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Water-Level Conditions in the Confined Aquifers of the New Jersey Coastal Plain, 2013

Scientific Investigations Report 2019–5146

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

Cover. Photograph showing well located in Monmouth County, New Jersey, November 2018. Photo by Stephen Cauller, U.S. Geological Survey.

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(available at https://doi.org/10.3133/sir20195146)

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
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)
	Hydraulic conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)
	Transmissivity*	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

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

$$°F = (1.8 \times °C) + 32.$$

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

$$°C = (°F - 32) / 1.8.$$

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88), except as otherwise noted.

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

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

Supplemental Information

*Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [(ft^3/d)/ft^2]ft. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Concentrations of chemical constituents are in milligrams per liter (mg/L).

Abbreviations

GIS	Geographic information system
GWSI	Groundwater Site Inventory
NJDEP	New Jersey Department of Environmental Protection
PRM	Potomac-Raritan-Magothy
RASA	Regional Aquifer System Analysis
USGS	U.S. Geological Survey

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Abstract

The Coastal Plain aquifers of New Jersey provide an important source of water for more than 3.5 million people. In 2013, groundwater withdrawals from 10 confined aquifers of the New Jersey Coastal Plain totaled about 190 million gallons per day. Steadily increasing withdrawals from the late 1800s to the early 1990s resulted in declining water levels and the formation of regional cones of depression in many confined Coastal Plain aquifers. Starting in 1978, the U.S. Geological Survey (USGS) began mapping the potentiometric surfaces of the major confined Coastal Plain aquifers every 5 years to provide a regional assessment of groundwater conditions.

In a study conducted by the USGS, in cooperation with the New Jersey Department of Environmental Protection, water levels in 10 confined aquifers of the New Jersey Coastal Plain were measured and evaluated to provide a regional overview of groundwater conditions during fall 2013. Water levels were measured in 987 wells in New Jersey, and parts of Pennsylvania and Delaware. Potentiometric-surface maps were prepared for, in ascending order of age, the confined Cohansey aquifer of Cape May County, Rio Grande water-bearing zone, Atlantic City 800-foot sand, Piney Point aquifer, Vincentown aquifer, Wenonah-Mount Laurel aquifer, Englishtown aquifer system, and the Upper, Middle, and Lower aquifers of the Potomac-Raritan-Magothy (PRM) aquifer system.

Persistent, regionally extensive cones of depression were present in the potentiometric surfaces of the Englishtown aquifer system and Wenonah-Mount Laurel aquifer in Ocean and Monmouth Counties; Wenonah-Mount Laurel and Upper, Middle, and Lower PRM aquifers in Camden County; and Atlantic City 800-foot sand in Atlantic County. Changes in water levels from 2008 to 2013 were measured in many Coastal Plain aquifers in New Jersey. In some areas, water levels continued to decline as a result of pumping, but in other areas water levels continued to recover as a result of regulated decreases in groundwater withdrawals. Since 2008, in the confined Cohansey aquifer in Cape May County, water levels generally did not change; however, cones of depression in the potentiometric surface of the Piney Point aquifer in some areas of Cumberland County deepened by more than 20 feet (ft). In Critical Area 1, an area of restricted withdrawals, measured water levels in the Wenonah-Mount Laurel aquifer declined in parts of southern Monmouth County by more than 10 ft; however, rises in water levels of more than 10 ft were measured in parts of northern Ocean and Monmouth Counties. Since 2008, in Critical Area 2, also an area of restricted withdrawals, measured water levels in the Wenonah-Mount Laurel aquifer rose more than 20 ft in parts of western Burlington County and more than 20 ft in parts of western Camden County. Since 2008, in Critical Area 1, measured water levels in the Englishtown aquifer system declined in parts of eastern Ocean County by more than 10 ft and in southeastern Monmouth County by more than 20 ft; however, rises in water levels of more than 10 ft were measured in other parts of Ocean and Monmouth Counties.

In general, since 2008 in Critical Area 2, in the Upper PRM aquifer, measured water levels continued to rise by 10 ft or more in central and western Burlington and central Camden Counties. In the Middle PRM aquifer in Critical Area 2, measured water levels rose in parts of central Camden County by 10 ft or more. However, measured water levels in the Lower PRM aquifer in Critical Area 2 were more than 10 ft lower in the center of the cone of depression in central Camden County, but measured water levels continued to rise updip from this area in Critical Area 2.

Seasonal water-level fluctuations are presented in time-series hydrographs for 77 wells during 1978–2013. Analyses of long-term water-level changes for the period 2008–13 indicate downward water-level trends at 14 wells (18 percent), upward trends at 34 wells (44 percent), and no substantial change at 29 wells (38 percent). Downward trends were most often observed for wells screened in the Piney Point aquifer and the Atlantic City 800-foot sand. Upward water-level trends were most often measured for wells screened in the PRM aquifer system. Upward water-level trends also were measured for wells in the Englishtown aquifer system and the Wenonah-Mount Laurel aquifer in Critical Area 1 in some areas; however, downward trends and no substantial changes were measured in other areas.

Introduction

The Coastal Plain aquifers of New Jersey are an important source of water for more than 3.5 million people (U.S. Census Bureau, 2016). Groundwater withdrawals from the confined and unconfined Coastal Plain aquifers have steadily increased from less than 50 million gallons per day (Mgal/d) in 1918 to more than 350 Mgal/d in 1980 (Zapecza and others, 1987). Groundwater withdrawals from 10 confined Coastal Plain aquifers totaled 189.6 Mgal/d in 2013. As a result of increasing groundwater withdrawals over the decades, water levels in the confined aquifers steadily declined, and regional cones of depression formed. In addition to loss of aquifer storage, declining water levels in these aquifers have caused reversals in natural hydraulic gradients. These reversals have induced local incursion of brackish or saline water from surface-water bodies and adjacent aquifers. Declining water levels and instances of saltwater intrusion initiated a shift toward alternate sources of supply. From 1990 to 2009, withdrawals of potable water from surface-water sources in the Coastal Plain increased from about 27,000 million gallons to more than 69,000 million gallons (Hoffman and Lieberman, 2000; Hoffman, 2014).

Groundwater-Management Critical Areas

To provide water-supply managers and regulators with a regional assessment of groundwater conditions in the confined aquifers of the New Jersey Coastal Plain, the U.S. Geological Survey (USGS), in cooperation with the New Jersey Department of Environmental Protection (NJDEP), initiated a plan in 1978 to map the potentiometric surfaces of the major confined aquifers on a 5-year cyclical basis. Such assessments provide a broad view of the effects of groundwater development and are an essential component for managing and sustaining the region's water supply. To date, potentiometric surfaces have been mapped for 1978, 1983, 1988, 1993, 1998, 2003, and 2008. During 1988–2003, the plan of study was expanded to include selected water-level measurements in Delaware to better define cones of depression that propagated beneath the Delaware River and Bay in the Piney Point and Lower Potomac-Raritan-Magothy aquifers.

In 1985, the NJDEP used these water-level measurements to designate two water supply Critical Areas in the State where excessive water usage threatens the long-term sustainability of the water supply. Critical Area 1 is in the east-central part of the State, and Critical Area 2 encompasses Camden County and surrounding counties of southern New Jersey (fig. 1). Each Critical Area is composed of a depleted zone and a threatened margin (New Jersey Administrative Code 7:19–8.4, 2005). The boundary of the depleted zone corresponds to the average -30-foot potentiometric contour in each regulated aquifer in the Critical Areas, based on the 1983 maps by Eckel and Walker (1986). A 3-mile-wide buffer, known as the threatened margin, surrounds the depleted zone of each aquifer and incorporates areas where there is a potential for saltwater intrusion as a result of the decline in water levels. Critical Area boundaries shown on maps in this report are a composite that includes the largest surface extents of both the depleted zone and the threatened margins of each of the affected aquifers.

Critical Area 1, designated in 1985, encompasses parts of Middlesex, Monmouth, and Ocean Counties (fig. 1). Regulated aquifers within Critical Area 1 apply to, in order of increasing depth, Wenonah-Mount Laurel aquifer, Englishtown aquifer system, and Upper and Middle Potomac-Raritan-Magothy (PRM) aquifers. During the early 1990s throughout Critical Area 1, water levels declined as much as 135, 260, and 300 ft, relative to predevelopment conditions in the Middle PRM aquifer, Wenonah-Mount Laurel aquifer, and Englishtown aquifer system, respectively (DePaul and Rosman, 2015). Mandatory reductions in groundwater withdrawals from pumped wells within the depleted zones of the Wenonah-Mount Laurel aquifer, the Englishtown aquifer system, and the Middle PRM aquifer were set to 50 percent relative to 1983 volumes; reductions in the Upper PRM aquifer were set to 40 percent of 1983 volumes. Within the threatened margin, allocated withdrawals remained at 1983 volumes (New Jersey Administrative Code 7:19–8.4, 2005).

Critical Area 1 restrictions were implemented in 1989, but because access to alternate water supplies was not initially available, compliance by most purveyors was deferred until 1991. The Manasquan Reservoir was placed in operation in 1990 for use throughout Monmouth County and can supply the region with approximately 30 Mgal/d of surface water (New Jersey Water Supply Authority, 2005). Withdrawals from confined Coastal Plain aquifers in this area were reduced and replaced with surface-water withdrawals and, to a lesser extent, withdrawals from shallower, unconfined aquifers. As of 2008, water levels have recovered from lows measured during 1983–88 by as much as 67, 150, and 187 ft in the Middle PRM and Wenonah-Mount Laurel aquifers, and the Englishtown aquifer system, respectively (DePaul and Rosman, 2015).

To improve the management of groundwater resources of the Potomac-Raritan-Magothy aquifer system in southwestern New Jersey, Critical Area 2 was designated in 1993. The management area encompasses Camden, most of Burlington and Gloucester, and parts of Atlantic, Cumberland, Ocean, Monmouth, and Salem Counties (fig. 1). Restrictions on groundwater withdrawals apply only to the aquifers of the PRM aquifer system and were initiated in 1996. Groundwater withdrawals in the depleted zone were reduced by an average of 22 percent relative to 1983 volumes, whereas, within the threatened margin, withdrawals were limited to the maximum annual volume between 1983 and 1991 (New Jersey Administrative Code 7:19-8.5, 2005). Development of shallower, non-restricted aquifers was encouraged, and specific conservation measures that were introduced to curtail groundwater withdrawals within the region include the Tri-County Pipeline, which began operation in 1996 and can provide more than 30 Mgal/d of water from the Delaware River to users throughout Burlington, Camden, and Gloucester Counties. Reductions in groundwater withdrawals coupled with the use of alternative surface-water

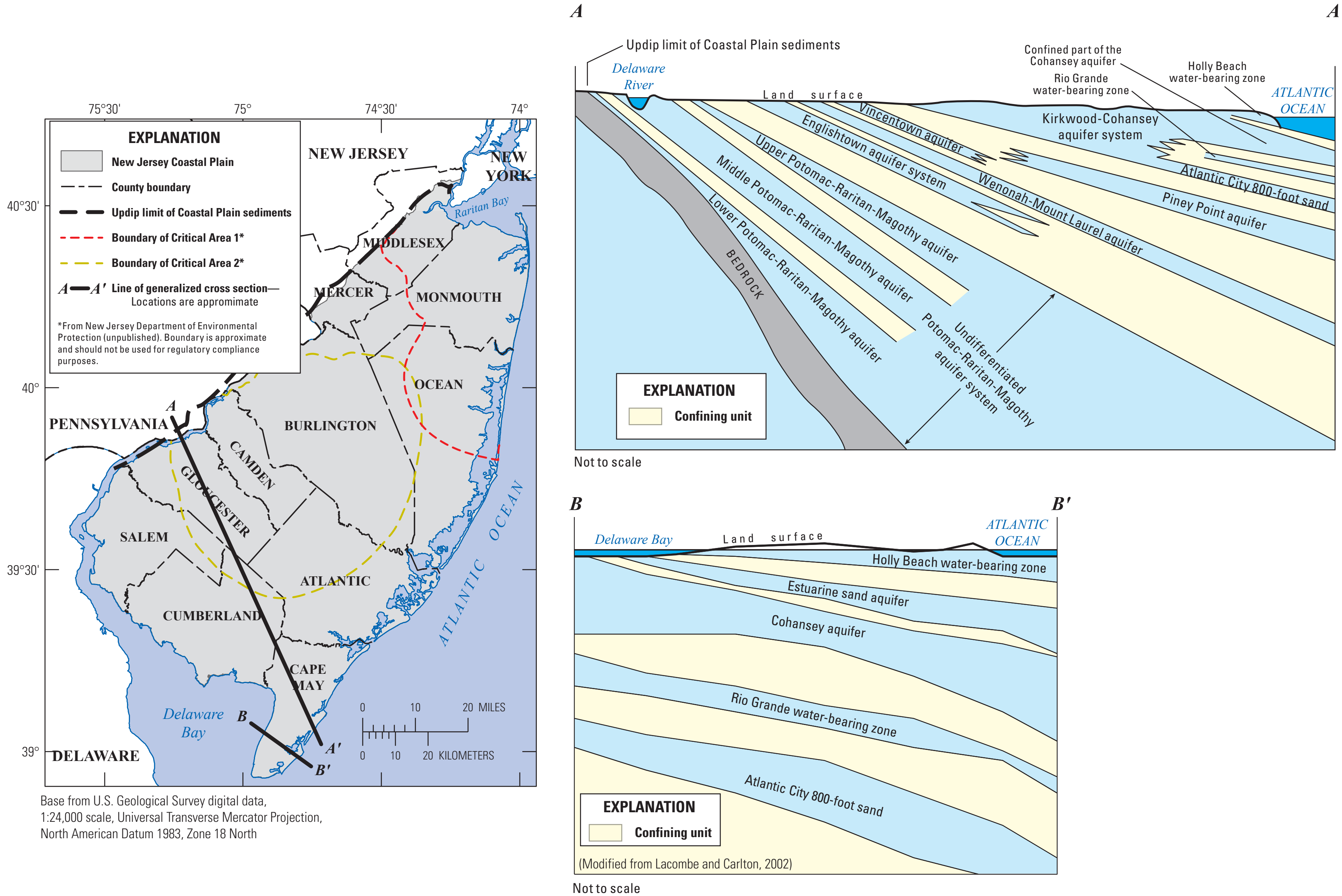


Figure 1. Location of the study area, generalized hydrogeologic section *A–A′* through the Coastal Plain of southern New Jersey, and generalized hydrogeologic section *B–B′* through the southern Cape May County, New Jersey.

sources have resulted in substantial recoveries in water levels in Critical Area 2, and as of 2008, water levels had recovered from lows measured during 1988–93 by as much as 53, 40, and 50 ft in the Upper, Middle, and Lower PRM aquifers, respectively (DePaul and Rosman, 2015). A more detailed discussion of water-level recovery in the regulated aquifers as a result of Critical Area management strategies is provided in Spitz and others (2008) and Spitz and DePaul (2008).

Purpose and Scope

The objectives of this report are to characterize 2013 groundwater conditions within selected confined aquifers of the New Jersey Coastal Plain and to evaluate the effect of water-level changes in each aquifer on the potentiometric surface during selected periods. Hydrographs that illustrate seasonal variations and the long-term effects of groundwater withdrawals are provided for 77 wells. Estimated groundwater withdrawals from the 10 confined aquifers in New Jersey are compiled for 1978–2013 and presented in maps, graphs, and tables throughout the report. In addition, all collected water-level measurements are compiled in appendixes at the end of the report for ease of use; however, these data are also publicly available in the USGS National Water Information System (NWIS) database (U.S. Geological Survey, 2017). Basic well-characteristic and water-level data also are provided in the report appendixes. This report is the eighth in the series of reports that show the potentiometric surfaces for the major confined aquifers of the New Jersey Coastal Plain. The 2013 potentiometric surface contours and geospatial well data are available as a data release (Cauller and Gordon, 2021).

Description of Study Area

The study area encompasses the Coastal Plain Physiographic Province of New Jersey and eastern Pennsylvania and parts of the Coastal Plain in Delaware (fig. 1). The study area covers approximately 5,400 square miles (mi^2) and is bounded on the northwest by the updip limit of the Coastal Plain sediments (Fall Line), which separates the Coastal Plain sediments from the Piedmont sediments; on the east and southeast by the Atlantic Ocean; and on the southwest by Delaware Bay. This investigation focused on the counties of Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Monmouth, Ocean, Salem, and parts of Mercer and Middlesex in New Jersey but includes limited parts of Kent and New Castle Counties in Delaware and part of Philadelphia County in Pennsylvania. Topography within the study area is relatively flat; altitudes range from 0 foot (ft) along estuaries, bays, and the Atlantic coastline to nearly 400 ft in western Monmouth County, New Jersey.

Hydrogeologic Framework

The hydrogeologic framework used in this report was developed for the New Jersey Coastal Plain Regional Aquifer System Analysis (RASA) study by Zapecza (1989) and consists of a southeastward dipping and thickening wedge of unconsolidated deposits of sand, silt, and clay of Cretaceous to Neogene age underlain by basement rocks and overlain by a veneer of locally occurring Quaternary sediments (fig. 1, table 1). Coastal Plain sediments were deposited in various shelf, marginal marine, near-shore or coastal beach, and deltaic environments, the extent of which fluctuated in response to relative changes in sea level. Units composed of distinctly less permeable sediments (predominantly clays and fine-grained silts) form the confining units, and coarser, more permeable sand and gravel units, which readily produce water, form the aquifers (fig. 1). These deposits are less than 50 ft thick along the western limit of the Coastal Plain (Fall Line) and thicken to more than 6,500 ft in southern Cape May County. Coastal Plain sediments generally strike northeast-southwest and dip 10–60 feet per mile to the southeast (Zapecza, 1989); overlying Quaternary deposits are flat. These sediments crop out near the Fall Line parallel to strike, transitioning into unconfined aquifers, except for the Piney Point aquifer, which is confined throughout the study area. The aquifers and confining units in the New Jersey Coastal Plain range in age from Lower Cretaceous to Miocene (table 1). A brief description of each aquifer is included in this report. More detailed discussions are presented in Zapecza (1989) and Sugarman and others (2005), describing the hydrogeology of New Jersey, and Vroblesky and Fleck (1991) describe the hydrogeology of Delaware. The confining units are described in Zapecza (1989) and Rosman and others (1995).

Well numbering system

In this report, wells are listed by their USGS identification number. For wells located in New Jersey, the well-numbering system consists of an odd-numbered county code followed by a sequence number for wells within that county. For example, well number 15-123 is the 123rd well inventoried in Gloucester County. For Pennsylvania, the well-numbering system consists of a P, followed by a sequence number for the well. County codes for New Jersey and Pennsylvania are listed in table 2. For wells in Delaware, identifiers are assigned by the Delaware Geological Survey and are numbered on the basis of a coordinate system using 5-minute quadrangles of latitude and longitude.

Previous Investigations

Various regional studies describe water-level data, potentiometric surfaces, and groundwater flow in the New Jersey Coastal Plain. Previous potentiometric-surface maps in this series present water levels in the study area at 5-year intervals from 1978 through 2008: 1978, Walker (1983); 1983, Eckel and Walker (1986); 1988, Rosman and others (1995); 1993 and 1998, Lacombe and Rosman (1997, 2001); 2003 and 2008, DePaul and others (2009) and DePaul and Rosman (2015). The potentiometric-surface map series is supplemented

Table 1. Geologic and hydrogeologic units of the New Jersey Coastal Plain and hydrologic units of the Delaware Coastal Plain.

[Shaded units are those discussed in this report; Cohansey aquifer is referenced in Gill (1962); table modified from Zapecza (1989), Sugarman (2001)]

System	Series	Geologic unit	New Jersey hydrogeologic unit	Delaware hydrogeologic unit
Quaternary	Holocene	Alluvial deposits	Undifferentiated	
		Beach sand and gravel		
	Pleistocene	Cape May Formation	Kirkwood-Cohansey	Columbia group
Neogene	Pliocene	Pensauken Formation		
	Miocene	Bridgeton Formation	Kirkwood-Cohansey aquifer system	Chesapeake Group: Pokomoke aquifer
		Beacon Hill Gravel		
		Cohansey Formation	Cohansey aquifer[1]	Manokin aquifer
				Confining unit
		Kirkwood Formation		Frederica aquifer
				Confining unit
			"Upper" Wildwood-Belleplain confining unit	Federalsburg aquifer
			Rio Grande water-bearing zone	Confining unit
			"Lower" Wildwood-Belleplain confining unit	Cheswold aquifer
			Atlantic City 800-foot sand	
Paleogene	Oligocene	Shark River Formation	Composite confining unit: Piney Point aquifer	
	Eocene			Piney Point aquifer
		Manasquan Formation	Composite confining unit	Rancocas aquifer
	Paleocene	Vincentown Formation	Vincentown aquifer	
		Hornerstown Sand	Hornerstown Sand[1]	Confining unit
Cretaceous	Upper Cretaceous	Tinton Sand	Composite confining unit	
		Red Bank Sand	Red Bank Sand	
		Navesink Formation		
		Mount Laurel Formation	Wenonah-Mount Laurel aquifer	Mount Laurel aquifer
		Wenonah Formation		
		Marshalltown Formation	Marshalltown-Wenonah confining unit	Confining unit
		Englishtown Formation	Englishtown aquifer system	Englishtown aquifer
		Woodbury Clay	Merchantville-Woodbury confining unit	Confining unit
		Merchantville Formation		
		Magothy Formation	Potomac-Raritan-Magothy aquifer system: Upper aquifer	Magothy aquifer
		Raritan Formation	Confining unit	Confining unit
			Middle aquifer	Upper and Middle Potomac aquifers
		Potomac Formation	Confining unit	Confining unit
	Lower Cretaceous		Lower aquifer	Lower Potomac aquifer
Pre Cretaceous		Bedrock	Bedrock confining unit	Bedrock confining unit

[1]Not designated as a formal aquifer by Zapecza (1989).

Table 2. County prefix codes used in well-numbering systems in New Jersey and Pennsylvania.

County name	Code	County name	Code
New Jersey			
Atlantic	01	Mercer	21
Burlington	05	Middlesex	23
Camden	07	Monmouth	25
Cape May	09	Ocean	29
Cumberland	11	Salem	33
Gloucester	15		
Pennsylvania			
Philadelphia	P		

by water-table maps for the unconfined aquifers within the following basins of the New Jersey Coastal Plain: Great Egg Harbor River Basin (Watt and Johnson, 1992); Toms River, Metedeconk River, and Kettle Creek Basins (Watt and others, 1994); upper Maurice River Basin (Lacombe and Rosman, 1995); Mullica River Basin (Johnson and Watt, 1996); Salem River, and Raccoon, Oldmans, Alloway, and Stow Creek Basins (Johnson and Charles, 1997); Rancocas, Crosswicks, Assunpink, Blacks, and Crafts Creek Basins (Watt and others, 2003); and Forked River and Cedar, Oyster, Mill, Westecunk, and Tuckerton Creek Basins (Gordon, 2004).

Countywide water-resources studies were conducted by Barksdale and others (1943), Jablonski (1968), and Anderson and Appel (1969) for Middlesex, Monmouth, and Ocean Counties, respectively. Rush (1968), Farlekas and others (1976), Hardt and Hilton (1969), and Rosenau and others (1969) completed water-resources studies for the counties of Burlington, Camden, Gloucester, and Salem, respectively, and Gill (1962) and Lacombe and Carleton (2002) completed water-resources studies for Cape May County.

Martin (1998), Pope and Gordon (1999), and Voronin (2004) describe simulated groundwater flow from a regional perspective within the New Jersey Coastal Plain. Pucci and others (1994), Navoy and Carleton (1995), and McAuley and others (2001) did detailed studies, including groundwater-flow models of Critical Area 1, Critical Area 2, and the Atlantic City area, respectively. For Critical Area 2, Navoy and others (2005) simulated the vulnerability of public-supply wells screened in the Potomac-Raritan-Magothy aquifer system to saltwater intrusion, and Navoy (1994) simulated effects of projected withdrawals on water levels in the Wenonah-Mount Laurel aquifer. Water-level recovery in Critical Area 1 and Critical Area 2 is discussed in Spitz and others (2008) and Spitz and DePaul (2008), respectively. Voronin and others (1996), Spitz (1998), and Lacombe and others (2009) simulated groundwater flow in confined aquifers in Cape May County. Pope (2006) simulated effects on water levels of increased withdrawals from the Atlantic City 800-foot sand. Charles and others (2011) simulated effects of allocated and projected withdrawals on water levels in the Potomac-Raritan-Magothy aquifer system in Gloucester and Salem Counties.

Data Collection and Analysis

Static groundwater-level altitudes (hereafter water levels) were measured in 982 wells in New Jersey and Pennsylvania by USGS personnel. In addition, water levels in five wells in Delaware were obtained from the Delaware Geological Survey (Delaware Geological Survey, 2017). Most of the water levels used in this study were measured during October–December 2013 after heavy summer withdrawals had lessened. Water levels in the study area typically reach their annual highs in winter and early spring (Rosman and others, 1995). Reliable comparisons can be made of water levels measured at the same time of year, and these can be used to evaluate water-level trends. However, variations in some wells may be caused by local variations in withdrawal or recharge, or differences in the recovery interval preceding measurements at recently pumped wells.

Water levels were measured at observation wells and pumped (production) wells used for industrial, commercial, irrigation, domestic, and public supply; measurement sites were generally chosen on the basis of areal distribution within each aquifer. Measurements made at observation wells constitute about 30 percent of the dataset. Measurements were made using (1) steel or electric tapes graduated to hundredths of a foot, which are the most accurate devices; (2) pressure transducers calibrated to within 0.03 ft by the USGS; (3) purveyor pressure transducers that may or may not be calibrated; or (4) an airline, graduated to 0.5 ft, which is less accurate. The airline method or purveyor transducers were used only at wells that were inaccessible for measuring by either electric or steel tape. Pumps in high-capacity water-supply wells were turned off for a minimum of 1 hour before measurement of the water level in the well so that the water levels could recover. In addition, nearby pumping was controlled at the time of measurement; pumps in all other high-capacity pumped wells screened in the same aquifer within 0.25 mile (mi) of the measured well were idle for at least 1 hour prior to measurement of the water level. Measurements were made in each well until two consecutive measurements within 0.05 ft were obtained at least 5 minutes apart to assure that the aquifer had recovered sufficiently from its stressed condition. The resulting water-level measurement was considered representative of static or near-static conditions. Importantly, "static" in this report is not intended to mean unaffected by withdrawals, but rather representative of water levels in the area, not of those affected by local effects of individual withdrawals. Aquifer transmissivities vary. Some aquifers, such as the Englishtown aquifer system and the Wenonah-Mount Laurel aquifer, have lower transmissivities in some areas compared to the Potomac-Raritan-Magothy aquifer system, and the water levels may require a longer time to recover.

Groundwater in three observation wells (11-137 screened in the Middle PRM aquifer; 25-568, screened in the Upper PRM aquifer; and 25-771, screened in the Englishtown aquifer system) measured in this study have been sampled periodically and have chloride concentrations greater than

5,000 milligrams per liter (mg/L). Therefore, the water levels in these wells were converted from a measured saltwater hydraulic head to a calculated freshwater head. The conversion equation follows a modification of the Ghyben-Herzberg relation (Todd, 1980) to determine the equivalent length of freshwater in a well filled with saltwater:

$$l_f = (p_s/p_f)l_s \quad (1)$$

where

l_f is length of the freshwater column in the well casing,

p_s is the density of saltwater,

p_f is the density of freshwater, and

l_s is the length of saltwater column in the well casing.

The density of freshwater is 1.00 gram per cubic centimeter, and the density of water increases with increasing solute concentrations. The freshwater equivalent water levels were used to contour the potentiometric surfaces; the measured water levels and freshwater equivalents for these wells are presented in appendixes 1–10.

The water level in a well represents the hydraulic head in the part of the aquifer at which the well is screened. Hydraulic heads at each well were calculated by subtracting the water level, in feet below land surface, from the land-surface altitude, in feet above the North American Vertical Datum of 1988 (NAVD 88), and this calculation is indicated in this report as the water-level altitude. In confined aquifers, this level typically stands above the top of the aquifer owing to increases in pressure with depth and the presence of overlying, relatively impermeable strata. Maps depicting the areal distribution of hydraulic head within each aquifer were manually constructed; lines of equal hydraulic head are represented on these maps by manually generated potentiometric-surface contours. From these maps, groundwater flow in each aquifer can be inferred because general flow directions are assumed to be perpendicular to the potentiometric-surface contours and in the direction of decreasing water levels. Although most of the data used in this study are water-level measurements made in the confined parts of the aquifers, in some cases, measurements made in the unconfined parts are included to guide placement of potentiometric contours where the aquifer crops out. In addition, climatic variations affect water levels in confined aquifers only indirectly and are not considered in this report. Further, the density and number of wells available for measurement can limit the interpretation of the potentiometric surface of an aquifer.

On the plate maps accompanying this report, the symbol for an observation well applies to non-withdrawal wells or wells that are listed in the USGS National Water Information System (NWIS), Groundwater Site Inventory (GWSI) database as non-withdrawal for water-use type. The symbol for a pumped well applies to wells that are listed in the GWSI database as withdrawal for water-use type.

All water levels in this report are referenced to the North American Vertical Datum of 1988 (NAVD 88), whereas previous reports in this series used the National Geodetic Vertical Datum of 1929 (NGVD 29). Water levels in the Coastal Plain of New Jersey referenced to NAVD 88 are generally about 1 ft lower than those referenced to NGVD 29, with altitude differences between NGVD 29 and NAVD 88 of 0.84 ft near the Delaware Memorial Bridge, 1.05–1.20 ft along the Delaware River from Trenton to Camden, 1.26–1.33 from Barnegat Inlet to Cape May, and 0.83–1.08 ft along the Raritan Bay shoreline (Greenfeld, 2009).

Potentiometric-Surface Change Between 2008 and 2013

Maps showing the differences between potentiometric surfaces (water-level contours) were constructed using the differences between the 2008 (DePaul and Rosman, 2015) and 2013 potentiometric surfaces and by comparing the water-level measurements in 832 wells made during the fall 2008 and 2013. The changes in the potentiometric surface from 2008 to 2013 were plotted on digital base maps and contoured using a geographic information systems (GIS). Although these maps provide a spatial perspective in assessing water-level change throughout individual aquifers over a given period, interpretations based on these maps have limitations. The GIS interpretation of the difference may slightly differ from actual measurement. The contours were manually adjusted in areas to reflect the understanding of the groundwater system. In most cases, the density of data throughout a given aquifer may be insufficient to support the interpretation and use on a local scale. Additionally, many of the data points used in the construction of the potentiometric-surface change maps are based on two measurements that represent a net change in water levels; in the absence of continuous long-term water-level data, the direction and change during intervening periods may fluctuate, may not be known, and cannot be resolved through use of intermittent data points. Finally, equivalent gradational scales were used on all maps to maintain consistency to allow maps to be compared. Changes of from −5 to +5 ft are classified as “no substantial change,” and smaller changes in the water-level contours are not shown.

Hydrographs

Data from wells that had at least 15 years of record were used to produce the hydrographs in this report, except for hydrographs for the Rio Grande water-bearing zone where water levels were measured intermittently. In many cases, hydrographs show periods of record beyond 15 years, and many span the 36-year period from 1978 to 2013. The data used to construct the hydrographs are a combination of continuous measurements and intermittent measurements collected on a seasonal basis. These data illustrate seasonal variations in water levels and the long-term effects of artificial stresses such as pumping and, in some cases, the development and recovery of cones of depression in the potentiometric surface. The magnitude of water-level changes depends upon changes in storage within the aquifer, which is a function of its hydraulic properties, and the distribution and changes in patterns of recharge and discharge (including withdrawals). Long-term water-level trends for the periods 2008–13 were evaluated graphically. DePaul and Rosman (2015) used a Mann-Kendall statistical trend test (Mann, 1945; Helsel and Hirsch, 2002) to show water-level trends from 1978 to 2008, and the results of their statistical analysis were used to compare the water-level data trends for the 2009–13 data to the period 1978–2008.

Isochlors

The locations of the 10,000-mg/L lines of equal chloride concentration (approximately one-half that of seawater) were simulated for selected aquifers in the New Jersey Coastal Plain by use of the USGS SHARP model (Pope and Gordon, 1999). The locations of the lines (hereafter referred to as “isochlor”) on selected plates represent the toe of the saltwater interface, that is, the intersection of the interface with the bottom of the aquifer, generally its furthest landward or updip position. Because of the disequilibrium of the flow system with present day (2013) sea level, the position of the interface is more closely related to previous geologic groundwater conditions than to current (2013) groundwater conditions, and despite future scenarios of increasing withdrawals and deepening cones of depression, numerical simulations indicate little to no movement (Pope and Gordon, 1999). Therefore, these lines likely have not moved substantially in response to changing groundwater conditions observed throughout past study cycles and, therefore, have not been updated. The location of the 250-mg/L isochlor, which designates the limit of potable water in each aquifer as defined by NJDEP secondary drinking-water standards (New Jersey Administrative Code, 2004), is based on published maps that are cited for each aquifer. All chloride data referred to in this report are available in the NWIS database (U.S. Geological Survey, 2017).

Groundwater-Withdrawal Data

Groundwater-withdrawal data for central and southern New Jersey were tabulated and mapped to assess volumes of water pumped from each of the aquifers. These data were compiled from permitted data only; that is, data from wells in which daily withdrawals meet or exceed 100,000 gallons for a period of more than 30 days in a consecutive 365-day period. Such wells include those used for public supply, large-scale agriculture (irrigation), and commercial or industrial purposes. No attempt was made to estimate withdrawals from numerous small-capacity pumped wells, such as those used for domestic supply, which is a limitation of the analysis. Withdrawal data from 1978 to 2008 cited in this report were reported in DePaul and Rosman (2015) and obtained and quality reviewed from data that are reported to the New Jersey Department of Environmental Protection. Additional withdrawal data from the late 1970s were provided in Zapecza and others (1987). Withdrawal data from 2009 to 2013 cited in this report were obtained from the NJWATr database developed by the U.S. Geological Survey and maintained by the New Jersey Department of Environmental Protection to track water withdrawals, use, treatment, and discharge in New Jersey (New Jersey Department of Environmental Protection, 2017). The withdrawal data are quality reviewed and incorporated into the water-use database of the USGS New Jersey Water Science Center.

Water-level measurement taking place December 2018 in Gloucester County, New Jersey. Photo by Robert Rosman, U.S. Geological Survey.

Cohansey Aquifer

The Cohansey aquifer in Cape May County is composed of gravel and coarse- to fine-grained sands and encompasses the lower part of the Cohansey Formation and the sand-rich uppermost section of the Kirkwood Formation (Zapecza, 1989). Throughout Cape May County, Pleistocene deposits of sand and clay overlie the Cohansey aquifer, providing effective confinement from surficial recharge. In northern Cape May County, the aquifer underlies the Holly Beach water-bearing zone (fig. 1) and is confined by one or more discontinuous clay deposits, whereas in the southern part of the county, two intervening widespread and uniform confining units and the estuarine sand aquifer overlie the aquifer (fig. 1). The updip limit of the confined aquifer is in central Cape May County (fig. 2) but is not well documented; the aquifer is generally unconfined north of Middle Township (Lacombe and others, 2009). The aquifer in Cape May County ranges in thickness from 50 ft near Ocean City to more than 150 ft near the southern tip of the peninsula (Lacombe and Carleton, 2002). Pope and others (2012) report a hydraulic conductivity of 60 feet per day (ft/d) for this aquifer.

The Cohansey aquifer contains freshwater throughout most of its extent underlying mainland Cape May County; however, DePaul and Rosman (2015) state that saline water is present in the aquifer beneath the extreme southern part of the peninsula, beneath the back bays and barrier islands north of Wildwood, and beneath near-shore and offshore areas of the Atlantic Ocean and the Delaware Bay (plate 1). The saltwater–freshwater interface, as indicated by 250-mg/L isochlor, was originally mapped by Gill (1962) and updated by Lacombe and Rosman (2001), Lacombe and Carleton (2002), DePaul and others (2009), and DePaul and Rosman (2015).

Groundwater Withdrawals

The distribution of withdrawals from the confined Cohansey aquifer in Cape May County during 2013 is shown in figure 2. Groundwater was most typically withdrawn from the southern part of the peninsula in Middle and Lower

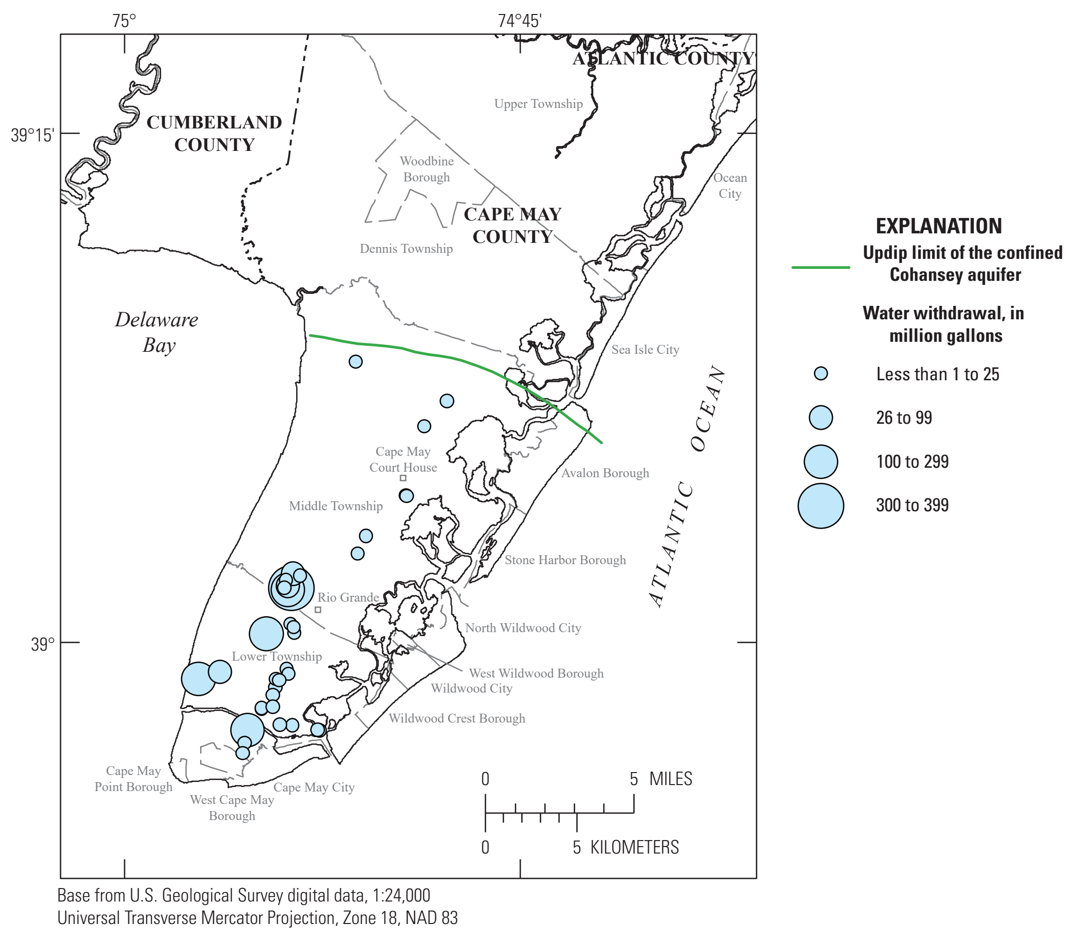


Figure 2. Location and volume of groundwater withdrawals from the confined Cohansey aquifer, Cape May County, New Jersey Coastal Plain, 2013.

Townships; however, small-capacity pumped wells are located throughout the central and northern parts of the county where the Cohansey aquifer may not be confined (the updip limit of the confined aquifer is shown in fig. 2). During 2013, estimated withdrawals from the confined Cohansey aquifer totaled 3.3 Mgal/d (table 3) of which about 3.1 Mgal/d were withdrawn for public supply, and the remaining amounts were withdrawn for industrial, irrigation, and other purposes. The largest user of groundwater from the Cohansey aquifer withdrew about 1.7 Mgal/d for public supply from wells near Rio Grande. The second largest user of the Cohansey aquifer accounted for about an additional 1.0 Mgal/d withdrawn for public supply from wells in Lower Township.

Estimated withdrawals from 2009 to 2013 averaged about 3.5 Mgal/d (fig. 3). From 1978 to 2008, average withdrawals from the confined Cohansey aquifer ranged from 3.8 to 6.1 Mgal/d, and in 1982, withdrawals peaked and remained above 5 Mgal/d throughout the 1980s (fig. 3). Withdrawals decreased with the introduction of Cape May City Water Department wells that tap the Atlantic City 800-foot sand and supply water to the desalination plant, which was completed in 1998.

Water Levels

The potentiometric-surface map during fall 2013 for the confined Cohansey aquifer present in the southern half of the Cape May peninsula is shown on plate 1; supporting water-level data used to construct this map and determine differences between 2008 and 2013 water levels are presented in appendix 1. (All water-level measurements are compiled in appendixes at the end of the report and are publicly available in the USGS NWIS database (U.S. Geological Survey, 2017)). The configuration of the potentiometric surface shows a broad cone of depression centered beneath major withdrawal areas in the southern part of the peninsula, encompassing Lower Township and Cape May City Borough, as well as parts of southern Middle Township. The highest measured water levels occurred in central Middle Township and in areas to the north, ranging from less than 1 to 5 ft. The lowest measured water level, −16 ft, occurred at one well in central Lower Township (well 9-960). The configuration of the potentiometric surface is similar to that of 2008; however, the area encompassed by the −10-ft contour has contracted slightly from its previous extent as a result of reductions in Cohansey aquifer withdrawals at the well field used for public supply near Rio Grande. Similarly, the extent of the −10-ft contour in 2008 is smaller than that in 2003 (DePaul and others, 2009).

Differences in vertical water levels between underlying and overlying aquifers are an indication of the direction and magnitude of hydraulic gradients that affect the vertical component of flow and provide insight into the potential for inter-aquifer flow. Because the Cohansey aquifer is the uppermost aquifer in this study and a recent potentiometric surface has not been constructed for the overlying estuarine sand aquifer, comparison with only the underlying unit, the Rio Grande water-bearing zone, is made. Water levels within the Cohansey aquifer generally are greater than those in the underlying Rio Grande water-bearing zone. The potential for downward flow from the aquifer is greatest throughout the central part of Cape May County, where the differences in water levels between the two aquifers are more than 20 ft at the border of Middle and Lower Townships and less than 20 ft toward the southern tip of the peninsula.

Small to moderate net water-level changes (about 5 ft or less) were measured in most wells during 2013 (app. 1), although from a regional perspective, water levels generally remained about the same relative to those measured in 2008 (fig. 4). Water-level changes at well locations ranged from a decline of 5 ft at well 9-301 in southern Lower Township to a rise of 7 ft at well 9-74 in Middle Township near Delaware Bay (app. 1). Of the 38 wells measured in the confined Cohansey aquifer in 2008 and 2013, water levels rose in 27 wells (about 71 percent), were unchanged in 6 wells (16 percent), and declined in 5 wells (about 13 percent) (app. 1). Water-level altitudes are listed in appendix 1 and water-level changes are summarized in table 4 for this aquifer.

Long-term water-level trends in the Cohansey aquifer were evaluated graphically and compared to water-level trends from the previous 2008 study. Hydrographs of four wells within the cones of depression in southern Cape May County are shown in figure 5. Each hydrograph depicts water levels at or below the vertical reference datum of NAVD 88 since the initial study in 1978. The hydrographs also show the response of water levels to seasonal changes in withdrawals. The fluctuations were as much as 20 ft or more for wells 9-60 and 9-150, which are the closest to pumping centers and exhibited the greatest annual variability. Well 9-60 in northern Lower Township less than 1 mi from pumped wells near Rio Grande had annual high water levels of about −7 and −8 ft in April and January 2010, respectively, based on measurements made only 2–4 times per year, but had annual low water levels of about −26 and −24 ft in August 2010 and 2012, respectively. During the period 2009–13, the average water-level rise from the previous 2004–08 study period was about 4.2 ft. The hydrograph of well 9-150, which is near the tip of the peninsula, shows stable water levels between 2004–13 (fig. 5). The water levels in well 9-80, which is near the northeastern edge of the cone of depression and farthest from considerable withdrawals, had the least annual variability, and during the period 2009–13, the average water-level rise from the previous 2004–08 study period was about 2.3 ft. At well 9-49, water levels were stable during 2009–13 and similar to water levels during 2004–08 (fig. 5).

Table 3. Estimated groundwater withdrawals by county and aquifer from selected confined aquifers of the New Jersey Coastal Plain, 2013.

[Withdrawal values are from New Jersey Department of Environmental Protection, 2017. Withdrawals are in million gallons per day; only permitted and reported values included; <, less than; <<, much less than 0.1; --, not applicable]

County	Aquifer: Cohansey[1]	Rio Grande water-bearing zone	Atlantic City 800-foot sand	Piney Point	Vincentown[2]	Wenonah-Mount Laurel	Englishtown	Upper Potomac-Raritan-Magothy	Middle Potomac-Raritan-Magothy	Lower Potomac-Raritan-Magothy
Atlantic	--	--	11.7	0.5	--	--	--	--	--	--
Burlington	--	--	--	<<0.1	<0.1	2.1	0.9	2.9	14.3	6.7
Camden	--	--	--	0.1		1.6	1.4	8.1	5.6	23.1
Cape May	3.3	0.3	6.8	--	--	--	--	--	--	--
Cumberland	--	--	--	0.6	--	--	--	--	--	--
Gloucester	--	--	--	<<0.1	0.1	0.9	--	8.0	5.7	1.4
Mercer	--	--	--	--	--	--	--	0.6	8.7	--
Middlesex	--	--	--	--	--	--	--	14.9	9.5	--
Monmouth	--	--	--		1.0	0.6	3.5	6.7	5.8	--
Ocean	--	0.2	5.3	4.0	0.4	0.2	2.1	6.5	6.4	--
Salem	--	--	--	--	<0.1	1.3	--	1.3	2.7	1.7
Total	3.3	0.5	23.8	5.2	1.6	6.7	7.9	49.0	58.7	32.9

[1]Cape May County only.

[2]Includes Hormertown sand in Monmouth County.

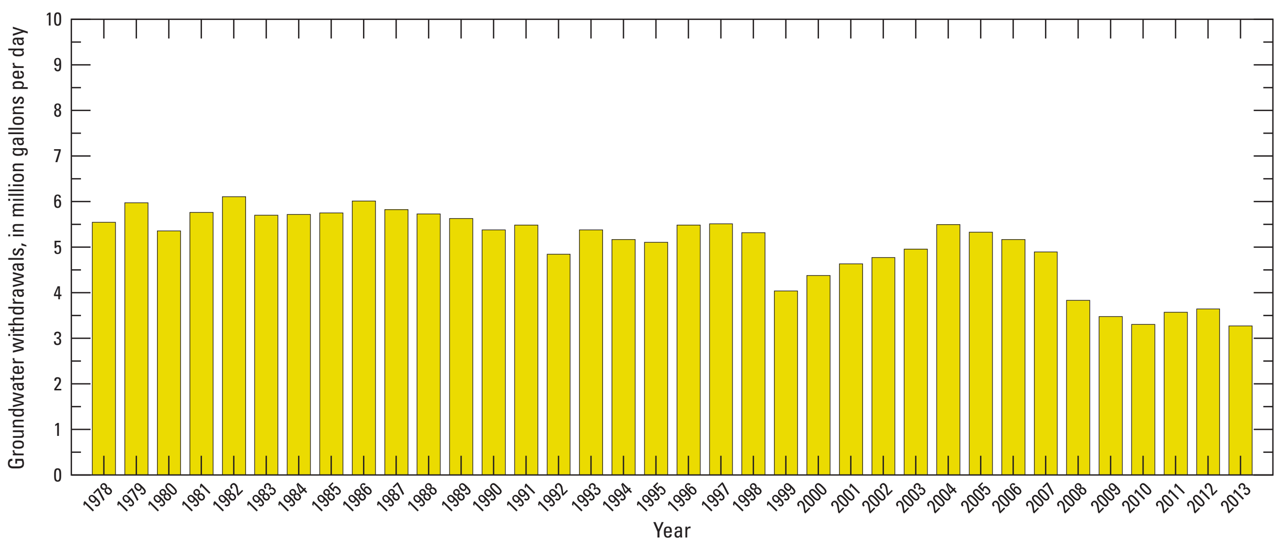


Figure 3. Estimated groundwater withdrawals from the confined Cohansey aquifer in Cape May County, New Jersey Coastal Plain, 1978–2013.

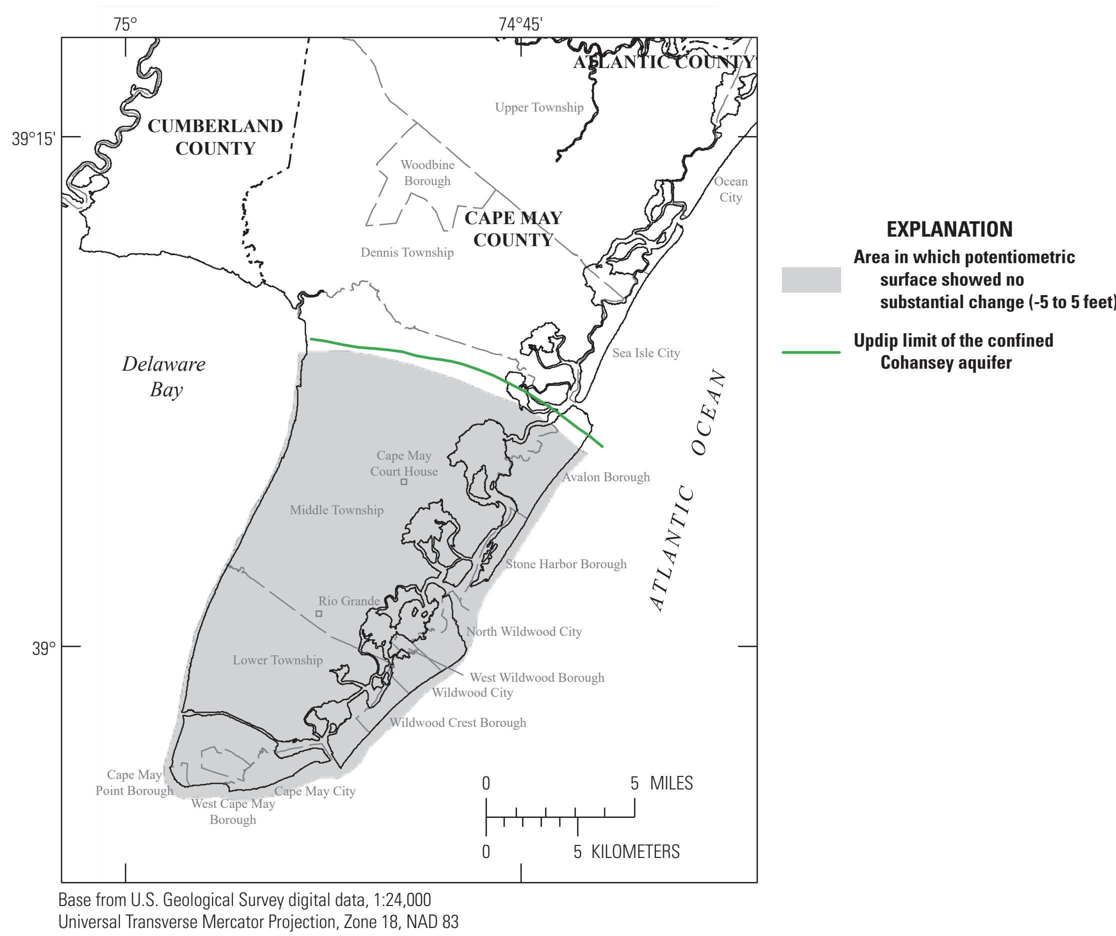


Figure 4. Difference between the 2008 and 2013 potentiometric surfaces in the confined Cohansey aquifer, Cape May County, New Jersey Coastal Plain.

Table 4. Water-level decline, recovery, or no change measured in wells completed in 10 aquifers in the New Jersey Coastal Plain, and measured in both 2008 and 2013.

Aquifer	Total number of wells[1]	Number of wells with water level			Percent of wells with water level			Total percent for all wells in aquifer
		Decline	Recovery	No change	Decline	Recovery	No change	
Cohansey[2]	38	5	27	6	13	71	16	100
Rio Grande water-bearing zone	10	4	5	1	40	50	10	100
Atlantic City 800-foot sand	84	5	74	5	6	88	6	100
Piney Point	49	23	19	7	47	39	14	100
Vincentown[3]	25	2	19	4	8	76	16	100
Wenonah-Mount Laurel	117	15	98	4	13	84	3	100
Englishtown aquifer system	73	25	42	6	34	58	8	100
Upper Potomac-Raritan-Magothy	191	13	161	17	7	84	9	100
Middle Potomac-Raritan-Magothy	159	19	124	16	12	78	10	100
Lower Potomac-Raritan-Magothy	86	9	73	4	10	85	5	100
Total for all aquifers	832	120	642	70	15	77	8	100

[1]Total number of wells does not include wells with the freshwater equivalent.

[2]Cape May County only.

[3]Includes Hormertown Sand in Monmouth County.

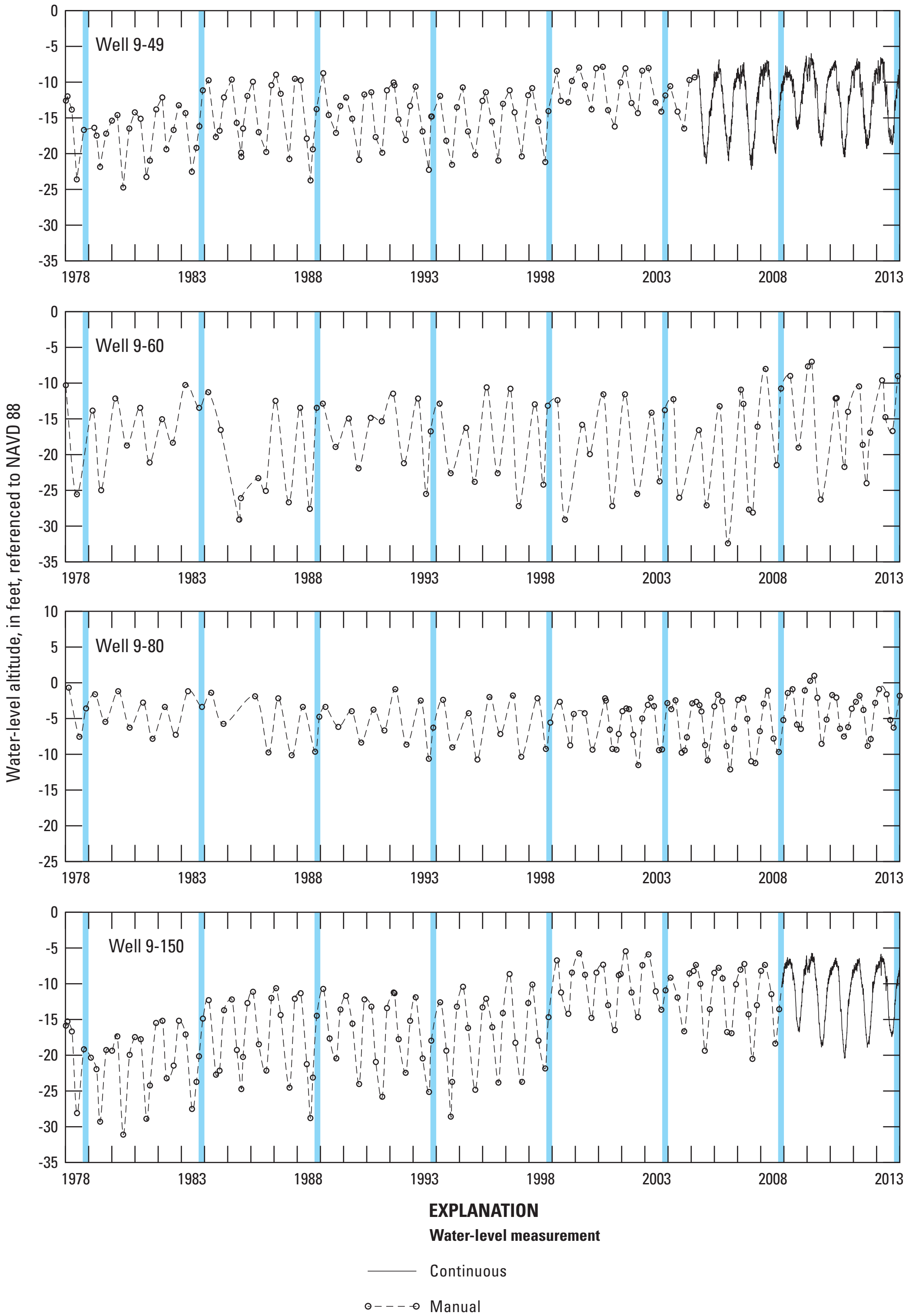


Figure 5. Water-level hydrographs for selected observation wells screened in the confined Cohansey aquifer, Cape May County, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

Rio Grande Water-Bearing Zone

The Rio Grande water-bearing zone, as described by Zapecza (1989), is a relatively thin unit composed of coarse- to fine-grained sand situated midway within the confining unit that overlies the Atlantic City 800-foot sand (fig. 1). The water-bearing zone is approximately 40 ft thick throughout its extent in coastal Ocean and Atlantic Counties (Zapecza, 1989) but thickens considerably in southeastern Cape May where, near Stone Harbor, it is as great as 170 ft thick (Lacombe and Carleton, 2002). The updip extent of the Rio Grande water-bearing zone approximately coincides with that of the Atlantic City 800-foot sand though it is slightly seaward, extending from southern Ocean County through eastern Cumberland County (plate 1). Fresh groundwater is present within the aquifer underlying coastal regions of the mainland and the barrier islands from its northwestern limit in southern Ocean County southward through most of mainland Cape May County; however, the aquifer contains saline water near the tip of the peninsula in southern Cape May County (DePaul and others, 2009). Pope and others (2012) report a hydraulic conductivity of 50 ft/d for this aquifer.

Groundwater Withdrawals

The Rio Grande water-bearing zone is of minor importance as a source of potable water in New Jersey and is the least utilized of the aquifers included in this study (table 3). Estimated withdrawals from the aquifer totaled approximately 0.5 Mgal/d during 2013. Withdrawals were made primarily by water purveyors in Long Beach and Little Egg Harbor Townships in southern Ocean County (0.3 Mgal/d or 102 Mgal/yr) and in Middle Township in Cape May County (0.2 Mgal/d or 80.2 Mgal/yr) (fig. 6*A*). Withdrawals from 1978 to 2013 typically were less than 1 Mgal/d (fig. 7*A*).

Water Levels

The potentiometric-surface map for the Rio Grande water-bearing zone in 2013 is shown on plate 1; water-level data used to construct this map and determine differences between 2008 and 2013 water levels are listed in appendix 2. The potentiometric-surface configuration is an elongated cone of depression centered beneath coastal New Jersey and extending from the Cape May peninsula northward past Ship Bottom in southern Ocean County (plate 1). Water levels within the Rio Grande water-bearing zone ranged from a low of −33 ft (well 9-67) in southern Cape May County to a maximum of 16 ft (well 9-149) in northern Cape May County. As noted by Lacombe and Rosman (2001), the configuration of the regional cone of depression is consistent with the configuration and sustained water-level decline of the cone of depression in the underlying Atlantic City 800-foot sand. Locally, withdrawals from the Rio Grande water-bearing zone in Middle Township in Cape May County (fig. 6*A*) contribute to the low water levels in this vicinity. In general, water levels in the Rio Grande water-bearing zone are greater than those in the underlying Atlantic City 800-foot sand throughout the study area; vertical differences are greatest where water levels are lowest in the Atlantic City 800-foot sand, in eastern Atlantic County and, to a lesser extent, in southern Cape May County.

Small to moderate net water-level changes (about 5 ft or less) were measured in most wells during 2013 and are shown in appendix 2 and summarized in table 4 for this aquifer. Of the 10 wells with measured 2008 and 2013 water levels, 1 well had negligible change (29-1621), and 4 wells had small declines (1–5 ft) from 2008, although withdrawal data indicate little change during the same period. Five wells had water-level rises of 1–7 ft (app. 2). A decline in water levels of between −5 and −10 ft was observed in coastal southern Atlantic and northern Cape May Counties because of withdrawals in the underlying Atlantic City 800-foot sand (fig. 8*A*). A rise in water-levels of between 5 and 10 ft was observed in southern Ocean County (fig. 8*A*). Withdrawals in this area decreased by about 0.1 Mgal/d when compared to 2008 withdrawals.

Hydrographs for two observation wells (9-71 and 9-304) in Cape May County are shown in figure 9, and the locations of the wells are shown on plate 1. Seasonal fluctuations in water levels occurred at both wells. Data were collected more frequently at well 9-304 than at well 9-71, and from 2003 to 2013, the change in the water level was negligible.

Water-level measurement taking place October 2018 in Monmouth County, New Jersey. Photo by Emmanuel Charles, U.S. Geological Survey.

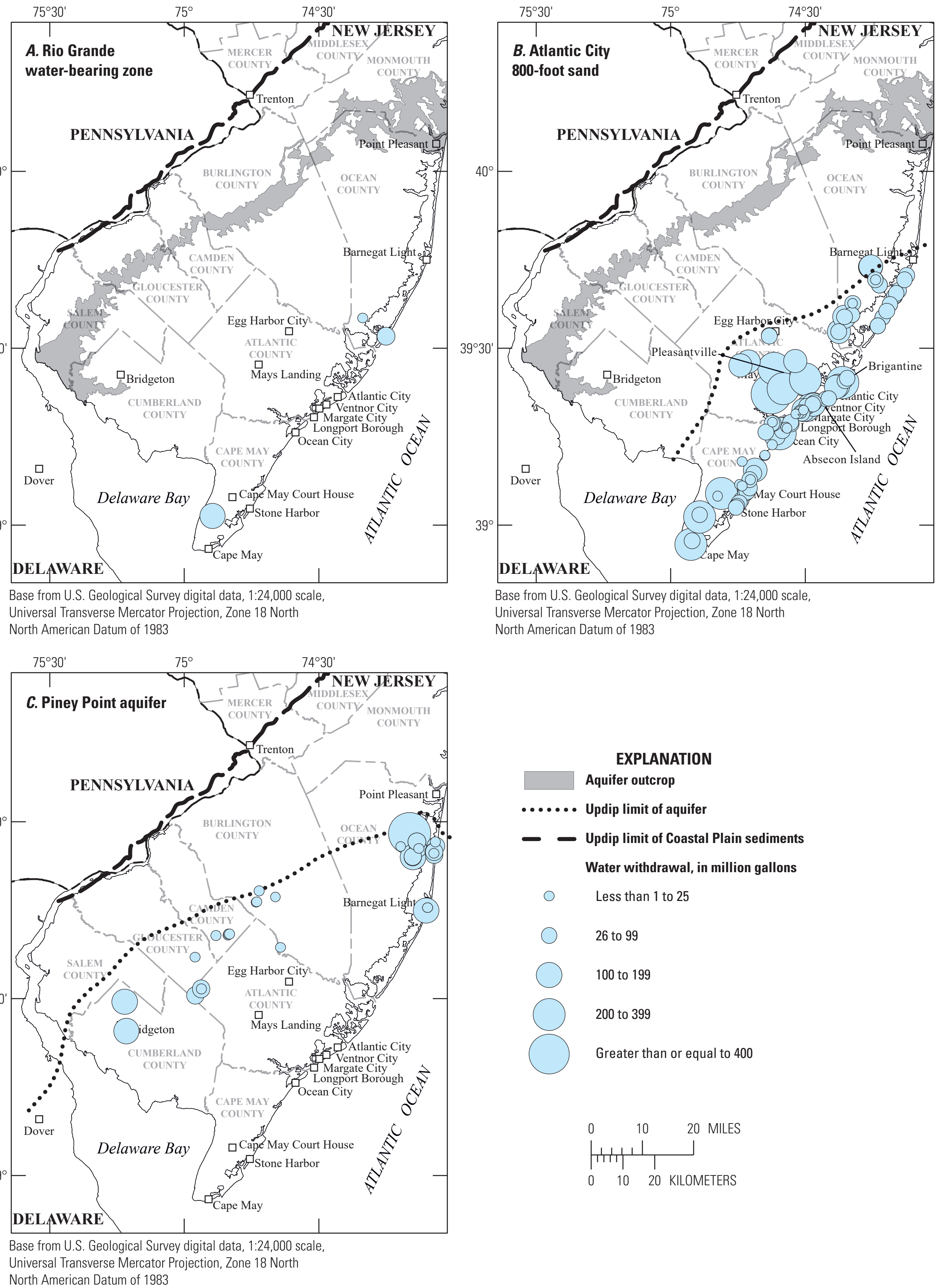


Figure 6. Location and volume of groundwater withdrawals from the *A*, Rio Grande water-bearing zone, *B*, Atlantic City 800-foot sand, and *C*, Piney Point aquifer, New Jersey Coastal Plain, 2013.

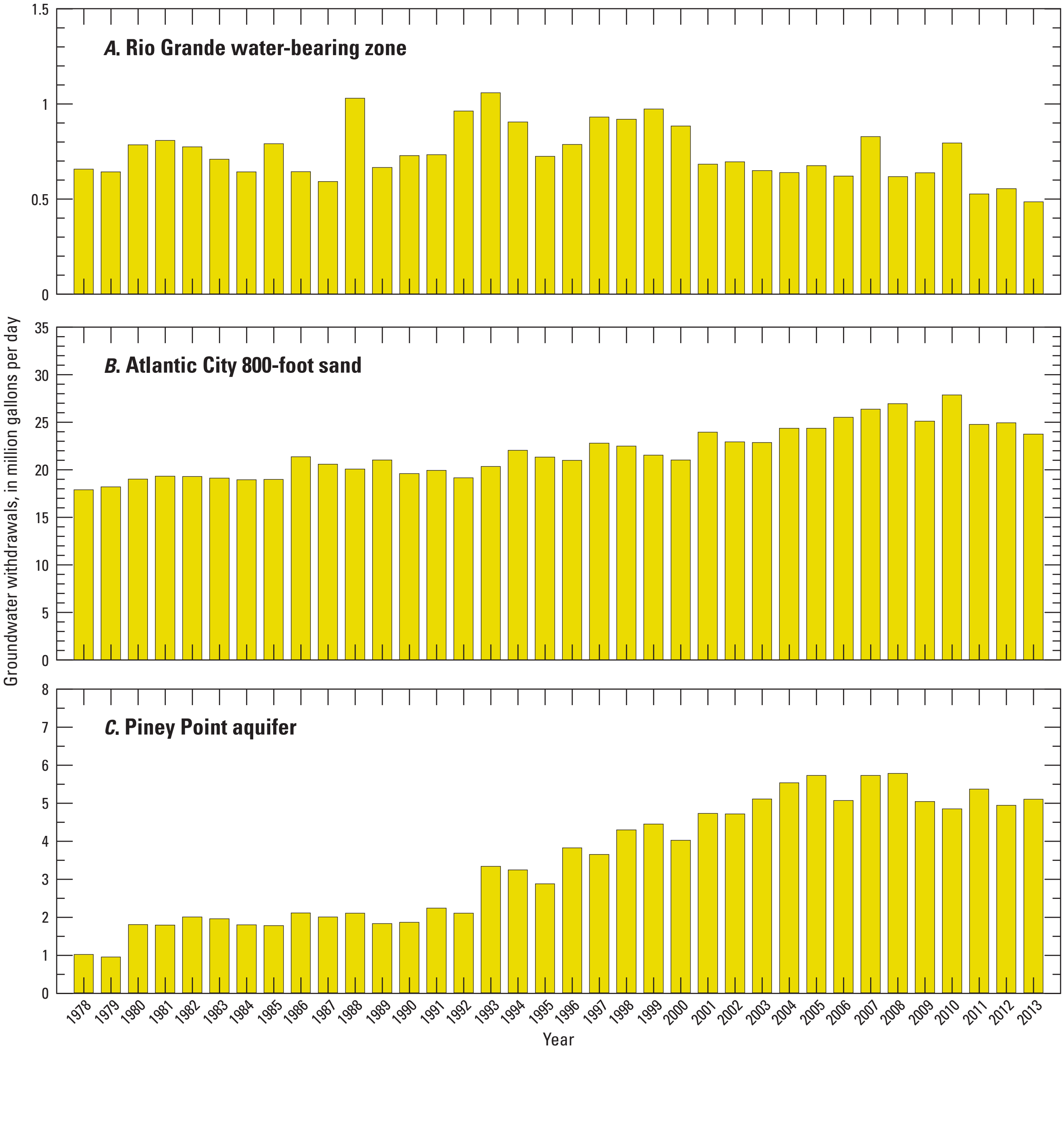


Figure 7. Estimated groundwater withdrawals from the *A*, Rio Grande water-bearing zone, *B*, Atlantic City 800-foot sand, and *C*, Piney Point aquifer, New Jersey Coastal Plain, 1978–2013.

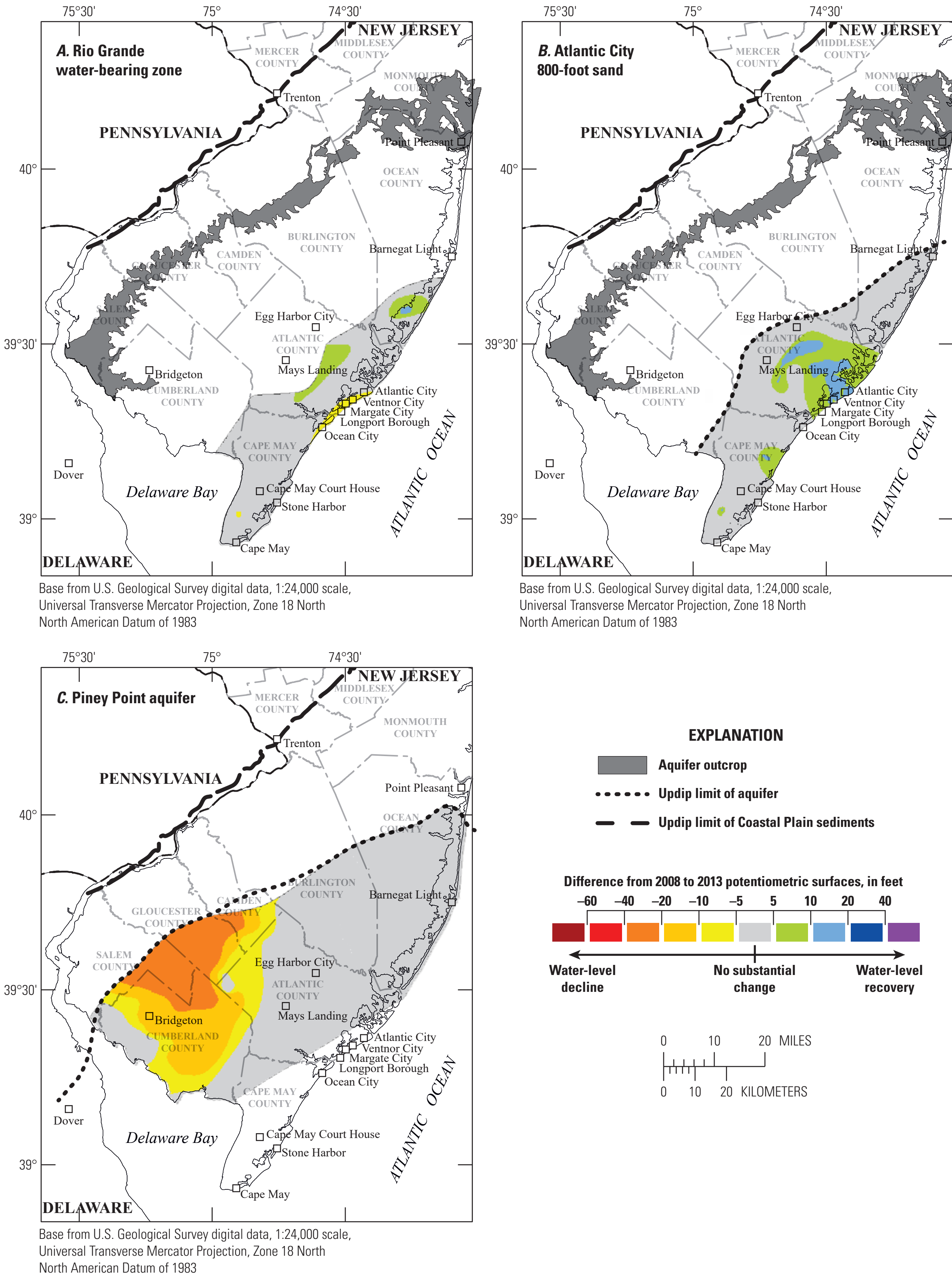


Figure 8. Difference between the 2008 and 2013 potentiometric surfaces in the *A*, Rio Grande water-bearing zone, *B*, Atlantic City 800-foot sand, and *C*, the Piney Point aquifer, New Jersey Coastal Plain.

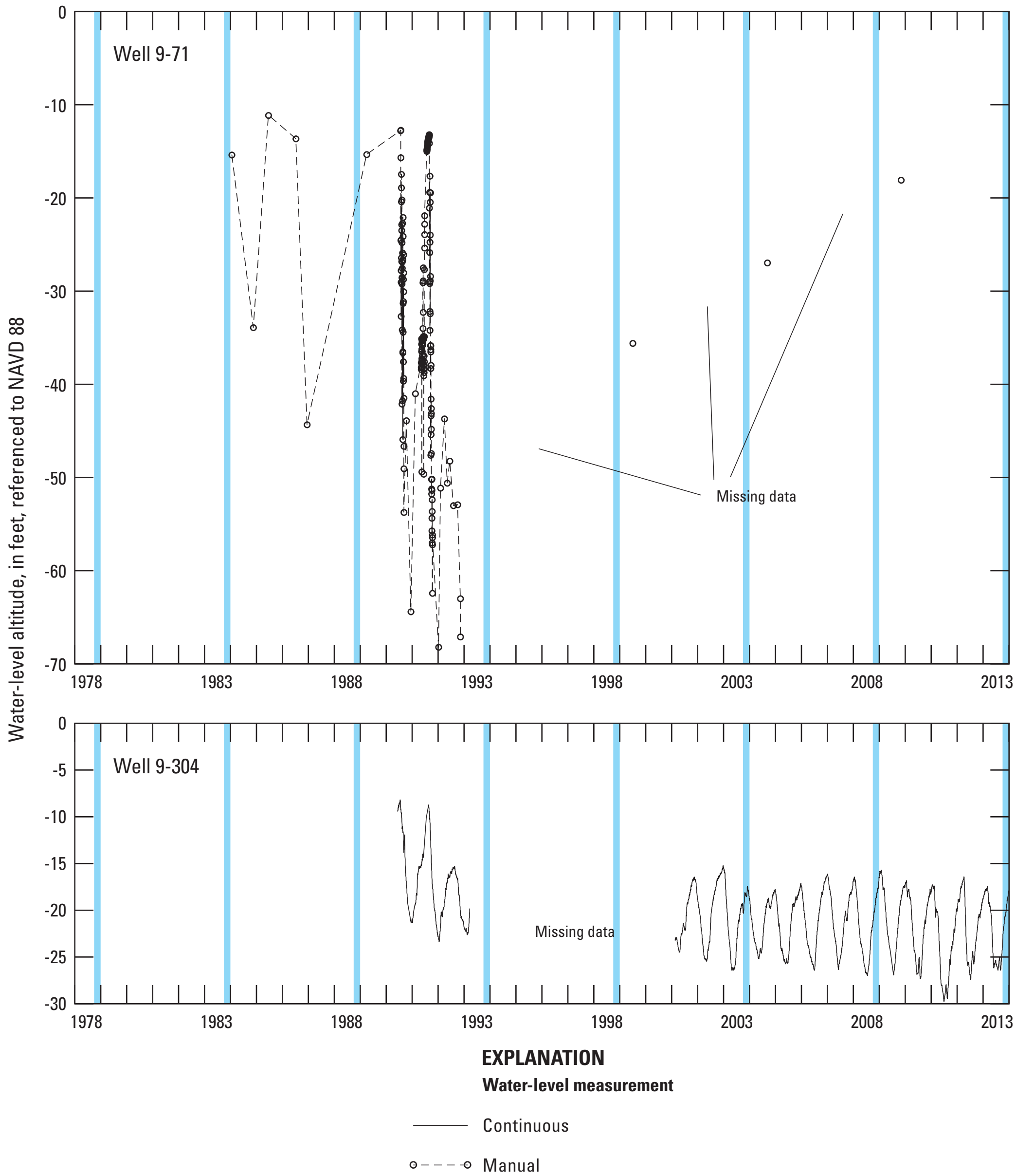


Figure 9. Water-level hydrographs for selected observation wells screened in the Rio Grande water-bearing zone, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

Atlantic City 800-Foot Sand

The Atlantic City 800-foot sand is a major confined aquifer within the Kirkwood Formation (table 1). The aquifer is composed of medium- to coarse-grained quartz sands with interspersed shell material. The updip limit of the aquifer is based on the updip limit of the overlying confining unit; however, this confining unit is poorly defined in places. The updip limit extends, from northeast to southwest, from southern Ocean County north of Barnegat Light to eastern Cumberland County (plate 2). The downdip limit of the aquifer is offshore from Ocean, Atlantic, and Cape May Counties but is not shown on plate 2. The aquifer thickens downdip and down coast from a thickness of 40 ft near Barnegat Light to more than 200 ft at Cape May City (McAuley and others, 2001). Recharge is through vertical flow from the overlying Kirkwood-Cohansey aquifer system and Rio Grande water-bearing zone throughout the extent of the aquifer, although recharge is more substantial near the updip limit where the confining unit is leaky or where the aquifers are in direct contact (Pope, 2006). Recharge also can occur by lateral flow from the Kirkwood-Cohansey aquifer system, a predominantly unconfined aquifer, near the updip limit.

The Atlantic City 800-foot sand contains freshwater throughout southern Ocean, Atlantic, and northern Cape May Counties, where dissolved chloride concentrations typically range from 2 to 20 mg/L (DePaul and Rosman, 2015). To the south, however, the groundwater becomes progressively more chloride rich, and near the southern tip of the Cape May Peninsula, concentrations are more than 400 mg/L (U.S. Geological Survey, 2017). The estimated position of the 250-mg/L isochlor is approximately 2 mi to the south-southeast of Stone Harbor Borough. The estimated location of the 10,000-mg/L isochlor is approximately 36 mi offshore and to the southeast of Atlantic City (Pope and Gordon, 1999).

Groundwater Withdrawals

The Atlantic City 800-foot sand is the principal confined aquifer supplying water to New Jersey's barrier island communities in southern Ocean County to the city of Cape May in Cape May County and as far inland as Egg Harbor City in Atlantic County (fig. 6*B*). Estimated withdrawals from the aquifer have gradually increased since 1978, ranging from 17.9 to 27 Mgal/d during 1978–2008 (fig. 7*B*) and totaling 23.8 Mgal/d in 2013 (table 3). Withdrawal rates are greatest in Atlantic County and least in Ocean County where the aquifer thins and becomes less transmissive. Three major pumping centers are along the barrier islands within Atlantic County: Absecon Island, Brigantine, and Pleasantville (fig. 6*B*). During 2013, withdrawals in Pleasantville totaled 4 Mgal/d. In Absecon Island, which includes Atlantic City, Margate, and Ventnor, withdrawals totaled 5.7 Mgal/d, and in Brigantine, withdrawals were 1.6 Mgal/d.

In Cape May County, most groundwater withdrawals are distributed throughout the barrier islands. In 2013, withdrawals were made near Rio Grande (0.7 Mgal/d) and near Ocean City (almost 1 Mgal/d); withdrawals also were made near Cape May Court House (about 0.6 Mgal/d) and near the city of Cape May (about 1 Mgal/d) at the southern end of the peninsula (fig. 6*B*). In early 1998, a 2-Mgal/d capacity desalination plant in lower Cape May County began operation to augment the existing groundwater supply, and by 2003, associated withdrawals from the aquifer were approximately 1 Mgal/d (DePaul and Rosman, 2015). In southern Ocean County, withdrawals from the aquifer were made over nearly the entire length of the barrier island complex; withdrawals made within the mainland communities totaled about 3.0 Mgal/d.

Water Levels

The potentiometric-surface map for fall 2013 for the Atlantic City 800-foot sand is shown on plate 2; water-level measurements used in the preparation of this map and determination of differences between 2008 and 2013 water levels are presented in appendix 3. Long-term groundwater withdrawals have created a large, elongated cone of depression that aligns along the general strike of the formation and extends beneath the coastal barrier island communities from Barnegat Light in Ocean County south to Cape May City. Water levels within the Atlantic City 800-foot sand range from 40 ft (well 29-1433) in southern Ocean County to −88 ft (well 1-702) within the deepest part of the cone beneath the eastern Atlantic County municipalities of Margate City and Ventnor City. At the northern end of the cone of depression, south of Barnegat Light, water levels ranged from −32 ft (well 29-561) near the northern limit of the confined aquifer to −40 ft (well 29-457) near the southern end of Long Beach Island. Three small cones of depression are present in southern Cape May County around pumped wells for Cape May City, Rio Grande, and Avalon.

Water levels measured in 84 wells during 2008 and 2013 were compared to evaluate water-level changes in the Atlantic City 800-foot sand (app. 3) and to map the differences between the potentiometric surfaces (fig. 8*B*). From 2008 to 2013, water levels declined in 5 wells (6 percent), were unchanged in 5 wells (6 percent), and rose in 74 wells (88 percent). These results are given in appendix 3 and summarized in table 4. In Atlantic County, rises in water levels were greatest near Ventnor City (about 10 ft) and Atlantic City (about 20 ft; fig. 8*B*). To the north and east, small to moderate declines were observed in southern Ocean County, ranging from less than 1 ft to more than 8 ft at a well (29-2057) near the updip limit of the aquifer. In southern coastal Cape May County, water-level declines ranged from less than 1 ft to more than 1 ft.

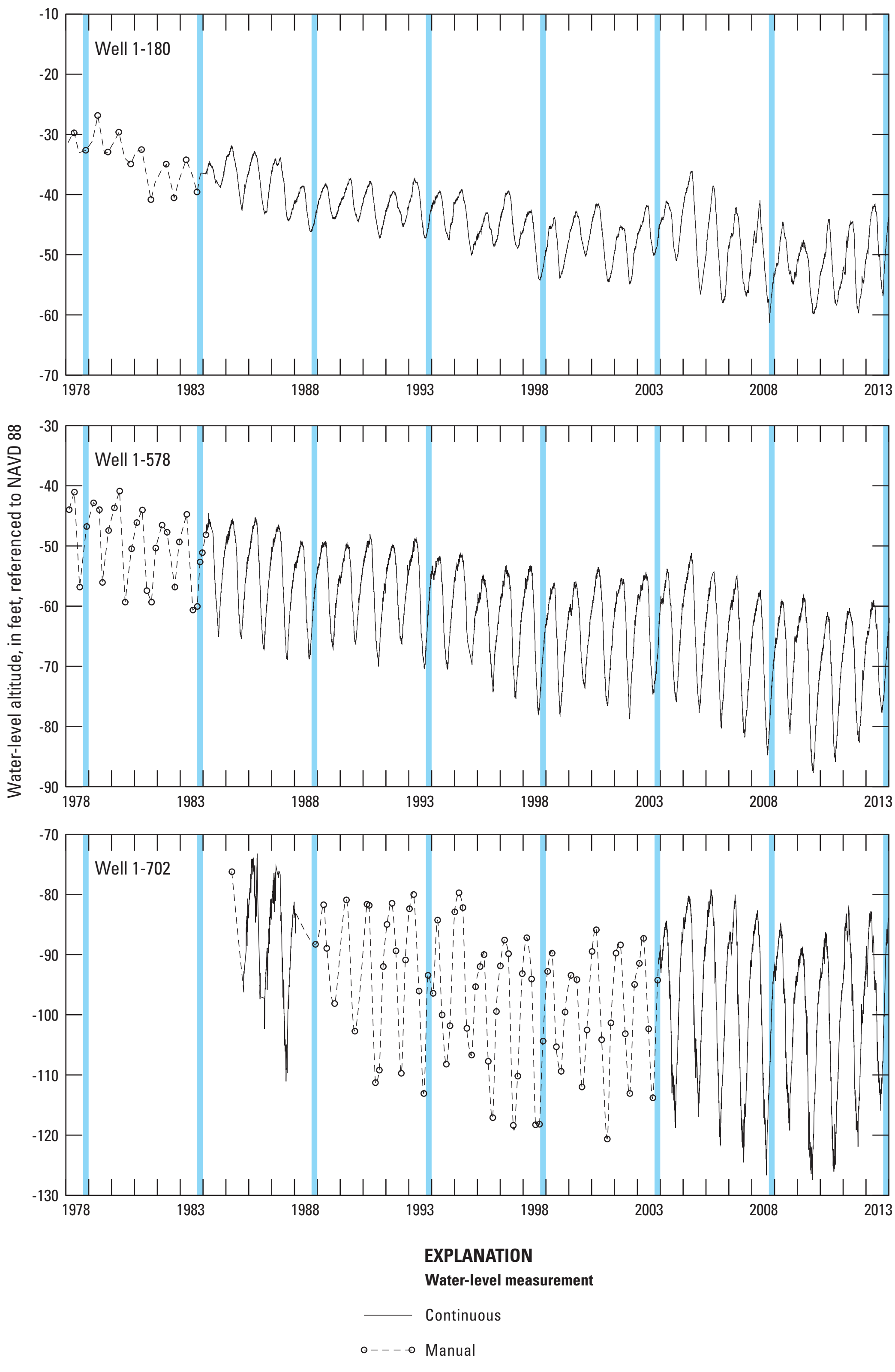


Figure 10. Water-level hydrographs for selected observation wells screened in the in the Atlantic City 800-foot sand, Atlantic County, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

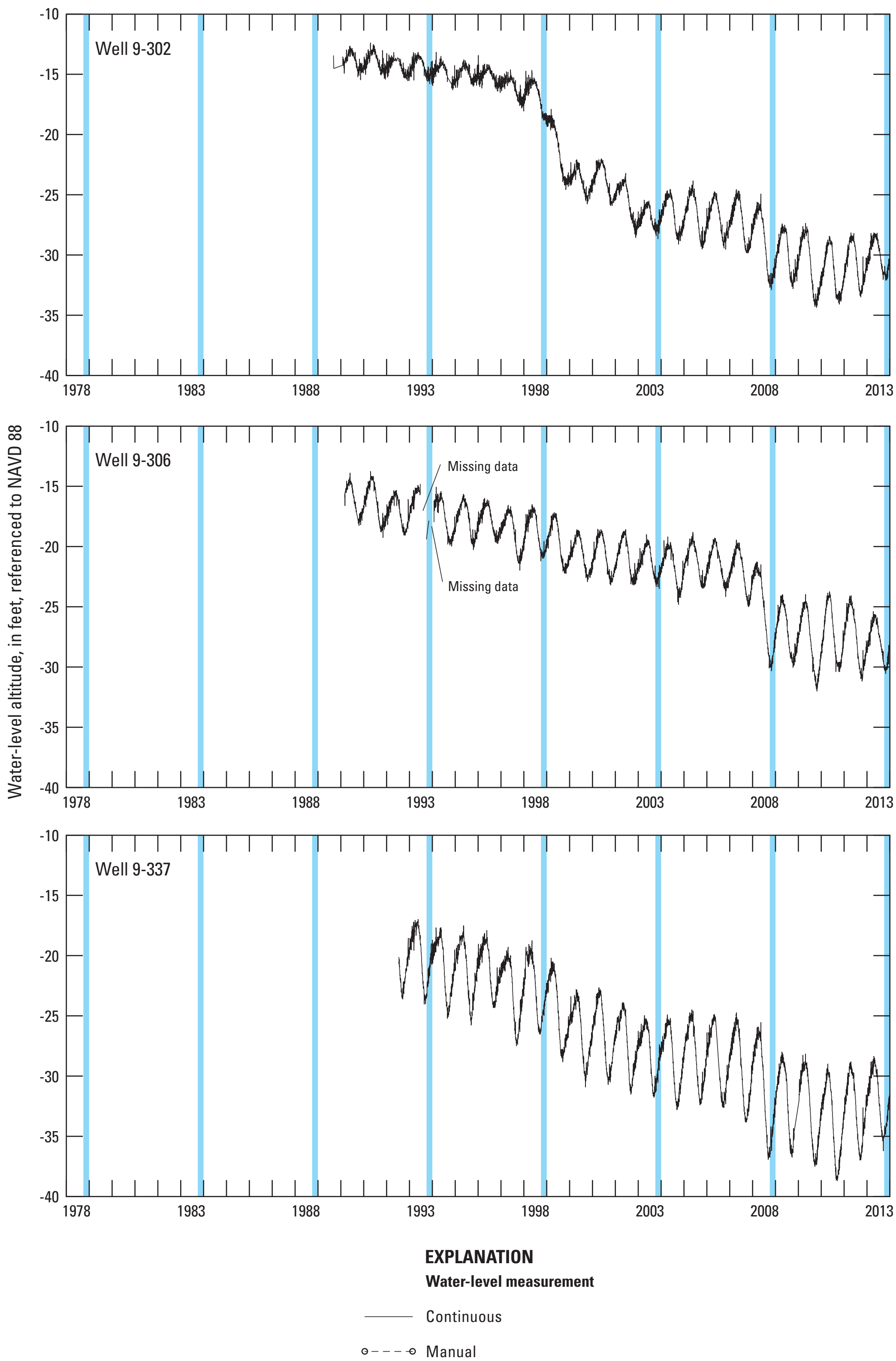


Figure 11. Water-level hydrographs for selected observation wells screened in the Atlantic City 800-foot sand, Cape May County, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

Long-term water-level trends in the Atlantic City 800-foot sand were evaluated graphically and compared to water-level trends from the 2008 study. Hydrographs that depict long-term and seasonal trends in the Atlantic City 800-foot sand from 1978 to 2013 are shown in figure 10 for 3 observations wells (1-180, 1-578, 1-702) in Atlantic County and in figure 11 for 3 observation wells (9-302, 9-306, 9-337) in Cape May County; the wells are shown on plate 2**.** The hydrographs for these wells show the summer decline in water levels that results from increased groundwater withdrawals in the summer at the shore communities. All six wells show an average water-level decrease of 5 ft or less from the 2004-08 water levels. In addition, DePaul and Rosman (2015) used results of a Mann-Kendall statistical trend test (Mann, 1945; Helsel and Hirsch, 2002) to show that water-level trends during 2003–08 were downward at these six wells, and downward trends were strongest at wells in eastern Atlantic County at and near the center of the cone of depression (wells 1-180, 1-578, and 1-702).

Water levels in wells 1-180, 1-578, and 1-702 show a downward trend, followed by a rise in water levels after 2010 (fig. 11). During 2010–13, estimated groundwater withdrawals in Atlantic County from this aquifer totaled 12.5, 11.9, 12.0, and 11.7 Mgal/d, respectively. The decrease in withdrawals in 2013 from the 2010–12 totals may account for the rise in water levels in 2013 indicated in figure 8*B*. Similarly, water-level hydrographs for wells 9-302, 9-306, and 9-337 (fig. 11) show a steep decline in water levels in 2009 followed by stable water levels during 2010-13. Estimated groundwater withdrawals during 2008–10 in Cape May County from this aquifer totaled 8.7, 8.2, and 9.3 Mgal/d, respectively. Withdrawals were less during 2011–13 and totaled 7.0, 7.0, and 6.8 Mgal/d, respectively, which may account for the rise in water levels indicated in figure 8*B* when compared to the 2008 water levels.

Water-level measurement taking place November 2018 in Burlington County, New Jersey. Photo by Emily Wengrowski, U.S. Geological Survey.

Piney Point Aquifer

The Piney Point aquifer is composed of sediments of middle to late Eocene and Oligocene age, consisting of fine- to coarse-grained glauconitic sands interspersed with shell material. The Piney Point aquifer does not crop out within the study area and therefore cannot be recharged directly by precipitation; recharge occurs by leakage through confining layers, primarily from overlying aquifers. The updip limit of the aquifer is in central Ocean, Burlington, Camden, Gloucester and Salem Counties (plate 3) and near the downdip limit of the Vincentown aquifer (plate 4). Near this updip limit the aquifer is generally 40 ft thick. There are two areas within the aquifer extent in New Jersey of substantial sand accumulation (Zapecza, 1989)—in southern Burlington and Ocean Counties where aquifer thickness can exceed 130 ft and to the southwest in southern Cumberland County where the maximum thickness is greater than 200 ft. In Delaware, the updip limit of the Piney Point aquifer is in central Kent County, and the downdip limit extends into southeastern Sussex County (Vroblesky and Fleck, 1991). The maximum thickness of the aquifer in Delaware, approximately 250 ft, occurs in Kent County.

The location of the 250-mg/L isochlor in New Jersey was modified by DePaul and others (2009) from Schaefer (1983) and Lacombe and Rosman, (2001); in Delaware, the location was mapped by Woodruff (1969) and modified by Lacombe and Rosman, (2001). The location of the onshore part of the isochlor extends from eastern Atlantic County southwest to northern Cape May County. The simulated 10,000-mg/L isochlor is offshore, approximately 8 mi from pumped wells at Barnegat Light (Pope and Gordon, 1999).

Groundwater Withdrawals

In New Jersey, groundwater withdrawals from the Piney Point aquifer were made predominantly in the coastal region of Ocean County, in Buena in western Atlantic County, and in and around the city of Bridgeton in Cumberland County (fig. 6*C*). Withdrawals from the Piney Point also are made in the updip parts of the aquifer in southwestern Burlington and southern Camden Counties in locations where yields are favorable to development. In Delaware, the Piney Point aquifer is a major source of groundwater in Kent County and has long been utilized for supply in and around the city of Dover.

Estimated withdrawals in New Jersey from the Piney Point aquifer totaled 5.2 Mgal/d during 2013 (table 3) with most withdrawals made in Ocean County (4.0 Mgal/d) and smaller amounts in Atlantic, Camden, and Cumberland Counties (0.1–0.6 Mgal/d). Negligible amounts were withdrawn in Burlington and Gloucester Counties (<0.1 Mgal/d). Withdrawals from the aquifer have gradually increased since 1978 and ranged from 0.95 to 5.8 Mgal/d during 1978–2013 (fig. 7*C*).

Water Levels

The potentiometric surface of the Piney Point aquifer during fall 2013 in New Jersey and central-eastern Delaware is shown on plate 3; water-level data that were used in the preparation of this map and determination of differences with 2008 are listed in appendix 4**.** Maximum water levels within the Piney Point aquifer (up to 118 ft, well 5-676) occurred near the updip limit of the aquifer along the border of Burlington and Ocean Counties, and the lowest (−166 ft, well 11-1571) occurred in central Cumberland County. The configuration of the 2013 potentiometric surface indicates the presence of six distinct cones of depression. One cone underlies Seaside Park in Ocean County near the area where the aquifer is most heavily utilized in New Jersey; the minimum water level at the center of this cone of depression was −45 ft (wells 29-935 and 29-1681). To the south, the cone of depression centered beneath Barnegat Light had a potentiometric minimum of −47 ft (well 29-607).

A cone of depression in coastal Atlantic County is consistent with a sustained decline in water levels in the overlying Atlantic City 800-foot sand. The Piney Point aquifer is unused in this area, and the presence of this cone is in response to lower water levels in the overlying aquifer. Above the Atlantic City 800-foot sand, a cone of depression in the infrequently used Rio Grande water-bearing zone also is an indicator of hydraulic stress propagating through the hydrogeologic section in this area (fig. 1). The 2013 water level at the center of this cone (−40 ft, well 1-834) showed a slight decrease (1 ft) from the 2008 water level.

Development of the Piney Point aquifer in the city of Bridgeton, Cumberland County, after 2003 caused a deep and regionally extensive cone of depression to form within an area already characterized by persistent potentiometric-surface lows and a long-term gradual decline in water levels because of withdrawals in Delaware (plate 3). Yields within the Piney Point aquifer vary at different locations because of variations in hydraulic conductivity that result from facies changes within the formation. In the city of Bridgeton in Cumberland County, withdrawals resulted in the formation of a deep cone of depression and caused water levels to decline 20 to 40 ft in areas of Cumberland County (fig. 8*C*). Measured water levels at the pumping center in the city of Bridgeton ranged from −164 (wells 11-1220 and 11-1221) to −166 ft (well 11-1571), a decline of as much as 10 ft in this area from the previous 2008 study. To the east of this cone of depression is a smaller cone of depression centered in Buena Borough where measured water levels range from −39 to −46 ft; a rise in water levels of 8 ft at well 1-1445 located outside of the cone of depression is indicated from the previous 2008 study.

Interpretation of the potentiometric surface was extended into northeastern Delaware. Water levels in two wells in Delaware are shown on plate 3 (Delaware Geological Survey, 2017). In Delaware, a cone of depression with a minimum water level of −124 ft (well Id55-01) persists in and around the city of Dover. Substantial long-term withdrawals in Dover have placed significant hydraulic stress on the aquifer, which extends throughout a large area beneath the Delaware Bay and into southern New Jersey. Until 2004, those withdrawals were the primary cause of declining water levels in the Piney Point aquifer in Cumberland County (DePaul and Rosman, 2015).

In updip areas of the aquifer in Camden, Gloucester, Cumberland, and western Atlantic Counties, water levels are lower in the Piney Point aquifer than in the overlying Kirkwood-Cohansey aquifer system, indicating flow is downward into the Piney Point aquifer (DePaul and Rosman, 2015). In southern Burlington County, water levels are generally higher in the Piney Point aquifer, particularly in low-lying areas near the border of Burlington and Atlantic Counties, indicating an upward vertical gradient that is demonstrated by the presence of a flowing artesian well (5-488). Water levels in central Burlington and southern Camden and Gloucester Counties are greater in the Piney Point aquifer than in the overlying Wenonah-Mount Laurel aquifer, as much as 60 ft greater, indicating the potential for flow out of the Piney Point aquifer to the overlying Wenonah-Mount Laurel aquifer in that area. Along the coast from southern Ocean County toward Atlantic City, water levels are as much as 40 ft greater in the Piney Point aquifer than in the overlying Atlantic City 800-foot sand, indicating flow is upward from the Piney Point aquifer to the overlying aquifer.

Water levels measured during 2008 and 2013 were compared for 49 wells in New Jersey (app. 4) to evaluate water-level changes in the Piney Point aquifer to map the difference between the 2008 and 2013 potentiometric surfaces (fig. 8*C*). Of the 49 wells, water levels declined in 23 (47 percent), remained about the same in 7 (14 percent), and rose in 19 (39 percent). These results are given in appendix 4 and summarized in table 4 for this aquifer. The difference between the 2008 and 2013 potentiometric surfaces indicates water-level declines of 10 ft or more in northern Cumberland County (fig. 8*C*). The difference between the 2008 and 2013 potentiometric surfaces indicates water-level declines ranging from 20–40 ft were indicated near the updip limit of the aquifer in Salem and Gloucester Counties and a small part of Camden County (fig. 8*C*). Although there is pumping from the Piney Point aquifer in this area in Gloucester and Camden Counties (fig. 6*C*), measured water levels in this area declined primarily because of much larger withdrawals downdip in Cumberland County, resulting in new flow patterns near the updip limit of the aquifer from the previous 2008 study.

Long-term water-level trends in the Piney Point aquifer were evaluated graphically and compared to water-level trends from the previous 2008 study. Hydrographs for nine observation wells that depict long-term and seasonal trends in the Piney Point aquifer from 1978 to 2013 are shown in figure 12; the well locations are shown on plate 3**.** The average decline in water levels during 2009–13 from the previous 2004–08 study period ranges from 11 to 16 ft at wells 11-44, 11-96, and 11-163 in Cumberland County. Well 1-834 in Atlantic County had decreasing water levels during 1998–2013 punctuated by step increases, possibly occurring during well development prior to pumping, in years 2003, 2009, and 2011. Small changes in water levels (less than 1 ft) from 2004 to 2008 occurred in wells 5-407, 5-676, 29-18, 29-425, and 29-585 in Burlington and Ocean Counties during 2009–13.

Water-level measurement taking place December 2018 in Cape May County, New Jersey. Photo by Eric Jacobsen, U.S. Geological Survey.

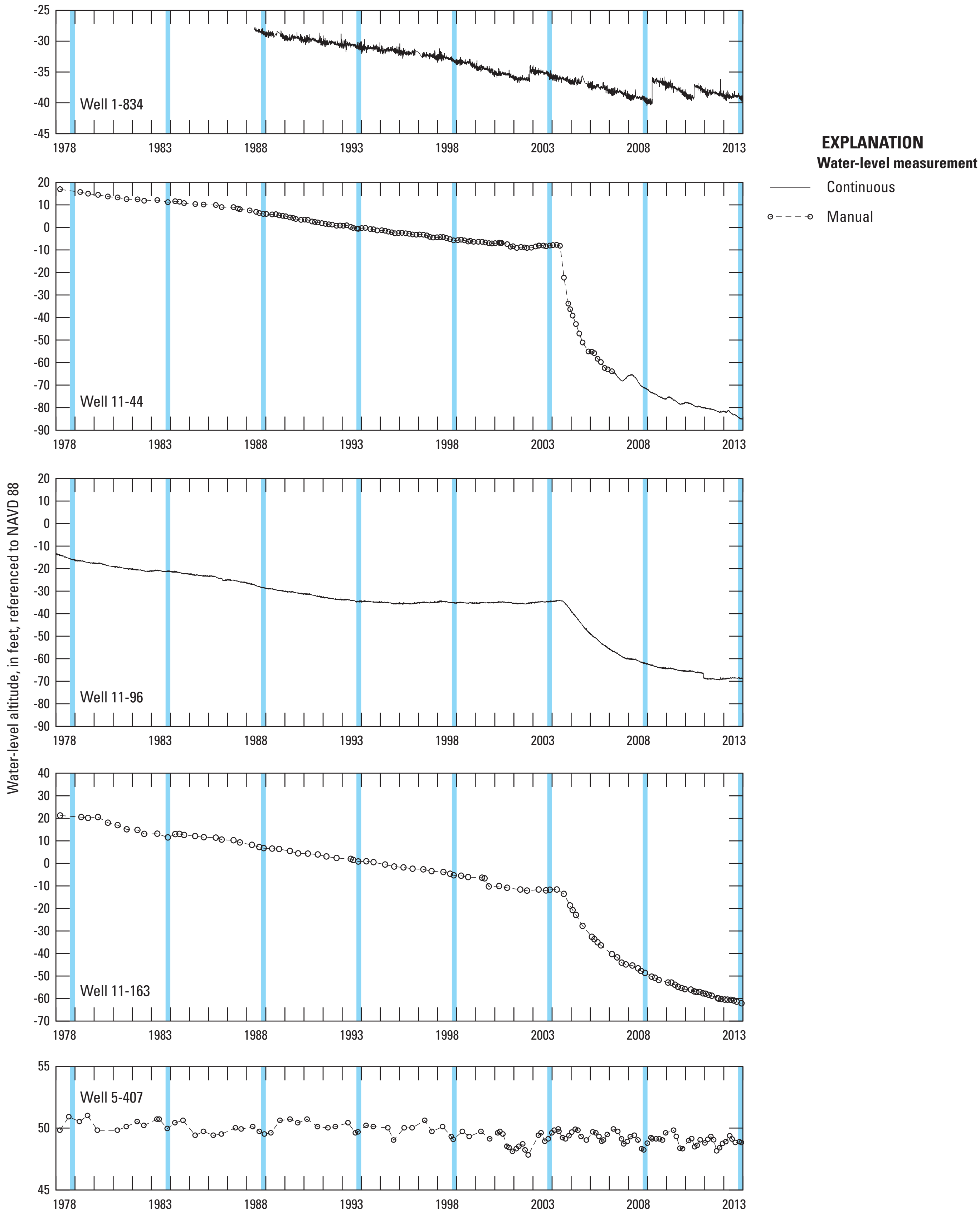


Figure 12. Water-level hydrographs for selected observation wells screened in the Piney Point aquifer, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

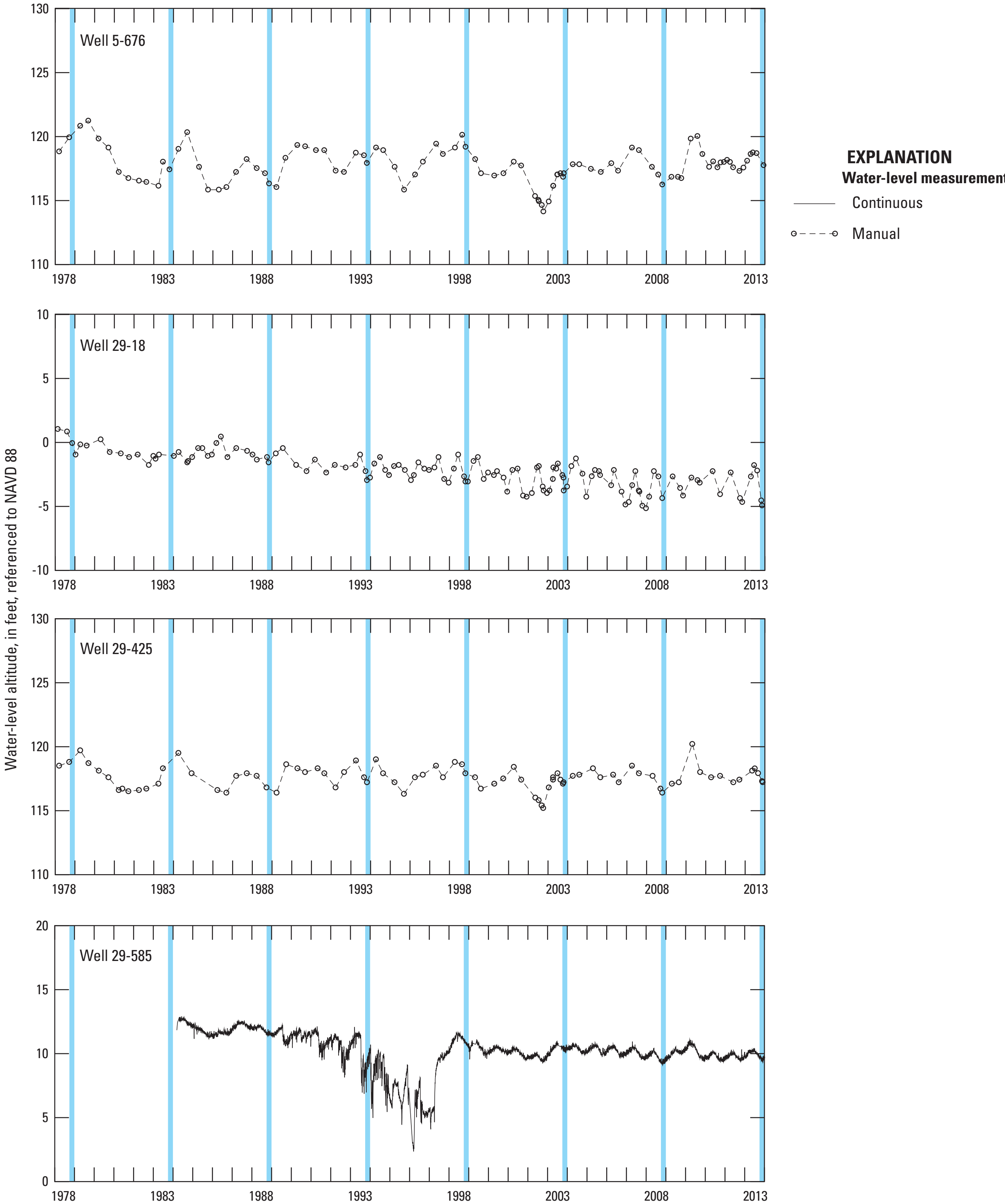


Figure 12. Water-level hydrographs for selected observation wells screened in the Piney Point aquifer, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)—Continued

Vincentown Aquifer

The Vincentown aquifer is composed of the sandy parts of the Paleocene Vincentown Formation. Within the outcrop (plate 4) and from 8 mi to 10 mi downdip, the Vincentown Formation can yield quantities of groundwater capable of sustaining small withdrawal and domestic-supply wells; beyond this extent, it functions primarily as a confining unit (Zapecza, 1989). In the outcrop and the shallow subsurface, the formation is composed primarily of massive quartzose sand containing abundant glauconite, mica, and shell material. The formation grades to silty sand then to silt downdip from the outcrop (Sugarman, 1992). The aquifer is well defined in northern Ocean and southern Monmouth Counties but is less well defined in the rest of the Coastal Plain. The formation is thickest (more than 100 ft thick) in Monmouth County in east-central New Jersey, the area where it is used for water supply. Beyond Monmouth and Ocean Counties, the Vincentown Formation is silty and produces appreciable quantities of water only locally; the Vincentown aquifer is not a significant source of water in any part of southwestern or south-central New Jersey. Transmissivity simulated in this aquifer using the New Jersey RASA model ranged from 1,000 square feet per day (ft^2/d) to 3,000 ft^2/d in southern coastal Monmouth County (Martin, 1998).

The Vincentown aquifer contains freshwater throughout its confined extent. Because of the low to moderate concentrations of chlorides in the groundwater, the 250-mg/L isochlor was not mapped for the Vincentown aquifer.

Groundwater Withdrawals

Estimated groundwater withdrawals from the Vincentown aquifer during 2013 totaled about 1.6 Mgal/d (table 3); about 63 percent occurred in Monmouth County (fig. 13*A*). Public-supply wells near the border between northern Ocean and southern Monmouth Counties accounted for nearly 88 percent (about 1.4 Mgal/d) of total withdrawals from the aquifer. Estimated groundwater withdrawals from the Vincentown aquifer ranged from 0.8 to 1.9 Mgal/d from 1978 to 2013 (fig. 14*A*).

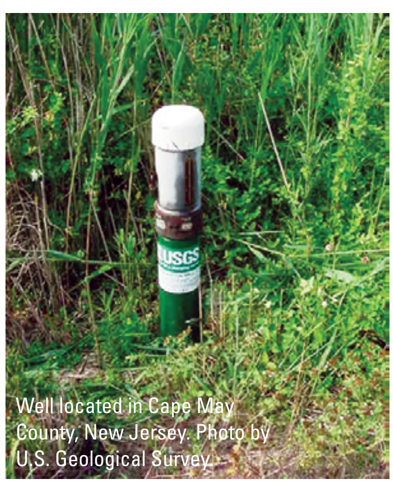
Water Levels

The 2013 potentiometric-surface map for the Vincentown aquifer is shown on plate 4; supporting water-level data used to determine water-level differences between 2008 and 2013 are presented in appendix 5. The highest water levels occurred near the updip limit in northwestern Ocean County (135 ft, well 29-698) in areas of greatest topographic relief; the lowest measured water level occurred in coastal Salem County (2 ft, well 33-1148) in the southwestern extent of the aquifer. Groundwater flow in Monmouth, Ocean, and northern Burlington Counties is generally to the east-southeast from high water levels near the updip limit in the west toward pumped wells and the Atlantic Ocean.

The lack of accessible wells in Burlington and Camden Counties precluded mapping of water levels in this area, and usage of the aquifer is infrequent in this area. The limited water-level data in central Gloucester County indicate that a local potentiometric high, originally mapped by Hardt and Hilton (1969) and confirmed by DePaul and others (2009), is present. Water levels progressively decrease to the southwest of the potentiometric high in Gloucester County, indicating regional flow is toward the Delaware River.

Water levels measured during 2008 and 2013 were compared for 25 wells (app. 5) to evaluate water-level changes in the Vincentown aquifer and to map the differences between the 2008 and 2013 potentiometric surfaces (fig. 15*A*). Of the 25 wells measured during the 2008 and 2013 studies, water levels declined in 2 (8 percent), remained the same in 4 (16 percent), and rose in 19 (76 percent). The largest water-level decline of 4 ft (well 29-917) occurred in northern Ocean County (app. 5). Water levels and differences are listed in appendix 5 and summarized in table 4 for this aquifer.

Long-term water-level data collected at three wells (5-1250, 25-636, 29-139) screened in the Vincentown aquifer are represented in figure 16, and the well locations are shown on plate 4. Water levels were stable during 2009–13 and similar to water levels during 2004–08 for the three wells (fig. 16).



Well located in Cape May County, New Jersey. Photo by U.S. Geological Survey.

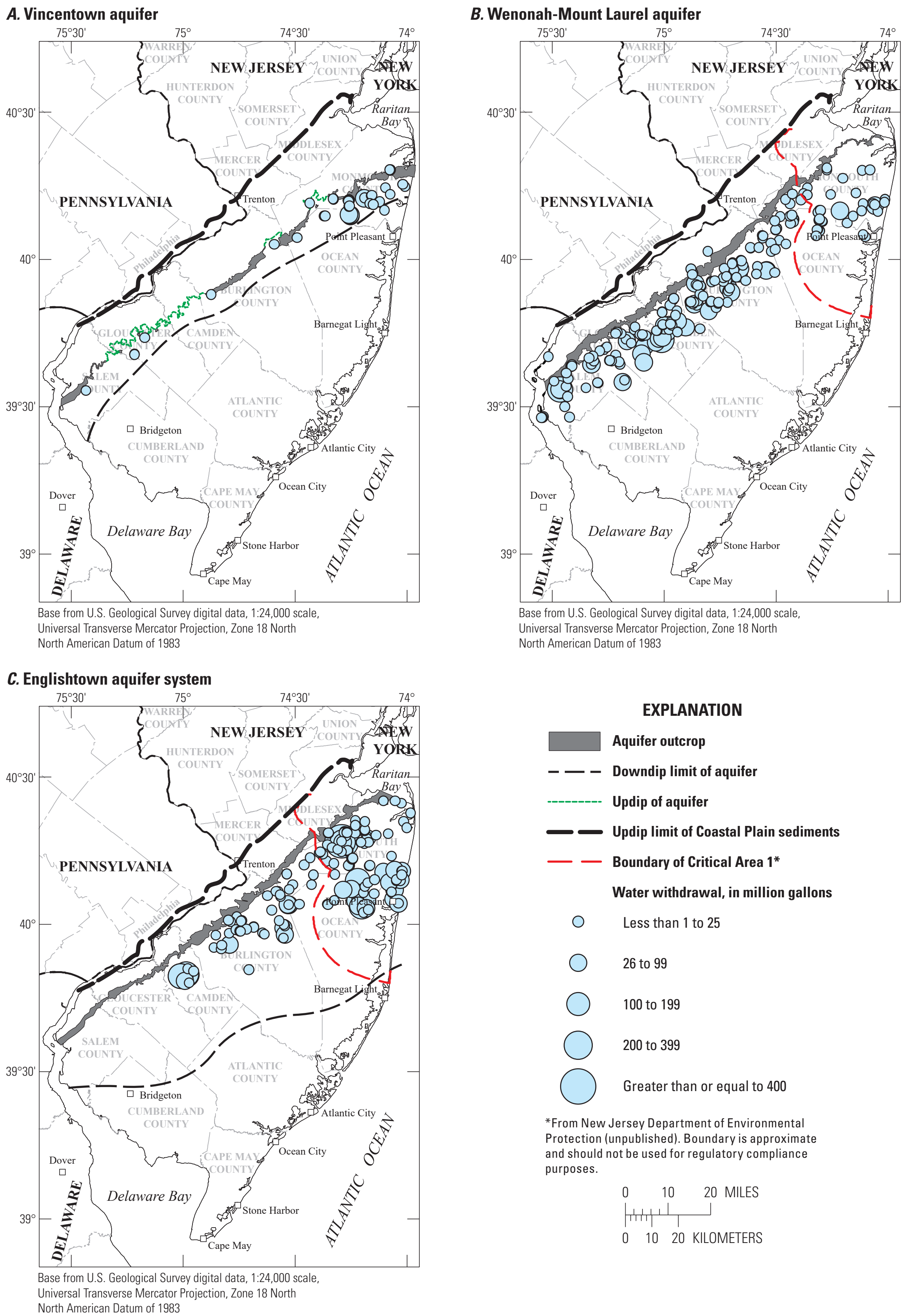


Figure 13. Location and volume of groundwater withdrawals from the *A*, Vincentown aquifer, *B*, Wenonah-Mount Laurel aquifer, and *C*, Englishtown aquifer system, New Jersey Coastal Plain, 2013.

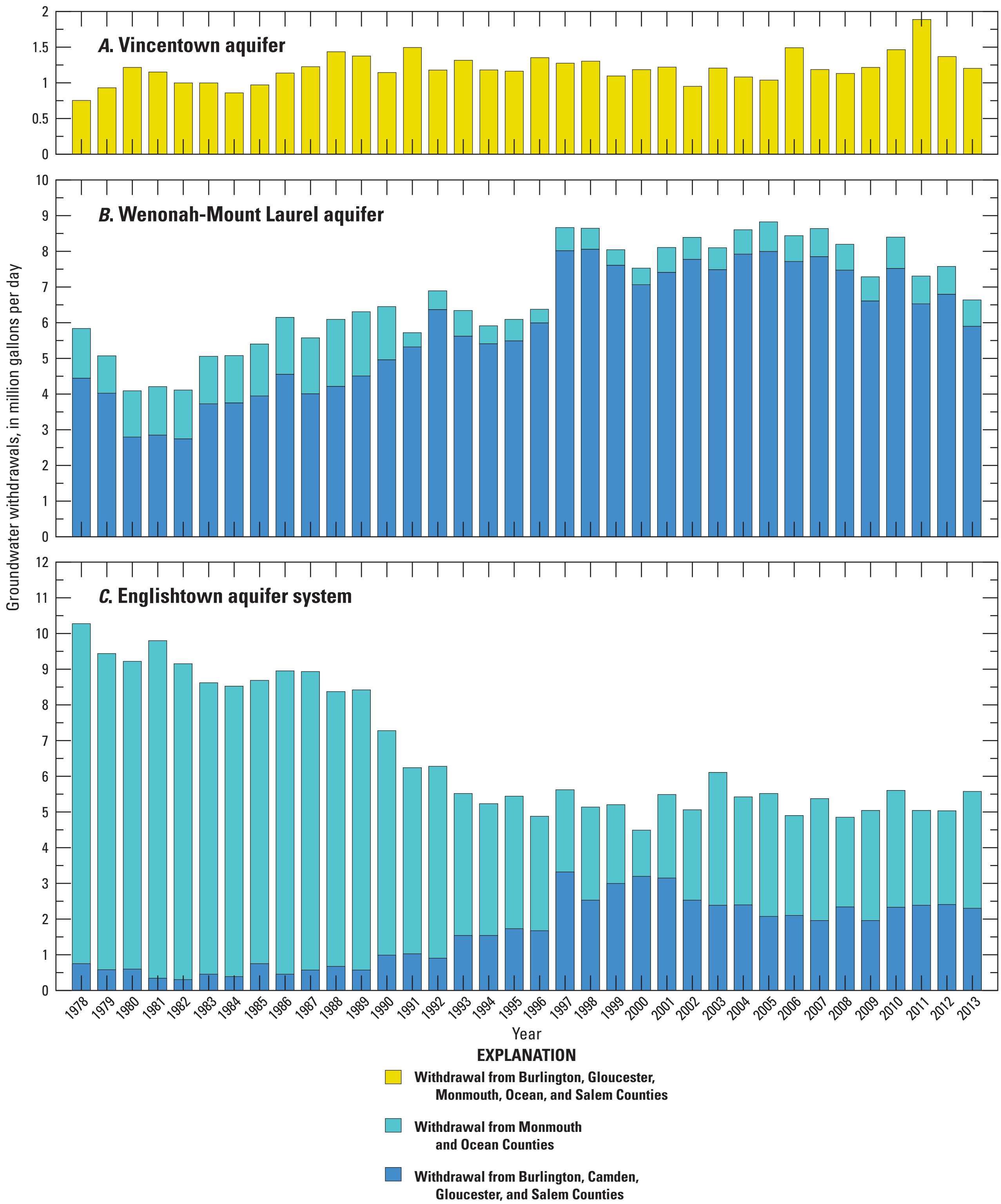


Figure 14. Estimated groundwater withdrawals from the *A*, Vincentown aquifer, *B*, Wenonah-Mount Laurel aquifer, and *C*, the Englishtown aquifer system, New Jersey Coastal Plain, 1978–2013.

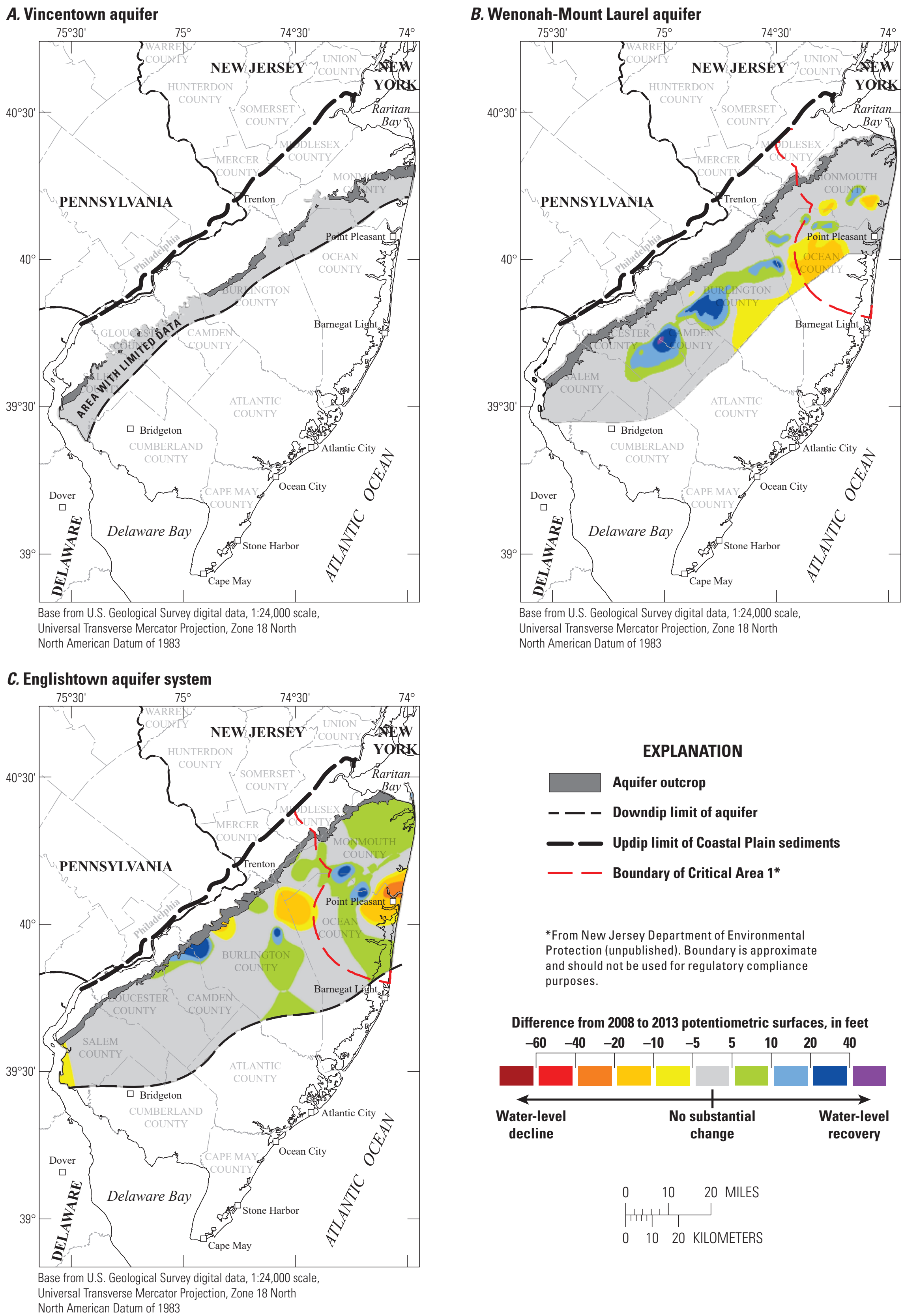


Figure 15. Difference between the 2008 and 2013 potentiometric surfaces in the *A*, Vincentown aquifer, *B*, Wenonah-Mount Laurel aquifer and *C*, the Englishtown aquifer system, New Jersey Coastal Plain.

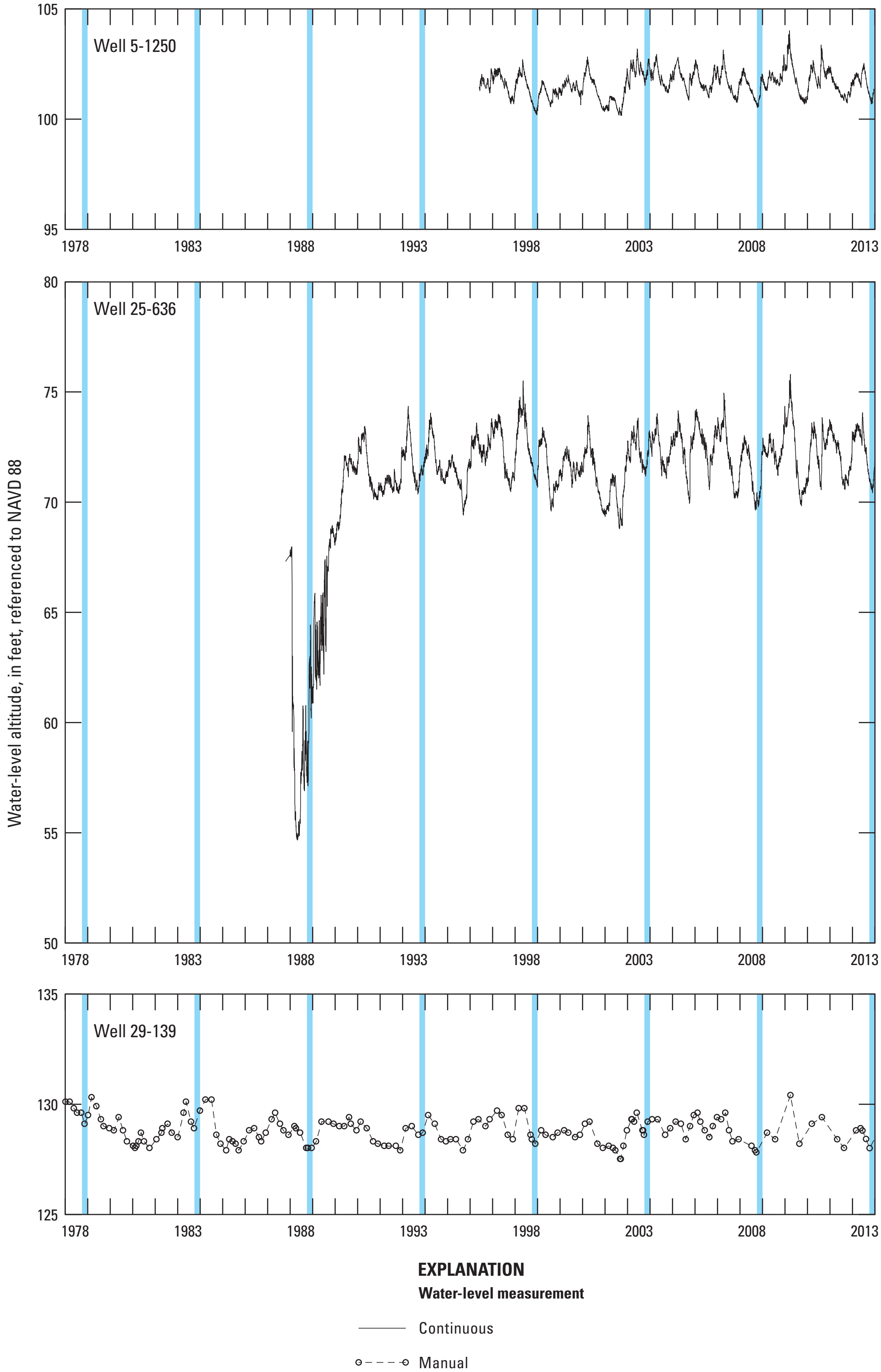


Figure 16. Water-level hydrographs for selected observation wells screened in the Vincentown aquifer, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

Wenonah-Mount Laurel Aquifer

The Wenonah-Mount Laurel aquifer is composed of the sand of the Mount Laurel Formation and, locally, the upper part of the Wenonah Formation where the latter is not composed predominantly of silt. The Mount Laurel Formation is a slightly glauconitic, micaceous quartz sand; shell beds are common throughout. The upper part of the Wenonah Formation consists of slightly glauconitic, clayey fine sand or silt containing abundant lignite fragments and some pyrite (Owens and others, 1970); at its base the formation grades to a silt. The aquifer crops out within the exposures of the Mount Laurel and Wenonah Formations from Monmouth and Middlesex Counties in the northeastern part of the Coastal Plain to Salem County in the southwest (pl. 5). The downdip limit of the aquifer is offshore from Monmouth and Ocean Counties, and in Atlantic, Cumberland, and Cape May Counties, this limit is poorly defined. The downdip limit of this aquifer is not shown in Zapecza (1989). The aquifer is thickest in southwestern New Jersey (western Salem County, and central Gloucester and Camden Counties) where it is used for water supply. In this area, thicknesses of 100–200 ft are common (Zapecza, 1989), but to the southwest in Salem County, the silt content increases, and the productive sands decrease accordingly. In the northeastern part of the Coastal Plain, the aquifer is used for water supply in eastern Monmouth and northern Ocean Counties; the aquifer here is generally 60–80 ft thick (Zapecza, 1989), although thicknesses may exceed 100 ft in some areas of Monmouth County. Transmissivity simulated for this aquifer using the New Jersey RASA model ranged from 500 ft^2/d in updip and downdip areas to 1,000 ft^2/d throughout most of the areas with pumped wells (Martin, 1998).

The Wenonah-Mount Laurel aquifer contains freshwater throughout much of its confined extent. In southern Cumberland and Salem Counties, saline groundwater is present along the Delaware estuary, and the 250-mg/L isochlor extends approximately 2 mi inland in the southwestern part of Salem County (pl. 5). Elsewhere in southern New Jersey, in areas where the aquifer is utilized, the groundwater is generally fresh, and chloride concentrations are typically less than 25 mg/L (U.S. Geological Survey, 2017).

Groundwater Withdrawals

Groundwater withdrawals from the Wenonah-Mount Laurel aquifer occur in a band from central Burlington County to central Salem County from the outcrop to less than 10 mi downdip (fig. 13*B*). Groundwater is also withdrawn in Monmouth and northern Ocean Counties. The estimated groundwater withdrawals in Monmouth and Ocean Counties, shown in figure 14*B*, indicate that the fluctuation in annual withdrawals from 2003 to 2013 from the Wenonah-Mount Laurel aquifer in these two counties is small. The largest change in withdrawals occurred between 2009 and 2010 (0.2 Mgal/d), and no change occurred between 2011 and 2012 (0 Mgal/d).

In 2013, estimated withdrawals totaled 6.7 Mgal/d (table 3). Withdrawals were greatest in Burlington (2.1 Mgal/d), Camden (1.6 Mgal/d), Gloucester (0.9 Mgal/d), and Salem (1.3 Mgal/d) Counties; smaller withdrawals occurred in Monmouth (0.6 Mgal/d) and Ocean (0.2 Mgal/d) Counties.

Water Levels

The potentiometric-surface map depicting water levels during fall 2013 for the Wenonah-Mount Laurel aquifer is shown on plate 5; supporting water-level data used to construct this map and determine differences between 2008 and 2013 water levels are presented in appendix 6. The 2013 potentiometric surface shows high water levels near the outcrop in Monmouth County and two regional cones of depression within the aquifer—one straddling central-western Burlington, southern Camden, and southeastern Gloucester Counties and another straddling southeastern Monmouth and northeastern Ocean Counties. The highest water levels occurred near the outcrop in Monmouth County (155 ft in well 25-412); the lowest occurred in coastal Monmouth and Ocean Counties (−69 ft and −66 ft in wells 25-443 and 29-49, respectively). The regional cone of depression in the coastal region of Monmouth and Ocean Counties is elongate in shape and centered beneath the coastal parts of southeastern Monmouth County; the lowest water levels occurred in this cone of depression. A small cone of depression in central-eastern Burlington County has low water levels of −20 and −21 ft (wells 5-366 and 5-367, respectively); however, in well 5-367 there was a rise of 7 ft from the water level measured in 2008 (app. 6). Well 5-366 was not measured in 2008.

The large elongated cone of depression through southeastern Gloucester, southern Camden, and central-western Burlington Counties, which began to form after 1983, encompasses three smaller cones. The center of the easternmost smaller cone near Medford Lakes in Burlington County has potentiometric lows of −37 ft (well 5-1253), −33 ft (well 5-1818), and −28 ft (well 5-1828). However, there was a 19-ft water-level rise in well 5-1253 from the 2008 water level (app. 6). The other two wells were not measured in 2013. The center of the westernmost smaller cone of depression underlies an area straddling the border between Camden and Gloucester Counties where the water level for well 7-847 was −30 ft. The water level measured in well 7-847 rose 54 ft from 2008 (DePaul and Rosman, 2015) to 2013. However, in 2008 the pump in well 7-847 was turned off for 4 hours before the measurement was made, and it was determined that the water level was still recovering, whereas in 2013, although the length of time the pump was turned off was not recorded, the water level had stabilized when the measurement was made. A small cone of depression is present in eastern Camden County near the border of Burlington County and has a minimum water level of −22 ft (well 7-449).

In southern Camden and Gloucester Counties, water levels in the Wenonah-Mount Laurel aquifer are as much as 60 ft lower than those in the overlying Piney Point aquifer, particularly in the Williamstown quadrangle (pl. 5), indicating the potential for flow downward from the Piney Point aquifer. At the cone of depression in the Wenonah-Mount Laurel aquifer in coastal Ocean and Monmouth Counties, water levels are more than 40 ft greater in some areas than those in the underlying Englishtown aquifer system, indicating the potential for downward flow from the Wenonah-Mount Laurel aquifer to the Englishtown aquifer system. Water levels in the overlying Vincentown aquifer were 20–100 ft greater than those in the underlying Wenonah-Mount Laurel aquifer in southeastern Monmouth County potentially resulting in downward flow from the Vincentown aquifer to the Wenonah-Mount Laurel aquifer.

Water levels measured during 2008 and 2013 were compared for 117 wells (app. 6) to evaluate water-level changes in the Wenonah-Mount Laurel aquifer and to map the difference between the potentiometric surfaces (fig. 15*B*). Water levels recovered in 98 wells (84 percent), declined in 15 wells (13 percent), and remained the same in 4 wells (3 percent). These results are given in appendix 6 and summarized in table 4 for this aquifer. The largest water-level decline was measured in well 25-443 in southeastern Monmouth County at 16 ft (app. 6). The water level in well 25-698 in southeastern Monmouth County near the cone of depression (pl. 5) declined 14 ft from the 2008 water level. This decline may be attributed to an increase in withdrawals in Monmouth County from the underlying Englishtown aquifer system from 2.9 Mgal/d in 2008 (DePaul and Rosman, 2015) to 3.5 Mgal/d in 2013 (table 3). Withdrawals from the Wenonah-Mount Laurel aquifer in this area were much smaller (0.6 Mgal/d in 2008 and 2013) than those from the Englishtown aquifer system.

The differences between the 2008 and 2013 potentiometric surfaces in the Wenonah-Mount Laurel aquifer are shown in figure 15*B*. Areas of water-level declines are indicated in western Ocean and southeastern Monmouth Counties. However, figure 15*B* includes areas where wells were not measured in both 2008 and 2013, resulting in new flow patterns in these areas from the previous 2008 study. The water-level decline in southeastern Monmouth County may be attributed to increased withdrawals of 0.6 Mgal/d from 2008 to 2013 from wells pumping from the Englishtown aquifer in this area. Water levels in some areas in western Burlington County rose more than 20 ft compared to 2008 water levels (fig. 15*B*). The rise in water levels may be attributed to a decrease in withdrawals from the Wenonah-Mount Laurel aquifer in Burlington County from 2.9 Mgal/d in 2008 (DePaul and Rosman, 2015) to 2.1 Mgal/d in 2013 (table 3). Water levels in some wells straddling Camden and Gloucester Counties rose more than 20 ft (wells 7-847 and 15-1384) compared to 2008 water levels (fig. 15*B*). The water level in well 7-847 (pl. 5) in western Camden County rose 54 ft from the 2008 measurement (DePaul and Rosman, 2015) to the 2013 measurement; however, the 2008 water level was not considered to be stabilized and still recovering, or was affected by nearby pumping when the 2008 measurement was made.

Long-term water-level trends in the Wenonah-Mount Laurel aquifer were evaluated graphically and compared to water-level trends from the previous 2008 study. Hydrographs for eight selected observation wells that show long-term and seasonal trends in the Wenonah-Mount Laurel aquifer from 1978 to 2013 are provided in figures 17 and 18; well locations are shown on plate 5**.** Compared to the previous study period 2004–08, well 7-478 had an average water-level increase of 7.1 ft, wells 33-20 and 7-118 had no change, and well 33-252 had a small decline during 2009–13. Well 7-478 is near the border of Camden and Gloucester Counties and along the downdip side of the southern cone of depression, well 33-20 is in southeastern Salem County, well, 7-118 is downdip from the outcrop area of the aquifer in Camden County, and well 33-252 is near the aquifer outcrop in western Salem County (pl. 5). Well 29-140 in northern Ocean County showed no upward or downward trend during 2009–13 when compared to the previous study period 2004–08. Upward trends were observed at wells 25-486 and 25-637 in southeastern Monmouth County during 2009–13; however, data were not collected for well 25-637 after January 13, 2013. DePaul and Rosman (2015) also observed upward trends for these two wells during the previous 2008 study. Well 25-353 in Monmouth County showed an upward trend during 2009–13 when compared to the previous study period 2004–08. The average water level rose about 1 ft in well 25-353 during 2009–13. For comparison, from 2003 to 2008, DePaul and Rosman (2015) calculated statistically significant downward trends using a Mann-Kendall trend test at 5 wells (7-118, 7-478, 29-140, 33-20 and 33-252) and upward trends at 2 wells (25-486 and 25-637).

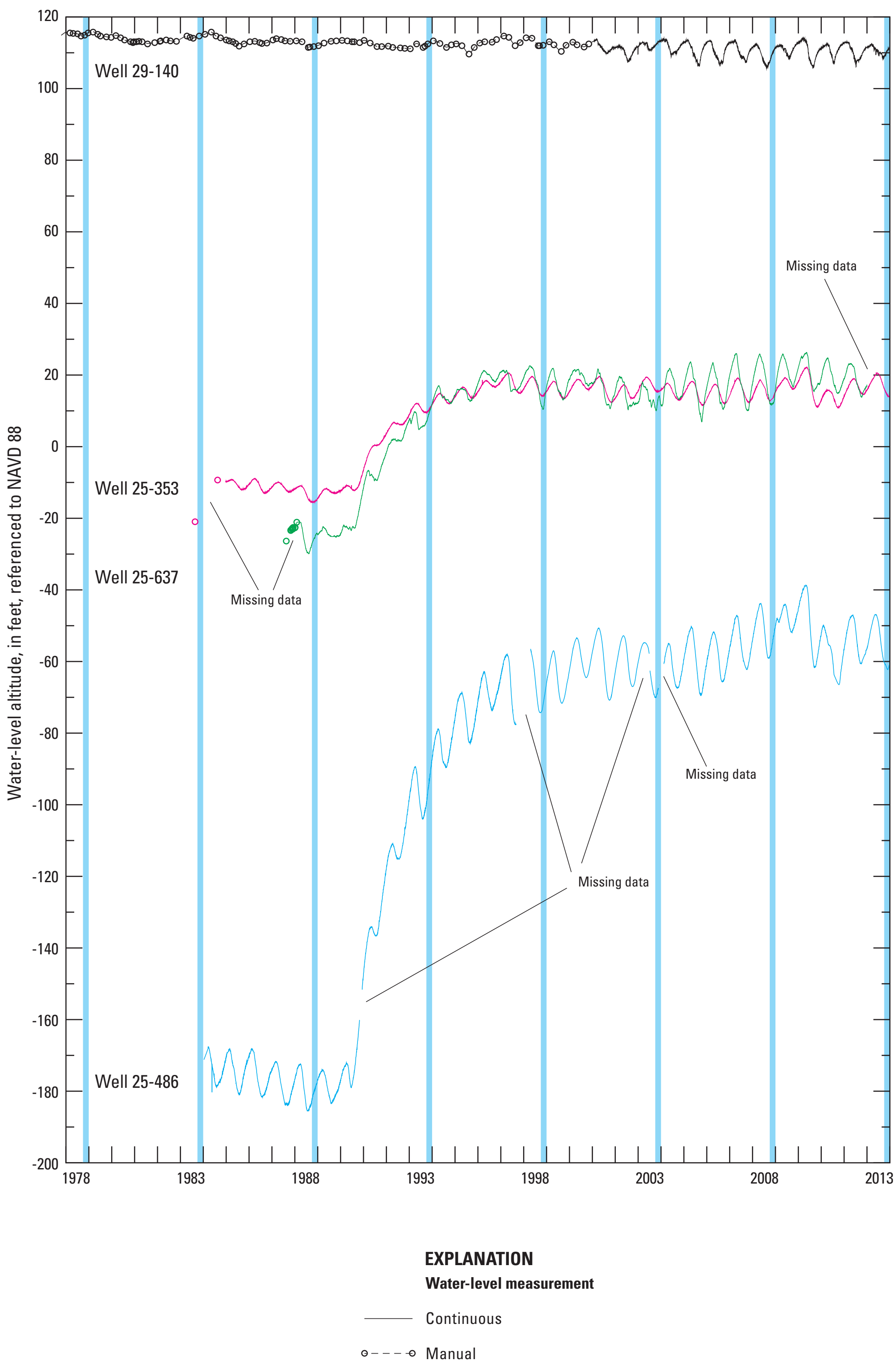


Figure 17. Water-level hydrographs for selected observation wells screened in the Wenonah-Mount Laurel aquifer in Monmouth and Ocean Counties, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

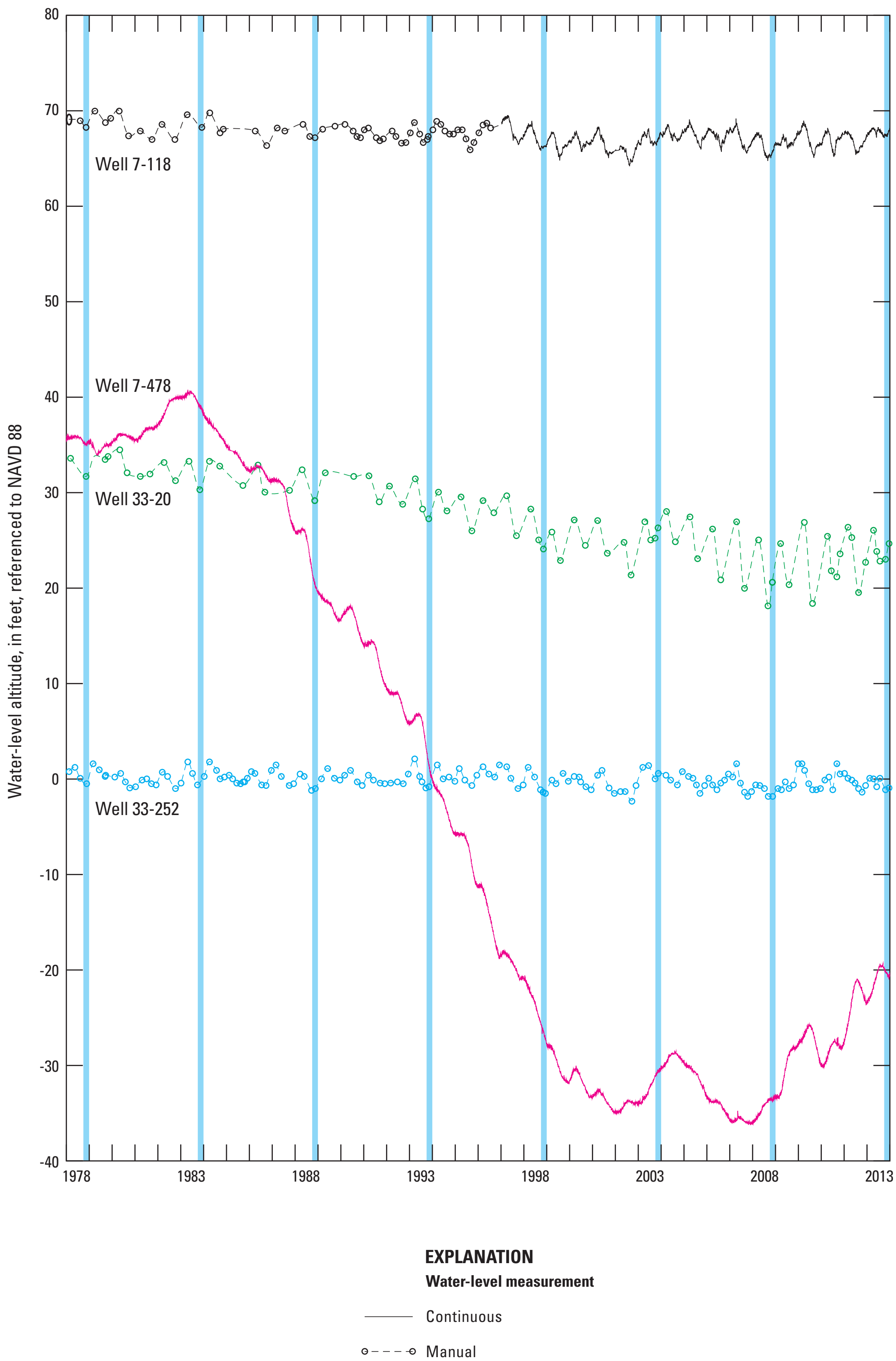


Figure 18. Water-level hydrographs for selected observation wells screened in the Wenonah-Mount Laurel aquifer in Camden and Salem Counties, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

Englishtown Aquifer System

The Englishtown Formation is a fine- to medium-grained feldspathic quartzose sand that in some places grades to a silt. The formation is thickest (200 ft) in Monmouth County and remains sandy and thick a substantial distance downdip from the outcrop where the aquifer yields large quantities of water in Monmouth and Ocean County. In central and southern Ocean County, a confining unit partitions the Englishtown Formation into a system of an upper and lower aquifer. The aquifer system is underlain by the Merchantville-Woodbury confining unit, which is the most regionally extensive confining unit in the Coastal Plain (Zapecza, 1989). The Englishtown Formation thins considerably to the southwest, where sandy units are discontinuous and silt beds predominate (Zapecza, 1989). The approximate downdip limit of the aquifer system is shown on plate 6 and extends through southern Burlington and Ocean Counties, through northern Atlantic County, then along an east-west trending line through northern Cumberland County to the Delaware Estuary in Salem County. The distance from outcrop to the downdip boundary is approximately 34 mi in Ocean County, but to the southwest, the lateral extent of the confined aquifer decreases to about 12 mi in southern Salem County. South and east of this line the aquifer is not recognized on geophysical logs that penetrate the section (Zapecza, 1989). Transmissivity in the Englishtown aquifer system decreases substantially to the southwest as geologic material composing the aquifer matrix becomes finer grained (Nichols, 1977); little water is produced from the aquifer in the southwestern part of the State (Zapecza, 1989). Transmissivity simulated in this aquifer using the New Jersey RASA groundwater-flow model ranged from 500 ft^2/d in eastern Salem and northern Burlington Counties to 4,000 ft^2/d in coastal Monmouth County (Martin, 1998).

Most of the confined part of the Englishtown aquifer system contains fresh groundwater, except for a limited area at and surrounding the Sandy Hook observation well (25-771) in northeastern Monmouth County, where chloride concentrations exceed 15,000 mg/L. The geochemical composition of the groundwater from this well indicates a direct connection to, and mixing with, seawater (DePaul and Rosman, 2015).

Groundwater Withdrawals

Estimated withdrawals from the Englishtown aquifer system in 2013 were 7.9 Mgal/d (table 3). Withdrawals from the Englishtown aquifer system are made primarily in Monmouth, northern Ocean, central Camden, and north-central Burlington Counties (fig. 13*C*). The aquifer is used locally in eastern Mercer County and near the outcrop in Salem and Gloucester Counties, where withdrawals are made primarily for domestic self-supply (domestic self-supply withdrawals are not provided in table 3). Total withdrawals decreased from more than 10 Mgal/d in 1978 to less than 7 Mgal/d by 1996 (fig. 14*C*) because of mandated restrictions in Critical Area 1 and, beginning in 1991, the use of the Manasquan Reservoir as an alternative source of water. Groundwater withdrawals during 1990–2013 have been smaller than those prior to 1990 in Critical Area 1, as shown in figure 14*C*. However, withdrawals in the counties within Critical Area 2 (Burlington, Camden, Gloucester, and a small section of Salem) increased after 1996; the Englishtown aquifer system is not a regulated aquifer in Critical Area 2.

Water Levels

The potentiometric surface during fall 2013 for the Englishtown aquifer system is shown on plate 6; supporting water-level data used to construct this map and determine differences with 2008 are presented in appendix 7. The highest water levels within the confined aquifer exceeded 100 ft (wells, 25-408, 25-787, and 25-1079) and occurred near the outcrop in western Monmouth County, roughly coinciding with areas of greatest topographic relief. The lowest water levels (−100 and −102 ft) occurred in southeastern Monmouth County and are associated with pumping centers north of Point Pleasant (wells 25-28 and 25-30, respectively). A prominent cone of depression underlies northeastern Ocean and southeastern Monmouth Counties (pl. 6). This regionally extensive cone of depression has been well documented since 1978; the potentiometric-surface map by Walker (1983) shows water levels in this area were more than 240 ft below NGVD 29. Eckel and Walker (1986) and Rosman and others (1995) document declines in water levels for 1983 and 1988, respectively, of more than 220 ft below NGVD 29 in this area. The cone of depression is composed of two local cones underlying pumping centers located near Lakewood and Point Pleasant in Ocean County. The local cone of depression near Lakewood is characterized by a potentiometric surface of more than −90 ft (pl. 6). In the western extent of the aquifer, water levels ranged from a high of 83 ft (well 5-1896) in northern Burlington County near the outcrop area to a low of 9 ft (wells 5-1390 and 5-1762) in central Burlington County.

The location of the cone of depression in northeastern Ocean and southeastern Monmouth Counties is similar to that in the overlying Wenonah-Mount Laurel aquifer, which indicates that vertical leakance through the Marshalltown-Wenonah confining unit allows good hydraulic connection between the two aquifers. The water levels in the Englishtown aquifer system range from 10 to 40 ft lower than those in the overlying Wenonah-Mount Laurel aquifer in central and western Monmouth County and in northwestern Ocean County. The Englishtown aquifer system is used for water supply in these areas. Along the western edge of the cone of depression in coastal Monmouth and Ocean Counties, water levels are more than 30 ft greater in the overlying Wenonah-Mount Laurel aquifer than in the Englishtown aquifer system, indicating the potential for flow from the Wenonah-Mount Laurel aquifer to the Englishtown aquifer system. In eastern Burlington County, water levels are as much as 20 ft lower in the Englishtown aquifer system than those in the overlying Wenonah Mount Laurel aquifer, indicating the potential for flow downward into the Englishtown aquifer system.

Water levels measured during 2008 and 2013 were compared for 73 wells (app. 7) to evaluate water-level changes in the Englishtown aquifer system and to map the differences between the potentiometric surfaces (fig. 15*C*). Of the 73 wells measured in both 2008 and 2013, water levels declined in 25 (34 percent), recovered in 42 (58 percent) and remained the same in 6 (8 percent). These results are given in appendix 7 and summarized in table 4 for this aquifer. Water-level declines ranged from 1 to 37 ft and were most common in eastern Monmouth County and northeastern Ocean County. The largest declines were measured at and near the center of the regional cone of depression near the coast and straddling the border of Ocean and Monmouth Counties. On the western and updip side of the cone of depression, water levels were stable or had recovered by 1 to 20 ft. In central Camden, water levels declined as much as 9 ft (7-672) from those measured in 2008; however, farther updip near the outcrop area, the potentiometric surface indicates more than a 5 ft rise in water levels (fig. 15*C*).

Long-term water-level trends in the Englishtown aquifer system were evaluated graphically and compared to water-level trends from the previous studies. Hydrographs for nine observation wells that graphically depict long-term and seasonal trends in the Englishtown aquifer system from 1978 to 2013 are shown in figure 19, and the well locations are shown on plate 6**.** The hydrograph for well 23-104 in Middlesex County near the outcrop area of the aquifer shows little to no change in water levels during 1978–2013. The hydrograph for well 25-715 in Monmouth County near the outcrop area of the aquifer shows little to no change in water levels during 1991–2013. The water level in well 25-715, which is near Sandy Hook Bay in northern Monmouth County, has remained relatively constant since it was installed in 1991. However, the hydrograph for well 29-138 in northwestern Ocean County west of the cone of depression in coastal Ocean and southeastern Monmouth Counties shows periods of decline from 1978 to about 1993 when a rise in water levels is indicated on the hydrograph. The hydrograph for well 29-138 shows little change in water levels during 2004–2013. Wells 23-104, 25-715, and 29-138 are in updip areas of the aquifer distal from the regional cone of depression along the coast.

During 2009–13, an upward trend was observed at well 5-259 in central Burlington County, and the average increase was less than 2 ft from the previous 2004–08 study. During 2009–13 in observation well 25-250 in western Monmouth County, the average increase in water level was about 3.8 ft from the water levels observed during the previous 2004–08 study. The wells 5-259 and 25-250 are in updip areas of the counties, far from major cones of depression but near areas where the aquifer is pumped.

Well 29-530 is near the center of the cone of depression in northeastern Ocean County, and proceeding updip, in order of increasing distance, are wells 25-429 and 25-638 in southeastern Monmouth County. Owing to Critical Area water conservation strategies introduced in the late 1980s, water levels rose sharply in all three wells from 1990 to 1996; the magnitude of recovery during this period was greatest in well 29-530 at approximately 100 ft (DePaul and Rosman, 2015). At well 29-530, despite a brief decline during 2001–03, an upward trend in water levels is apparent during 1998–2008 (DePaul and Rosman, 2015); the trend continued through 2009. From 2010 to 2013, an average decrease of about 1 ft was observed compared to the 2004–08 average water level; however, water levels in this well are measured only 2–4 times a year. For well 25-429 in southeastern Monmouth County, from 2011 to 2013, an average decrease in water levels of 1.7 ft was measured from the previous 2004–08 period. For well 25-638, farther updip from well 25-429 in Monmouth County, an increase in water levels was measured for 2009–13 from the previous 2004–08 period. DePaul and Rosman (2015) calculated an upward trend in water levels from 1993 to 2008 for well 29-534 in central Ocean County; this trend continued through 2013.

Water-level measurement taking place December 2018 in Gloucester County, New Jersey. Photo by Emily Wengrowski, U.S. Geological Survey.

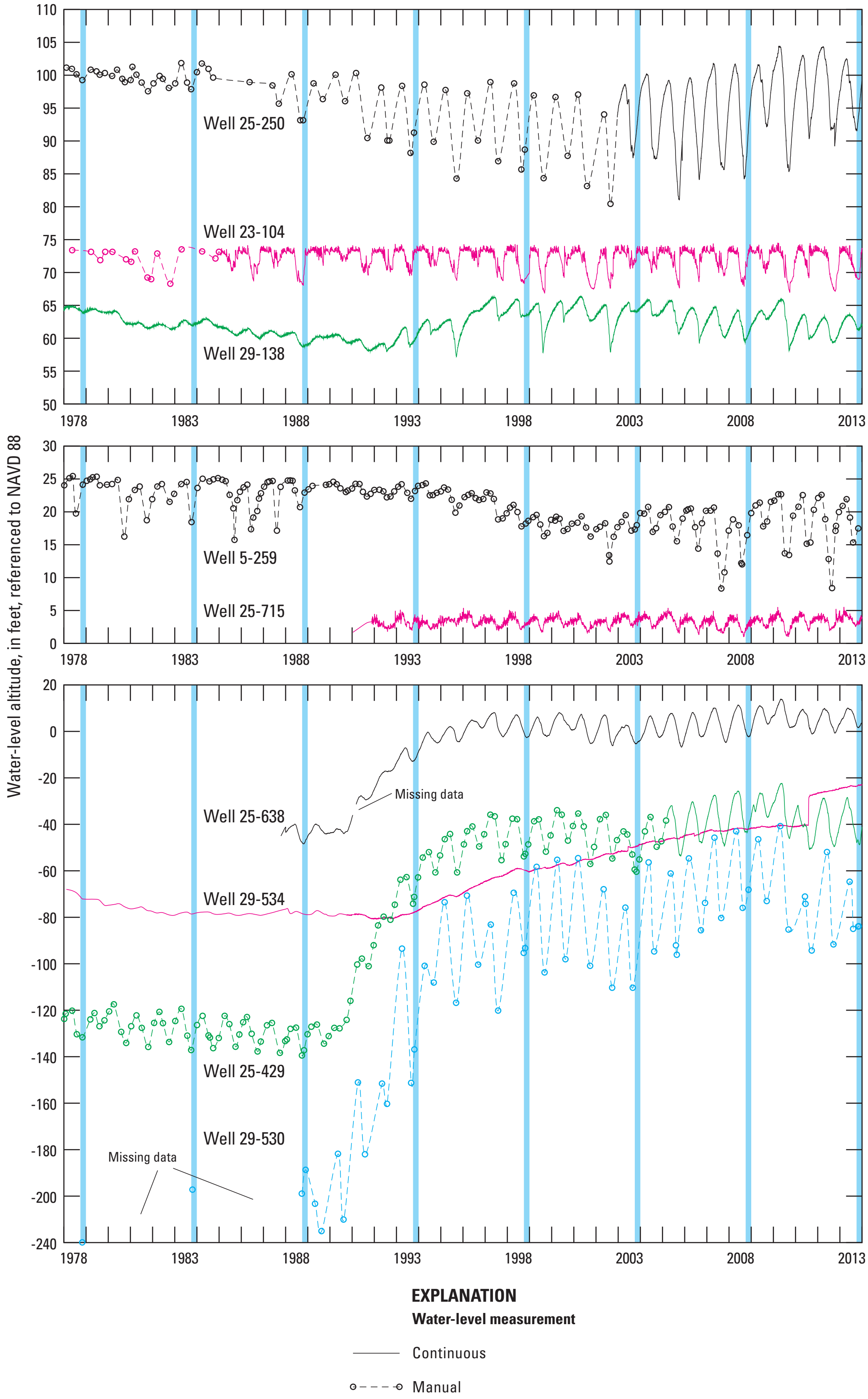


Figure 19. Water-level hydrographs for selected observation wells screened in the Englishtown aquifer system, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

Potomac-Raritan-Magothy Aquifer System

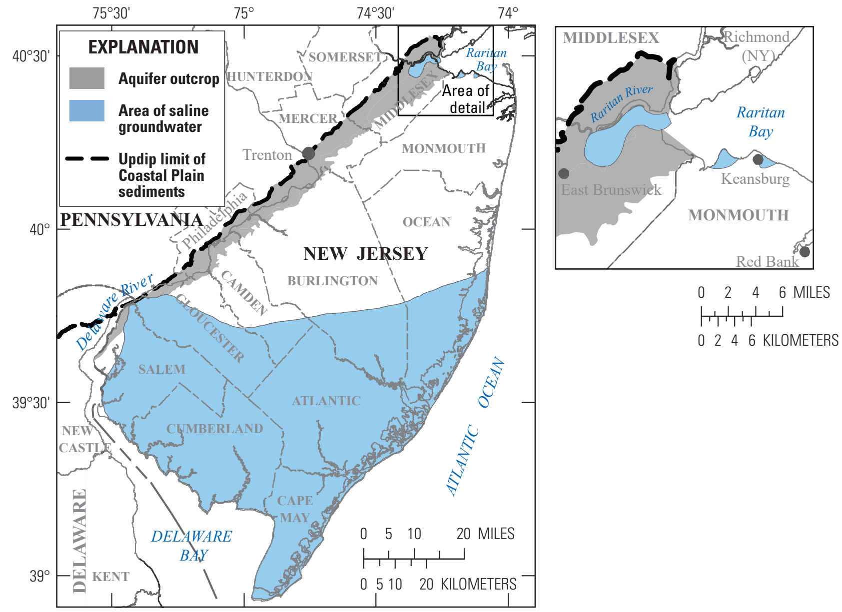
The PRM aquifer system includes the most productive aquifers in the New Jersey Coastal Plain. In order of increasing depth, they are the Upper, Middle, and Lower PRM aquifers. The Upper PRM aquifer generally corresponds to the Magothy Formation in New Jersey (Zapecza, 1989; table 1) and is the most extensive unit within the aquifer system. In Monmouth and Middlesex Counties, the aquifer is locally referred to as the Old Bridge aquifer. The aquifer consists of coarse-grained permeable sands with thin interbedded clay and clayey silt layers present locally. The outcrop extends in a northeast to southwest trending band from the Raritan Bay to the Delaware River adjacent to Salem County (plate 7) and is mostly coincident with the outcrop of the Magothy Formation. The thickness of the sand interval ranges from more than 200 ft in eastern Monmouth County to about 50 ft in Cape May County (Zapecza, 1989). Recharge to the aquifer is mainly from outcrop areas in Mercer, Middlesex, and Monmouth Counties and from the overlying Englishtown aquifer system, but water also enters the system from outcrop areas in Burlington, Camden, and Gloucester Counties. The overlying Merchantville-Woodbury confining unit, ranging in thickness from 200 to 300 ft throughout Monmouth, Ocean, and southern Burlington Counties, is relatively impermeable and effectively impedes vertical flow in downdip areas (Zapecza, 1989). Transmissivity simulated in this aquifer in the New Jersey RASA groundwater-flow model ranged from 2,000 ft^2/d in downdip areas to 10,000 ft^2/d in central Gloucester and northwestern Monmouth Counties (Martin, 1998).

The Middle and undifferentiated aquifer of the PRM aquifer system extends from the Raritan Bay in the northeastern part of the study area to Maryland in the southwest (plate 8). Northeast of Burlington County, the aquifer is locally referred to as the Farrington aquifer. The aquifer in this area is well defined from the outcrop area to about 20 mi downdip; beyond this distance the aquifer cannot be distinguished from the underlying sediments within the PRM aquifer system. Zapecza (1989) refers to the aquifer south of Middlesex County and western Monmouth County as the undifferentiated PRM aquifer. Similarly, in southern New Jersey the aquifer can be traced in the subsurface from the outcrop to an area extending approximately 10–12 mi downdip, beyond which the aquifer is indistinguishable from the Lower PRM aquifer. Where the confining unit between the Lower and Middle PRM aquifers is absent, the aquifer unconformably overlies bedrock or weathered bedrock. The transmissivity of the aquifer is greatest in northern Ocean County (greater than 16,000 ft^2/d), but the aquifer is most productive in Burlington, Camden, and Gloucester Counties in and within a short distance from the outcrop area where the transmissivity simulated in the New Jersey RASA groundwater-flow model ranged from 6,000 ft^2/d to more than 10,000 ft^2/d (Martin, 1998). To the southwest, discontinuous silt and clay units within the Middle PRM aquifer in Salem County inhibit its productivity. The Middle PRM aquifer is continuous into Delaware (plate 8). The updip limit of the aquifer in Delaware is within the outcrop of the Potomac Formation in northern New Castle County.

The Lower PRM aquifer is the lowermost aquifer within the Coastal Plain of New Jersey and Delaware. The aquifer does not crop out in New Jersey and is entirely overlain by the confining bed separating the Middle and the Lower PRM aquifers. The aquifer is recognizable about 8–12 mi downdip from the outcrop area of the Potomac and Raritan Formations (Zapecza, 1989); beyond this limit the aquifer cannot be differentiated from the overlying sediments of the Middle PRM aquifer. The transmissivity simulated in the aquifer with the New Jersey RASA groundwater-flow model is highest in northwestern and central Camden County and adjoining areas in Gloucester and Burlington Counties in New Jersey and ranges from 6,000 ft^2/d to 10,000 ft^2/d (Martin, 1998); this is where the aquifer is most productive. The Lower PRM is continuous into Delaware, coinciding with the lower part of the Potomac Formation (table 1). The updip limit of the aquifer in Delaware lies between the western edge of the Coastal Plain sediments and the updip limit of the middle Potomac aquifer (plate 9); the downdip limit is in northern Kent County (Vroblesky and Fleck, 1991). Groundwater flow in the PRM aquifer system is discussed in detail in Martin (1998), and flow in the Camden area is discussed in Navoy and Carleton (1995).

Extent of Saline Water

The PRM aquifer system contains saline water throughout a broad area of southern New Jersey, extending from the banks of the Delaware River in Salem and Gloucester Counties east through southern Ocean County and south, encompassing much of Atlantic and all of Cumberland and Cape May Counties (fig. 20). The presence of saline water in the aquifer system throughout much of southern New Jersey is largely the result of past seawater incursions and the subsequent deposition of paleoseawaters that accompanied eustatic rises in sea level (Barksdale and others, 1958). These waters have not yet been flushed with more dilute groundwater from northern recharge areas owing to low freshwater heads at and near the transitional zone. Because the aquifer system is in good hydraulic connection with the Delaware River in Camden, Gloucester, and to a lesser degree in Salem Counties, induced infiltration resulting from withdrawals during periods of drought and low river discharge may also be a source of chloride contamination in southern New Jersey (Navoy and others, 2005). Similarly, in the northern parts of the Coastal Plain, the PRM aquifer system underlying Middlesex and Monmouth Counties is hydraulically connected to the Raritan and South Rivers, the Washington Canal in eastern Sayreville Borough, and the Raritan Bay (plate 8), permitting saline water to recharge the aquifer system where prevailing hydraulic gradients are landward (Pucci and others, 1994).



Base modified from U.S. Geological Survey digital data, 1:24,000 Universal Transverse Mercator Projection, Zone 18, NAD 83

Figure 20. Area of saline groundwater, Potomac-Raritan-Magothy aquifer system, New Jersey Coastal Plain (from DePaul and Rosman, 2015).

Within the Upper PRM aquifer, freshwater is present throughout most of the updip extent, but saline groundwater is present in Salem County east through southern Ocean County and south, encompassing most of Atlantic and all of Cumberland and Cape May Counties (plate 7). In areas adjacent to and where the Upper PRM aquifer is in good hydraulic connection with the Raritan Bay, saline water recharges the aquifer underlying parts of Keansburg and surrounding areas (DePaul and Rosman, 2015). In southern New Jersey, saline groundwater is present within the aquifer throughout large parts of southern Salem, central and southeastern Gloucester, and southern Camden Counties (DePaul and Rosman, 2015). The 250-mg/L isochlor in the Upper PRM aquifer system arcs in the updip direction toward the Delaware River in southern Gloucester County, reflecting predevelopment flow paths and movement of groundwater toward predevelopment discharge areas (plate 7; DePaul and Rosman, 2015). The simulated 10,000-mg/L isochlor trends northeast to southwest from southeast Atlantic County to northwest Cape May County (Pope and Gordon, 1999).

Within the Middle PRM aquifer, groundwater is generally fresh throughout Mercer, Middlesex, and Monmouth Counties, except in areas where the aquifer underlies or is adjacent to the Raritan and South Rivers in Middlesex County (plate 8). Within the southern extent of the Middle PRM aquifer, the 250-mg/L isochlor roughly bisects southern New Jersey from Salem County in the west to southern Ocean County in the east. As with the geographic pattern of saltwater occurrence in the Upper PRM aquifer, a tongue of saline groundwater arcs in an updip direction toward areas where there is a rise in water levels in central Gloucester County. The simulated 10,000-mg/L isochlor trends northeast to southwest from southern Ocean County to southern Cumberland County (Pope and Gordon, 1999).

The extent of freshwater within the Lower PRM aquifer is shown on plate 9. The location of the 250-mg/L isochlor is based on previously published works by Barksdale and others (1958), Gill and Farlekas (1976), and Schaefer (1983) and was updated using recent water-quality data from 2008 (DePaul and others, 2009). The simulated 10,000-mg/L isochlor trends northeast to southwest from southern Burlington County to southern Salem County (Pope and Gordon, 1999).

Upper Potomac-Raritan-Magothy Aquifer

This section presents a discussion of groundwater withdrawals from the Upper PRM aquifer. The water levels used to construct the potentiometric surface for the Upper PRM aquifer, change in water levels between 2008 and 2013, and hydrographs are also discussed.

Groundwater Withdrawals

Withdrawals from the Upper PRM aquifer are made in Middlesex, Monmouth, and northern Ocean Counties from upland recharge areas to the Atlantic coastline **(**fig. 21*A***)**; however, in the southern part of the study area from Burlington County south to Salem County, withdrawals are limited to a narrow band extending from the outcrop to about 12 mi downdip. Beyond this limit, depth to the top of the aquifer is substantial, and concentrations of dissolved solids in the groundwater, elevated above background conditions, encourage the use of shallower aquifers.

Estimated groundwater withdrawals from the Upper PRM aquifer during 2013 totaled 49.0 Mgal/d (table 3). In 2013, Upper PRM aquifer withdrawals were largest in Middlesex, Camden, and Gloucester Counties at 14.9, 8.1, and 8.0 Mgal/d,

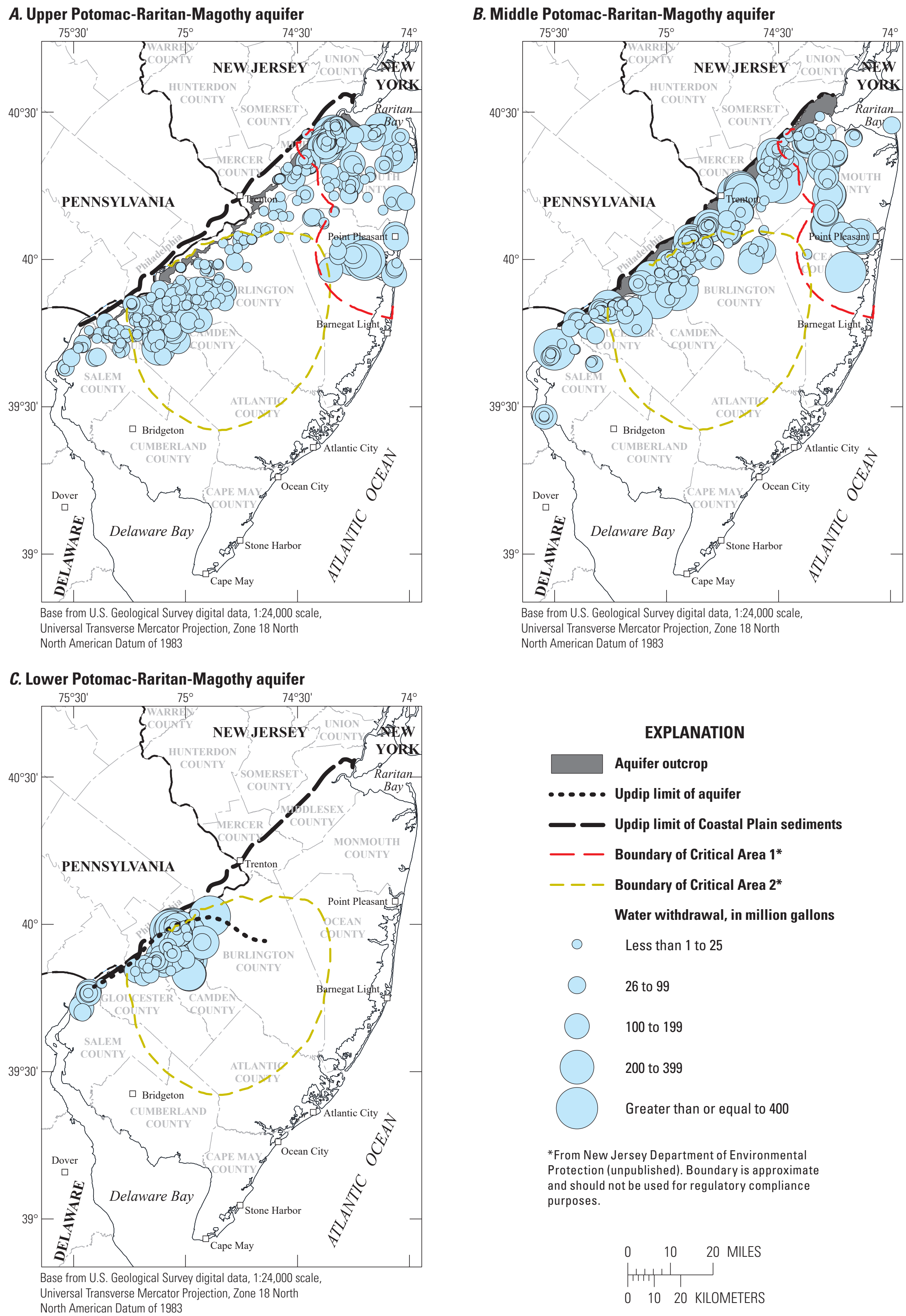


Figure 21. Location and volume of groundwater withdrawals from the *A*, the Upper Potomac-Raritan-Magothy aquifer, *B*, Middle Potomac-Raritan-Magothy aquifer and *C*, Lower Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 2013.

respectively (table 3). Withdrawals also were made in Burlington County (2.9 Mgal/d), northern Ocean County (6.5 Mgal/d), and throughout Monmouth County (6.7 Mgal/d). Minor withdrawals were made in Mercer County (0.6 Mgal/d) and Salem County (1.3 Mgal/d) within proximity to the updip limit of the aquifer. Withdrawals peaked during the early to mid-1980s prior to emplacement of mandatory restrictions and alternative sources of supply (fig. 22*A*). From 1989 to 1995, withdrawals were relatively constant, ranging from 65.3 to about 69.5 Mgal/d. From 1996 to 2008, withdrawals ranged from 54.4 to 62.9 Mgal/d (DePaul and Rosman, 2015), and from 2009 to 2013, withdrawals ranged from 48.4 to 54.7 Mgal/d.

Water Levels

The potentiometric-surface map for fall 2013 for the Upper PRM aquifer is shown on plate 7; supporting water-level data used to construct the map and determine differences between 2008 and 2013 water levels are provided in appendix 8. The highest water levels occurred in and near the outcrop area in eastern Mercer (65 ft, well 21-19) and western Middlesex (74 ft, well 23-292) Counties; the lowest water levels occurred in northern Ocean (−84 and −66 ft, wells 29-1040 and 29-1380, respectively) and central Camden (−65 ft, 7-824) Counties. The dominant feature of the potentiometric surface is the extensive cone of depression that extends from the Raritan Bay in the northeastern part of the study area to Salem and Cumberland Counties in the southwest and includes two deeper local cones of depression. The two cones of depression are centered beneath pumping centers in northeastern Ocean County and in central Camden County. Smaller cones of depression are present in northern Gloucester (−33 ft and −22 ft, wells 15-194 and 15-1529, respectively) and western Salem (−28 ft and −21 ft, wells 33-253 and 33-111, respectively) Counties. In areas where data are sparse or absent, the potentiometric surfaces of the 2008 study (DePaul and Rosman, 2015) were adapted to close the contours on the downdip edge of the regional cone.

Water-level differences in eastern Monmouth County in Critical Area 1 in the Upper PRM aquifer are more than 10 ft lower than those in the underlying Middle PRM aquifer, indicating upward flow from the Middle PRM aquifer to the Upper PRM aquifer in that area. In north-central Ocean County within the cone of depression in the southeast Lakehurst, southwest Lakewood, northeast Keswick Grove, and northwest Toms River quadrangles, water-level differences are nearly 60 ft greater in the underlying Middle PRM aquifer than in the Upper PRM aquifer, indicating possible upward flow from the Middle PRM aquifer to the Upper aquifer in that area. Near the cone of depression centered in Camden County in Critical Area 2, water-level differences are about 10 ft lower in the Upper PRM aquifer than in the underlying Middle PRM aquifer, indicating the potential for upward flow from the Middle PRM aquifer to the Upper PRM aquifer. Water levels near the center of the cone of depression in Camden County rose more than 10 ft compared to the water levels measured in 2008 (DePaul and Rosman, 2015) (fig. 23*A*).

Water levels in the overlying Englishtown aquifer system were as much as 80 ft greater near the center of the cone of depression in Camden County, more than 90 ft greater in the Adelphia quadrangle in Monmouth County, and more than 50 ft greater in north-central Ocean County compared to those in the Upper PRM aquifer. The higher water levels in the Englishtown aquifer system indicate the potential for downward flow from the Englishtown aquifer system to the Upper PRM aquifer in those areas.

Water levels measured during 2008 and 2013 were compared for 191 wells (app. 8) to evaluate water-level changes in the Upper PRM aquifer and to map the differences between the potentiometric surfaces (fig. 23*A*). Of the 191 wells measured in 2008 and 2013, water levels declined in 13 (7 percent); a decline of greater than 10 ft was measured in 1 well (well 23-101, −11 ft). In contrast, water levels rose in 161 wells (about 84 percent) and rose 10 ft or more in 23 of those wells (14 percent). Water levels remained stable compared to those in 2008 in 17 wells (9 percent). These results are given in appendix 8 and summarized in table 4 for this aquifer. The differences between the potentiometric surfaces of the Upper PRM aquifer for 2008 and 2013 are shown in figure 23*A*. Water-level recoveries throughout Critical Area 2 are shown in figure 23*A*, whereas water-level declines of about 10 ft are shown in some areas in southeastern Mercer, northwestern Monmouth, and southwestern Middlesex Counties.

Long-term water-level trends in the Upper PRM aquifer were evaluated graphically and compared to water-level trends from the previous 2008 study. Hydrographs for 7 wells in the Upper PRM aquifer in Middlesex or Monmouth County are shown in figure 24 and for 6 wells in Burlington, Camden, Gloucester, or Salem County in figure 25. Well locations are shown on plate 7. For the wells in Monmouth and Middlesex Counties (fig. 24), well 23-292 showed a slight upward trend during 2009–13; a trend was not observed at four wells (23-228, 23-351, 25-206, 25-316). Wells 25-206 and 25-316 are within the boundary of Critical Area 1. A downward trend was observed for one well (25-639) in southern Monmouth County at the northern edge of the cone of depression centered in northeastern Ocean County from the previous 2004–08 study; the water levels in this well from 1998 to 2008 indicate a downward trend using a Mann-Kendall trend test (DePaul and Rosman, 2015). Well 25-639 is within the boundary of Critical Area 1. Data for well 23-180 are too sparse to determine a trend from 2004 to 2013.

In Burlington, Camden, and Gloucester Counties (fig. 25), upward trends during 2009–13 were measured at four wells (5-258, 7-117, 7-477, and 15-741). These four wells are within the boundary of Critical Area 2. DePaul and Rosman (2015) indicate a downward trend from 2003 to 2008 using a Mann-Kendall trend test for these wells. Compared to water levels during 2004–08, the water levels in well 33-253 in Salem County showed an upward trend from 2009 to 2013, and no trend was observed for well 15-728 in Gloucester County.

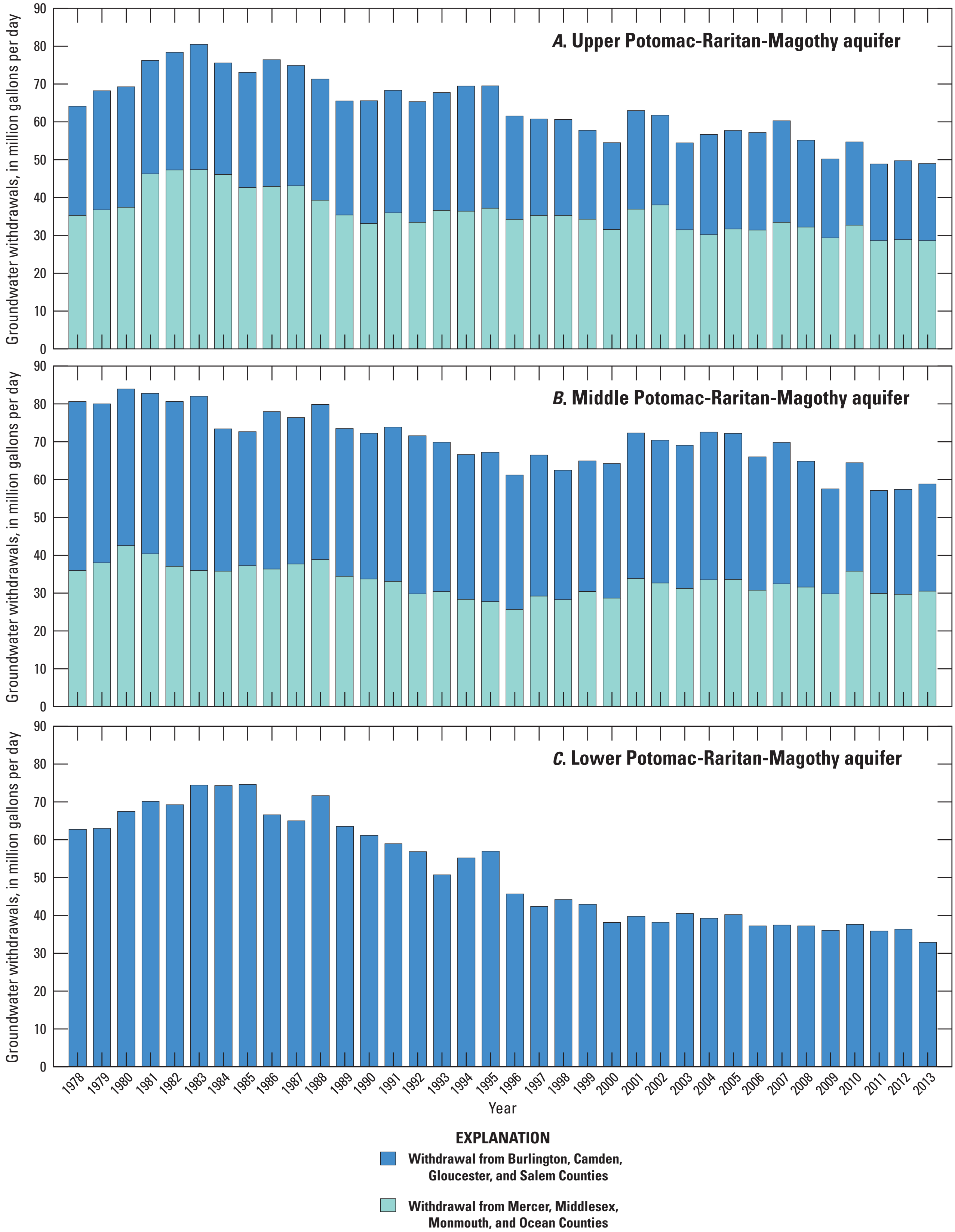


Figure 22. Estimated groundwater withdrawals from the *A*, the Upper, *B*, Middle, and *C*, Lower Potomac-Raritan-Magothy aquifers, New Jersey Coastal Plain, 1978–2013.

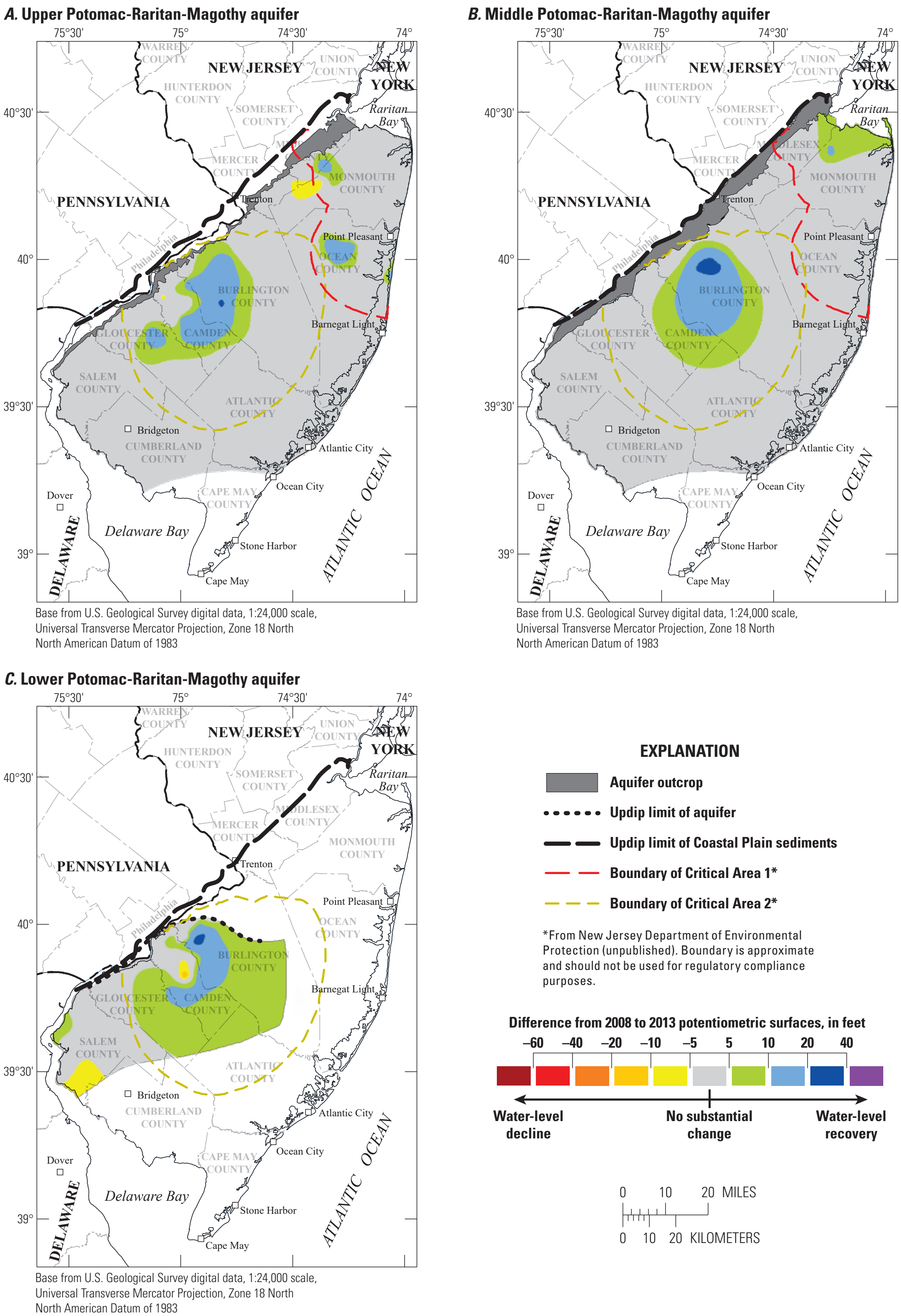


Figure 23. Difference between the 2008 and 2013 potentiometric surfaces in the *A*, Upper, *B*, Middle, and *C*, Lower Potomac-Raritan-Magothy aquifers, New Jersey Coastal Plain.

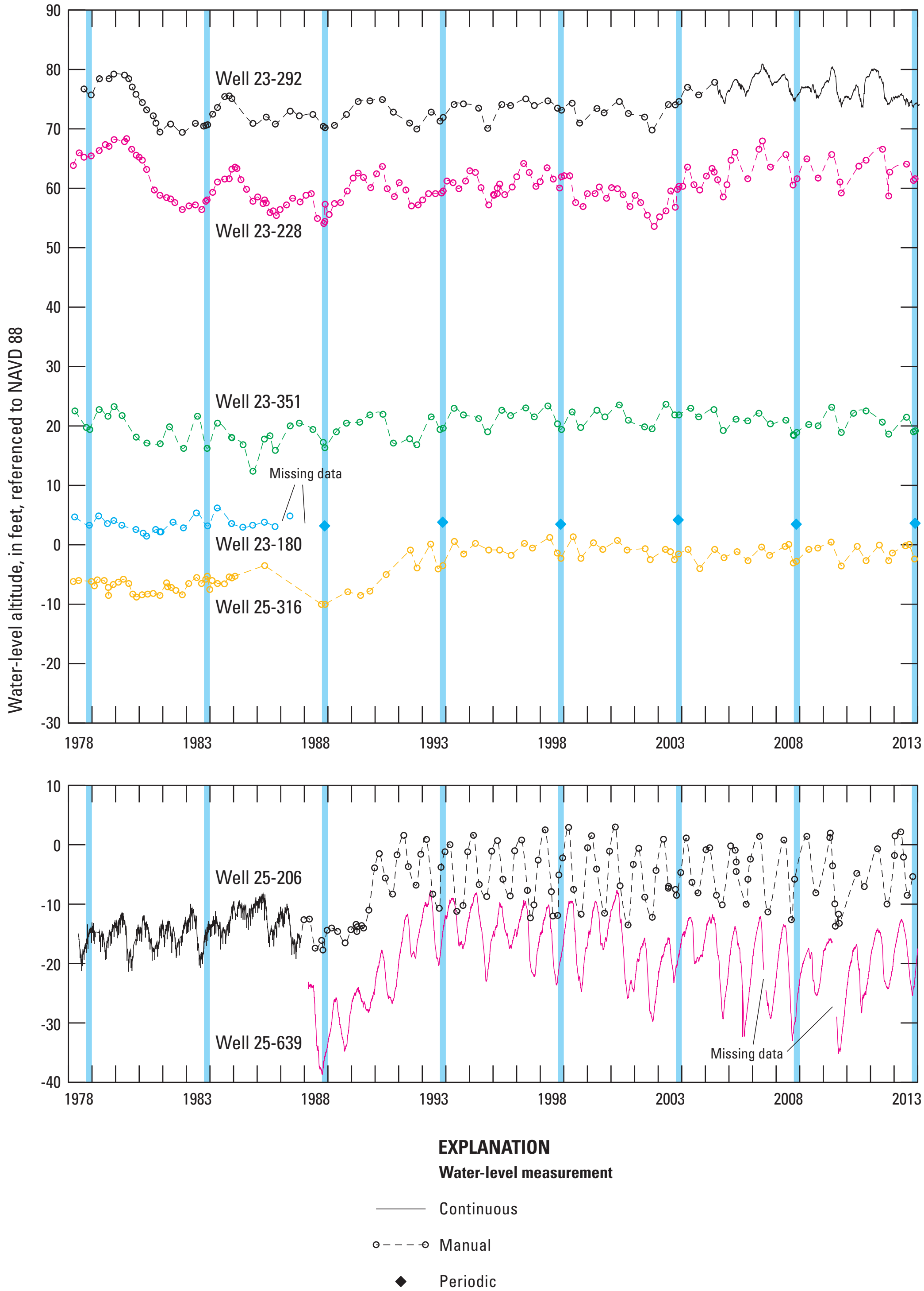


Figure 24. Water-level hydrographs for selected observation wells screened in the Upper Potomac-Raritan-Magothy aquifer in the Middlesex and Monmouth Counties, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

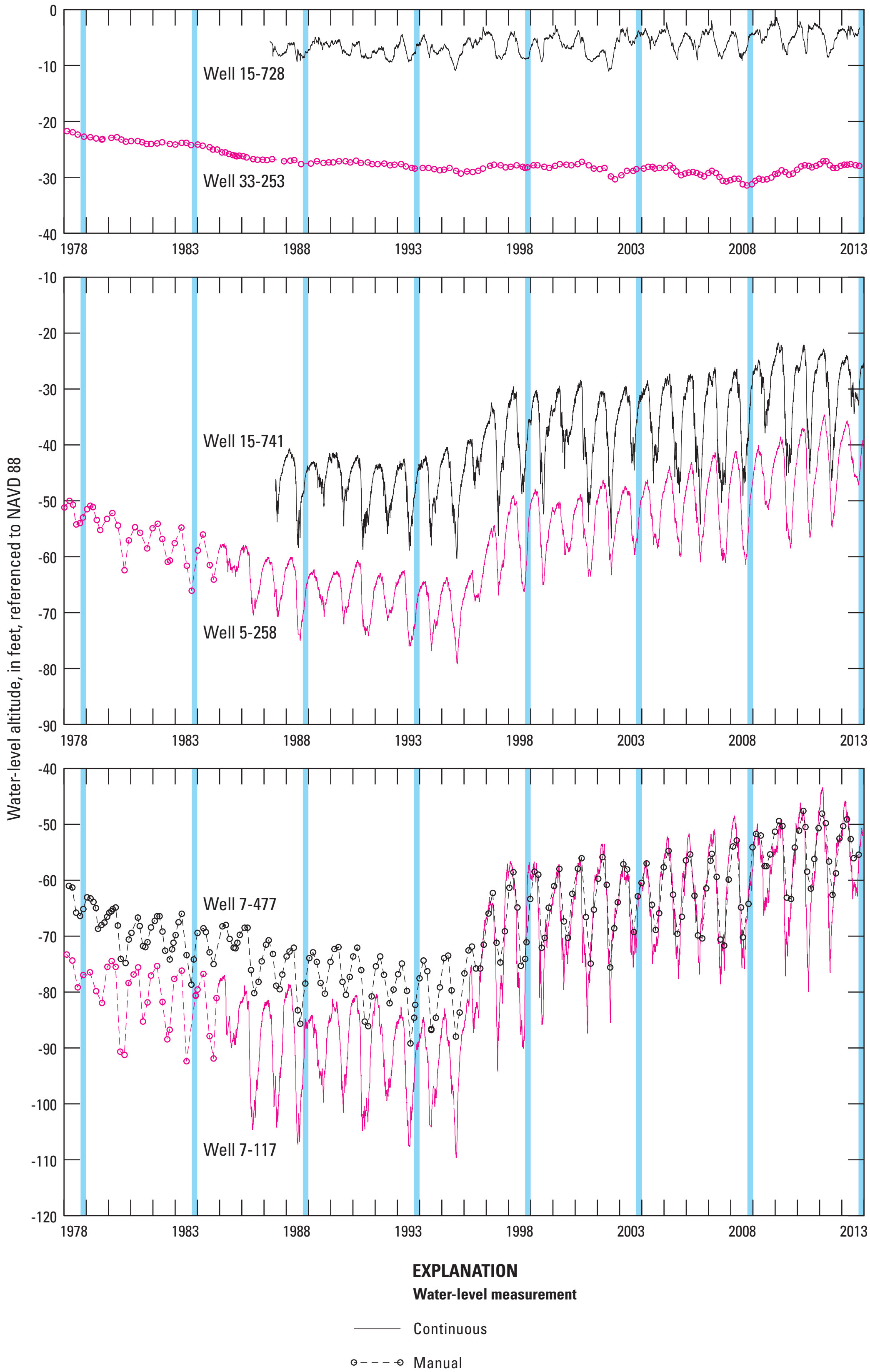


Figure 25. Water-level hydrographs for selected observation wells screened in the Upper Potomac-Raritan-Magothy aquifer in the Burlington, Camden, Gloucester, and Salem Counties, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

Middle and Undifferentiated Potomac-Raritan-Magothy Aquifer

This section presents the discussion of the groundwater withdrawals from the Middle and undifferentiated PRM aquifer. The water levels used to construct the potentiometric surface for the Middle and undifferentiated Potomac-Raritan-Magothy aquifer, change in water levels between 2008 and 2013, and hydrographs are also discussed.

Groundwater Withdrawals

Groundwater withdrawals from the Middle and undifferentiated PRM aquifer occurred from Raritan Bay to Salem County (fig. 21*B*). Primary pumping centers in the aquifer's northern extent are in southern Mercer, western Middlesex, eastern Monmouth, and northern Ocean Counties and in the south, pumping centers are in northern Burlington, Camden, and Gloucester Counties, and parts of Salem County. The distribution of withdrawals is similar to that in the Upper PRM aquifer (fig. 21*A*). As in the Upper PRM aquifer, the presence of elevated dissolved solids in the groundwater inhibits development of the aquifer farther downdip.

Estimated groundwater withdrawals from the Middle PRM aquifer peaked during the early 1980s and were as high as 83.9 Mgal/d in 1980, but from 1984 to 2000 withdrawals were reduced by as much as about 23 Mgal/d in 1996 because of mandated Critical Area restrictions (fig. 22*B*). During 2001–05, withdrawals increased to as much as 72.5 Mgal/d. In 2013, estimated withdrawals totaled 58.7 Mgal/d (table 3), and groundwater withdrawals were greatest in Burlington (14.3 Mgal/d), Middlesex (9.5 Mgal/d), Mercer (8.7 Mgal/d); and Ocean Counties (6.4 Mgal/d). Estimated withdrawals for Monmouth County totaled 5.8 Mgal/d; Gloucester County, 5.7 Mgal/d; and Camden County, 5.6 Mgal/d (table 3). Withdrawals from the aquifer were least in Salem County (2.7 Mgal/d).

Water Levels

The potentiometric-surface map for fall 2013 for the Middle and undifferentiated PRM aquifer is shown on plate 8; supporting water-level data used to construct the map and for determining differences with 2008 water levels are presented in appendix 9. The highest water levels in the Middle PRM aquifer occurred near the updip limit in Mercer and Middlesex Counties (68, 68, and 69 ft at wells 21-120, 21-122, and 23-291, respectively). This high potentiometric surface coincides with groundwater highs in the overlying Upper PRM aquifer; in this area the aquifer historically received the most recharge. The lowest water levels occurred in central Camden County (−57, −53, and −53 ft at wells 7-186, 7-124, and 7-413, respectively) and are associated with the long-term regional cone of depression, and one low water level occurred in Salem County (−71 ft, well 33-934) adjacent to the Delaware River. The major feature of the potentiometric surface is the regionally extensive cone of depression that encompasses much of the study area and extends from the Raritan Bay in the northeast to Salem County in the southwest, much like the regional cone of depression in the Upper PRM aquifer.

The north-central area of the regional cone of depression includes much of southeastern Monmouth and northern Ocean Counties and is within Critical Area 1. Water levels in this area ranged from −31 ft (well 29-440) to −11 ft (well 29-1113); the lowest water levels occurred near pumping centers near Lakewood in northern Ocean County (plate 8). Water levels east of the area near Lakewood ranged from −27 ft (well 29-588) to −21 ft (wells 29-47 and 29-779). In parts of Monmouth County and north-central Ocean County within Critical Area 1 where the overlying Upper PRM aquifer is pumped, water levels were generally from 10 to 60 ft lower in the Upper PRM aquifer than in the Middle PRM aquifer, indicating the potential for upward flow from the Middle PRM aquifer to the Upper PRM aquifer.

The central segment of the regional cone of depression underlies a broad area of the New Jersey Coastal Plain, extending through Ocean, Burlington, Camden, Atlantic, and Gloucester Counties. The lowest water levels measured in central Camden County in Critical Area 2 ranged from −57 ft (well 7-186) to −50 ft (well 7-734). Low water levels were present in central Camden County despite few withdrawal wells screened in the Middle PRM aquifer in this area; substantial withdrawals from the Upper PRM and the underlying Lower PRM aquifers likely induce leakage through adjacent confining layers. Within the regional cone of depression in Camden, Gloucester, and Burlington Counties in Critical Area 2, water levels were about 10 ft lower in the Upper PRM aquifer than in the Middle PRM aquifer, indicating the potential for upward flow from the Middle PRM aquifer to the Upper PRM aquifer.

Water levels in Salem County ranged from −71 ft (well 33-934) to −16 ft (well 33-166). Water levels were estimated to be highest in the central part of the county, and measured water levels were lowest along the Delaware River where localized cones of depression are present adjacent to the Delaware River. Previous studies documented potentiometric-surface lows extending beneath the Delaware Bay and into northern Delaware and eastern Maryland (Lacombe and Rosman, 2001; DePaul and others, 2009).

The difference in the potentiometric surface between 2008 and 2013 in the Middle PRM aquifer is shown in figure 23*B*; supporting water-level data used to construct the potentiometric surface and for determining differences between 2008 and 2013 are presented in appendix 9. Of the 159 wells measured in 2008 and 2013, water levels declined in 19 wells (12 percent) in 2013; a decline of greater than 5 ft was measured in one well (5-127, −6 ft) (app. 9). In contrast, water levels increased in 124 wells (78 percent); of these wells, water levels increased 10 ft or greater in 13 wells (10 percent). Water levels remained about the same compared to 2008 in 16 wells (10 percent). These results are summarized in table 4 for this aquifer. Stable or rising water levels were associated with the regional cone of depression in Critical Area 1 in eastern Middlesex and northeastern Monmouth Counties. In Critical Area 2, water-level recoveries of greater than 5 ft were measured in most central parts of Burlington and Camden Counties and in eastern Gloucester County. Two wells, 7-132 and adjacent 7-135, in eastern Camden County within the boundary of Critical Area 2 had water-level recoveries of 17–18 ft, respectively. Most wells in the updip area of Burlington County experienced recoveries in water levels of about 1–14 ft, although one well (5-127) had a decline of 6 ft.

Long-term water-level trends in the Middle PRM aquifer were evaluated graphically and compared to water-level trends from the previous 2008 study. Water-level hydrographs for nine wells screened in the Middle and the undifferentiated PRM aquifer within or adjacent to Critical Area 1 are shown in figure 26; well locations are shown on plate 8. From 2003 to 2008, downward trends in water levels were determined using a Mann-Kendall trend test (DePaul and Rosman, 2015) for wells 29-19 and 29-85 within Critical Area 1 in Ocean County; however, during 2009–13 an upward trend in water levels was indicated at these wells. The average increase in water levels during 2009–13 was 1.3 ft for well 29-19 and 1.1 ft for well 29-85. Results of the Mann-Kendall trend test indicate that the water levels in well 23-291 in western Middlesex County outside Critical Area 1 and well 25-635 in southern Monmouth County in Critical Area 1 show no apparent change during 2003–08 (DePaul and Rosman, 2015), and this trend continued through 2013 for well 23-291. However, the average increase in water levels during 2009–13 was 2.6 ft for well 25-635. Limited water-level data during 2003–08 precluded a statistical analysis of well 23-273 (DePaul and Rosman, 2015); this well shows no apparent change during 2009–13. Results of the Mann-Kendall statistical test (DePaul and Rosman, 2015) indicate an upward trend for well 25-272 from 2003 to 2008; this trend continues through 2013. The average increase in water levels during 2009–13 was 3.5 ft for this well. Available water-level data for well 23-439 indicate a slight increase during 2009–13 from 2004–08, although data for this well are limited. Available water-level data for 23-97 and 23-482 are sparse; neither an upward nor downward trend was determined for these wells.

Groundwater hydrographs for 10 wells screened in the Middle and undifferentiated PRM aquifer within or adjacent to Critical Area 2 or in Salem County are shown in figure 27; well locations are shown on plate 8. Upward trends during 2009–13 were observed for nine wells (5-63, 5-261, 5-440, and 5-683 in Burlington County; 7-413 and 7-476 in Camden County; 11-137 in Cumberland County; 15-713 in Gloucester County; and 33-251 in Salem County) from 2004–08. This upward trend is also documented by DePaul and Rosman (2015) by using a Mann-Kendall statistical test, which indicated a significant rise in the water levels from 2003 to 2008 for five wells (5-261, 5-683, 7-413, 7-476, and 11-137). However, results of the Mann-Kendall statistical test (DePaul and Rosman, 2015) indicate no significant trend for wells 5-63, 5-440, and 15-713 from 2003 to 2008 and a downward trend for well 33-251 in Salem County. Seasonal water-level fluctuations were greatest at wells nearest the center of the cone of depression (7-413 and 5-261). Limited data are available for the period 2004–13 for well 33-187 to determine a trend.

Lower Potomac-Raritan-Magothy Aquifer

This section presents the discussion of the groundwater withdrawals from the Lower PRM aquifer. The water levels used to construct the potentiometric surface for the Lower PRM aquifer, determine change in water levels between 2008 and 2013, and hydrographs are also discussed.

Groundwater Withdrawals

Estimated groundwater withdrawals from the Lower PRM aquifer in New Jersey were made predominantly in areas adjacent to the Delaware River (fig. 21*C*) and totaled 32.9 Mgal/d in 2013 (table 3). Most withdrawals (approximately 23.1 Mgal/d or 70 percent) were made in northern Camden County in proximity to the Delaware River, although pumping centers are present as far as 11 mi downdip in the central part of the county. Substantial withdrawals (6.7 Mgal/d) were made in Burlington County along the Camden County border and near the northern limit of the aquifer. In Salem (1.7 Mgal/d) and Gloucester (1.4 Mgal/d) Counties, withdrawals were made in the extreme updip parts of the aquifer owing to the presence of saline water in downdip areas. Three primary water purveyors in Camden County made withdrawals from this aquifer and together accounted for about 82 percent of withdrawals in the county during 2013. Groundwater withdrawals from the Lower PRM aquifer peaked during the mid-1980s and were nearly 75 Mgal/d in 1985, but from 1986 to 2013 withdrawals were reduced, by as much as about 42 Mgal/d in 2013, because of mandated Critical Area restrictions on withdrawals (fig. 22*C*).

Water Levels

The potentiometric-surface map during fall 2013 for the Lower PRM aquifer is shown on plate 9; water-level data from wells used to construct this map and determine differences in water levels between 2008 and 2013 are listed in appendix 10. Water-level measurements were made at 92 wells—87 in New Jersey and 2 in Pennsylvania (P10113 and P10114). Water levels for three wells (Db33-17, Db33-18, and Dc34-05) in Delaware were obtained from the Delaware Geological Survey (Delaware Geological Survey, 2017). Interpretation of the potentiometric surface was extended into northeastern Delaware because of the potential effect of long-term withdrawals in Delaware on water levels in southwestern New Jersey. The cone of depression in Delaware has been documented and mapped during previous water-level studies (DePaul and others, 2009; DePaul and Rosman, 2015).

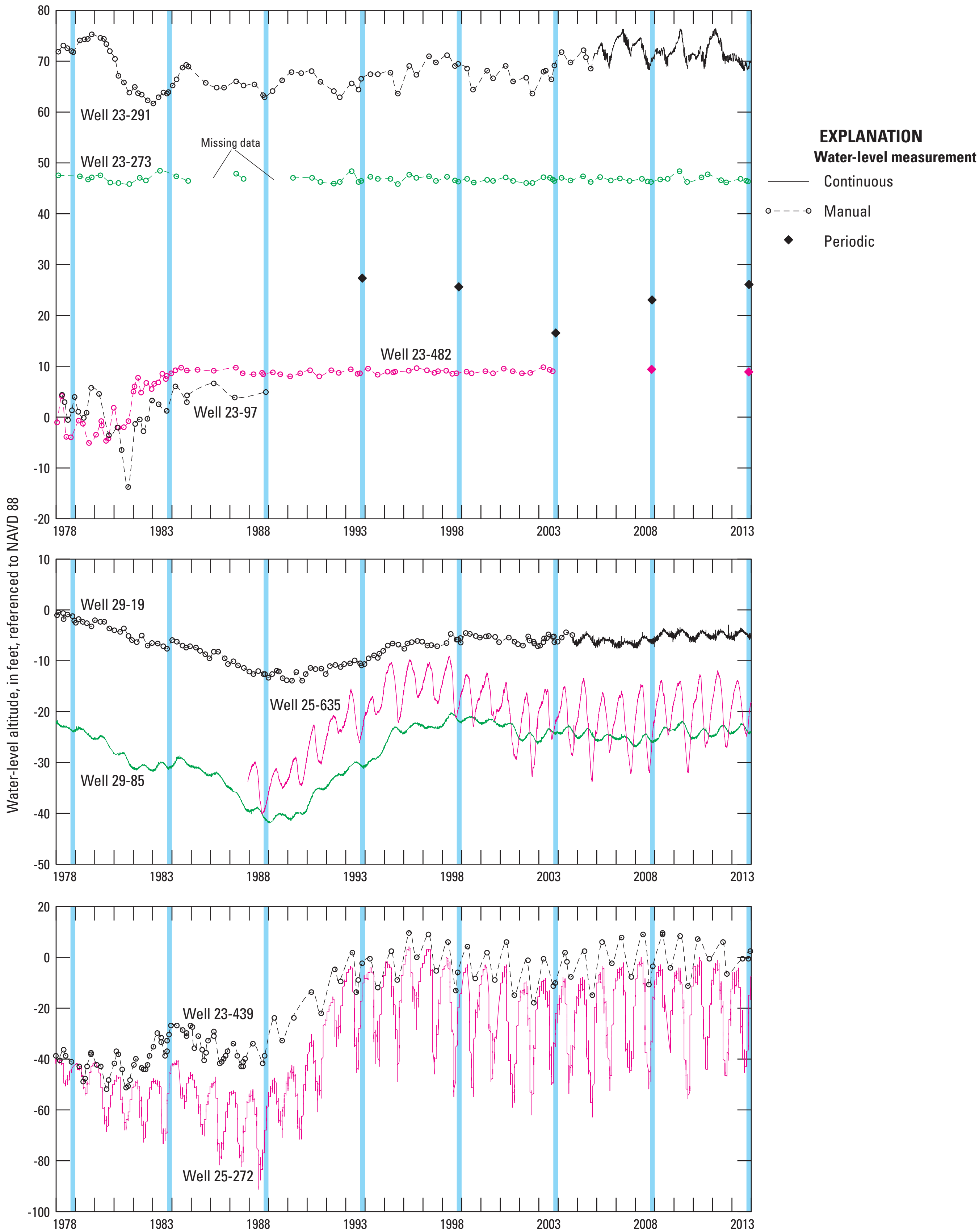


Figure 26. Water-level hydrographs for selected observation wells screened in the Middle and undifferentiated Potomac-Raritan-Magothy aquifer in the Middlesex, Monmouth, and Ocean Counties, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

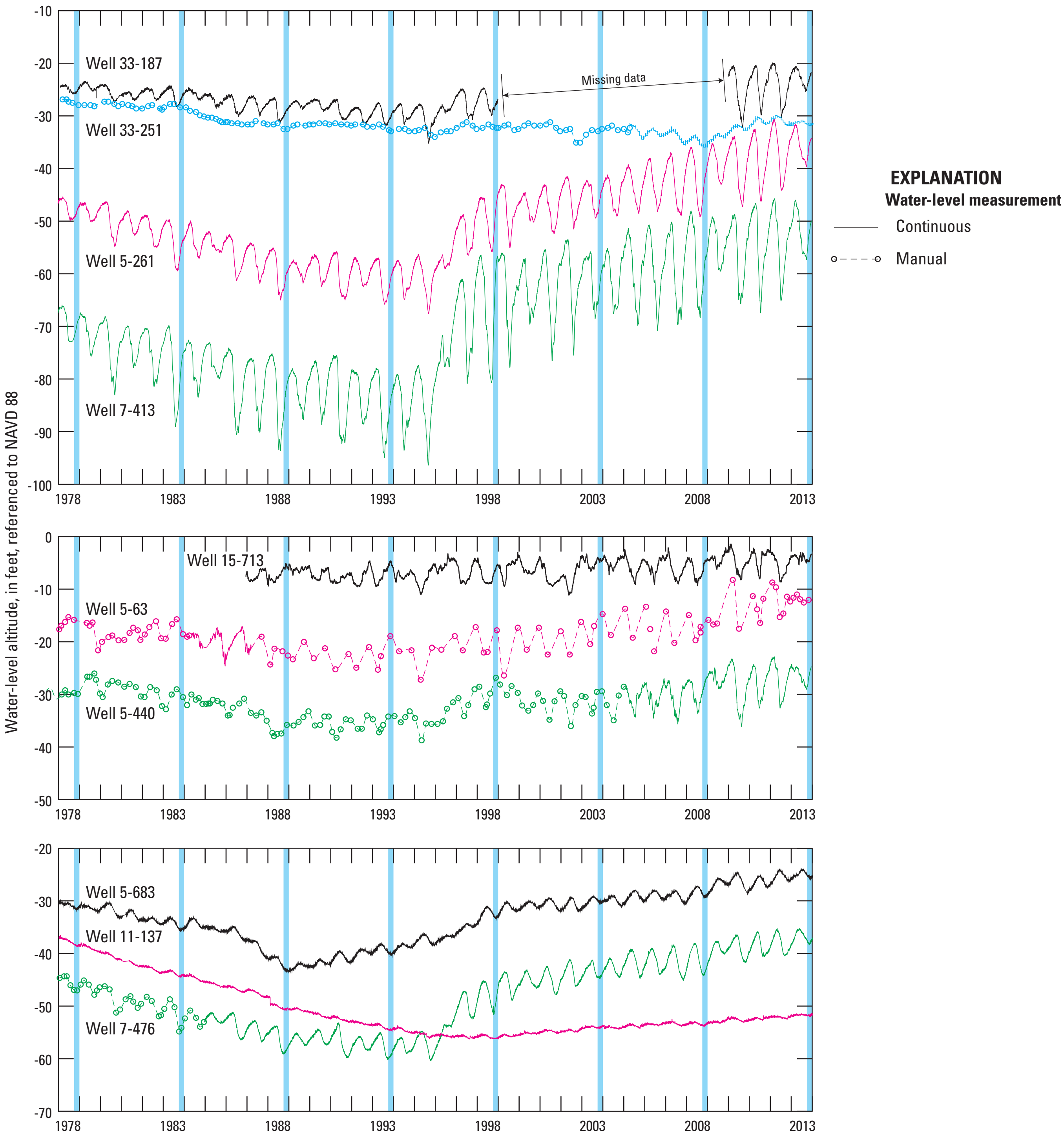


Figure 27. Water-level hydrographs for selected observation wells screened in the Middle and undifferentiated Potomac-Raritan-Magothy aquifer in the Burlington, Camden, Cumberland, and Gloucester Counties, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles. Well 11-137 not corrected for density.)

The configuration of the potentiometric surface in New Jersey is slightly elongated from northeast to southwest along the formational strike and centered in Camden County. The location and configuration of the cone of depression is similar to that of the overlying Middle PRM aquifer. During 2013, water levels ranged from −78 ft at well 7-185 in central Camden County to 2 ft at well 5-146 in northwestern Burlington County. Throughout the aquifer, water levels typically were at or below 0 ft; water levels at or greater than this value occurred adjacent to the Delaware River along the northwestern boundary of the aquifer in Burlington and Gloucester Counties. The lowest water levels (less than −70 ft) in New Jersey were measured in central Camden County. The general direction of lateral groundwater flow is dominated by the large cone of depression; flow moves radially from the updip and downdip margins of the aquifer toward potentiometric lows at pumping centers. A groundwater divide is present approximately along the border between Gloucester and Salem Counties; southwest of this divide groundwater flow is beneath the Delaware Bay toward the regional cone of depression in Delaware.

The differences in potentiometric surfaces between 2008 and 2013 in the Lower PRM aquifer are shown in figure 23*C*; supporting water-level data used for determining differences are presented in appendix 10. Of the 86 wells measured in 2008 and 2013, water levels were lower in 9 of the wells (10 percent), 5 of which show water-level declines of greater than 10 ft (appendix 10). Water levels increased in 73 wells (85 percent) and remained the same in 4 wells (5 percent). These results are summarized in table 4 for this aquifer. A small area in central Camden County had water-level declines of greater than 10 ft (app. 10 and fig. 23*C*), and another small area of water-level decline of between 5 and 10 ft was observed in southwestern Salem County. Elsewhere, water levels showed a rise or were stable throughout most of Critical Area 2.

Long-term water-level trends in the Lower PRM aquifer were evaluated graphically and compared to water-level trends from the previous 2008 study. Groundwater hydrographs for four wells in southern New Jersey are presented in figure 28; well locations are shown on plate 9. Compared to water levels from the 2004–08 study, water levels during 2009–13 showed upward trends at the four wells (5-262, 7-412, 15-671, and 15-712). Results of a Mann-Kendall statistical test indicate that during 2003 to 2008 upward trends occurred at 3 wells (5-262, 7-412, and 15-671), and a downward trend occurred at 1 well (15-712) (DePaul and Rosman, 2015).

Water-level measurement taking place October 2018 in Monmouth County, New Jersey. Photo by Alex Fiore, U.S. Geological Survey.

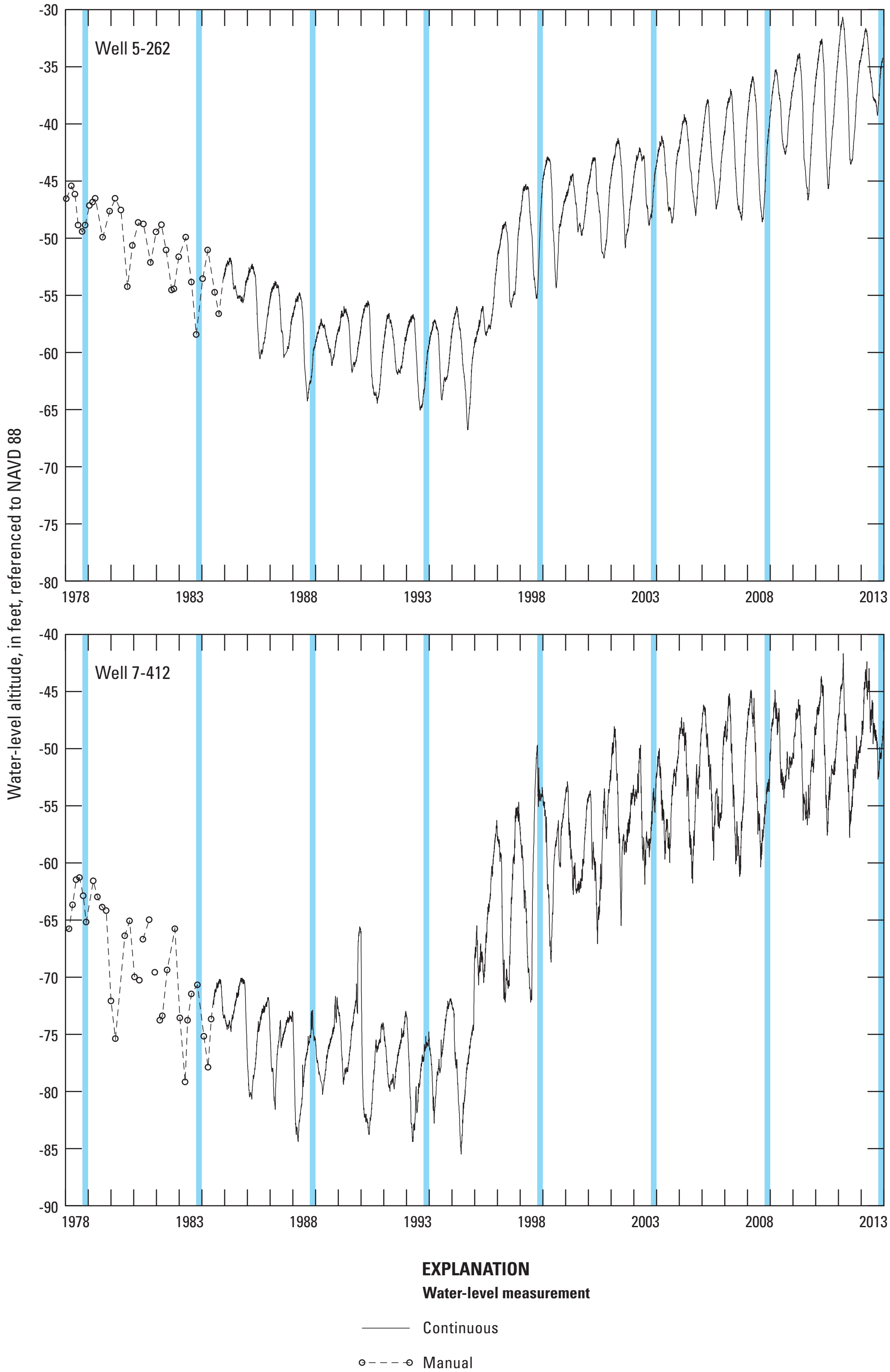


Figure 28. Water-level hydrographs for selected observation wells screened in the Lower Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)

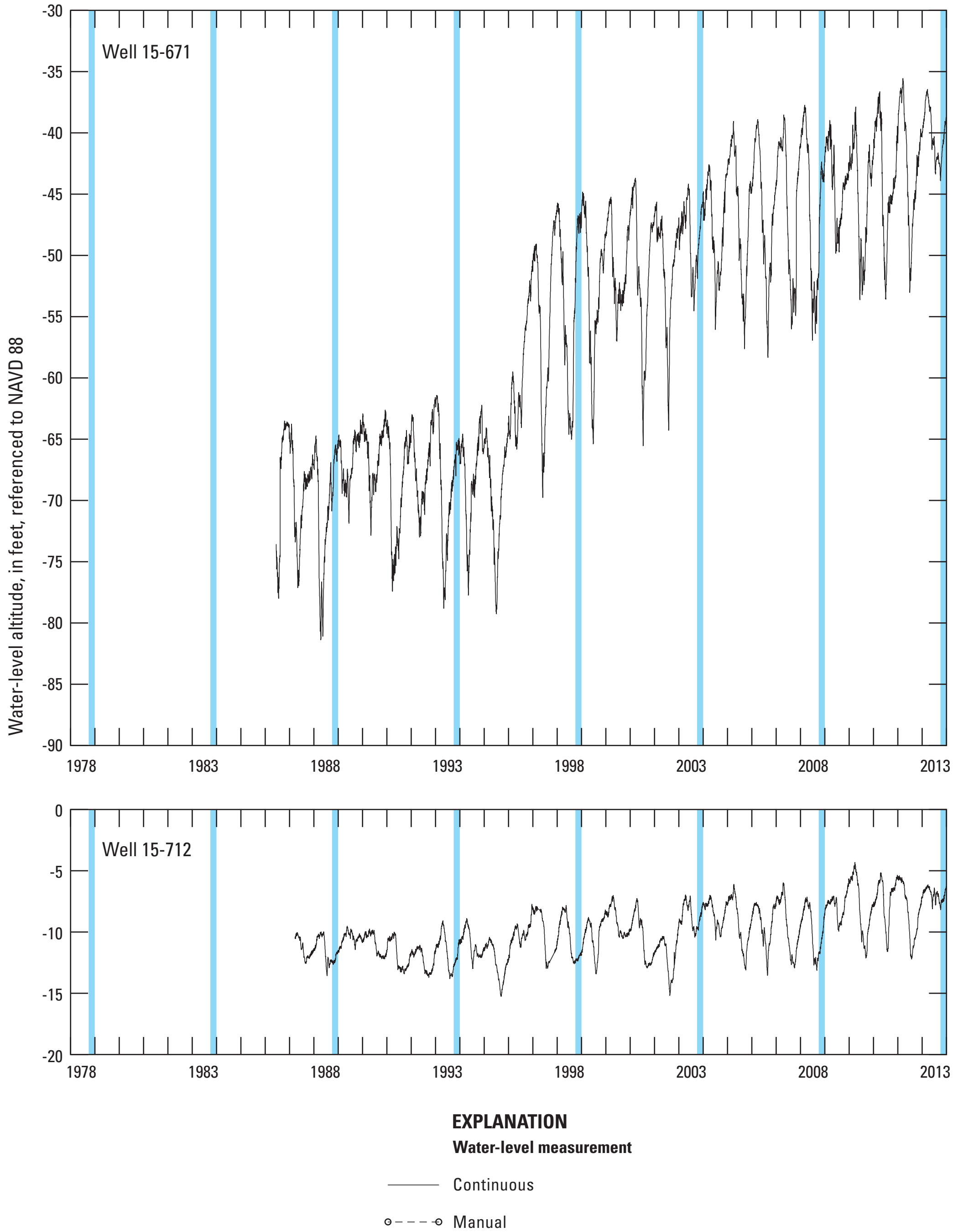


Figure 28. Water-level hydrographs for selected observation wells screened in the Lower Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013. (Vertical bars denote 5-year data collection cycles.)—Continued

Comparison of 1983 and 2013 Water Levels in Critical Areas 1 and 2

As previously mentioned, the State of New Jersey instituted a program in the late 1980s to reduce groundwater withdrawals in two designated Critical Areas that had large declines in water levels in certain aquifers used for water supply. These declines, if continued, would have affected the water supply in those two regions of the State. The water levels for 1983 (Eckel and Walker, 1986) and 2013, in this report, are shown as a series of potentiometric-surface maps with contoured water levels. The potentiometric surface for 2013 indicate that the water levels generally are recovering in the Critical Areas, particularly at the center of the regional cones of depression measured in the Critical Areas in 1983. In 1983 in Middlesex, Monmouth, and Ocean Counties (the counties located in Critical Area 1), groundwater withdrawals totaled approximately 8.9 and 1.1 Mgal/d for the Englishtown aquifer system and the Wenonah-Mount Laurel aquifer, respectively; withdrawals from the Upper and Middle PRM aquifers totaled 74.8 Mgal/d (Eckel and Walker, 1986). In 2013 in Middlesex, Monmouth, and Ocean Counties, groundwater withdrawals totaled approximately 5.6 and 0.8 Mgal/d from the Englishtown aquifer system and the Wenonah-Mount Laurel aquifer, respectively, and withdrawals from the Upper and Middle PRM aquifers totaled 49.8 Mgal/d (table 5). This is a reduction in withdrawals from the Englishtown aquifer system and the Wenonah-Mount Laurel aquifer of 37 and 27 percent, respectively, and 33 percent from the Upper and Middle PRM aquifers, from the 1983 amounts in these three counties in Critical Area 1. The groundwater withdrawals in Critical Area 1 from these aquifers are summarized in table 5 for 1983 and 2013.

In 1983 in Burlington, Camden, and Gloucester Counties (the counties in Critical Area 2), groundwater withdrawals from the Upper, Middle, and Lower PRM aquifers totaled about 130.4 Mgal/d (Eckel and Walker, 1986). The counties with smaller areas in Critical Area 2 were not used in this analysis (Atlantic, Cumberland, Ocean, and Salem). In 2013 in Burlington, Camden, and Gloucester Counties, the withdrawals from these aquifers totaled approximately 75.8 Mgal/d (table 5). This is a reduction in withdrawals from the Upper, Middle, and Lower PRM aquifers of about 42 percent from the 1983 amounts in these counties. The groundwater withdrawals in Critical Area 2 from the Upper, Middle, and Lower PRM aquifers are summarized in table 5 for 1983 and 2013. Restrictions in groundwater withdrawals, along with obtaining water supply from other sources mentioned previously, have resulted in water-level recoveries within the Critical Areas.

Water-level trends were evaluated for 249 wells measured in 1983 and 2013 within the Critical Areas. An analysis using the statistical program R (The R Core Team, 2016) was completed to evaluate the recovery of water levels within the Critical Areas after mandated withdrawal reductions were implemented by comparing data from 1983 with data from 2013. The 1983 water levels were chosen because they predate the mandatory restrictions in groundwater withdrawals in both Critical Areas, and the 1983 potentiometric surfaces for many aquifers show low water levels in the Critical Areas resulting from large withdrawals (Eckel and Walker, 1986).

The water-level data for 1983 and 2013 were grouped by well location in Critical Area 1 or 2 and by aquifer. Because the data are not normally distributed, which was verified by qqplots in R, a non-parametric Wilcoxon signed-rank test was used to test the difference between the 2013 and 1983 measurements for the paired wells grouped by aquifer and by

Table 5. Groundwater withdrawals in Critical Areas 1 and 2, by aquifer and county, New Jersey Coastal Plain, 1983 and 2013

[Withdrawals, in million gallons per day; PRM, Potomac-Raritan-Magothy]

Aquifer	Withdrawals		Percent decrease in withdrawals between 1983 and 2013
	[1]1983	[2]2013	
Middlesex, Monmouth and Ocean Counties (Critical Area 1)			
Wenonah-Mount Laurel	1.1	0.8	27
Englishtown aquifer system	8.9	5.6	37
Upper and Middle PRM	74.8	49.8	33
Burlington, Camden and Gloucester Counties (Critical Area 2)			
Upper, Middle and Lower PRM	130.4	75.8	42

[1]Withdrawals from Eckel and Walker, 1986.

[2]Withdrawals from New Jersey Department of Environmental Protection, 2017.

Critical Area. Tests were performed on the data grouped by these criteria. A one-tailed test was done to determine whether the 2013 water-level measurement is greater (water-level recovery) than the 1983 measurement. Each water-level measurement made in 1983 was subtracted from the corresponding 2013 measurement to test for a significant change in water level. Statistical tests were performed on the paired differences between the 1983 and 2013 measurements using the nonparametric Wilcoxon signed-rank test (Wilcoxon, 1945; Helsel and Hirsch, 2002). The null hypothesis for each test was the difference between paired measurements is equal to zero or no statistical difference exists. The alternative hypothesis is that there is a difference, which would indicate a water-level recovery. Because the ranks of differences rather than the actual values are used, the magnitude of the differences does not affect the outcome of the test. Nine Wilcoxon signed-rank tests were performed—7 on each aquifer in each Critical Area and 2 on all the measurements made in each Critical Area. A summary for each Wilcoxon signed-rank test is given in table 6. Differences were considered significant if a p-value of less than or equal to 0.05 was attained. As the p-value decreases, evidence for rejecting the null hypothesis increases.

Results of the Wilcoxon signed-rank test determined that all p-values are less than 0.05, indicating statistically significant differences between water-level measurements from 1983 and 2013. The results of the one-tailed test indicate water-level recovery. The number of wells compared for each test is given in table 6. The null hypothesis (no statistical difference in 1983 and 2013 water levels) is rejected at the 0.05 level for the designated aquifers in Critical Area 1 and Critical Area 2.

In Critical Area 1, water levels have recovered about 140, 100, and 80 ft from 1983 water levels (Eckel and Walker, 1986) in the Englishtown aquifer system, the Wenonah-Mount Laurel aquifer, and Middle PRM aquifer, respectively, at the center of the regional cones of depression or areas of potentiometric lows in these aquifers. In the Upper PRM aquifer, water levels in central Monmouth County recovered by as much as 40 ft; however, during the 1983 study, water levels were not measured in northern Ocean County where a cone of depression was observed in 2013. In Critical Area 2, water levels recovered about 30, 30, and 10 ft from 1983 water levels (Eckel and Walker, 1986) in the Upper, Middle, and Lower PRM aquifers, respectively, at the regional cone of depression in each of these aquifers centered in Camden County.

Table 6. Results of the Wilcoxon signed-rank tests for paired differences for wells in designated aquifers within Critical Areas 1 and 2, New Jersey Coastal Plain, 1983 and 2013.

[<, less than]

Aquifer	p-value	Number of wells in analysis
Critical Area 1		
Wenonah-Mount Laurel aquifer	<0.001	17
Englishtown aquifer system	0.008	32
Upper Potomac-Raritan-Magothy aquifer	0.003	51
Middle Potomac-Raritan-Magothy aquifer	<0.001	27
All four aquifers	<0.001	127
Critical Area 2		
Upper Potomac-Raritan-Magothy aquifer	0.014	55
Middle Potomac-Raritan-Magothy aquifer	0.004	31
Lower Potomac-Raritan-Magothy aquifer	<0.001	36
All three aquifers	<0.001	122

Summary and Conclusion

The Coastal Plain aquifers of New Jersey provide an important source of water for more than 3.5 million people. In 2013, estimated groundwater withdrawals from 10 confined aquifers of the New Jersey Coastal Plain totaled about 189.6 million gallons per day. Steadily increasing withdrawals from the late 1800s to the early 1990s resulted in declining water levels. The formation of regional cones of depression in many confined Coastal Plain aquifers intensified during the late 1970s and early 1980s, prompting the designation of two water-supply Critical Areas by the New Jersey Department of Environmental Protection. The cones of depression have been of concern since then. Starting in 1978, the U.S. Geological Survey began mapping the potentiometric surfaces of the major confined Coastal Plain aquifers every 5 years to provide a regional assessment of groundwater. This report is the eighth in the series of reports that show the potentiometric surfaces for the major confined aquifers of the New Jersey Coastal Plain. The study was conducted by the U.S. Geological Survey in cooperation with the New Jersey Department of Environmental Protection.

Water levels in 10 confined aquifers of the New Jersey Coastal Plain were measured and evaluated to provide a regional overview of groundwater conditions during fall 2013. Water levels were measured in 987 wells in New Jersey, Pennsylvania, and Delaware, and potentiometric-surface maps were prepared for, in ascending order of age, the confined Cohansey aquifer in Cape May County, Rio Grande water-bearing zone, Atlantic City 800-foot sand, Piney Point aquifer, Vincentown aquifer, Wenonah-Mount Laurel aquifer, Englishtown aquifer system, and the Upper, Middle, and Lower aquifers of the Potomac-Raritan-Magothy (PRM) aquifer system. Potentiometric surfaces show persistent, regionally extensive cones of depression are present in the potentiometric surfaces of the Englishtown aquifer system and Wenonah-Mount Laurel aquifer centered in Ocean and Monmouth Counties; in the Wenonah-Mount Laurel and the Upper, Middle, and Lower PRM aquifers centered in Camden County; and in the Atlantic City 800-foot sand centered in Atlantic County. Since 2008, cones of depression in the potentiometric surfaces have deepened in the Piney Point aquifer in Cumberland County and coastal Atlantic and Ocean Counties, in the Englishtown aquifer system in northeastern Ocean and southeastern Monmouth Counties, and in the Lower PRM aquifer in central Camden County.

Water-level changes were assessed in 832 wells measured in New Jersey during fall 2008 and 2013. In the confined Cohansey aquifer in Cape May County, water levels generally did not change. Water levels in the Atlantic City 800-foot sand were about 10 feet (ft) greater in some areas in southern Cape May County compared to those from the previous 2008 study. Water-level declines of more than 20 ft occurred in the Piney Point aquifer, relative to 2008 water levels in central and northern Cumberland County, and declines of 10 ft or more occurred in areas of coastal Atlantic and Ocean Counties. In the Wenonah-Mount Laurel aquifer throughout parts of central Burlington County water-level recoveries of 10 ft or more were measured, and water-level recoveries of 20 ft or more were measured at the border of central Gloucester and Camden Counties compared to those from the previous 2008 study. Water levels in the Englishtown aquifer system declined in southeastern Monmouth and northeastern Ocean County by more than 10 ft. From 2008 to 2013 in the Upper PRM aquifer, water levels were stable or showed recovery in parts of northern coastal Ocean County and eastern Monmouth County (Critical Area 1), and water levels continued to recover by about 10 ft or more in central Burlington, Gloucester, and Camden Counties (Critical Area 2). In the Middle PRM aquifer, water levels recovered in parts of central Camden and Burlington Counties (Critical Area 2) by more than 10 ft; water levels were stable through most coastal areas of Monmouth and Ocean Counties (Critical Area 1). Compared to 2008, water levels in 2013 in the Lower PRM aquifer were more than 10 ft lower in the center of the cone of depression in central Camden County in Critical Area 2 but remained stable or showed a recovery throughout most of the aquifer.

Because the potentiometric-surface maps included in this report are based on water levels measured generally toward the end of 2013, seasonal water-level fluctuations are presented in time-series hydrographs for 77 wells during 1978–2013. Analyses of hydrographs of water levels for 77 wells from 1978 to 2013 indicate that during 2009–13 a downward water-level trend was observed for 14 wells (18 percent), an upward trend was observed for 34 wells (44 percent), and no significant change or no determination was observed for 29 wells (38 percent). Downward trends occurred most often for wells screened in the Piney Point aquifer and the Atlantic City 800-foot sand. Upward water-level trends were most frequent in wells screened in the PRM aquifer system.

Water-level trends were evaluated statistically for 249 wells measured within the Critical Areas in 1983 and 2013. Water levels from a previous 1983 study, which predates any mandatory pumping restrictions in the Critical Areas, were compared with water levels from the 2013 study. In Critical Area 1, water levels have recovered about 140, 100, and 80 ft from 1983 water levels in the Englishtown aquifer system, Wenonah-Mount Laurel aquifer, and Middle PRM aquifers, respectively, at the center of the regional cones of depression or areas of potentiometric lows in these aquifers. In the Upper PRM aquifer, water levels in Monmouth County recovered by as much as 40 ft; however, during the 1983 study, water levels were not measured in northern Ocean County where a cone of depression was observed in 2013. In Critical Area 2, water levels recovered about 30, 30, and 10 ft from 1983 water levels in the Upper, Middle, and Lower PRM aquifers, respectively, at the regional cone of depression centered in Camden County.

Because of the large population in the New Jersey Coastal Plain dependent on groundwater pumped from the confined aquifers for water supply, as well as for commercial and industrial uses, monitoring and periodically examining the condition of this important resource is necessary. These large-scale water-level data surveys and the subsequent evaluation of the data completed every 5 years provide a regional overview of groundwater conditions that assesses this resource and helps identify vulnerabilities to ensure their sustainability for current and future groundwater use.

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Appendix 1. Water-level data for wells screened in the confined Cohansey aquifer, New Jersey Coastal Plain, 1978–2013.

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
9−11	5700004898	Cape May	281–321	6	--	−22	−15	−18	−16	−13	−11	−9	2	12/9/2013
9−18	--	Cape May	295–325	6	--	--	--	--	--	−12	−12	−10	2	12/12/2013
9−27	3700000013	Cape May	277–306	11	−20	−26	−16	−20	−17	−10	−11	−9	2	12/9/2013
9−30	--	Cape May	305–325	10	--	--	--	--	−15	−14	−15	−14	1	12/12/2013
9−36	--	Cape May	174–282	13	−23	−30	−17	−23	−14	−12	−13	−10	3	12/9/2013
9−42	3700000268	Cape May	259–289	6	--	−17	−11	--	−15	−18	−10	−8	2	12/8/2013
9−43	5700000011	Cape May	246–276	14	--	−29	−17	−25	−20	−12	−13	−10	3	12/9/2013
9−48	--	Cape May	242–252	16.18	--	−23	−18	−23	−18	−13	−11	−10	1	12/7/2013
9−49	**--**	**Cape May**	**241–250**	**4.72**	**−17**	**−16**	**−14**	**−15**	**−14**	**−14**	**−15**	**−10**	**5**	**12/12/2013**
9−52	3700000113	Cape May	241–262	18	--	−15	−16	−22	−19	−14	−17	−14	3	12/10/2013
9−54	3700000223	Cape May	212–247	14	--	−18	−16	−20	−21	−17	−16	−14	2	12/10/2013
9−60	**--**	**Rio Grande**	**242–257**	**11.79**	**--**	**−13**	**−14**	**−17**	**−13**	**−14**	**−11**	**−9**	**2**	**12/12/2013**
9−74	5700000007	Rio Grande	191–231	6.9	--	--	--	−25	−15	--	−14	−7	7	12/11/2013
9−78	3700000002	Rio Grande	229–250	6.5	--	--	--	--	--	--	−10	−9	1	12/11/2013
9−80	**--**	**Stone Harbor**	**242–252**	**12.34**	**−4**	**−3**	**−5**	**−6**	**−6**	**−3**	**−5**	**−2**	**3**	**12/16/2013**
9−89	3700000158	Rio Grande	195–210	6.06	−3	−3	−3	−3	−2	−4	−6	−3	3	12/12/2013
9−99	3500000680	Stone Harbor	214–230	9.43	2	3	2	2	2	3	1	4	3	12/12/2013
9−150	**3700000155**	**Cape May**	**283–293**	**5.33**	**−19**	**−20**	**−15**	**−18**	**−15**	**−14**	**−14**	**−9**	**5**	**12/4/2013**
9−180	3700000375	Rio Grande	250	12.7	--	−16	−15	--	--	--	−7	−6	1	12/12/2013
9−187	--	Rio Grande	186–190	9	--	--	−7	−8	−4	−5	−6	−6	0	12/7/2013
9−188	--	Rio Grande	229–233	4.2	--	--	−11	−12	−10	−9	−7	−7	0	12/7/2013
9−210	--	Cape May	216–221	9.74	--	--	−10	−15	−14	−11	−11	−7	4	12/7/2013
9−219	3500003380	Rio Grande	150–200	16	--	--	--	−1	0	2	1	1	0	12/7/2013
9−281	3700000254	Stone Harbor	176–181	5	--	--	−1	−1	−2	0	−1	0	1	12/16/2013
9−292	3700003035	Stone Harbor	251–261	5	--	--	1	2	1	0	2	3	1	12/16/2013

Appendix 1. Water-level data for wells screened in the confined Cohansey aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
9−301	3700000831	Wildwood	190–245	6	--	--	--	--	−7	−6	−5	−10	−5	12/11/2013
9−310	3700001781	Stone Harbor	279–357	5	--	--		−2	0	1	3	0	−3	12/11/2013
9−314	3700000640	Wildwood	212–325	6	--	--	--	−2	−1	0	2	1	−1	12/11/2013
9−315	3500001373	Stone Harbor	228–248	8	--	--	--	--	--	5	4	5	1	12/16/2013
9−353	3700004871	Cape May	262–272	15	--	--	--	−17	−17	−13	−16	−10	6	12/7/2013
9−354	3700004873	Stone Harbor	230–240	3.35	--	--	--	0	0	2	3	3	0	12/10/2013
9−358	3700002274	Stone Harbor	240–270	12	--	--	--	--	−3	−1	−4	−1	3	12/16/2013
9−366	3700001039	Wildwood	270–290	4	--	--	--	--	−4	−3	−2	−4	−2	12/11/2013
9−385	3700000861	Rio Grande	156–274	12.6	--	--	--	--	−16	−13	−7	−6	1	12/12/2013
9−394	3700000327	Wildwood	250–275	3	--	--	--	--	−11	−13	−9	−9	0	12/8/2013
9−395	3700004368	Cape May	255–275	14	--	--	--	−18	−16	−16	−13	−13	0	12/7/2013
9−430	3700003223	Cape May	234–254	10	--	--	--	--	--	--	--	−12	--	12/8/2013
9−505	3700000508	Stone Harbor	260–280	19	--	--	--	--	--	0	−4	−3	1	12/20/2013
9−525	--	Rio Grande	260	21	--	--	--	--	--	--	−12	−13	−1	12/10/2013
9−623	3500017985	Woodbine	154–174	12	--	--	--	--	--	--	--	2	--	12/9/2013
9−662	3700009403	Rio Grande	245–275	20	--	--	--	--	--	--	--	−14	--	12/10/2013
9−684	E201215464	Rio Grande	250–260	9	--	--	--	--	--	--	--	−8	--	12/10/2013
9−685	E201215463	Rio Grande	220–230	13	--	--	--	--	--	--	--	−7	--	12/10/2013
9−687	E201300369	Stone Harbor	230–245	8	--	--	--	--	--	--	--	−3	--	12/10/2013
9−689	E201301310	Rio Grande	245–260	18	--	--	--	--	--	--	--	−8	--	12/10/2013
9−690	E201305132	Cape May	224–264	20	--	--	--	--	--	--	--	−16	--	12/10/2013

[1]All water-level data in the appendixes reside in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2017).

Appendix 2. Water-level data for wells screened in the Rio Grande water-bearing zone, New Jersey Coastal Plain, 1978–2013.

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
1-717	3600065514	Pleasantville	320–330	40	--	--	--	--	--	--	--	14	--	12/18/2013
9-67	3700000271	Rio Grande	461–590	7.7	--	--	−14	--	−48	−35	−29	−33	−4	12/12/2013
9-71	**--**	**Rio Grande**	**473–523**	**5**	**--**	**−15**	**−15**	**--**	**−36**	**−27**	**−18**	**−23**	**−5**	**12/12/2013**
9-149	3700000005	Tuckahoe	250–290	19	--	19	19	--	17	17	15	16	1	12/13/2013
9-304	**3700003763-3**	**Rio Grande**	**495–505**	**24**	**--**	**--**	**--**	**--**	**−22**	**−21**	**−27**	**−21**	**6**	**12/12/2013**
9-305	3700000214	Stone Harbor	--	7	--	--	--	--	−18	−19	--	−27	--	12/20/2013
9-526	3700005559	Rio Grande	578–598	8	--	--	--	--	--	−20	−28	−26	2	12/7/2013
9-629	3600032630	Marmora	478–498	26	--	--	--	--	--	--	−31	−32	−1	12/16/2013
9-637	3700007592	Stone Harbor	542–562	11	--	--	--	--	--	--	--	−26	--	12/16/2013
11-737	3500003449	Heislerville	307–317	5	--	--	--	--	−3	−4	−5	−4	1	12/9/2013
29-775	3200008715	New Gretna	293–318	5	--	−8	−6	--	−2	−3	−1	−2	−1	12/3/2013
29-813	3200011971	Tuckerton	307–337	19	--	--	−4	--	0	2	−7	0	7	12/3/2013
29-1621	3300040378	Tuckerton	417–456	6	--	--	--	--	--	−21	−23	−23	0	11/25/2013

[1]All water-level data in the appendixes reside in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2017).

Appendix 3. Water-level data for wells screened in the Atlantic City 800-foot sand, New Jersey Coastal Plain, 1978–2013.

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
1-37	5600000071	Atlantic City	782–837	8.22	−66	−74	−81	−85	−90	−87	−95	−74	21	12/18/2013
1-39	5600000012	Oceanville	733–788	6.2	−64	−69	−77	−72	−81	−78	−94	−71	23	12/4/2013
1-180	**3600000294**	**Oceanville**	**560–570**	**22**	**−33**	**−37**	**−45**	**−46**	**−52**	**−48**	**−59**	**−45**	**14**	**12/13/2013**
1-227	3600000391	Mays Landing	316–347	13	--	--	7	--	−41	--	--	12	--	12/12/2013
1-367	5600000038	Ocean City	750–800	6	−70	−72	−79	−84	−90	−85	−86	−78	8	12/19/2013
1-369	3600000402	Ocean City	760–810	5	--	--	--	--	--	--	−81	−78	3	12/19/2013
1-376	3600000278	Ocean City	741–791	7	--	−77	−84	--	--	--	−89	−79	10	12/19/2013
1-578	**3600000295**	**Ocean City**	**670–680**	**8.7**	**−47**	**−53**	**−57**	**−61**	**−67**	**−66**	**−79**	**−66**	**13**	**12/13/2013**
1-593	3600000372	Atlantic City	740–790	5	--	−79	−100	--	--	−91	−102	−82	20	12/19/2013
1-599	5600000015	Atlantic City	800–830	4	--	--	--	--	--	--	−96	−87	9	12/19/2013
1-600	5600000016	Atlantic City	750–810	4	−73	−77	−83	−87	−97	−92	−92	−83	9	12/19/2013
1-637	3200005113	Egg Harbor City	335–425	39	--	--	--	--	--	13	9	11	2	12/5/2013
1-648	3600001084	Atlantic City	775–835	6	--	−75	−81	--	--	−84	−95	−77	18	12/18/2013
1-650	--	Mays Landing	380	20	--	--	14	17	14	14	11	12	1	12/11/2013
1-683	3600002091	Brigantine Inlet	725–775	6	--	--	−66	−72	−73	−72	−72	−69	3	12/4/2013
1-702	**3400002305**	**Ocean City**	**740–750**	**3.7**	**--**	**--**	**−88**	**−93**	**−104**	**−94**	**−114**	**−88**	**26**	**12/13/2013**
1-703	3600005092	Pleasantville	560–570	37	--	--	−46	−47	−59	−49	−66	−51	15	12/13/2013
1-704	--	Mays Landing	596–606	50	--	--	−39	−38	−50	−51	−67	−57	10	12/4/2013
1-706	3600004982-1	Pleasantville	520–530	40	--	--	−25	−25	−35	−30	−40	−29	11	12/18/2013
1-889	3600011871	Ocean City	735–795	6.9	--	--	--	−87	−96	−88	−88	−78	10	12/19/2013
1-967	3600013010	Brigantine Inlet	702–776	6	--	--	--	−61	−63	−59	−61	−58	3	12/4/2013
1-990	3600019288	Pleasantville	496–652	29	--	--	--	--	−56	−51	−67	−60	7	12/16/2013
1-991	3600016204	Pleasantville	492–642	60	--	--	--	--	−58	−51	−64	−54	10	12/16/2013
1-1218	3600017655	Mays Landing	520–610	66	--	--	--	--	−49	−48	−56	−51	5	12/12/2013
1-1220	3600017339	Pleasantville	552–603	74	--	--	--	--	−42	−40	−50	−42	8	12/12/2013

Appendix 3. Water-level data for wells screened in the Atlantic City 800-foot sand, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
1-1252	3200020165	Egg Harbor City	337–441	41	--	--	--	--	--	16	13	15	2	12/5/2013
1-1253	3600016750	Pleasantville	344–598	46	--	--	--	--	−52	−45	−59	−43	16	12/16/2013
1-1256	3600017667	Ocean City	649–796	6	--	--	--	--	--	−94	−88	−79	9	12/19/2013
1-1257	3600018120	Pleasantville	524–614	64	--	--	--	--	--	--	--	−49	--	12/12/2013
1-1456	3600021156	Pleasantville	602–652	5	--	--	--	--	--	--	−71	−62	9	12/23/2013
1-1909	3600026185	Atlantic City	722–772	4	--	--	--	--	--	--	--	−76	--	12/23/2013
1-1972	3600011760	Oceanville	520–530	42	--	--	--	--	--	--	--	−37	--	12/2/2013
1-1974	3600032164	Marmora	356–660	60	--	--	--	--	--	--	−67	−63	4	12/16/2013
1-1975	3600022085	Pleasantville	550–650	18	--	--	--	--	--	--	−70	−57	13	12/16/2013
1-1976	3600022109	Pleasantville	531–631	41	--	--	--	--	--	--	−39	−31	8	12/16/2013
1-2175	E201304746	Egg Harbor City	347–427	38	--	--	--	--	--	--	--	14	--	12/5/2013
9-4	3700000265	Avalon	880–920	7	−43	−45	−43	−46	−54	−51	−53	−50	3	12/17/2013
9-5	3700000313	Avalon	784–839	6.71	−35	−49	−41	--	--	--	--	−48	--	12/17/2013
9-79	3700000233	Stone Harbor	833–876	2	--	--	--	−36	−46	−41	−44	−43	1	12/10/2013
9-92	3700000240	Stone Harbor	681–791	18	−31	−30	−33	−37	−40	−41	−44	−44	0	12/16/2013
9-106	5600000006	Sea Isle City	760–810	6	−48	−48	−53	−56	−64	−63	−64	−61	3	12/16/2013
9-108	3600000412	Sea Isle City	774–840	6	--	−58	−59	−89	−71	−68	−70	−59	11	12/16/2013
9-116	5600000007	Ocean City	760–810	4	--	−65	−67	−77	−78	−77	−78	−72	6	12/16/2013
9-125	3600000314	Ocean City	800	5	--	--	−71	−81	−92	−78	−81	−75	6	12/16/2013
9-136	5600000147	Sea Isle City	802–834	4	--	−48	−48	−50	−57	−57	−61	−56	5	12/16/2013
9-144	3600000451	Marmora	650–690	9	−47	−54	−50	−60	−70	−66	−70	−63	7	12/15/2013
9-161	--	Stone Harbor	639–654	14.4	--	−28	−33	−36	−39	−39	−42	−41	1	12/11/2013
9-185	3700001340-8	Marmora	640–650	13.73	--	--	−36	--	−43	−42	−49	−44	5	12/4/2013
9-291	3600009846	Avalon	764–940.66	6	--	--	--	−46	−50	−50	−52	−48	4	12/17/2013
9-296	3500006073	Stone Harbor	682–812	19	--	--	−28	−34	−36	−37	−42	−39	3	12/16/2013

Appendix 3. Water-level data for wells screened in the Atlantic City 800-foot sand, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
9-302	**3700003628-9**	**Wildwood**	**883–893**	**4**	**--**	**--**	**--**	**−15**	**−19**	**−27**	**−32**	**−31**	**1**	**12/12/2013**
9-306	**3500009239**	**Rio Grande**	**656–666**	**5**	**--**	**--**	**--**	**−19**	**−20**	**−22**	**−30**	**−30**	**0**	**12/12/2013**
9-311	3600010378	Sea Isle City	732–896	7	--	--	--	−47	−51	−49	−52	−52	0	12/13/2013
9-337	**3700004660**	**Stone Harbor**	**910–960**	**9**	**--**	**--**	**--**	**−21**	**−25**	**−30**	**−35**	**−32**	**3**	**12/12/2013**
9-359	3600007286	Avalon	708–773	6	--	--	--	−45	−51	−49	−51	−49	2	12/17/2013
9-423	3700005244	Rio Grande	825–875	15	--	--	--	−25	−26	−28	−35	−33	2	12/16/2013
9-459	3600000377	Ocean City	620	6	--	--	--	--	−68	−67	−71	−65	6	12/5/2013
9-461	3600030023	Marmora	639–710	9	--	--	--	−57	−66	−64	--	−61	--	12/5/2013
9-479	3700006313	Cape May	655–825	6	--	--	--	--	−18	−38	−43	−44	−1	12/9/2013
9-480	3700006314	Cape May	621–820	12	--	--	--	--	−19	−51	−44	−42	2	12/9/2013
9-481	3600017001	Marmora	603–738	27	--	--	--	−62	--	−61	−64	−60	4	12/16/2013
9-482	3600020238	Sea Isle City	724–884	6	--	--	--	--	--	−51	−55	−53	2	12/13/2013
9-506	3700005659	Stone Harbor	795–880	7	--	--	--	--	--	--	--	−45	--	12/17/2013
9-507	3700006563	Cape May	615–810	15	--	--	--	--	--	−36	−37	−37	0	12/9/2013
9-521	3700007541	Stone Harbor	830–953	8	--	--	--	--	--	−42	−44	−44	0	12/17/2013
9-522	3700007594	Rio Grande	570–664	15	--	--	--	--	--	--	−56	−39	17	12/12/2013
9-523	3700007593	Rio Grande	563–653	10	--	--	--	--	--	--	−59	−42	17	12/12/2013
9-527	3600023696	Sea Isle City	660–790	29	--	--	--	--	--	--	−51	−50	1	12/11/2013
9-613	3600028902	Sea Isle City	722–815	6	--	--	--	--	--	--	−54	−53	1	12/13/2013
9-632	3600027785	Avalon	850–940	8	--	--	--	--	--	--	--	−49	--	12/17/2013
9-636	3500025747	Rio Grande	605–700	5	--	--	--	--	--	--	--	−32	--	12/7/2013
9-669	P200804567	Avalon	806–866	8	--	--	--	--	--	--	--	−46	--	12/17/2013
9-700	3600031946	Ocean City	630–805	4	--	--	--	--	--	--	--	−68	--	12/16/2013
29-111	3300001180	Ship Bottom	465–500	7	−24	−54	−25	−29	−32	−36	−30	−31	−1	11/26/2013
29-112	3300000674	Ship Bottom	451–493	5	−20	−36	−24	−27	−29	−33	−29	−28	1	11/26/2013

Appendix 3. Water-level data for wells screened in the Atlantic City 800-foot sand, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
29-457	3300001275	Beach Haven	551–650	6.77	−27	−28	−27	--	--	−47	−38	−40	−2	11/25/2013
29-549	3300001723	Ship Bottom	528–588	4.03	−31	−3	−30	--	--	--	−36	−33	3	11/26/2013
29-561	3300001268	Ship Bottom	520–562	6	−29	−32	−28	−24	−34	−39	−35	−32	3	11/26/2013
29-597	3200005858	Tuckerton	400–500	22	--	−9	−6	--	--	−21	−22	−18	4	12/4/2013
29-598	3300000967	Ship Bottom	460	2.9	--	--	−21	−24	−25	−25	−27	−24	3	11/26/2013
29-814	3200012329	New Gretna	512–552	7	--	--	--	−27	−29	−32	−35	−29	6	12/3/2013
29-936	3300024693	Beach Haven	528–594	4	--	--	−30	−30	−31	−43	−38	−33	5	11/25/2013
29-1063	3200015207	Tuckerton	475–521	32	--	--	−25	−26	−28	−29	−28	−25	3	12/3/2013
29-1077	3300025686	Ship Bottom	514–574	4	--	--	--	--	--	−42	−28	−21	7	11/26/2013
29-1078	3300026875	Ship Bottom	366–429	22	--	--	--	--	24	26	20	23	3	11/26/2013
29-1421	3200022507	Tuckerton	405–511	7	--	--	--	--	--	−27	−25	−21	4	12/4/2013
29-1433	3300041143	West Creek	375–415	57	--	--	--	--	--	45	39	40	1	11/21/2013
29-1624	3300042213	Ship Bottom	501–582	4	--	--	--	--	--	−44	−36	−33	3	11/26/2013
29-1729	3300040839	Beach Haven	518–634	5	--	--	--	--	--	−34	−37	−32	5	11/25/2013
29-1730	3200025614	Tuckerton	460–521	32	--	--	--	--	--	--	−30	−27	3	12/3/2013
29-1774	3300041391	Ship Bottom	365–431	21	--	--	--	--	--	--	18	21	3	11/26/2013
29-1779	3300039413	Beach Haven	541–616	4	--	--	--	--	--	--	−36	−37	−1	11/26/2013
29-1803	3200027684	Tuckerton	403–520	77	--	--	--	--	--	1	−1	1	2	12/3/2013
29-2056	3300045394	Ship Bottom	379–421	9	--	--	--	--	--	--	11	16	5	12/2/2013
29-2057	P200905744	West Creek	356–432	60	--	--	--	--	--	--	41	33	−8	12/6/2013
29-2058	3200028028	Tuckerton	406–509	6	--	--	--	--	--	--	−26	−22	4	12/4/2013

[1]All water-level data in the appendixes reside in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2017).

Appendix 4. Water-level data for wells screened in the Piney Point aquifer, New Jersey Coastal Plain, 1978–2013.

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
1-270	3100003648	Newtonville	390–410	93	--	33	33	31	22	18	19	20	1	12/19/2013
1-700	3500004274	Dorothy	479–539	39	--	--	16	11	17	17	16	17	1	12/12/2013
1-701	3500003992	Buena	410–460	117	--	28	--	--	--	−29	−46	−46	0	12/6/2013
1-713	3500004656	Dorothy	525–535	100	--	--	−2	−4	−6	−8	−9	−11	−2	12/12/2013
1-834	**3600010548**	**Ocean City**	**970–991**	**4**	**--**	**--**	**−29**	**−31**	**−34**	**−35**	**−39**	**−40**	**−1**	**12/13/2013**
1-1219	3600016546	Pleasantville	722–742	67	--	--	--	−16	−17	−19	−21	−22	−1	12/12/2013
1-1238	55-00008	Buena	391–463	100	--	--	--	--	−39	−25	−42	−42	0	12/6/2013
1-1405	3600023678	Mays Landing	545–620	24	--	--	--	--	--	−5	−7	−9	−2	12/12/2013
1-1445	3500022078	Buena	360–540	97	--	--	--	--	--	−31	−47	−39	8	12/6/2013
5-407	**--**	**Atsion**	**240–260**	**45.52**	**--**	**50**	**50**	**50**	**49**	**49**	**48**	**49**	**1**	**12/5/2013**
5-488	3200000913	Atsion	419–449	32	46	45	45	49	43	42	42	41	−1	12/5/2013
5-676	**--**	**Woodmansie**	**530–540**	**197.94**	**--**	**117**	**116**	**118**	**119**	**117**	**116**	**118**	**2**	**12/11/2013**
5-800	3200004454	Medford Lakes	200–210	85	--	73	72	73	72	73	72	73	1	11/14/2013
5-1162	3200005879	Indian Mills	215–235	63	--	--	--	58	54	58	56	56	0	12/19/2013
5-1649	3200022352	Indian Mills	250–310	77	--	--	--	--	--	--	--	43	--	11/19/2013
7-980	3100009893	Hammonton	274–294	105	--	--	--	--	--	52	45	44	−1	11/22/2013
7-1147	3100064921	Williamstown	390	127	--	--	--	--	--	--	59	52	−7	12/23/2013
7-1280	3100072548	Hammonton	290–320	109	--	--	--	--	--	--	44	42	−2	12/4/2013
11-44	**3500001197**	**Bridgeton**	**361–376**	**80.78**	**--**	**11**	**6**	**−1**	**−6**	**−8**	**−71**	**−85**	**−14**	**12/5/2013**
11-92	--	Ben Davis Point	397–417	5	--	−28	−37	−44	−44	−46	−75	−82	−7	12/17/2013
11-96	**3400000852**	**Cedarville**	**365–375**	**9.03**	**−16**	**−21**	**−28**	**−35**	**−35**	**−35**	**−62**	**−69**	**−7**	**12/5/2013**
11-163	**3500001196**	**Millville**	**463–473**	**78.86**	**--**	**11**	**7**	**1**	**−5**	**−12**	**−49**	**−62**	**−13**	**12/5/2013**
11-349	3400001463	Cedarville	380–410	5	--	−28	−35	−42	−42	−44	−70	−77	−7	12/17/2013
11-1220	3400006736	Bridgeton	235–375	28	--	--	--	--	--	−23	−155	−164	−9	12/12/2013
11-1221	3400006556	Bridgeton	250–390	34	--	--	--	--	--	−23	−159	−164	−5	12/12/2013

Appendix 4. Water-level data for wells screened in the Piney Point aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
11-1571	3400006557	Bridgeton	245–390	41	--	--	--	--	--	--	−156	−166	−10	12/12/2013
11-1827	3400007237	Cedarville	450–460	4	--	--	--	--	--	--	--	−77	--	12/17/2013
15-1592	3100058699	Buena	290–350	100.1	--	--	--	--	--	--	−3	−7	−4	12/19/2013
15-1593	3100058698	Buena	335–405	118	--	--	--	--	--	--	21	11	−10	12/19/2013
15-1757	3100070478	Buena	290–350	118	--	--	--	--	--	--	19	10	−9	12/12/2013
15-1800	3100066477	Buena	332–402	98	--	--	--	--	--	--	--	−8	--	12/19/2013
29-2	3300001206	Barnegat Light	597–654	5	--	−42	−35	−40	--	−40	−37	−46	−9	12/2/2013
29-18	**--**	**Barnegat Light**	**468–474**	**7.26**	**0**	**--**	**−1**	**−3**	**−3**	**−3**	**−4**	**−5**	**−1**	**11/14/2013**
29-23	3300001494	Seaside Park	490–527	4	--	--	--	−60	−61	−46	−43	−37	6	11/20/2013
29-425	**--**	**Whiting**	**348–348**	**127**	**--**	**--**	**--**	**117**	**118**	**117**	**116**	**117**	**1**	**11/14/2013**
29-537	5300000001	Seaside Park	400–430	4	--	−35	−30	−35	−58	−17	−19	−16	3	11/20/2013
29-582	3300004511	Seaside Park	435–485	8	--	--	--	−55	--	−60	−41	−33	8	11/21/2013
29-585	**5300000133**	**Forked River**	**412–422**	**12**	**--**	**--**	**12**	**9**	**13**	**10**	**9**	**9**	**0**	**11/19/2013**
29-607	3300007876	Long Beach NE	567–662	5	--	−41	−34	−38	−44	−57	−50	−47	3	12/2/2013
29-616	5300000005	Toms River	340–360	9	--	−4	−10	--	--	−15	−14	−8	6	11/18/2013
29-739	3300001247	Lakewood	200–220	22	--	15	13	15	10	13	12	13	1	11/14/2013
29-808	3300006595	Seaside Park	395–475	4	--	--	−30	−47	−77	−38	−32	−26	6	11/20/2013
29-935	3300022528	Seaside Park	474–514	4	--	--	--	--	−54	−43	--	−45	--	11/21/2013
29-1096	3300029653	Toms River	345–440	31	--	--	--	--	−2	−10	−8	−7	1	11/18/2013
29-1114	2900024912	Point Pleasant	206–276	8	--	--	--	--	−5	−2	−3	−1	2	10/31/2013
29-1210	3600020855	Tuckerton	860–880	4.3	--	--	--	--	−15	−18	−20	−21	−1	11/21/2013
29-1217	3300029690	Forked River	468–583	32	--	--	--	--	--	16	15	15	0	11/14/2013
29-1220	3300032755	Forked River	300–340	38	--	--	--	--	--	--	--	4	--	11/19/2013
29-1579	3300041928	West Creek	595–645	61	--	--	--	--	--	24	24	24	0	12/6/2013
29-1675	3300040849	Toms River	335–445	74	--	--	--	--	--	22	21	21	0	11/18/2013

Appendix 4. Water-level data for wells screened in the Piney Point aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
29-1681	3300040235	Seaside Park	459–503	4	--	--	--	--	--	−42	−46	−45	1	11/21/2013
29-1721	3300040608	Toms River	265–345	9	--	--	--	--	--	--	--	−3	--	11/15/2013
29-1999	3300041870	Toms River	301–386	66	--	--	--	--	--	--	13	14	1	11/18/2013
29-2038	3300027794	Toms River	405–455	32	--	--	--	--	--	--	--	−8	--	11/18/2013
Id55-01[2]	10225	Dover	329–349	25	--	--	--	--	--	--	−129	−124	5	10/16/2013
Kc31-01[2]	--	Marydel	370–380	55	--	--	--	--	--	--	−66	−67	−1	10/15/2013

[1]All water-level data in the appendixes reside in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2017).

[2]Measurements were obtained from data at http://data.dgs.udel.edu/sites/groundwater/recent-and-historical-groundwater-level-data.html. Water-level measurements for 2008 were made close to the date of 2013 measurement. Water levels are referenced to the National Geodetic Vertical Datum of 1929.

Appendix 5. Water-level data for wells screened in the Vincentown aquifer, New Jersey Coastal Plain, 1978–2013.

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
5-1250	**2800020189**	**New Egypt**	**45–55**	**111**	**--**	**--**	**--**	**--**	**101**	**102**	**101**	**101**	**0**	**10/24/2013**
5-1720	2800010989	New Egypt	118–126	128	--	--	--	--	--	--	115	116	1	11/18/2013
15-123	3100000216	Pitman West	121–150	145	--	--	--	--	80	82	84	89	5	12/11/2013
15-1005	3000003319	Pitman West	140–156	148	--	--	70	--	62	70	64	68	4	12/5/2013
15-1360	3100042096	Pitman West	166–191	117	--	--	--	--	75	77	77	81	4	12/9/2013
15-1544	3100032489	Pitman West	130–140	133	--	--	--	--	--	--	81	84	3	12/11/2013
15-1767	3100075745	Pitman West	148–188	140	--	--	--	--	--	--	--	87	--	12/9/2013
25-448	2900004725	Asbury Park	219–235	125	--	--	--	--	70	72	69	71	2	11/19/2013
25-636	**2900055506**	**Farmingdale**	**85–95**	**110.7**	**--**	**--**	**58**	**71**	**72**	**72**	**70**	**71**	**1**	**11/6/2013**
25-691	2900015843	Farmingdale	5–25	49	--	--	42	--	43	45	43	44	1	11/13/2013
25-702	2900009528	Asbury Park	129–140	43	--	--	--	--	42	40	41	43	2	11/19/2013
25-703	2900011712	Asbury Park	167–187	83	--	--	--	--	73	73	73	73	0	11/20/2013
25-717	2900028188	Adelphia	38– 43	143	--	--	--	--	124	126	123	124	1	11/19/2013
25-788	2900036417	Long Branch	120–166	51	--	--	--	--	30	32	30	29	−1	11/18/2013
25-789	2900006311	Farmingdale	198	78	--	--	--	--	--	54	53	54	1	11/13/2013
25-847	2900023330	Farmingdale	88–118	78	--	--	--	--	--	--	74	74	0	11/8/2013
25-1065	2900005506	Adelphia	110–195	94	--	--	--	--	--	--	76	83	7	10/30/2013
25-1066	2900055717	Adelphia	105–190	94	--	--	--	--	--	--	--	85	--	10/30/2013
25-1115	2900010614	Farmingdale	100	64	--	--	--	--	--	--	--	59	--	11/8/2013
25-1146	2900057802	Farmingdale	122–162	115	--	--	--	--	--	--	73	74	1	10/30/2013
29-139	**2800004784**	**Cassville**	**161–171**	**134.61**	**129**	**--**	**128**	**129**	**128**	**129**	**128**	**128**	**0**	**11/13/2013**
29-230	2800005038	Cassville	85–100	144	--	--	124	--	126	127	123	125	2	11/13/2013
29-241	2900007425	Adelphia	115–165	87	--	--	--	--	--	88	82	86	4	11/13/2013
29-658	2900008966	Lakehurst	202–215	113	--	--	94	--	92	92	87	91	4	11/4/2013
29-698	2800011275	Cassville	120–132	152	--	--	141	--	137	137	134	135	1	11/13/2013

Appendix 5. Water-level data for wells screened in the Vincentown aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
29-916	2900013024	Adelphia	139–155	120	--	--	101	--	106	105	101	102	1	11/3/2013
29-917	2900016962	Adelphia	126–186	81	--	--	81	--	69	75	71	67	−4	11/13/2013
29-1318	2800011574	Adelphia	95–118	142	--	--	--	--	--	--	--	126	--	11/5/2013
29-2026	2800020768	Cassville	89–110	148	--	--	--	--	--	--	--	122	--	11/15/2013
33-292	3000000397	Woodstown	190–218	145	--	--	--	--	--	46	40	45	5	12/16/2013
33-1110	3000017849	Salem	65– 85	21	--	--	--	--	--	--	--	4	--	12/6/2013
33-1148	3000000695	Salem	97	21	--	--	--	--	--	--	--	2	--	12/4/2013

[1]All water-level data in the appendixes reside in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2017).

Appendix 6. Water-level data for wells screened in the Wenonah-Mount Laurel aquifer, New Jersey Coastal Plain, 1978–2013.

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
5-257	5100000156	Mount Holly	90	74	21	19	21	48	44	48	46	48	2	11/20/2013
5-354	3200000103	Pemberton	178–198	63	41	40	37	41	37	40	37	41	4	12/3/2013
5-355	5200000004	Pemberton	155–185	80	38	37	37	40	38	41	38	40	2	11/26/2013
5-359	3200000539	Pemberton	181–242	65	31	30	32	29	32	37	31	27	−4	11/25/2013
5-365	3200000386	Browns Mills	290–330	96	19	−2	−10	−11	1	7	5	15	10	11/25/2013
5-366	3200000775	Browns Mills	301–323	89	−43	−49	−62	−51	−37	−33	--	−20	--	1/30/2014
5-367	3200000818	Browns Mills	308–338	89	--	−55	−63	--	--	--	−28	−21	7	11/25/2013
5-427	3200000749	Pemberton	260–348	67	8	−11	−16	−8	−8	0	−11	2	13	12/4/2013
5-695	3200001240	Browns Mills	428–496	104	26	20	17	11	9	10	0	7	7	11/29/2013
5-711	3100005707	Medford Lakes	260–275	74	--	--	--	--	--	−13	−36	−16	20	11/14/2013
5-718	3200000361	Browns Mills	376–388	93	--	--	--	--	−11	−7	−6	1	7	11/26/2013
5-720	3100011574	Medford Lakes	410	124	19	21	−9	−1	−16	−16	--	−16	--	12/19/2013
5-724	3200003118	Pemberton	199–275	42	17	14	5	5	−7	−2	−9	5	14	12/4/2013
5-744	3200000520	Whiting	456	103	12	−10	−18	−18	−6	6	−3	2	5	11/14/2013
5-1004	3200008631	Pemberton	209–254	78	--	--	23	30	30	25	20	26	6	11/25/2013
5-1086	3200010112	Browns Mills	242–247	74	--	--	25	--	27	31	--	34	--	12/4/2013
5-1087	3200009937	Pemberton	227–232	57	--	--	13	11	0	7	−5	7	12	12/4/2013
5-1155	3100039849	Mount Holly	120–180	44.96	--	--	--	30	21	24	17	24	7	10/28/2013
5-1165	3200000490	Browns Mills	275–307	123	--	--	--	9	17	20	--	31	--	12/5/2013
5-1166	2800017342	New Egypt	119–129	136	--	--	--	101	98	101	99	100	1	11/18/2013
5-1178	3200013264	Pemberton	140–180	41	--	--	--	31	20	22	16	22	6	12/3/2013
5-1186	3200015968	Browns Mills	267–358	92	--	--	--	−25	−4	1	1	9	8	11/25/2013
5-1245	5200000082	Mount Holly	180	42	--	--	--	--	13	22	13	19	6	11/14/2013
5-1253	3100046953	Medford Lakes	357–417	117	--	--	--	--	−48	−33	−56	−37	19	11/14/2013
5-1387	3100040373	Clementon	335–355	117.82	--	--	--	--	1	−1	−7	−1	6	10/28/2013

Appendix 6. Water-level data for wells screened in the Wenonah-Mount Laurel aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
5-1414	3100049988	Medford Lakes	199–259	62	--	--	--	--	--	−15	−33	8	41	11/14/2013
5-1415	3100050015	Medford Lakes	162–212	49	--	--	--	--	--	2	−14	14	28	11/14/2013
5-1449	3200012425	Pemberton	160–198	44	--	--	--	--	--	26	18	24	6	11/25/2013
5-1475	3200018506	Browns Mills	276–326	115	--	--	--	--	12	17	9	26	17	11/25/2013
5-1495	3200006317	Whiting	512–522	118	--	--	--	--	0	3	3	5	2	11/14/2013
5-1744	3100051943	Clementon	213–235	73	--	--	--	--	--	--	--	26	--	12/19/2013
5-1745	3100056458	Clementon	245	69	--	--	--	--	--	--	--	25	--	12/19/2013
5-1785	3200025769	Indian Mills	360–400	95	--	--	--	--	--	--	--	−12	--	11/29/2013
5-1818	3100046847	Medford Lakes	347	116	--	--	--	--	--	--	--	−33	--	11/14/2013
5-1828	3100046845	Medford Lakes	358–418	116	--	--	--	--	--	--	--	−28	--	11/14/2013
5-1840	2800050468	Columbus	140	66	--	--	--	--	--	--	--	62	--	11/8/2013
5-1868	3100074968	Mount Holly	95–140	39	--	--	--	--	--	--	--	24	--	11/19/2013
7-22	3100000513	Clementon	310–360	147	34	--	11	−7	4	3	0	10	10	11/26/2013
7-118	**3100004898**	**Clementon**	**137–147**	**156.38**	**68**	**68**	**67**	**67**	**66**	**67**	**65**	**67**	**2**	**11/19/2013**
7-308	5100000014	Runnemede	126	74	54	55	53	52	46	47	45	47	2	11/26/2013
7-391	3100005628	Clementon	315–335	162	30	31	10	−4	−20	−15	−18	−4	14	11/22/2013
7-401	3100002371	Clementon	267	88	39	46	26	12	−3	−0	1	11	10	11/21/2013
7-414	5100000010	Clementon	237–275	148	58	50	34	49	56	50	47	51	4	12/3/2013
7-421	--	Clementon	220–234	173	89	89	87	87	85	86	84	86	2	11/23/2013
7-449	3100004749	Clementon	420–460	157	18	17	−6	--	−12	−11	−14	−22	−8	12/4/2013
7-478	**--**	**Williamstown**	**520–530**	**110.26**	**35**	**39**	**20**	**2**	**−27**	**−30**	**−33**	**−21**	**12**	**10/28/2013**
7-513	3100007766	Clementon	410–460	165.2	--	--	−5	−20	−32	−35	−29	−19	10	11/21/2013
7-685	3100022273	Williamstown	322–427	142.83	--	--	--	−21	−63	−51	−52	−21	31	12/6/2013
7-847	3100036246	Pitman East	329–380	148	--	--	--	--	−83	−73	−84	−30	54	12/6/2013
7-993	3100016443	Clementon	394–448	159	--	--	--	--	--	−36	--	−16	--	11/22/2013

Appendix 6. Water-level data for wells screened in the Wenonah-Mount Laurel aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
7-1079	3100022832	Runnemede	120–130	56	--	--	--	--	--	40	39	41	2	11/25/2013
7-1086	3100061104	Clementon	299–389	185	--	--	--	--	--	--	−11	13	24	12/6/2013
7-1202	3100062243	Medford Lakes	495–525	112	--	--	--	--	--	--	−15	−8	7	12/5/2013
15-542	3100016873	Pitman East	265–295	147	--	--	70	48	22	33	--	45	--	12/6/2013
15-687	3100022088	Woodbury	5.5–23.5	26.5	--	--	20	20	21	21	21	21	0	12/6/2013
15-910	3000002454	Pitman West	140–160	107	--	--	81	80	77	84	80	83	3	12/9/2013
15-953	3100006570	Runnemede	86–100	83	--	--	58	57	56	57	54	56	2	12/3/2013
15-1009	3100022018	Pitman East	149–178	103	--	--	68	65	61	65	62	64	2	12/5/2013
15-1040	3000005046	Woodstown	77–87	119	--	--	76	78	77	80	77	80	3	12/17/2013
15-1060	3100030571	Pitman East	335–386	134	--	--	--	18	−49	−25	1	13	12	12/6/2013
15-1104	3000002422	Woodstown	40	101.03	--	--	--	80	78	81	78	80	2	11/26/2013
15-1119	3100044252	Pitman West	159–199	139	--	--	--	--	66	79	--	92	--	12/9/2013
15-1126	3100034033	Pitman East	328–338	144.77	--	--	--	--	−23	−4	7	10	3	12/6/2013
15-1206	3100039283	Pitman West	195–215	138	--	--	--	--	--	81	85	93	8	12/9/2013
15-1223	3100033093	Pitman East	485–495	135	--	--	--	--	--	−9	--	6	--	12/6/2013
15-1367	3100045997	Pitman East	278–342	148	--	--	--	--	--	−3	--	14	--	12/6/2013
15-1384	3100045999	Pitman East	342–382	161	--	--	--	--	--	−46	−64	−20	44	12/6/2013
15-1387	5100000215	Woodbury	70–100	46	--	--	--	--	--	39	38	38	0	12/6/2013
15-1517	3000011753	Pitman West	112–132	86	--	--	--	--	63	65	62	64	2	12/9/2013
15-1524	3100022318	Runnemede	174–225	85	--	--	--	--	--	61	60	62	2	12/4/2013
15-1634	3100056244	Pitman West	340–370	140	--	--	--	--	--	--	--	37	--	12/11/2013
15-1756	3100065912	Pitman West	300–310	136	--	--	--	--	--	--	40	47	7	12/11/2013
15-1787	3000016051	Woodstown	60–110	87	--	--	--	--	--	--	--	60	--	12/19/2013
15-1804	3000018580	Woodstown	140–180	82	--	--	--	--	--	--	--	81	--	12/17/2013
15-1827	3100075720	Pitman East	290–330	143	--	--	--	--	--	--	--	29	--	12/5/2013

Appendix 6. Water-level data for wells screened in the Wenonah-Mount Laurel aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
15-1873	3100036289	Pitman West	200–210	138	--	--	--	--	--	--	--	80	--	12/11/2013
15-1874	3100033644	Pitman East	360–370	160	--	--	--	--	--	--	--	−27	--	12/6/2013
25-14	4900000017	Asbury Park	424–504	27	−146	−163	−203	−84	−78	−60	−53	−55	−2	11/19/2013
25-88	2900005886	Adelphia	143–163	148	--	--	112	110	111	111	108	110	2	11/19/2013
25-95	2900004709	Freehold	128–140	171	--	--	--	142	143	142	140	141	1	1/6/2014
25-166	2900004381	Farmingdale	336–396	113	--	--	−39	11	11	13	12	22	10	10/30/2013
25-168	2900003105	Farmingdale	354–440	160	−46	−44	−56	--	−2	11	0	−1	−1	10/30/2013
25-335	--	Asbury Park	465–480	87	−113	−121	−139	−59	−62	−41	−40	−51	−11	11/20/2013
25-353	**--**	**Long Branch**	**321–327**	**138.88**	**--**	**−22**	**−16**	**8**	**14**	**15**	**12**	**14**	**2**	**11/6/2013**
25-391	2900007506	Asbury Park	485–561	29	−186	−157	−211	−100	−79	−68	−64	−62	2	11/20/2013
25-396	2800006896	New Egypt	92–102	123	86	86	84	87	84	87	83	85	2	11/15/2013
25-405	--	Roosevelt	124	150	119	120	118	119	137	139	137	138	1	10/30/2013
25-412	2800005835	Roosevelt	100–140	199	158	157	156	157	155	155	152	155	3	11/7/2013
25-443	2900002871	Asbury Park	435–465	77	−145	−156	--	--	--	−61	−53	−69	−16	12/2/2013
25-486	**--**	**Point Pleasant**	**604–614**	**8.9**	**--**	**--**	**−186**	**−103**	**−75**	**−70**	**−60**	**−62**	**−2**	**10/31/2013**
25-521	2900009867	Adelphia	222–228	143	--	--	92	95	96	95	--	94	--	11/4/2013
25-533	2900005113	Farmingdale	349–365	115	--	−66	−79	−26	−21	−13	−26	−6	20	11/7/2013
25-542	--	Asbury Park	430–450	67	--	−100	−116	−52	−35	−26	−27	−23	4	11/22/2013
[2]**25-637**	**29-18400-2**	**Farmingdale**	**307–317**	**110.7**	**--**	**--**	**−30**	**6**	**14**	**12**	**12**	**--**	**--**	**--**
25-687	2900015008	Long Branch	177–187	22	--	--	3	10	13	13	10	9	−1	11/6/2013
25-698	2900017963	Asbury Park	421–451	86	--	--	--	--	--	−53	−47	−61	−14	12/2/2013
25-720	2900016821	Adelphia	235–255	120	--	--	--	51	72	--	80	69	−11	10/30/2013
25-800	2800048499	Roosevelt	13.5–18.5	151	--	--	--	--	--	--	140	141	1	12/5/2013
25-829	2900036936	Farmingdale	395–402	59	--	--	--	--	--	--	−28	−23	5	11/7/2013
25-897	2900017602	Farmingdale	288–298	94	--	--	--	--	--	--	44	47	3	11/21/2013

Appendix 6. Water-level data for wells screened in the Wenonah-Mount Laurel aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
25-976	2900045800	Long Branch	160	46	--	--	--	--	--	--	13	14	1	11/6/2013
25-1075	2900048307	Long Branch	300–340	80	--	--	--	--	--	--	--	25	--	11/5/2013
25-1108	2800051702	Roosevelt	160–170	201	--	--	--	--	--	--	--	138	--	11/7/2013
25-1135	E201116250	Freehold	177–217	176	--	--	--	--	--	--	--	108	--	11/19/2013
29-31	2900004663	Lakewood	605–625	10	−120	−127	−136	−123	−76	−62	−57	−55	2	11/6/2013
29-36	2900006021	Lakewood	518–548	27	--	−134	−149	−118	−78	−66	−60	−58	2	11/6/2013
29-37	2900004283	Point Pleasant	576–591	27	−129	−134	−148	−122	−83	−69	−61	−57	4	12/2/2013
29-49	2900006022	Point Pleasant	556–586	26	--	−138	−152	−125	−85	−72	−66	−66	0	11/6/2013
29-140	**2800004785**	**Cassville**	**257–267**	**134**	**114**	**113**	**111**	**111**	**111**	**110**	**106**	**110**	**4**	**12/5/2013**
29-227	2900005007	Lakehurst	358	94	26	22	--	31	30	23	3	19	16	11/6/2013
29-234	2800008255	Roosevelt	180–200	139	122	129	121	120	120	118	113	118	5	11/7/2013
29-699	2800007966	Roosevelt	214–226	164	--	128	125	127	126	122	113	120	7	10/31/2013
29-713	2800010063	Lakehurst	318–324	123	--	76	75	77	77	71	51	71	20	11/13/2013
29-740	2900008522	Lakehurst	340–380	96	--	32	30	33	43	44	37	36	−1	11/12/2013
29-781	2900009069	Lakehurst	302–325	99	--	--	29	25	31	48	27	43	16	11/4/2013
29-782	2900009348	Lakehurst	375–381	122	--	--	--	--	--	1	0	3	3	11/12/2013
29-783	2900009681	Adelphia	310–325	114	--	51	41	41	50	48	44	47	3	11/5/2013
29-784	2900010449	Lakehurst	341–347	92	--	--	4	6	11	8	−8	−4	4	11/6/2013
29-786	2900008581	Lakehurst	364–379	120	--	10	7	14	23	19	7	16	9	11/13/2013
29-926	2800018902	Cassville	127–160	107	--	--	111	112	112	112	109	110	1	11/1/2013
29-1138	2800023392	New Egypt	100–120	91	--	--	--	--	92	93	89	90	1	10/31/2013
29-1337	2800039790	New Egypt	120–140	103	--	--	--	--	--	--	--	87	--	10/31/2013
29-1578	2800041095	New Egypt	218–238	88	--	--	--	--	--	70	--	68	--	11/22/2013
29-1767	2900024855	Lakehurst	370	99	--	--	--	--	--	--	--	22	--	11/13/2013
29-1868	2800040634	Cassville	294	186	--	--	--	--	--	--	--	111	--	11/15/2013

Appendix 6. Water-level data for wells screened in the Wenonah-Mount Laurel aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
29-2012	2800041495	Roosevelt	242–262	142	--	--	--	--	--	--	--	118	--	11/7/2013
29-2043	2900023464	Lakehurst	463–473	67	--	--	--	--	--	--	--	−31	--	11/6/2013
29-2055	2800056401	Adelphia	249–269	159	--	--	--	--	--	--	103	109	6	11/5/2013
29-2109	2800050812	Cassville	299–314	144	--	--	--	--	--	--	--	94	--	11/15/2013
33-2	--	Alloway	462–472	90	--	27	25	24	19	20	15	17	2	12/5/2013
33-8	3000000030	Alloway	322–345	61	--	--	11	9	6	8	3	6	3	12/3/2013
33-20	**--**	**Alloway**	**283**	**75.68**	**32**	**30**	**29**	**27**	**24**	**25**	**21**	**23**	**2**	**10/23/2013**
33-22	3100004612	Elmer	460–500	106	29	31	28	21	7	15	4	16	12	12/3/2013
33-50	--	Salem	73–97	19	4	5	3	4	5	6	4	5	1	12/3/2013
33-56	--	Salem	93	23	5	5	5	5	5	6	4	5	1	12/5/2013
33-249	5000000042	Salem	110–150	5	0	−2	−5	--	--	−6	−6	−7	−1	12/13/2013
33-252	**--**	**Salem**	**91–96**	**2.32**	**0**	**0**	**−1**	**−1**	**−1**	**0**	**−2**	**−1**	**1**	**12/19/2013**
33-381	3000001505	Salem	85–125	9.06	--	−1	0	0	−1	0	−1	1	2	12/6/2013
33-384	3000001356	Salem	320	15	--	1	--	0	−1	1	0	1	1	12/4/2013
33-407	3400001600	Salem	250–300	8	--	--	--	--	−4	1	1	2	1	12/9/2013
33-456	3100019206	Elmer	443–503	124	--	27	26	21	7	8	7	14	7	12/3/2013
33-664	3000001454	Woodstown	123–166	67	--	--	--	--	33	35	33	39	6	12/16/2013
33-842	3500017374	Elmer	675–695	76	--	--	--	--	24	23	16	14	−2	12/5/2013
33-886	3000006741	Pitman West	358–378	143	--	--	--	--	--	37	30	37	7	12/12/2013
33-902	3000009510	Woodstown	100–143	48	--	--	--	--	36	37	36	32	−4	11/25/2013
33-904	3000005669	Pitman West	300–310	145	--	--	--	--	--	50	42	48	6	12/5/2013
33-932	3000005631	Salem	70–80	26	--	--	--	--	5	7	5	6	1	12/3/2013
33-937	3000008556	Alloway	318–338	109	--	--	--	--	--	22	16	19	3	12/3/2013
33-938	3400000970	Taylors Bridge	270–290	17.49	--	--	--	--	1	2	4	2	−2	12/13/2013
33-973	3000005372	Alloway	230–240	34	--	--	--	--	--	--	6	8	2	12/6/2013

Appendix 6. Water-level data for wells screened in the Wenonah-Mount Laurel aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
33-974	3000014867	Salem	108–168	6	--	--	--	--	--	--	--	−7	--	12/13/2013
33-981	--	Alloway	400	124	--	--	--	--	28	30	--	28	--	12/5/2013
33-1107	3400008297	Salem	240–250	16	--	--	--	--	--	--	0	0	0	12/4/2013
33-1121	3000016331	Penns Grove	75–90	46	--	--	--	--	--	--	--	20	--	12/23/2013
33-1145	3000013489	Woodstown	130–150	70	--	--	--	--	--	--	--	55	--	12/16/2013
33-1154	3000001048	Salem	120	24	--	--	--	--	--	--	--	5	--	12/4/2013
33-1157	3000020033	Salem	151–231	20	--	--	--	--	--	--	--	3	--	12/6/2013
33-1180	E201303382	Alloway	370	126	--	--	--	--	--	--	--	31	--	12/4/2013

[1]All water-level data in the appendixes reside in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2017).

[2]Water levels were not measured after January 14, 2013, at this well. Well used in this report for hydrograph only.

Appendix 7. Water-level data for wells screened in the Englishtown aquifer system, New Jersey Coastal Plain, 1978–2013.

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
5-195	3100001164	Mount Holly	70–74	58	23	21	20	24	20	20	19	20	1	12/2/2013
5-197	3100001191	Mount Holly	148–159	43	28	27	21	28	26	28	24	27	3	12/5/2013
5-256	3100001399	Mount Holly	440	79	--	--	--	--	19	20	18	20	2	11/20/2013
5-259	**--**	**Mount Holly**	**253–263**	**71.75**	**24**	**--**	**23**	**23**	**18**	**17**	**16**	**18**	**2**	**10/28/2013**
5-375	3200000276	Pemberton	343–378	67	16	26	22	17	9	18	21	28	7	11/25/2013
5-387	3200001103	Pemberton	208–228	55	57	59	54	57	54	53	54	54	0	11/26/2013
5-437	2800003831	Columbus	94–105	74	62	61	61	66	58	62	59	60	1	11/6/2013
5-754	--	Browns Mills	419–447	99	49	45	42	36	31	30	28	22	−6	1/24/2014
5-1390	3200021804	Browns Mills	615–635	105.7	--	--	--	--	11	10	6	9	3	12/11/2013
5-1427	2700011807	Bristol	40–60	47	--	--	--	--	--	43	39	41	2	11/6/2013
5-1434	2800007339	Columbus	150	57	--	--	--	--	--	54	--	51	--	11/7/2013
5-1476	3100055694	Mount Holly	9–14	16	--	--	--	--	--	11	9	10	1	10/24/2013
5-1492	3200022557	Browns Mills	411–451	92	--	--	--	--	27	27	25	18	−7	11/25/2013
5-1547	3200027283	Browns Mills	460–495	80	--	--	--	--	--	9	--	12	--	12/4/2013
5-1762	3100065897	Mount Holly	249–279	47	--	--	--	--	--	--	4	9	5	11/8/2013
5-1763	3100070362	Mount Holly	231–281	54	--	--	--	--	--	--	9	15	6	11/8/2013
5-1787	2800058602	Columbus	115–175	64	--	--	--	--	--	--	46	47	1	11/7/2013
5-1855	3200030103	Pemberton	206–236	57	--	--	--	--	--	--	--	41	--	12/4/2013
5-1889	P200907593	Moorestown	134–174	87	--	--	--	--	--	--	--	70	--	11/15/2013
5-1896	E201209943	Columbus	136–190	111	--	--	--	--	--	--	--	83	--	11/14/2013
5-1898	E201010500	New Egypt	200–220	164	--	--	--	--	--	--	--	75	--	11/21/2013
7-166	3100001202	Clementon	367–457	148	−2	45	9	13	11	8	17	13	−4	11/25/2013
7-672	3100024779	Runnemede	195–215	72	--	--	46	42	25	0	20	11	−9	11/26/2013
15-344	3000000064	Bridgeport	69–83	84	--	--	--	--	71	73	--	73	--	12/19/2013
15-676	--	Woodbury	68–78	26.33	--	--	29	29	28	29	29	29	0	12/6/2013

Appendix 7. Water-level data for wells screened in the Englishtown aquifer system, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
23-104	**--**	**Freehold**	**110**	**75.63**	**--**	**--**	**68**	**73**	**68**	**72**	**71**	**69**	**−2**	**10/18/2013**
25-16	2900000045	Asbury Park	563–594	19	−189	−197	−203	−92	−69	−69	−53	−59	−6	11/22/2013
25-28	2900005292	Point Pleasant	770–820	85	−224	−225	−212	−124	−98	−105	−68	−100	−32	11/6/2013
25-30	2900000069	Point Pleasant	690–750	30	−236	−252	−228	−119	−94	−103	−65	−102	−37	11/6/2013
25-46	2900004196	Marlboro	212–232	122	70	68	61	--	58	52	41	43	2	11/8/2013
25-63	2900004386	Farmingdale	420–460	74	--	--	−84	−40	−28	−30	−12	−10	2	11/8/2013
25-80	2900005417	Adelphia	294–334	116	71	74	69	69	74	71	64	68	4	11/5/2013
25-96	2900004435	Freehold	327–356	199	86	87	80	73	67	69	59	62	3	10/24/2013
25-107	2900003177	Marlboro	249–257	167	85	85	77	74	68	69	--	64	--	11/5/2013
25-144	4900000031	Marlboro	154	107	--	--	62	--	60	61	60	58	−2	11/1/2013
25-162	2900007043	Farmingdale	500–560	70	−113	−119	−124	−65	−47	−50	−47	−42	5	11/8/2013
25-165	2900005346	Farmingdale	363–550	136	--	--	−93	−45	−35	−29	−52	−32	20	10/30/2013
25-250	**2900004437**	**Freehold**	**185–215**	**137.51**	**99**	**--**	**93**	**91**	**89**	**91**	**88**	**92**	**4**	**10/18/2013**
25-365	2900004513	Long Branch	268–333	7	--	--	--	5	1	7	5	5	0	11/8/2013
25-374	2900004102	Asbury Park	660–710	24	−201	−214	−212	−109	−87	−90	--	−89	--	11/19/2013
25-383	4900000014	Asbury Park	631–711	14	--	--	--	--	--	--	−62	−88	−26	11/20/2013
25-408	2800006655	Allentown	96–119	107	--	102	102	101	--	101	102	103	1	11/6/2013
25-428	2900002869	Asbury Park	689–740	90	--	--	--	--	--	−67	−84	−81	3	12/2/2013
25-429	**2900004140**	**Farmingdale**	**623–633**	**96.87**	**−144**	**--**	**−150**	**−79**	**−59**	**−66**	**−48**	**−54**	**−6**	**11/6/2013**
25-441	2900005289	Asbury Park	549–649	121	−161	−162	−169	−73	−64	−72	−49	−54	−5	12/2/2013
25-442	4900000032	Asbury Park	627–657	68	--	−179	--	--	--	−69	−52	−60	−8	12/2/2013
25-638	**2900018401**	**Farmingdale**	**483–493**	**110.9**	**--**	**--**	**−54**	**−15**	**−4**	**−7**	**−3**	**0**	**3**	**11/6/2013**
25-686	2900015362	Marlboro	320–340	75	--	--	--	26	--	22	23	18	−5	10/28/2013
25-697	2900013591	Long Branch	247–277	64	--	--	12	15	16	16	13	14	1	11/5/2013
25-704	2900015337	Adelphia	290–320	182	--	--	92	94	94	93	89	91	2	11/5/2013

Appendix 7. Water-level data for wells screened in the Englishtown aquifer system, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
25-710	2900016728	Lakewood	594–644	39	--	--	−170	−102	−76	−77	−66	−70	−4	11/19/2013
25-713	2900020565	Marlboro	300–320	81	--	--	20	--	24	--	--	17	--	10/28/2013
25-714	2900025383	Sandy Hook	198–248	79	--	--	--	--	--	9	3	4	1	10/29/2013
25-715	**2900025384**	**Sandy Hook**	**350–360**	**227.7**	**--**	**--**	**--**	**4**	**3**	**4**	**3**	**3**	**0**	**10/18/2013**
25-727	2900024425	Freehold	149–206	110	--	--	--	--	--	66	60	61	1	10/24/2013
25-733	2900028556	Marlboro	316–366	133	--	--	--	--	45	46	37	36	−1	10/29/2013
25-735	2900026191	Marlboro	140–191	139	--	--	--	32	82	83	81	80	−1	10/29/2013
25-771	2900036217	Sandy Hook	258–278	7.3	--	--	--	--	−2	1	−1	5	6	10/18/2013
[2]25-771	Freshwater	equivalent	258–278	7.3	--	--	--	--	3	6	4	0	−4	10/18/2013
25-782	2800014424	Allentown	215–245	148	--	--	--	--	--	102	90	99	9	11/7/2013
25-786	2900030436	Marlboro	233–273	86	--	--	--	--	31	32	29	25	−4	10/29/2013
25-787	2800036906	Allentown	90–100	130	--	--	--	--	110	111	110	111	1	11/6/2013
25-837	2900026791	Adelphia	243–318	114	--	--	--	--	--	--	92	95	3	11/5/2013
25-838	2900019719	Marlboro	315–335	77	--	--	18	--	--	--	--	17	--	10/28/2013
25-908	2900039924	Sandy Hook	145–155	49	--	--	--	--	--	--	--	7	--	10/24/2013
25-932	2900021582	Sandy Hook	208–220	14	--	--	--	--	--	--	--	2	--	10/29/2013
25-1002	2900045380	Marlboro	200	113	--	--	--	--	--	--	66	59	−7	11/1/2013
25-1058	2900052364	Long Branch	260–300	51	--	--	--	--	--	--	--	37	--	11/6/2013
25-1079	2800058020	Roosevelt	198–218	175	--	--	--	--	--	--	--	130	--	11/14/2013
25-1086	2900041044	Marlboro	270–310	107	--	--	--	--	--	--	--	31	--	11/1/2013
25-1154	2900046123	Marlboro	205–220	107	--	--	--	--	--	--	--	42	--	11/1/2013
25-1155	2900046124	Marlboro	205–220	107	--	--	--	--	--	--	--	47	--	11/1/2013
29-5	4900000002	Point Pleasant	750–834	4	−232	−225	−208	−159	−110	−100	−70	−78	−8	10/31/2013
29-138	**--**	**Cassville**	**417–427**	**135.37**	**64**	**62**	**59**	**60**	**63**	**64**	**60**	**62**	**2**	**12/5/2013**
29-236	2900003883	Adelphia	541–577	162	--	−51	−61	−24	−64	−15	−17	−8	9	11/13/2013

Appendix 7. Water-level data for wells screened in the Englishtown aquifer system, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
29-430	2900005721	Lakewood	752–817	108	--	−178	−172	−101	--	−72	−72	−78	−6	11/4/2013
29-433	2900005110	Lakewood	673–741	45	−207	−202	−184	−105	−78	−75	−71	−80	−9	11/4/2013
29-434	2900004304	Lakewood	697–757	124	−188	−159	−322	−92	−67	−71	−63	−78	−15	10/31/2013
29-438	2900004834	Lakewood	600–758	80	−150	−168	−159	−110	−77	−88	−89	−68	21	10/30/2013
29-441	2900005068	Lakewood	726–736	29	−137	−142	−141	−113	−71	−62	−54	−52	2	10/30/2013
29-450	2900003324	Lakewood	520–582	69	−136	−154	−134	−88	−62	−71	−66	−54	12	10/30/2013
29-451	2900002207	Lakehurst	510–530	71	−91	−97	−92	−53	−41	−43	−40	−32	8	11/12/2013
29-452	3300000001	Seaside Park	1,020–1,180	3	--	−123	−112	−93	--	−59	−59	−52	7	11/20/2013
29-503	2900001325	Point Pleasant	845–906	3.88	--	−196	−195	−134	−99	−95	−67	−72	−5	10/31/2013
29-519	4800000022	New Egypt	214–239	74	--	68	66	--	--	--	--	49	--	10/31/2013
29-530	**2900004530**	**Point Pleasant**	**730–790**	**16**	**−240**	**−215**	**−206**	**−150**	**−103**	**--**	**−76**	**−93**	**−17**	**10/31/2013**
29-534	**3300001117**	**Toms River**	**1,080–1,146**	**17.1**	**−80**	**--**	**−87**	**−86**	**−67**	**−55**	**−47**	**−27**	**20**	**10/31/2013**
29-938	2800020499	Lakehurst	487–527	122	--	--	−16	−1	14	15	15	16	1	11/14/2013
29-1316	2900026316	Lakehurst	512–553	105	--	--	--	--	4	2	3	5	2	11/13/2013
29-1336	2800034164	Cassville	305–355	118	--	--	--	--	64	64	59	61	2	11/7/2013
29-2013	2800041494	Roosevelt	378–398	142	--	--	--	--	--	--	98	98	0	11/7/2013
29-2197	2900056684	Point Pleasant	728–788	17	--	--	--	--	--	--	--	−93	--	11/12/2013
29-2225	P200800890	Lakewood	652–714	71	--	--	--	--	--	--	--	−95	--	10/31/2013
33-168	3000000029	Penns Grove	113–124	40	--	--	--	--	17	19	16	17	1	11/25/2013
33-581	3000001467	Penns Grove	95–115	21	--	--	15	10	--	14	12	12	0	11/25/2013

[1]All water-level data in the appendixes reside in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2017).

[2]Chloride concentrations in well in excess of 5,000 milligrams per liter, so water level was converted to freshwater head.

Appendix 8. Water-level data for wells screened in the Upper Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
5-116	2800002847	Columbus	247–253	95	0	−1	−4	−3	−2	−8	−7	−6	1	11/8/2013
5-165	3100005458	Moorestown	464–500	118	−67	−73	−97	−96	−77	−77	−73	−51	22	11/15/2013
5-167	3100007883	Mount Holly	478–548	48	−72	−81	−86	−90	−71	−75	--	−56	--	11/15/2013
5-207	2800003986	Columbus	325	90	−18	−21	−25	−25	−23	−24	--	−24	--	12/5/2013
5-212	2800003560	Columbus	290–310	87	−9	−11	−14	−14	−13	−17	−18	−17	1	11/14/2013
5-218	--	Columbus	100	67	5	3	3	5	4	5	0	1	1	11/8/2013
5-229	3100008922	Moorestown	160–200	40	−47	−57	−56	−53	−46	−37	−35	−29	6	11/12/2013
5-249	3100005282	Medford Lakes	523–541	50	−70	−80	−89	−91	−73	−65	−69	−57	12	11/14/2013
5-254	3100010560	Mount Holly	451–471	31	--	--	--	−78	−67	−61	−61	−50	11	11/8/2013
5-258	**3100004627**	**Mount Holly**	**400–410**	**69.6**	**−53**	**--**	**67**	**−71**	**−60**	**−57**	**−53**	**−44**	**9**	**10/28/2013**
5-317	3100000212	Moorestown	192–222	43	--	--	−47	−48	−48	−34	−31	−25	6	12/19/2013
5-438	--	Bristol	220–230	40	−23	−24	--	--	--	−24	−26	−19	7	11/14/2013
5-728	--	Pemberton	485–500	50	−36	−36	−42	−47	−48	−38	−41	−31	10	12/5/2013
5-729	3100000060	Moorestown	91–121	13	--	--	−43	−43	--	−32	--	−21	--	11/12/2013
5-731	--	Trenton East	118–128	92	4	3	2	2	2	1	0	0	0	11/1/2013
5-745	2700005937	Bristol	260–290	102	−18	−17	−21	−23	−23	−20	−21	−13	8	11/6/2013
5-759	3100016976	Medford Lakes	593–672	90	--	--	--	--	--	−61	−66	−55	11	11/14/2013
5-795	3100009595	Moorestown	416–463	60	−79	−96	−97	−97	−76	−74	−76	−61	15	11/15/2013
5-820	3100006841	Clementon	545–591	87	--	−81	−83	--	--	−78	−73	−57	16	11/15/2013
5-1157	2800028845	Columbus	251–266	43	--	--	--	−27	--	−29	−28	−25	3	11/11/2013
5-1159	2800015286	Bristol	165–205	43	--	--	--	−16	−16	−16	−19	−14	5	12/3/2013
5-1181	3100041329	Mount Holly	313–343	17	--	--	--	−81	−55	−50	−51	−30	21	12/3/2013
5-1183	2800028543	Bristol	200–220	77	--	--	--	−14	−12	−12	−14	−9	5	11/7/2013
5-1194	3100029146	Moorestown	300–310	79	--	--	--	−65	−54	−49	−45	−38	7	11/8/2013
5-1389	3200022005	Browns Mills	900–920	106	--	--	--	--	−41	−39	−45	−39	6	12/11/2013

Appendix 8. Water-level data for wells screened in the Upper Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
5-1391	3200021805	Woodmansie	1416–1436	185.6	--	--	--	--	−26	−27	−36	−35	1	12/11/2013
5-1490	3100017792	Mount Holly	364–376	42	--	--	--	--	−56	−49	−49	−37	12	12/5/2013
5-1777	3100049822	Medford Lakes	623	78	--	--	--	--	--	--	--	−58	--	11/15/2013
5-1784	2800054309	New Egypt	525–565	177	--	--	--	--	--	--	--	−18	--	11/21/2013
5-1792	2800047868	Columbus	255–270	56	--	--	--	--	--	--	--	−21	--	11/7/2013
5-1852	2800059342	Columbus	250–270	86	--	--	--	--	--	--	--	−16	--	11/14/2013
5-1863	3100069852	Moorestown	143–163	68	--	--	--	--	--	--	--	−11	--	11/7/2013
7-15	3100006208	Clementon	675–745	152	−76	−87	−95	−95	--	−88	−73	−58	15	11/26/2013
7-18	3100002079	Clementon	650–713	146	--	146	−94	−97	−101	−77	−75	−60	15	11/26/2013
7-115	3100000051	Clementon	400–420	64	--	−90	−107	−101	−68	−64	−62	−56	6	11/21/2013
7-117	**3100004897**	**Clementon**	**552–562**	**156.46**	**−77**	**−81**	**−85**	**−97**	**−68**	**−68**	**−63**	**−54**	**9**	**11/19/2013**
7-131	3100005096	Moorestown	342	71	−74	−87	−83	−86	−54	−65	−59	−49	10	11/26/2013
7-249	3100002703	Runnemede	426–447	63	--	--	−88	−88	−65	−66	−53	−49	4	12/11/2013
7-252	3100005581	Runnemede	407–477	64	−84	−95	−92	−97	−67	−70	−57	−56	1	12/6/2013
7-274	3100005226	Runnemede	269–349	57	−84	−90	−84	−89	−56	−61	--	−61	--	11/20/2013
7-275	3100003375	Camden	236–267	58.86	−78	−79	−82	−73	--	−62	−48	−52	−4	12/3/2013
7-285	3100003308	Camden	144–191	23	−64	−65	−65	−59	−43	−43	−41	−35	6	11/26/2013
7-299	2100002570	Camden	206–246	70	−75	−80	−80	--	--	--	−49	−44	5	11/26/2013
7-311	3100004723	Runnemede	395–473	74	−81	−87	−92	−89	−64	−73	−57	−60	−3	11/26/2013
7-316	3100005100	Runnemede	271–348	72	--	−90	−86	−82	−55	−62	−54	−51	3	11/20/2013
7-322	3100004283	Camden	101–112	31.5	--	−54	−51	−48	−36	−32	−29	−24	5	12/3/2013
7-398	3100006646	Clementon	668–698	199	−82	−97	−98	--	--	−76	−69	−62	7	11/22/2013
7-404	3100003307	Runnemede	297–339	65.84	−79	−84	−83	−76	−51	−56	−53	−49	4	11/20/2013
7-410	3100002360	Runnemede	441	97	−88	−93	−92	−91	−61	−67	−61	−57	4	11/20/2013
7-423	--	Clementon	459	73	--	--	--	--	−58	−62	−56	−52	4	11/20/2013

Appendix 8. Water-level data for wells screened in the Upper Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
7-477	**3100004448**	**Williamstown**	**829–839**	**109.94**	**−65**	**−74**	**−78**	**−85**	**−74**	**−63**	**−64**	**−55**	**9**	**10/28/2013**
7-521	3100012301	Clementon	600–629	191	--	--	−92	−93	−76	−73	−75	−59	16	11/25/2013
7-727	3100031110	Moorestown	175–202	42	--	--	--	−68	−51	−50	−43	−38	5	12/3/2013
7-824	3100037826	Clementon	590–665	148	--	--	--	--	−92	−74	−76	−65	11	11/22/2013
7-935	3100044510	Camden	48– 68	35.79	--	--	--	--	−16	--	--	−6	--	11/1/2013
7-1162	3100037393	Camden	159–179	67	--	--	--	--	--	--	--	−28	--	12/11/2013
7-1173	3100041034	Camden	89–119	29	--	--	--	--	--	--	--	−12	--	11/1/2013
7-1234	3100063874	Clementon	475–505	100	--	--	--	--	--	--	−68	−56	12	12/11/2013
15-1	3100002889	Pitman East	746–800	135	−60	−67	−75	−78	−63	−51	--	−46	--	12/6/2013
15-3	3100006676	Pitman East	670–740	141	−62	−32	−70	−73	−61	−52	−50	−45	5	12/6/2013
15-8	5100000101	Woodbury	244–307	17	−54	−57	−65	--	−56	−50	−45	−37	8	12/4/2013
15-28	3000000432	Woodbury	191–216	70	−21	−23	−23	−27	−24	−19	−20	−15	5	12/4/2013
15-60	3100002358	Pitman West	562–612	150	−60	−70	−66	−70	−63	−65	−47	−44	3	12/6/2013
15-63	3100004176	Pitman East	549–599	148	−61	−67	−66	−69	−59	−65	−60	−45	15	12/6/2013
15-127	3100003280	Pitman West	524	137	−49	−52	−53	--	−48	−40	−38	−33	5	12/11/2013
15-187	--	Woodbury	325–355	48	--	--	−66	−63	--	−50	−50	−37	13	12/6/2013
15-194	3100005309	Woodbury	230–265	8.83	−49	−54	−53	−53	−42	−41	−41	−33	8	12/9/2013
15-227	3100004061	Pitman West	447–487	99	−60	−64	−71	−68	−62	−55	--	−41	--	12/9/2013
15-238	5000000036	Woodstown	217–240	33	−18	−18	−18	--	--	--	−19	−15	4	11/26/2013
15-240	3000000973	Bridgeport	190–231	33	−19	−18	−19	−20	−18	−14	−18	−13	5	11/26/2013
15-248	5100000029	Pitman East	559–618	121	−67	−72	−84	−77	--	−58	−57	−49	8	12/6/2013
15-274	5100000065	Woodbury	273–310	89	--	--	--	--	--	--	−32	−32	0	12/2/2013
15-275	3100000170	Woodbury	268–310	59	−42	−44	−53	−54	−57	−36	−34	−32	2	12/2/2013
15-276	3100004567	Woodbury	242–289	61	−38	−43	−45	−47	−39	−31	--	−28	--	12/5/2013
15-295	3100006200	Woodbury	120–140	11	--	--	--	--	--	−1	--	−14	--	12/2/2013

Appendix 8. Water-level data for wells screened in the Upper Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
15-303	--	Woodbury	84–114	13	−3	−5	−6	−5	−4	--	−2	−1	1	12/3/2013
15-330	3100006356	Woodbury	190–235	38	−46	−52	−51	−49	−40	−33	−32	−30	2	12/6/2013
15-339	3000001161	Woodstown	247–267	91	−18	−18	−19	−20	−19	−17	−21	−14	7	11/26/2013
15-346	3000001565	Woodbury	267–343	76	--	−28	−33	−39	−31	−25	−30	−21	9	12/9/2013
15-355	3000001426	Woodbury	205–245	42	−28	−30	−28	−28	−29	−19	−19	−15	4	12/4/2013
15-378	--	Bridgeport	239	100	--	--	−26	−26	−24	−20	−23	−18	5	12/19/2013
15-433	3100017801	Runnemede	512–552	142	--	−62	−71	−75	−60	−58	−52	−48	4	12/6/2013
15-617	3000003533	Bridgeport	60–70	29.4	--	--	−9	−9	−9	−5	−9	−5	4	11/25/2013
15-728	**3000004549**	**Bridgeport**	**46–56**	**3.29**	**--**	**--**	**−9**	**−8**	**−9**	**−5**	**−7**	**−5**	**2**	**11/5/2013**
15-741	**--**	**Woodbury**	**293–313**	**80.8**	**--**	**--**	**−45**	**−47**	**−43**	**−32**	**−33**	**−27**	**6**	**11/5/2013**
15-773	3100026238	Woodbury	30–50	9	--	--	−8	--	--	1	0	2	2	12/2/2013
15-779	3100026239	Woodbury	25–35	5	--	--	−8	−1	−1	0	0	1	1	12/2/2013
15-1000	3100021614	Runnemede	354–359	77	--	--	−69	−68	−54	−50	−55	−49	6	12/4/2013
15-1031	3000003412	Bridgeport	95–105	45	--	--	−11	−12	−11	−8	−12	−7	5	11/26/2013
15-1088	5000000050	Pitman West	285	35	--	--	--	--	--	−23	−25	−18	7	12/11/2013
15-1089	3100037705	Runnemede	198–258	45	--	--	--	--	−45	−42	−39	−35	4	12/3/2013
15-1105	3000004335	Woodstown	357–377	143	--	--	--	−27	−24	−21	−22	−18	4	11/26/2013
15-1106	3000007949	Woodbury	101–111	14	--	--	--	−5	−5	−2	−3	−1	2	12/3/2013
15-1112	3000008730	Woodstown	207–280	74	--	--	--	--	--	--	--	−15	--	11/26/2013
15-1346	3000003764	Bridgeport	60– 90	10	--	--	--	--	−11	−7	−9	−5	4	11/26/2013
15-1349	3100033937	Pitman East	680–690	160	--	--	--	--	--	−63	−60	−53	7	12/6/2013
15-1365	3100045998	Pitman East	628–712	160	--	--	--	--	--	−62	−59	−53	6	12/6/2013
15-1483	3000012606	Woodstown	186–216	101	--	--	--	--	−18	−13	−15	−10	5	11/26/2013
15-1513	3000005444	Woodstown	357–367	80	--	--	--	--	−31	−28	−29	−23	6	12/17/2013
15-1529	3000014503	Woodstown	198–248	46	--	--	--	--	--	--	--	−22	--	12/11/2013

Appendix 8. Water-level data for wells screened in the Upper Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
15-1543	3100049895	Pitman East	616–703	156	--	--	--	--	--	--	−58	−51	7	12/6/2013
15-1545	3000006144	Pitman West	476–486	133	--	--	--	--	--	--	−33	−28	5	12/5/2013
15-1577	3100061731	Runnemede	450	68	--	--	--	--	--	--	−50	−48	2	12/3/2013
15-1754	3100056367	Williamstown	873–958	149	--	--	--	--	--	--	−60	−51	9	12/12/2013
15-1755	3100060817	Pitman East	700–820	150	--	--	--	--	--	--	−60	−52	8	12/12/2013
15-1784	3100073192	Woodbury	345–355	89	--	--	--	--	--	--	−33	−27	6	12/6/2013
15-1786	3000012477	Woodbury	79– 89	14.54	--	--	--	--	--	--	--	−6	--	12/9/2013
15-1838	E201117131	Woodbury	212–297	92	--	--	--	--	--	--	--	−15	--	12/4/2013
15-1841	E201309554	Woodstown	222–242	33	--	--	--	--	--	--	--	−18	--	12/17/2013
15-1842	E201311409	Woodstown	258–273	107	--	--	--	--	--	--	--	−12	--	11/26/2013
21-1	--	Allentown	285–315	128	--	--	--	--	39	38	33	33	0	11/8/2013
21-19	2800005897	Hightstown	133–181	85	66	63	64	65	66	64	63	65	2	11/4/2013
21-84	4800000063	Hightstown	181–205	79	56	49	46	51	52	51	50	52	2	10/30/2013
21-651	2800019394	Allentown	224–229	134	--	--	--	--	--	--	--	35	--	11/8/2013
23-98	2800001426	Jamesburg	99–120	47	44	41	38	42	39	43	43	43	0	10/24/2013
23-100	2800001612	Jamesburg	118–129	43	--	42	43	--	--	--	--	42	--	10/24/2013
23-101	2800007904	Freehold	211–223	48	15	--	9	17	16	17	26	15	−11	10/28/2013
23-108	4800000194	New Brunswick	87–107	26	--	--	--	−16	12	−2	4	−5	−9	10/28/2013
23-109	--	New Brunswick	101	22.41	−1	−3	−3	−3	15	6	13	4	−9	10/28/2013
23-142	4900029698	South Amboy	199–249	91	9	5	10	9	--	3	4	10	6	10/31/2013
23-143	--	South Amboy	81–91	31	--	6	6	8	7	9	6	7	1	10/28/2013
23-173	--	South Amboy	173–193	64	0	−3	−4	5	3	4	3	4	1	10/29/2013
23-180	**--**	**South Amboy**	**57–67**	**18.06**	**3**	**3**	**3**	**4**	**3**	**4**	**3**	**3**	**0**	**10/28/2013**
23-182	--	South Amboy	66–71	29.49	16	14	12	14	16	15	14	15	1	10/30/2013
23-213	2800006470	Jamesburg	195–198	110	--	--	--	--	25	26	22	24	2	10/24/2013

Appendix 8. Water-level data for wells screened in the Upper Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
23-228	**2800004251**	**Jamesburg**	**128–138**	**146.26**	**65**	**58**	**54**	**59**	**61**	**59**	**61**	**61**	**0**	**10/24/2013**
23-244	2800007145	Jamesburg	152–158	84	22	18	21	--	22	22	20	21	1	10/28/2013
23-292	**2800004250**	**Hightstown**	**93–104**	**105.87**	**75**	**70**	**70**	**71**	**73**	**74**	**75**	**74**	**−1**	**11/15/2013**
23-344	--	South Amboy	31– 37	21.11	14	12	13	16	15	16	14	14	0	10/31/2013
23-351	**--**	**South Amboy**	**76– 82**	**34.19**	**19**	**16**	**16**	**19**	**19**	**22**	**19**	**19**	**0**	**10/30/2013**
23-490	2800008490	Jamesburg	287–325	165	49	--	--	--	--	47	45	44	−1	10/25/2013
23-508	--	Hightstown	90	105	68	65	63	65	66	65	63	64	1	10/29/2013
23-565	2800011720	Jamesburg	165–197	143	--	58	--	--	62	60	62	62	0	10/25/2013
23-569	2900011861	South Amboy	102–132	71	--	--	--	--	15	16	17	16	−1	10/30/2013
23-759	2800012941	Jamesburg	250–256	119	--	--	--	--	--	--	--	36	--	10/22/2013
23-775	2800011436	Jamesburg	182–190	119	--	--	--	--	40	40	36	39	3	10/25/2013
23-1156	2900012379	Freehold	230–238	60	--	--	−4	4	3	1	0	2	2	10/28/2013
23-1159	2900019607	South Amboy	95–105	88	--	--	44	45	49	45	46	46	0	11/5/2013
23-1172	2900019614	South Amboy	68–78	102	--	--	39	--	--	--	41	41	0	11/5/2013
23-1200	2800017439	Jamesburg	166–176	104	--	--	--	--	59	58	56	56	0	10/24/2013
23-1358	2900045498	South Amboy	50–55	46	--	--	--	--	--	--	4	5	1	10/29/2013
23-1529	2800056726	Jamesburg	190–220	110	--	--	--	--	--	--	--	41	--	12/20/2013
25-4	2800008915	Allentown	212–262	68	--	21	--	--	26	20	15	20	5	11/7/2013
25-13	2900007461	Asbury Park	1,105–1,165	25	−20	−31	−33	−19	−21	−19	−28	−22	6	11/19/2013
25-37	2900004068	Marlboro	686–706	135	−32	−37	−23	−16	−20	−17	−24	−22	2	10/31/2013
25-56	2800005400	Freehold	363–384	66	5	−3	14	12	8	10	3	8	5	11/8/2013
25-62	2900003492	Farmingdale	831–885	75	−25	−39	−34	−16	−20	−21	−30	−25	5	11/8/2013
25-91	2900005708	Freehold	632–685	138	−40	−49	−36	−15	−17	−17	−27	−14	13	11/19/2013
25-97	2900004708	Freehold	596–656	201	−36	−41	−32	−13	−17	−13	−23	−18	5	10/30/2013
25-103	2900007494	Freehold	478–575	111	−49	−28	−35	−10	−13	−7	−16	−11	5	10/24/2013

Appendix 8. Water-level data for wells screened in the Upper Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
25-112	2900003096	Keyport	312–352	42.56	−41	−37	−40	−15	−13	−21	−15	−13	2	10/29/2013
25-116	2900003509	Sandy Hook	600–660	8	−17	−20	−18	--	−6	−7	−7	−8	−1	11/1/2013
25-154	2900004207	Keyport	400–430	71.95	−40	−36	−39	−13	−14	--	−16	−8	8	10/29/2013
25-195	2900001297	Keyport	290–350	14	--	−36	−33	−22	−19	−20	−14	−13	1	10/28/2013
25-197	2900008379	Keyport	304–354	39	−23	−22	−21	−6	−6	−8	−6	−5	1	10/29/2013
25-206	**--**	**Keyport**	**225–249**	**13.56**	**−13**	**−14**	**−18**	**−4**	**−5**	**−8**	**−6**	**−5**	**1**	**1/13/2014**
25-214	2100007184	Adelphia	585–641	193	−3	−2	--	--	6	6	−3	3	6	11/7/2013
25-218	2800006213	Jamesburg	510–527	242	12	5	4	--	14	14	19	12	−7	10/24/2013
25-220	2800006114	Freehold	539–569	134	−7	−15	−15	4	1	2	−7	−2	5	10/28/2013
25-244	2900005790	Freehold	524–594	170.26	−25	−32	−37	−10	−16	−9	−16	−13	3	10/31/2013
25-259	2900000073	Marlboro	508–593	153.97	−19	−27	−28	−6	−6	−6	−9	−9	0	10/29/2013
25-284	2900001731	Keyport	231–271	86	−11	−11	−15	0	0	−4	−1	1	2	10/29/2013
25-292	2900003729	Keyport	341–414	88	−32	−32	−33	--	--	−11	−14	−10	4	11/1/2013
25-293	2900003818	Keyport	354	72.16	--	--	--	--	--	--	--	−13	--	11/1/2013
25-316	**2900004299**	**Sandy Hook**	**371–397**	**9.8**	**−6**	**−5**	**−10**	**−4**	**−2**	**−2**	**−3**	**−3**	**0**	**1/13/2014**
25-322	2800001842	Roosevelt	667–697	213	7	1	−1	10	10	8	0	7	7	11/19/2013
25-360	2900007941	Long Branch	668–759	143	−34	−37	−37	--	--	−36	−30	−17	13	11/18/2013
25-436	2900006193	Asbury Park	990–1,033	58	−28	−43	−45	−19	−23	−21	−32	−25	7	11/22/2013
25-459	2900009335	Long Branch	551–612	76	--	−28	−29	−19	−23	−17	−19	−18	1	11/5/2013
25-493	2900007784	Farmingdale	860	115	--	−35	−38	−17	−19	−19	−29	−23	6	10/30/2013
25-496	2900010478	Sandy Hook	510–543	10	--	−23	−24	--	−4	--	−12	−12	0	10/29/2013
25-499	2900010810	Keyport	322–372	90	--	--	--	--	--	--	--	−7	--	11/1/2013
25-500	2800012215	Allentown	270–305	87	--	3	−1	--	3	1	−5	−1	4	11/13/2013
25-501	2900011335	Asbury Park	1,000–1,075	38	--	--	−40	--	--	--	−29	−23	6	11/1/2013
25-502	2900011033	Adelphia	616–671	127	--	−49	−41	--	−18	−12	−22	−24	−2	10/24/2013

Appendix 8. Water-level data for wells screened in the Upper Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
25-509	2800012280	Roosevelt	390–430	152	--	11	9	19	18	16	10	13	3	10/30/2013
25-513	2900011230	Sandy Hook	506–548	8	--	--	--	−15	−11	−2	−11	−13	−2	10/29/2013
25-514	2900012732	Keyport	266–312	15	--	−25	−26	−14	−8	−15	−11	−7	4	10/24/2013
25-550	2900013610	Adelphia	636–656	105	--	--	−39	−12	−16	−13	−25	−18	7	10/24/2013
25-567	2900015851	Keyport	250–270	10	--	--	−23	−9	−7	−14	−11	−7	4	11/1/2013
25-568	2900016343	Keyport	245–265	4	--	--	−18	−8	−6	−11	−7	0	7	10/24/2013
[2]25-568	Freshwater	equivalent	245–265	4	--	--	−17	−7	−5	−10	−6	1	7	10/24/2013
25-639	**2900018403**	**Farmingdale**	**891.2–901.2**	**110.5**	**--**	**--**	**−17**	**−17**	**−20**	**−20**	**−30**	**−24**	**6**	**11/6/2013**
25-712	2900021610	Long Branch	598–668	44	--	--	−33	--	--	−20	−26	−21	5	11/1/2013
25-721	2900015170	Asbury Park	999–1,149	126	--	--	--	--	−21	−19	−31	−24	7	11/1/2013
25-724	2900017817	Freehold	446–551	134.27	--	--	--	−7	−14	−9	−15	−13	2	10/31/2013
25-729	2900021611	Long Branch	575–655	33	--	--	--	−19	−20	−19	−26	−23	3	11/1/2013
25-736	2900021612	Long Branch	569–669	43	--	--	−28	--	--	−18	−24	−21	3	11/1/2013
25-749	4800000045	Allentown	350	101	--	--	--	--	1	−1	−8	0	8	11/7/2013
25-828	2900044304	Keyport	399–428	59.31	--	--	--	--	--	--	−16	−8	8	11/29/2013
25-830	2800018879	Allentown	330–340	103	--	--	--	--	--	--	11	15	4	11/6/2013
25-987	2800048342	Allentown	196.3	136	--	--	--	--	--	--	--	24	--	11/7/2013
25-1063	2900055195	Keyport	312–352	10	--	--	--	--	--	--	−16	−13	3	10/28/2013
25-1074	2900048138	Marlboro	675–715	86	--	--	--	--	--	--	--	−20	--	10/31/2013
25-1083	2900053160	Freehold	334–354	125	--	--	--	--	--	--	1	4	3	10/31/2013
29-70	3300001159	Seaside Park	1,375–1,495	6	−20	−27	−25	−21	−26	−28	−43	−37	6	10/31/2013
29-134	2900003570	Lakehurst	846–962	103	−16	−20	−23	−35	−44	−36	−59	−51	8	11/15/2013
29-453	3300000908	Seaside Park	1,358–1,515	3.85	−20	−29	−28	--	--	−11	--	−43	--	11/20/2013
29-504	2900003142	Point Pleasant	1,263–1,368	3.88	−19	−28	−27	−19	−23	−24	−36	−31	5	10/31/2013
29-531	2900003345	Point Pleasant	1,256–1,342	15	−22	−36	−32	−21	−28	−25	--	−30	--	11/12/2013

Appendix 8. Water-level data for wells screened in the Upper Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
29-577	3300005553	Seaside Park	1,394–1,498	3	--	−26	−24	−24	−25	−45	−51	−43	8	11/20/2013
29-1040	2900023401	Lakehurst	1,013–1,184	36	--	--	--	−29	−40	−51	−97	−84	13	11/6/2013
29-1365	3300037776	Seaside Park	1,389–1,580	4	--	--	--	--	−27	−60	−66	−50	16	11/20/2013
29-1380	2900039030	Lakehurst	937–1,024	69	--	--	--	--	−28	−48	−78	−66	12	11/6/2013
29-1381	2900041029	Lakehurst	928–984	70	--	--	--	--	--	--	−76	−65	11	11/6/2013
29-1577	2900048781	Lakehurst	905–985	76	--	--	--	--	--	−42	−69	−61	8	11/6/2013
29-1623	2900048193	Point Pleasant	1,190–1,283	7	--	--	--	--	--	--	−35	−31	4	11/12/2013
29-2011	2800041493	Roosevelt	692–712	142	--	--	--	--	--	--	−9	−8	1	11/12/2013
[3]29-2072	3200028003	Keswick Grove	1,111–1,141	160	--	--	--	--	--	--	--	−54	--	11/14/2013
29-2085	2800050700	Adelphia	656–696	105	--	--	--	--	--	--	--	−35	--	11/4/2013
33-76	3000000661	Penns Grove	118–123	22	−2	−5	−3	−4	−4	−2	−5	−1	4	11/13/2013
33-111	3000001253	Penns Grove	190–235	10	−14	−15	−17	−19	−20	−21	−21	−21	0	12/13/2013
33-253	**--**	**Salem**	**335–340**	**2.07**	**−23**	**−24**	**−28**	**−29**	**−28**	**−29**	**−32**	**−28**	**4**	**12/19/2013**
33-342	--	Penns Grove	46–51	16.84	−6	−1	−2	−2	2	7	4	6	2	12/19/2013
33-348	--	Penns Grove	17.5	24.27	--	--	--	17	--	18	16	18	2	10/23/2013
33-355	--	Woodstown	360	55	−32	−25	−27	−20	−27	−25	−29	−22	7	12/16/2013
33-361	3000001815	Penns Grove	44–54	13	−9	−8	−9	−6	1	4	2	3	1	12/11/2013
33-671	3000005148	Wilmington South	87–102	6	--	--	--	−4	−8	−4	−5	−3	2	12/13/2013
33-686	3000008335	Wilmington South	110–130	5	--	--	--	−15	−12	−6	--	−5	--	12/13/2013
33-697	3000001113	Penns Grove	47–62	14	--	--	--	--	--	4	2	3	1	12/11/2013
33-841	3500017766	Elmer	1,005–1,025	75.4	--	--	--	--	−48	−44	−44	−40	4	12/5/2013
33-920	3000011400	Woodstown	184–204	80	--	--	--	--	--	−5	−16	−13	3	12/18/2013
33-922	3000010178	Woodstown	210–230	60	--	--	--	--	--	--	--	−14	--	12/23/2013
33-952	3000013727	Delaware City	147–152	23.4	--	--	--	--	--	−9	−10	−8	2	12/5/2013
33-953	3000013726	Delaware City	109–114	6.1	--	--	--	--	--	−1	−1	0	1	12/5/2013

Appendix 8. Water-level data for wells screened in the Upper Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
33-955	--	Wilmington South	124–134	4.98	--	--	--	--	--	--	−3	−4	−1	12/6/2013
33-956	--	Penns Grove	140–150	16.52	--	--	--	--	--	--	−8	−7	1	12/6/2013
33-1142	3000018045	Penns Grove	230–238	38	--	--	--	--	--	--	--	−16	--	12/23/2013
33-1172	E201117237	Penns Grove	80–90	21	--	--	--	--	--	--	--	−3	--	12/18/2013
33-1174	E201112199	Penns Grove	1,310–150	37	--	--	--	--	--	--	--	−12	--	12/19/2013
P10116	--	Philadelphia	60–75	8.3	--	--	--	--	−7	−8	−7	−7	0	11/13/2013

[1]All water-level data in the appendixes reside in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2017).

[2]Chloride concentration in well in excess of 5,000 milligrams per liter, so water level was converted to freshwater head.

[3]Second open interval is 1,190–1,220 feet.

Appendix 9. Water-level data for wells screened in the Middle and undifferentiated Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
5-63	**--**	**Bristol**	**284–294**	**44.17**	**−17**	**--**	**−21**	**−23**	**−22**	**−17**	**−18**	**−12**	**6**	**11/19/2013**
5-70	2700005259	Bristol	140–200	62	−11	−9	−14	--	--	--	−6	−5	1	11/7/2013
5-87	2700003694	Beverly	50–60	13	--	−5	−10	−6	−8	−13	−8	−1	7	11/15/2013
5-114	2800002901	Columbus	388–392	84	−8	−9	−13	−14	−12	−12	−14	−13	1	11/12/2013
5-119	2800004082	Trenton East	305	94	--	--	--	--	2	0	−3	−1	2	11/1/2013
5-122	2800005042	Trenton East	337–367	74	3	−1	−2	−5	−1	−2	−2	11	13	10/31/2013
5-126	3100004276	Moorestown	157–196	71	−10	−17	−18	−18	−17	−15	−7	−6	1	11/20/2013
5-127	3100004697	Moorestown	179–229	35	−13	−17	−20	−22	--	--	−10	−16	−6	11/26/2013
5-128	3100004733	Moorestown	225	35	--	--	--	--	--	−16	−10	−4	6	11/20/2013
5-214	--	Columbus	319	66	−4	--	−7	−6	−6	−12	−14	−17	−3	11/4/2013
5-261	**--**	**Mount Holly**	**740–750**	**71.43**	**−49**	**−56**	**−62**	**−63**	**−53**	**−49**	**−46**	**−38**	**8**	**10/28/2013**
5-265	3100004727	Moorestown	248–288	23	−57	−66	−66	--	−55	−52	−47	−40	7	11/14/2013
5-284	3100003806	Moorestown	298–338	61	−27	−30	−29	--	−29	−24	−20	−16	4	11/14/2013
5-290	3100006674	Mount Holly	545–615	16	−54	−56	−62	−59	−47	−44	−44	−31	13	12/3/2013
5-297	3100001610	Moorestown	441–457	49	--	--	−70	−68	−56	−51	−48	−40	8	11/8/2013
5-330	5200000008	Browns Mills	1,056–1,086	146	−43	−45	−59	−59	−53	−47	−35	−30	5	11/26/2013
5-332	4800000269	New Egypt	1,064–1,104	143	−46	−49	−59	−58	−46	−40	−35	−32	3	11/22/2013
5-333	3200007668	New Egypt	1,030–1,051	129	−49	−50	−63	--	−48	−41	−35	−39	−4	11/22/2013
5-336	2800000795	New Egypt	1,036–1,089	99	--	--	−61	−69	−59	−49	−41	−34	7	11/22/2013
5-388	5200000009	Pemberton	1,090–1,140	161	−41	−46	−61	−49	−51	−37	−35	−32	3	11/26/2013
5-436	--	Columbus	757–800	94.8	--	--	−38	−43	−34	−33	−33	−29	4	11/6/2013
5-440	**2800005128**	**Columbus**	**603–613**	**70.25**	**−30**	**--**	**−64**	**−37**	**−32**	**−33**	**−31**	**−29**	**2**	**10/24/2013**
5-634	4700000001	Bristol	516	51	−60	−62	−64	−68	−81	−76	−46	−34	12	12/3/2013
5-683	**3200000468**	**Chatsworth**	**2,102–2,117**	**139.41**	**−32**	**−36**	**−43**	**−40**	**−33**	**−30**	**−29**	**−26**	**3**	**12/11/2013**
5-726	2800008443	New Egypt	667–732	135	--	--	−46	−41	−42	−28	−30	−28	2	12/13/2013

Appendix 9. Water-level data for wells screened in the Middle and undifferentiated Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
5-749	3100007140	Moorestown	425	74	−61	−70	−76	−74	−62	−55	−52	−50	2	11/14/2013
5-801	2700006877	Frankford	5–25	17	--	−3	−4	−7	−6	−4	−2	0	2	11/6/2013
5-1089	2700008534	Beverly	176–251	16	--	--	−28	−28	−38	−18	−26	−20	6	11/5/2013
5-1158	2800028844	Columbus	450–460	41	--	--	--	−32	−28	−30	−29	−26	3	11/11/2013
5-1172	2800020985	Bristol	270–290	48	--	--	--	--	−7	6	4	4	0	11/4/2013
5-1472	2700010750	Beverly	190–240	30	--	--	--	--	--	−20	−22	−18	4	11/5/2013
5-1484	2700014624	Beverly	215–253	42	--	--	--	--	−14	−9	−11	−6	5	11/5/2013
5-1524	2700015940	Beverly	155–175	62	--	--	--	--	--	−2	0	2	2	11/7/2013
5-1525	2800019074	New Egypt	800–820	131	--	--	--	--	--	−26	−40	−26	14	11/22/2013
5-1527	2700015342	Bristol	70–110	51	--	--	--	--	--	--	1	2	1	11/5/2013
5-1546	2700012676	Bristol	168–178	80	--	--	--	--	--	−8	−9	−4	5	11/5/2013
5-1702	3100026455	Moorestown	176–254	65	--	--	--	--	--	--	−24	−17	7	11/14/2013
5-1758	3100065774	Moorestown	210–284	10	--	--	--	--	--	−34	--	−26	--	11/12/2013
5-1788	--	Bristol	80–100	17	--	--	--	--	--	--	−1	−1	0	11/5/2013
5-1806	2800054748	New Egypt	660–725	135	--	--	--	--	--	--	−36	−28	8	12/13/2013
7-48	3100000013	Camden	111–135	12	−28	−28	−22	−20	−13	−10	--	−6	--	12/19/2013
7-124	3100007020	Moorestown	483–626	75.86	−78	−85	−94	−86	−56	−61	−53	−53	0	11/20/2013
7-132	3100005095	Moorestown	500	71	−82	−81	−81	--	−53	−66	−66	−49	17	11/26/2013
7-135	3100005218	Moorestown	443–493	70.86	--	--	−74	−82	−51	−65	−67	−49	18	11/26/2013
7-142	3100004098	Camden	321–378	30.87	--	--	−67	−65	−49	−45	−39	−36	3	11/20/2013
7-186	--	Clementon	680.5	68	−79	−87	−90	−91	−66	−67	−59	−57	2	11/26/2013
7-304	3100005108	Camden	307–372	50	--	--	−72	−75	−56	−46	−42	−39	3	11/26/2013
7-329	3100004836	Camden	110–140	10	−42	−37	−40	−35	−27	−23	−19	−14	5	11/22/2013
7-413	**3100004561**	**Clementon**	**706–717**	**147.57**	**−71**	**−83**	**−83**	**−89**	**−68**	**−64**	**−67**	**−53**	**14**	**11/19/2013**
7-476	**--**	**Williamstown**	**1,485–1,495**	**109.94**	**−47**	**−54**	**−58**	**−60**	**−50**	**−44**	**−44**	**−38**	**6**	**10/28/2013**

Appendix 9. Water-level data for wells screened in the Middle and undifferentiated Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
7-726	3100031111	Moorestown	276–422	42	--	--	--	−68	−51	−50	−43	−38	5	12/3/2013
7-733	3100040817	Runnemede	452–535	72	--	--	--	−85	−56	−64	−56	−52	4	11/20/2013
7-734	3100040970	Runnemede	333–499	54	--	--	--	--	−55	−59	−52	−50	2	12/3/2013
7-986	3100043797	Camden	102–180	27	--	--	--	--	−26	−20	−16	−12	4	11/22/2013
7-1007	3100058577	Camden	99–109	31.98	--	--	--	--	--	−14	−11	−7	4	11/22/2013
7-1022	3100058628	Camden	63–73	24.27	--	--	--	--	--	--	−15	−12	3	11/22/2013
7-1040	3100059619	Camden	105–115	39.18	--	--	--	--	--	−16	−15	−11	4	11/22/2013
7-1057	3100059365	Camden	78–83	65.15	--	--	--	--	--	−9	−8	−5	3	11/22/2013
7-1264	3100060880	Camden	305–407	17	--	--	--	--	--	--	−37	−28	9	11/18/2013
11-137	**--**	**Dorothy**	**2,083–2,093**	**83.8**	**−39**	**−44**	**−51**	**−55**	**−56**	**−54**	**−54**	**−52**	**2**	**12/5/2013**
[2]11-137	**Freshwater**	**equivalent**	**2,083–2,093**	**83.8**	**−16**	**−21**	**−28**	**−32**	**−33**	**−31**	**−31**	**−29**	**2**	**12/5/2013**
15-24	3100005513	Runnemede	282–345	38	−50	−52	−48	−42	−33	−30	--	−24	--	12/3/2013
15-140	3000001248	Bridgeport	132–184	4.9	1	−2	−3	−12	−3	−2	−3	−2	1	11/25/2013
15-213	3000000602	Woodbury	135–175	10	−10	−10	−10	−10	−10	−6	−8	−4	4	12/3/2013
15-236	3000001177	Woodstown	241–312	76	−20	−19	−21	−11	−19	−18	−18	−14	4	11/26/2013
15-348	3000001776	Bridgeport	105–135	20	−9	−10	−11	−10	−10	−7	−10	−5	5	11/26/2013
15-374	3100013385	Runnemede	430–486	55	--	−60	−58	−58	−45	−41	−38	−34	4	12/3/2013
15-415	3100014478	Woodbury	287–307	43	--	−39	−36	−39	−31	−24	−26	−20	6	12/5/2013
15-444	3000002032	Marcus Hook	65–70	14	--	--	--	--	−10	−9	−8	−9	−1	11/21/2013
15-585	3000002522	Bridgeport	79–89	6.33	--	--	0	0	−2	0	0	−1	−1	11/26/2013
15-616	3000003532	Bridgeport	230–240	29.4	--	--	−9	−9	−10	−6	−9	−5	4	12/9/2013
15-620	3000003677	Bridgeport	131–141	5.8	--	--	1	1	0	3	1	1	0	11/25/2013
15-679	3000003624	Bridgeport	118–128	8.57	--	--	−4	−8	−6	−3	−4	−2	2	12/13/2013
15-713	**3000004348**	**Bridgeport**	**125–155**	**4.47**	**--**	**--**	**−9**	**−8**	**−9**	**−5**	**−7**	**−5**	**2**	**11/5/2013**
15-727	3000004548	Bridgeport	195–205	3.89	--	--	−9	−9	−10	−6	−8	−5	3	11/5/2013

Appendix 9. Water-level data for wells screened in the Middle and undifferentiated Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
15-774	3100026241	Woodbury	93–113	9	--	--	−2	--	--	−3	−2	0	2	11/5/2013
15-780	3100026244	Woodbury	75–85	6	--	--	−1	−4	−3	−2	0	1	1	12/2/2013
15-998	--	Pitman East	820–837	139	--	--	−66	--	−58	−49	−48	−42	6	12/5/2013
15-1015	--	Bridgeport	137–142	4	--	--	--	--	--	−5	−6	−1	5	12/4/2013
15-1036	3100022504	Woodbury	259–319	64	--	--	--	−59	−47	−41	−44	−36	8	12/3/2013
15-1122	3000007015	Woodbury	45–90	16	--	--	--	--	−1	--	--	−2	--	12/9/2013
15-1176	3100043251	Woodbury	174–184	44	--	--	--	--	−27	−21	−21	−19	2	12/2/2013
15-1484	3000012608	Woodstown	280–300	103	--	--	--	--	−15	−15	−17	−13	4	11/26/2013
15-1485	3100048720	Woodbury	160–306	30	--	--	--	--	−33	−29	−28	−22	6	12/4/2013
15-1504	3000012671	Bridgeport	458–478	91	--	--	--	--	−30	−28	−29	−25	4	12/11/2013
15-1530	3000013148	Woodstown	376–396	48	--	--	--	--	--	--	−29	−22	7	12/11/2013
15-1540	--	Woodbury	130–140	14.43	--	--	--	--	--	−5	−6	−11	−5	12/9/2013
15-1728	3000013075	Bridgeport	30–40	10	--	--	--	--	--	--	1	4	3	12/11/2013
15-1829	E201002435	Bridgeport	160–200	31	--	--	--	--	--	--	--	−5	--	12/11/2013
21-12	2800007034	Jamesburg	520–560	106	19	18	14	16	28	23	18	21	3	11/4/2013
21-22	2800005440	Hightstown	337–367	106	53	48	38	44	50	49	46	48	2	11/4/2013
21-43	2800005409	Trenton East	118–138	10	--	6	8	8	7	7	6	7	1	11/1/2013
21-54	2800004602	Trenton East	194–243	86	--	--	39	41	40	37	44	39	−5	11/1/2013
21-73	2800002927	Trenton East	128–144	74	--	--	36	41	34	39	41	42	1	11/1/2013
21-101	2800006030	Allentown	366–421	140	35	42	40	43	42	41	37	42	5	12/20/2013
21-120	2800005368	Hightstown	96–121	72	69	67	55	--	66	69	68	68	0	11/4/2013
21-122	2800006455	Hightstown	75–126	74	--	--	--	--	66	70	68	68	0	11/4/2013
21-554	2800042865	Allentown	353–443	134	--	--	--	--	--	44	33	38	5	11/8/2013
21-561	2800014731	Hightstown	230–270	105	--	--	--	--	--	48	49	49	0	10/30/2013
21-706	--	Hightstown	400	77	--	--	--	--	--	--	43	47	4	10/30/2013

Appendix 9. Water-level data for wells screened in the Middle and undifferentiated Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
23-9	2800000180	Hightstown	250–280	96	67	63	60	63	63	65	62	63	1	10/29/2013
23-70	--	New Brunswick	0–21	71.99	56	55	55	56	56	57	55	55	0	11/15/2013
23-97	**--**	**New Brunswick**	**236–301**	**37.9**	**1**	**1**	**5**	**27**	**26**	**17**	**23**	**26**	**3**	**10/28/2013**
23-106	--	New Brunswick	132	27	--	--	--	4	13	7	9	6	−3	10/28/2013
23-107	--	New Brunswick	311–334	26.86	--	−4	−2	--	6	5	7	9	2	10/28/2013
23-114	--	New Brunswick	225–237	24	--	−32	−32	2	−25	−23	−2	5	7	10/28/2013
23-132	--	South Amboy	262–267	23.84	−45	−39	−37	−4	3	12	10	10	0	10/28/2013
23-147	2900004998	South Amboy	425–475	78	--	−81	−67	−18	−20	−30	−20	−8	12	10/31/2013
23-171	4800000208	South Amboy	240–300	18.85	--	−45	−46	−9	--	−23	−12	−2	10	10/28/2013
23-176	2900006429	South Amboy	321–363	46	−60	--	--	--	--	−28	−19	−6	13	10/31/2013
23-194	--	South Amboy	201–281	17.2	--	−47	−61	−9	−15	−19	−12	−3	9	10/30/2013
23-273	**--**	**Hightstown**	**70–75**	**74.91**	**--**	**--**	**--**	**46**	**46**	**46**	**46**	**46**	**0**	**10/30/2013**
23-291	**2800004249**	**Hightstown**	**192–203**	**105.77**	**72**	**64**	**63**	**66**	**69**	**69**	**69**	**69**	**0**	**11/15/2013**
23-365	--	South Amboy	148–160	4.65	−54	−44	−52	−10	−15	−20	−2	−4	−2	11/5/2013
23-401	2900005352	South Amboy	254–288	42	−77	−82	−79	--	−16	−40	−15	−8	7	10/30/2013
23-434	2800000332	South Amboy	173–198	21	--	--	--	--	--	--	--	−1	--	10/29/2013
23-438	2800009722	South Amboy	132–182	18.63	−50	−39	−47	−5	−9	−12	−6	1	7	10/29/2013
23-439	**2800005987**	**South Amboy**	**121–126**	**19.65**	**−41**	**−33**	**−39**	**−3**	**−6**	**−10**	**−4**	**2**	**6**	**10/29/2013**
23-482	**--**	**Perth Amboy**	**44–76**	**9.97**	**−4**	**8**	**9**	**9**	**9**	**9**	**9**	**9**	**0**	**10/24/2013**
23-552	2800010991	Hightstown	116–166	107	--	--	61	90	70	66	62	62	0	10/30/2013
23-1160	2800020882	South Amboy	210–230	89	--	--	−51	−10	−10	−16	−8	0	8	11/5/2013
23-1346	2800040082	Jamesburg	276–337	142	--	--	--	--	56	53	53	53	0	10/25/2013
23-1500	2800045485	Jamesburg	444–514	163	--	--	--	--	--	--	43	40	−3	10/25/2013
23-1501	2800050046	Jamesburg	350–445	117	--	--	--	--	--	--	42	37	−5	10/25/2013
23-1526	E201002392	Jamesburg	329–430	116	--	--	--	--	--	--	--	36	--	10/25/2013

Appendix 9. Water-level data for wells screened in the Middle and undifferentiated Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
25-153	2900005942	Keyport	635–690	64.11	−48	−71	−116	−21	−22	−21	−25	−17	8	10/29/2013
25-230	2900006353	Freehold	580–670	125	−41	−36	−49	−14	−16	−13	−18	−9	9	10/31/2013
25-247	2900004285	Freehold	762–832	144.86	−27	−35	−49	−9	−17	−15	−26	−13	13	10/31/2013
25-262	2900005023	Marlboro	730–810	133	−43	--	--	--	--	−29	−24	−18	6	10/29/2013
25-268	2900006361	Freehold	632–698	111	−43	−53	−67	−15	--	−27	−23	−13	10	11/19/2013
25-272	**2900006527**	**Marlboro**	**670–680**	**115.94**	**−45**	**−56**	**−74**	**−18**	**−22**	**−30**	**−34**	**−22**	**12**	**10/18/2013**
25-320	2900048826	Sandy Hook	838–878	14	−4	−9	−10	−1	−1	0	2	1	−1	10/24/2013
25-495	--	Long Branch	1,000	9	--	--	−12	−4	−3	−3	−3	−2	1	11/8/2013
25-545	2900013277	Keyport	712	71	--	--	--	--	--	--	−25	−17	8	10/29/2013
25-562	2900013329	Keyport	500–555	37	--	--	--	--	--	−30	−25	−17	8	10/29/2013
25-635	**2900018402**	**Farmingdale**	**1,226–1,330**	**110.1**	**--**	**--**	**−39**	**−24**	**−20**	**−23**	**−29**	**−23**	**6**	**11/6/2013**
25-711	2900014303	Freehold	649–756	84.65	--	--	−40	−10	−14	−12	−17	−11	6	10/31/2013
25-725	2900024426	Adelphia	918–997	104	--	--	--	--	−23	−26	--	−24	--	10/30/2013
25-728	2800021488	Freehold	541–621	68	--	--	−26	−3	−5	−6	−12	−4	8	11/8/2013
25-731	2800022008	Freehold	541–628	63	--	--	--	--	−5	−6	−11	−3	8	11/8/2013
25-1102	2800048031	Freehold	530–600	59	--	--	--	--	--	--	--	1	--	11/8/2013
29-19	**--**	**Barnegat Light**	**2,736–2,756**	**7.78**	**−1**	**--**	**−13**	**−11**	**−6**	**−5**	**−6**	**−6**	**0**	**10/31/2013**
29-47	--	Lakewood	1,709–1,749	6	−38	−43	−67	−47	−42	−19	−23	−21	2	11/19/2013
29-85	**--**	**Toms River**	**1,460–1,480**	**65.48**	**−24**	**−31**	**−41**	**−31**	**−22**	**−24**	**−26**	**−24**	**2**	**10/31/2013**
29-118	2900004322	Cassville	1,397–1,583	94.59	−28	−29	−42	−30	−42	−25	−28	−23	5	11/15/2013
29-132	2900003726	Lakehurst	1,606–1,728	102	−26	−30	−44	−38	−34	−25	−28	−24	4	11/15/2013
29-440	2900006549	Lakewood	1,357–1,602	67	−25	−36	−49	−34	−25	−26	−29	−31	−2	10/30/2013
29-490	3300001343	Keswick Grove	1,436–1,636	88	−42	−59	−45	−30	−31	−33	−34	−30	4	11/14/2013
29-576	2900008936	Lakehurst	1,276–1,462	140	−27	−30	−43	−35	−31	−28	−34	−26	8	11/14/2013
29-581	4800000056	Roosevelt	876–976	127	−4	−19	−29	−20	−17	−15	−12	−14	−2	11/13/2013

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					1978	1983	1988	1993	1998	2003	2008	2013		
29-588	2900009259	Lakewood	1,410–1,620	69	--	−28	−57	−37	−25	−29	−28	−27	1	11/4/2013
29-595	2900008356	Lakewood	1,565–1,800	7	--	--	--	--	--	--	−22	−23	−1	11/19/2013
29-626	3300010224	Toms River	1,700–1,875	5	--	−27	−37	−27	−18	−28	−20	−23	−3	11/21/2013
29-779	2900012006	Lakewood	1,700–1,860	32.91	--	--	−83	--	--	--	−23	−21	2	11/19/2013
29-1113	2900025859	Point Pleasant	1,852–1,974	8	--	--	--	--	−9	−9	−12	−11	1	10/31/2013
29-1265	2800037964	Cassville	1,315–1,552	97	--	--	--	--	--	−21	--	−23	--	11/15/2013
29-1659	2900034751	Adelphia	1,100–1,300	127	--	--	--	--	--	--	−30	−24	6	11/13/2013
29-1781	2900044970	Adelphia	1,100–1,325	143	--	--	--	--	--	--	−20	−25	−5	11/12/2013
29-2054	2900041799	Lakewood	1,542 –1,746	90	--	--	--	--	--	--	--	−24	--	11/21/2013
29-2059	3300044152	Toms River	1,585–1,932	78	--	--	--	--	--	--	--	−21	--	11/21/2013
33-65	--	Penns Grove	501–512	28.94	−15	−16	−19	--	−19	−18	−23	−17	6	11/25/2013
33-106	--	Salem	359–365	7	--	--	−28	−29	−29	−29	−32	−27	5	12/5/2013
33-119	3000000018	Wilmington South	210–230	6.07	−47	−40	−44	−45	−39	−47	−49	−51	−2	12/13/2013
33-158	3000000763	Woodstown	562–575	54	--	--	−33	−25	−33	−31	−34	−26	8	12/16/2013
33-166	--	Penns Grove	568–578	45.9	−15	−16	−19	--	−19	−17	−21	−16	5	11/25/2013
33-187	**--**	**Woodstown**	**664–672**	**71.83**	**−26**	**−27**	**−30**	**−31**	**−29**	**−26**	**−30**	**−24**	**6**	**10/23/2013**
33-251	**--**	**Salem**	**699–709**	**2.07**	**−28**	**--**	**−33**	**−33**	**−32**	**−33**	**−36**	**−32**	**4**	**10/23/2013**
33-305	3000001083	Penns Grove	381–457	7	−20	−21	−23	--	−23	−22	−27	−22	5	11/25/2013
33-918	3400001512	Taylors Bridge	1,115–1,135	10	--	--	--	--	--	−46	−45	−49	−4	12/13/2013
33-933	3000013120	Woodstown	535–670	47	--	--	--	--	−34	−32	−34	−29	5	11/25/2013
33-934	3400004055	Taylors Bridge	826–836	14.79	--	--	--	--	−61	−71	−76	−71	5	12/13/2013
33-972	3000012165	Wilmington South	202–264	10	--	--	--	--	--	--	−52	−52	0	12/13/2013

[1]All water-level data in the appendixes reside in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2017).

[2]Chloride concentration in well in excess of 5,000 milligrams per liter, so water level was converted to freshwater head.

Appendix 10. Water-level data for wells screened in the Lower Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
5-123	3100005321	Camden	226–261	22	−13	−15	−19	−19	−19	−15	−11	−6	5	11/20/2013
5-125	3100003835	Moorestown	239–281	78	−12	−16	−17	−20	−18	−16	−11	−7	4	11/20/2013
5-129	2700004844	Camden	174	48	--	--	--	--	--	−12	−9	−4	5	11/22/2013
5-130	3100004576	Frankford	167–198	71	−3	−2	−13	−11	−13	−8	−5	−1	4	11/20/2013
5-146	2700003080	Beverly	89–130	21		−2	−4	--	--	1	0	2	2	11/26/2013
5-228	3100008923	Moorestown	440–500	39	−48	−52	−61	−54	−56	−39	−43	−28	15	11/12/2013
5-262	**--**	**Mount Holly**	**1,125–1,145**	**71.15**	**−49**	**--**	**−62**	**−63**	**−53**	**−48**	**−45**	**−38**	**7**	**10/28/2013**
5-274	3100003674	Moorestown	241–262	38.87	−21	−27	−31	−32	−29	−26	−20	−16	4	11/19/2013
5-645	--	Bristol	431–441	39.18	−32	−36	−42	−43	−40	−31	−36	−25	11	10/24/2013
5-648	--	Beverly	306–316	33	−21	−24	−30	−29	−30	−20	−23	−17	6	11/5/2013
5-746	3100012925	Moorestown	389–450	14	−28	−40	−42	−42	−37	−31	−28	−39	−11	11/12/2013
5-823	--	Moorestown	590–640	35	−48	−62	−75	−64	−50	−50	−47	−19	28	11/18/2013
5-1075	3100026130	Moorestown	528–644	39	--	−29	−64	−62	--	−44	−43	−16	27	11/18/2013
7-12	3100002687	Runnemede	334–359	29	−59	−62	−54	−52	−43	−38	−35	−30	5	12/9/2013
7-68	3100000904	Camden	185–225	27	−39	−38	−31	--	−25	--	−11	−7	4	12/11/2013
7-111	3100003456	Camden	139–170	7.89	--	--	−28	--	−11	−8	−9	−4	5	11/26/2013
7-121	--	Moorestown	672–729	78	−87	−96	−105	--	−57	−71	−55	−65	−10	11/20/2013
7-122	3100007021	Moorestown	684–741	75	--	--	−105	--	--	--	−56	−68	−12	11/20/2013
7-130	3100005077	Moorestown	743–748	70	−68	−76	−81	−80	−53	−60	−52	−48	4	11/26/2013
7-144	3100000684	Camden	491–527	37.87	−61	−65	−69	−66	−50	−43	−39	−37	2	11/20/2013
7-157	3100005033	Camden	376–427	43.86	--	--	--	--	−44	−38	−34	−28	6	12/3/2013
7-163	3100004051	Camden	371–453	37.86	−47	−52	−54	−46	−38	−36	−27	−25	2	12/3/2013
7-171	3100004797	Camden	224–313	7	−49	−48	−36	--	−98	−14	−25	−21	4	11/18/2013
7-172	3100004799	Camden	218–312	6	−50	−44	−41	−42	--	−39	−12	−19	−7	11/18/2013
7-175	3100000079	Camden	266–306	26	−50	−47	−46	--	−33	−26	−24	−18	6	11/18/2013

Appendix 10. Water-level data for wells screened in the Lower Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
7-185	--	Clementon	940–950	68	−78	−91	−88	--	--	--	−65	−78	−13	11/26/2013
7-188	3100005950	Clementon	934–986	66	--	--	−88	−96	−61	−68	−65	−76	−11	11/26/2013
7-273	3100004756	Runnemede	612–712	57	−75	−74	−80	−79	−58	−56	−53	−47	6	11/20/2013
7-278	3100002434	Camden	452–594	63.86	−73	−77	−84	--	−51	−57	−50	−45	5	12/3/2013
7-283	3100004282	Camden	445–455	22.5	−64	−66	−66	−63	−49	−44	−48	−35	13	11/19/2013
7-284	3100005054	Camden	484	28	--	--	−68	−63	−47	−46	−42	−37	5	11/26/2013
7-302	3100002130	Camden	523–572	20	−77	−84	−90	−96	−63	−56	−53	−51	2	11/26/2013
7-320	3100004642	Camden	245–285	65	−37	−40	−38	−36	−30	−22	−19	−14	5	11/22/2013
7-335	3100002915	Camden	243–278	62	−32	−34	−34	−33	−28	−26	−19	−12	7	11/22/2013
7-350	5100000064	Camden	232–257	9	--	--	--	--	−26	--	−18	−18	0	11/22/2013
7-368	5100000053	Camden	106–126	10	−13	−22	−17	--	--	−12	−9	−7	2	12/19/2013
7-372	3100005110	Camden	195–230	67	--	--	−24	−21	−17	−14	−13	−9	4	11/22/2013
7-412	**3100009560**	**Clementon**	**1,082–1,092**	**147.52**	**−64**	**−74**	**−79**	**−82**	**−59**	**−59**	**−59**	**−51**	**8**	**11/19/2013**
7-523	3100012315	Runnemede	458–557	73	−64	−66	−69	−66	−51	−46	−46	−40	6	12/11/2013
7-528	3100008526	Camden	140–180	19	−24	−29	−33	−23	−16	−14	−12	−10	2	12/19/2013
7-541	3100015720	Camden	215–253	19	--	−35	−32	−27	−20	−15	−11	−7	4	12/11/2013
7-547	3100018944	Camden	155–195	35	--	--	−32	--	−12	−10	−7	−5	2	11/26/2013
7-597	3100020270	Camden	136–176	9.89	--	--	−31	--	−12	−9	−9	−4	5	11/26/2013
7-739	3100038319	Moorestown	695–754	82	--	--	--	--	--	--	−54	−65	−11	11/20/2013
7-932	3100043420	Camden	125–145	27.6	--	--	--	--	−12	−8	−6	−6	0	11/22/2013
7-933	3100045075	Camden	177–182	27.31	--	--	--	--	−23	−20	--	−11	--	11/21/2013
7-965	3100026140-0	Camden	85–105	17.64	--	--	--	--	−13	−8	−6	−4	2	11/22/2013
7-1006	3100058576	Camden	250–260	31.94	--	--	--	--	--	−17	−15	−10	5	11/22/2013
7-1027	3100058626	Camden	148–158	24.49	--	--	--	--	--	--	−16	−15	1	11/22/2013
7-1042	3100059990	Camden	265–275	88.12	--	--	--	--	--	--	−11	−8	3	11/22/2013

Appendix 10. Water-level data for wells screened in the Lower Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

[USGS, U.S. Geological Survey; --, data not available; **bold** type indicates well with accompanying hydrograph; vertical datum is North American Vertical Datum of 1988; positive differences in water-level change indicate a rise in water levels from 2008 to 2013, whereas negative values indicate a decline in water levels from 2008 to 2013]

USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
7-1043	3100059991	Camden	210–220	87.8	--	--	--	--	--	--	−12	−7	5	11/22/2013
7-1055	3100059303	Camden	210–220	66.17	--	--	--	--	--	−10	−9	−6	3	11/22/2013
7-1070	3100056691	Camden	93–120	10	--	--	--	--	--	--	−11	−16	−5	12/19/2013
7-1085	3100059128	Camden	355–445	50.09	--	--	--	--	--	--	−40	−33	7	11/18/2013
7-1245	3100064874	Camden	118	3	--	--	--	--	--	--	--	−3	--	12/11/2013
7-1250	3100064870	Camden	22	3	--	--	--	--	--	--	--	−21	--	12/19/2013
15-139	3000001223	Bridgeport	301–345	5.8	−11	−11	−12	−2	−12	−10	−12	−9	3	11/25/2013
15-282	3100007056	Woodbury	388–450	49	−36	--	−40	−38	−57	−25	−25	−19	6	12/5/2013
15-308	--	Woodbury	231–271	13	−11	−12	−16	−38	−23	−10	−12	−7	5	12/3/2013
15-312	5100000063	Woodbury	322–372	23	−55	−52	−53	−42	−49	−26	−22	−17	5	12/5/2013
15-321	3100000028	Woodbury	237–277	22	--	−48	−52	--	--	−25	−21	−14	7	12/3/2013
15-331	3100004259	Woodbury	405–457	36	−43	−46	−52	−48	−41	−33	−31	−24	7	12/4/2013
15-357	--	Bridgeport	105	7	−1	−1	--	--	--	−3	−4	1	5	12/4/2013
15-373	3100017452	Woodbury	323–363	27	--	--	--	--	--	--	--	−19	--	12/5/2013
15-398	3000002016	Bridgeport	50–60	1	--	--	−2	−1	−2	−0	--	−1	--	11/26/2013
15-430	3100017788	Woodbury	256–328	17	--	−47	−51	--	--	−17	−18	−13	5	12/3/2013
15-615	30000003530	Bridgeport	378–388	28.1	--	--	−16	−17	−17	−13	−16	−12	4	11/25/2013
15-618	30000003531	Bridgeport	230–240	5.8	--	--	−9	−8	−9	−6	−8	−6	2	11/25/2013
15-671	**--**	**Runnemede**	**650–670**	**33.83**	**--**	**--**	**−70**	**−70**	**−64**	**−49**	**−48**	**−41**	**7**	**11/19/2013**
15-678	3000003625	Bridgeport	194–204	8.27	--	--	−9	−6	−9	−6	−7	−3	4	12/13/2013
15-680	3000003602	Bridgeport	186–196	7.56	--	--	−6	−8	−6	−3	−7	−2	5	11/25/2013
15-712	**3000004347**	**Bridgeport**	**275–290**	**5.3**	**--**	**--**	**−12**	**−12**	**−12**	**−9**	**−11**	**−8**	**3**	**11/5/2013**
15-738	3000003612-7	Bridgeport	188–198	3.4	--	--	−10	−10	−10	−7	−8	−5	3	11/25/2013
15-742	3100025266-4	Woodbury	757–777	82.8	--	--	−38	−38	−35	−27	−27	−22	5	11/5/2013
15-770	3100026237-6	Woodbury	204–224	8	--	--	−27	−23	−19	−14	−12	−7	5	12/2/2013

Appendix 10. Water-level data for wells screened in the Lower Potomac-Raritan-Magothy aquifer, New Jersey Coastal Plain, 1978–2013.—Continued

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USGS well identifier	New Jersey permit number	USGS quadrangle	Screened interval (feet)	Altitude of land surface (feet)	Water-level altitude (feet)[1]								Difference between 2008 and 2013 (feet)	2013 measurement date
					1978	1983	1988	1993	1998	2003	2008	2013		
15-772	3100026242	Woodbury	196–216	9	--	--	--	--	--	−16	−12	−6	6	11/5/2013
15-778	3100026245	Woodbury	170–190	6	--	--	--	--	−16	−12	−7	−5	2	12/2/2013
15-1004	--	Pitman East	1,038–1,206	89	--	--	−109	−54	−46	−40	−39	−33	6	12/6/2013
15-1125	3000004112	Bridgeport	186–196	14	--	--	--	−4	−5	−5	−4	0	4	12/4/2013
15-1201	3000011328	Woodbury	235–245	10.95	--	--	--	--	--	−6	−7	−3	4	12/13/2013
15-1487	3000012609	Woodstown	495–525	103	--	--	--	--	−16	−17	−18	−14	4	11/26/2013
15-1726	3000013076	Bridgeport	180–200	10	--	--	--	--	--	--	−7	−6	1	12/11/2013
33-86	3000001139	Marcus Hook	169–189	11.9	−11	−14	−13	−18	−15	−13	−14	−14	0	12/4/2013
33-335	3000001133	Penns Grove	270–430	12	--	−31	−34	--	--	−33	−37	−29	8	11/25/2013
33-458	3400001511	Taylors Bridge	1,112–1,132	10	--	−34	--	−42	−43	−46	−47	−49	−2	12/13/2013
33-951	3000008958	Marcus Hook	130–150	21.37	--	--	--	--	--	--	−9	−9	0	12/4/2013
33-1141	3000019273	Penns Grove	353–401	13	--	--	--	--	--	--	--	−32	--	12/11/2013
P10113	--	Philadelphia	–	4.53	−8	--	--	--	--	−4	−2	−1	1	11/13/2013
P10114	--	Philadelphia	122–167	8.6	--	--	--	--	--	−6	−6	−4	2	11/13/2013
[2]Db33-17	10398	Newark East	185–189	46	--	--	--	--	--	--	−60	−46	14	10/14/2013
[2]Db33-18	--	Newark East	138–143	46	--	--	--	--	--	--	−56	−44	12	10/14/2013
[2]Dc34-05	--	Wilmington South	574–579	30	--	--	--	--	--	--	−67	−57	10	10/14/2013

[1]All water-level data in the appendixes reside in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2017).

[2]Measurements obtained from data from http://data.dgs.udel.edu/sites/groundwater/recent-and-historical-groundwater-level-data.html. Water-level measurements for 2008 were made close to the date of the 2013 measurements. Water levels are referenced to the National Geodetic Vertical Datum of 1929.

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