withdrawals for thermoelectric power generation and transfers out of the DRB) is also shown in figure 10c.

In this report, discussion of results is done by grouping water use categories into sectors of water use (table 6). The Power Generation sector (4,910 Mgal/d; 69 percent of total withdrawals) includes the categories of thermoelectric power generation (an offstream water use) and hydroelectric power generation (an instream water use). The Drinking Water sector (1,610 Mgal/d; 23 percent of total withdrawals) includes public supply and self-supplied domestic uses. The Industrial sector (408 Mgal/d; less than 6 percent of total withdrawals) includes self-supplied industrial, commercial, and mining uses. The Agricultural sector (201 Mgal/d; less than 3 percent of total withdrawals) includes irrigation, livestock, and aquaculture uses. Data on total withdrawals by sector and subwatershed were calculated, and the sector with the largest water withdrawals for each subwatershed is shown in figure 12. Whereas withdrawals for the Drinking Water sector are distributed throughout the DRB, Power sector withdrawals are found mainly along the Delaware Estuary and the main stem and major tributaries of the Delaware River. The Agricultural sector is the largest sector in many subwatersheds in the Coastal Plain areas of Delaware and New Jersey.

Total water withdrawals by category and subbasin are listed in table 7; they are also listed by source of water in tables 8 (surface water) and 9 (groundwater). Thermoelectric power (4,910 Mgal/d) was the largest category of water use, followed by public supply (1,490 Mgal/d), self-supplied industrial (350 Mgal/d), irrigation (175 Mgal/d), and self-supplied domestic (117 Mgal/d). The remaining categories of water use—mining, aquaculture, livestock, and commercial—combined were about 1 percent (73.2 Mgal/d) of total withdrawals.

Power Generation Sector

The Power Generation sector consists of the thermoelectric power generation and hydroelectric power generation categories. Thermoelectric power generation withdrawals were considered to be offstream withdrawals and thus were included in the calculations of total withdrawals in this report. Hydroelectric power generation water withdrawals were considered to be instream withdrawals and were not included along with offstream withdrawal calculations, but they are discussed in the *Instream Hydroelectric Power Water Use* section.

Offstream Thermoelectric Power Water Withdrawals

Total water withdrawals in the DRB for the thermoelectric power generation category were 4,910 Mgal/d (table 10), or 5,510 thousand acre-ft/yr in 2010. About 61 percent of thermoelectric withdrawals (2,990 Mgal/d) were saline water from the estuary. Thermoelectric power generation represents 69 percent of total withdrawals, and 47 percent of all freshwater withdrawals in the DRB. Almost all of the freshwater

Table 5. Total water withdrawals by source and subbasin, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Hydrologic unit	Hydrologic unit code	Population (thousands)	Withdrawals (million gallons per day)							Withdrawals (thousand acre-feet per year)		
			By source and type				Total		Total	By source		Total
			Groundwater	Surface water						Groundwater	Surface water	
			Fresh	Fresh	Saline	Total	Fresh	Saline				
Study Area (total)												
		8,260	**545**	**3,590**	**3,000**	**6,590**	**4,130**	**3,000**	**7,130**	**611**	**7,380**	**7,990**
Upper Delaware River Basin (total)												
	020401	**1,700**	**134**	**1,050**	**0**	**1,050**	**1,190**	**0**	**1,190**	**150**	**1,180**	**1,330**
Upper Delaware River Subbasins												
Upper Delaware	02040101	43.8	4.75	152	0	152	157	0	157	5.32	170	176
East Branch Delaware	02040102	17.2	1.96	341	0	341	343	0	343	2.20	382	385
Lackawaxen	02040103	57.1	4.31	0.72	0	0.72	5.03	0	5.03	4.83	0.81	5.64
Middle Delaware-Mongaup-Brodhead	02040104	232	14.2	109	0	109	123	0	123	15.9	122	138
Middle Delaware-Musconetcong	02040105	669	57.8	400	0	400	458	0	458	64.8	449	514
Lehigh	02040106	678	50.5	50.1	0	50.9	101	0	101	56.6	57.0	114
Lower Delaware River Basin (total)												
	020402	**6,560**	**411**	**2,530**	**3,000**	**5,530**	**2,940**	**3,000**	**5,940**	**461**	**6,200**	**6,660**
Lower Delaware River Subbasins												
Crosswicks-Neshaminy	02040201	669	41.4	569	0	569	610	0	610	46.4	638	684
Lower Delaware	02040202	2,990	104	1,030	1.69	1,030	1,130	1.69	1,130	117	1,150	1,270
Schuylkill	02040203	1,660	72.5	498	0	498	571	0	571	81.3	558	640
Brandywine-Christina	02040205	754	37.6	380	0	380	418	0	418	42.2	426	469
Cohansey-Maurice	02040206	299	81.8	50.3	3,000	3,050	132	3,000	3,130	91.7	3,420	3,510
Broadkill-Smyrna	02040207	193	74.1	9.41	0	9.41	83.5	0	83.5	83.0	10.5	93.6

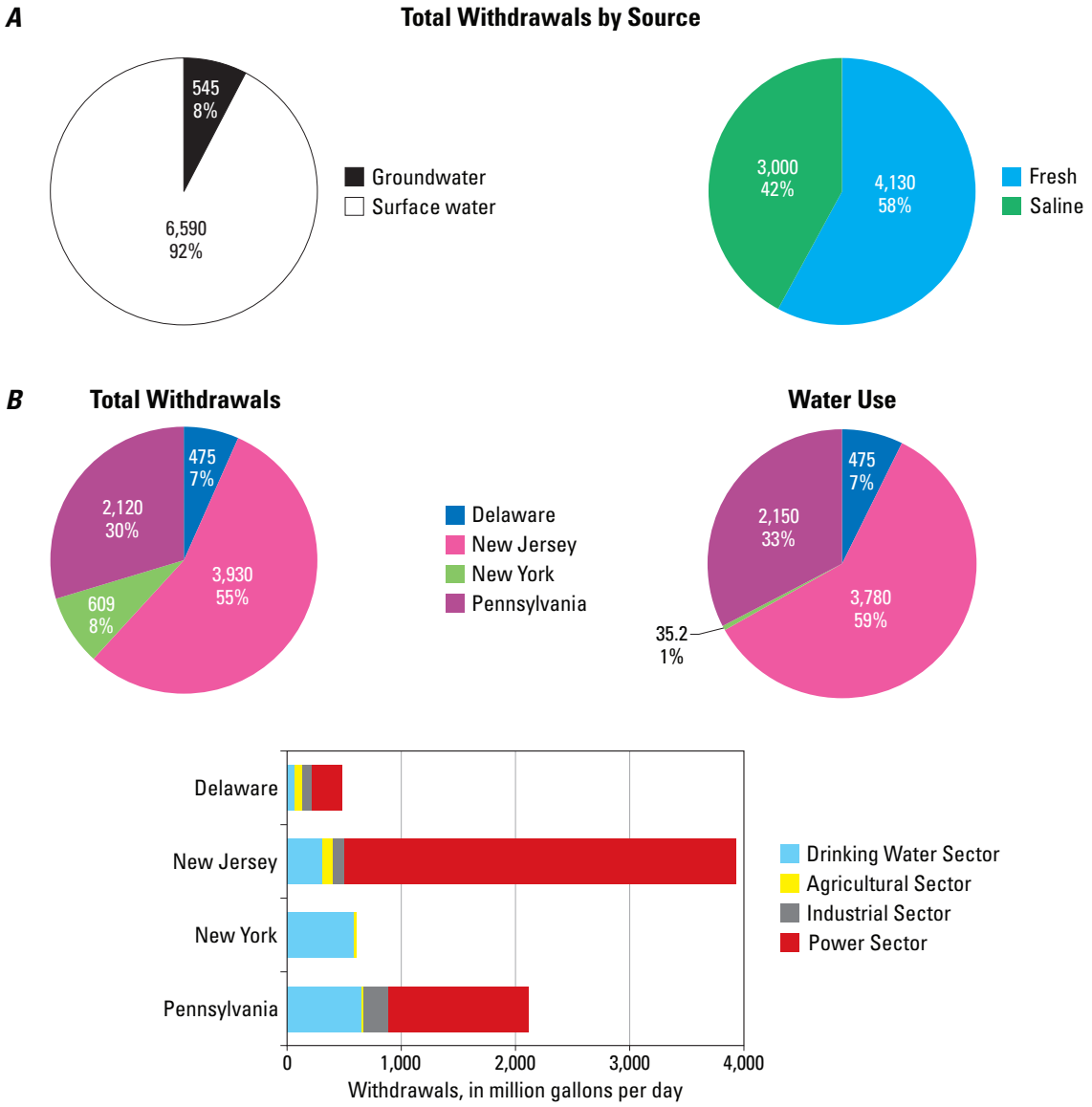


Figure 10. Distribution of total water withdrawals by *A,* source, *B,* state and sector, and *C,* water use category and state in the Delaware River Basin, 2010. (<, less than; %, percent)

withdrawn (1,920 Mgal/d) for thermoelectric power generation in the DRB was from surface-water sources; less than 1 percent (3.00 Mgal/d) was from groundwater sources.

The Lower basin accounted for 95 percent (4,650 Mgal/d) of the total Power Generation sector withdrawals, whereas the Upper basin accounted for only 5 percent (262 Mgal/d) (table 11, fig. 13a). The Lower basin water withdrawals were almost all from surface-water sources (4,650 Mgal/d of surface water, 2.65 Mgal/d of groundwater). The Lower basin water withdrawals were also 64 percent (2,990 Mgal/d) saline water from the estuary, and 36 percent (1,660 Mgal/d) freshwater. The Upper basin withdrawals were all freshwater withdrawals, and they were almost all from surface-water sources (261 Mgal/d of surface water, 0.35 Mgal/d of groundwater). The large amounts of water withdrawn for thermoelectric power generation were used primarily for once-through cooling in thermoelectric powerplants.

The geographic distribution of total thermoelectric power water withdrawals by subbasin and subwatershed is shown in figure 13b. The largest withdrawals were near urban centers, and were primarily on the largest rivers (the Delaware and the Schuylkill) and the Delaware Estuary. The subbasin with the largest water withdrawals for thermoelectric power generation (02040206) accounted for 61 percent (2,990 Mgal/d) of the

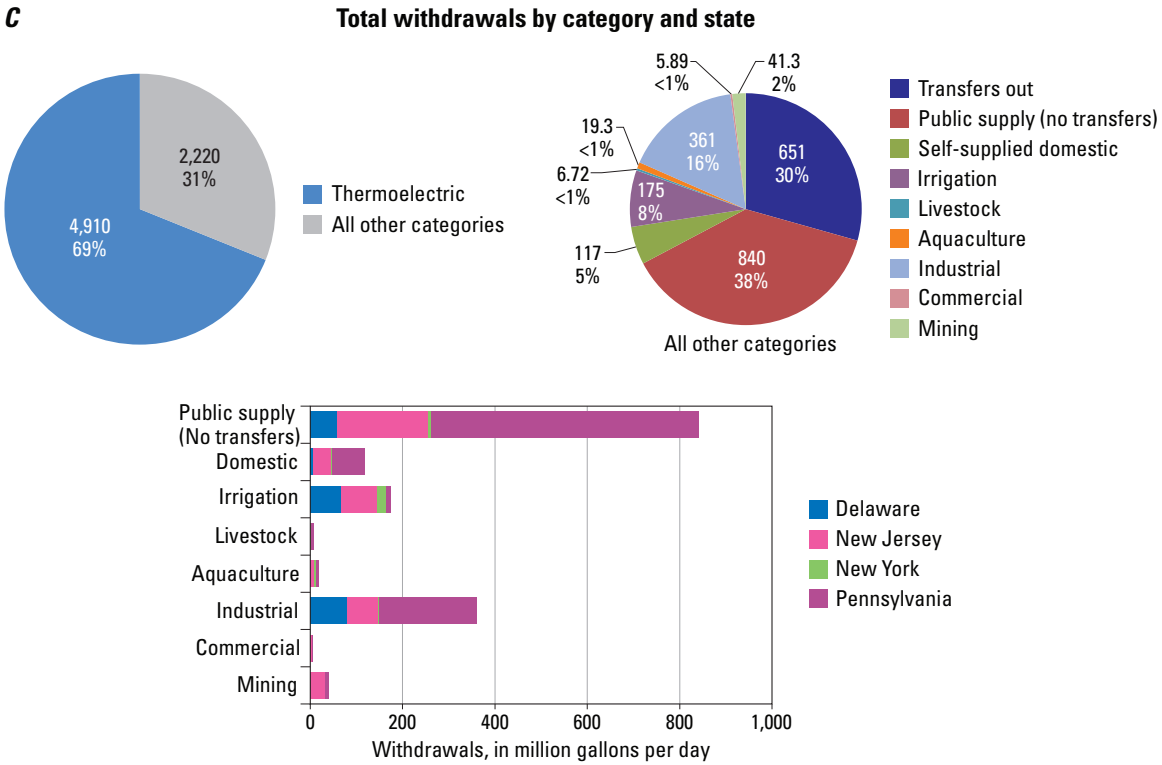


Figure 10. Distribution of total water withdrawals by *A,* source, *B,* state and sector, and *C,* water use category and state in the Delaware River Basin, 2010. (<, less than; %, percent)—Continued

thermoelectric power generation water withdrawn in the DRB and was all saline water; most of this water was used by a single facility. The largest freshwater withdrawals were in subbasins 02040202 (706 Mgal/d) and 02040201 (478 Mgal/d) and accounted for 62 percent (1,180 Mgal/d) of the total freshwater withdrawals for thermoelectric power generation in the DRB. The subwatershed with the largest saline-water withdrawals (2,980 Mgal/d) was 020402060602, where the PSEG Salem Generating Station Powerplant is located. The subwatershed with the largest freshwater withdrawals (690 Mgal/d) was 020402020601, where the Exelon Eddystone Powerplant is located.

A single subbasin (02040202) had fresh surface-water withdrawals that accounted for 37 percent (706 Mgal/d) of the total for the DRB whereas another subbasin (02040203) accounted for 76 percent (2.28 Mgal/d) of thermoelectric power generation fresh groundwater withdrawals.

Almost 64 percent (1,220 Mgal/d) of the freshwater withdrawn for thermoelectric power generation was withdrawn in Pennsylvania. Subbasin 02040202 in Pennsylvania accounted for 36 percent (690 Mgal/d) of the thermoelectric power generation freshwater withdrawn in the DRB. In New Jersey, reported water withdrawals for thermoelectric power generation were 3,430 Mgal/d (70 percent of the total) and were mainly (87 percent, 2,990 Mgal/d) from the saline estuary. Reported withdrawals in Delaware represented 5 percent of total category withdrawals and were almost exclusively from fresh surface-water sources. No water withdrawals for thermoelectric power generation were reported for New York.

Instream Hydroelectric Power Water Use

Controlled daily releases (in cubic feet per second) for reservoirs that produce power in the DRB were reported to the Office of the Delaware River Master in 2010. The Wallenpaupack Hydroelectric Powerplant on the Lackawaxen River depends on water from Wallenpaupack Creek contained by a 1,280-ft long and 70-ft high dam (Pennsylvania Power and Light, 2014). The Mongaup River system consists of five reservoirs and three hydroelectric stations that utilize available water resources from the 210-mi^2 Mongaup River Basin (Eagle Creek Renewable Energy, 2014). The amount of instream use for hydroelectric power generation purposes in 2010 was reported to be 273 Mgal/d for the Wallenpaupack plant and 127 Mgal/d for the Mongaup River system.

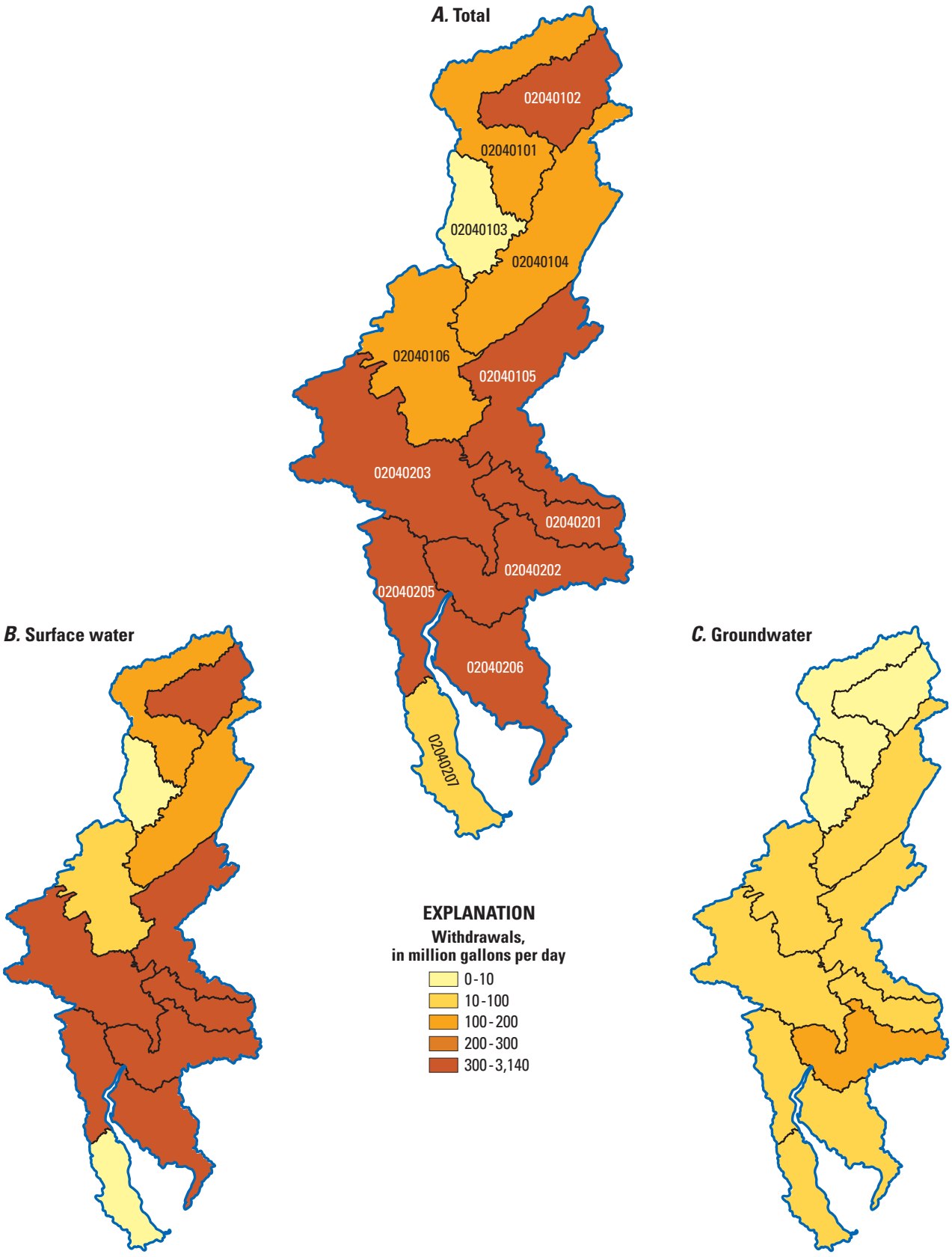


Figure 11. *A,* Total, *B,* surface-water, and *C,* groundwater withdrawals by subbasin in the Delaware River Basin, 2010.

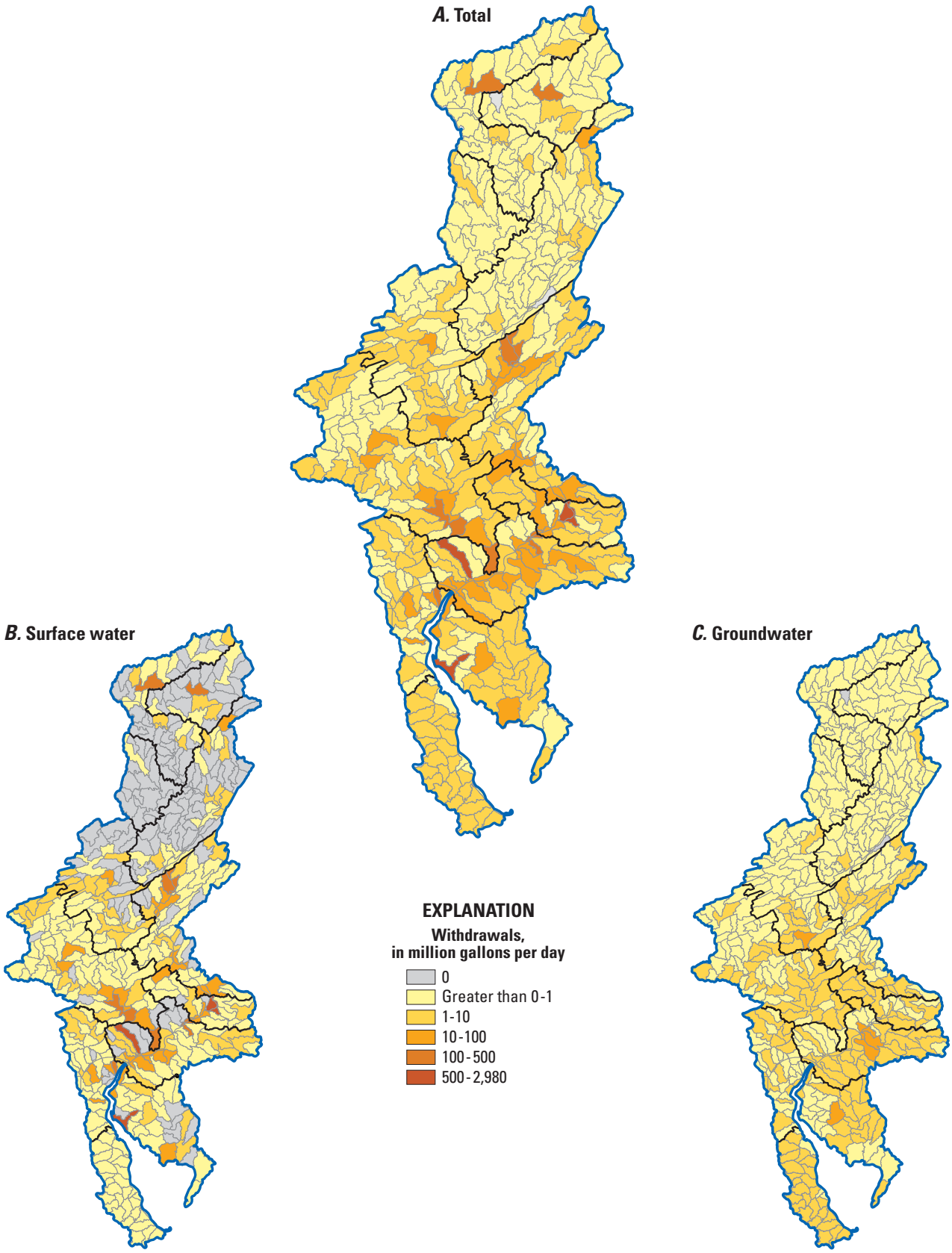


Figure 11a. *A,* Total, *B,* surface-water, and *C,* groundwater withdrawals by subwatershed in the Delaware River Basin, 2010.

Table 6. Total water withdrawals by source and sector, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Sector	Withdrawals (million gallons per day)							Withdrawals (thousand acre-feet per year)		
	By source and type				Total		Total	By source		Total
	Ground-water	Surface water								
	Fresh	Fresh	Saline	Total	Fresh	Saline		Ground-water	Surface water	
Study Area (total)										
	545	**3,590**	**3,000**	**6,590**	**4,130**	**3,000**	**7,130**	**611**	**7,380**	**7,990**
Sector										
Power	3.00	1,920	2,990	4,910	1,920	2,990	4,910	3.36	5,510	5,510
Drinking Water	370	1,240	0	1,240	1,610	0	1,610	415	1,390	1,800
Industrial	51.1	346	10.6	357	397	10.6	408	57.2	400	457
Agricultural	121	79.9	0	79.9	201	0	201	136	90.0	225

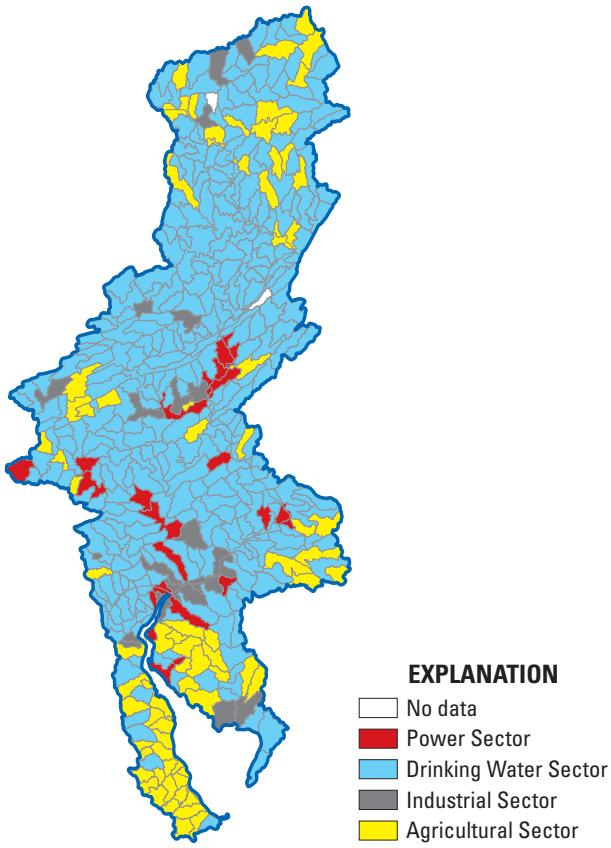


Figure 12. Sector with the largest water withdrawals by subwatershed in the Delaware River Basin, 2010.

Table 7. Total water withdrawals by water use category, Delaware River Basin, 2010.

[Mgal/d, million gallons per day; Values may not sum to totals because of independent rounding.]

Hydrologic unit code	Withdrawals (million gallons per day)													Withdrawals (thousand acre-feet per year)		
	Public supply	Domestic	Irrigation	Livestock	Aquaculture	Industrial		Commercial	Mining	Thermoelectric		Total		Total		Total
	Fresh					Fresh	Saline	Fresh		Fresh	Saline	Fresh	Saline	Fresh	Saline	
Study Area (total)																
	1,490	**117**	**175**	**6.72**	**19.3**	**350**	**10.6**	**5.89**	**41.3**	**1,920**	**2,990**	**4,130**	**3,000**	**4,630**	**3,360**	**7,990**
Upper Delaware River Basin (total)																
020401	**810**	**36.2**	**25.2**	**1.31**	**16.1**	**32.0**	**0**	**2.04**	**3.32**	**262**	**0**	**1,190**	**0**	**1,330**	**0**	**1,330**
Upper Delaware River Subbasins																
02040101	146[1]	1.63	6.97	0.44	0	1.37	0	0	0	0	0	157	0	176	0	176
02040102	335[2]	0.63	3.58	0.08	3.33	0	0	0	0.22	0	0	343	0	385	0	385
02040103	2.10	1.76	0.11	0.17	0.89	0	0	0	0	0	0	5.03	0	5.64	0	5.64
02040104	107[3]	4.71	9.71	0.01	0.21	0.33	0	0.82	0.09	0	0	123	0	138	0	138
02040105	156[4]	19.2	2.99	0.31	9.36	13.0	0	0.41	2.57	255	0	458	0	514	0	514
02040106	63.2	8.29	1.88	0.30	2.30	17.2	0	0.81	0.44	6.87	0	101	0	114	0	114
Lower Delaware River Basin (total)																
020402	**682**	**80.8**	**150**	**5.41**	**3.18**	**318**	**10.6**	**3.85**	**38.0**	**1,660**	**2,990**	**2,940**	**3,000**	**3,300**	**3,360**	**6,660**
Lower Delaware River Subbasins																
02040201	65.8	12.5	11.2	0.01	0	40.8	0	0.26	1.77	478	0	610	0	684	0	684
02040202	264	17.3	26.3	0.33	0	114	0	0.99	0.04	706	1.69	1,130	1.69	1,270	1.89	1,270
02040203	248	25.6	4.28	3.25	2.44	60.2	0	0.13	3.58	223	0	571	0	640	0	640
02040205	60.5	13.0	5.39	0.80	0.70	82.3	0	0.02	0	255	0	418	0	469	0	469
02040206	30.2	8.81	39.0	0.63	0	18.3	10.6	2.45	32.6	0	2,990	132	3,000	148	3,360	3,510
02040207	13.7	3.49	63.4	0.39	0.04	2.12	0	0	0	0.37	0	83.5	0	93.6	0	93.6

[1] Includes transfers of 145 Mgal/d.

[2] Includes transfers of 334 Mgal/d.

[3] Includes transfers of 94.7 Mgal/d.

[4] Includes transfers of 77.3 Mgal/d.

Table 8. Surface-water withdrawals by water use category, Delaware River Basin, 2010.

[Mgal/d, million gallons per day; Values may not sum to totals because of independent rounding.]

Hydrologic unit code	Withdrawals (million gallons per day)													Withdrawals (thousand acre-feet per year)		
	Public supply	Domestic	Irrigation	Livestock	Aquaculture	Industrial		Commercial	Mining	Thermoelectric		Total		Total		Total
	Fresh					Fresh	Saline	Fresh		Fresh	Saline	Fresh	Saline	Fresh	Saline	
Study Area (total)																
	1,240	**0**	**72.3**	**0.64**	**6.99**	**312**	**10.6**	**1.54**	**32.6**	**1,920**	**2,990**	**3,590**	**3,000**	**4,020**	**3,360**	**7,380**
Upper Delaware River Basin (total)																
020401	**748**	**0**	**22.1**	**0.12**	**4.28**	**16.2**	**0**	**1.45**	**0.22**	**261**	**0**	**1,050**	**0**	**1,180**	**0**	**1,180**
Upper Delaware River Subbasins																
02040101	145[1]	0	6.85	0.09	0	0	0	0	0	0	0	152	0	170	0	170
02040102	334[2]	0	3.55	0	2.90	0	0	0	0.22	0	0	341	0	382	0	382
02040103	0	0	0	0	0.72	0	0	0	0	0	0	0.72	0	0.81	0	0.81
02040104	98.3[3]	0	9.58	0	0.21	0.33	0	0.59	0	0	0	109	0	122	0	122
02040105	134[4]	0	1.53	0.02	0.25	9.11	0	0.31	0	255	0	400	0	449	0	449
02040106	36.3	0	0.55	0.01	0.20	6.75	0	0.55	0	6.52	0	50.9	0	57.0	0	57.0
Lower Delaware River Basin (total)																
020402	**491**	**0**	**50.2**	**0.52**	**2.71**	**296**	**10.6**	**0.09**	**32.3**	**1,660**	**2,990**	**2,530**	**3,000**	**2,840**	**3,360**	**6,200**
Lower Delaware River Subbasins																
02040201	41.1	0	9.87	0	0	40.0	0	0.04	0.01	478	0	569	0	638	0	638
02040202	187	0	21.8	0.01	0	110	0	0	0	706	1.69	1,030	1.69	1,150	1.89	1,150
02040203	219	0	1.21	0.41	2.20	54.2	0	0.05	0.01	221	0	498	0	558	0	558
02040205	42.9	0	1.16	0.10	0.51	80.6	0	0	0	255	0	380	0	426	0	426
02040206	0.18	0	6.74	0	0	11.0	10.6	0	32.3	0	2,990	50.3	3,000	56.4	3,360	3,420
02040207	0	0	9.41	0	0	0	0	0	0	0	0	9.41	0	10.5	0	10.5

[1] Includes transfers of 145 Mgal/d.

[2] Includes transfers of 334 Mgal/d.

[3] Includes transfers of 94.7 Mgal/d.

[4] Includes transfers of 77.3 Mgal/d.

Table 9. Groundwater withdrawals by water use category, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Hydrologic unit code	Withdrawals (million gallons per day)												Withdrawals (thousand acre-feet per year)		
	Public supply	Domestic	Irrigation	Livestock	Aquaculture	Industrial		Commercial	Mining	Thermoelectric		Total		Total		Total
	Fresh					Fresh	Saline	Fresh		Fresh	Saline	Fresh	Saline	Fresh	Saline	
Study Area (total)																
	253	**117**	**103**	**6.08**	**12.3**	**37.9**	**0**	**4.35**	**8.78**	**3.00**	**0**	**545**	**0**	**611**	**0**	**611**
Upper Delaware River Basin (total)																
020401	**61.4**	**36.2**	**3.18**	**1.19**	**11.8**	**15.8**	**0**	**0.59**	**3.10**	**0.35**	**0**	**134**	**0**	**150**	**0**	**150**
Upper Delaware River Subbasins																
02040101	1.28	1.63	0.12	0.35	0	1.37	0	0	0	0	0	4.75	0	5.32	0	5.32
02040102	0.79	0.63	0.03	0.08	0.43	0	0	0	0	0	0	1.96	0	2.20	0	2.20
02040103	2.10	1.76	0.11	0.17	0.17	0	0	0	0	0	0	4.31	0	4.83	0	4.83
02040104	9.03	4.71	0.13	0.01	0	0	0	0.23	0.09	0	0	14.2	0	15.9	0	15.9
02040105	21.2	19.2	1.46	0.29	9.11	3.90	0	0.10	2.57	0	0	57.8	0	64.8	0	64.8
02040106	27.0	8.29	1.33	0.29	2.10	10.5	0	0.26	0.44	0.35	0	50.5	0	56.6	0	56.6
Lower Delaware River Basin (total)																
020402	**191**	**80.8**	**99.4**	**4.89**	**0.47**	**22.2**	**0**	**3.76**	**5.68**	**2.65**	**0**	**411**	**0**	**461**	**0**	**461**
Lower Delaware River Subbasins																
02040201	24.7	12.5	1.36	0.01	0	0.80	0	0.22	1.76	0	0	41.4	0	46.4	0	46.4
02040202	76.5	17.3	4.52	0.32	0	4.23	0	0.99	0.04	0	0	104	0	117	0	117
02040203	28.8	25.6	3.07	2.84	0.24	5.99	0	0.08	3.57	2.28	0	72.5	0	81.3	0	81.3
02040205	17.6	13.0	4.23	0.70	0.19	1.77	0	0.02	0	0	0	37.6	0	42.2	0	42.2
02040206	30.1	8.81	32.3	0.63	0	7.26	0	2.45	0.31	0	0	81.8	0	91.7	0	91.7
02040207	13.7	3.49	54.0	0.39	0.04	2.12	0	0	0	0.37	0	74.1	0	83.0	0	83.0

Table 10. Thermoelectric power water withdrawals, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Geographic area	Withdrawals (million gallons per day)									Withdrawals (thousand acre-feet per year)		
	Groundwater			Surface water			Total			By source		Total
	Fresh	Saline	Total	Fresh	Saline	Total	Fresh	Saline	Total	Fresh	Saline	
Study Area (total)												
Total	**3.00**	**0**	**3.00**	**1,920**	**2,990**	**4,910**	**1,920**	**2,990**	**4,910**	**2,160**	**3,350**	**5,510**
Delaware												
Total	**0.37**	**0**	**0.37**	**260**	**0**	**260**	**260**	**0**	**260**	**292**	**0**	**292**
02040202	0	0	0	4.97	0	4.97	4.97	0	4.97	5.57	0	5.57
02040205	0	0	0	255	0	255	255	0	255	286	0	286
02040207	0.37	0	0.37	0	0	0	0.37	0	0.37	0.41	0	0.41
New Jersey												
Total	**0**	**0**	**0**	**441**	**2,990**	**3,430**	**441**	**2,990**	**3,430**	**495**	**3,350**	**3,850**
02040104	0	0	0	0	0	0	0	0	0	0	0	0
02040105	0	0	0	0.77	0	0.77	0.77	0	0.77	0.86	0	0.86
02040201	0	0	0	429	0	429	429	0	429	481	0	481
02040202	0	0	0	11.3	1.69	13.0	11.3	1.69	13.0	12.7	1.89	14.6
02040206	0	0	0	0	2,990	2,990	0	2,990	2,990	0	3,350	3,350
New York												
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
02040101	0	0	0	0	0	0	0	0	0	0	0	0
02040102	0	0	0	0	0	0	0	0	0	0	0	0
02040104	0	0	0	0	0	0	0	0	0	0	0	0
Pennsylvania												
Total	**2.63**	**0**	**2.63**	**1,220**	**0**	**1,220**	**1,220**	**0**	**1,220**	**1,370**	**0**	**1,370**
02040101	0	0	0	0	0	0	0	0	0	0	0	0
02040103	0	0	0	0	0	0	0	0	0	0	0	0
02040104	0	0	0	0	0	0	0	0	0	0	0	0
02040105	0	0	0	254	0	254	254	0	254	285	0	285
02040106	0.35	0	0.35	6.52	0	6.52	6.87	0	6.87	7.70	0	7.70
02040201	0	0	0	48.9	0	48.9	48.9	0	48.9	54.9	0	54.9
02040202	0	0	0	690	0	690	690	0	690	773	0	773
02040203	2.28	0	2.28	221	0	221	223	0	223	250	0	250
02040205	0	0	0	0	0	0	0	0	0	0	0	0

Table 11. Thermoelectric power generation water withdrawals by basin, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Withdrawals (million gallons per day)								
Groundwater			Surface water			Total		
Fresh	Saline	Total	Fresh	Saline	Total	Fresh	Saline	Total
Study Area (total)								
3.00	0	3.00	1,920	2,990	4,910	1,920	2,990	4,910
Upper Delaware River Basin (total)								
0.35	0	0.35	261	0	261	262	0	262
Lower Delaware River Basin (total)								
2.65	0	2.65	1,660	2,990	4,650	1,660	2,990	4,650

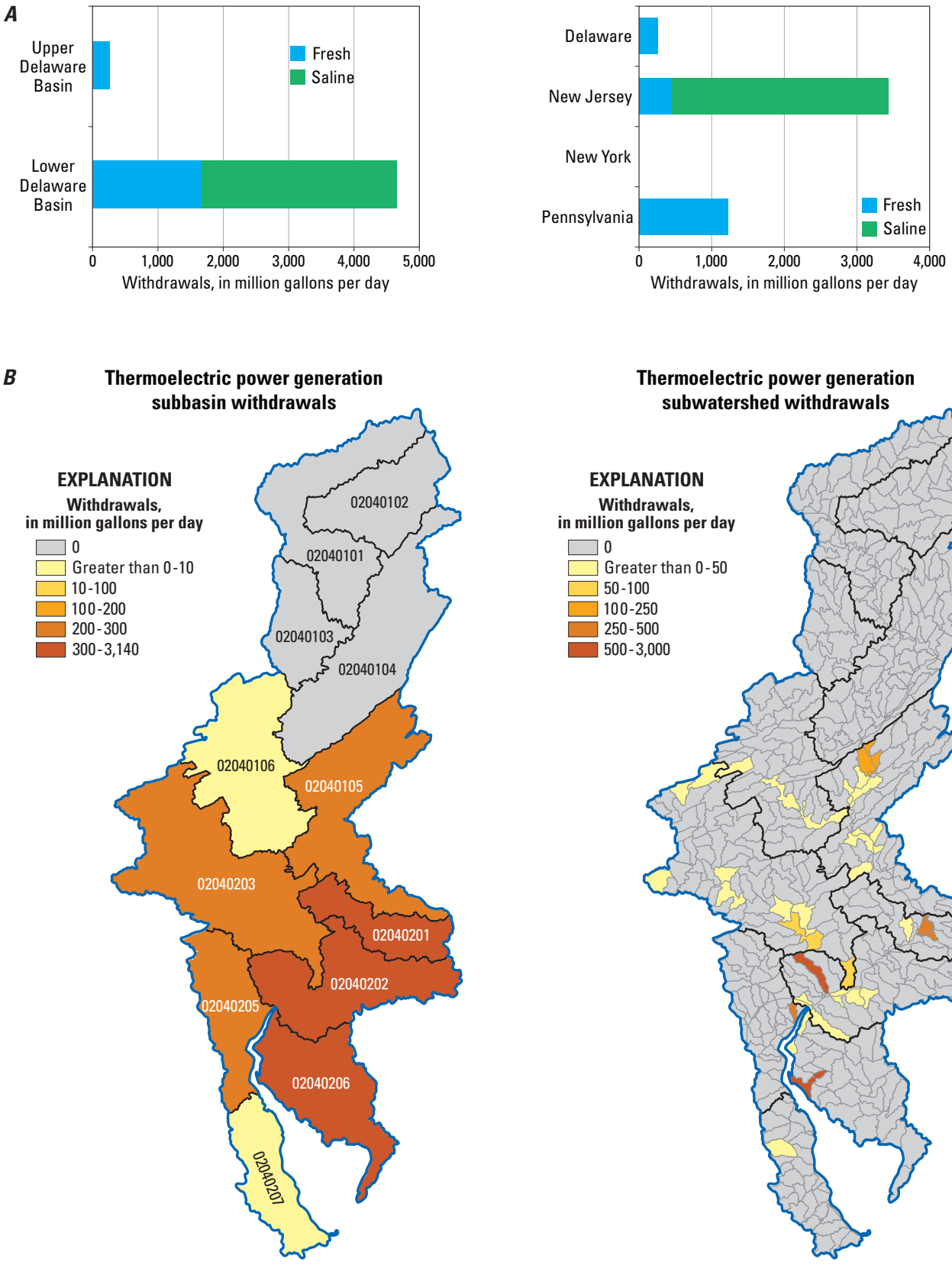


Figure 13. Distribution of thermoelectric power generation water withdrawals by *A,* type, basin, state, and *B,* subbasin and subwatershed in the Delaware River Basin, 2010.

Drinking Water Sector

The drinking water sector consists of the public supply and self-supplied domestic water use categories. Total withdrawals of 1,610 Mgal/d for the Drinking Water sector represented 39 percent of the total freshwater withdrawals in the DRB in 2010 (table 12). Over three-quarters (1,240 Mgal/d) of the drinking water withdrawn was from surface-water sources, and less than a quarter (370 Mgal/d) was from groundwater sources (fig. 14a). Forty percent (651 Mgal/d) of the drinking water total was transferred out of the basin. Water withdrawn for public supply uses within the DRB (840 Mgal/d) accounted for 52 percent of the water withdrawals for this sector. Self-supplied domestic (117 Mgal/d) accounted for the remaining withdrawals for this sector.

The Upper basin (020401) accounted for 53 percent (846 Mgal/d) of the total Drinking Water sector withdrawals, whereas the Lower basin (020402) accounted for 47 percent (763 Mgal/d) (fig. 14b). However, out-of-basin drinking water exports accounted for 77 percent (651 Mgal/d) of drinking water withdrawals in the Upper basin. Within basin drinking water withdrawals (excluding exports) for the Upper basin were about evenly split between surface water (97.1 Mgal/d) and groundwater (97.6 Mgal/d) sources. Upper basin self-supplied domestic was 36.2 Mgal/d, or about 19 percent of the Upper basin drinking water use. The Lower basin withdrawals were 64 percent (491 Mgal/d) surface water and 36 percent (272 Mgal/d) groundwater and were used primarily for public supply. Drinking Water sector use in the Lower basin includes 32.4 Mgal/d of water that is transferred in (imported) from the Susquehanna River Basin in Pennsylvania. Lower basin self-supplied domestic withdrawals were 80.8 Mgal/d, or about 10 percent of the Lower basin drinking water use.

The geographic distribution of total Drinking Water sector water withdrawals by subbasin is shown in figure 14c. Sector withdrawals are dominated by public supply water withdrawals in the Upper basin for New York City and in the Lower basin for the greater Philadelphia area.

Public Supply

Total water withdrawals in the DRB for the public supply category were 1,490 Mgal/d (table 13), or 1,670 thousand acre-ft/yr in 2010. Public supply represents about 36 percent of total freshwater withdrawals and about 68 percent of all withdrawals not including thermoelectric power. Approximately 83 percent (1,240 Mgal/d) of water withdrawn for public supply in the DRB was from surface sources, such as reservoirs, lakes, and streams; the other 17 percent (253 Mgal/d) was from groundwater (fig. 15).

An estimated 14.7 million people relied on drinking water withdrawn in the DRB for their household use; over 8 million people outside of the basin (in New York City and New Jersey) and 6.7 million people within the DRB. The publicly supplied population of the DRB represents about 81 percent of the total 2010 DRB population of approximately 8.2 million people. The subbasins with the largest water withdrawals for public supply were those in which withdrawals for New York City, New York; Philadelphia, Pennsylvania; and Trenton, New Jersey occurred. Approximately 651 Mgal/d were transferred out of the DRB and 32.4 Mgal/d were transferred into the DRB.

Over three-quarters (1,160 Mgal/d) of the water withdrawn for public supply was withdrawn in New York and Pennsylvania. Almost 40 percent of the total was withdrawn in New York and was transferred out of the DRB to New York City. Water withdrawn by public suppliers for use within the DRB was primarily from surface-water sources in Pennsylvania (86 percent surface water; 14 percent groundwater), groundwater sources in New Jersey (31 percent surface water; 69 percent groundwater) and in New York (21 percent surface water; 79 percent groundwater); and almost equally split between sources in Delaware (55 percent surface water; 45 percent groundwater).

Three subbasins (02040103, 02040206, and 02040207) had public supply withdrawals almost exclusively (greater than 99 percent) from groundwater sources, most likely

Table 12. Drinking Water sector water withdrawals, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Withdrawals (million gallons per day)									Water use (million gallons per day)		
Public supply			Domestic			Total			Transfers		
Groundwater	Surface water	Total	Groundwater	Surface water	Total	Groundwater	Surface water	Total	Imports	Exports	Total use
Study Area (total)											
253	1,240	1,490	117	0	117	370	1,240	1,610	32.4	651	990
Upper Delaware River Basin (total)											
61.4	748	810	36.2	0	36.2	97.6	748	846	0	651	195
Lower Delaware River Basin (total)											
191	491	682	80.8	0	80.8	272	491	763	32.4	0	795

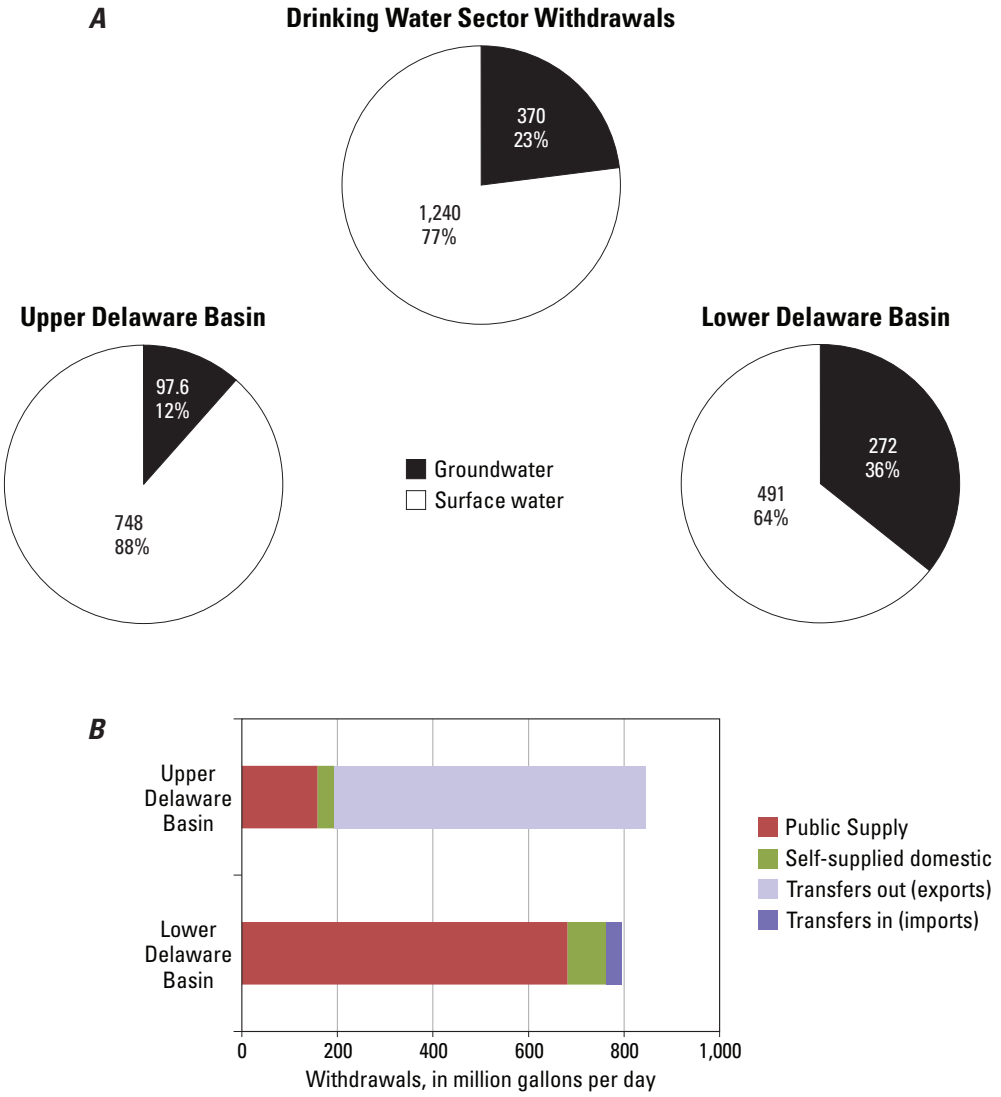


Figure 14. Distribution of water withdrawals for the Drinking Water sector in the Delaware River Basin, 2010, by *A,* source and basin, *B,* basin and water use category, and *C,* subbasin and source. (%, percent)

because these basins have low to moderate populations and access to productive aquifers (glaciofluvial for the first subbasin, Coastal Plain for the latter two) (fig. 16). Two subbasins (02040101 and 02040102) had public supply withdrawals almost exclusively (greater than 99 percent) from surface-water sources due to the withdrawal and subsequent transfer of water to New York City; however, groundwater sources account for most of the publicly supplied water use for residents within these two subbasins of the DRB.

The six subwatersheds with the largest surface-water withdrawals were the three subwatersheds that include reservoirs that are part of the New York City supply system (020401020405, Pepacton Reservoir, 334 Mgal/d; 020401010207, Cannonsville Reservoir, 145 Mgal/d; and 020401040303, Neversink Reservoir, 94.7 Mgal/d) and the three subwatersheds where water is withdrawn to supply the City of Philadelphia (020402031008, 121 Mgal/d), the Cities of Camden (020401050803, 77.3 Mgal/d), and Trenton, New Jersey (020402020305, 178 Mgal/d) along with other uses along the D & R Canal. The four subwatersheds with the largest groundwater withdrawals were 020401060703 (12.5 Mgal/d, in the vicinity of Allentown, Pennsylvania) and three subwatersheds in the vicinity of Camden, New Jersey (020402020401, 15.2 Mgal/d; 020402020404, 11.8 Mgal/d; and 020402020403, 10.2 Mgal/d).

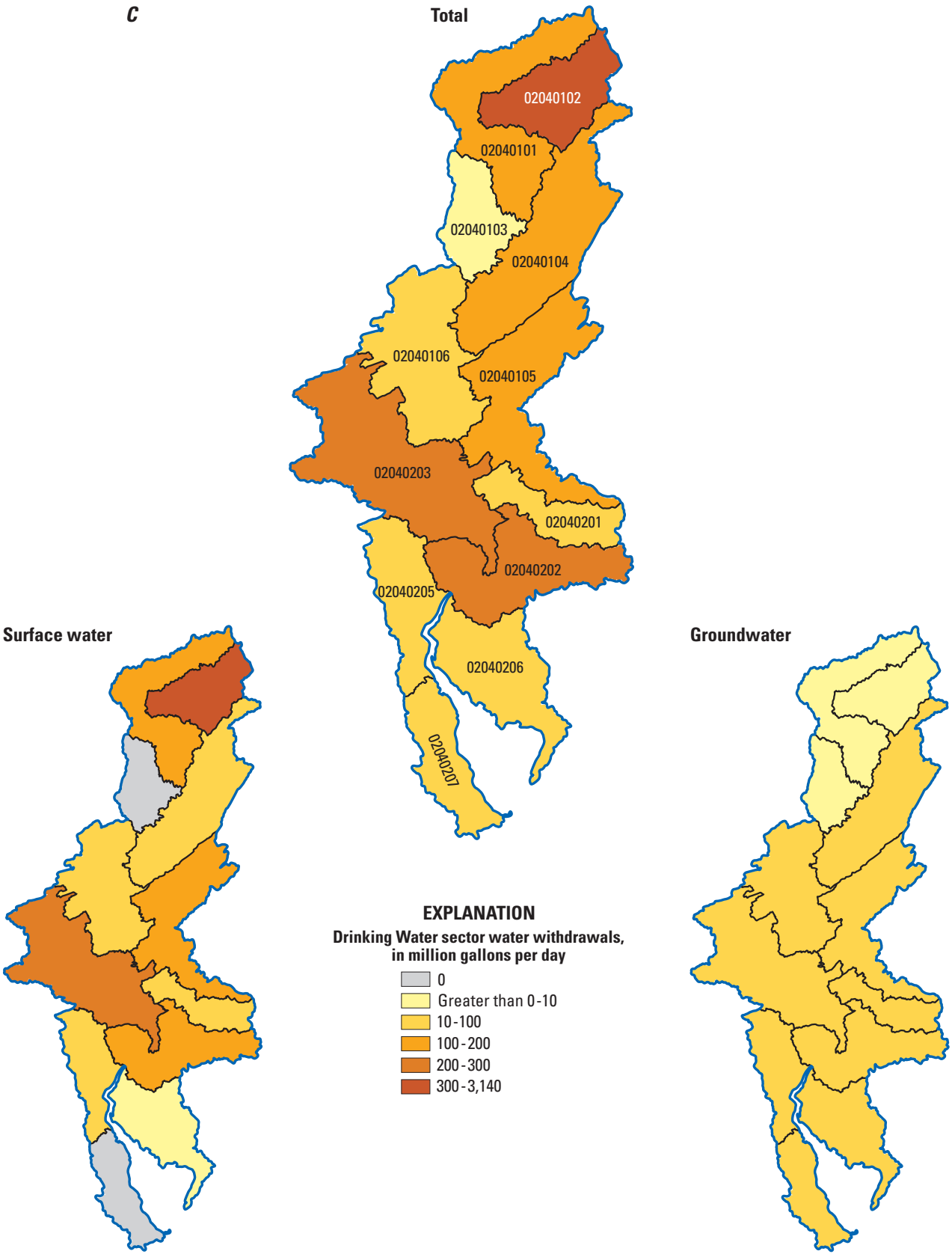


Figure 14. Distribution of water withdrawals for the Drinking Water sector in the Delaware River Basin, 2010, by *A,* source and basin, *B,* basin and water use category, and *C,* subbasin and source. (%, percent)—Continued

Table 13. Public supply water withdrawals and transfers, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Geographic area	Population (thousands)			Withdrawals (million gallons per day)			Withdrawals (thousand acre-feet per year)			Transfers (million gallons per day)		
	Total	Served by public supply		By source		Total	By source		Total	Imports	Exports	Use
		Population	Population (percent)	Groundwater	Surface water		Groundwater	Surface water				
Study Area (total)												
Total	**8,260**	**6,700**	**81**	**253**	**1,240**	**1,490**	**283**	**1,390**	**1,670**	**32.4**	**651**	**840**
Delaware												
Total	**711**	**625**	**88**	**26.5**	**32.2**	**58.7**	**29.7**	**36.1**	**65.8**	**0**	**0**	**58.7**
02040202	23.2	23.2	100	0	0	0	0	0	0	0	0	0
02040205	495	456	92	12.8	32.2	45.0	14.4	36.1	50.4	0	0	45.0
02040207	193	146	76	13.7	0	13.7	15.4	0	15.4	0	0	13.7
New Jersey												
Total	**1,940**	**1,440**	**74**	**135**	**139**	**274**	**151**	**156**	**307**	**0**	**77.3**	**196**
02040104	5.87	0.19	3	0.10	0	0.10	0.11	0	0.11	0	0	0.10
02040105	449	283	63	16.9	111	128	19.0	124	143	0	77.3	50.5
02040201	190	138	72	13.7	1.17	14.8	15.3	1.31	16.6	0	0	14.8
02040202	1,000	838	84	73.9	26.6	100	82.8	29.8	113	0	0	100
02040206	299	181	60	30.1	0.18	30.2	33.7	0.20	33.9	0	0	30.2
New York												
Total	**119**	**71.9**	**60**	**4.93**	**575**	**580**	**5.53**	**645**	**650**	**0**	**574**	**6.25**
02040101	34.6	19.1	55	1.02	145	146	1.14	162	164	0	145	1.17
02040102	17.2	8.56	50	0.79	334	335	0.89	375	376	0	334	0.79
02040104	67.6	44.2	65	3.12	95.9	99.0	3.50	107	111	0	94.7	4.29
Pennsylvania												
Total	**5,480**	**4,560**	**83**	**86.7**	**493**	**579**	**97.2**	**552**	**649**	**0**	**0**	**579**
02040101	9.24	2.94	32	0.26	0	0.26	0.29	0	0.29	0	0	0.26
02040103	57.1	34.0	60	2.10	0	2.10	2.35	0	2.35	0	0	2.10
02040104	158	124	78	5.81	2.41	8.22	6.51	2.70	9.21	0	0	8.22
02040105	220	130	59	4.26	23.4	27.7	4.78	26.3	31.1	0	0	27.7
02040106	678	567	84	27.0	36.3	63.2	30.2	40.7	70.9	0	0	63.2
02040201	479	366	76	11.0	39.9	50.9	12.3	44.7	57.1	0	0	50.9
02040202	1,960	1,900	97	2.62	161	164	2.94	180	183	0	0	164
02040203	1,660	1,320	79	28.8	219	248	32.3	245	278	0	0	248
02040205	259	125	48	4.84	10.7	15.6	5.43	12.0	17.4	32.4	0	48.0

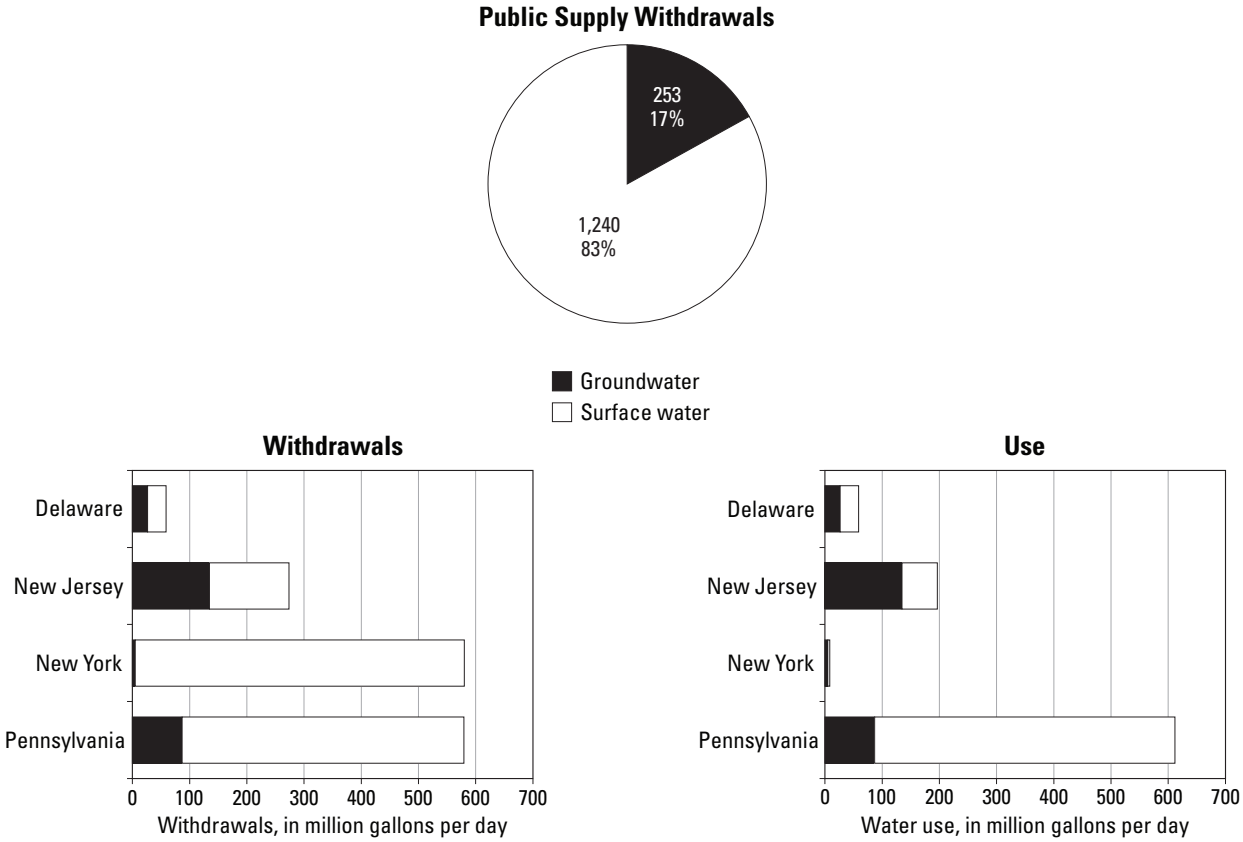


Figure 15. Distribution of public supply water withdrawals and use by source and state in the Delaware River Basin, 2010. (%, percent)

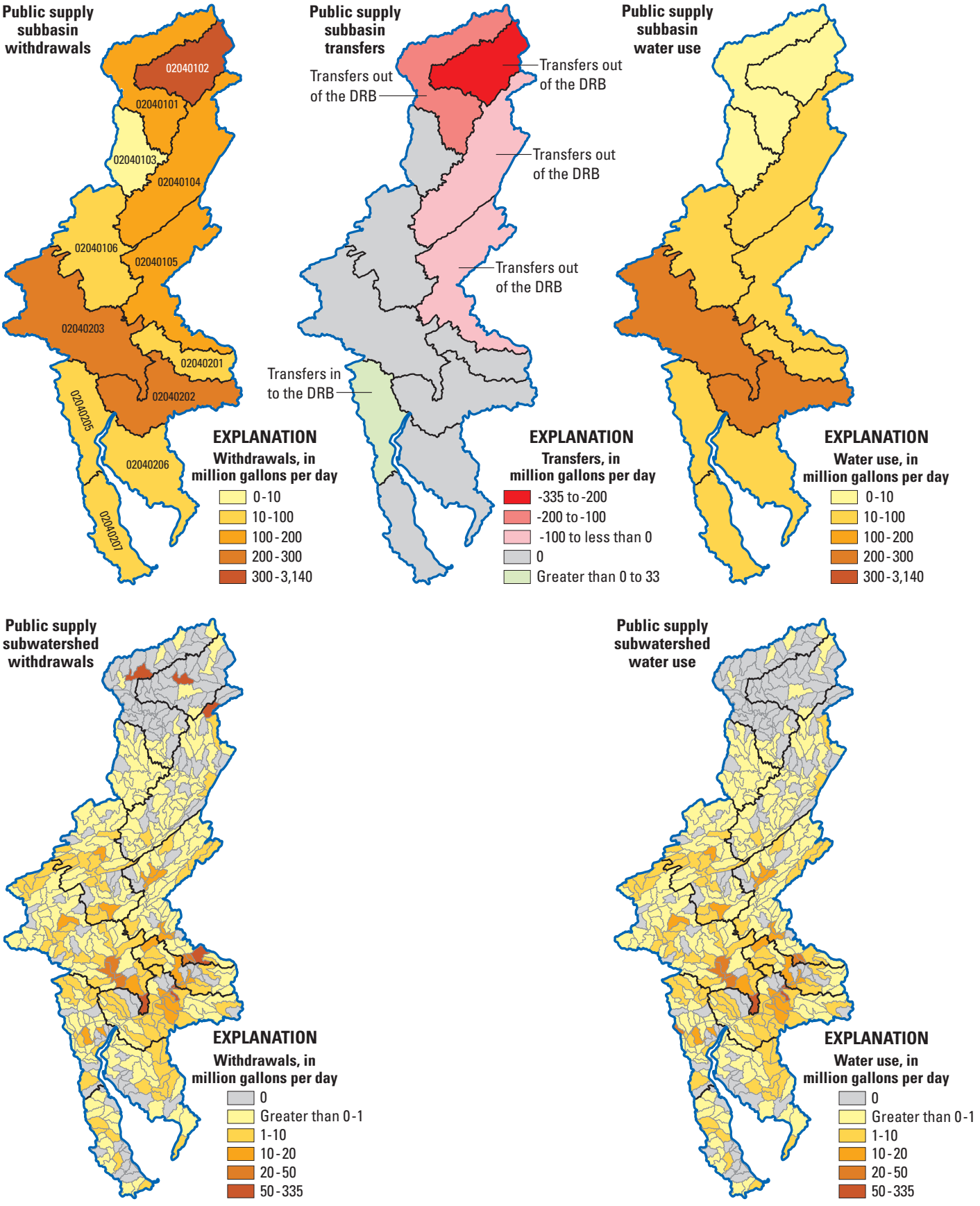


Figure 16. Public supply water withdrawals, transfers, and use by source, subbasin, and subwatershed in the Delaware River Basin, 2010.

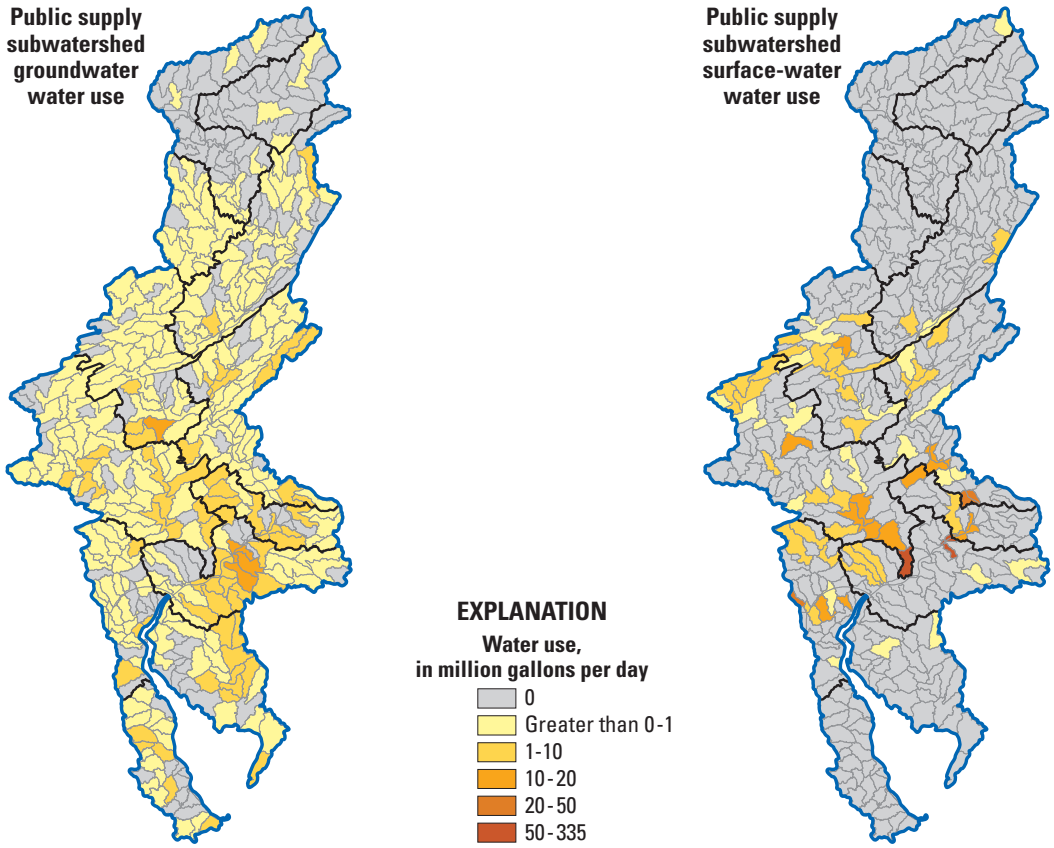


Figure 16. Public supply water withdrawals, transfers, and use by source, subbasin, and subwatershed in the Delaware River Basin, 2010.—Continued

Self-Supplied Domestic

Total water withdrawals in the DRB for the self-supplied domestic category were 117 Mgal/d (table 14), or 131 thousand acre-ft/yr in 2010. Self-supplied domestic represents about 3 percent of total freshwater withdrawals and about 5 percent of all withdrawals not including thermoelectric power. Totals for this category were almost exclusively (greater than 99 percent) calculated based on areal estimates.

An estimated 1.56 million people within the DRB supplied their own water for domestic use in 2010. This number represents about 19 percent of the total 2010 DRB population of approximately 8.2 million people. Over half (62.2 Mgal/d) of the self-supplied domestic withdrawals were from three subbasins (02040203, 02040105, and 02040202) (fig. 17), which contained 64 percent of the DRB total population. Self-supplied domestic withdrawals were greatest outside of metropolitan areas such as Philadelphia, Pennsylvania; Wilmington, Delaware; and Trenton, New Jersey.

Over 90 percent (107 Mgal/d) of the water withdrawn for self-supplied domestic use was withdrawn in Pennsylvania and New Jersey, where the majority (90 percent) of the DRB population resides (fig. 18). Almost one-quarter (25.6 Mgal/d) of that water was withdrawn in Pennsylvania from subbasin 02040203, which includes areas outside of Philadelphia.

Table 14. Self-supplied domestic water withdrawals, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Geographic area	Population (thousands)				Withdrawals (million gallons per day)			Withdrawals (thousand acre-feet per year)		
	Total	Served by public supply	Self-supplied domestic		By source		Total	By source		Total
			Population	Population (percent)	Ground-water	Surface water		Ground-water	Surface water	
Study Area (total)										
Total	**8,260**	**6,700**	**1,560**	**19**	**117**	**0**	**117**	**131**	**0**	**131**
Delaware										
Total	**711**	**625**	**86.4**	**12**	**6.48**	**0**	**6.48**	**7.26**	**0**	**7.26**
02040202	23.2	23.2	0.06	0	0	0	0	0	0	0
02040205	495	456	39.3	8	2.99	0	2.99	3.35	0	3.35
02040207	193	146	47.1	24	3.49	0	3.49	3.91	0	3.91
New Jersey										
Total	**1,940**	**1,440**	**505**	**26**	**37.9**	**0**	**37.9**	**42.5**	**0**	**42.5**
02040104	5.87	0.19	5.68	97	0.42	0	0.42	0.47	0	0.47
02040105	449	283	166	37	12.4	0	12.4	13.9	0	13.9
02040201	190	138	52.6	28	4.04	0	4.04	4.53	0	4.53
02040202	1,000	838	163	16	12.2	0	12.2	13.7	0	13.7
02040206	299	181	118	40	8.81	0	8.81	9.88	0	9.88
New York										
Total	**119**	**71.9**	**47.5**	**40**	**3.54**	**0**	**3.54**	**3.97**	**0**	**3.97**
02040101	34.6	19.1	15.4	45	1.16	0	1.16	1.30	0	1.30
02040102	17.2	8.56	8.69	50	0.63	0	0.63	0.71	0	0.71
02040104	67.6	44.2	23.4	35	1.75	0	1.75	1.96	0	1.96
Pennsylvania										
Total	**5,480**	**4,560**	**921**	**17**	**69.1**	**0**	**69.1**	**77.5**	**0**	**77.5**
02040101	9.24	2.94	6.30	68	0.47	0	0.47	0.53	0	0.53
02040103	57.1	34.0	23.1	40	1.76	0	1.76	1.97	0	1.97
02040104	158	124	34.0	22	2.54	0	2.54	2.85	0	2.85
02040105	220	130	90.5	41	6.80	0	6.80	7.62	0	7.62
02040106	678	567	111	16	8.29	0	8.29	9.29	0	9.29
02040201	479	366	114	24	8.50	0	8.50	9.53	0	9.53
02040202	1,960	1,900	68.2	3	5.09	0	5.09	5.71	0	5.71
02040203	1,660	1,320	341	21	25.6	0	25.6	28.7	0	28.7
02040205	259	125	134	52	10.1	0	10.1	11.3	0	11.3

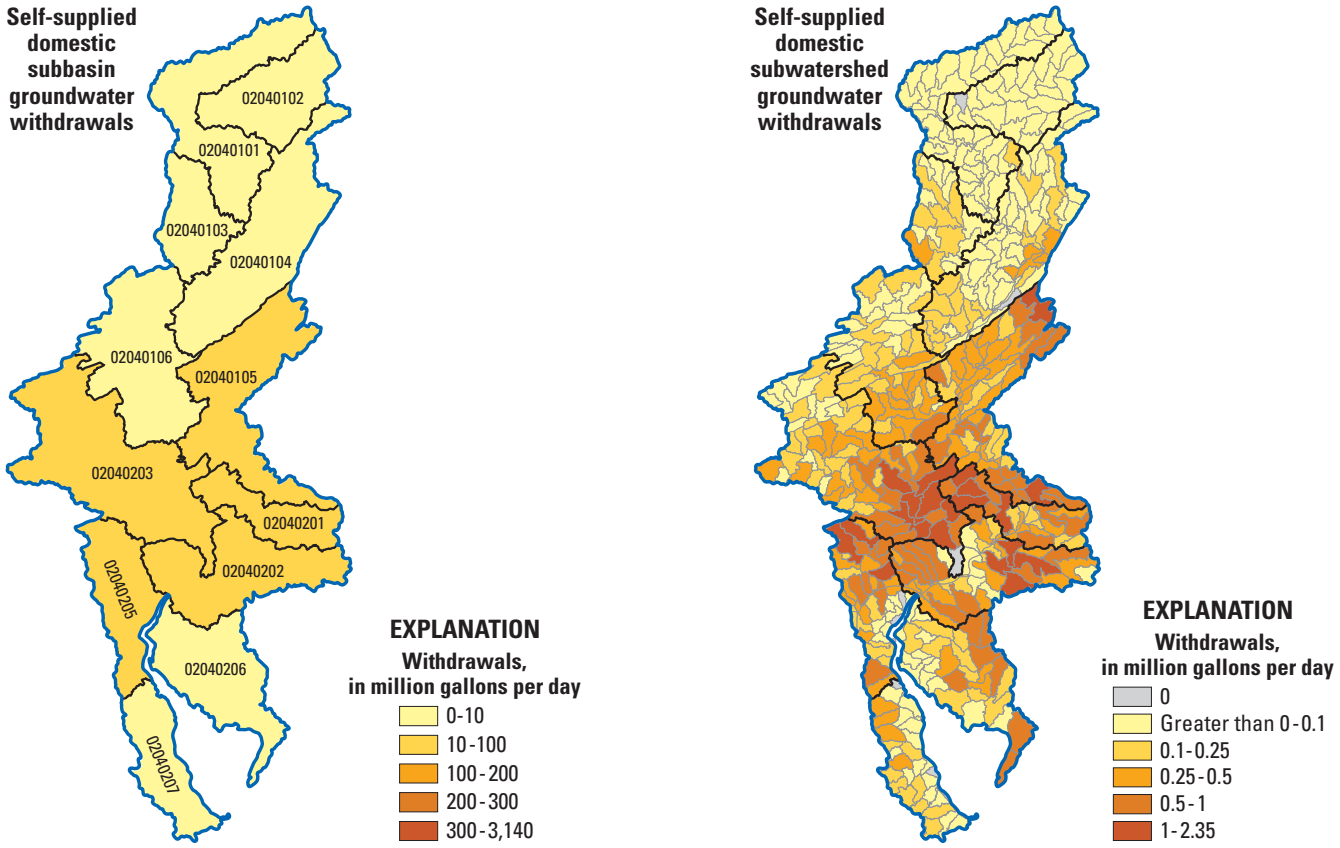


Figure 17. Self-supplied domestic groundwater withdrawals by subbasin and subwatershed in the Delaware River Basin, 2010.

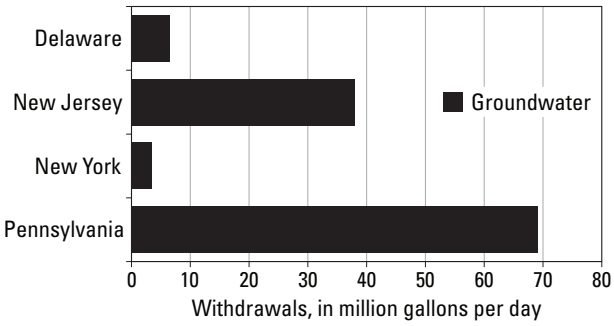


Figure 18. Distribution of domestic water withdrawals by state in the Delaware River Basin, 2010.

Industrial Sector

The Industrial sector consists of the industrial, commercial, and mining categories. Total withdrawals of 408 Mgal/d for the Industrial sector represented 10 percent of the total freshwater withdrawals in the DRB in 2010 (table 15). Eighty-seven percent (357 Mgal/d) of the water withdrawn was from surface-water sources, and 13 percent (51.1 Mgal/d) was from groundwater sources (fig. 19a). Industrial withdrawals (361 Mgal/d) accounted for 88 percent of the water withdrawals for this sector, mining water withdrawals (41.3 Mgal/d) accounted for 10 percent, and commercial water withdrawals (5.89 Mgal/d) accounted for the remaining amount.

The Lower basin accounted for 91 percent (371 Mgal/d) of the total Industrial sector withdrawals, whereas the Upper basin accounted for 9 percent (37.3 Mgal/d) (fig. 19b). The Lower basin Industrial sector water withdrawals were 91 percent from surface-water sources (339 Mgal/d) and 9 percent (31.6 Mgal/d) from groundwater sources. The Upper basin Industrial sector withdrawals were almost equally distributed between sources, with 52 percent from groundwater sources (19.5 Mgal/d) and 48 percent from surface-water sources (17.9 Mgal/d).

The geographic distribution of total Industrial sector water withdrawals by subbasin is shown in figure 19c. Sector withdrawals are dominated by industrial withdrawals in Pennsylvania, Delaware, and New Jersey.

Industrial

Total water withdrawals in the DRB for the industrial category were 361 Mgal/d (table 16), or 404 thousand acre-ft/yr in 2010. Industrial represents 8 percent of total freshwater withdrawals and 16 percent of all withdrawals not including thermoelectric power. Approximately 89 percent (323 Mgal/d) of water withdrawn for industrial use in the DRB was from surface-water sources; the other 11 percent (37.9 Mgal/d) was from groundwater sources (fig. 20).

The four subbasins with the largest water withdrawals for industrial (02040202, 02040205, 02040203, and 02040201) accounted for 83 percent (298 Mgal/d) of the industrial water withdrawn in the DRB (fig. 21). These subbasins include the urban areas surrounding Camden and Trenton, New Jersey; Philadelphia, Pennsylvania; and Wilmington, Delaware. The four subwatersheds with the largest surface-water withdrawals, also located near these urban areas, were 020402020607 (73.9 Mgal/d), 020402050704 (71.4 Mgal/d), 020402010404 (38.4 Mgal/d), and 020402031008 (27.4 Mgal/d). One subbasin, the Lower Delaware (02040202), had industrial surface-water withdrawals that accounted for 34 percent (110 Mgal/d) of the total for the DRB. Another subbasin, the Lehigh River (02040106), accounted for 28 percent (10.5 Mgal/d) of industrial groundwater withdrawals, most of which were from the carbonate aquifer in the Lehigh Valley. The subwatershed with the largest groundwater withdrawals (5.62 Mgal/d) was 020401060810, in the vicinity of Allentown and Bethlehem, Pennsylvania. The only subwatershed where saline surface-water withdrawals were reported was 020402060103 (10.6 Mgal/d), near Wilmington, Delaware.

Water withdrawals for industrial use were greatest in Pennsylvania (212 Mgal/d), Delaware (81.6 Mgal/d), and New Jersey (65.4 Mgal/d); less than 1 percent of industrial withdrawals occurred in New York (fig. 20). Twenty-four percent (87.5 Mgal/d) of the industrial water withdrawn in the DRB was from the part of subbasin 02040203 that is in Pennsylvania and 22 percent (79.4 Mgal/d) was withdrawn from subbasin 02040205 in Delaware.

Table 15. Industrial sector water withdrawals, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Withdrawals (million gallons per day)											
Industrial			Commercial			Mining			Total		
Ground-water	Surface water	Total	Ground-water	Surface water	Total	Ground-water	Surface water	Total	Ground-water	Surface water	Total
Study Area (total)											
37.9	323	361	4.35	1.54	5.89	8.78	32.6	41.3	51.1	357	408
Upper Delaware River Basin (total)											
15.8	16.2	32.0	0.59	1.45	2.04	3.10	0.22	3.32	19.5	17.9	37.3
Lower Delaware River Basin (total)											
22.2	307	329	3.76	0.09	3.85	5.68	32.3	38.0	31.6	339	371

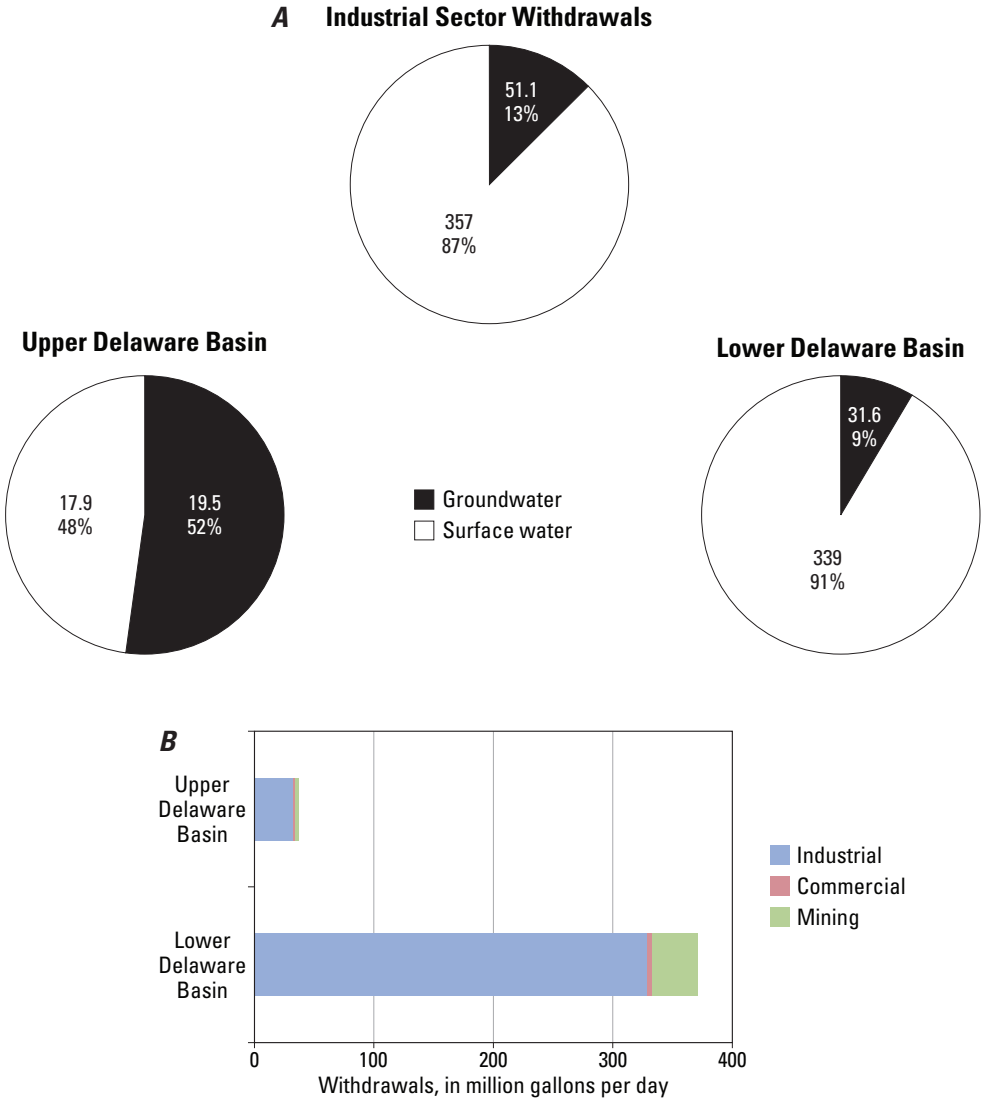


Figure 19. Distribution of water withdrawals for the Industrial sector in the Delaware River Basin, 2010, by *A,* source and basin, *B,* basin and water use category, and *C,* subbasin and source. (%, percent)

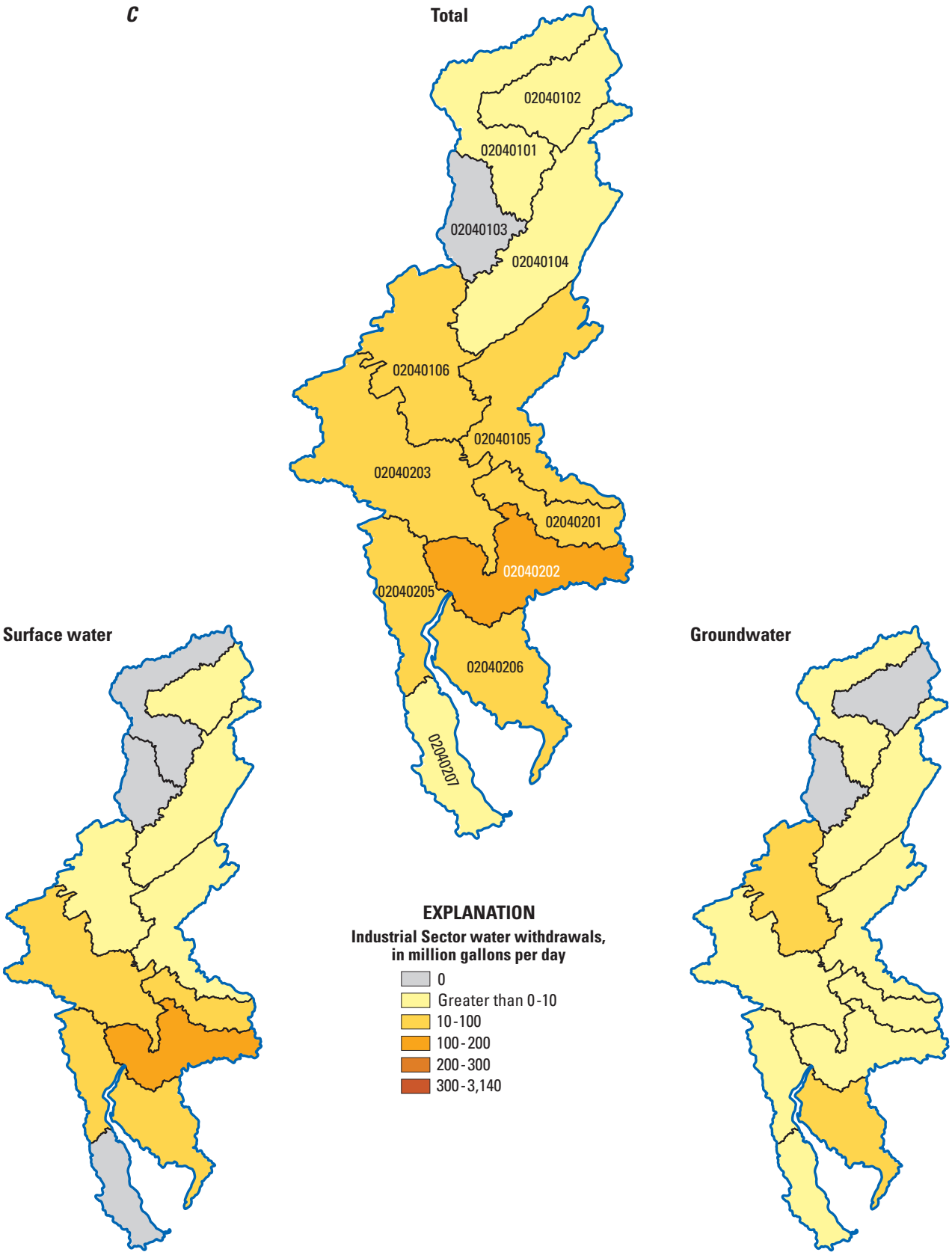


Figure 19. Distribution of water withdrawals for the Industrial sector in the Delaware River Basin, 2010, by *A,* source and basin, *B,* basin and water use category, and *C,* subbasin and source. (%, percent)—Continued

Table 16. Industrial water withdrawals, Delaware River Basin, 2010.

[Mgal/d, million gallons per day; Values may not sum to totals because of independent rounding.]

Geographic area	Withdrawals (million gallons per day)			Withdrawals (thousand acre-feet per year)		
	By source		Total	By source		Total
	Groundwater	Surface water		Groundwater	Surface water	
Study Area (total)						
Total	**37.9**	**323**	**361**	**42.6**	**362**	**404**
Delaware						
Total	**3.69**	**77.9**	**81.6**	**4.14**	**87.3**	**91.4**
02040202	0	0	0	0	0	0
02040205	1.57	77.9	79.4	1.76	87.3	89.1
02040207	2.12	0	2.12	2.38	0	2.38
New Jersey						
Total	**15.5**	**49.8**	**65.4**	**17.4**	**55.8**	**73.3**
02040104	0	0	0	0	0	0
02040105	3.41	4.72	8.13	3.82	5.29	9.11
02040201	0.74	0.75	1.49	0.83	0.84	1.67
02040202	4.12	22.7	26.8	4.62	25.5	30.1
02040206	7.26	21.6[1]	28.9	8.14	24.2	32.4
New York						
Total	**1.37**	**0**	**1.37**	**1.54**	**0**	**1.54**
02040101	1.37	0	1.37	1.54	0	1.54
02040102	0	0	0	0	0	0
02040104	0	0	0	0	0	0
Pennsylvania						
Total	**17.4**	**195**	**212**	**19.4**	**219**	**238**
02040101	0	0	0	0	0	0
02040103	0	0	0	0	0	0
02040104	0	0.33	0.33	0	0.37	0.37
02040105	0.49	4.39	4.88	0.55	4.92	5.47
02040106	10.5	6.75	17.2	11.8	7.57	19.3
02040201	0.06	39.3	39.4	0.07	44.0	44.1
02040202	0.11	87.4	87.5	0.12	98.0	98.1
02040203	5.99	54.2	60.2	6.71	60.8	67.5
02040205	0.20	2.68	2.88	0.22	3.00	3.23

[1] Includes 10.6 Mgal/d of saline surface water.

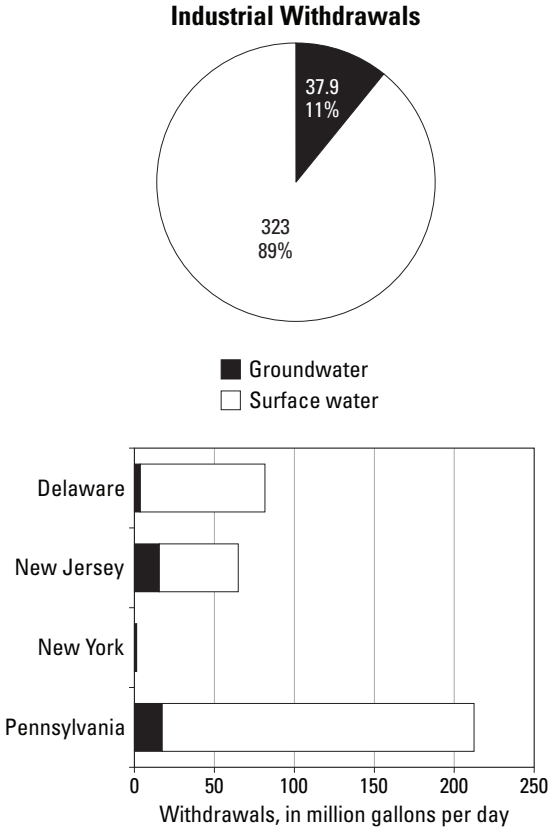


Figure 20. Distribution of industrial water withdrawals by source and state in the Delaware River Basin, 2010. (%, percent)

Commercial

Total water withdrawals in the DRB for the commercial category were 5.89 Mgal/d (table 17), or 6.60 thousand acre-ft/yr in 2010. Approximately 74 percent (4.35 Mgal/d) of water withdrawn for commercial uses in the DRB was from groundwater sources; the other 26 percent (1.54 Mgal/d) was from surface-water sources (fig. 22). Commercial use represents less than 1 percent of total freshwater withdrawals and also less than 1 percent of all withdrawals not including thermoelectric power. Water withdrawals for commercial use were not reported for Delaware or New York, so no data were available for this category for those states.

Subbasin 02040206 had the largest water withdrawals for commercial use and accounted for 42 percent (2.45 Mgal/d) of the commercial water withdrawn in the DRB (fig. 23); all of these withdrawals were from groundwater sources, the majority of which came from a single facility in subwatershed 020402060103. Three subbasins (02040202, 02040104, and 02040106) accounted for another 44 percent (2.62 Mgal/d) of commercial groundwater withdrawals. The largest amount of surface water (0.59 Mgal/d) was withdrawn in subwatershed 020401040803, in the Pocono Mountains region of Pennsylvania.

Reported water withdrawals for commercial uses were largest in New Jersey (3.85 Mgal/d; 66 percent of the total withdrawals for the commercial category), where withdrawals from groundwater sources (3.54 Mgal/d) far exceeded withdrawals from surface-water sources (0.31 Mgal/d) (fig. 22). Water withdrawals for commercial uses in Pennsylvania were reported to be from 60 percent (1.23 Mgal/d) surface-water sources and 40 percent groundwater sources (0.81 Mgal/d).

Mining

Total water withdrawals in the DRB for the mining category were 41.3 Mgal/d (table 18), or 46.3 thousand acre-ft/yr in 2010. Approximately 79 percent (32.6 Mgal/d) of water withdrawn for mining in the DRB was from surface-water sources; the other 21 percent (8.78 Mgal/d) was from groundwater sources (fig. 24). Mining represents 1 percent of total freshwater withdrawals and only 2 percent of all withdrawals not including thermoelectric power.

The subbasin with the largest water withdrawals for mining (02040206) accounted for 79 percent (32.6 Mgal/d) of the mining water withdrawn in the DRB (fig. 25) and can be attributed to sand and gravel mining operations. The same subbasin had mining surface-water withdrawals that accounted for 78 percent (32.3 Mgal/d) of the total mining withdrawals for the DRB. The majority of mining withdrawals (25.2 Mgal/d) were in subwatershed 020402060605. Three subbasins (02040203, 02040105, and 02040201) accounted for another 19 percent (7.92 Mgal/d) of mining withdrawals and were almost exclusively from groundwater sources. Two subwatersheds collectively accounted for 57 percent of the total groundwater withdrawals for mining in the DRB, 020402030204 (2.67 Mgal/d) and 020401050908 (2.36 Mgal/d). No withdrawals were reported for mining purposes in subbasins 02040101, 02040103, 02040205, and 02040207.

Almost all (80 percent, 32.9 Mgal/d) of the water withdrawn for mining was withdrawn in New Jersey; 20 percent (8.25 Mgal/d) in Pennsylvania, and less than 1 percent in New York (fig. 24). No withdrawals were reported for mining purposes in Delaware. Withdrawals in New Jersey were reported to be almost exclusively from surface-water sources whereas those in Pennsylvania were almost exclusively from groundwater sources.

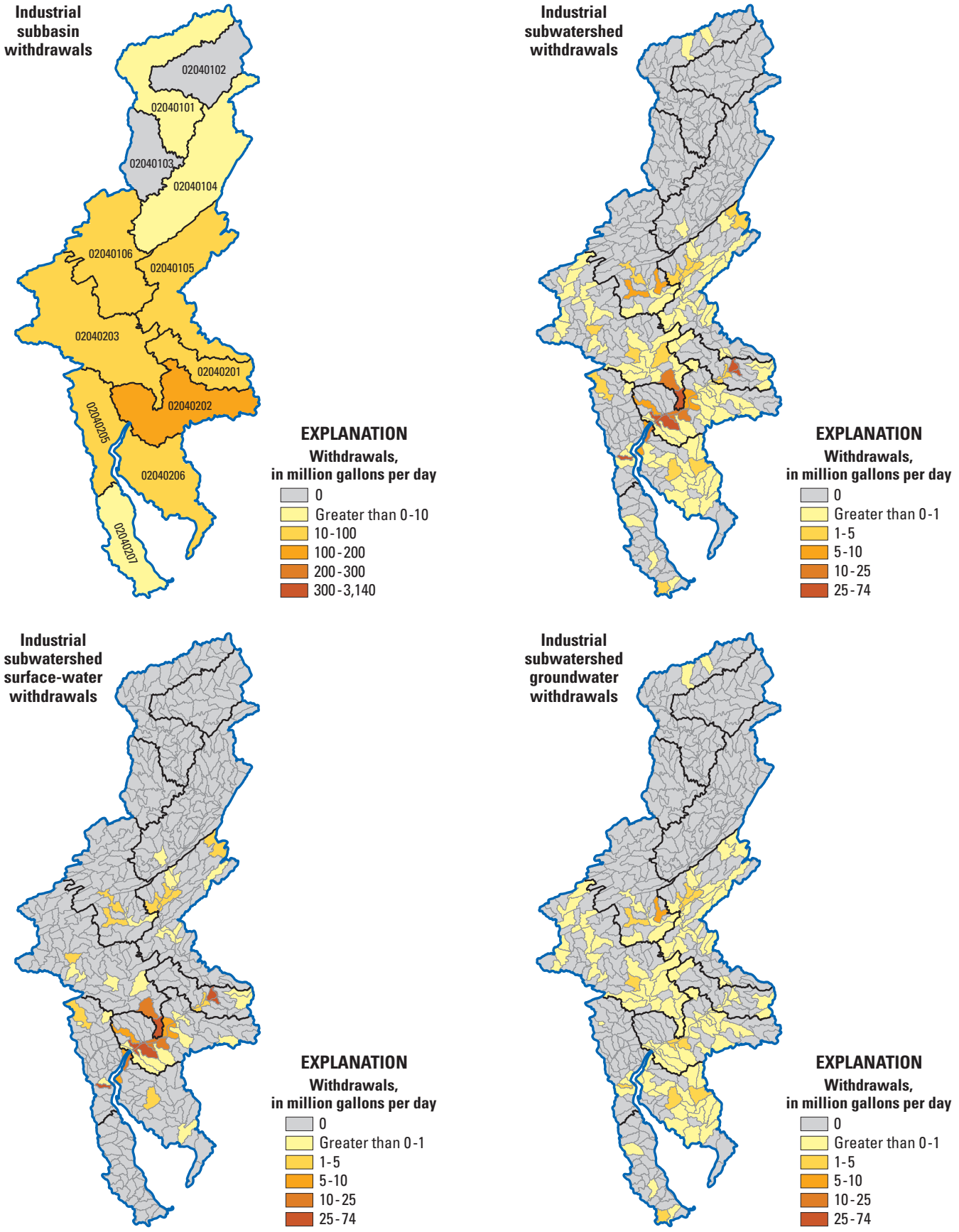


Figure 21. Industrial water withdrawals by source, subbasin, and subwatershed in the Delaware River Basin, 2010.

Table 17. Commercial water withdrawals, Delaware River Basin, 2010.

[No withdrawals were reported for commercial purposes in Delaware and New York. Values may not sum to totals because of independent rounding.]

Geographic area	Withdrawals (million gallons per day)			Withdrawals (thousand acre-feet per year)		
	By source		Total	By source		Total
	Groundwater	Surface water		Groundwater	Surface water	
Study Area (total)						
Total	**4.35**	**1.54**	**5.89**	**4.88**	**1.73**	**6.60**
Delaware						
Total	**0**	**0**	**0**	**0**	**0**	**0**
02040202	0	0	0	0	0	0
02040205	0	0	0	0	0	0
02040207	0	0	0	0	0	0
New Jersey						
Total	**3.54**	**0.31**	**3.85**	**3.97**	**0.35**	**4.32**
02040104	0	0	0	0	0	0
02040105	0.06	0.31	0.37	0.07	0.35	0.41
02040201	0.04	0	0.04	0.04	0	0.04
02040202	0.99	0	0.99	1.11	0	1.11
02040206	2.45	0	2.45	2.75	0	2.75
New York						
Total	**0**	**0**	**0**	**0**	**0**	**0**
02040101	0	0	0	0	0	0
02040102	0	0	0	0	0	0
02040104	0	0	0	0	0	0
Pennsylvania						
Total	**0.81**	**1.23**	**2.04**	**0.91**	**1.38**	**2.29**
02040101	0	0	0	0	0	0
02040103	0	0	0	0	0	0
02040104	0.23	0.59	0.82	0.26	0.66	0.92
02040105	0.04	0	0.04	0.04	0	0.04
02040106	0.26	0.55	0.81	0.29	0.62	0.91
02040201	0.18	0.04	0.22	0.20	0.04	0.25
02040202	0	0	0	0	0	0
02040203	0.08	0.05	0.13	0.09	0.06	0.15
02040205	0.02	0	0.02	0.02	0	0.02

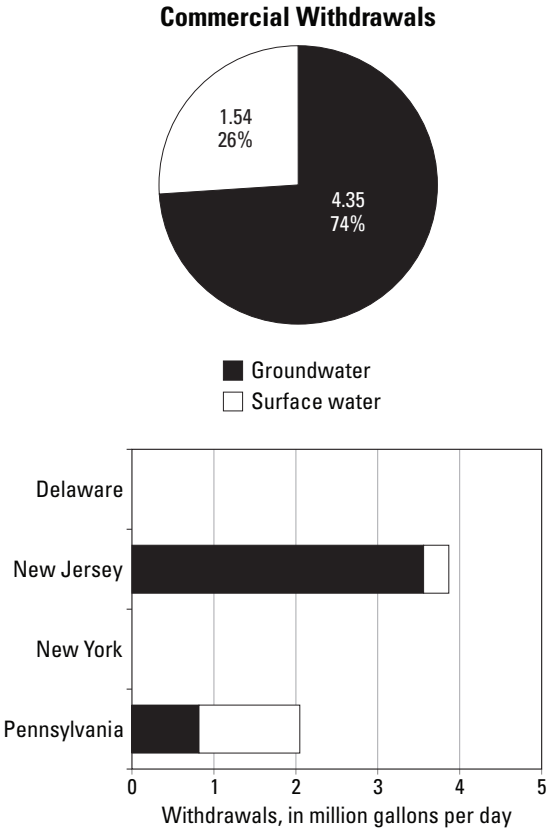


Figure 22. Distribution of commercial water withdrawals by source and state in the Delaware River Basin, 2010. (%, percent)

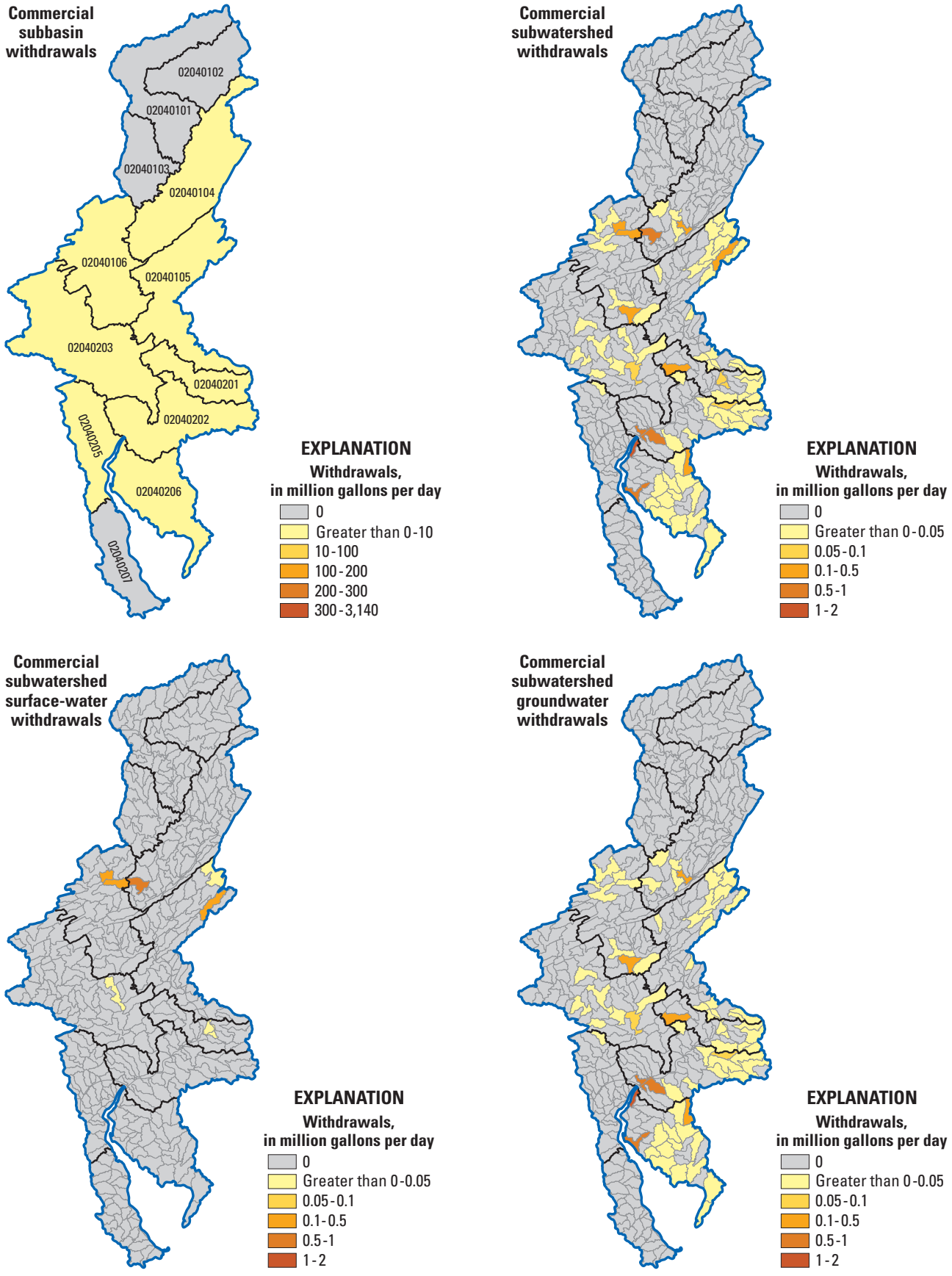


Figure 23. Commercial water withdrawals by source, subbasin, and subwatershed in the Delaware River Basin, 2010.

Table 18. Mining water withdrawals, Delaware River Basin, 2010.

[No withdrawals were reported for mining purposes in Delaware. Values may not sum to totals because of independent rounding.]

Geographic area	Withdrawals (million gallons per day)			Withdrawals (thousand acre-feet per year)		
	By source		Total	By source		Total
	Groundwater	Surface water		Groundwater	Surface water	
Study Area (total)						
Total	**8.78**	**32.6**	**41.3**	**9.84**	**36.5**	**46.3**
Delaware						
Total	**0**	**0**	**0**	**0**	**0**	**0**
02040202	0	0	0	0	0	0
02040205	0	0	0	0	0	0
02040207	0	0	0	0	0	0
New Jersey						
Total	**0.55**	**32.3**	**32.9**	**0.62**	**36.2**	**36.8**
02040104	0	0	0	0	0	0
02040105	0.20	0	0.20	0.22	0	0.22
02040201	0	0	0	0	0	0
02040202	0.04	0	0.04	0.04	0	0.04
02040206	0.31	32.3	32.6	0.35	36.2	36.6
New York						
Total	**0**	**0.22**	**0.22**	**0**	**0.25**	**0.25**
02040101	0	0	0	0	0	0
02040102	0	0.22	0.22	0	0.25	0.25
02040104	0	0	0	0	0	0
Pennsylvania						
Total	**8.23**	**0.02**	**8.25**	**9.23**	**0.02**	**9.25**
02040101	0	0	0	0	0	0
02040103	0	0	0	0	0	0
02040104	0.09	0	0.09	0.10	0	0.10
02040105	2.37	0	2.37	2.66	0	2.66
02040106	0.44	0	0.44	0.49	0	0.49
02040201	1.76	0.01	1.77	1.97	0.01	1.98
02040202	0	0	0	0	0	0
02040203	3.57	0.01	3.58	4.00	0.01	4.01
02040205	0	0	0	0	0	0

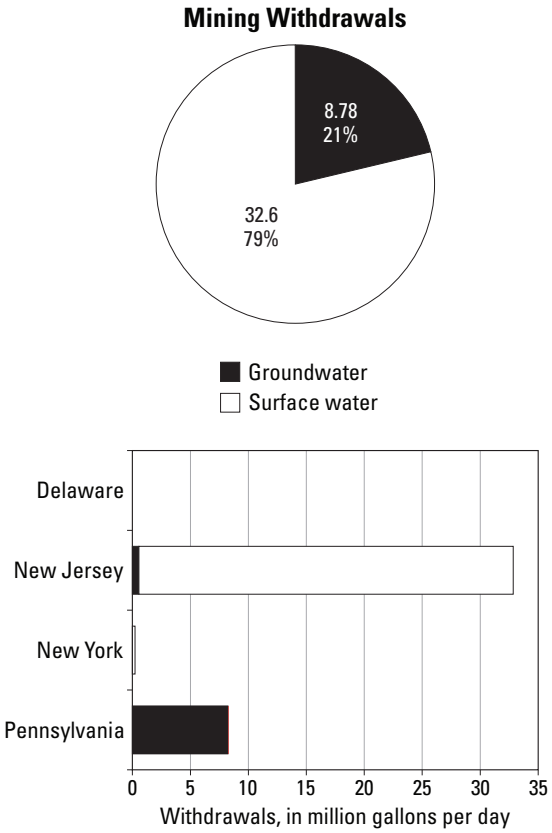


Figure 24. Distribution of mining water withdrawals by source and state in the Delaware River Basin, 2010. (%, percent)

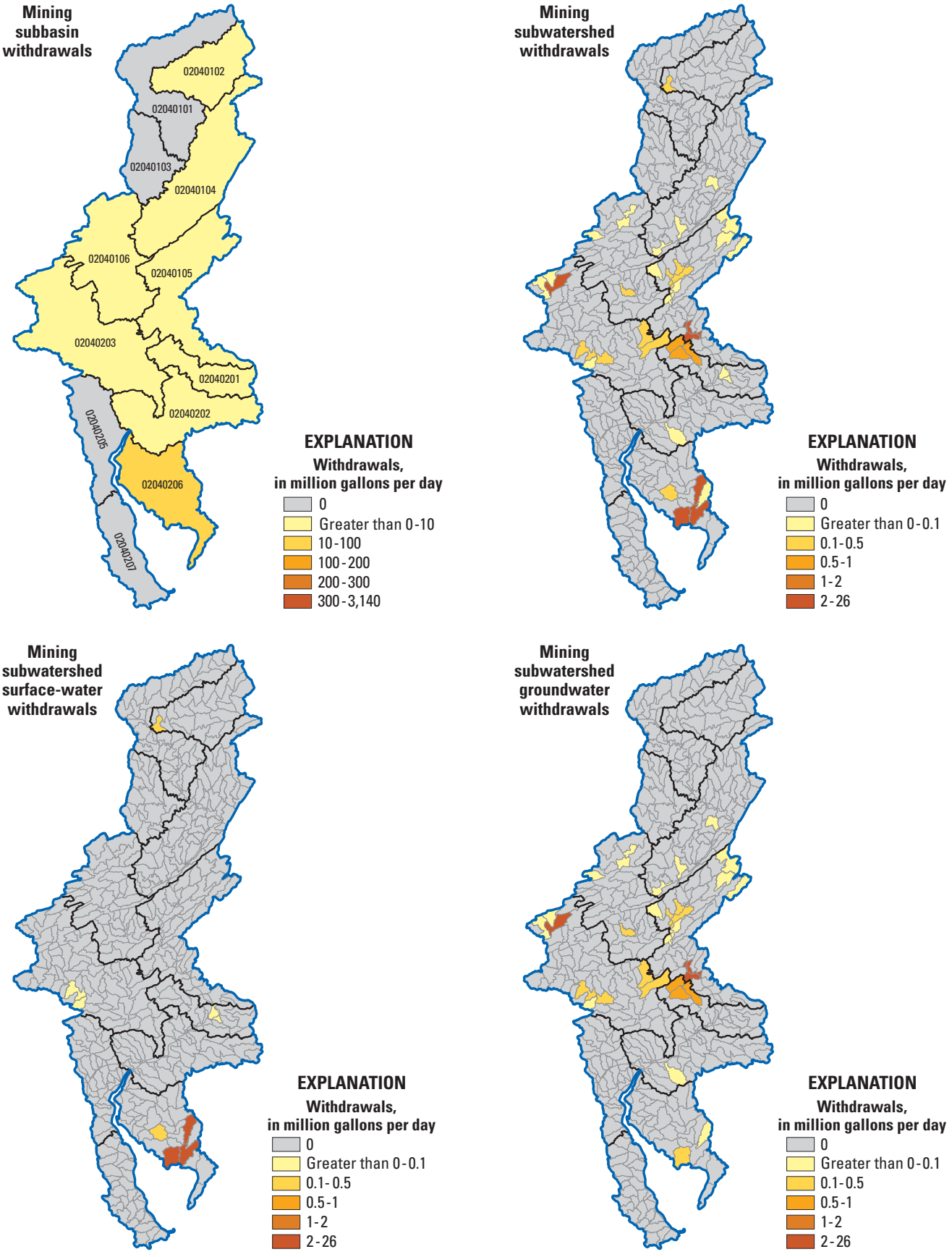


Figure 25. Mining water withdrawals by source, subbasin, and subwatershed in the Delaware River Basin, 2010.

Agricultural Sector

The Agricultural sector consists of the irrigation, livestock, and aquaculture categories. Total withdrawals of 201 Mgal/d for the Agricultural sector represented 5 percent of the total freshwater withdrawals in the DRB in 2010 (table 19). Sixty percent (121 Mgal/d) of the water withdrawn was from groundwater sources; 40 percent (79.9 Mgal/d) was from surface-water sources (fig. 26a). Sector withdrawals are dominated by irrigation withdrawals in the Coastal Plain Physiographic Province in New Jersey and Delaware. Irrigation withdrawals (175 Mgal/d) accounted for 87 percent of the water withdrawals for this sector, aquaculture water withdrawals (19.3 Mgal/d) accounted for 10 percent, and livestock water withdrawals (6.72 Mgal/d) accounted for the remaining 3 percent.

The Lower basin (020402) accounted for 79 percent (158 Mgal/d) of the total Agricultural sector withdrawals, whereas the Upper basin (020401) accounted for 21 percent (42.6 Mgal/d) (fig. 26b). The Lower basin water withdrawals were about two-thirds from groundwater sources (105 Mgal/d of groundwater, 53.4 Mgal/d of surface water) and used primarily for irrigation. The Upper basin withdrawals were about two-thirds from surface-water sources (26.5 Mgal/d of surface water and 16.2 Mgal/d of groundwater) and were used primarily for irrigation and aquaculture. The geographic distribution of total Agricultural sector water withdrawals by subbasin is shown in figure 26c.

Table 19. Agricultural sector water withdrawals, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Withdrawals (million gallons per day)											
Irrigation			Livestock			Aquaculture			Total		
Ground-water	Surface water	Total	Ground-water	Surface water	Total	Ground-water	Surface water	Total	Ground-water	Surface water	Total
Study Area (total)											
103	72.3	175	6.08	0.64	6.72	12.3	6.99	19.3	121	79.9	201
Upper Delaware River Basin (total)											
3.18	22.1	25.2	1.19	0.12	1.31	11.8	4.28	16.1	16.2	26.5	42.6
Lower Delaware River Basin (total)											
99.4	50.2	150	4.89	0.52	5.41	0.47	2.71	3.18	105	53.4	158

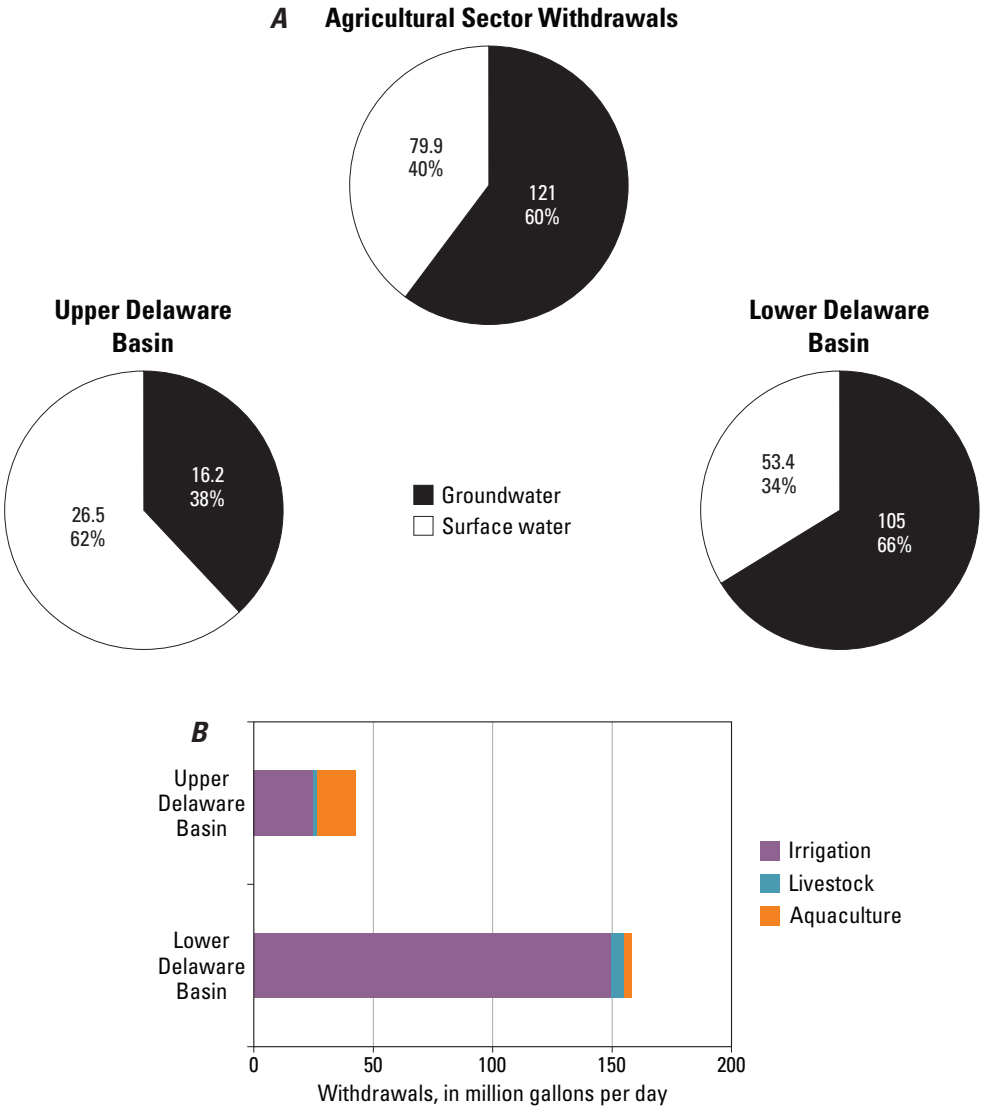


Figure 26. Distribution of water withdrawals for the Agricultural sector in the Delaware River Basin, 2010 by *A,* source and basin, *B,* basin and water use category, and *C,* subbasin and source. (%, percent)

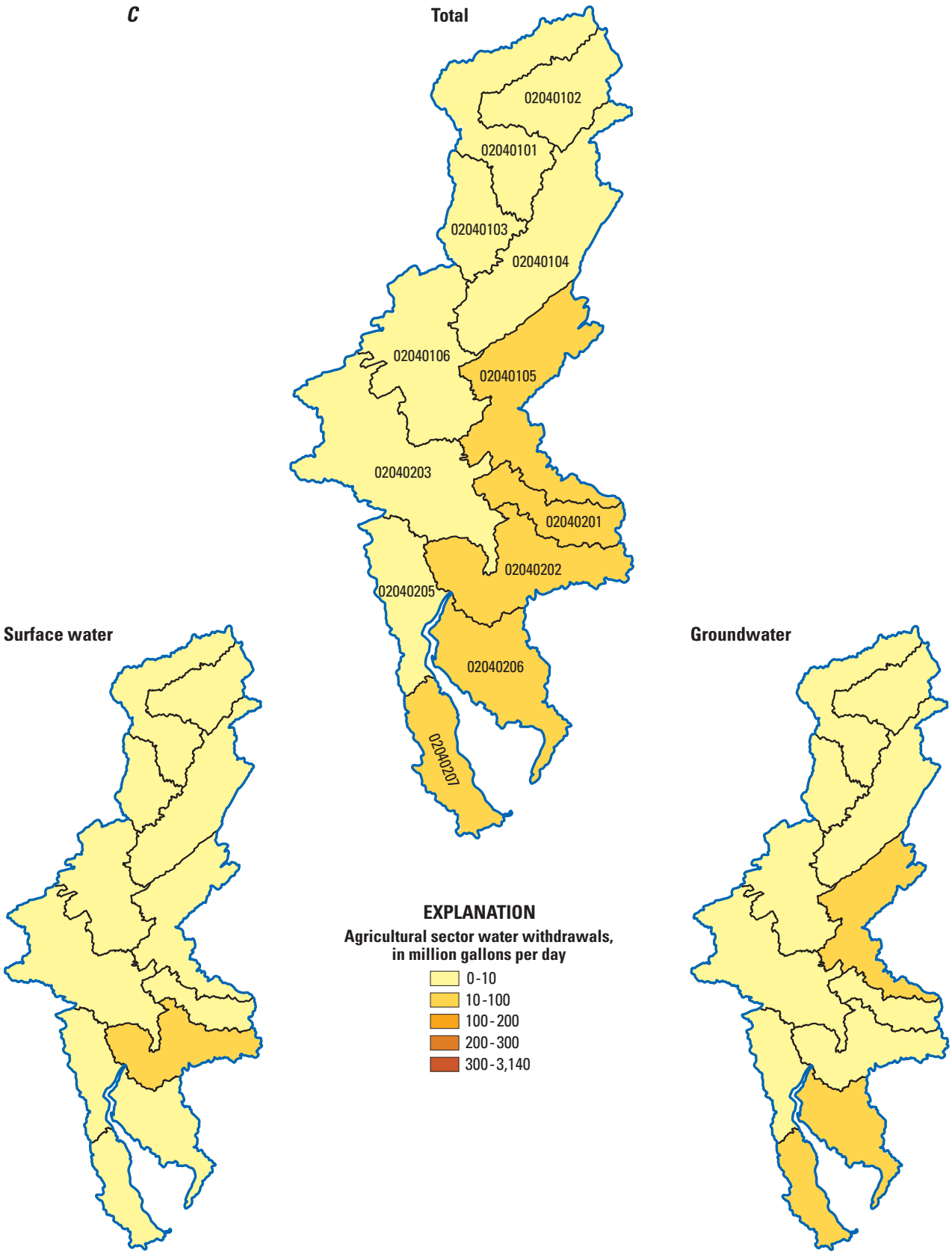


Figure 26. Distribution of water withdrawals for the Agricultural sector in the Delaware River Basin, 2010 by *A,* source and basin, *B,* basin and water use category, and *C,* subbasin and source. (%, percent)—Continued

Irrigation

Total water withdrawals in the DRB for the irrigation category were 175 Mgal/d (table 20), or 196 thousand acre-ft/yr in 2010. Irrigation represents about 4 percent of total freshwater withdrawals and about 8 percent of all withdrawals not including thermoelectric power. Approximately 59 percent (103 Mgal/d) was from groundwater; the other 41 percent (72.3 Mgal/d) of water withdrawn for irrigation in the DRB was from surface-water sources, such as reservoirs, lakes, and streams (fig. 27). Calculations of water withdrawals based on areal estimates of crop irrigation accounted for 42 percent (73.3 Mgal/d) of total category withdrawals.

The subbasins with the largest water withdrawals for irrigation (02040207, 02040206, and 02040202) were located primarily in the Coastal Plain in the southeastern part of the DRB (fig. 28). These subbasins accounted for almost three-quarters (129 Mgal/d) of the irrigation water withdrawn. Two subbasins

Table 20. Irrigation water withdrawals, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Geographic area	Withdrawals (million gallons per day)			Withdrawals (thousand acre-feet per year)		
	By source		Total	By source		Total
	Groundwater	Surface water		Groundwater	Surface water	
Study Area (total)						
Total	**103**	**72.3**	**175**	**115**	**81.0**	**196**
Delaware						
Total	**57.3**	**10.1**	**67.5**	**64.3**	**11.3**	**75.6**
02040202	0.01	0	0.01	0.01	0	0.01
02040205	3.38	0.71	4.09	3.79	0.80	4.58
02040207	54.0	9.41	63.4	60.5	10.5	71.0
New Jersey						
Total	**38.0**	**39.5**	**77.6**	**42.7**	**44.3**	**86.9**
02040104	0	0.02	0.02	0	0.02	0.02
02040105	0.69	1.29	1.98	0.77	1.45	2.22
02040201	0.84	9.66	10.5	0.94	10.8	11.8
02040202	4.21	21.8	26.0	4.72	24.4	29.2
02040206	32.3	6.74	39.0	36.2	7.56	43.8
New York						
Total	**0.19**	**19.9**	**20.1**	**0.21**	**22.3**	**22.5**
02040101	0.06	6.85	6.91	0.07	7.68	7.75
02040102	0.03	3.55	3.58	0.03	3.98	4.01
02040104	0.10	9.52	9.62	0.11	10.7	10.8
Pennsylvania						
Total	**7.04**	**2.71**	**9.75**	**7.89**	**3.04**	**10.9**
02040101	0.06	0	0.06	0.07	0	0.07
02040103	0.11	0	0.11	0.12	0	0.12
02040104	0.03	0.04	0.07	0.03	0.04	0.08
02040105	0.77	0.24	1.01	0.86	0.27	1.13
02040106	1.33	0.55	1.88	1.49	0.62	2.11
02040201	0.52	0.21	0.73	0.58	0.24	0.82
02040202	0.30	0.01	0.31	0.34	0.01	0.35
02040203	3.07	1.21	4.28	3.44	1.36	4.80
02040205	0.85	0.45	1.30	0.95	0.50	1.46

in the Coastal Plain (02040206 and 02040207) had irrigation groundwater withdrawals that accounted for 84 percent (86.3 Mgal/d) of the total irrigation groundwater withdrawals for the DRB; one subbasin (02040202) accounted for 30 percent (21.8 Mgal/d) of irrigation surface-water withdrawals. The subwatersheds with the largest groundwater and surface-water withdrawals were also located in the Coastal Plain region of New Jersey and Delaware.

Eighty-three percent (145 Mgal/d) of the water withdrawn for irrigation was withdrawn in New Jersey and Delaware (fig. 27). Irrigation withdrawals were mostly from groundwater sources in Delaware (85 percent groundwater) and Pennsylvania (72 percent groundwater); in New Jersey, they were split equally (49 percent groundwater, 51 percent surface water) between groundwater and surface-water sources; and in New York, they were almost exclusively (99 percent) surface water.

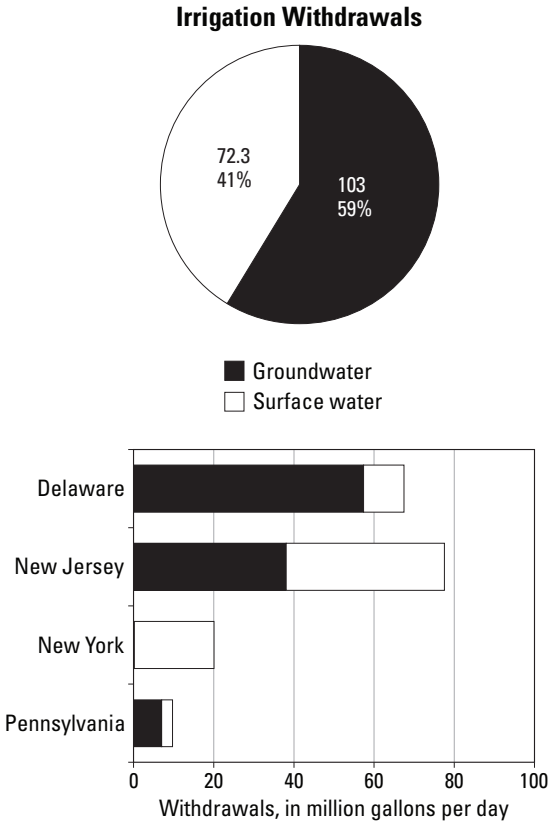


Figure 27. Distribution of irrigation water withdrawals by source and state in the Delaware River Basin, 2010. (%, percent)

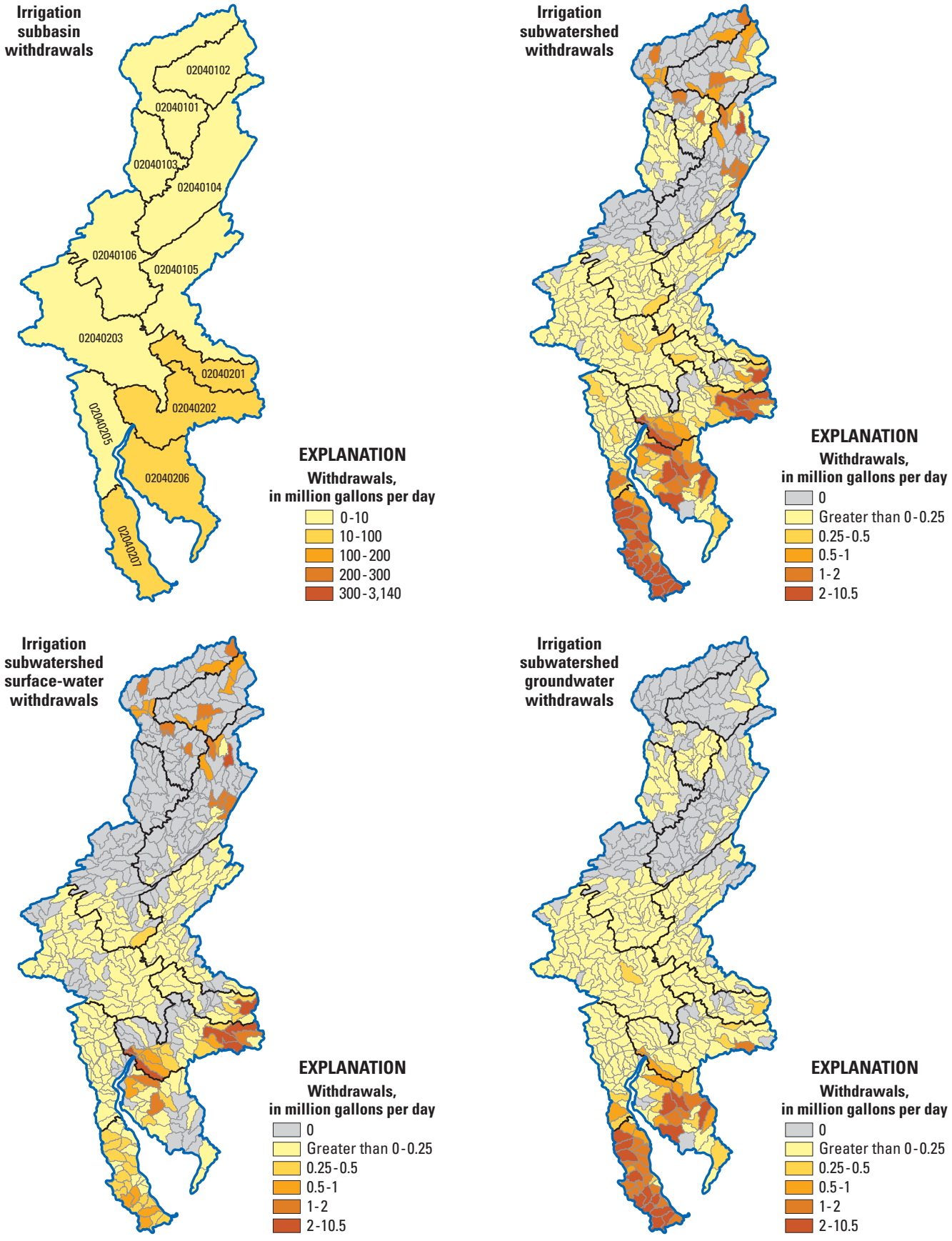


Figure 28. Irrigation water withdrawals by source, subbasin, and subwatershed in the Delaware River Basin, 2010.

Livestock

Total water withdrawals in the DRB for the livestock category were 6.72 Mgal/d (table 21), or 7.53 thousand acre-ft/yr in 2010. Livestock represents less than 1 percent of total freshwater withdrawals and less than 1 percent of all withdrawals not including thermoelectric power. Approximately 90 percent (6.08 Mgal/d) of water withdrawn for livestock in the DRB was from groundwater sources; the other 10 percent (0.64 Mgal/d) was from surface-water sources (fig. 29). Areal estimates accounted for 85 percent (5.69 Mgal/d) of the total withdrawals for this category.

Table 21. Livestock water withdrawals, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Geographic area	Withdrawals (million gallons per day)			Withdrawals (thousand acre-feet per year)		
	By source		Total	By source		Total
	Groundwater	Surface water		Groundwater	Surface water	
Study Area (total)						
Total	**6.08**	**0.64**	**6.72**	**6.82**	**0.72**	**7.53**
Delaware						
Total	**0.42**	**0**	**0.42**	**0.47**	**0**	**0.47**
02040202	0	0	0	0	0	0
02040205	0.03	0	0.03	0.03	0	0.03
02040207	0.39	0	0.39	0.44	0	0.44
New Jersey						
Total	**1.04**	**0**	**1.04**	**1.17**	**0**	**1.17**
02040104	0	0	0	0	0	0
02040105	0.14	0	0.14	0.16	0	0.16
02040201	0.01	0	0.01	0.01	0	0.01
02040202	0.26	0	0.26	0.29	0	0.29
02040206	0.63	0	0.63	0.71	0	0.71
New York						
Total	**0.34**	**0.09**	**0.43**	**0.38**	**0.10**	**0.48**
02040101	0.25	0.09	0.34	0.28	0.10	0.38
02040102	0.08	0	0.08	0.09	0	0.09
02040104	0.01	0	0.01	0.01	0	0.01
Pennsylvania						
Total	**4.28**	**0.55**	**4.83**	**4.80**	**0.62**	**5.41**
02040101	0.10	0	0.10	0.11	0	0.11
02040103	0.17	0	0.17	0.19	0	0.19
02040104	0	0	0	0	0	0
02040105	0.15	0.02	0.17	0.17	0.02	0.19
02040106	0.29	0.01	0.30	0.33	0.01	0.34
02040201	0	0	0	0	0	0
02040202	0.06	0.01	0.07	0.07	0.01	0.08
02040203	2.84	0.41	3.25	3.18	0.46	3.64
02040205	0.67	0.10	0.77	0.75	0.11	0.86

The subbasins with the largest water withdrawals for livestock (02040203, 02040205, and 02040206) accounted for 70 percent (4.68 Mgal/d) of the livestock water withdrawn (fig. 30). These three subbasins accounted for 69 percent (4.17 Mgal/d) of the total livestock groundwater withdrawals for the DRB; one subbasin (02040203) accounted for 64 percent (0.41 Mgal/d) of livestock surface-water withdrawals. The two subwatersheds with the largest withdrawals were 020402030402 (0.23 Mgal/d) in Pennsylvania and 020402060404 (0.22 Mgal/d) in New Jersey. Almost three-quarters (4.83 Mgal/d) of the water withdrawn for livestock was withdrawn in Pennsylvania; another 15 percent (1.04 Mgal/d) of the total was withdrawn in New Jersey (fig. 29).

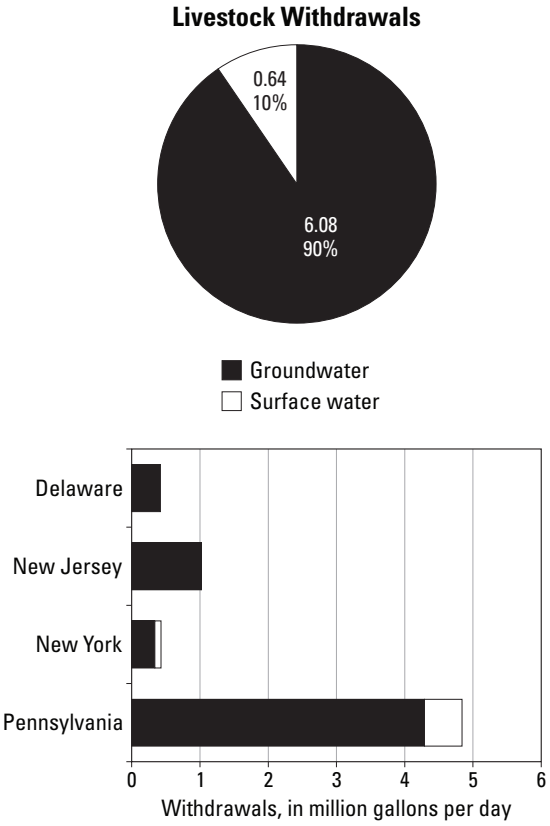


Figure 29. Distribution of livestock water withdrawals by source and state in the Delaware River Basin, 2010. (%, percent)

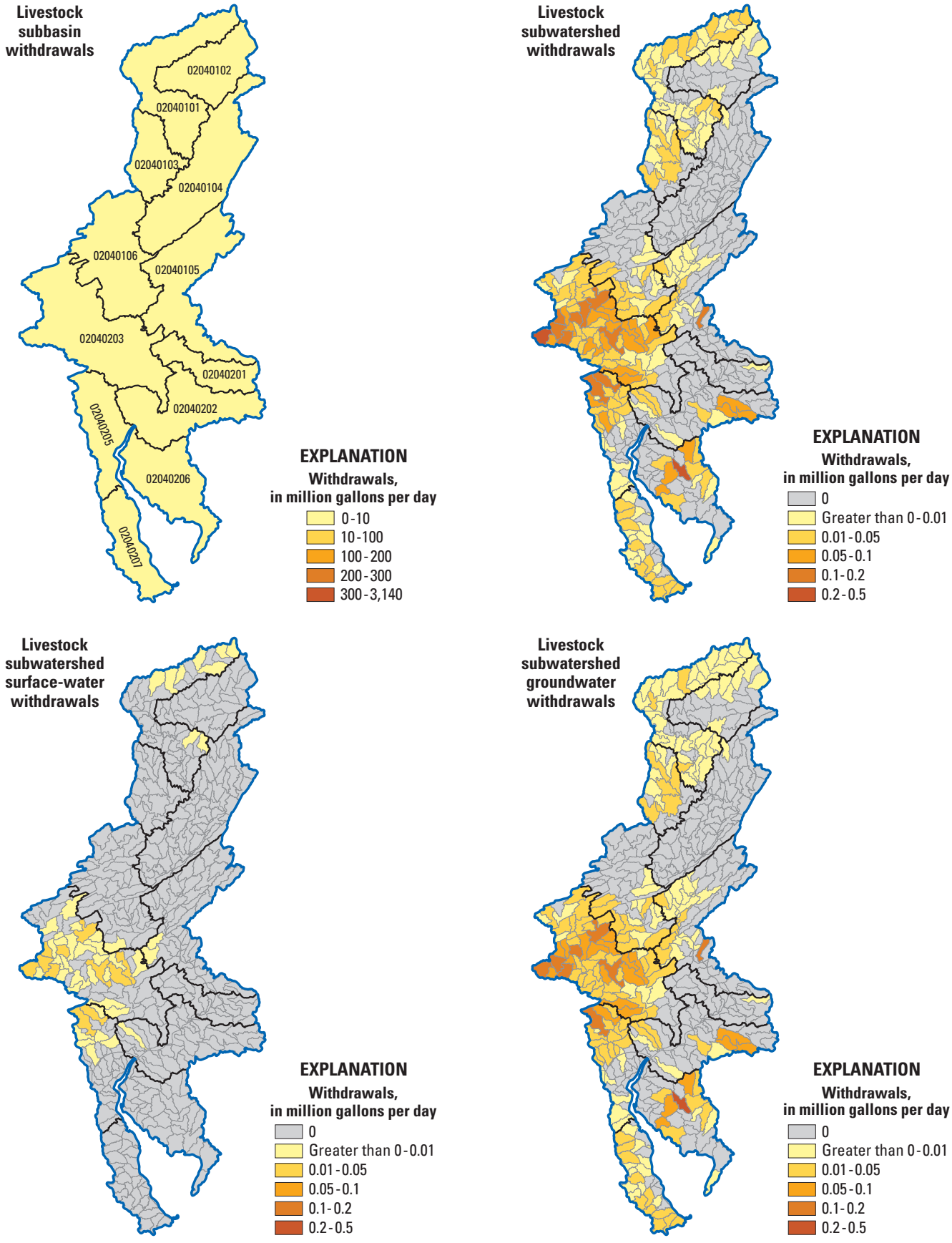


Figure 30. Livestock water withdrawals by source, subbasin, and subwatershed in the Delaware River Basin, 2010.

Aquaculture

Total water withdrawals in the Delaware River Basin for the aquaculture category were 19.3 Mgal/d (table 22), or 21.6 thousand acre-ft/yr in 2010. Aquaculture represents less than 1 percent of total freshwater withdrawals and also less than 1 percent of all withdrawals not including thermoelectric power. Approximately 64 percent (12.3 Mgal/d) of water withdrawn for aquaculture in the DRB was from groundwater; the other 36 percent (6.99 Mgal/d) was from surface-water sources (fig. 31).

Subbasin 02040105 had the largest water withdrawals for aquaculture and accounted for almost half (9.36 Mgal/d) of the aquaculture water withdrawn in the DRB (fig. 32). One subwatershed (020401050204) in New Jersey accounted for not only almost all of this amount (9.11 Mgal/d), but also

Table 22. Aquaculture water withdrawals, Delaware River Basin, 2010.

[Values may not sum to totals because of independent rounding.]

Geographic area	Withdrawals (million gallons per day)			Withdrawals (thousand acre-feet per year)		
	By source		Total	By source		Total
	Groundwater	Surface water		Groundwater	Surface water	
Study Area (total)						
Total	**12.3**	**6.99**	**19.3**	**13.8**	**7.84**	**21.6**
Delaware						
Total	**0.04**	**0**	**0.04**	**0.04**	**0**	**0.04**
02040202	0	0	0	0	0	0
02040205	0	0	0	0	0	0
02040207	0.04	0	0.04	0.04	0	0.04
New Jersey						
Total	**9.11**	**0**	**9.11**	**10.2**	**0**	**10.2**
02040104	0	0	0	0	0	0
02040105	9.11	0	9.11	10.2	0	10.2
02040201	0	0	0	0	0	0
02040202	0	0	0	0	0	0
02040206	0	0	0	0	0	0
New York						
Total	**0.43**	**2.90**	**3.33**	**0.48**	**3.25**	**3.73**
02040101	0	0	0	0	0	0
02040102	0.43	2.90	3.33	0.48	3.25	3.73
02040104	0	0	0	0	0	0
Pennsylvania						
Total	**2.70**	**4.09**	**6.79**	**3.03**	**4.58**	**7.61**
02040101	0	0	0	0	0	0
02040103	0.17	0.72	0.89	0.19	0.81	1.00
02040104	0	0.21	0.21	0	0.24	0.24
02040105	0	0.25	0.25	0	0.28	0.28
02040106	2.10	0.20	2.30	2.35	0.22	2.58
02040201	0	0	0	0	0	0
02040202	0	0	0	0	0	0
02040203	0.24	2.20	2.44	0.27	2.47	2.74
02040205	0.19	0.51	0.70	0.21	0.57	0.78

accounted for 74 percent of the total groundwater withdrawals. Two subbasins (02040102 and 02040203) accounted for 73 percent (5.10 Mgal/d) of aquaculture surface-water withdrawals, more than half (2.90 Mgal/d) of which was withdrawn in subwatershed 020401020103 in New York.

Eighty-three percent (15.9 Mgal/d) of the water withdrawn for aquaculture was withdrawn in New Jersey and Pennsylvania, and the remaining withdrawals were almost all from New York (3.33 Mgal/d) (fig. 31). All the withdrawals for aquaculture purposes in New Jersey (9.11 Mgal/d) and Delaware (0.04 Mgal/d) were reported to be from groundwater sources, whereas withdrawals in the other states were reported to be mostly from surface-water sources (Pennsylvania, 6.79 Mgal/d, 60 percent surface water and 40 percent groundwater; New York, 3.33 Mgal/d, 87 percent surface water and 13 percent groundwater.)

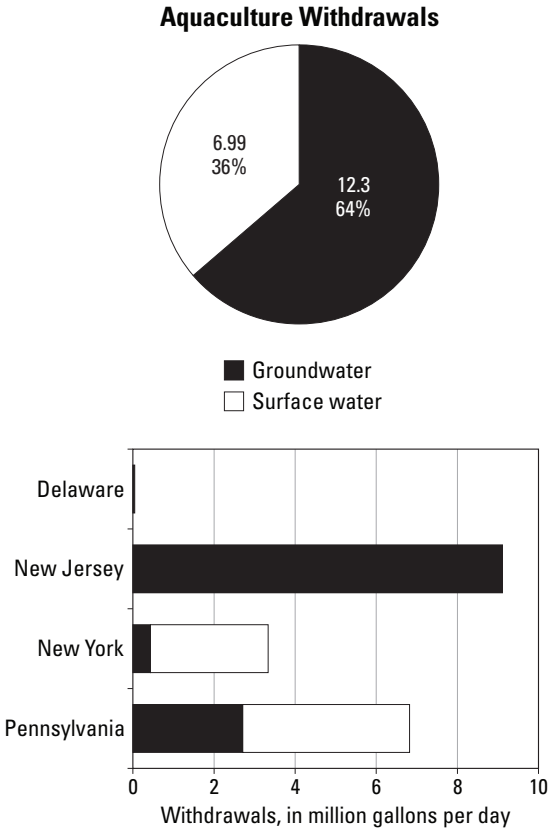


Figure 31. Distribution of aquaculture water withdrawals by source and state in the Delaware River Basin, 2010. (%, percent)

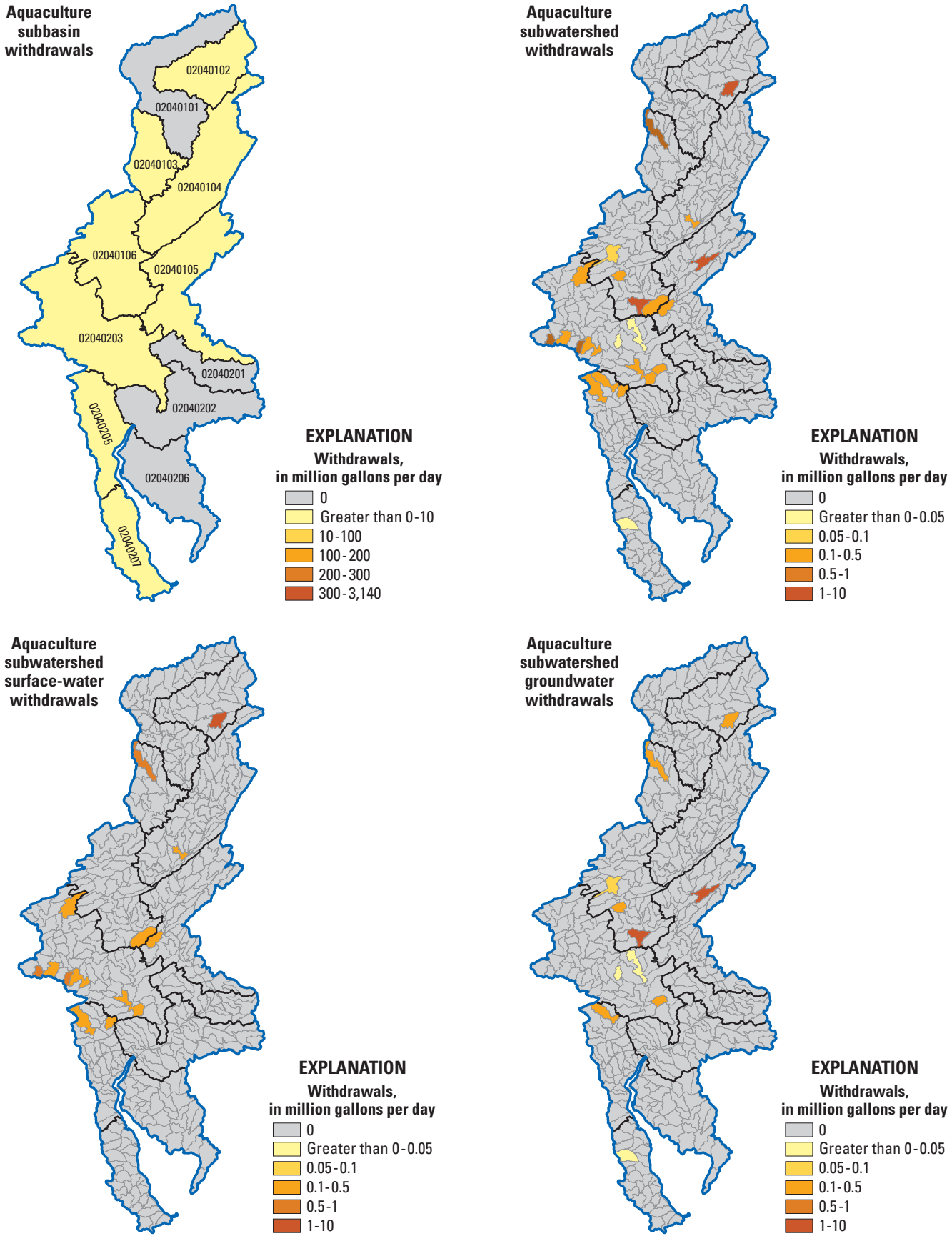


Figure 32. Aquaculture water withdrawals by source, subbasin, and subwatershed in the Delaware River Basin, 2010.

Return Flow

Total return flows in the Delaware River Basin were 2,960 Mgal/d (table 23), or 3,320 thousand acre-ft/yr in 2010. Thirty-eight percent (1,110 Mgal/d) of the total returns were in subbasin 02040202, which has a large number of municipalities that discharge to the tidal river (fig. 33). Eighty-seven percent (2,590 Mgal/d) of the returns were in the lower part of the DRB, mainly on the larger rivers. Only 13 percent (372 Mgal/d) of the returns occurred in the upper part of the DRB. Two subwatersheds (020402020601, 676 Mgal/d, and 020402010404, 597 Mgal/d) accounted for 43 percent of the total return flows.

Data were reported for a total of 554 return-flow sites (fig. 34) in 2010. Although municipal wastewater-treatment plants accounted for 539 (97 percent) of the sites, they accounted for about 70 percent of the total return flows in the DRB. There was limited information on return flows from thermoelectric power. Of the 554 return-flow sites, only 3 were thermoelectric powerplants; these 3 plants accounted for 30 percent (872 Mgal/d) of the total DRB returns.

Table 23. Total return flows, 2010.

[Values may not sum to totals because of independent rounding.]

Subregion, basin, or subbasin identifier	Return flow (million gallons per day)			Return flow (thousand acre-feet per year)
	Municipal	Other	Total	
Study Area (total)				
0204	2,070	888	2,960	3,320
Upper Delaware River Basin (total)				
020401	97.3	274	372	416
Upper Delaware River Subbasins				
02040101	1.79	0	1.79	2.01
02040102	0.22	0	0.22	0.24
02040103	1.90	0	1.90	2.13
02040104	5.77	0	5.77	6.46
02040105	52.3	274	326	366
02040106	35.4	0	35.4	39.6
Lower Delaware River Basin (total)				
020402	1,970	614	2,590	2,900
Lower Delaware River Subbasins				
02040201	117	542	659	739
02040202	1,100	12.7	1,110	1,250
02040203	260	0	260	291
02040204	75.7	0	75.7	84.8
02040205	376	0	376	422
02040206	26.4	58.9	85.4	95.7
02040207	16.9	0	16.9	19.0

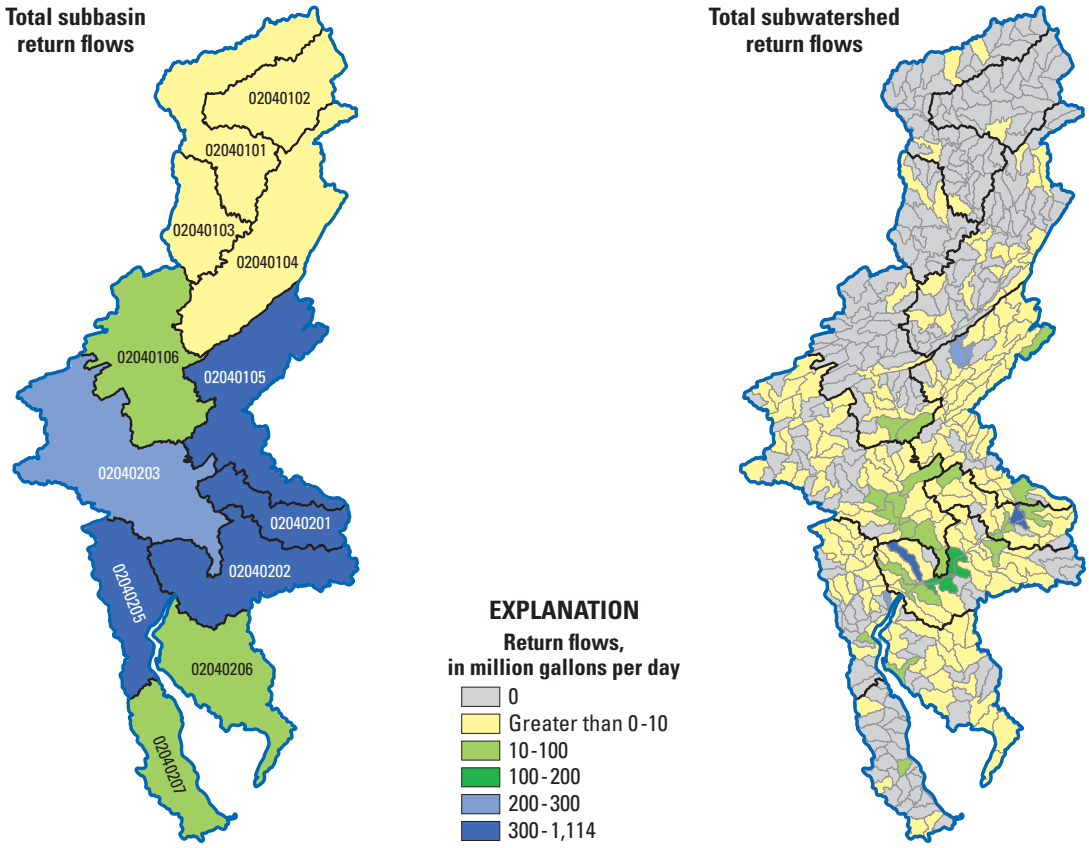


Figure 33. Return flows by subbasin and subwatershed in the Delaware River Basin, 2010.

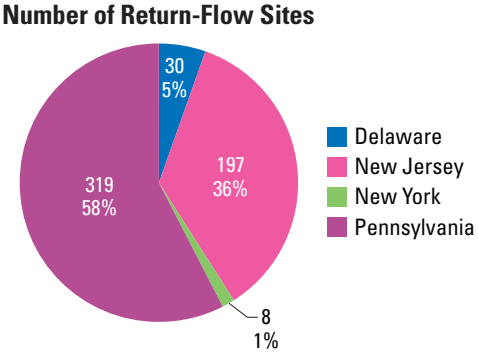


Figure 34. Number of return-flow sites by state in the Delaware River Basin, 2010. (%, percent)

Summary

To address water availability and water use concerns, the Delaware River Basin (DRB) was selected as a Focus Study Area in 2011 by the U.S. Geological Survey (USGS) as part of the USGS National Water Census. Instream and offstream water use was calculated for 2010 for the DRB based on information received from Delaware, New Jersey, New York, and Pennsylvania.

Water withdrawal, interbasin transfers, return flow, and hydroelectric power generation release data were compiled for 11 categories by hydrologic subregion, basin, subbasin, and subwatershed. Site-specific data from all the states were the basis for calculations of water withdrawals for thermoelectric power, public supply, self-supplied industrial, mining, and aquaculture; of instream use for hydroelectric power; and of return flows. Site-specific information was used in New Jersey for all categories except self-supplied domestic. Areal estimates based on county data were made for Delaware, New York, and Pennsylvania for the categories of self-supplied domestic and livestock; irrigation water withdrawals in these states were estimated using site-specific information for golf course irrigation and areal estimates for crop irrigation. Data on commercial water withdrawals were only available for New Jersey and Pennsylvania.

Total water withdrawals in the DRB were calculated to be about 7,130 million gallons per day (Mgal/d) in 2010. Estimates of withdrawals by source indicate that freshwater withdrawals were about 4,130 Mgal/d (58 percent of the total) and the remaining 3,000 Mgal/d (42 percent) were from saline water. Total surface-water withdrawals were calculated to be 6,590 Mgal/d, or 92 percent of the total; about 54 percent (3,590 Mgal/d) of surface water withdrawn was freshwater. Total groundwater withdrawals were calculated to be 545 Mgal/d (8 percent of the total), all of which was freshwater. During 2010, calculated withdrawals by category, in decreasing order, were: thermoelectric power, 4,910 Mgal/d; public supply, 1,490 Mgal/d; self-supplied industrial, 350 Mgal/d; irrigation, 175 Mgal/d; self-supplied domestic, 117 Mgal/d; mining, 41.3 Mgal/d; aquaculture, 19.3 Mgal/d; livestock, 6.72 Mgal/d, and commercial, 5.89 Mgal/d.

Thermoelectric power generation represented 69 percent (4,910 Mgal/d) of total withdrawals in the DRB and 47 percent (1,920 Mgal/d) of all freshwater withdrawals. Calculated saline water withdrawals for thermoelectric power generation were 2,990 Mgal/d, which represents almost all of the total saline water withdrawal in the basin. Almost all of the freshwater withdrawn for thermoelectric power generation in the DRB was from surface-water sources; less than 1 percent (3.00 Mgal/d) was from groundwater sources.

Public supply and self-supplied domestic withdrawals were about 23 percent of total water withdrawals and about 73 percent of total water withdrawals for all categories excluding thermoelectric power. Calculated withdrawals by source for public supply were 83 percent (1,240 Mgal/d) surface water and 17 percent (253 Mgal/d) groundwater. Withdrawals for self-supplied residential were estimated to be 117 Mgal/d, all of which was considered to be from groundwater sources. Of the 1,490 Mgal/d withdrawn for public supply, 651 Mgal/d (44 percent) was transferred out of the DRB. Some water withdrawn in the Susquehanna River Basin (32.4 Mgal/d) is transferred into the DRB for public supply uses.

Self-supplied industrial (361 Mgal/d), mining (41.3 Mgal/d), and commercial (5.89 Mgal/d) withdrawals were about 6 percent of total water withdrawals and about 18 percent of total water withdrawals for all categories excluding thermoelectric power. Calculated withdrawals by source for self-supplied industrial were 89 percent (323 Mgal/d) surface water and 11 percent (37.9 Mgal/d) groundwater; for mining, 79 percent (32.6 Mgal/d) surface water and 21 percent (8.78 Mgal/d) groundwater; and for commercial, 26 percent (1.54 Mgal/d) surface water and 74 percent (4.35 Mgal/d) groundwater.

Irrigation (175 Mgal/d), aquaculture (19.3 Mgal/d), and livestock (6.72 Mgal/d) withdrawals were about 3 percent of total water withdrawals and about 9 percent of total water withdrawals for all categories excluding thermoelectric power. Calculated withdrawals by source for irrigation were 41 percent (72.3 Mgal/d) surface water and 59 percent (103 Mgal/d) groundwater; for aquaculture, 36 percent (6.99 Mgal/d) surface water and 64 percent (12.3 Mgal/d) groundwater; and for livestock, 10 percent (0.64 Mgal/d) surface water and 90 percent (6.08 Mgal/d) groundwater.

Water withdrawals were calculated at the hydrologic subregion (the entire DRB), basin (the Upper and Lower DRB), subbasin (8-digit hydrologic unit), and subwatershed (12-digit hydrologic unit) levels for all categories. The Lower basin (020402) accounted for about 71 percent (2,940 Mgal/d) of the calculated total freshwater withdrawals. The largest freshwater withdrawals in the Lower basin were for thermoelectric power (1,660 Mgal/d) and for public supply (682 Mgal/d) and accounted for 85 percent (2,150 Mgal/d) of the total surface-water withdrawals in the Lower basin. Subbasin 02040206 accounted for about 44 percent (3,130 Mgal/d) of the calculated total withdrawals, however 95 percent (2,980 Mgal/d) of this was saline water withdrawn from the estuary in New Jersey in subwatershed 020402060602 for thermoelectric power generation.

The subbasin with the largest water withdrawals for thermoelectric power generation (02040206) accounted for 61 percent (2,990 Mgal/d) of the thermoelectric power generation water withdrawn in the DRB and was all saline water; most of this water was used by a single facility. The largest freshwater withdrawals were in subbasins 02040202 (706 Mgal/d) and 02040201 (478 Mgal/d) and accounted for 62 percent (1,180 Mgal/d) of the total freshwater withdrawals for thermoelectric power generation in the DRB. The subwatershed with the largest saline water withdrawals (2,980 Mgal/d) was 020402060602, where the PSEG Salem Generating Station Powerplant is located. The subwatershed with the largest freshwater withdrawals (690 Mgal/d) was 020402020601, where the Exelon Eddystone Powerplant is

located. The amount of instream use for hydroelectric power generation purposes in 2010 was reported to be 273 Mgal/d for the Wallenpaupack plant and 127 Mgal/d for the Mongaup River system.

The Upper basin (020401) accounted for 53 percent (846 Mgal/d) of the total Drinking Water sector withdrawals, whereas the Lower basin (020402) accounted for 47 percent (763 Mgal/d). Out-of-basin drinking-water exports accounted for 651 Mgal/d (77 percent) of Drinking Water sector withdrawals in the Upper basin. Drinking Water sector withdrawals were dominated by public supply water withdrawals in the Upper basin for New York City, and in the Lower basin for the greater Philadelphia area.

An estimated 14.7 million people relied on drinking water withdrawn in the DRB for their household use; over 8 million people outside of the Basin (in New York City and New Jersey) and 6.7 million people within the DRB. The publicly supplied population of the DRB represents about 81 percent of the total 2010 DRB population of approximately 8.2 million people. The subbasins with the largest water withdrawals for public supply were those in which withdrawals for New York City, Philadelphia, and Trenton, New Jersey occurred.

Three subbasins (02040103, 02040206, and 02040207) had public supply withdrawals almost exclusively (greater than 99 percent) from groundwater sources. Two subbasins (02040101 and 02040102) had public supply withdrawals almost exclusively (greater than 99 percent) from surface-water sources due to the withdrawal and subsequent transfer of water to New York City; however, groundwater sources accounted for most of the publicly supplied water use for residents within these two subbasins of the DRB.

The six subwatersheds with the largest surface-water withdrawals for public supply water use were the three subwatersheds that include reservoirs that are part of the New York City supply system (020401020405, Pepacton Reservoir, 334 Mgal/d; 020401010207, Cannonsville Reservoir, 145 Mgal/d; and 020401040303, Neversink Reservoir, 94.7 Mgal/d) and the three subwatersheds where water is withdrawn to supply the City of Philadelphia (020402031008, 121 Mgal/d), the City of Camden, New Jersey (020401050803, 77.3 Mgal/d), and the City of Trenton, New Jersey (020402020305, 178 Mgal/d) along with other uses along the Delaware and Raritan Canal. The four subwatersheds with the largest groundwater withdrawals were 020401060703 (12.5 Mgal/d, in the vicinity of Allentown, Pennsylvania) and three subwatersheds in the vicinity of Camden, New Jersey (020402020401, 15.2 Mgal/d; 020402020404, 11.8 Mgal/d; and 020402020403, 10.2 Mgal/d).

An estimated 1.56 million people within the DRB supplied their own water for domestic use in 2010. This number represents about 19 percent of the total 2010 DRB population of approximately 8.2 million people. Over half (62.2 Mgal/d) of the self-supplied domestic withdrawals were from three subbasins (02040203, 02040105, and 02040202), which contained 64 percent of the total population of the DRB. Self-supplied domestic withdrawals were greatest outside of metropolitan areas such as Philadelphia, Pennsylvania; Wilmington, Delaware; and Trenton, New Jersey.

The Lower basin accounted for 91 percent (371 Mgal/d) of the total Industrial sector withdrawals, whereas the Upper basin accounted for 9 percent (37.3 Mgal/d). The Lower basin Industrial sector water withdrawals were 91 percent from surface-water sources (339 Mgal/d) and 9 percent (31.6 Mgal/d) from groundwater sources. The Upper basin Industrial sector withdrawals were almost equally distributed between sources, with 52 percent from groundwater sources (19.5 Mgal/d) and 48 percent from surface-water sources (17.9 Mgal/d).

The four subbasins with the largest water withdrawals for industrial use (02040202, 02040205, 02040203, and 02040201) accounted for 83 percent (298 Mgal/d) of the industrial water withdrawn in the DRB. These subbasins include the urban areas surrounding Camden and Trenton, New Jersey; Philadelphia, Pennsylvania; and Wilmington, Delaware. The four subwatersheds with the largest surface-water withdrawals, also located near these urban areas, were 020402020607 (73.9 Mgal/d), 020402050704 (71.4 Mgal/d), 020402010404 (38.4 Mgal/d), and 020402031008 (27.4 Mgal/d). One subbasin, the Lower Delaware (02040202), had industrial surface-water withdrawals that accounted for 34 percent (110 Mgal/d) of the total for the DRB. Another subbasin, the Lehigh River (02040106), accounted for 28 percent (10.5 Mgal/d) of industrial groundwater withdrawals. The subwatershed with the largest groundwater withdrawals (5.62 Mgal/d) was 020401060810, in the vicinity of Allentown and Bethlehem, Pennsylvania. The only subwatershed where saline surface-water withdrawals for industrial use were reported was 020402060103 (10.6 Mgal/d), near Wilmington, Delaware.

Subbasin 02040206 had the largest water withdrawals for commercial use and accounted for 42 percent (2.45 Mgal/d) of the commercial water withdrawn in the DRB; all of these withdrawals were from groundwater sources, and the largest of them came from a single facility in subwatershed 020402060103. Three subbasins (02040202, 02040104, and 02040106) accounted for another 44 percent (2.62 Mgal/d) of commercial groundwater withdrawals. The largest amount of surface water (0.59 Mgal/d) was withdrawn in subwatershed 020401040803, in the Pocono Mountains region of Pennsylvania.

The subbasin with the largest water withdrawals for mining use (02040206) accounted for 79 percent (32.6 Mgal/d) of the mining water withdrawn in the DRB. The same subbasin had mining surface-water withdrawals that accounted for 78 percent (32.3 Mgal/d) of the total mining withdrawals for the DRB. The majority of mining withdrawals (25.2 Mgal/d) were in subwatershed 020402060605. Three subbasins (02040203, 02040105, and 02040201) accounted for another 19 percent (7.92 Mgal/d) of mining withdrawals and were almost exclusively from groundwater sources. Two subwatersheds combined to account for 57 percent of

the total groundwater withdrawals for mining in the DRB—020402030204 (2.67 Mgal/d) and 020401050908 (2.36 Mgal/d). No withdrawals were reported for mining purposes in subbasins 02040101, 02040103, 02040205, and 02040207.

The Lower basin (020402) accounted for 79 percent (158 Mgal/d) of the total Agricultural sector withdrawals, whereas the Upper basin (020401) accounted for 21 percent (42.6 Mgal/d). The Lower basin water withdrawals were about two-thirds from groundwater sources (105 Mgal/d of groundwater, 53.4 Mgal/d of surface water) and were used for primarily for irrigation. The Upper basin withdrawals were about two-thirds from surface-water sources (26.5 Mgal/d of surface water and 16.2 Mgal/d of groundwater) and were used primarily for irrigation and aquaculture.

The subbasins with the largest water withdrawals for irrigation use (02040207, 02040206, and 02040202) were located primarily in the Coastal Plain in the southeastern part of the DRB. These subbasins accounted for almost three-quarters (129 Mgal/d) of the irrigation water withdrawals. Two subbasins in the Coastal Plain (02040206 and 02040207) had irrigation groundwater withdrawals that accounted for 84 percent (86.3 Mgal/d) of the total irrigation groundwater withdrawals for the DRB; one subbasin (02040202) accounted for 30 percent (21.8 Mgal/d) of irrigation surface-water withdrawals. The subwatersheds with the largest groundwater and surface-water withdrawals were also located in the Coastal Plain of New Jersey and Delaware.

The subbasins with the largest water withdrawals for livestock use (02040203, 02040205, and 02040206) accounted for 70 percent (4.68 Mgal/d) of the livestock water withdrawn. These three subbasins accounted for 60 percent (4.17 Mgal/d) of the total livestock groundwater withdrawals for the DRB; one subbasin (02040203) accounted for 64 percent (0.41 Mgal/d) of livestock surface-water withdrawals. The two subwatersheds with the largest withdrawals were 020402030402 (0.23 Mgal/d) in Pennsylvania and 020402060404 (0.22 Mgal/d) in New Jersey.

Subbasin 02040105 had the largest water withdrawals for aquaculture use and accounted for almost half (9.36 Mgal/d) of the aquaculture water withdrawn in the DRB. One subwatershed (020401050204) in New Jersey accounted for almost all (9.11 Mgal/d) of this amount, in addition to 74 percent of the total groundwater withdrawals. Two subbasins (02040102 and 02040203) accounted for 73 percent (5.10 Mgal/d) of aquaculture surface-water withdrawals, more than half (2.90 Mgal/d) of which was withdrawn in subwatershed 020401020103 in New York.

Total return flows in the DRB were 2,960 Mgal/d, or 3,320 thousand acre-feet per year, in 2010. Thirty-eight percent (1,110 Mgal/d) of the total return flows were in subbasin 02040202. Eighty-seven percent (2,590 Mgal/d) of the returns were in the lower part of the DRB; only 13 percent (372 Mgal/d) of the returns occurred in the upper part of the DRB. Two subwatersheds (020402020601, 676 Mgal/d, and 020402010404, 597 Mgal/d) accounted for 43 percent of the total return flows.

Data were reported for a total of 554 return-flow sites. Although municipal wastewater-treatment plants accounted for 539 (97 percent) of the sites, they accounted for about 70 percent of the total return flows in the DRB. There was limited information available on return flows from thermoelectric power. Of the 554 return-flow sites, only 3 were thermoelectric powerplants; these 3 plants accounted for 30 percent (872 Mgal/d) of the total DRB returns.

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Glossary

The following terms are referenced in the text.

A

aggregated summarized values for a specific data element either by spatial area or category of use.

Agricultural sector includes the categories of irrigation, livestock, and aquaculture.

aquaculture aquaculture water use is water associated with raising organisms that live in water—such as finfish and shellfish—for food, restoration, conservation, or sport. Aquaculture production occurs under controlled feeding, sanitation, and harvesting procedures primarily in ponds, flow-through raceways, and, to a lesser extent, cages, net pens, and closed-recirculation tanks.

aquifer storage and recovery aquifer storage and recovery (ASR) is a specific type of aquifer recharge (AR) practiced with the purpose of both augmenting groundwater resources and recovering the water in the future for various uses (U.S. Environmental Protection Agency, 2014).

areal estimate water use estimate for a geographic unit such as a county, or watershed. *See also* subregion, basin, subbasin, and subwatershed.

artificial aquifer recharge the enhancement of natural groundwater supplies using man-made conveyances such as infiltration basins or injection wells.

B

basin hydrologically based watershed delineation assigned a 6-digit hydrologic unit code (HUC).

block group U.S. census block groups are statistical divisions of census tracts, are generally defined to contain between 600 and 3,000 people, and are used to present data and control block numbering. A block group consists of clusters of blocks within the same census tract that have the same first digit of their four-digit census block number.

C

census block U.S. census blocks are statistical areas bounded by visible features, such as streets, roads, streams, and railroad tracks, and by nonvisible boundaries, such as selected property lines and city, township, school district, and county limits and short line-of-sight extensions of streets and roads. Generally, census blocks are small in area; for example, a block in a city bounded on all sides by streets. Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features, such as roads, streams, and transmission lines. In remote areas, census blocks may encompass hundreds of square miles. Census blocks nest within all other tabulated census geographic entities and are the basis for all tabulated data.

choropleth a symbol or marked and bounded area on a map denoting the distribution of some property.

commercial commercial water use includes water for snowmaking, motels, hotels, restaurants, office buildings, other commercial facilities, and civilian and military institutions.

consumptive use the part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate environment.

D

Drinking Water sector includes the categories of public supply and self-supplied domestic.

F

freshwater water that contains less than 1,000 milligrams per liter (mg/L) of dissolved solids. Generally, water with more than 500 mg/L of dissolved solids is undesirable for drinking and industrial uses. *See also* saline water.

H

hydroelectric power generation the use of water in the generation of electricity at plants where the turbine generators are driven by falling water. Hydroelectric water use is classified as an instream use in this report. *See also* instream water use.

I

industrial industrial water use includes water used for such purposes as fabricating, processing, washing, diluting, cooling, or transporting a product; incorporating water into a product; or for sanitation needs within the manufacturing facility. Some industries that use large amounts of water produce such commodities as food, paper, chemicals, refined petroleum, or primary metals. Water for industrial use may be delivered from a public supplier or be self-supplied. In this report, industrial use refers to self-supplied industrial withdrawals only.

Industrial sector includes the categories of industrial, commercial, and mining.

instream water use water that is used, but not withdrawn, from a surface-water source for such purposes as hydroelectric power generation, navigation, water-quality improvement, fish propagation, and recreation.

interbasin transfer artificial conveyance of water from one basin to another. In this report, interbasin transfer refers specifically to water that moves into or out of the DRB. *See also* water transfer.

irrigation irrigation water use includes water that is applied by an irrigation system to sustain plant growth in all agricultural and horticultural practices. Irrigation also includes water that is applied for pre-irrigation, frost protection, application of chemicals, weed control, field preparation, crop cooling, harvesting, dust suppression, leaching salts from the root zone, and water lost in conveyance. Irrigation of golf courses, parks, nurseries, turf farms, cemeteries, and other self-supplied landscape-watering uses also are included. Irrigation water use includes self-supplied withdrawals and deliveries from irrigation companies, irrigation districts, cooperatives, or governmental entities.

L

livestock livestock water use is water associated with livestock watering, feedlots, dairy operations, and other on-farm needs. Livestock includes dairy cows and heifers, beef cattle and calves, sheep and lambs, goats, hogs and pigs, horses, and poultry. Other livestock water uses include cooling of facilities for the animals and animal products such as milk, dairy sanitation and wash down of facilities, animal waste-disposal systems, and incidental water losses.

M

mining mining water use is water used for the extraction of minerals that may be in the form of solids, such as coal, iron, sand, and gravel; liquids, such as crude petroleum; and gases, such as natural gas. The category includes quarrying, milling (crushing, screening, washing, and flotation of mined materials), re-injecting extracted water for secondary oil recovery, and other operations associated with mining activities. All mining withdrawals were considered self-supplied. Dewatering was not reported as a mining withdrawal unless the water was used beneficially, such as dampening roads for dust control.

monthly operating reports monthly data reports of average daily water withdrawals or water purchases submitted by each public supplier to a governmental agency.

municipal supply *See* public supply.

O

offstream water use water withdrawn or diverted from a groundwater or surface-water source for beneficial use. *See also* water withdrawal and water use.

P

physiographic province geomorphic, or physiographic, regions are broad-scale subdivisions based on terrain texture, rock type, and geologic structure and history. Nevin Fenneman's (Fenneman and Johnson, 1946) three-tiered classification of the

United States—by division, province, and section—has provided an enduring spatial organization for the great variety of physical features.

Power Generation sector includes the categories of thermoelectric power generation (offstream withdrawals) and hydroelectric power generation (instream water use).

public supply public supply refers to water withdrawn by public and private water suppliers that provide water to at least 25 people or have a minimum of 15 connections. Public-supply statistics also include water delivered for domestic, commercial, industrial, and public use purposes, and system losses, but are excluded from the 2010 DRB water use compilation.

public supply water use water distributed within the DRB by public suppliers.

public supply withdrawals water withdrawn, treated, and distributed by public suppliers. Public suppliers provide water for a variety of uses such as residential, commercial, industrial, thermoelectric power, and public water use. In this report, public supply withdrawals refer specifically to water removed from a groundwater or surface-water source in the DRB for a beneficial purpose.

R

return flow water that reaches a groundwater or surface-water source after release from the point of use and thus becomes available for further use. *See also* water use.

S

saline water water that contains 1,000 mg/L or more of dissolved solids. *See also* freshwater.

salt line an estimation of where the 7-day average chloride concentration equals 250 parts per million along the tidal Delaware River.

self-supplied domestic domestic water use includes indoor and outdoor uses at residences. Domestic water is either self-supplied or provided by public suppliers. Self-supplied domestic water use is usually withdrawn from a private source, such as a well.

site-specific data data for an individual water-using entity.

subbasin hydrologically based watershed delineation assigned an 8-digit hydrologic unit code (HUC).

subregion hydrologically based watershed delineation assigned a 4-digit hydrologic unit code (HUC).

subwatershed hydrologically based watershed delineation assigned a 12-digit hydrologic unit code (HUC).

T

thermoelectric power generation water for thermoelectric power is used in generating electricity with steam-driven turbine generators.

W

water transfer artificial conveyance of water from one area to another.

water use (1) in a restrictive sense, the term refers to water that is used for a specific purpose, such as for residential use, irrigation, thermoelectric-power cooling, or industrial processing. In this report, the quantity of water use for a specific category is the water withdrawal by that category of users. (2) More broadly, water use pertains to the interaction of humans with and their influence on the hydrologic cycle, and includes elements such as water withdrawal, delivery, consumptive use, wastewater release, reclaimed wastewater, return flow, and instream use. *See also* offstream water use and instream water use.

water use transaction a water use activity that is a withdrawal, water delivery, water release, return flow, or water transfer. *See also* return flow, water transfer, or water withdrawal.

water withdrawal water removed from the ground or diverted from a surface-water source for use. *See also* offstream water use.

watershed hydrologically based watershed delineation assigned a 10-digit hydrologic unit code (HUC).

Appendixes 1–3

Appendix 1. Description of the Watershed Boundary Dataset.

The Watershed Boundary Dataset (WBD) defines the areal extent of surface-water drainage to a point, accounting for all land and surface areas. Watershed boundaries are determined solely upon science-based hydrologic principles, not favoring any administrative boundaries or special projects, nor any particular program or agency (U.S. Geological Survey, 2014d, and U.S. Department of Agriculture, Natural Resources Conservation Service, 2014). The purpose of defining Hydrologic Units (HUs) for the WBD is to establish a base-line drainage boundary framework, accounting for all land and surface areas. At a minimum, the WBD is being delineated and geo-referenced to the USGS 1:24,000-scale topographic base map meeting National Map Accuracy Standards (NMAS). Hydrologic units are given a Hydrologic Unit Code (HUC) (table 1-1). For example, a hydrologic region has a 2-digit HUC. A HUC describes where the unit is in the country and the level of the unit.

The WBD is being developed under the leadership of the Subcommittee on Spatial Water Data, which is part of the Advisory Committee on Water Information (ACWI) and the Federal Geographic Data Committee (FGDC). The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), along with many other Federal agencies and national associations, have representatives on the Subcommittee on Spatial Water Data.

Table 1-1. Watershed definitions for the United States.

Watershed definitions			
Name	**Level**	**Digit**	**Number of hydrologic unit codes (HUCs)**
Region	1	2	21
Subregion	2	4	222
Basin	3	6	352
Subbasin	4	8	2,149
Watershed	5	10	22,000
Subwatershed	6	12	160,000

Appendix 2. Hydrologic Subbasins, Watersheds, and Subwatersheds in the Delaware River Basin.

The Delaware River Basin includes 13 subbasins, 86 watersheds, and 427 subwatersheds. The hydrographic classification scheme used for this report and in the following summary tables is from the Watershed Boundary Dataset (WBD) that is described in Appendix 1.

The tables in this appendix list the subbasins within the Delaware River Basin and their associated watersheds and subwatersheds, along with their hydrologic unit codes and names. A map of each subbasin that shows the watershed and subwatershed boundaries within that subbasin is included; each subwatershed is labeled by the last four digits of the Hydrologic Unit Code (HUC). Also included is a map that shows the location of each subbasin within the Delaware River Basin.

Appendix 2 is available online at http://pubs.usgs.gov/sir/2015/5142/appendix/sir20155142_appendix2.

Appendix 3. Delaware River Basin Water Use by Subbasin.

The summaries of water use information by hydrologic subbasin in this Appendix present withdrawals by water use categories. Population and land area totals also are listed along with a map that shows the location of the subbasin within the Delaware River Basin.

In each of the summaries, a table lists average daily withdrawals for the water use categories in the subbasin. If there are no withdrawals for a particular category, that category is not listed. The withdrawals are totaled by source of water used (groundwater or surface water) and by category, and the percentage by source is indicated.

In the tables, categories were listed as withdrawing 0 million gallons per day (Mgal/d) if the withdrawal was less than 0.01 Mgal/d. As a result, some totaled withdrawals from these tables may be less than the totals for public supply or industry in the water use-category table. Numbers were summed using three decimal places and then rounded to two decimal places for the final number. Values may not sum to totals because of independent rounding.

Appendix 3 is available online at http://pubs.usgs.gov/sir/2015/5142/appendix/sir20155142_appendix3.

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