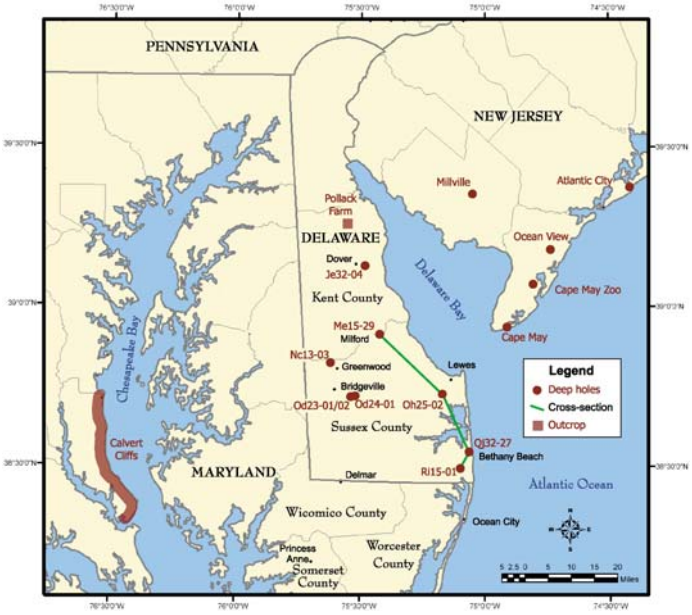
TWELFTH REPORT TO THE GOVERNOR AND GENERAL ASSEMBLY

Regarding the Progress of the

DELAWARE WATER SUPPLY COORDINATING COUNCIL

Estimates of Water Supply & Demand for Kent County and Sussex County through 2030



June 20, 2014

Prepared by the

Delaware Department of Natural Resources and Environmental Control
Division of Water

Delaware Geological Survey

University of Delaware
Institute for Public Administration – Water Resources Agency

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

Office of the
Secretary

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June 30, 2014

The Honorable Jack Markell
Governor, State of Delaware
Legislative Hall
Dover, Delaware 19901

147th General Assembly
Legislative Hall
Dover, Delaware 19901

Dear Governor Markell and Members of the 147th General Assembly:

I have the distinct pleasure of forwarding to you the latest report of the Delaware Water Supply Coordinating Council (WSCC), regarding *Estimates of Water Supply & Demand for Kent County and Sussex County through 2030.* This is the Twelfth Report issued by the WSCC addressing water supply resources with the focus on Kent and Sussex Counties.

Improved mapping of key aquifers and better estimates of water use provide a sound framework for improved management and protection of freshwater resources in these counties. Key findings and recommendations in the Twelfth Report provide state and private entities with a clear path forwards. These include expanding drought guidelines to these counties, interconnection of public water systems, and water supply use projections that bring all parts of the state on similar footing. Other Council recommendations address better groundwater monitoring, climate change considerations, groundwater availability research, and recommendations for state program enhancements.

I would like to express my thanks to the Water Supply Coordinating Council members for their diligence and thoughtfulness in preparing this report and recommendations. I also express my appreciation for the work of the Delaware Geological Survey in greatly elevating our understanding of water sources and use in southern Delaware.

As always, please do not hesitate to contact the Office of the Secretary at (302) 739-9000 or the Division of Water at (302) 739-9949.

Sincerely,

Collin P. O'Mara
Secretary

Attachment: Water Supply Coordinating Council Twelfth Report

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1. Delaware Water Supply Coordinating Council

1.1. Introduction

The Delaware Water Supply Coordinating Council Act of 2003 authorized the Water Supply Coordinating Council (WSCC) to develop and publish water supply plans for southern New Castle County, Kent County, and Sussex County. These plans shall identify and describe uses, localities, or areas where water supply issues exist and identify and describe localities or areas where future water supply issues may occur. These areas and uses should include, but not be limited to, Middletown-Odessa-Townsend, Dover and central Kent County, coastal Sussex County, and agricultural irrigation uses. These plans shall contain an estimate of existing and future public and private water supplies and water demands through 2025 including private demands.

In July 2009, Governor Markell signed Senate Bill 72 passed on June 24, 2009 by the House of the 145th General Assembly that reauthorized the WSCC to develop water supply and demand plans for Kent County and Sussex County through 2030 and extended the authority of the WSCC from January 1, 2010 to January 1, 2016. On December 3, 2009, the WSCC approved a work plan authorizing the following subcommittee to prepare a report that estimates water supply and demand in Kent County and Sussex County through 2030.

Bruce Kraueter	Artesian Water Company
Laura Mensch	Delaware Department of Agriculture
Kathy Stiller/John Barndt	Delaware Department of Natural Resources and Environmental Control
Ed Hallock	Delaware Division of Public Health
Peter McLaughlin/Scott Andres	Delaware Geological Survey (coauthor)
Jonathan Urbanski	Delaware State Golf Association
Mary Ellen Gray	Kent County
Designee	Sussex County
Sheila Shannon	Tidewater Utilities, Inc.
Gerald Kauffman/Andrew Homsey	University of Delaware Water Resources Agency (coauthor)

1.2. Purpose and Scope

The purpose of this report is to assess water resources in Kent County and Sussex County, Delaware, and evaluate groundwater availability, use, water allocations, and water requirements through 2030. This work is designed to address anticipated increases in water demands and support programs and policies in management, development, conservation, and protection of the State's water resources. This assessment accounts for factors that affect water supply and demand in Kent County and Sussex County such as: (1) population growth, (2) land use change, (3) water quality, (4) increased crop irrigation, and (5) drought. This is the twelfth in a series of WSCC reports to the Governor and General Assembly dating to 2000 (see www.wra.udel.edu).

1.3. Delaware Water Supply Coordinating Council

In July 2000, Governor Carper signed HB 549 that formed the Water Supply Coordinating Council and designated the Secretary of DNREC as Chair; appointed the Delaware Geological Survey as technical advisor; and assigned the University of Delaware Water Resources Agency as "Temporary Water Coordinator". In July 2009, Governor Markell signed SB 72 passed by the 145th General Assembly that reauthorized the Council until January 1, 2016. By law, the following members are appointed to the Council:

- Office of the Governor
- Secretary of the Delaware Department of Natural Resources and Environmental Control (Chair)
- Secretary of the Department of Public Safety
- Secretary of the Delaware Department of Agriculture
- Executive Director of the Public Service Commission

- Director of the Delaware Emergency Management Agency
- Director of the Delaware Geological Survey
- Director of the Delaware Division of Public Health
- Delaware State Climatologist
- Public Advocate
- Director of the University of Delaware Water Resources Agency
- Executive Director of the Delaware River Basin Commission
- New Castle County Executive
- Artesian Water Company
- City of Newark
- City of Wilmington
- New Castle Municipal Services Commission
- Tidewater Utilities, Inc.
- United Water Delaware
- New Castle County Chamber of Commerce
- Delaware State Chamber of Commerce
- Delaware Nursery and Landscape Association
- Delaware Grounds Management Association
- Delaware State Golf Association
- Delaware Nature Society
- Coalition for Natural Stream Valleys
- New Castle County Civic League
- Kent County Executive
- Sussex County Administrator
- Public Water Supply Utility in Sussex County Association of Towns (SCAT)
- Public Water Supply Utility in League of Local Governments, Kent County
- Delaware Rural Water Association
- National Association of Water Companies, Delaware Chapter
- Local Chamber of Commerce in New Castle County, Kent County, and Sussex County
- Delaware Farm Bureau
- Center for Inland Bays
- State Fire Marshal

1.4. Drought Advisories

The Water Supply Coordinating Council plays a part in mitigating the effects of mild to severe drought on Delaware. At the September 11, 2008 meeting, the WSCC approved the following resolution:

"Whenever we are on any of the levels there shall be a status update by DGS at intervals no greater than four weeks, posted at the DGS website. Responsibility for providing technical guidance for a move up to or down from (drought) watch is with the WSCC. Responsibility for providing technical guidance for a move up to or down from (drought) warning or emergency is with the Governor's Drought Advisory Committee (GDAC). Any member of WSCC may request, for reasons to be stated, that the chair or designee call a meeting of the WSCC at his/her discretion. A meeting may also be called upon the request of eight or more members of the WSCC, to be held within two weeks of such request."

In 2013, the Drought Operating Guidelines Subcommittee revised the Drought Operating Plan documented in the 2005 Seventh Report and recommended: (1) Add six-month precipitation deficit, (2) Add Marsh Creek Reservoir capacity, (3) Add DRBC lower basin criteria, (4) Revise Hoopes Reservoir capacity, (5) Revise Newark Reservoir capacity, (6) Add Division of Public Health to subcommittee. On October 30, 2013, the WSCC agreed to adopt revised water use recommendations proposed by the Green Industry (see Appendix K).

2. Demographics

Population growth (DPC 2012) and conversion of land from agriculture to urban/suburban uses (DSPC 2007) will increase water demand in Kent and Sussex counties with accompanying increases in wastewater flow. While cropland continues to decline in Delaware, farm irrigation is expected to continue to grow (USDA 2014).

2.1. Land Use

Kent County and Sussex County are rural, yet suburbanizing regions that occupy 1,573 mi^2 or three quarters of Delaware's land area (Table 2.1 and Figure 2.1). In 2007, land use in the two counties was broken down as follows: agriculture (43%), forest/wetland/open space (37%), urban/suburban (16%), and open water (4%).

Table 2.1. Land use in Kent County and Sussex County in 2007 (Delaware State Planning Office 2007)

Land Use	2007 (mi^2)	2007 (%)
Kent County	**597**	**100%**
Urban/Suburban	97	16%
Agriculture	272	46%
Forest/Wetlands/Open	210	35%
Water	18	3%
Sussex County	**976**	**100%**
Urban/Suburban	150	15%
Agriculture	407	42%
Forest/Wetlands/Open	369	38%
Water	50	5%
Kent and Sussex Counties	**1,573**	**100%**
Urban/Suburban	247	16%
Agriculture	679	43%
Forest/Wetlands/Open	579	37%
Water	68	4%

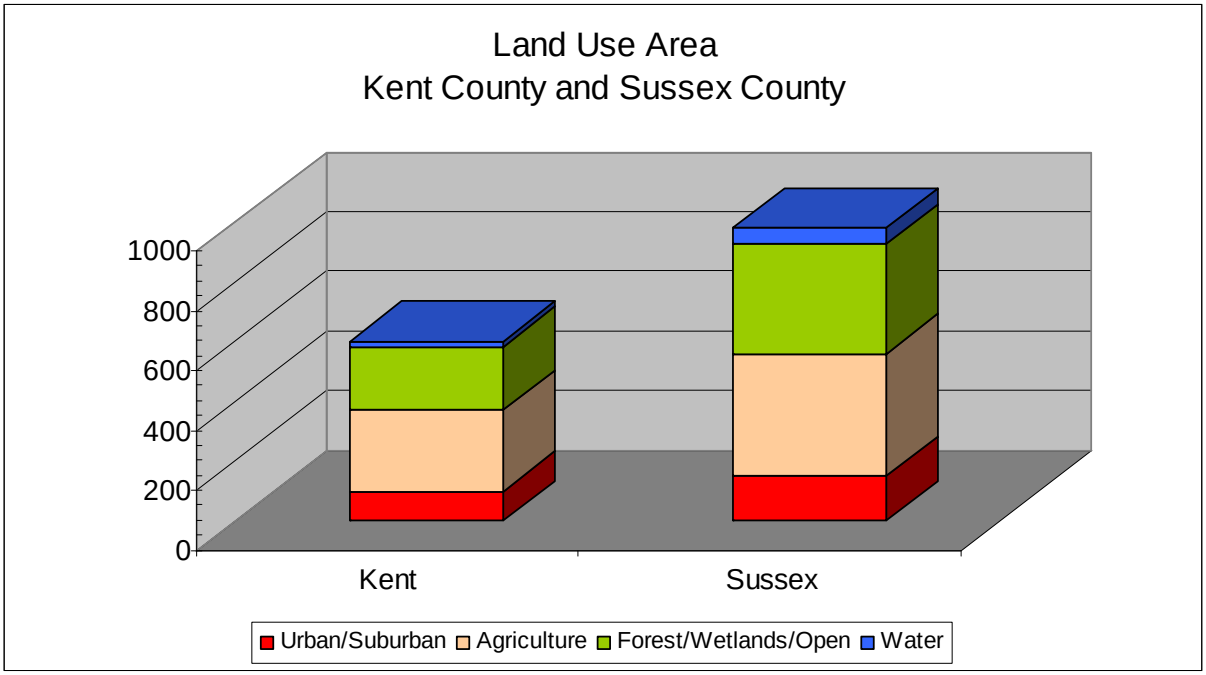


Figure 2.1. Land use in Kent County and Sussex County in 2007

2.2. Population

According to the Delaware Population Consortium (2012), the population of Kent County and Sussex County was 360,786 in 2010 (40% of Delaware's population) and is projected to increase 29% to 465,243 by 2030 (Table 2.2 and Figure 2.2). The population of Kent County is projected to increase 19% from 162,916 in 2010 to 194,225 by 2030. The population of Sussex County is projected to increase 37% from 197,870 in 2010 to 271,018 by 2030. Population is projected to continue to grow along the Route 1 and Route 13 corridors and in the Atlantic Ocean beach towns (Figure 2.3).

Table 2.2. Population projections in Kent County and Sussex County, 2010-2030
(Delaware Population Consortium 2012)

	2010 (pop.)	**2020 (pop.)**	**2030 (pop.)**
Kent County	162,916	180,357	194,225
Sussex County	197,870	235,574	271,018
Total	**360,786**	**415,931**	**465,243**
		2010-2020 (%)	**2010-2030 (%)**
Kent County		11%	19%
Sussex County		19%	37%
Total		15%	29%

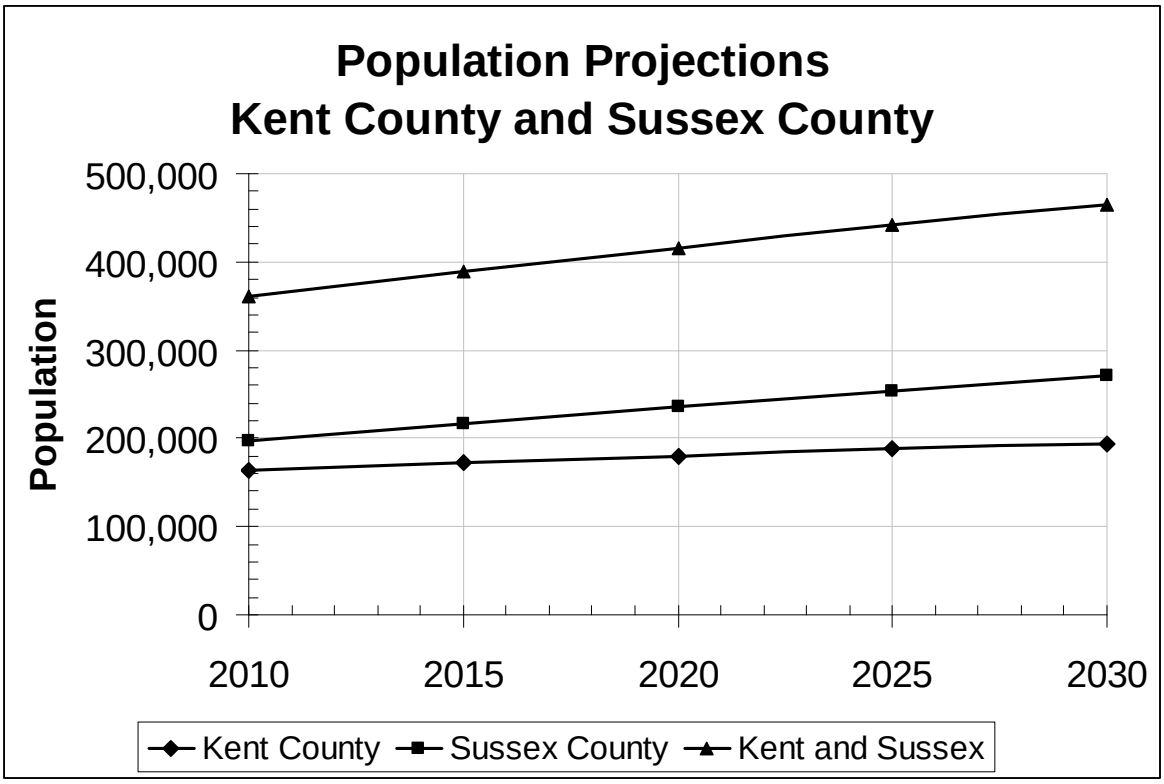


Figure 2.2. Population projections in Kent County and Sussex County, 2010-2030

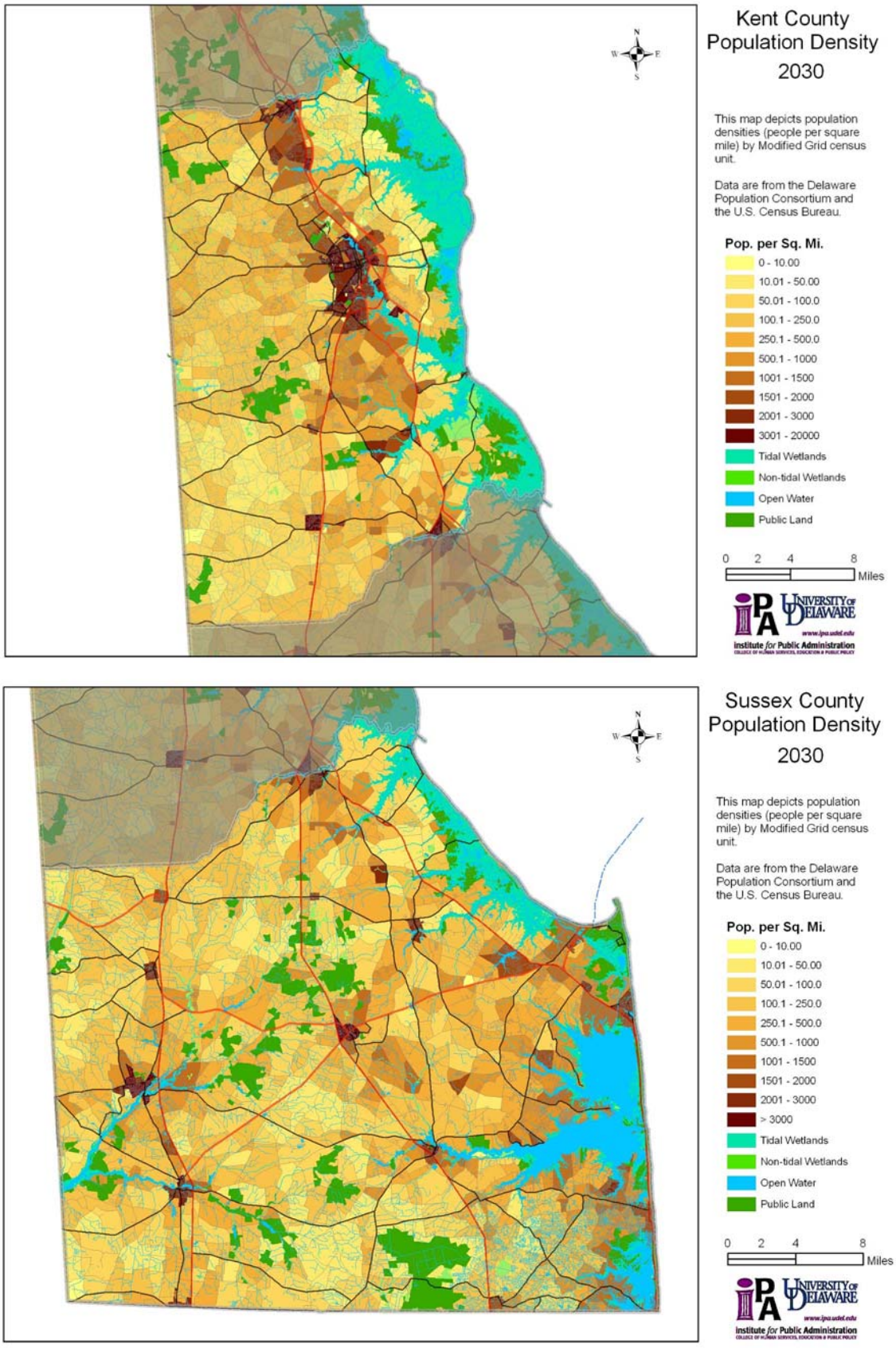


Figure 2.3. Population density projections in Kent County and Sussex County, 2010-2030

2.3. Comprehensive Plans

The Kent County Comprehensive Plan (2008) reported almost 122,000 people or 76% of the county population were served by public water systems with an estimated water demand of 18.3 million gallons per day (mgd). The Kent County Department of Public Works wastewater treatment plant along the Murderkill River treats an average flow of 12.5 mgd and serves 77,000 people or about half of the county population. Areas east of Route 1 near the Delaware Bay are designated as agricultural conservation zones where little development is expected to occur (Figure 2.4). Areas west of Dover are designated as agricultural residential where low density development may occur. Most development in Kent County is planned to occur within the non-agricultural growth zone as depicted by the land use map from the 2008 Kent County Comprehensive Plan.

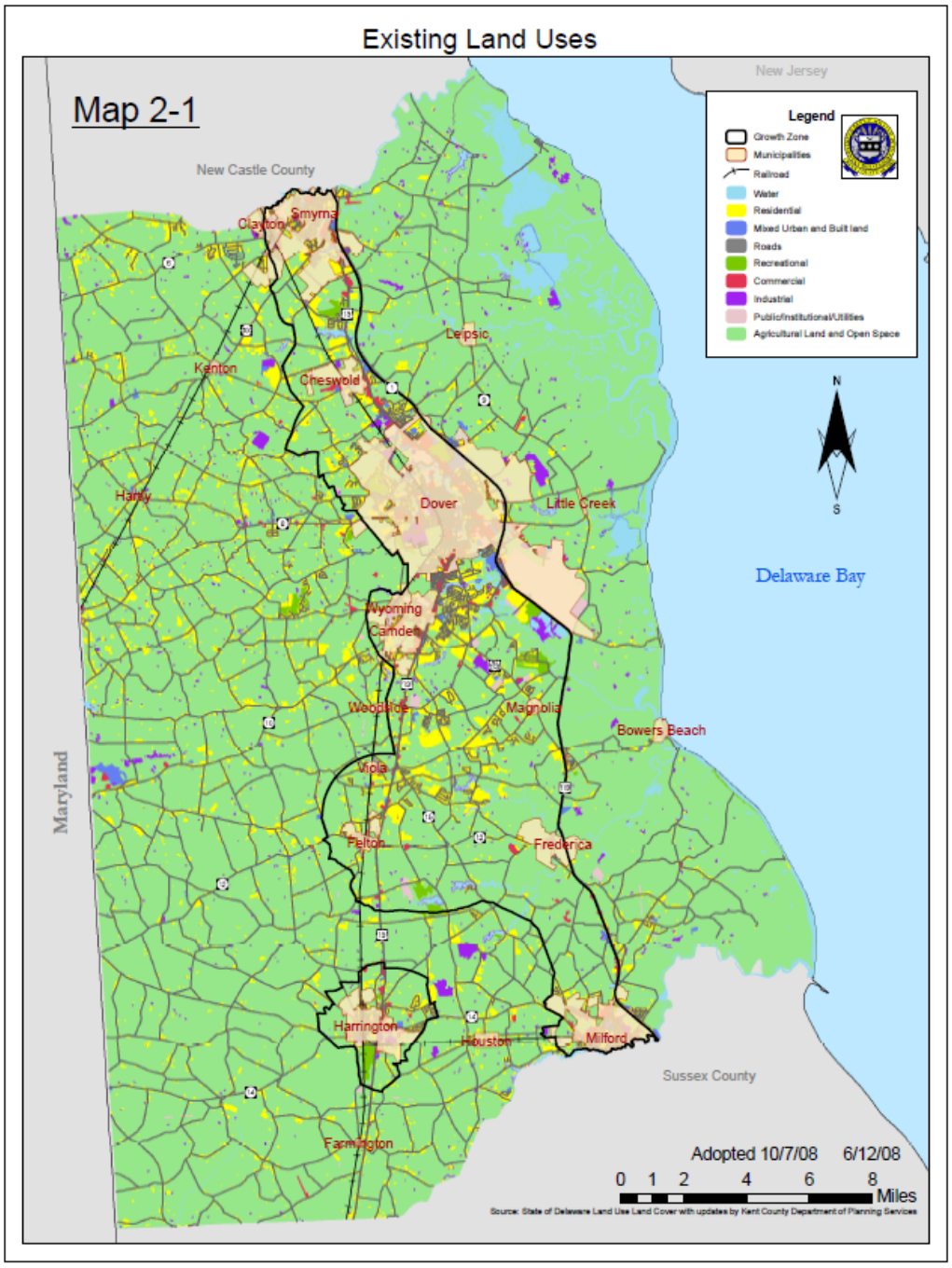


Figure 2.4. Kent County land use map (Kent County 2008)

The Sussex County Comprehensive Plan (2008) reported normal public water demand was 17.7 mgd with a projected increase to 42.2 mgd by 2025. In 2006, Sussex County had 111,606 housing units with 59% single family detached, 5% single family attached, 12% 2-5 units, and 23% mobile homes. Between 2008 and 2012, the plan estimated that 14,766 homes would be needed including 9,521 existing homes, 4,887 new homes, and 358 new manufactured houses. The Sussex County future land use map indicates growth is planned in residential, commercial, business, industrial zoning districts along Route 13, Route 1, and the beach towns (Figure 2.5). Coastal Sussex County near the Atlantic Ocean and Inland Bays accounted for half of the county's residential building permits issued between 2003 and 2006.

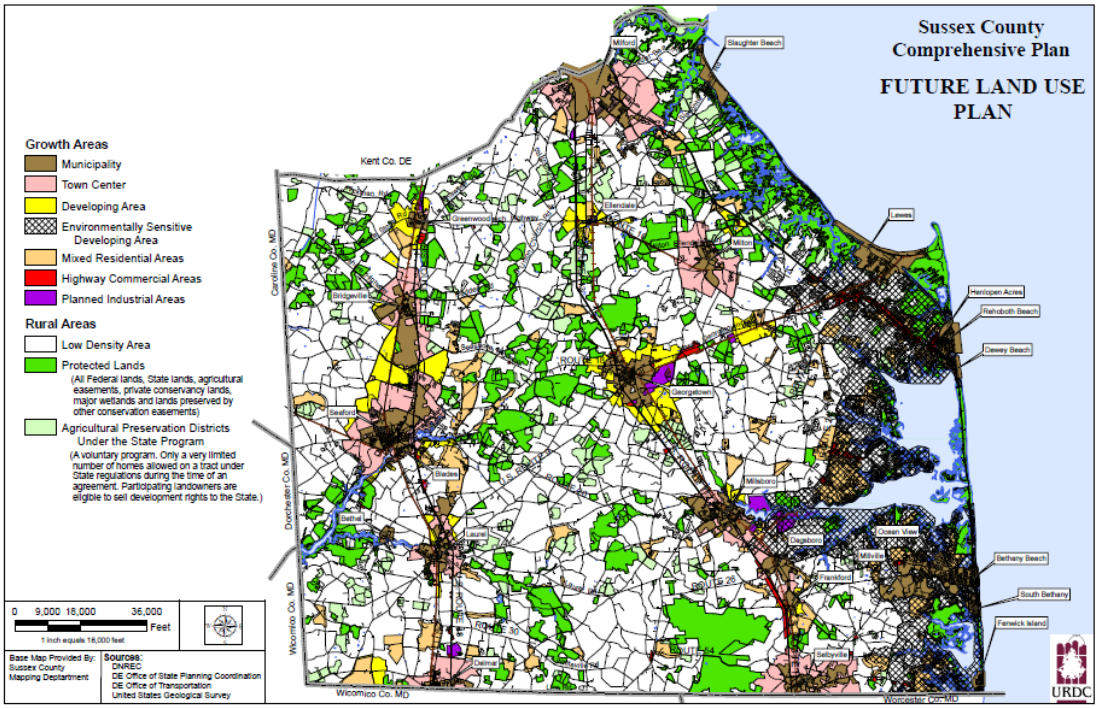


Figure 2.5. Sussex County future land use plan (Sussex County 2008)

2.4. Water Supply Service Areas (CPCN)

The Public Service Commission has approved Certificates of Public Convenience and Necessity (CPCNs) to operate the following public water supply service areas in Kent County and Sussex County (Figures 2.6-2.8).

<u>Kent County</u>
Artesian Water Company
Camden-Wyoming
Blades
Dover
Felton
Frederica
Harrington
J.H. Wilkerson & Son
Magnolia
Milford
Pickering Beach Water
Smyrna
Tidewater Utilities
Clayton

<u>Sussex County</u>
Artesian Water Company
Bethany Beach
Long Neck Water Company
Bridgeville
Dagsboro
Delmar
Frankford
Georgetown
Greenwood
J.H. Wilkerson & Son
Laurel
Lewes Board of Public Works
Milford
Millsboro
Milton
Rehoboth Beach
Seaford
Selbyville
Sussex County
Sussex Shores
Tidewater Utilities

The Public Service Commission has granted CPCNs since 2001 and administers regulations to encourage compact service territories in accordance with the following principles (1) water supply purveyors have compact and contiguous regional service areas that provide efficient delivery of drinking water without redundancy in infrastructure, (2) CPCN certification based upon a regional network that enables utilities to prepare long range plans to serve growing areas, and (3) CPCN applications evaluated on the basis of past customer performance and approval from the vast majority of the property owners.

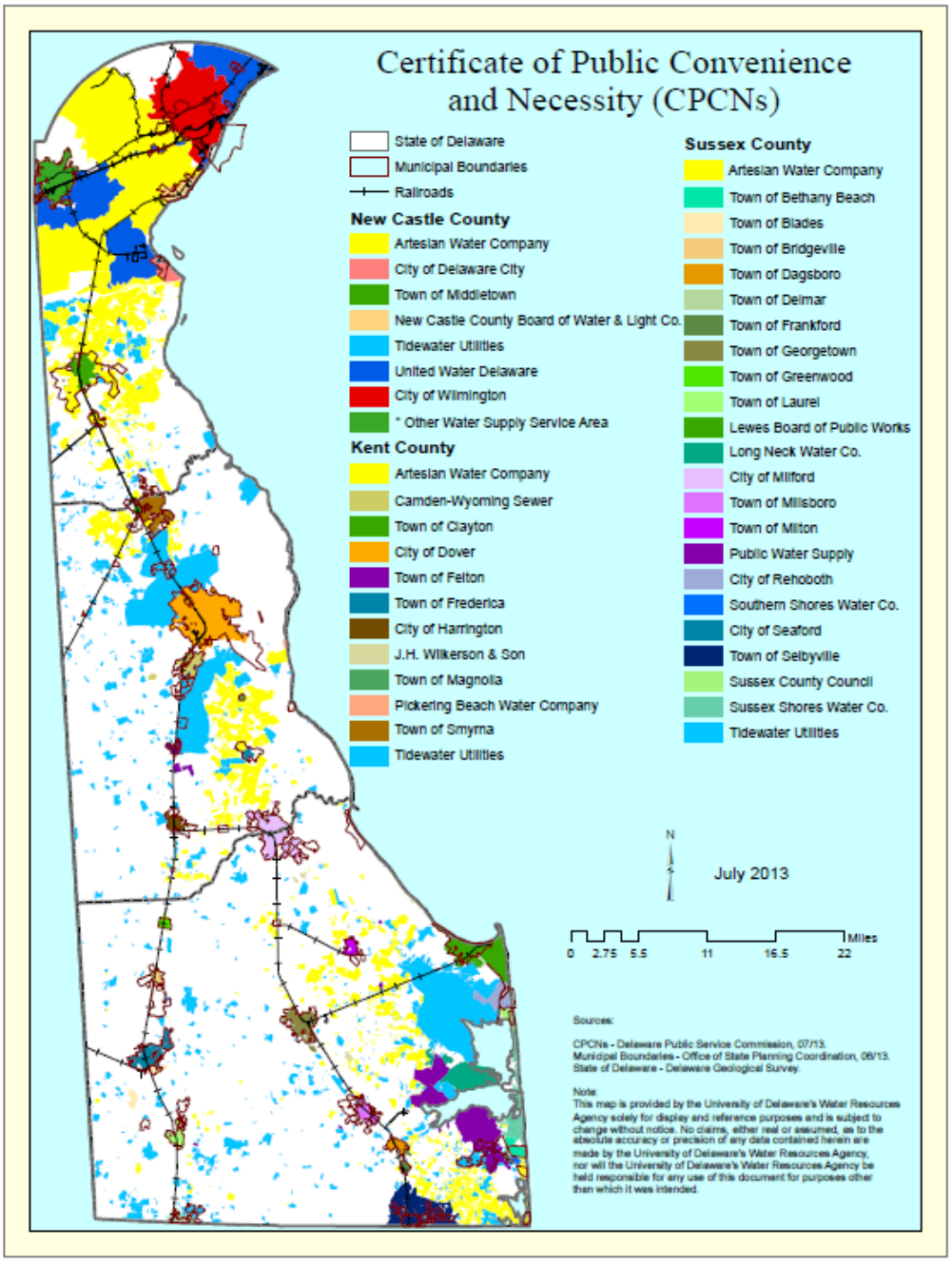


Figure 2.6. Water Supply Certificates of Public Convenience and Necessity (CPCNs) in Delaware (PSC 2013) (Note: Public Water Supply is part of Tidewater Utilities, Inc.)

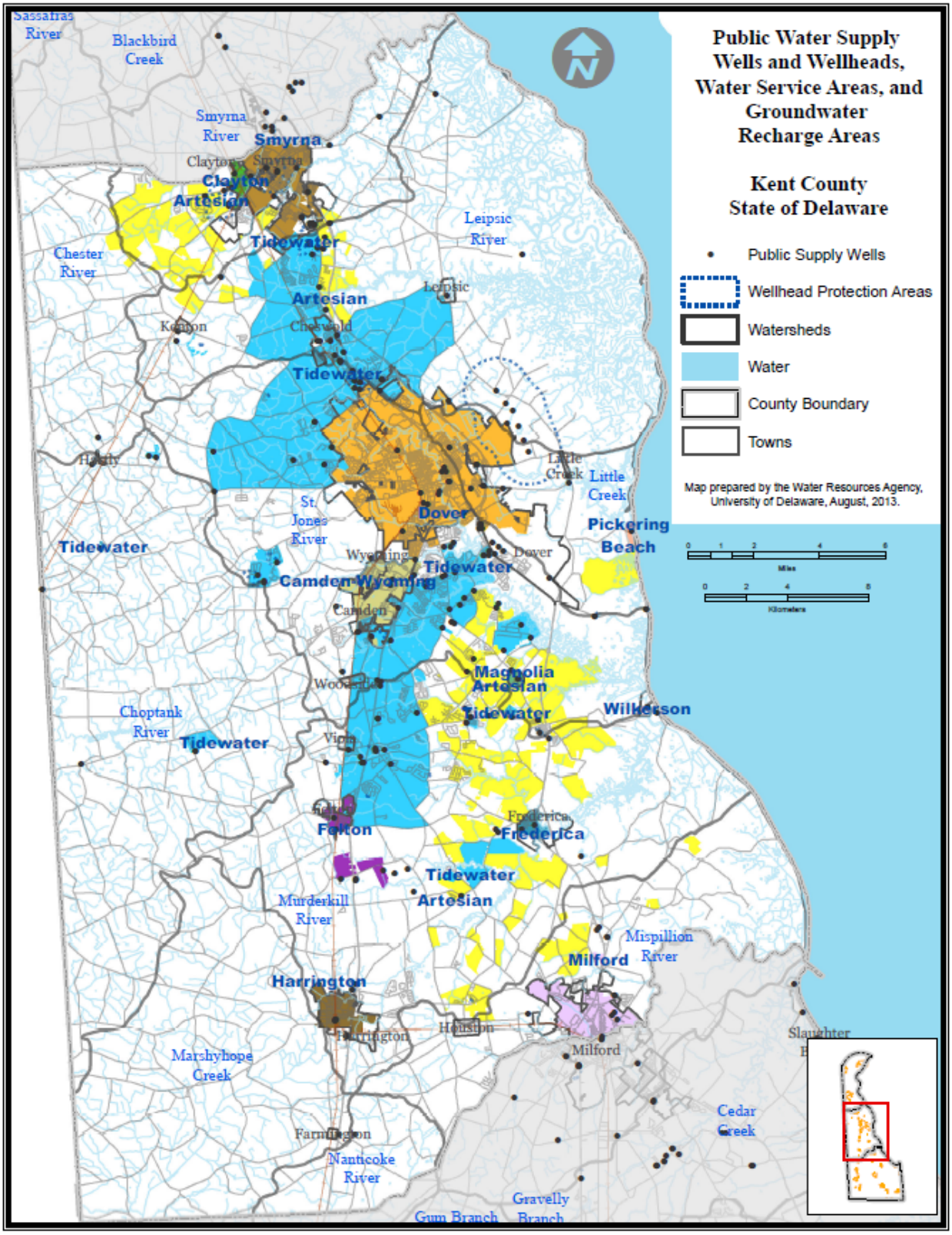


Figure 2.7. Public water supply service areas (CPCNs) in Kent County (Public Service Commission 2013)

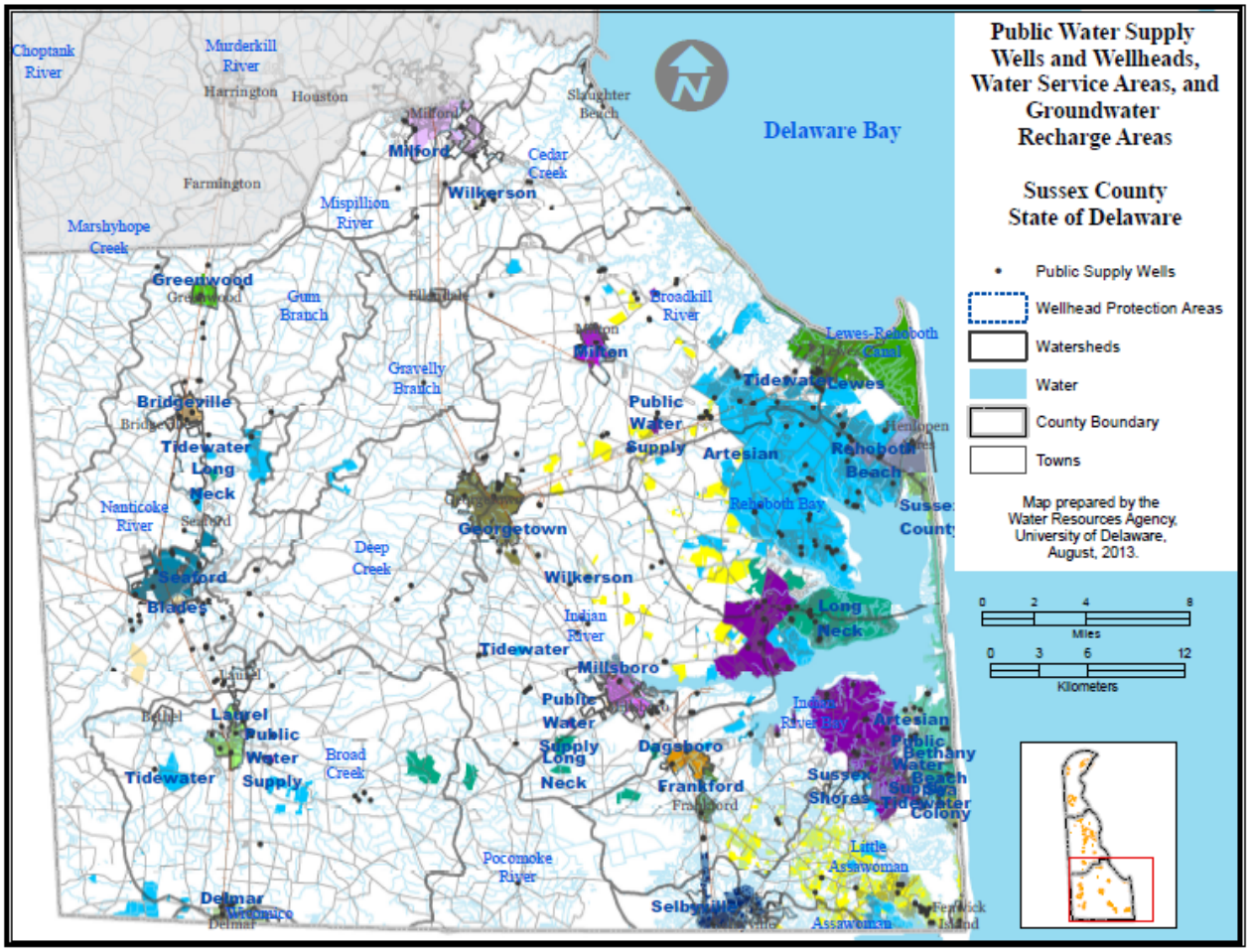


Figure 2.8. Public water supply service areas (CPCNs) in Sussex County (Public Service Commission 2013)

2.5. Interconnected Water Systems

Water utilities in Kent County and Sussex County have limited interconnections between public water systems to transport water when and where needed based on supply and demand fluctuations. Water purveyors are developing information to prepare a regional, interconnected systems map using GIS depicting water lines, interconnections, water tanks, pumps, and other infrastructure. The Water Supply Coordinating Council should work with the public water providers to develop and map interconnections between the water systems in Kent County and Sussex County.

3. Hydrogeology

Groundwater is the sole source of drinking water in Kent and Sussex Counties. It is also the most important source of water for agriculture and industry. Aquifers in the subsurface of Kent and Sussex counties provide groundwater to meet these needs. This section summarizes the results of the Kent-Sussex County Aquifer and Groundwater Study conducted by the Delaware Geological Survey under contract with the DNREC Division of Water. The study examined groundwater resources from two perspectives: (1) the standpoint of the geology, examining the areal extent and thickness of the aquifers used in the study area and (2) the standpoint of water use to understand groundwater withdrawals in Kent and Sussex Counties in three dimensions – geographically, by aquifer, and through time.

3.1. Aquifer Geology

The geology of the southern Delaware Coastal Plain can be characterized generally as layers of nearly flat-lying surficial and near surface Quaternary deposits, underlain by Cretaceous to Cenozoic age sediments that dip gently to the southeast. The geologic formations that make up the subsurface geology include a number of permeable sand bodies that yield groundwater and thus serve as valuable aquifers for multiple uses in southern Delaware (Figure 3.1).

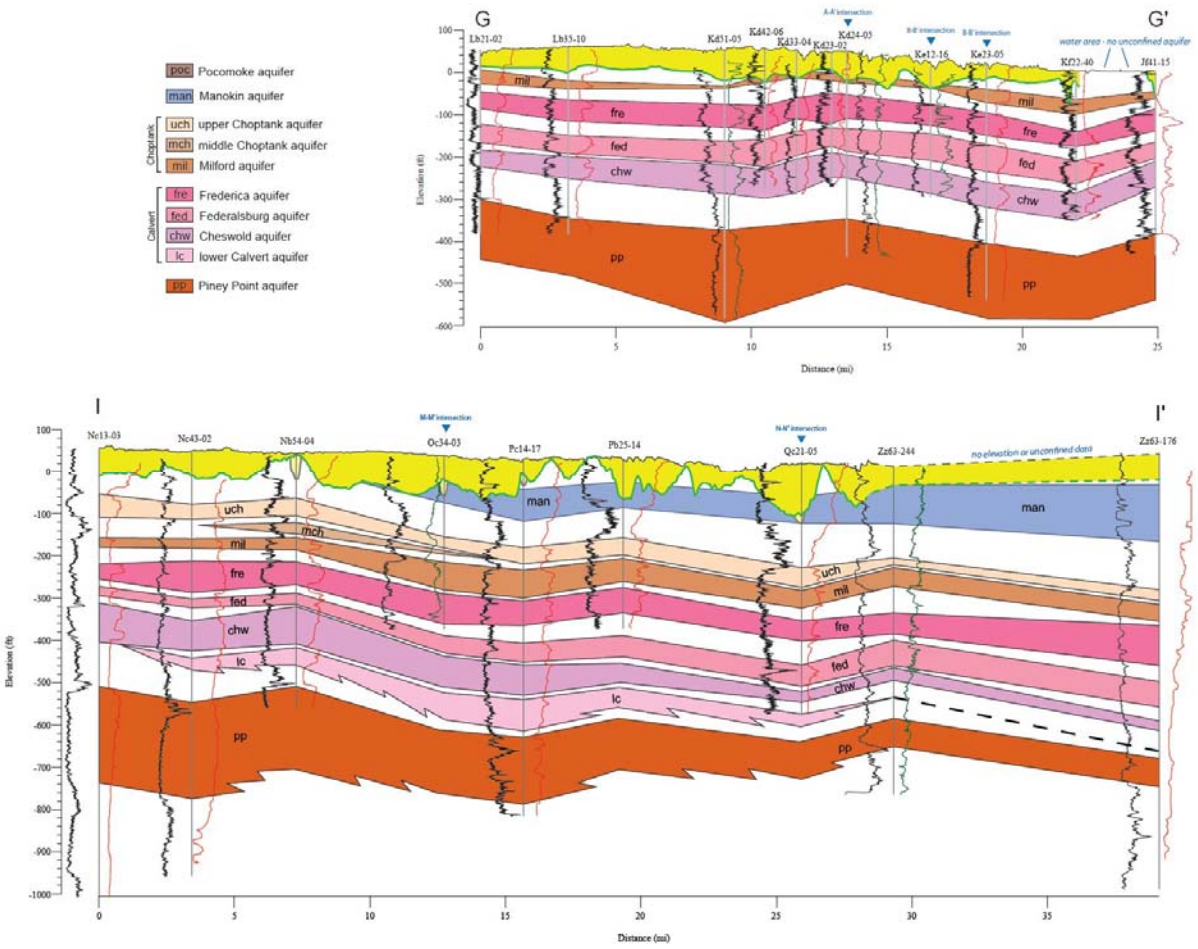


Figure 3.1. Typical geologic cross sections from Kent County (G-G') and Sussex County (I-I')

The unconfined aquifer occurs across Kent and Sussex counties and is a geologically complex unit that includes deposits from numerous formations. In most areas it is formed in sands of one of seven Quaternary-age

formations, or of the slightly older Beaverdam Formation, but may include older deposits in the subcrop areas of other aquifers. The unconfined aquifer is generally less than 100 ft thick in Kent County. Though it shows a more significant degree of variability for Sussex County, with thicknesses of more than 200 ft at some locations, the unconfined aquifer is between 50 and 100 ft thick in slightly more than half the area of the county.

Two confined aquifers are important only in northern Kent County. The Late Cretaceous age Mount Laurel aquifer is a groundwater resource in the northern half of Kent County. It deepens south-southeastward from around 300 ft below sea level in northern Kent County to around 600 ft below sea level in the area between south Smyrna to north Dover where it passes into finer non-aquifer. The aquifer interval is approximately 100 ft thick and thins to as little as a few tens of feet thick in areas where aquifer facies are not present. The Paleogene-age Rancocas aquifer is the next aquifer above the Mount Laurel aquifer. In northernmost Kent County it is thick, as much as 200 ft, but becomes much thinner and finer-grained in a narrow zone that extends approximately west-southwest to east-northeast through the south side of Smyrna. The top of the Rancocas aquifer occurs as high as 100 ft below sea level in northwestern Kent County and becomes deeper southeastward to around 300 ft below sea-level where it transitions to poorer aquifer lithologies. The Piney Point aquifer is the next highest unit, middle Eocene age, and is a very important groundwater resource in central and southern Kent County. Its top ranges in depth from around 250 ft below sea level in the Dover area to more than 700 ft below sea level in northern Sussex County. The Piney Point aquifer subcrops under fine-grained Miocene deposits rather than under younger surficial sands. It is also reflected in the paucity of good aquifer lithologies northwest of a southwest-to-northeast-trending line that runs just north of the Cheswold area, and a trend of thickening of the aquifer southeastward across Kent County from as little as 55 ft to nearly 300 ft.

The Miocene-age shallow-marine sediments of the Calvert and Choptank Formation include seven aquifers. In the Calvert Formation, these are the Lower Calvert, Cheswold, Federalsburg, and Frederica sands, in upward order; in the Choptank Formation, they are the Milford, Middle Choptank, and Upper Choptank sands. The Cheswold and Frederica aquifers are the most important sources of groundwater of this group, each supplying a total of 3.5 to 5% of withdrawals in the study area. The Lower Calvert, Middle Choptank, and Upper Choptank sands are minor aquifers newly defined in this study from aquifer mapping results. All seven of these aquifers are permeable shelly sands that represent the culmination of shallowing-upward cycles. The Calvert-Choptank succession shows a trend from thinner shallow-marine deposits updip in the north and west, to a thicker package with greater thicknesses of finer-grained open marine deposits between sandy aquifer beds to the south and east.

The Lower Calvert sand is a local lower Miocene sand body that could potentially serve as an aquifer in northwest Sussex County, where it occurs within approximately 600 ft on the land surface. The overlying Cheswold aquifer is widely used in northern and central Kent County (Figure 3.2). It subcrops under surficial Quaternary Formations in northern Kent County, where it is recharged, and deepens to more than 500 ft below sea level in southeastern Kent County to more than 1000 ft below sea level in southeastern Sussex County. The Cheswold aquifer varies from less than 20 to more than 100 ft thick, with variable thickness in Kent County and a general increase southeastward in Sussex County. The name “Federalsburg” aquifer is applied to the sand that overlies the Cheswold sand in southern Delaware. This sand is different than the true Federalsburg aquifer of Maryland, which is equivalent to the Frederica aquifer of Delaware. The “Federalsburg” aquifer subcrops between Dover and Smyrna and deepens southeastward to around 400 ft below sea level in southeast Kent County and more than 1000 ft in southeast Sussex County. It has significant thickness variations, in most areas between 30 and 80 ft thick, and commonly includes thinner or muddier, lower aquifer quality sands than do the other Miocene aquifers. The highest of the Calvert Formation sands comprises the Frederica aquifer, which is an important groundwater source in much of Kent County south of Dover and in areas of northwest Sussex County. From its subcrop zone in the Dover area, it deepens to more than 250 ft below sea level in the Milford area and to more than 800 ft below sea level in southeastern Sussex County. The Frederica aquifer is between 40 and 100 ft thick across most of the study area. The confining layers between the aquifers in the Calvert Formation are thin in some areas, likely creating a locally leaky system where adjacent aquifers may be in hydrologic communication.

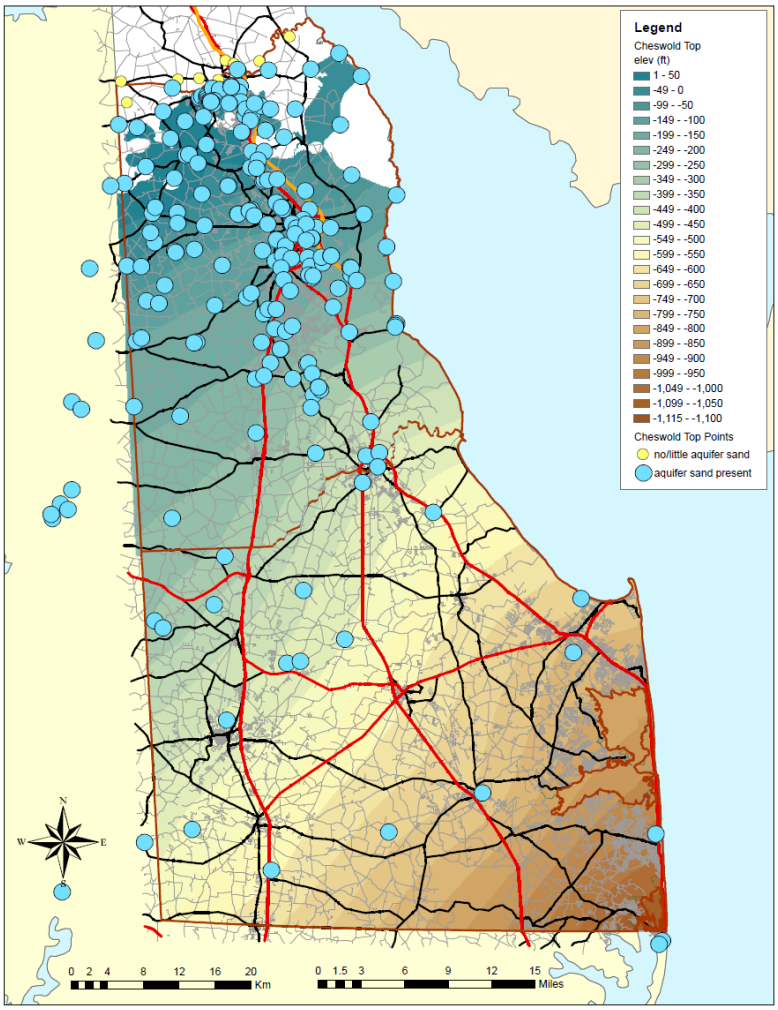


Figure 3.2. Elevation of the top of the Cheswold aquifer

The Milford aquifer is the lowest of the aquifer sands in the Choptank Formation and used for smaller public systems, domestic supplies, and irrigation in southern Kent County and northeastern Sussex County. It is recharged in its subcrop area in an east-west trending belt south of Dover and deepens south-southeastward to around 200 ft below sea level in southern Kent County and to more than 600 ft below sea level in southeast Sussex County. In most of the study area it is between 20 and 60 ft thick. The Milford aquifer is typically separated from the underlying Frederica sand by a well-developed confining layer, commonly a brown mud. However, the confining layer that separated it from the overlying Choptank sands may be poorly developed.

The overlying Middle and Upper Choptank sands are minor, locally used aquifers. The Middle Choptank sand occurs only in eastern Sussex County and southeastern Kent County, deepening to the southeast from around 150 ft below sea level in Milford to more than 700 ft in southeastern Sussex County. It is between 15 and 30 ft thick in most of the study area. It changes facies to less sandy lithologies and pinches out westward. The Upper Choptank sand is the highest aquifer in the Calvert-Choptank succession and immediately underlies the silts and clays of the regional St. Marys Formation confining unit. It subcrops in a narrow zone from Harrington to the north side of Milford and deepens into the subsurface southward, with the top of the formation reaching depths of approximately 250 ft below sea level in Seaford and Milford and 600 ft or more in southeastern Sussex County. It is between 25 and 45 ft thick in most of the study area, with facies changes resulting in thicknesses reaching more than 50 ft in some of its northwesterly occurrences and generally thinner intervals in southeastern Sussex County.

The Manokin and Pocomoke aquifers are major groundwater sources in Sussex County. The Manokin aquifer is a fairly laterally extensive and continuous complex of sand that occurs in the subsurface of most of Sussex County. It is the sandy upper portion of a coarsening upward succession of shallow-marine to estuarine deposits that make up the Cat Hill Formation. It subcrops under the Beaverdam Formation and sandy Quaternary sediments across a wide belt of northern Sussex County, south of which it descends to more than 350 feet below sea level in the southeastern corner of coastal Sussex County. It is thinnest in the western half of Sussex County, where it can be less than 20 ft thick and is more than 80 ft thick over most of the eastern half of Sussex County, in some places more than 130 ft thick. In many places, the sands that make up the Manokin aquifer are in direct contact with shallower sands, with no intervening confining layer, creating recharge "windows" where it is part of the unconfined aquifer rather than confined Manokin aquifer.

The Pocomoke aquifer overlies the Manokin aquifer and has its best development and greatest thickness in eastern and southern Sussex County. Rather than being a single uniform sand body, the Pocomoke aquifer is made up of a complex of sand bodies of variable thickness that occur within the mosaic of coastal facies that make up the Bethany Formation. The Pocomoke aquifer subcrops under surficial sands in a broad band that extends northeastward from the Laurel area through Georgetown to Milton and deepens southeastward, its top occurring as much as 125 ft below sea level in the southeastern part of the county. Because this aquifer is composed of multiple sand bodies, the net thickness of sand was mapped, which shows a general trend from a few tens of feet in updip areas to more than 100 ft downdip along the coast. As with the Manokin aquifer, the top of the Pocomoke aquifer interval is commonly in direct contact with sands of overlying formations, creating potential recharge "windows"; at its base, it may also be in contact with sands of the underlying Manokin aquifer interval (Figure 3.3). The implication is that the Manokin and Pocomoke aquifers have a reasonable probability of being hydrologically connected to each other and/or the unconfined aquifer in many areas.

3.2. Methods

The analysis of groundwater withdrawals in this study examined groundwater use in the years between 2004 and 2008. Annual withdrawals are reported in millions of gallons per day and represent an annual average rate. The intent of this analysis is to establish reasonable estimates of groundwater withdrawals, tied to each category of well and water use, that can be delineated geographically and – most of all – on an aquifer-by-aquifer basis. What is not intended, however, is for the estimates of groundwater withdrawals made for that purpose to be considered a definitive "final word" on water use; they are generally uncalibrated and unverified beyond data available so should be considered a first-pass estimate. This study has not examined variability of water use within individual years, including questions like peak demand, nor does it address issues such as consumptive use or detailed trends in water use beyond the study period. The main intent of the water use analyses is to better understand the distribution and availability of southern Delaware's groundwater resources and provide a starting point for future, more detailed analyses of site- or problem-specific questions.

Two types of data were utilized in the analysis of groundwater withdrawals in this study, reported data and estimated data. Reliable reported monthly pumping data were extracted from DNREC databases for 366 public wells and 62 industrial wells, likely representing complete coverage for those reported-use categories. For categories of water use that do not have reported or usable data, the analysis established reproducible methodologies for estimation using populations and/or spatial data from the period of interest in this study (2004-2008) or from the 2010 census. For two of the categories estimated, Public Community Non-Reported and Domestic Self-Supplied, a domestic water-use model was developed to calibrate reported pumping in public water systems dominated by domestic use to water-related factors in the 2010 census. Using those relationships, withdrawals were calculated for smaller community water systems, using census block data within, and withdrawals by self-supplied domestic users for census blocks, or portions of blocks (sub-blocks), that lie outside of public water system service areas. For smaller non-community public systems that supply transient and non-transient users, water use on the basis of water use characteristics were documented in the literature for each specific facility type.

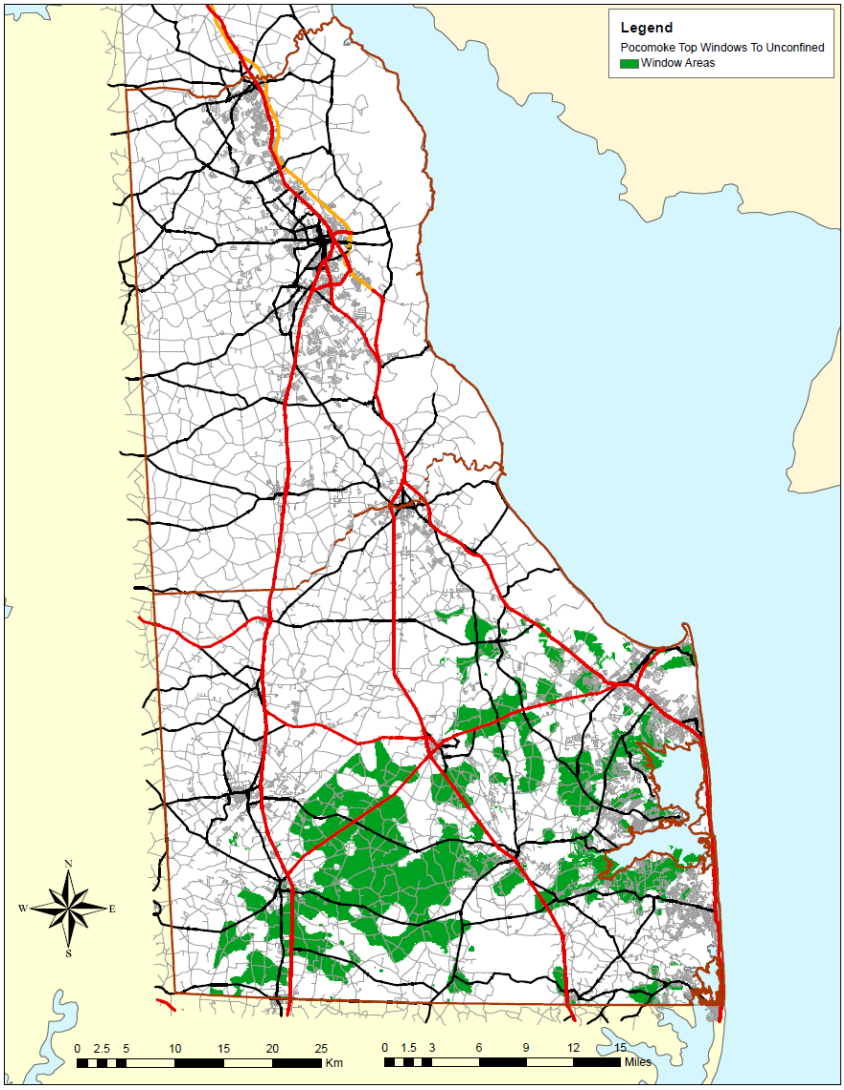


Figure 3.3. Windows between the unconfined aquifer and the Pocomoke aquifer

To estimate irrigation withdrawals, KanSched2 irrigation software calculated irrigation needs for 2,407 individual irrigated areas for the years 2005 through 2008 accounting for crop type, soil water storage capacity, precipitation, and evapotranspiration in determining daily crop-water demand. A recent USGS report (Levin and Zarriello, 2013) used a similar daily crop-water-demand model in studies of eastern US Coastal Plain agricultural sites and concluded it superior to the other approach tested. Withdrawals for livestock water use were estimated on the basis of the locations of 2,727 chicken houses in Kent and Sussex Counties that appeared to be active on 2008 aerial photography. Withdrawals were estimated using a simplistic literature-based estimate of 575,000 gallons per year per house for drinking water and evaporative cooling system needs. Golf course irrigation well withdrawals were determined from reported data, where available, or estimates based on assumed pumping of 100% of the withdrawal allocation. Lawn irrigation withdrawals were estimated for census blocks served by public water system service by assuming a water use increase of approximately 50% in summer months over baseline household water use for the number of properties with lawn wells.

A key objective of this study was assignment of water use to the appropriate aquifer, essentially the intersection of the aquifer geology and groundwater use portions of the study. The approach was dependent on the type of water use. For public industrial, and golf course wells, each individual well could be assigned to an aquifer by comparing the elevation of the well screen to the elevation of each aquifer grid at that location. All lawn

irrigation wells were considered to be withdrawing groundwater from the unconfined aquifer. For irrigation, domestic self-supplied, and livestock (poultry) water use, estimated withdrawals could not be correlated to individual wells. Instead estimated withdrawals for each census block were subdivided among aquifers used for that category in that census block on the basis of proportions of wells in each aquifer.

3.3. Results

The results of this water use analysis suggest that values for annual rates of ground withdrawals for all uses in the study area ranged from approximately 99 to 144 mgd (Table 3.1). Although the population of Sussex County is only 20% larger than that of Kent County, groundwater withdrawals were approximately three to four times greater in Sussex County and largely reflects the higher demand for water for irrigation in Sussex County which peaks during the crop growing season.

Withdrawals from the unconfined aquifer present more than half of the groundwater pumped in the study area (Figure 3.4). The confined Columbia aquifer and the Pocomoke aquifer are estimated to each represent around 11% of total withdrawals and the Manokin aquifer approximately 8%. The next tier of withdrawals are for aquifers most important in Kent County – the Cheswold, Frederica, and Piney Point – which each represent 3 to 5% of total estimated withdrawals in the study area. Other aquifers each represent less than 2% of withdrawals.

Crop irrigation is the largest use category for groundwater in the study area. Maps of irrigated areas polygons represent a total of more than 102,000 acres in the study area, with 74,206 acres in Sussex County and 28,370 acres in Kent County; approximately half of the acreage is corn. These analyses suggests that groundwater withdrawals for irrigation in the period of 2005 to 2008 totaled as much as 91 mgd for a dry year in 2007 and as little as 50 mgd in a year with abundant, well-timed rainfall in 2006. The unconfined aquifer is the largest source of irrigation water in the study area, estimated to represent almost two-thirds of irrigation withdrawals. The confined Columbia aquifer, Pocomoke aquifer, and Manokin aquifer each are estimated to have provided approximately 10% of the irrigation groundwater withdrawals, and the other aquifers very small amounts.

Table 3.1. Summary of annualized groundwater withdrawals for each water use in Kent and Sussex counties

Water Use	Kent (mgd)	Sussex (mgd)	Total (mgd)
Public Reported (high use yr)	11.0	15.2	26.2
Public Reported (low use yr)	10.1	12.7	22.8
Public Non-Reported (est. C + TNC + NTNC)	0.6	1.2	1.8
Domestic self-supplied (model)	4.2	7.4	11.6
Irrigation: Ag (seasonal high use 2007)	19.1	71.7	90.8
Irrigation: Ag (seasonal low use 2006)	5.6	44.5	50.2
Ag: Livestock (estimated)	0.7	3.6	4.3
Irrigation: Golf Course (seasonal median rpt+est)	0.2	2.0	2.2
Industrial self-supplied (high use values)	1.3	7.0	7.6
Industrial self-supplied (low use values)	0.8	5.6	6.7
Ag: Lawn wells (seasonal)	0.01	0.02	0.03
Total (high end)	**37.2**	**108.1**	**144.6**
Total (low end)	**22.2**	**77.0**	**99.5**

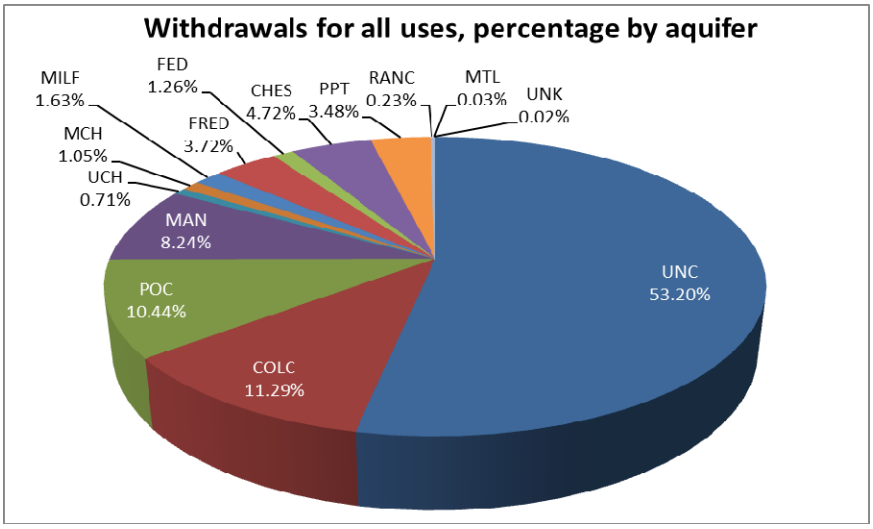


Figure 3.4. Groundwater withdrawals by aquifer in Kent and Sussex counties

Mount Laurel (MTL)	Milford (MIL)
Rancocas (RAN)	Middle Choptank (MCH)
Piney Point (PPT)	Upper Choptank (UCH)
Lower Calvert (LCAL)	Manokin (MAN)
Cheswold (CHE)	Pocomoke (POC)
Federalsburg (FED)	Confined Columbia (COLC)
Frederica (FRE)	Unconfined (UNC)

Public water supply is the second largest category of groundwater withdrawals. The majority of public water use is reported annually to DNREC. Compilation and editing of the reported data from years between 2004 and 2008 yielded volumes between 22.8 mgd (2004) and 26.2 mgd (2007), with slightly greater totals of withdrawals in Sussex County than Kent County. Table 3.2 indicates that approximately half of the public water use is in three areas: City of Dover (5.0 mgd), Lewes-Rehoboth area (three systems total 4.0 mgd), and City of Milford (2.4 mgd). Analysis of 2010 census data for census blocks, or parts of blocks, that are located within areas served by public water supply systems as of 2008 identifies a population of 200,620 residents in service areas, with 101,656 in Kent County and 98,964 in Sussex County. The greater usage but lower resident population in Sussex County reflects, in part, the additional demands on visitors and non-permanent seasonal residents. The unconfined aquifer represents approximately one-fourth of reported public well withdrawals in the study area, making it the largest source, and the closely associated confined Columbia aquifer provided around 10%. The Piney Point, Cheswold, and Pocomoke aquifers each represent approximately 15% of the public supply, the former two in Kent County and the latter in Sussex County. The Manokin and Frederica aquifers provided 7 to 8% of the public supply in general, with other aquifers representing smaller percentages.

Most public systems serve a combination of household, industrial, commercial, and other institutional users. However, in certain areas where portions or combinations of public systems serve principally domestic household users, pumping data for domestic use could be isolated and compared to census factors to develop a regression-based domestic water demand model. This domestic demand model served as the basis for water use estimates for unreported withdrawals by smaller community water systems. Together with two other categories of smaller public water systems – transient non-community and non-transient non-community – unreported public water withdrawals are estimated to add 1.8 mgd to the public water totals. The unconfined aquifer and confined Columbia aquifer are the most important sources in these three smaller public categories, with the Cheswold, Pocomoke, and Piney Point being notable in some areas.

Table 3.2. Average annual withdrawals for the top 15 public water systems in southern Delaware

System ID	System	Years	Average Pumping (gal)	Average Pumping (mgd)
DE0000571	Dover Water	2004-2008	1,830,912,200	5.016
DE0000616	Milford Water Department	2004-2008	892,154,684	2.444
DE0000723	Rehoboth Water	2004-2008	540,782,618	1.482
DE0000991	Tidewater Utilities (Rehoboth District)	2004-2008	493,493,635	1.352
DE0000602	Lewes Water	2004-2008	434,809,660	1.191
DE0000246	Seaford Water	2004-2008	424,107,563	1.162
DE0000592	Georgetown Water	2004-2008	299,004,084	0.819
DE0000221	Tidewater Utilities (Bethany Bay)	2004-2008	278,816,464	0.764
DE0000124	Tidewater Utilities (Camden District)	2004-2008	254,066,103	0.696
DE0000657	Smyrna Water	2005-2008	243,811,000	0.668
DE00A0323	Artesian Water Co. (South Bethany)	2004-2008	205,408,380	0.563
DE0000625	Long Neck Water	2004-2008	202,452,480	0.555
DE0000833	Perdue (Georgetown)	2004-2008	196,947,060	0.540

Domestic self-supplied water use makes up the third category of withdrawals, totaling 11.6 mgd for the study area including 4.23 mgd in Kent County and 7.37 mgd in Sussex County. Comparison of populations in areas of self-supplied domestic well use to public supply suggests that more Kent County residents utilize public water supplies than their own domestic wells, whereas Sussex County residents have nearly equal numbers of public supplied and self-supplied users. Analysis of 2010 census data for census blocks, or parts of blocks, that are located outside of areas served by public water supply systems as of 2008 identifies a population of nearly 159,000 residents who depend on withdrawals from their own domestic wells, with nearly 61,000 in Kent County and nearly 98,000 in Sussex County (Figure 3.5). Self-supplied withdrawals are estimated on a per capita basis to be 72.9 gallons per day per person in the study area, which includes 69.9 gallons per person per day in Kent County and 76.7 gallons per capita per day in Sussex County; the average is likely higher in Sussex County than in Kent County, at least in part, because of self-supplied household use by occupants of non-resident seasonal housing. The unconfined aquifer provides the lion's share of domestic self-supplied groundwater in the study area, representing almost two-thirds of the supply. The confined Columbia aquifer is estimated to represent nearly 14% of withdrawals, with other aquifers providing no more than 5% each.

Reported pumping from industrial wells represents the fourth largest category of groundwater withdrawals. Withdrawals between 2004 and 2008 ranged from 6.66 mgd (2006) to 7.66 mgd (2008), most from Sussex County. The unconfined aquifer represented more than half of the volume of reported industrial well withdrawals in the study area and the Pocomoke aquifer approximately one-fourth. The Manokin (11%) and Cheswold (7%) aquifers are the only other significant sources.

Three additional categories represent smaller proportions of withdrawals in the study area. Livestock water use for the poultry industry was estimated to represent more than 4 million gallons of withdrawals, most of it in Sussex County. The unconfined aquifer represents more than half of the volume of estimated withdrawals for poultry houses in the study area and the confined Columbia aquifer accounts for approximately one-fourth. Pumping of wells used for golf course irrigation was principally in Sussex County and estimated from a combination of reported and assumed pumping volumes. The totals suggest withdrawals of around 2 mgd or slightly more, nearly half from the unconfined aquifer and significant portions (13-17%) from the confined Columbia, Pocomoke, and Manokin aquifers. The smallest category is agricultural wells used for lawn irrigation, which is estimated to be 0.03 mgd, entirely from the unconfined aquifer.

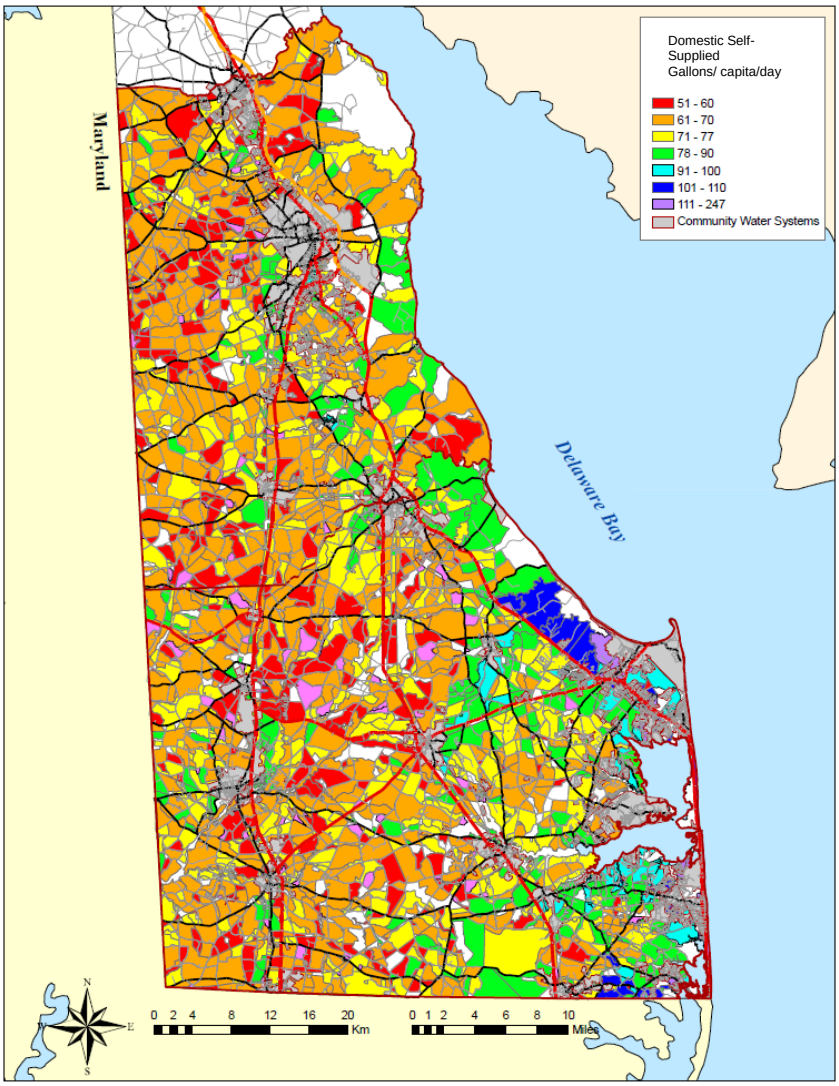


Figure 3.5. Per capita domestic self-supplied water use for each census block in Kent and Sussex counties

3.4. Groundwater Availability Implications

DGS staff members have evaluated numerous reports that included estimates of water availability for Kent and Sussex Counties and in numerous presentations to the WSCC has identified where new data, new methods, and data gaps render those availability estimates inappropriate for future use. DGS has developed a scope of work and budget needed to generate data needed by modern planning tools that better estimate groundwater availability and submitted those items to DNREC for inclusion in the FY 2015 Capital Budget bill. Though incorporated in DNREC's capital request, the project was not selected by the Governor or the Legislature for funding. These work plans and budgets were the subject of a presentation to the Water Infrastructure Advisory Council in March 2014.

Key information related to DNREC regulations, policies, and permit conditions that should be addressed in future water availability reports include:

- Permit limits on drawdown by well and wellfield
- Special rules applied to areas that have experienced depletion, such as Dover area aquifers
- Summary of regulations, policies, and details of special cases for groundwater management zones.

4. Water Quality

This chapter provides a summary of existing groundwater quality in Kent County and Sussex County as measured by chlorides, nutrients, organic compounds, pesticides, radon, or other parameters. Public drinking water supplies are generally safe to drink and treated in accordance with EPA and Delaware drinking water standards. However, contamination of wells in Ellendale and Millsboro has required cleanup by the DNREC Division of Waste and Hazardous Management. In some locations, untreated groundwater in Kent County and Sussex County contains elevated chlorides, nitrogen, organic chemicals, and pesticides.

The Federal government and State of Delaware administer several groundwater quality protection programs. The EPA seeks to protect and improve groundwater quality through public drinking water standards and source water provisions of the 1974 Safe Drinking Water Act and 1986 and 1996 Amendments. The Delaware DNREC Division of Water administers a source water protection program that identifies potential pollutant sources and works with local governments to adopt water resource protection area ordinances through the Delaware Source Water Protection Act of 2001. The DNREC Division of Waste and Hazardous Substances administers hazardous waste and underground storage tank cleanup programs. The Delaware Department of Agriculture operates a state-wide groundwater quality monitoring network that samples for pesticides. To focus on strategic cleanup of legacy VOCs, pesticides, and emerging contaminants and improve groundwater quality in wellhead areas, the Water Supply Coordinating Council should appoint a representative to participate on the Hazardous Substance Cleanup Act (HSCA) committee organized by the DNREC Division of Waste and Hazardous Substances. Groundwater quality monitoring programs operated by the Delaware Geological Survey, DNREC, and Delaware Department of Agriculture should continue to be funded to screen for levels of chlorides, nutrients, VOCs, pesticides, radionuclides, and emerging contaminants.

The Delaware Sea Level Rise Advisory Committee (2012) reported that: “Residents and businesses in Kent and Sussex Counties rely on groundwater resources for drinking, irrigation and industrial purposes. Operation of wells that extract groundwater can be compromised by inundation from sea level rise, and the quality of groundwater can be compromised by saltwater intrusion resulting from sea level rise. Statewide, 3%-7% of domestic wells, 3%-7% of industrial wells, 1%-2% of irrigation wells, and 2%-10% of public wells are within an area that could be inundated by sea level rise by 2100. Potential exposure of wells to sea level rise is focused along the coast; however, reduction in availability of groundwater in the coastal areas may increase demand on inland public wells. Because access to clean water is a necessity and because demand on inland wells may increase, sea level rise impacts to wells was ranked as a high concern.” Additional groundwater monitoring should be considered to assess the effects of inundation due to coastal storms and sea level rise including monitoring of chloride levels in wells along the Delaware Bay and Atlantic coast.

4.1. Water Quality

Chlorides: Chlorides greater than the secondary 250 mg/l EPA drinking water standard have been detected in wells in scattered locations in Delaware Bay beach communities, the Atlantic beaches, and around the Inland Bays. From results of monitoring conducted by the DGS, USGS, and others over several decades, there are no clear temporal trends of increasing chloride concentrations and no indication of saline water intrusion into freshwater aquifers (Woodruff 1969, USGS 1986, DGS unpublished data).

Nitrogen: Elevated nitrogen levels above the 10 mg/l drinking water standard have been detected in shallow unconfined aquifer wells in coastal Sussex County (Woodruff 1970, Andres 1991), between Millsboro and Selbyville and at Moores Lake near Dover (Miller 1971 and 1972) in Kent and Sussex counties (USGS 1986, Pellerito et al. 2008, and Reyes 2010), and throughout the Delmarva Peninsula (DGS 1993, USGS 2004).

Volatile Organic Compounds: Industrial, commercial, and fuel-related synthetic VOCs such as chloroform, tetrachloroethene, tetrachloroethylene, and methyl tert-butyl ether (MTBE) have been detected in some locations at levels mostly below EPA drinking water standards in shallow domestic wells and shallow public water supply

wells near Smyrna, Garrisons Lake, Cheswold, and Georgetown (Cabe 1980, USGS 2002, USGS 2004, Pellerito et al. 2008, and Reyes 2010). VOCs such as MTBE have been detected in private wells used for drinking water in Ellendale and trichloroethylene (TCE) has been found in Millsboro public water supply wells.

Pesticides: Low levels of metabolites such as desethylatrazine, alachlor ethane sulfonic acid, metolachlor ethane sulfonic acid and pesticides such as metolachlor and atrazine have been detected in Delmarva Peninsula shallow aquifers (USGS 1992, USGS 2002, USGS 2004, and Reyes 2010). Dieldrin, a banned insecticide, was detected above the screening level at nine sites.

Radionuclides: Naturally occurring radon and radium are present at low levels in Delaware shallow groundwater but rarely exceed the proposed EPA drinking water standard of 300 picocuries/liter (USGS 2002 and Reyes 2010).

Emerging Contaminants: In 2008 and 2009, the Delaware Division of Public Health (2010) reported that 17 drugs and personal care chemicals were detected in low levels in 55% of public water systems and 14 of these compounds were found in 95 Delaware Department of Agriculture monitoring wells.

4.2. Source Water Protection

The Delaware Division of Public Health (2009) reported that 15% of 486 public water systems in Delaware reported exceedances of drinking water standards for maximum residual disinfection (1 system), total trihalomethanes (2 systems), fluoride (2 systems), nitrate (23 systems), and total coliform rule (43 systems).

The Federal Safe Drinking Water Act (SDWA) amendments of 1996 required that states develop Source Water Assessment Plans (SWAP) to identify sources of contamination to public drinking water supplies. The Delaware SWAP (1999) was developed by a Citizens and Technical Advisory Committee (CTAC) of scientists, water industry professionals, conservation groups, government agencies, and interested citizens in 1998 and approved by EPA in 1999. Note that most public water supply wells have water treatment systems that remove impurities, to meet drinking water standards before the water reaches the tap. A source water assessment for groundwater systems consists of four steps:

- delineate and map the source water area of a drinking water well such as the wellhead protection area
- determine vulnerability of the well to contamination for factors such as aquifer permeability, well construction/integrity, and depth of the well
- identify existing/potential sources of contamination using the DNREC site inventory, land use mapping, and Division of Public Health drinking water quality data based on eight contaminant categories (Table 4.1)
- determine susceptibility of the source water area to contamination for untreated water based on a rating scale ranging from not susceptible (NS) to exceeds drinking water standards.

Table 4.1. Contaminant categories for Delaware source water assessment

Contaminant	Typical Substances
Inorganics	Fluoride, Chloride, pH, Sulfate, Radon, Radium, Strontium
Metals	Copper, Arsenic, Iron, Manganese
Nutrients	Nitrates, Phosphorus
Organics	Vinyl Chloride, PCE, TCE
Pathogens	Coliform Bacteria, Cryptosporidium, Giardia lambia
Pesticides	Alachlor, Atrazine, Glyphosphate
Petroleum Hydrocarbons	Gasoline, MTBE, Heating Oil, Benzene, Toluene
Polychlorinated Biphenyls	PCBs

In accordance with the Delaware Source Water Protection Law of 2001, eight governments have adopted source water protection ordinances in Kent County including Camden, Cheswold, Dover, Frederica, Harrington,

Milford, Smyrna, and Wyoming and eight governments have adopted source water protection ordinances in Sussex County including Bridgeville, Georgetown, Laurel, Lewes, Millsboro, Seaford, Selbyville, and Sussex County (Figure 4.1). A law suit forced Kent County to repeal part of their source water protection ordinance, however, the County has other land use practices in place that are highly protective of source water. Clayton and Milton are currently developing new source water protection ordinances. The DNREC Division of Water will continue to work with local governments to adopt source water and wellhead protection ordinances and/or comparable land use practices to protect the quality and quantity of groundwater supplies.

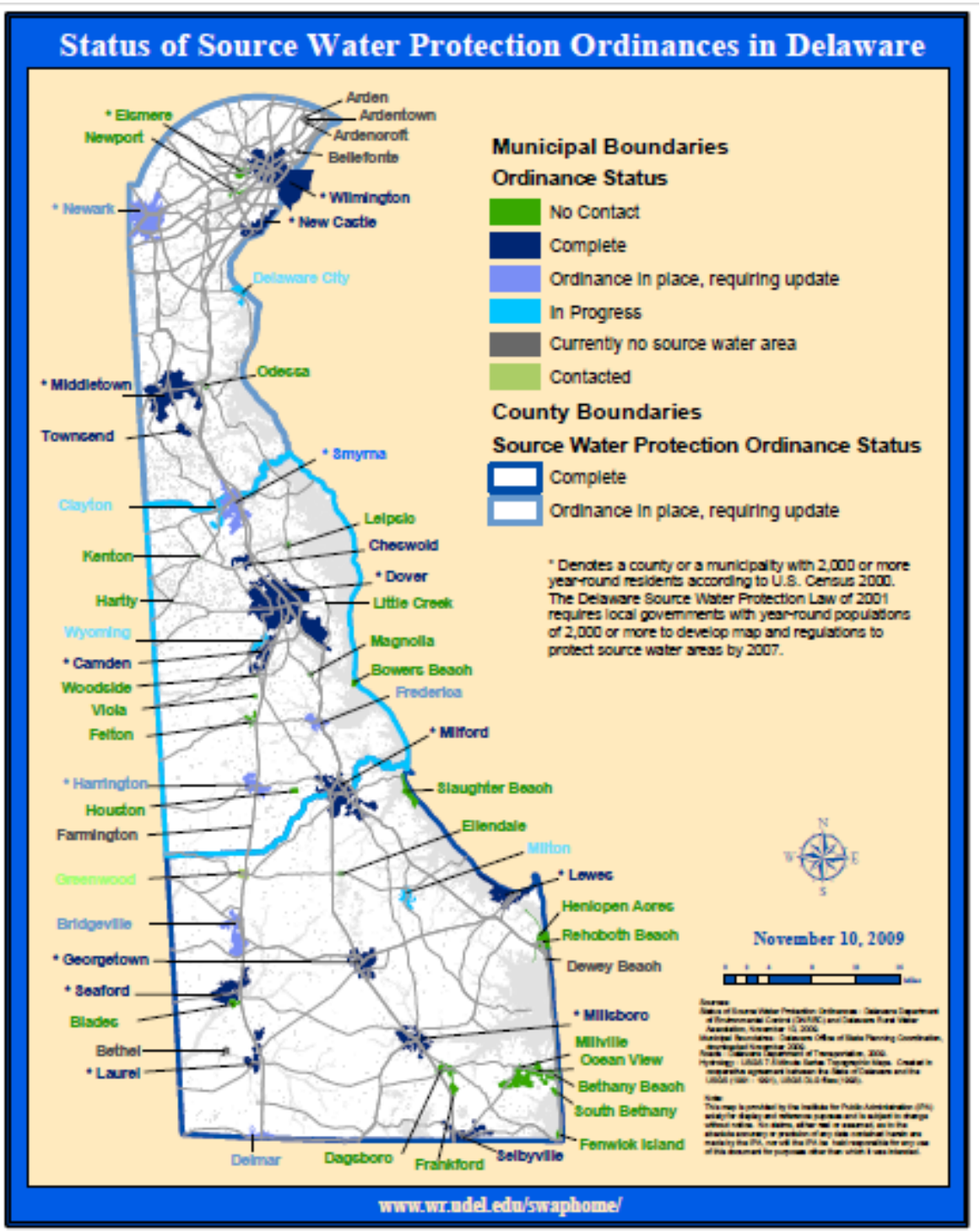


Figure 4.1. Status of source water protection ordinances in Delaware

5. Water Supply

Water supplies in Kent County and Sussex County are drawn from: (1) public water supply wells for community water systems, (2) transient non-community wells for restaurants, stores, hotels, and parks and non-transient non-community wells for schools and offices, (3) domestic self-supplied individual wells, (4) farm irrigation wells, (5) golf course irrigation wells, and (6) industrial wells.

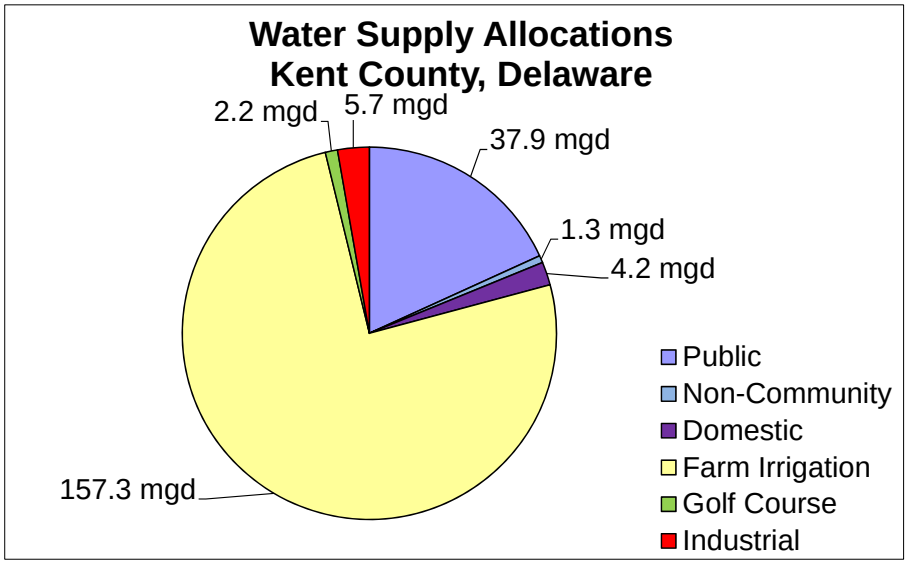
DNREC groundwater allocations greater than 50,000 gpd for public, domestic, farm irrigation, golf course irrigation, and industrial uses (and domestic wells) total 940 mgd on a maximum daily basis with 209 mgd in Kent County and 731 mgd in Sussex County (Table 5.1 and Figure 5.1). Farm irrigation (83%) has the largest allocation, followed by allocations for public water supply (10%), industrial (4%), golf course (2%), domestic (1%), and non-community (<1%) wells. The appendices summarize the water supply well allocation database.

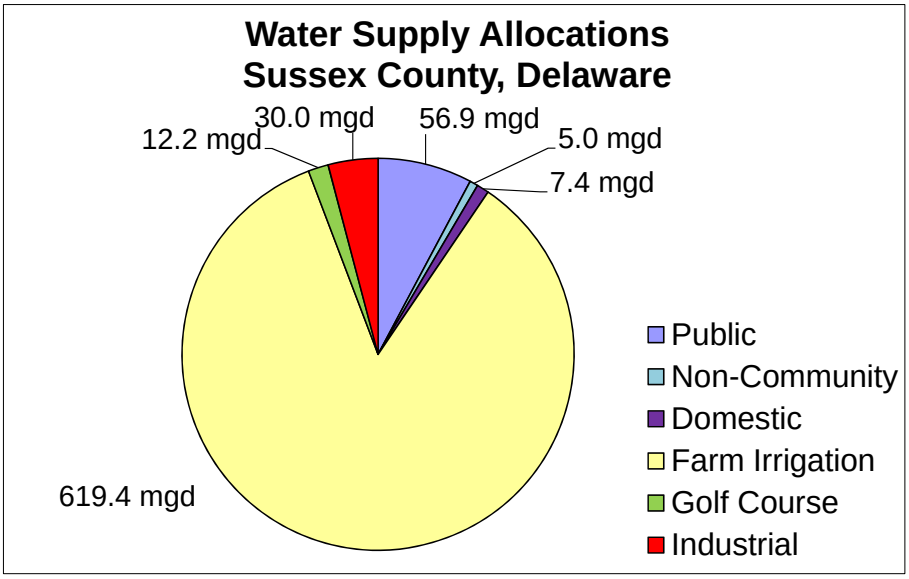
Table 5.1. Water supply allocations in Kent County and Sussex County (DNREC)

County	Use[1]	Daily Maximum Supply (mgd)	Monthly Maximum Supply (mgd)	Yearly Maximum Supply (mgd)
Kent County	Public	37.9	26.8	19.7
	Non-Community	1.3	1.3	1.3
	Domestic	4.2		
	Farm Irrigation	157.3	125.1	19.5
	Golf Course	2.2	0.9	0.2
	Industrial	5.7	4.5	6.2
	Total	**208.6**	**158.6**	**46.9**
Sussex County	Public	56.9	45.7	26.6
	Non-Community	5	5	5
	Domestic	7.4		
	Farm Irrigation	619.4	454.3	72.2
	Golf Course	12.2	7	1.4
	Industrial	30	23.3	19.1
	Total	**730.9**	**535.3**	**124.3**
Kent and Sussex	Public	94.8	72.5	46.3
	Non-Community	6.3	6.3	6.3
	Domestic	11.6	0	0
	Farm Irrigation	776.7	579.4	91.7
	Golf Course	14.4	7.9	1.6
	Industrial	35.7	27.8	25.3
	Total	**939.5**	**693.9**	**171.2**

1. Wells using less than 50,000 gpd and domestic wells do not receive DNREC water supply allocations.

In the two counties, DNREC has issued maximum daily public community water supply allocations that total 95 mgd including 38 mgd in Kent County and 57 mgd in Sussex County. The Delaware Geological Survey evaluated 2010 census socioeconomic and population factors with adjustments on the basis of 2008 aerial photography and estimated self-supplied domestic wells provide 4.2 mgd in Kent County and 7.4 mgd in Sussex County or 11.6 mgd in both counties. Farms and nurseries hold DNREC water supply allocations to pump 777 mgd on a maximum daily basis in both counties including 157 mgd in Kent County and 619 mgd in Sussex County. In Kent County and Sussex County, DNREC issued irrigation well allocations to 14 golf courses with capability to withdraw 14 mgd on a maximum daily basis. DNREC issued groundwater supply allocations to 20 industries in Kent County and Sussex County with a maximum daily withdrawal of 36 mgd or 5.7 mgd in Kent County and 30.0 mgd in Sussex County.





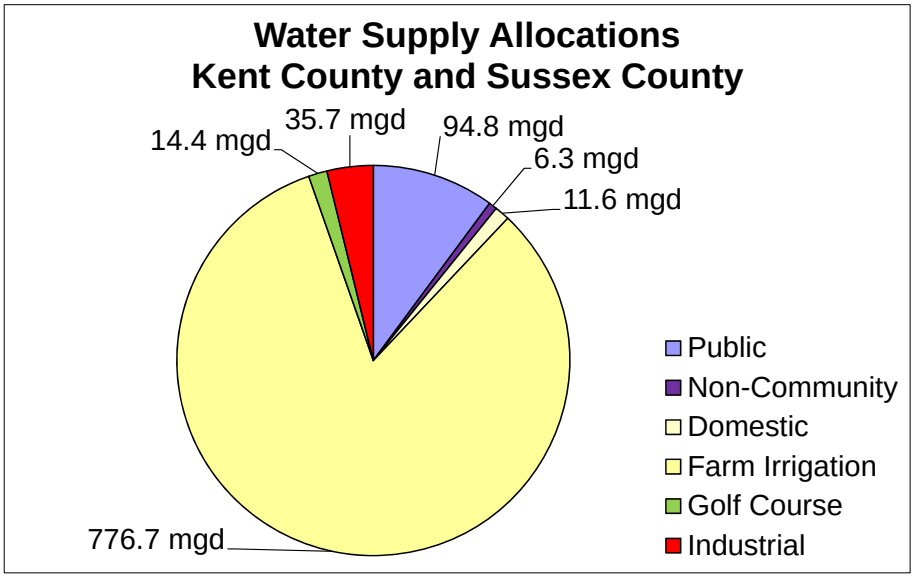


Figure 5.1. Water supply allocations in Kent County and Sussex County (DNREC)

6. Water Demand

In Kent and Sussex counties, existing peak day water demands for base year 2010 were 44.8 mgd for public community water systems, 1.8 mgd for non-community (transient/non-transient) systems, 11.6 mgd from domestic wells, 90.8 mgd for farm irrigation, 14.4 mgd for golf course irrigation, and 6.9 mgd from industry (Table 6.1).

Table 6.1. Peak day water demand in Kent County and Sussex County, Delaware

County	Use	Peak Day Demand (mgd)
Kent County	Public Water	14.3
	Non-community	0.6
	Domestic Well	4.2
	Farm Irrigation	18.9
	Golf Course	2.2
	Industrial	1.3
Sussex County	Public Water	30.5
	Non-community	1.2
	Domestic Well	7.4
	Farm Irrigation	71.7
	Golf Course	12.2
	Industrial	5.6
Total	Public Water	44.8
	Non-community	1.8
	Domestic Well	11.6
	Farm Irrigation	90.8
	Golf Course	14.4
	Industrial	6.9

6.1. Public Water Demand

Peak daily public water demands were recorded at 14.3 mgd in Kent County and 30.5 mgd in Sussex County for a total of 44.8 mgd in both counties. During 2009 and 2010, public water purveyors compiled daily water demand data in Kent County and Sussex County that were used to estimate peak day demands (Figures 6.1 and 6.2). Maximum monthly demand is defined as the mean recorded for the month of July in 2009 and 2010. Peak daily demands are tabulated for the peak day recorded by each water purveyor in 2009 and 2010. Peaking factor is defined as the ratio of peak daily demand (usually during the summer) to average annual demand. Peaking factors range from 1.5 in older, established towns such as Milford and Seaford to 2.0 to 3.0 or higher in beach towns such as Rehoboth Beach and Bethany Beach that host an influx of summer residents and visitors.

Peak public water demands are verified by comparing data to wastewater flow records, county comprehensive plan data, and estimates of water use by the Delaware Geological Survey (Table 6.2). The Kent County Department of Public Works wastewater treatment plant along the Murderkill serves 77,000 people with a 12.5 mgd discharge which computes to 13.9 mgd in public water demand assuming wastewater flow is 90% of water demand. In Sussex County, five regional wastewater treatment plants treat 24 mgd which computes to 26.7 mgd of water demand. The Kent County Comprehensive Plan reported that public water demand was 18.3 mgd. The Sussex County Comprehensive Plan listed normal water demand as 17.7 mgd which equates to 26.5 mgd for a 1.5 peaking factor. Based on these comparisons to wastewater flows, peak public water demand estimates of 14.3 mgd in Kent County and 30.5 mgd in Sussex County seem to be reasonable. From 2004-2008, the Delaware Geological Survey concluded that annual public water supply withdrawals ranged from 10.1 to11.0 mgd in Kent County and 12.7 to 15.2 mgd in Sussex County.

The DGS estimated that 2004 to 2008 demand for small community public water systems, non-community transient public water systems, and non-community non-transient public water systems was 0.6 mgd in Kent County and 1.2 mgd in Sussex County.

Table 6.2. Public water demand in Kent County and Sussex County, 2010

Purveyor	Annual Demand (mgd)	Peak Daily Demand (mgd)	Peaking Factor
Kent County	**7.66**	**14.33**	**1.9**
Artesian Water Co.	0.60	1.18	2.0
Camden- Wyoming	0.53	1.60	3.0
Clayton	0.22	0.46	2.1
Dover	2.80	5.50	2.0
Dover Air Force Base	0.23	0.57	2.5
Felton	0.05	0.11	2.2
Frederica	0.07	0.17	2.4
Harrington	0.46	0.74	1.6
Magnolia	0.05	0.08	1.6
Milford	1.80	2.80	1.6
Smyrna			
Tidewater Utilities	1.45	2.22	1.5
Sussex County	**15.60**	**30.49**	**1.9**
Artesian Water Co.	1.20	2.61	2.2
Bethany Beach	0.49	1.13	2.3
Blades	0.13	0.25	1.9
Bridgeville	0.27	0.48	1.8
Dagsboro	0.05	0.10	2.0
Delmar	0.25	0.40	1.6
Frankford	0.11	0.19	1.7
Georgetown	0.60	1.00	1.7
Greenwood	0.06	0.09	1.5
J.H. Wilkerson & Son			
Laurel	0.49	0.73	1.5
Lewes Bd. Public Works	0.95	1.93	2.0
Long Neck Water	0.59	1.14	1.9
Milford	1.20	3.40	1.5
Millsboro	0.58	0.92	1.6
Milton	0.26	0.60	2.3
Rehoboth	2.50	6.90	2.8
Seaford	1.24	1.91	1.5
Selbyville	0.21	0.34	1.6
Sussex County Council			
Sussex Shores Water	0.38	1.03	2.7
Tidewater Utilities	3.58	7.04	2.0

Table 6.3. Benchmark of peak day public water demands in Kent County and Sussex County

Method	Kent Co. (mgd)	Sussex Co. (mgd)
Peak demand from water purveyor	14.3	30.5
Wastewater Treatment Flow	13.9 (12.5/0.9)	26.7 (24.0/0.9)
Comprehensive Plan	18.3	26.5 (17.70 x 1.5)
Delaware Geological Survey	10.1-11.0 (annual)	12.7-15.2 (annual)

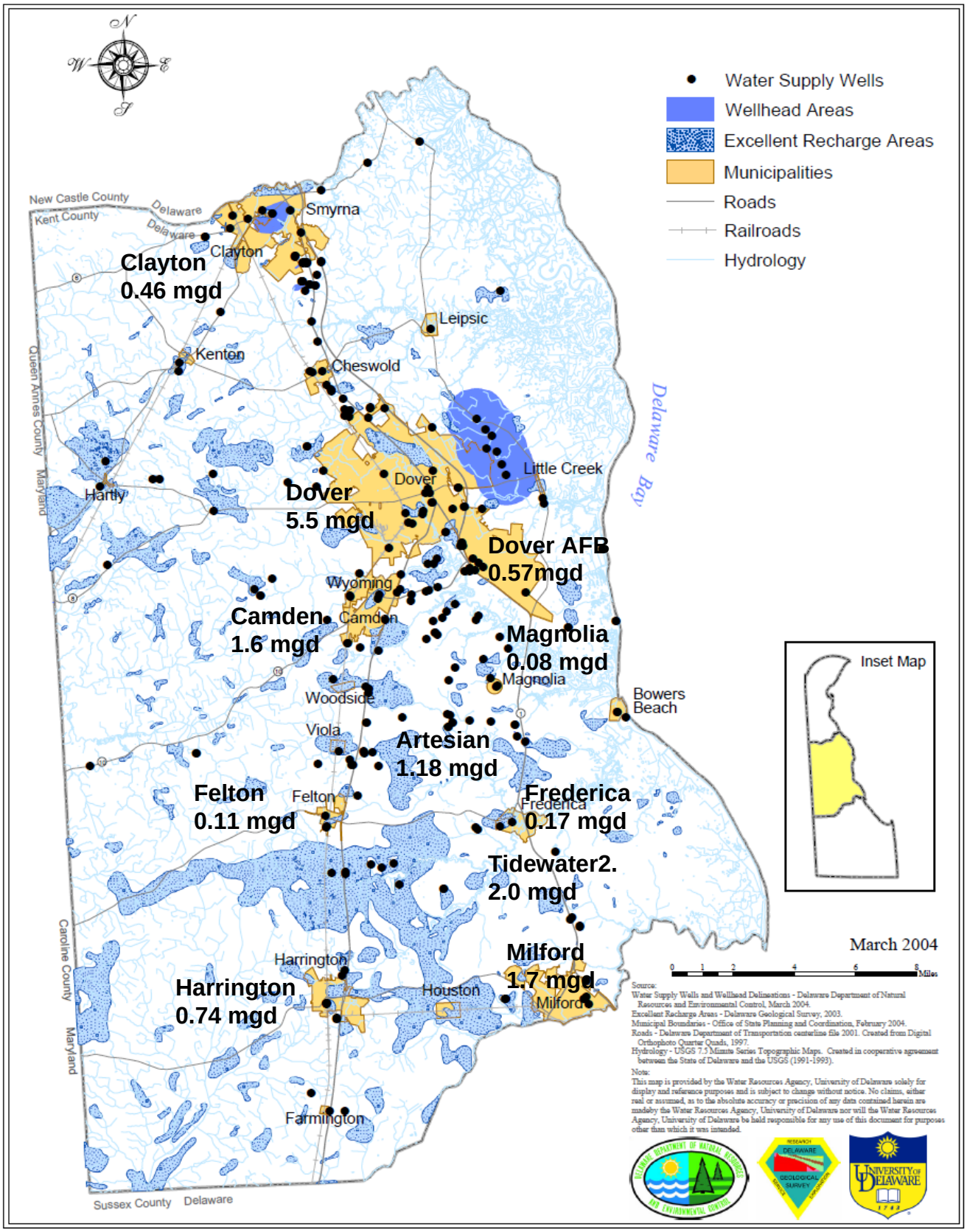


Figure 6.1. Peak public water demand in Kent County in 2010

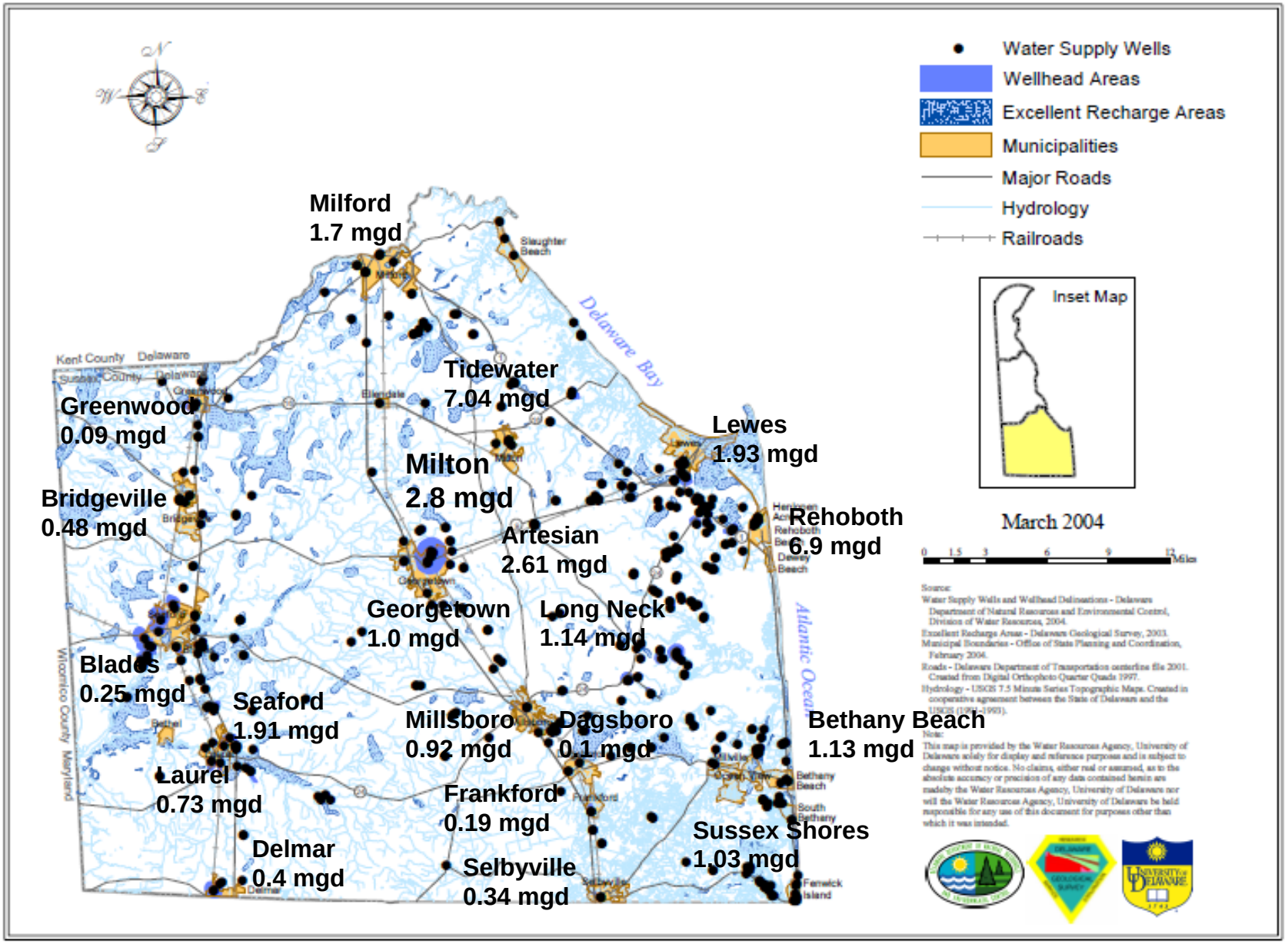


Figure 6.2. Peak public water demand in Sussex County in 2010

6.2. Domestic Wells

Over 130,000 people or 1/3 of the population in Kent and Sussex counties are served by self supplied domestic or individual wells (Table 6.4). The Delaware Division of Public Health estimated that 146,124 people or 16% of the State's population are served by wells, which includes 13,500 people from New Castle County and 132,624 people supplied by domestic wells in Kent and Sussex counties. The Kent County Comprehensive Plan (2008) indicates 24% of the population or 38,000 people have domestic wells. The Sussex County Comprehensive Plan (2008) estimate that 37,100 domestic wells served 92,500 people. The University of Delaware Water Resources Agency conducted a GIS analysis that concluded the population in public water supply service areas is 120,839 in Kent County and 101,401 in Sussex County. Subtracting the public water supply population from the population of each county, domestic wells serve 42,077 people in Kent County and 96,469 people in Sussex County or 138,546 people in both counties. The Delaware Geological Survey estimated that based on an analysis of 2010 census socioeconomic and population factors with some adjustments on the basis of 2008 aerial photography, domestic wells serve nearly 61,000 people in Kent County and 98,000 people in Sussex County or 159,000 people in both counties.

Table 6.4. Population served by domestic wells in Kent County and Sussex County

Population	Del. Div. of Public Health	County Comp. Plans	UDWRA GIS	DGS 2010 Census Data
Kent County				
Total Population		162,916	162,916	
Public Water Supply		124,916	120,839	
Domestic Wells		38,000[2]	42,077	61,000
Sussex County				
Total Population		197,870	197,870	
Public Water Supply		105,370	101,401	
Domestic Wells		92,500[3]	96,469	98,000
Kent and Sussex				
Total Population		360,786	360,786	
Public Water Supply		230,286	222,240	
Domestic Wells	132,624[1]	130,500	138,546	159,000

1. 146,124 people statewide minus 13,500 people in New Castle County. 2. 24% of Kent County population.
3. 37,100 wells in Sussex County @2.5 people/dwelling unit.

At an average daily pumping rate of 69.9 gpcd in Kent County and 76.7 gpcd in Sussex County, the Delaware Geological Survey estimated that domestic self-supplied well use is 4.2 mgd in Kent County and 7.4 mgd in Sussex County or 11.6 mgd in both counties (Table 6.5).

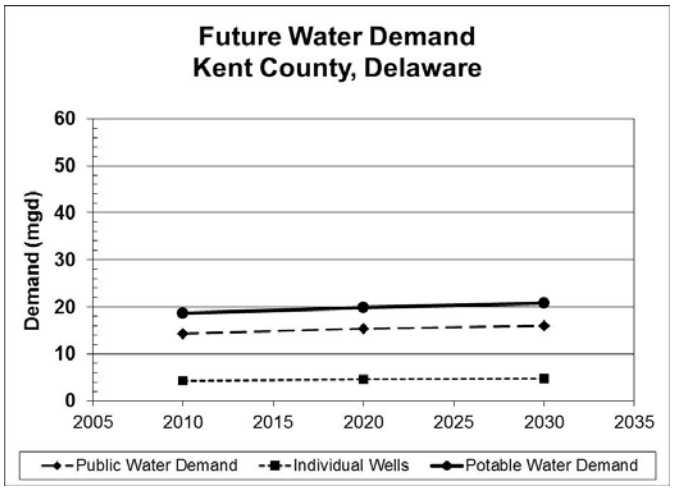
Table 6.5. Estimates of domestic well demand in Kent County and Sussex County

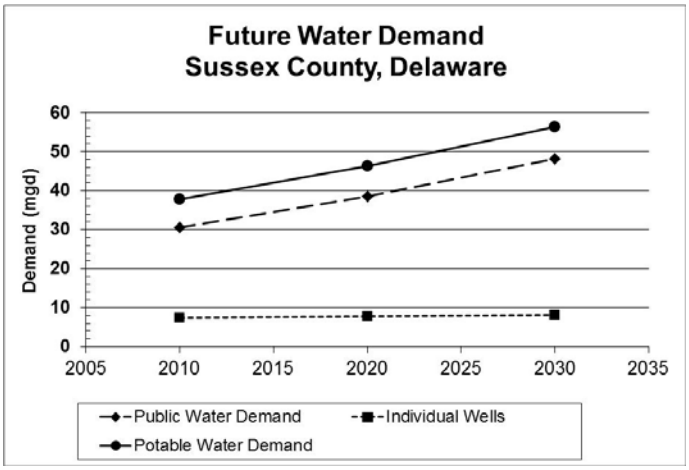
County	Population w/ Domestic Wells	Per Capita Demand (gpcd)	DGS Estimate (mgd)
Kent County	61,000	69.9	4.2
Sussex County	98,000	76.7	7.4
Total	**159,000**		**11.6**

The population of Kent and Sussex counties is projected to grow by 104,457 people from 360,786 in 2010 to 465,243 by 2030 (Delaware Population Consortium 2012) with commensurate increases in water demand. The 2010 population in the two counties includes 159,000 people who draw water from domestic wells. Under State regulations, new communities with 15 or more homes are required to be served by public water systems, therefore, most of increased water demand is projected to be served by public water systems. The number of domestic wells is estimated to rise at a rate commensurate with the number of well permits issued by the DNREC Division of Water over the last five years.

6.3. Potable Water Demand

Peak daily potable water demand in Kent County and Sussex County is projected to increase from 56.4 mgd in 2010 to 77.8 mgd by 2030 assuming demand coincides with population growth (Table 6.4 and Figure 6.3). Public water demand is projected to increase from 44.8 mgd in 2010 to 64.9 mgd in 2030. Domestic well demand is projected to increase from 11.6 mgd in 2010 to 12.9 mgd by 2030. Water conservation has tended to temper the effects of increased population growth on increased water demand.





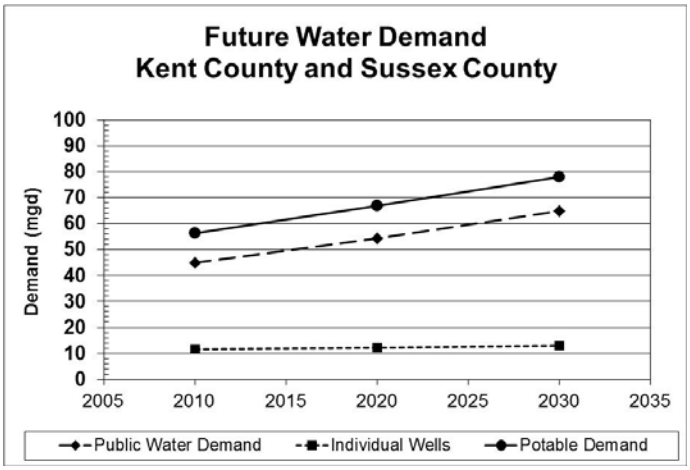


Figure 6.3. Peak potable water demand in Kent County and Sussex County, 2010-2030

Table 6.6. Peak day potable water demand in Kent and Sussex counties, 2010-2030

Drinking Water Provider	2010 (mgd)	2020 (mgd)	2030 (mgd)
Kent County	**18.5**	**19.8**	**20.8**
Public Water Demand.	14.3	15.3	16.1
Individual Domestic Wells	4.2	4.5	4.7
Sussex County	**37.9**	**46.9**	**57.0**
Public Water Demand	30.5	39.1	48.8
Individual Domestic Wells	7.4	7.8	8.2
Kent County and Sussex County	**56.4**	**66.7**	**77.8**
Public Water Demand	44.8	54.4	64.9
Individual Domestic Wells	11.6	12.3	12.9

6.4. Climate Change

Climate change during the 21st century may increase water demands. The Delaware Climate Change Impact Assessment (DNREC 2014) concluded that summer maximum temperatures may increase by 3°F from 1981-2010 to 2020-2039 (Figure 6.4). The assessment also projects that the annual number of days with maximum temperatures greater than 95°F may increase from 2-3 days during 1981-2010 to 15-17 days by 2020-2039.

A review of air temperature data for Wilmington Airport and water demand data in New Castle, Kent, and Sussex counties indicates that water demand increases by 3% for every 1% increase in maximum air temperature. At 90°F, peak potable water demand was 56.4 mgd during 2010 in Kent County and Sussex County. If summer maximum air temperatures are projected to increase by 3°F by 2020-2039 (or 3/90 = 3.3%), then peak water demand may increase by 9.9% to 62 mgd by 2020-2039 due to warming. Resources for the Future published a report that concluded a 1% rise in air temperature would increase water demand by as much as 3.8% (Frederick 1997). A study in northeastern Illinois concludes that by 2050, future water demand would increase by 9.1% with an air temperature increase of 6°F or 1.5% for every degree Fahrenheit (Dziegielewsky and Chowdhury 2008).

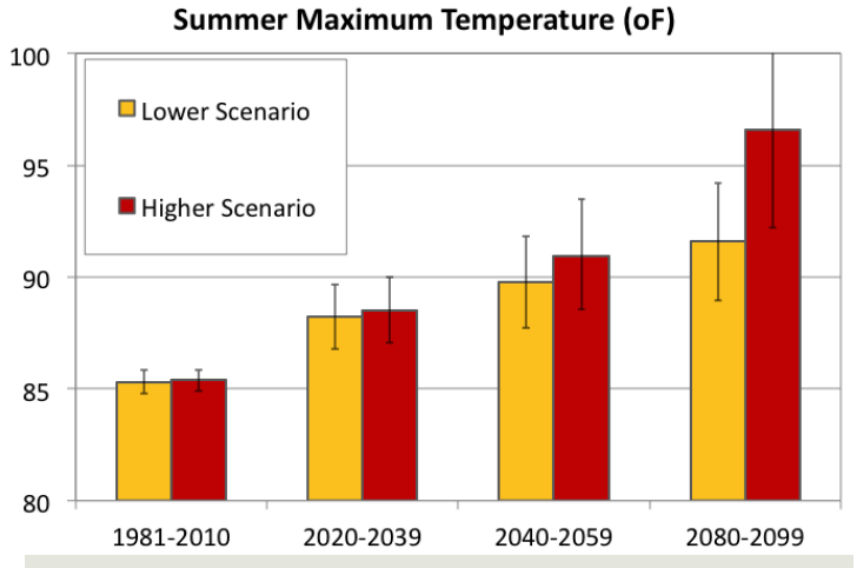


Figure 6.4. Change in summer maximum temperature in Delaware (DNREC 2014)

Figure 6.5 and Table 6.7 depict future water demands in Kent and Sussex counties with and without the effects of a 3°F rise in maximum summer air temperature by 2020-2039. By 2030, projected water demands in Kent and Sussex counties will increase 52% due to population growth (38%) and climate change (14%) drivers.

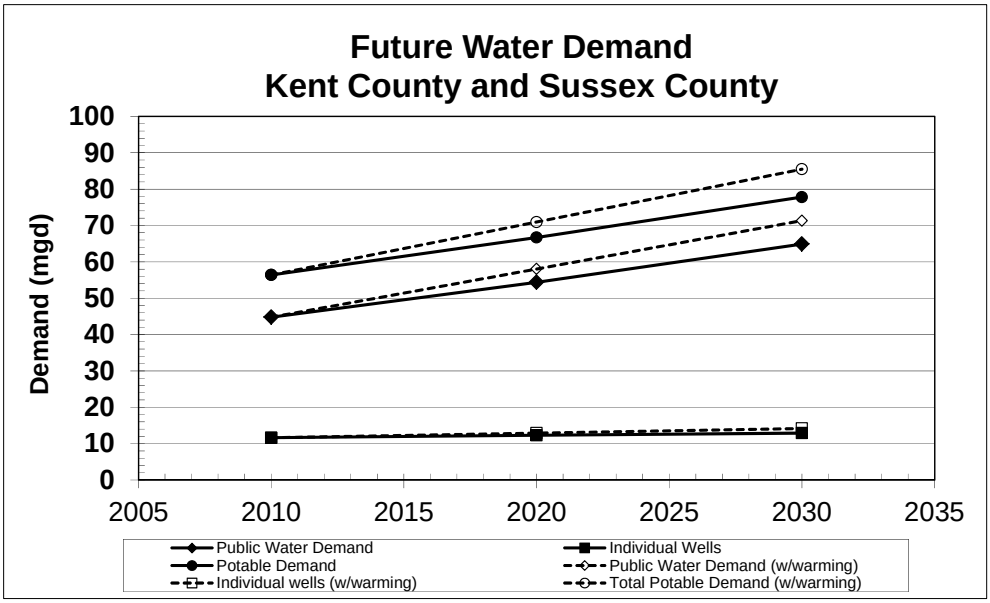


Figure 6.5. Future water demands with climate change in Kent and Sussex counties from 2010-2030

Table 6.7. Future water demands with climate change in Kent and Sussex counties from 2010-2030

Kent County and Sussex County	2010 (mgd)	2020 (mgd)	2030 (mgd)
Public Water Demand (w/ climate change)	44.8	58.1	71.3
Individual Wells (w/climate change)	11.6	12.9	14.2
Total Potable Demand (w/climate change)	56.4	71.0	85.5
Public Water Demand (w/o climate change)	44.8	54.4	64.9
Individual Wells (w/o climate change)	11.6	12.3	12.9
Total Potable Demand (w/o climate change)	56.4	66.7	77.8
Public Water Demand (increase w/climate change)	0	3.7	6.4
Individual Wells (increase w/climate change)	0	0.6	1.3
Total Potable Demand (increase w/climate change)	0	4.3	7.7

6.5. Irrigation Demand

While farmland may decline in Delaware after leveling off and even increasing slightly in Sussex County from 2007-2012, seasonal demand for irrigation is expected to grow. In 2012, farms covered 172,251 acres in Kent County and 272,232 acres in Sussex County, a 4% to 6% decline in farmland since 2002 (USDA 2004, 2009, 2014). In 2012, irrigated farmland covered 31,833 acres in Kent County and 90,809 acres in Sussex County, a 10% increase in Kent County since 2002 and 39% increase in Sussex County since 2002. In 2012, irrigated farmland covered 122,642 acres or 28% of the total farmland in both counties.

The University of Delaware Cooperative Extension recommends optimum moisture for a high-yield bushel of corn is 20 to 25 inches over a 92-day growing season from June through August. UD agronomy extension specialists report that a crop needs 30 to 40 inches of irrigation plus rain to have moisture for optimal yield of 200 bushels per acre for corn. Delaware Statute Title 7, Del. C., Section 6010 (House Bill 320) signed in August 2003 allows for a maximum yearly irrigation rate of 20 ac-in and maximum monthly rate of 10 ac-in.

The DGS estimated irrigation use using a KanSched scheduler with nearest weather station evapotranspiration (ET) and precipitation data for acreage from 2008 aerial photography and 2007 USDA census. For the 2006 wet case (17 in of rain during June-August) and 2007 dry case (9 in of rain during

June-August), farm irrigation demand ranged from 5.6-18.6 mgd in Kent County and 44.5-71.9 mgd in Sussex County (Table 6.8).

Table 6.8. Estimated agricultural irrigation withdrawals in Kent and Sussex counties

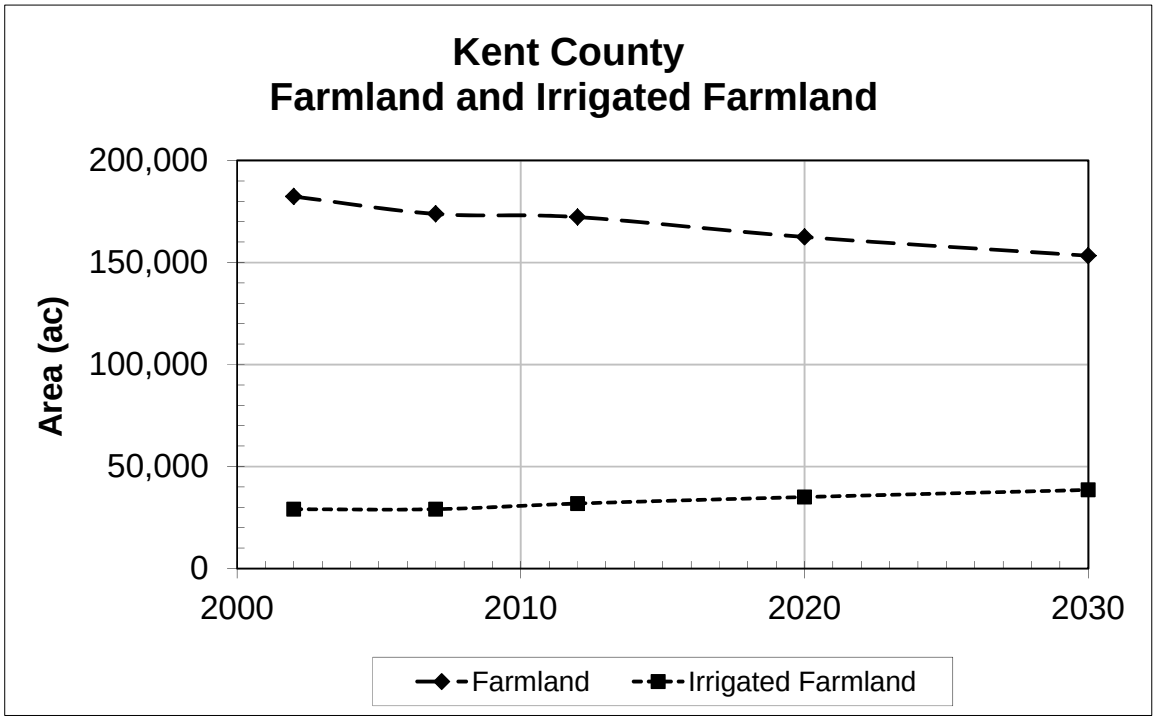
	2005	2006	2007	2008
Kent (mgd)	14.4	5.6	18.9	10.1
Sussex (mgd)	67.9	44.5	71.9	55.9
Total (mgd)	82.3	50.1	90.8	66.0
Kent (demand, in)	6.8	2.6	9.0	4.7
Sussex (demand, in)	12.3	8.1	13.0	10.1
Total (weighted avge., in)	10.7	6.4	11.9	8.6
June-Aug rain (in)	12.0	17.0	9.0	9.0

The University of Delaware Cooperative Extension concluded that farm irrigation needs are projected to continue to grow over the next 20 years. As agricultural land continues to decrease, producers may consider irrigating additional acres to remain competitive and profitable in the face of warmer and drier growing seasons. As the landscape changes and local customer bases develop, currently non-irrigated farms may convert from the predominate crops of corn, soybeans and small grains to smaller acreage, higher value vegetable crops that require more irrigation.

While farmland may decline, the demand for farm irrigation is projected to continue to rise in southern Delaware. From 2002 to 2012, farmland has declined by 10,078 acres in Kent County and 11,271 acres in Sussex County while irrigated farmland has increased by 2,794 acres in Kent County and 25,318 acres in Sussex County (Figure 6.6). At this growth rate, irrigated farmland in Kent County is projected to increase from 31,833 acres in 2012 to 38,518 acres by 2030 and associated irrigation demand is projected to grow from 5.6-18.9 mgd in 2012 to 6.8-22.9 mgd by 2030 (Table 6.9). Irrigated farmland in Sussex County is projected to increase from 90,809 acres in 2012 to 109,879 acres by 2030 and associated irrigation demand is projected to grow from 44.5-71.9 mgd in 2012 to 53.8-87.0 mgd by 2030 (Table 6.9). By 2030, irrigated land is projected to grow and cover 148,397 acres or 37% of all the farmland in Kent and Sussex counties.

Table 6.9. Future irrigation demand in Kent County and Sussex County

County	2002	2007	2012	% Change (02–12)	2020	2030
Kent County						
Farmland (ac)	182,329	173,808	172,251	-6%	162,501	153,303
Irrigated land (ac)	29,039	29,066	31,833	10%	35,016	38,518
Irrigation, wet (mgd)			5.6	10%	6.2	6.8
Irrigation, dry (mgd)			18.9	10%	20.8	22.9
Sussex County						
Farmland (ac)	283,503	269,464	272,232	-4%	261,762	251,694
Irrigated land (ac)	65,491	72,785	90,809	39%	99,890	109,879
Irrigation, wet (mgd)			44.5	39%	49.0	53.8
Irrigation, dry (mgd)			71.9	39%	79.1	87.0
Kent and Sussex Counties						
Farmland (ac)	465,832	443,272	444,483	-5%	424,262	404,997
Irrigated land (ac)	94,530	101,851	122,642	30%	134,906	148,397
Irrigation, wet (mgd)			50.1	30%	55.1	60.6
Irrigation, dry (mgd)			90.6	30%	99.9	109.9



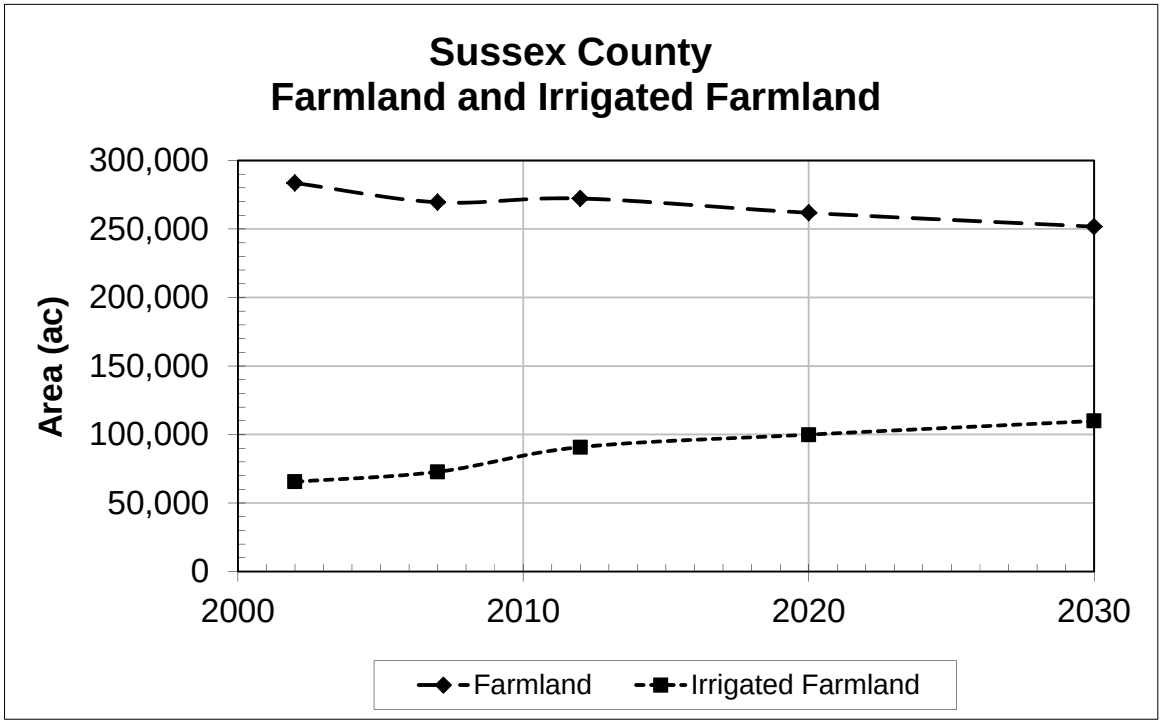


Figure 6.6. Farmland and irrigated farmland in Kent County and Sussex County (USDA 2004, 2009, 2014)

Since farm irrigation draws mostly from shallow aquifers and public water supplies pump from deeper aquifers, conflicts between the users can be minimized. Land disposal of treated effluent such as spray irrigation and rapid infiltration basins (RIBS) can be used to recharge and augment availability of groundwater for irrigation uses.

Golf course irrigation demand is 2.2 mgd in Kent County and 12.2 mgd in Sussex County. With the closure of golf courses throughout the state, golf course irrigation demand is expected to level off or decline in the future.

6.6. Industrial Demand

From 2004-2008, the DGS estimates industrial water demands peaked at 1.3 mgd in Kent County and 7.0 mgd in Sussex County. Industrial demand is projected to grow to 50% and 100% of present demand in 10 and 20 years respectively based on siting of new industries that may move into these counties.

6.7. Summary

Table 6.11 projects future water demands in Kent County and Sussex County from 2010 through 2030. Public water demands are projected to rise coincident with population growth as projected by the Delaware Population Consortium and may be accelerated by climate change Domestic well demand is projected to rise slowly as most new development is projected to be supplied by public water systems. While farmland acreage is declining, farm irrigation demand is expected to continue to rise as producers convert to specialty crops and farmers face warmer, drier summers as experienced in 2011 and 2012. Golf course irrigation demand is projected to stagnate as golf courses continue to close in Delaware. Industrial demand is projected to grow by 50% within 10 years and 100% within 20 years.

Table 6.10. Peak daily water demand in Kent County and Sussex County, Delaware

County	Water Use	2010 (mgd)	2020 (mgd)	2030 (mgd)
Kent County	Public Water	14.3	15.3	16.1
	Non-community	0.6	1.0	1.4
	Domestic Well	4.2	4.5	4.7
	Farm irrigation	18.9	20.8	22.9
	Golf Course	2.2	2.2	2.2
	Industrial	1.3	1.9	2.6
Sussex County	Public Water	30.5	39.1	48.8
	Non-community	1.2	1.6	2.0
	Domestic Well	7.4	7.8	8.2
	Farm irrigation	71.7	79.1	87.0
	Golf Course	12.2	12.2	12.2
	Industrial	5.6	8.4	11.2
Kent and Sussex Counties	Public Water	44.8	54.4	64.9
	Non-community	1.8	2.6	3.4
	Domestic Well	11.6	12.3	12.9
	Farm irrigation	90.8	99.9	109.9
	Golf Course	14.4	14.4	14.4
	Industrial	6.9	10.3	13.8

7. Water Supply and Demand

In 2010, public water purveyors held existing water supply allocations that exceed peak demands thus accounting for a healthy surplus. By 2030, water purveyors are projected to have supplies that exceed forecasted peak demands. Surplus/deficit calculations are based upon maximum daily supplies as per DNREC water allocation permits. Since this analysis compares maximum daily supply to peak day demands, the Delaware Water Supply Coordinating Council believes these projections are conservative and public water purveyors are equipped to comfortably meet future peak water demands in Kent County and Sussex County. Public water purveyors provide water storage in their systems that can provide backup supplies if needed to meet peak day demands. These water supply and demand projections may be influenced by employment projections and water conservation in addition to population projections.

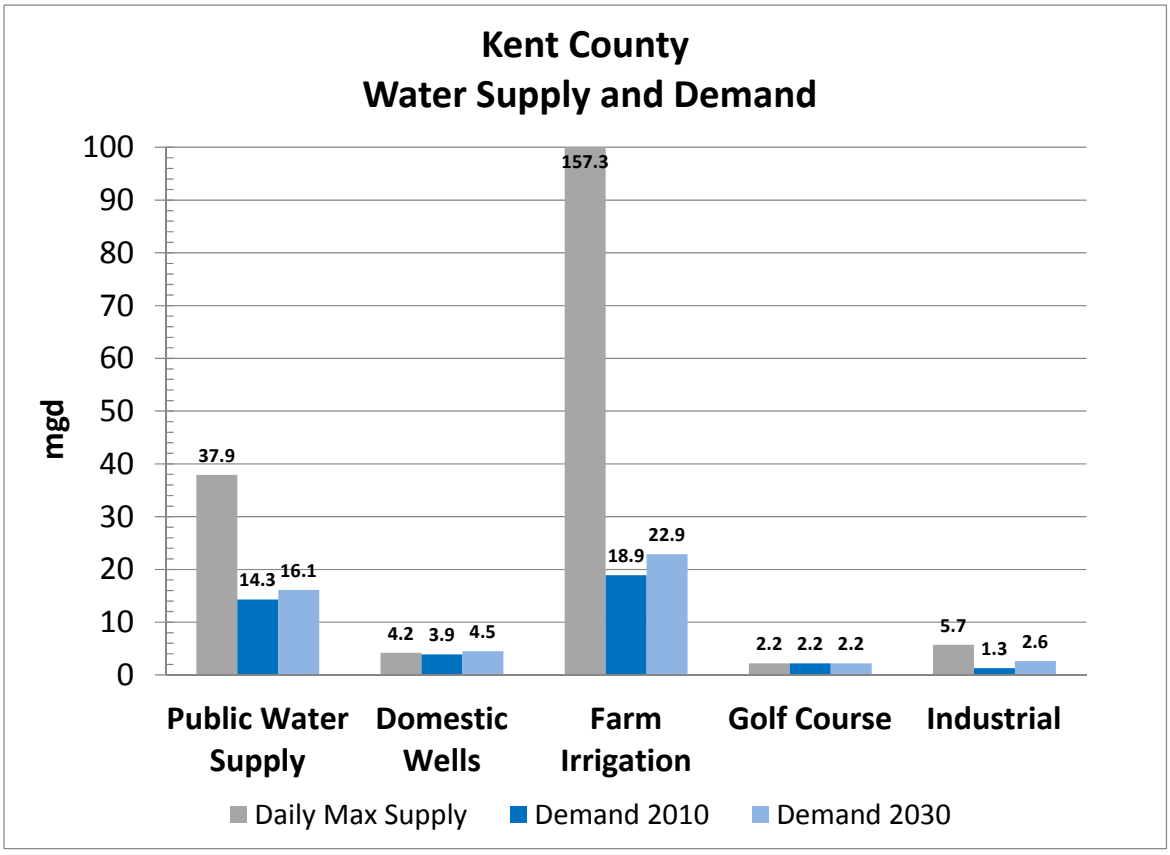
Peak public water demands may briefly exceed supplies in the future in certain coastal communities such as Rehoboth Beach and Dagsboro due to high summer peaking factors induced by the influx of summer residents and visitors. Public water purveyors in the coastal areas should plan to increase water supplies and construct interconnections to plan for increased summer peak demands in the beach communities.

Existing water supplies are compared to peak daily water demands in Kent County and Sussex County (Table 7.1 and Figure 7.1). The sum of existing public water supply and farm irrigation allocations exceed the demands projected for 2030, so there appears to be a surplus. However, there remains the possibility by 2020 or 2025 of increased competition between the public water supply and farm irrigation sectors for limited groundwater availability if peak farm irrigation demands coincide with rising peak public water supply demands during increasingly hot, dry summers. Since farm irrigation wells mostly rely on shallow aquifers and public water supplies rely on deeper aquifers, conflicts between the users can be minimized provided that water use is monitored especially during hot, dry summer weather. Also, land disposal of treated effluent for spray irrigation can augment availability of groundwater for irrigation uses.

The potential of future competition for available groundwater between public water supply and farm irrigation wells is possible. Adverse impacts can be averted by locating new public supply wells through a process of proactive investigation of hydrologic and geologic conditions and application of numerical simulation techniques that evaluate drawdown, low streamflow, and other criteria.

Table 7.1. Summary of water supply and demand in Kent County and Sussex County

Water Use	Daily Maximum Allocation (mgd)	2010 Peak Day Demand (mgd)	2010 Surplus/ Deficit (mgd)	2030 Peak Day Demand (mgd)	2030 Surplus/ Deficit (mgd)
Kent County					
Public Water Supply	37.9	14.3	23.6	16.1	21.8
Non-Community	1.3	0.5	0.8	0.6	0.7
Domestic Wells	4.2	3.9	0.3	4.5	-0.3
Farm Irrigation	157.3	18.9	138.4	22.9	134.4
Golf Course	2.2	2.2	0	2.2	0
Industrial	5.7	1.3	4.4	2.6	3.1
Sussex County					
Public Water Supply	56.9	30.5	26.4	48.8	8.1
Non-Community	5	1.5	3.5	2.4	2.6
Domestic Wells	7.4	7.4	0	8.2	-0.8
Farm Irrigation	619.4	71.7	547.7	87.0	532.4
Golf Course	12.2	12.2	0	12.2	0
Industrial	30.0	5.6	24.4	11.2	18.8



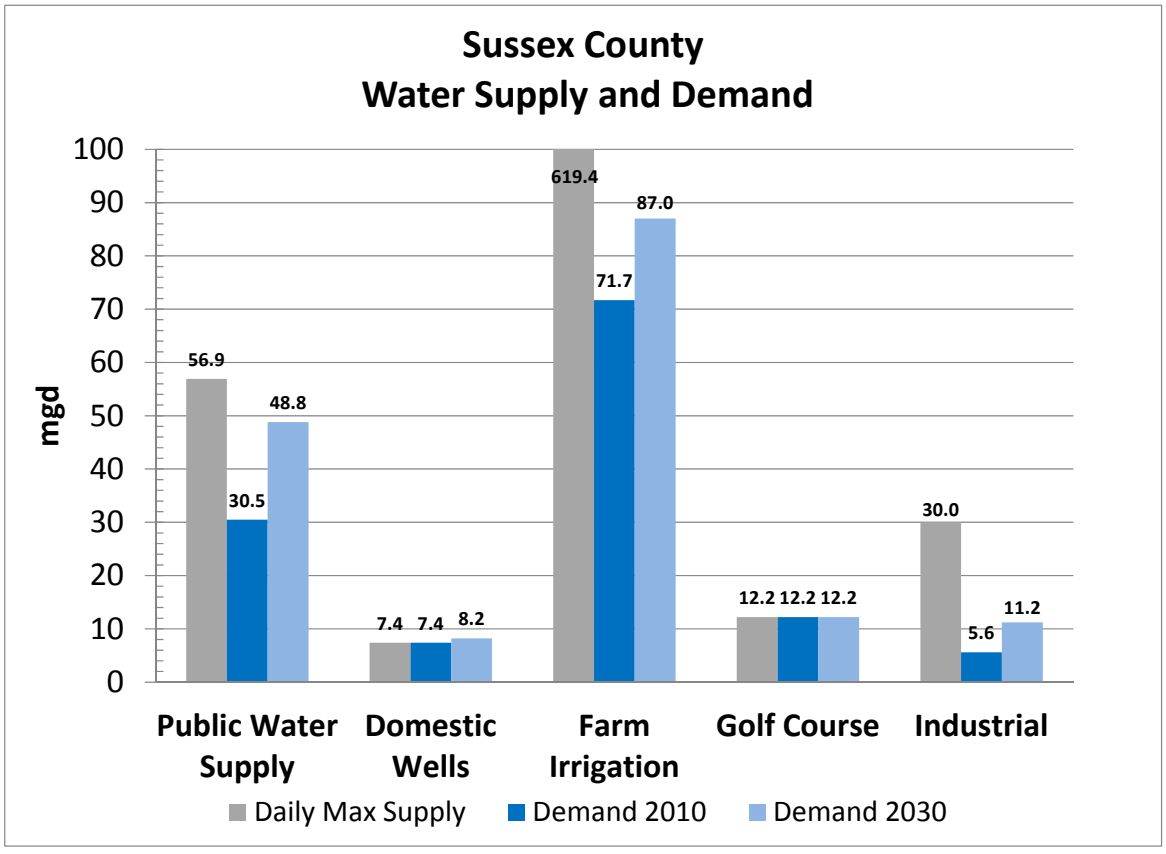


Figure 7.1. Comparison of water supply and demand in Kent County and Sussex County

Table 7.2. Public water supply and demand in Kent County and Sussex County

Water Purveyor	Daily Maximum Allocation (mgd)	2010 Peak Day Demand (mgd)	2010 Surplus/ Deficit (mgd)	2030 Peak Day Demand (mgd)	2030 Surplus / Deficit (mgd)
Kent County					
Artesian Water Co.	2.71	1.18	1.53	1.87	0.84
Camden-Wyoming	1.32	1.6	-0.28	1.63	-0.31
Clayton	0.50	0.46	0.04	0.47	0.03
Dover	16.32	5.5	10.82	5.72	10.6
Dover Air Force Base	8.93	0.57	8.36	0.57	8.36
Felton	0.47	0.11	0.36	0.11	0.36
Frederica	0.30	0.17	0.13	0.20	0.10
Harrington	0.85	0.74	0.11	0.75	0.10
Magnolia	0.09	0.08	0.01	0.08	0.01
Milford	2.00	1.70	0.30	1.80	0.20
Pickering Beach Water					
Smyrna	1.59		1.59		1.59
Tidewater Utilities Inc.	4.86	2.22	2.64	2.83	2.03
	37.94	**14.33**	**23.61**	**16.05**	**21.89**
Sussex County					
Artesian Water Co.	10.93	2.61	8.32	6.69	4.24
Bethany Beach	3.22	1.13	2.09	1.28	1.94
Blades	0.16	0.25	-0.09	0.27	-0.11
Bridgeville	1.51	0.48	1.03	0.5	1.01
Dagsboro		0.1	-0.1	0.11	-0.11
Delmar	1.3	0.4	0.9	0.42	0.88
Frankford	0.25	0.19	0.06	0.21	0.04
Georgetown	2.52	1	1.52	1.2	1.32
Greenwood	0.35	0.09	0.26	0.1	0.25
J.H. Wilkerson & Son					
Laurel	0.96	0.73	0.23	0.76	0.20
Lewes	2.50	1.93	0.57	2.25	0.25
Long Neck Water Co.	1.50	1.14	0.36	1.32	0.18
Milford	2.32	1.70	0.62	1.84	0.48
Millsboro	1.42	0.92	0.50	0.98	0.44
Milton	1.00	0.60	0.40	0.67	0.33
Rehoboth Beach	5.80	6.90	-1.10	7.83	-2.03
Seaford	4.00	1.91	2.09	2.03	1.97
Selbyville	0.80	0.34	0.46	0.40	0.40
Sussex Shores Water	1.96	1.03	0.93	1.28	0.68
Tidewater Utilities Inc.	14.44	7.04	7.40	18.69	-4.25
	56.94	**30.49**	**26.45**	**48.83**	**8.11**

8. Conclusions and Recommendations

8.1. Conclusions

1. **Population Growth**: Population growth is expected to increase water demands on public water supply systems in Kent County and Sussex County where groundwater is the sole source of drinking water. Accompanying increases in wastewater flow will occur. The population of Kent County and Sussex County exceeded 360,000 in 2010 (40% of Delaware's population) and is projected to increase 29% by over 100,000 people to 465,000 by 2030 (Figure 8.1).

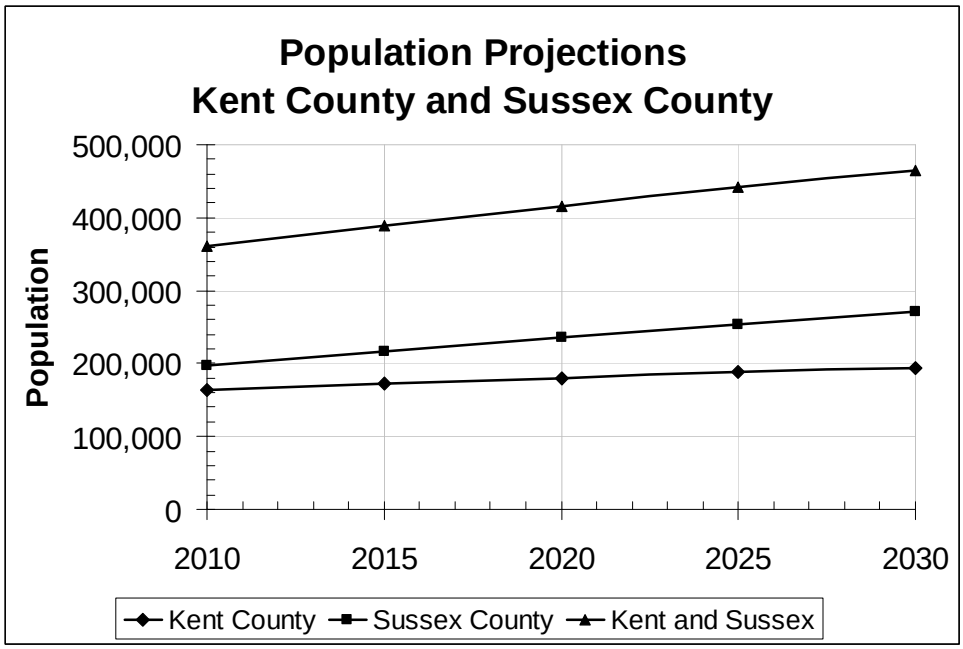


Figure 8.1. Projected population growth in Kent County and Sussex County, 2010-2030

2. **Public Water Systems:** Presently, 33 public and investor-owned water purveyors hold Certificates of Public Convenience and Necessity (CPCNs) to operate public water supply systems in Kent County and Sussex County. Water systems in the two counties presently have limited interconnection capabilities to distribute water between the public and private water supply service areas.

3. **Water Quality:** Public water supplies are safe to drink and are treated in accordance with EPA and Delaware Department of Health and Social Services (DHSS) drinking water standards. In some locations, however, untreated groundwater in Kent County and Sussex County contains elevated chlorides, nitrogen, organic chemicals, and pesticides. VOCs such as MTBE have been detected in private wells used for drinking water in Ellendale and trichloroethylene (TCE) has been found in Millsboro public water supply wells. The Delaware DNREC Division of Water and Division of Waste and Hazardous Substances and Delaware Department of Agriculture administer programs to protect the quality and quantity of groundwater. It is important to note that public water supply wells have water treatment systems that remove impurities to meet drinking water standards before the water reaches the tap.

4. **Source Water Protection:** In accordance with the Delaware Source Water Protection Law of 2001, eight local governments in Kent County and eight governments in Sussex County have adopted source water protection ordinances to protect drinking water supplies. Kent County repealed its source water ordinance, however, the County has other land use practices in place that protect source water supplies. Clayton and Milton are working with the DNREC Division of Water to develop source water protection ordinances.

5. **Hydrogeology:** The Delaware Geological Survey determined that the unconfined (shallow) aquifer supplies more than half of the groundwater pumped in Kent and Sussex counties (Figure 8.2). From the confined (deeper) aquifers, the Columbia and Pocomoke supply 11% of withdrawals and the Manokin 8%. In Kent County, the Cheswold, Frederica, and Piney Point aquifers each represent 3% to 5% of total withdrawals and the other aquifers each supply less than 2% of the total.

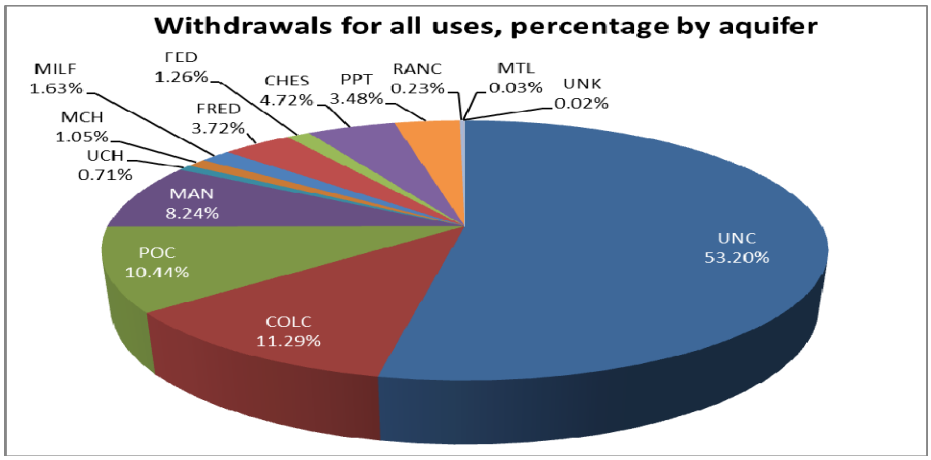


Figure 8.2. Groundwater withdrawals by aquifer in Kent and Sussex counties

Farm irrigation is the largest use of groundwater in Kent and Sussex counties where the unconfined aquifer supplies 2/3 and the confined Columbia, Pocomoke, and Manokin aquifers each supply 10% of irrigation water. Public water supply is the second largest use as the unconfined aquifer provides 25%, confined Columbia provides 10%, Piney Point, Cheswold, and Pocomoke aquifers represent 15%, and Manokin and Frederica aquifers provide 7% to 8% of the public supply. Domestic self-supplied water use is the third largest withdrawal where the unconfined aquifer provides 2/3 of the self-supplied wells, and the confined Columbia aquifer provides 14% of domestic well withdrawals. Pumping from industrial wells is the fourth largest category as the unconfined aquifer supplies half of the volume and the Pocomoke (25%), Manokin (11%), and Cheswold (7%) aquifers supply the balance.

6. **Water Supply:** In the two counties, DNREC groundwater allocation permits for public, farm/golf course irrigation, and industrial uses total 940 mgd on a maximum daily basis with 209 mgd in Kent County and 732 mgd in Sussex County (Figure 8.3). Agricultural allocations are 83% of the supply, followed by public water supply (10%), industrial (4%), golf course (2%), unallocated individual domestic (1%), and non-community (<1%) wells.

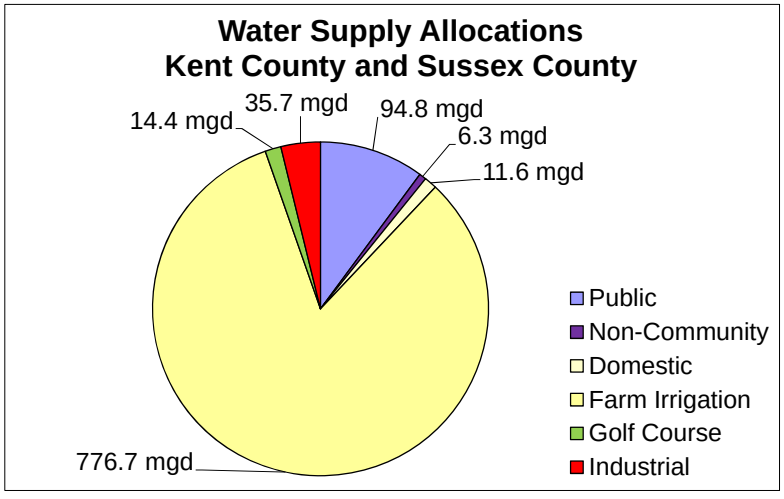


Figure 8.3. Water supply allocations in Kent County and Sussex County (DNREC)

7. **Water Demand:** Public water demand in Kent County and Sussex County is projected to increase from 44.8 mgd in 2010 to 64.9 mgd by 2030 due to population growth coupled with warming of the atmosphere (Table 8.1 and Figure 8.4). Domestic well demand is projected to barely rise as most new development will be supplied by public water systems. Irrigation demand is expected to continue to rise as producers convert to specialty crops and farmers face more frequent hot, dry summers as experienced in 2011 and 2012. Golf course irrigation demand may decline or remain stable as golf courses continue to close in Delaware. Industrial demand is projected to grow to 50% and 100% of present demand in 10 and 20 years respectively.

Table 8.1. Peak daily water demand in Kent County and Sussex County, Delaware

Water Use	2010 (mgd)	2020 (mgd)	2030 (mgd)
Public Water	44.8	54.4	64.9
Non-community	1.8	2.6	3.4
Domestic Well	11.6	12.3	12.9
Farm Irrigation	90.8	99.9	109.9
Golf Course	14.4	14.4	14.4
Industrial	6.9	10.3	13.8

8. **Farm Irrigation:** With the exception of a slight rise in Sussex County farmland between 2007 and 2012, farmland is expected to continue to decline in Delaware while seasonal demand for irrigation is projected to continue to grow, especially in Sussex County (Figure 8.5). By 2030, irrigated land is projected to grow to cover 148,397 acres (232 mi^2) or 37% of all the farmland in Kent and Sussex counties.

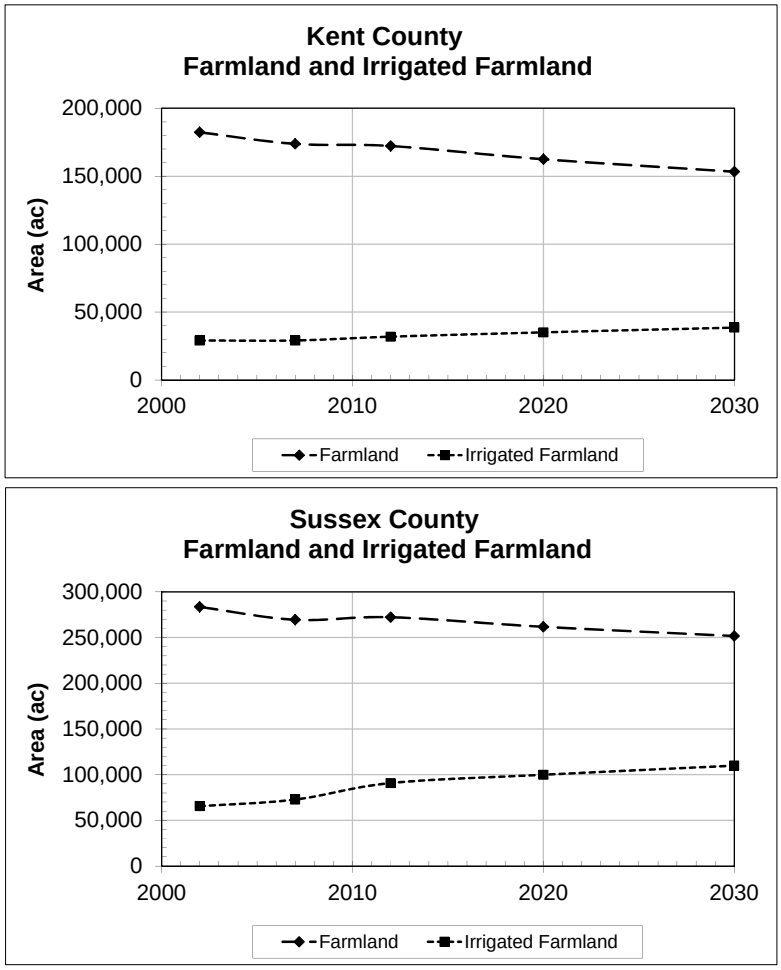


Figure 8.4. Farmland and irrigated farmland in Kent County and Sussex County (USDA 2002, 2007, 2012)

9. **Climate Change:** Climate change during the 21st century may increase water demands. If maximum summer air temperatures increase by 3°F by 2020-2039 as projected by the 2014 Delaware Climate Change Impact Assessment, then peak water demands in Kent and Sussex counties may increase by 52% or 38% due to population growth and 14% due to climate change.

   The Delaware Sea Level Rise Advisory Committee (2012) reported that up to 7% of domestic wells, 7% of industrial wells, 2% of irrigation wells, and 10% of public wells may be inundated by sea level rise and salt water by 2100.

10. **Water Supply and Future Demands:** Currently, public water systems have existing allocated supplies that exceed peak demands and represent a healthy surplus (Table 8.2). By 2030, water purveyors are projected to continue to have supplies that exceed peak demands. Since this analysis compares maximum daily allocations to peak day demands, the Water Supply Coordinating Council maintains these projections are conservative and public water purveyors are comfortably equipped to meet future peak water demands in Kent County and Sussex County provided that water can be transported where needed and through an interconnected system especially along the coastal beach towns that experience high summer peak demands. Public water purveyors are required to incorporate water storage that provides backup supplies if needed to meet peak daily demands.

Table 8.2. Summary of water supply and demand in Kent County and Sussex County

Water Use	Daily Maximum Allocation (mgd)	2010 Peak Day Demand (mgd)	2010 Surplus/ Deficit (mgd)	2030 Peak Day Demand (mgd)	2030 Surplus/ Deficit (mgd)
Public Water Supply	95	45	50	65	30
Non-Community	6	2	4	3	3
Domestic Wells	12	11	1	13	-1
Agricultural	777	91	686	110	667
Golf Course	14	14	0	14	0
Industrial	36	7	29	14	22

There is the potential after 2020 of increased competition between public water supply and farm irrigation sectors for groundwater availability if peak farm irrigation demands coincide during increasingly hot, dry summers with peak public water supply demands as population grows in Kent and Sussex counties. Since over 2/3 of farm irrigation wells rely on shallow, unconfined aquifers and 3/4 of public water supplies rely on deeper, confined aquifers, conflicts between the users can be minimized through careful coordination through Delaware DNREC, Department of Agriculture, and Delaware Geological Survey groundwater monitoring networks. Also, land disposal and reclamation of treated wastewater effluent through spray irrigation can help to augment availability of groundwater for irrigation uses.

8.2. Recommendations

1. **Drought Operating Guidelines:** The Water Supply Coordinating Council should appoint a committee composed of the Delaware DNREC Division of Water, Delaware Department of Agriculture, University of Delaware Water Resources Agency, public water utilities, and green industry to assist the Delaware Geological Survey to develop drought operating guidelines for Kent County and Sussex County based on streamflow, groundwater, precipitation, soil moisture, irrigation, and other parameters.

2. **Interconnected Water System:** The Water Supply Coordinating Council should work with the public water suppliers to encourage construction and mapping of interconnections between public water systems in Kent County and Sussex County.

3. **Hazardous Substance Cleanup:** To focus on strategic cleanup of volatile organic contaminants (VOCs), pesticides, and emerging contaminants and improve groundwater quality in wellhead areas, the Water Supply Coordinating Council should appoint a member to participate in the Hazardous Substance Cleanup Act (HSCA) committee organized by the DNREC Division of Waste and Hazardous Substances and Department of Agriculture nutrient management and pesticide committees.

4. **Groundwater Monitoring**: The State of Delaware should continue to fund and expand groundwater monitoring programs operated by the Delaware Geological Survey, Delaware DNREC, and Delaware Department of Agriculture for both water quantity and water quality. The key for monitoring water quantity is construction of new monitoring infrastructure and maintenance of existing monitoring infrastructure to meet changing water demand patterns. Two critical components to incorporate in water quality monitoring are having: (1) data collection and evaluation systems in place to recognize and respond to water quality threats and trends, and (2) a mechanism for state and local agencies to coordinate and prioritize data needs and identify cost effective and efficient projects and programs to make the best use of limited state resources.

5. **Climate Change:** The Delaware DNREC should enhance infrastructure for monitoring along the seacoast to detect salt water intrusion from coastal storm flooding or related to rising sea levels.

6. **Groundwater Availability:** The DGS has developed a scope of work and budget needed to generate data needed by modern planning tools that better estimate groundwater availability for growing areas of Kent and eastern Sussex Counties. These plans follow the goals and objectives of the Southern New Castle-Northern Kent Counties project that is now nearing successful completion. Groundwater monitoring infrastructure is designed with a 20 to 30 year lifespan and will evaluate adequacy of water availability by aquifer, threats of saltwater intrusion, and other large-scale potable water quality concerns. Proposed installation of automated salinity monitoring instruments in sentinel wells and tidal streams east of Route 9, around the Inland Bays, and along the Atlantic beaches will provide early warning of salinity encroachment. Targeted water quality testing during the New Castle-Kent project has characterized a threat of arsenic contamination in domestic water systems that tap the Rancocas Aquifer. These are examples of how monitoring work supported by the WSCC has provided the State with information to address a public health threat. The DGS should be supported in funding the plans for Kent and eastern Sussex Counties.

7. **Water Availability:** Key information related to DNREC regulations, policies, and permit conditions that should be addressed in future water availability reports include:
   - Permit limits on drawdown by well and wellfield
   - Special rules applied to areas that have experienced depletion, such as Dover area aquifers
   - Summary of regulations, policies, and details of special cases for groundwater management zones.

8. **Water Supply/Demand Projections**: The Water Supply Coordinating Council should update water supply and demand projections for Kent County and Sussex County at five-year intervals beginning in 2022 to utilize population data from the 2020 U.S. Census.

9. **Peak Summer Demands:** Public water utilities in coastal communities should examine peak daily demand patterns, plan to develop new water supplies, and construct interconnections with adjacent water systems to anticipate high peaking factors due to the influx of summer visitors to the beach communities.

10. **Water Use Database:** The DNREC Division of Water should continue modernization of the state water use database and consolidation of datasets, with attention to issues identified in the recently completed Delaware Geological Survey Kent-Sussex Aquifer and Groundwater Study. This USGS Water Census initiative should be utilized to provide financial resources through grants to State water resource agencies to improve the availability and quality of water use data that they collect.

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Appendix A. Public water supply allocation permits in Kent County (DNREC)

Water User	Permit No.	Daily Maximum (mgd)	Monthly Maximum (mgd)	Yearly Maximum (mgd)
Artesian Water Co. (Barkers Landing)	99-0007BM	0.40	0.27	0.21
Artesian Water Co. (Barkers Landing)	99-0007AM	0.40	0.27	0.21
Artesian Water Co. (Church Creek)	01-0010M	0.47	0.47	0.47
Artesian Water Co. (Weatherstone Crossing)	09-0006A	0.86	0.86	0.85
Artesian Water Co. (Big Oak-Burtonwood)	11-0001A	0.58	0.58	0.58
Camden-Wyoming Sewer and Water Authority	83-0017B	0.60	0.42	0.60
Camden-Wyoming Sewer and Water Authority	83-0017RM1	0.72	0.70	0.60
City of Harrington	87-0016RMM1	0.85	0.70	0.69
Clayton	87-0002RMM1	0.50	0.28	0.27
Delaware State Fair	98-0017B	0.20	0.06	0.05
Delaware State Fair	98-0017A	0.30	0.10	0.07
Dover	87-0018RAM	4.84	4.40	2.59
Dover	87-0018BR	6.88	6.00	3.56
Dover	92-0002	4.61	4.61	4.54
Dover Air Force Base	86-0003	1.51	0.50	0.32
Dover Air Force Base	88-0020BM2	1.38	0.20	0.12
Dover Air Force Base	88-0020AM2	6.04	1.67	1.04
Felton	07-0003B	0.24	0.18	0.12
Felton	07-0003A	0.24	0.18	0.12
Frederica	89-0005M	0.30	0.13	0.11
Harrington	87-0016RM	0.70	0.70	0.69
Holly Hill Estates	04-0001	0.07	0.07	0.05
Magnolia	87-0005R	0.09	0.08	0.08
Smyrna	87-0010RM5	1.59	1.21	0.79
Tidewater Util. Inc. (Wild Quail District)	02-0012AM1	0.17	0.11	0.07
Tidewater Util. Inc. (Wild Quail District)	02-0012BM1	0.05	0.04	0.02
Tidewater Util. Inc.(Camden District)	03-0016AM2	0.09	0.09	0.08
Tidewater Util. Inc.(Camden District)	03-0016BM2	0.16	0.03	0.01
Tidewater Util. Inc.(Camden District)	03-0016CM3	2.38	1.84	1.19
Tidewater Util. Inc.(Chimney Hill)	07-0006B	0.25	0.15	0.10
Tidewater Util. Inc.(Chimney Hill)	07-0006A	0.06	0.04	0.02
Tidewater Util. Inc.(Garrisons Lake)	05-0003CM2	0.53	0.46	0.29
Tidewater Util. Inc.(Garrisons Lake)	05-0003AM1	0.22	0.22	0.15
Tidewater Util. Inc.(Garrisons Lake)	05-0003BM2	0.95	0.52	0.32
Total		**39.21**	**28.12**	**20.96**

Appendix B. Public water supply allocation permits in Sussex County (DNREC)

Water User	Permit No.	Daily Maximum (mgd)	Monthly Maximum (mgd)	Yearly Maximum (mgd)
Artesian Water Co. (Bayville)	02-0013B	1.01	1.01	1.01
Artesian Water Company (Bayville)	02-0013AM1	1.01	1.01	1.01
Artesian Water Co. (Cat Hill-South Bethany)	99-0008AM	2.16	2.00	0.79
Artesian Water Co. (Cat Hill-South Bethany)	99-0008BM	2.16	2.00	0.79
Artesian Water Co. (Heron Bay)	11-0003A	2.45	1.38	1.15
Artesian Water Co. (Stonewater Creek)	11-0002A	1.73	1.38	1.15
Artesian Water Co. Inc (Beaver Creek)	09-0007A	0.41	0.28	0.14
Bethany Beach	90-0001AM3	2.00	1.75	0.66
Bethany Beach	90-0001BM3	1.22	1.22	0.55
Blades	89-0001	0.16	0.13	0.11
Bridgeville	83-0003AM4	0.54	0.54	0.27
Bridgeville	83-0003BM2	0.54	0.54	0.27
Bridgeville	83-0003CM1	0.43	0.43	0.27
Broadkill Beach	98-0006	0.04	0.04	0.04
Cape Windsor Community Association	04-0002	0.13	0.11	0.04
Delmar	89-0006B	0.65	0.65	0.44
Delmar	89-0006A	0.65	0.65	0.44
Frankford	90-0019	0.25	0.17	0.14
Georgetown	93-0005BM2	0.58	0.58	0.57
Georgetown	93-0005AM2	1.94	1.98	1.95
Greenwood	88-0024	0.25	0.18	0.12
Greenwood	00-0016M1	0.10	0.07	0.02
Henlopen Acres	95-0003B	0.11	0.11	0.02
Henlopen Acres	95-0003A	0.52	0.52	0.09
Laurel	87-0011RM	0.96	0.92	0.61
Laurel Village MHC, LC	91-0013M	0.19	0.19	0.10
Lewes Board Of Public Works	95-0008	2.50	2.00	1.64
Long Neck Water Co.	90-0021M2	1.50	1.50	0.96
Mallard Lakes	99-0005	0.79	0.09	0.04
Milford	88-0007CMM1	0.62	0.65	0.63
Milford	88-0007AM1	2.37	2.13	2.10
Milford	88-0007DM1	0.71	0.56	0.55
Milford	88-0007BM1	0.62	0.56	0.55
Millsboro	88-0006BM3	0.47	0.55	0.34
Millsboro	88-0006AM2	0.95	0.77	0.48
Milton	87-0009ARM3	0.50	0.33	0.27
Milton	87-0009BRM3	0.50	0.33	0.27
Rehoboth Bay Conservancy -West Bay	89-0007M2	0.07	0.07	0.06
Rehoboth Beach	89-0015RM3	5.80	4.90	2.14
Seaford	90-0006RM3	4.00	2.75	2.05
Selbyville	89-0004MM1	0.80	0.67	0.45
State Of Delaware Stockley Center	09-0003A	0.25	0.03	0.02
Sussex Shores Water Co.	00-0012M2	1.26	0.80	0.32
Sussex Shores Water Co.	90-0005M	0.70	0.50	0.21
Swann Keys Civic Association	91-0007M	0.30	0.23	0.14
The Peninsula On The Indian River Bay	08-0008A	0.30	0.09	0.02
Tidewater Util.Inc. (Bethany Bay District)	02-0011AM1	1.79	1.79	0.82
Tidewater Util. Inc. (Bethany Bay District)	02-0011D	2.10	1.04	0.27
Tidewater Util. Inc. (Bethany Bay District)	02-0011C	0.90	0.87	0.07
Tidewater Util. Inc. (Bethany Bay District)	02-0011BM1	1.15	0.56	0.50
Tidewater Util. Inc. (Bayside District)	07-0002A	1.08	0.76	0.38
Tidewater Util. Inc. (Meadows District)	91-0001M2	1.41	1.19	0.68
Tidewater Util. Inc. (Oak Crest Farms District)	06-0002	0.14	0.05	0.03
Tidewater Util. Inc. (Whispering Pines District)	04-0008	0.07	0.07	0.07
Tidewater Util. Inc.(Angola District)	91-0006M1	0.82	0.61	0.34
Tidewater Util. Inc.(Bridgeville District)	04-0015	0.11	0.11	0.11
Tidewater Util. Inc.(Clearbrooke District)	09-0002A	0.12	0.04	0.03
Tidewater Util. Inc.(East District)	06-0001M1	0.36	0.31	0.23
Tidewater Util. Inc. (Rehoboth-Lewes District)	01-0020M3	4.39	3.69	2.12
Treasure Beach Campground	94-0006	0.26	0.26	0.03
Total		**61.91**	**50.68**	**31.65**

Appendix C. Agricultural irrigation well allocation permits in Kent County (DNREC)

Water User	Permit No.	Daily Maximum (mgd)	Monthly Maximum (mgd)	Yearly Maximum (mgd)
Arthur Wicks Farms LP	07-0008A	4.03	3.17	0.52
Bonk, Brandon	10-0014A	1.30	1.30	0.21
Broad Acres, Inc.	94-0008BM1	3.53	3.13	0.43
Broad Acres, Inc.	94-0008C	1.73	1.63	0.22
Broad Acres, Inc.	94-0008AM2	3.74	3.87	0.65
C.E. Lynch and Sons, Inc.	93-0003A	3.60	1.98	0.36
C.E. Lynch and Sons, Inc.	93-0003B	1.44	1.44	0.28
Cannon Jr, James H.	11-0013A	1.57	0.90	0.15
Carey, Elwood P	09-0001A	0.36	0.36	0.06
Cartanza, Paul	10-0009A	2.02	1.56	0.26
Chandler Farm	04-0010	1.44	1.07	0.18
Delaware State University	92-0001	0.23	0.17	0.10
E Z Farms Inc.	10-0002A	1.15	0.87	0.14
Fifer Orchards Inc.	01-0009A	14.26	9.07	1.49
Fifer Orchards Inc.	01-0009BM1	6.68	6.57	1.08
Fry Farms Inc.	01-0012A	3.74	2.53	0.42
Gooden, Kenneth	08-0016A	0.58	0.27	0.04
Gooden, Kenneth	08-0016B	4.32	2.53	0.42
Gro Mor Farms	01-0014	1.08	1.81	0.30
Hill, Chris	11-0006C	1.87	1.11	0.18
Holly Hill Farms, Inc.	11-0006B	2.95	1.74	0.29
Holly Hill Farms, Inc.	11-0006A	1.44	0.59	0.10
Joseph Jackewicz Farms	94-0005B	8.71	5.17	1.12
Joseph Jackewicz Farms	94-0005A	10.87	7.33	1.74
Joseph Wick Nurseries	91-0016BM2	3.02	1.44	0.21
Joseph Wick Nurseries	07-0009A	1.58	0.39	0.06
Lazy Boy Farm	00-0007A	1.44	14.48	0.24
Lester Family LP	99-0006	2.52	2.17	0.36
Meyer Farms	03-0001	2.16	1.30	0.21
Mitchell, Rodney	12-0005A	1.15	0.80	0.13
Neal Farms Partnership	12-0010A	1.73	1.20	0.20
Papen Farms	88-0003AM2	7.14	6.90	1.29
Papen Farms	88-0003BM2	5.41	5.34	0.94
Poynter, Robert	08-0013A	0.17	0.03	0.01
Pries, Chad	07-0005A	0.65	0.65	0.11
Sapp, Richard L	11-0010B	7.34	4.33	0.71
Schiff Farms	99-0013	0.94	0.90	0.15
Shadybrook Farms	12-004A	5.33	5.47	0.90
Shadybrook Farms	12-004B	9.94	5.31	0.87
Shadybrook Farms	12-0004C	1.73	0.54	0.09
Shore Sand and Gravel, LLC	08-0001A	0.72	0.64	0.13
Thomas Properties LLC	10-0015B	1.94	1.36	0.22
Tidbury Creek Farms	08-0007A	0.72	0.25	0.04
Tidbury Creek Farms	08-0007B	1.44	1.43	0.24
Vernon Creek Farm	01-0003A	1.87	1.32	0.21
Vernon Creek Farm	01-0003BM1	2.30	0.90	0.15
Vogl Brothers	11-0012A	1.73	1.00	0.16
Warren, Elva	11-0011A	1.44	1.23	0.20
Warrington, Nelson C	08-0017A	1.15	0.50	0.08
Webb, H. Ronald	02-0015A	1.73	1.33	0.22
Webb, H. Ronald	02-0015B	0.86	0.40	0.07
Webb, Kyle S	08-0014B	1.08	0.83	0.14
Webb, Kyle S	08-0014A	1.30	0.33	0.05
Wheatley Farms, Inc.	03-0017A	1.44	1.33	0.22
Wilson Sisters	83-0011RM	1.01	0.32	0.10
Wyatt Farm	01-0013	1.69	0.48	0.08
Total		**157.32**	**125.07**	**19.50**

Appendix D. Agricultural irrigation well allocation permits in Sussex County (DNREC)

Water User	Permit No.	Daily Maximum (mgd)	Monthly Maximum (mgd)	Yearly Maximum (mgd)
Sussex County				
Adams, Mark	11-0007A	0.72	0.29	0.05
Allen's Hatchery, Inc.	89-0012M	15.34	11.68	2.16
Alro Corporation	04-0011	2.88	3.30	0.54
Ammons, Lester	94-0018M	4.68	1.67	0.27
Anderson Farms	04-0009	1.30	0.77	0.13
Baldwin, Daniel	93-0004	0.36	0.32	0.10
Bennett, Bruce	02-0008M1	1.73	1.00	0.16
Brittingham Farm (Gladys)	99-0015	0.65	0.19	0.03
Brittingham Plantation	88-0012	3.02	2.04	0.33
Brittingham, Burton S	10-0008A	5.18	2.14	0.35
Calhoun Farm	04-0006	5.00	3.43	0.56
Carpenter, James	10-0012A	17.14	12.46	2.05
Conaway Farms Inc.	04-0014	6.55	3.67	0.60
CP Townsend Farms	00-0004M	4.03	1.10	0.30
Cypress Turf Farms Inc.	01-0005	7.63	1.37	0.22
D C Farms	04-0005A	19.80	12.67	2.08
D C Farms	04-0005B	2.30	2.27	0.37
Deerfield Farms Inc.	99-0004M2	1.15	0.65	0.11
DE Solid Waste Authority	88-0021	0.36	0.32	0.21
Del-Ridge Farms, Inc.	10-0001B	0.86	0.43	0.07
Del-Ridge Farms, Inc.	10-0001A	1.58	1.30	0.21
Dickerson Farms	02-0014	4.50	2.87	0.47
DMC Farms	03-0011	14.26	10.17	1.67
Donald E Steen Farms	94-0020A	3.28	1.00	0.16
Donald E Steen Farms	94-0020B	2.66	0.79	0.13
Draper, Thomas	00-0017M1	8.35	5.50	0.90
Dukes, Donald E	84-0002	1.15	1.04	0.17
Dukes, Jerry	94-0022M	3.96	2.57	0.42
Dukes, Robert E	94-0002B	2.88	2.99	0.49
Dukes, Robert E	94-0002A	3.89	3.73	0.61
Elliott Family Partnership LP	12-0003A	1.44	1.33	0.22
Fifer Orchards Inc.	01-0009C	2.45	0.90	0.15
Figgs, Dale	03-0013	4.18	5.57	0.92
Freeman, Tony	10-0013A	1.44	0.36	0.06
Fry Farms Inc.	01-0012B	2.39	3.35	0.55
Garey, Robert F	10-0005A	2.59	1.24	0.20
Glenville Hollow Farm	02-0006B	5.69	4.40	0.73
Glenville Hollow Farm	02-0006A	1.44	0.32	0.05
Griner Farm	01-0016	1.15	0.23	0.04
H And H Brand Farms Inc.	11-0017A	2.88	0.87	0.14
H and V Farms Inc.	04-0012	2.88	2.87	0.47
Hill, Tracey L.	11-0014A	0.86	0.40	0.07
Hudson, Harry	94-0009	0.72	0.65	0.08
Issacs, Mark	05-0001	2.81	2.27	0.37
J Carlton Wells And Sons Inc.	99-0011M1	12.46	7.50	1.23
J Carlton Wells And Sons Inc.	99-0011B	3.46	2.37	0.38
J Rider Farms LLC	99-0010M1	12.50	7.50	1.23
J.G. Townsend Jr. Co., Inc.	88-0009M5	9.94	6.81	1.12
Jade Run Turf Farm	84-0018M4	10.10	8.33	1.52
JG Townsend, Jr. and Co.	88-0009M6	9.94	6.82	1.12
Johnson, Harold	10-0003A	1.08	0.83	0.14
Judy Bros.	94-0019	0.86	0.14	0.02
Kruger PAF LLC	02-0005A	2.74	24.87	0.41
Kruger PAF LLC	02-0005B	8.42	10.50	1.73

Lakeside Farms Inc.	02-0019	13.10	11.03	1.81
Lankford, Alan	03-0002B	4.61	4.20	0.69
Lankford, Alan	03-0002A	1.44	1.60	0.26
Layton, Alice	12-0002A	2.30	1.56	0.25
Loblolly LLC	00-0017	3.24	0.71	0.12
Lynch, Raymond (Cypress Turf)	98-0004	3.02	2.24	0.37
M and T Farms	08-0005AM1	7.63	4.87	0.80
M J Webb Farms Inc.	09-0004A	6.55	3.26	0.54
Magee, Daniel	11-0005A	10.37	5.26	0.86
Maghan, Steven	10-0007A	3.96	1.92	0.28
Malfitano, Joseph	99-0016	1.22	0.25	0.04
Massey, Ronald	12-0007A	0.72	0.27	0.04
Messick Farms	10-0010A	2.95	1.39	0.23
Messick, Burton	88-0027M2	6.19	2.53	0.42
Miller, Richard	02-0016	0.79	0.43	0.07
Mills, Alan	11-0016A	0.86	0.24	0.04
Moore, Charles	83-0031	0.08	0.08	0.05
Morgan, Richard	94-0001BM1	4.03	3.47	0.57
Morgan, Richard	94-0001A	2.88	2.11	0.27
Mountaire Farms Of DE (Millsboro)	00-0010	7.56	5.48	0.90
Ockles Farms Inc.	03-0005B	2.38	1.50	0.25
Ockles Farms Inc.	03-0005A	19.44	11.63	1.91
O'Day Farms Inc.	03-0008A	12.89	8.70	1.43
O'Day Farms Inc.	03-0008B	0.86	0.50	0.08
O'Day, William	03-0008AM1	16.63	8.93	1.47
Parker, Cliff	11-0015A	4.90	3.63	0.60
Pepper Farms	95-0014	0.50	0.33	0.04
Phillips, Charles	95-0002A	2.74	2.60	0.43
Phillips, Charles	95-0002B	1.15	0.92	0.15
Pine Breeze Farms, Inc.	99-0017B	6.80	4.23	0.70
Pine Breeze Farms, Inc.	99-0017A	6.80	4.23	0.70
Ray S. Mears and Sons Inc.	02-0010	5.76	4.98	0.82
Ray, John	10-0004A	0.72	0.18	0.03
Raymond Tull	02-0003	0.79	0.29	0.05
Reliance Farms Inc.	08-0006A	4.25	3.30	0.54
Richfield Farms, Inc.	08-0003A	1.94	1.67	0.27
Rider, Jerry	99-0010	11.13	5.50	0.90
RSC Farms Inc.	99-0014	1.44	0.60	0.10
Russell Farm	00-0011	8.06	6.15	1.01
Ryans Berry Farm and Orchard	00-0006	4.03	0.72	0.12
Sapp Sr., Richard L	11-0010A	4.03	3.33	0.55
Shawnee Country Club	07-0010A	0.50	0.18	0.03
Short, III, E Austin	08-0011A	1.51	0.58	0.10
Steen, Edward	08-0015A	4.54	3.63	0.60
Sussex County Council	03-0004	0.72	0.27	0.04
T G Adams and Sons, Inc.	05-0007	5.47	4.57	0.75
Tatman Farms	04-0013A	2.40	1.80	0.30
Tatman Farms	04-0013B	3.00	2.80	0.46
Tatman, Morris	02-0009A	0.94	0.27	0.04
Thomas Family Farms LLC*	10-0015A	5.90	4.63	0.76
Thomas Family Farms LLC*	10-0015B	1.99	1.36	0.22
Tatman, Morris	02-0009B	3.10	2.07	0.34
Townsends	85-0007BR	1.58	0.60	0.15
Townsends	85-0007ARM	10.66	7.11	1.17
Tri-Oak Farms	03-0006A	2.74	0.53	0.09
Tri-Oak Farms	03-0006B	6.18	5.57	0.92
Triple A Farms	11-0008A	1.94	0.77	0.13
Tull, William	04-0007	1.58	1.30	0.21

University Of DE	95-0013B	0.14	0.01	0.00
University Of DE	95-0013A	5.29	2.42	0.39
Webb, H Andrew	03-0003BM1	2.09	0.83	0.14
Webb, H Andrew	03-0003AM1	2.30	1.80	0.30
Wells Farms Inc.	99-0003	4.25	4.78	0.79
West Farms	03-0009	0.86	0.37	0.06
West, Charles	12-0008A	0.94	8.91	1.47
West, Charles	12-0008B	20.56	15.37	2.53
West, Charles	12-0008C	5.59	5.03	0.83
West, Charles	12-0008D	3.10	2.62	0.43
WG Passwaters Enterprise, Inc.	94-0021	4.75	3.44	0.57
Whaley, David	12-0006A	0.42	0.14	0.02
Whaley, Robert	95-0009	1.73	1.27	0.21
Wheatley Farms, Inc.	03-0017B	13.00	17.07	3.40
Wheatley Farms, Inc.	03-0017C	2.40	2.07	0.34
Wheatley, Robert	03-0012B	5.54	4.43	0.73
Wheatley, Robert	03-0012A	1.01	1.17	0.19
Willin Farms, Inc.	08-0010A	11.38	7.73	1.27
Wilson, Samuel	10-0011A	3.24	1.45	0.24
Wooden Hawk Farms	91-0009BM	2.34	1.18	0.19
Wooden Hawk Farms	91-0009AM	3.13	1.90	0.31
Workman, Brent	05-0006	1.44	0.80	0.13
Workmans Inc.	03-0010M1	14.69	9.50	1.56
Wright Farm	01-0015	1.76	0.90	0.15
Yoder, Gerald B	12-0012A	0.36	0.09	0.02
Total		**619.42**	**454.26**	**72.24**

Appendix E. Golf course irrigation well allocation permits in Kent County and Sussex County (DNREC)

Water User	Permit No.	Daily Maximum (mgd)	Monthly Maximum (mgd)	Yearly Maximum (mgd)
Kent County		**2.09**	**0.90**	**0.24**
Dover Air Force Base Golf Course	07-0007A	0.32	0.18	0.03
Dover Air Force Base Golf Course	07-0007B	0.10	0.07	0.01
Jonathan's Landing Golf Course	06-0003	0.86	0.18	0.03
State of Delaware	07-0004B	0.40	0.23	0.09
State of Delaware	07-0004A	0.40	0.23	0.09
Sussex County		**12.19**	**6.99**	**1.37**
Bear Trap Dunes Golf Club	03-0014B	1.04	0.87	0.14
Cripple Creek Golf Club	91-0008AM1	1.73	0.53	0.08
Cripple Creek Golf Club	91-0008BM1	1.08	0.32	0.05
Greens At Broadview LLC	00-0005	0.30	0.20	0.09
Kings Creek Country Club	89-0014AM	0.30	0.27	0.09
Kings Creek Country Club	89-0014BM	0.30	0.27	0.09
Marsh Island Golf Club	99-0012	0.35	0.10	0.02
Passwaters Farm LLC	09-0005A	1.00	0.74	0.23
Rehoboth Beach Country Club	91-0011	1.75	0.56	0.09
Salt Pond Golf Club	08-0012A	0.76	0.21	0.04
Sussex Pines Country Club	95-0007B	0.72	0.54	0.09
Sussex Pines Country Club	95-0007A	1.01	0.54	0.09
The Peninsula On The Indian River Bay	08-0008B	1.00	0.96	0.16
Tunnell Sussex County Companies LP	97-0002	0.85	0.88	0.12
Total		**14.29**	**7.89**	**1.62**

Appendix F. Industrial water supply allocations in Kent County and Sussex County (DNREC)

Water User	Permit Number	Daily Maximum (mgd)	Monthly Maximum (mgd)	Yearly Maximum (mgd)
Kent County		**5.73**	**4.45**	**6.21**
Energizer Personal Care	90-0004M	1.37	0.40	0.28
Hanover Foods Corp	95-0010A	2.50	2.50	2.10
Hanover Foods Corp.	95-0010B	0.17	0.17	0.52
Kraft Foods Inc.	83-0040M2	0.23	0.23	0.55
North American Energy Services	06-0005	0.25	0.10	0.10
NRG Energy Center Dover, LLC	96-0000	0.53	0.53	0.38
PPG Industries, Inc.	01-0017	0.09	0.05	0.04
Shore Sand and Gravel, LLC	03-0015	0.51	0.39	2.16
Van Sant Generating Station	90-0010	0.08	0.08	0.08
Sussex County		**30.00**	**23.32**	**19.09**
Allen Harim Foods, LLC.	89-0002AM1	1.90	1.50	1.44
Cogentrix Logan Generating Co. LP	91-0012M2	4.32	3.50	2.71
INVISTA Sarl	88-0014BM2	2.50	1.99	1.97
James Thompson and Company, Inc.	88-0023	0.18	0.12	0.10
JG Townsend Inc.	88-0011	0.50	0.50	0.37
ML Joseph Sand And Gravel	99-0018	1.89	1.26	0.85
Mountaire Farms (Millsboro)	00-0009B	0.58	0.40	0.39
Mountaire Farms (Millsboro)	00-0009A	5.62	4.40	3.84
Mountaire Farms (Selbyville)	89-0016M5	1.50	1.20	1.18
NRG Energy	95-0006BM1	1.87	1.73	1.73
NRG Energy	95-0006AM1	0.14	0.15	0.14
Perdue Farms Inc. (Georgetown)	91-0014M3	2.20	2.20	1.48
Perdue Farms Inc. (Milford)	94-0004M	1.10	1.10	0.82
Pictsweet	89-0003M	1.73	1.33	1.03
Pinnacle Foods Group, LLC	89-0009B	1.44	0.63	0.33
Pinnacle Foods Group, LLC	89-0009M3	2.10	1.25	0.66
Sussex County Council	95-0001	0.43	0.06	0.05
Total		**35.73**	**27.77**	**25.30**

Appendix G. Population projections in Kent and Sussex counties by water purveyor from 2010 to 2030

Water Purveyor	2010 pop.	% increase	2020 pop.	% increase	2030 pop.
Kent County					
Population	162,916	11%	180,357	8%	194,225
Less population w/domestic wells	38,883	7%	41,758	5%	43,641
Population with public water supply	124,022	12%	138,599	9%	150,584
Artesian Water Co.	20,600	29%	26,583	23%	32,639
Camden- Wyoming	4,106	1%	4,147	1%	4,189
Clayton	1,201	1%	1,213	1%	1,225
Dover	39,682	3%	40,872	1%	41,281
Dover Air Force Base					0
Felton	1,083	1%	1,094	1%	1,105
Frederica	691	8%	746	8%	806
Harrington	3,138	1%	3,169	1%	3,201
J.H. Wilkerson & Son	15	1%	15	1%	15
Magnolia	278	1%	281	1%	284
Milford	3,867	3%	3,983	3%	4,103
Pickering Beach Water	29	73%	50	14%	57
Smyrna	8,080	6%	8,565	6%	9,079
Tidewater Utilities (TUI)	41,252	16%	47,881	10%	52,600
Sussex County					
Population	197,870	19%	235,574	15%	271,018
Less population w/domestic wells	94,800	5%	99,476	1%	100,141
Population with public water supply	103,070	32%	136,098	26%	170,877
Artesian Water Co.	10,615	71%	18,196	43%	26,064
Bethany Beach	1,929	7%	2,064	6%	2,188
Blades	996	4%	1,036	4%	1,077
Bridgeville	1,571	2%	1,602	2%	1,634
Dagsboro	512	7%	548	6%	581
Delmar	1,484	3%	1,529	3%	1,574
Frankford	624	6%	661	5%	695
Georgetown	5,991	11%	6,650	8%	7,182
Greenwood	1,077	5%	1,131	5%	1,187
J.H. Wilkerson & Son	427	31%	559	19%	666
Laurel	3,370	2%	3,437	2%	3,506
Lewes Bd. Public Works	3,943	9%	4,298	7%	4,599
Long Neck Water	4,951	8%	5,347	7%	5,721
Milford	5,701	4%	5,929	4%	6,166
Millsboro	2,682	3%	2,762	3%	2,845
Milton	2,043	6%	2,166	5%	2,274
Public Water Supply(part of TUI)	11,314	16%	13,124	11%	14,568
Rehoboth	3,665	7%	3,922	6%	4,157
Seaford	7,275	3%	7,493	3%	7,718
Selbyville	2,602	9%	2,836	7%	3,035
Southern Shores Water Co. (part of TUI)	1,214	13%	1,372	10%	1,509
Sussex County Council	1,623	5%	1,704	4%	1,772
Sussex Shores Water	1,214	13%	1,372	10%	1,509
Tidewater Utilities (TUI)	26,247	77%	46,360	48%	68,650

Appendix H. Population in Kent and Sussex counties by local government from 2010 to 2030

Year	2010	% increase	2020	% increase	2030
Kent County					
Total Population	162,916	11%	180,357	8%	194,225
Unincorporated Population	58,608	20%	70,056	11%	77,456
Domestic Well Population	38,883	7%	41,758	5%	43,641
Municipal Population	65,425	5%	68,543	7%	73,128
Camden	2,565	9%	2,796	9%	3,047
Cheswold	473	170%	1,277	170%	3,448
Clayton	1,481	2%	1,511	2%	1,541
Dover	36,107	3%	37,190	3%	38,306
Dover AFB					
Felton	905	2%	923	2%	942
Frederica	751	8%	811	8%	876
Harrington	3,435	2%	3,504	2%	3,574
Kenton	268	2%	273	2%	279
Liepsic	229	2%	234	2%	238
Little Creek	217	2%	221	2%	226
Magnolia	250	2%	255	2%	260
Milford	8,511	3%	8,766	3%	9,029
Slaughter Beach	220	2%	224	2%	229
Smyrna	8,603	6%	9,119	6%	9,666
Wyoming	1,410	2%	1,438	2%	1,467
Sussex County					
Total Population	197,870	19%	235,574	15%	271,018
Unincorporated Population	63,257	48%	93,611	33%	124,696
Domestic Well Population	94,800	5%	99,476	1%	100,141
Municipal Population	39,813	7%	42,487	9%	46,181
Bethany Beach	964	7%	1,031	6%	1,093
Bethel	202	2%	206	2%	210
Blades	1,158	4%	1,204	4%	1,252
Bowers	346	2%	353	2%	360
Bridgeville	1,630	2%	1,663	2%	1,696
Dagsboro	578	7%	618	7%	662
Delmar	1,516	3%	1,561	3%	1,608
Dewey Beach	318	50%	477	50%	716
Ellendale	354	2%	361	2%	368
Farmington	85	2%	87	1%	88
Fenwick Island	366	150%	915	150%	2,288
Frankford	777	6%	824	5%	865
Georgetown	5,233	7%	5,599	8%	6,047
Greenwood	907	5%	952	5%	1,000
Hartly	88	2%	90	2%	92
Henlopen Acres	142	2%	145	2%	148
Houston	483	2%	493	2%	503
Laurel	3,982	2%	4,062	2%	4,143
Lewes	3,127	9%	3,408	9%	3,715
Millsboro	2,698	3%	2,779	3%	2,862
Millville	282	2%	288	2%	293
Milton	1,835	6%	1,945	5%	2,042
Ocean View	1,138	2%	1,161	2%	1,184
Rehoboth Beach	1,587	7%	1,698	6%	1,800
Seaford	7,260	3%	7,478	3%	7,702
Selbyville	1,853	9%	2,020	7%	2,161
South Bethany	526	30%	684	30%	889
Viola	174	2%	177	2%	181
Woodside	204	2%	208	2%	212

Appendix I. Peak water demand in Kent and Sussex counties by water purveyor from 2010 to 2030

Water Purveyor	2010 (mgd)	% increase	2020 (mgd)	% increase	2030 (mgd)
Kent County					
Artesian Water Co.	1.18	129%	1.52	123%	1.87
Camden- Wyoming	1.60	101%	1.62	101%	1.63
Clayton	0.46	101%	0.46	101%	0.47
Dover	5.50	103%	5.67	101%	5.72
Dover Air Force Base	0.57	100%	0.57	100%	0.57
Felton	0.11	101%	0.11	101%	0.11
Frederica	0.17	108%	0.18	108%	0.20
Harrington	0.74	101%	0.75	101%	0.75
Magnolia	0.08	101%	0.08	101%	0.08
Milford	1.70	103%	1.75	103%	1.80
Pickering Beach Water		173%		114%	
Smyrna		106%		106%	
Tidewater Utilities	2.22	116%	2.58	110%	2.83
Public Water Demand	14.33		15.29		16.05
Domestic Wells	4.20		4.50		4.70
Potable Water Demand	18.53		19.79		20.75
Sussex County					
Artesian Water Co.	2.61	171%	4.46	150%	6.69
Bethany Beach	1.13	107%	1.21	106%	1.28
Blades	0.25	104%	0.26	104%	0.27
Bridgeville	0.48	102%	0.49	102%	0.50
Dagsboro	0.10	107%	0.11	106%	0.11
Delmar	0.40	103%	0.41	103%	0.42
Frankford	0.19	106%	0.20	105%	0.21
Georgetown	1.00	111%	1.11	108%	1.20
Greenwood	0.09	105%	0.09	105%	0.10
J.H. Wilkerson & Son		131%	0.00	119%	0.00
Laurel	0.73	102%	0.74	102%	0.76
Lewes Bd. Public Works	1.93	109%	2.10	107%	2.25
Long Neck Water	1.14	108%	1.23	107%	1.32
Milford	1.70	104%	1.77	104%	1.84
Millsboro	0.92	103%	0.95	103%	0.98
Milton	0.60	106%	0.64	105%	0.67
Rehoboth	6.90	107%	7.38	106%	7.83
Seaford	1.91	103%	1.97	103%	2.03
Selbyville	0.34	109%	0.37	107%	0.40
Sussex County Council		105%	0.00	104%	0.00
Sussex Shores Water	1.03	113%	1.16	110%	1.28
Tidewater Utilities	7.04	177%	12.46	150%	18.69
Public Water Demand	30.49		39.12		48.82
Domestic Wells	7.40		7.80		8.20
Potable Water Demand	37.89		46.92		57.02

Appendix J. Peak water demand in Kent and Sussex counties by local government from 2010 to 2030

Year	Permanent Population	Summer Population	2010 (mgd)	% Change	2020 (mgd)	% Change	2030 (mgd)
Kent County							
Potable Water Demand	162,916		18.53	7%	19.91	6%	21.05
Unincorporated Area	58,608		3.20	20%	3.84	11%	4.26
Domestic Wells	38,883		4.20	7%	4.50	4%	4.70
Municipalities	65,379		11.13	4%	11.57	4%	12.09
Camden	2,565		1.00	9%	1.09	9%	1.19
Cheswold	473		0.07	100%	0.14	100%	0.28
Clayton	1,481		0.46	2%	0.47	2%	0.48
Dover	36,107		5.50	3%	5.67	3%	5.83
Dover AFB			0.57		0.57		0.57
Felton	905		0.11	2%	0.11	2%	0.11
Frederica	751		0.17	8%	0.18	8%	0.20
Harrington	3,435		0.74	2%	0.75	2%	0.77
Kenton	268		0.04	2%	0.04	2%	0.04
Liepsic	229		0.03	2%	0.04	2%	0.04
Little Creek	217		0.03	2%	0.03	2%	0.03
Magnolia	250		0.08	2%	0.08	2%	0.08
Milford	8,511		1.70	3%	1.75	3%	1.80
Smyrna	8,603			6%	0.00	6%	0.00
Viola	174		0.03	2%	0.03	2%	0.03
Wyoming	1,410		0.60	2%	0.61	2%	0.62
Sussex County							
Potable Water Demand	197,870		37.89	22%	46.32	22%	56.39
Unincorporated Area	63,211		9.76	68%	16.41	50%	24.69
Domestic Wells	94,800		7.40	5%	7.80	5%	8.20
Municipalities	39,859		20.73	7%	22.11	6%	23.50
Bethany Beach*	964	8,000	1.13	7%	1.21	6%	1.28
Bethel	202		0.03	2%	0.03	2%	0.03
Blades	1,158		0.25	4%	0.26	4%	0.27
Bowers Beach	346		0.05	2%	0.05	2%	0.05
Bridgeville	1,630		0.48	2%	0.49	2%	0.50
Dagsboro*	578	2,000	0.10	7%	0.11	7%	0.11
Delmar	1,516		0.40	3%	0.41	3%	0.42
Dewey Beach*	318	11,000	1.65	10%	1.82	10%	2.00
Ellendale	354		0.05	2%	0.05	2%	0.06
Farmington	85		0.01	2%	0.01	1%	0.01
Fenwick Island*	366	10,000	1.50	10%	1.65	10%	1.82
Frankford	777		0.19	6%	0.20	5%	0.21
Georgetown	5,233	7,500	1.00	7%	1.07	8%	1.16
Greenwood	907		0.09	5%	0.09	5%	0.10
Hartly	88		0.01	2%	0.01	2%	0.01
Henlopen Acres*	142	1,000	0.02	2%	0.02	2%	0.02
Houston	483		0.07	2%	0.07	2%	0.08
Laurel	3,982		0.73	2%	0.74	2%	0.76
Lewes*	3,127	13,000	1.93	9%	2.10	9%	2.29
Millsboro*	2,698	6,000	0.92	3%	0.95	3%	0.98
Millville*	282	1,000	0.04	2%	0.04	2%	0.04
Milton	1,835		0.60	6%	0.64	5%	0.67
Ocean View*	1,138	4,000	0.17	2%	0.17	2%	0.18
Rehoboth Beach*	1,587	45,000	6.90	7%	7.38	6%	7.83
Seaford	7,260		1.91	3%	1.97	3%	2.03
Selbyville	1,853		0.34	9%	0.37	7%	0.40
Slaughter Beach	220		0.03	2%	0.03	2%	0.03
South Bethany*	526	6,000	0.08	30%	0.10	30%	0.13
Woodside	204		0.03	2%	0.03	2%	0.03

Appendix K. Water Use Recommendations and Restrictions for Three Phase Drought Operating Plan

(Proposed by Delaware Nursery and Landscape Association and Delaware Grounds Management Association and approved by the Delaware Water Supply Coordinating Council on October 30, 2013)

Drought Watch

Lawn and Turf Watering (including residential, commercial, institutional, and government uses)

- Use of potable water for lawns and turf should be minimized and performed in a conservative manner.

Landscape Plant Watering (including residential, commercial, institutional, and government uses)

- Use of potable water for outdoor landscape plants (including groundcover, flowers, shrubs, and trees) should be minimized and performed in a conservative manner.

Golf Courses and Athletic Fields

- Use of potable water for turf and landscape plants should be minimized.
- All outdoor watering should be performed by efficient means in a conservative manner.
- A facility-specific drought management plan should be developed or updated in preparation for a drought emergency.
- Recommendation: Where a source of non-potable water exists at the location of use it should be used in lieu of potable water, in a conservative manner.

Miscellaneous Uses

- Water should be served in public establishments only at the customer's request.

Drought Warning

Lawn and Turf Watering (including residential, commercial, institutional, and government uses)

- Use of potable water for "established" lawns and turf should be avoided. Watering of "newly-planted" turf should be limited to between the hours of 5 p.m. and 9 a.m. by any efficient means.
- Recommendation: Where a source of non-potable water exists at the location of use it should be used in lieu of potable water in a conservative manner.
- "Established" means planted 1 year or more. "Newly-planted" means planted less than 1 year.

Landscape Plant Watering (including residential, commercial, institutional, and government uses)

- Use of potable water for "established" landscape plants (including groundcover, flowers, shrubs, and trees), should be avoided.
- Use of potable water for watering of landscape plants should be limited to new plants. New plants should be watered either manually or with soaker hoses.
- Irrigation bags or similar devices are recommended for trees and other individual plants.
- Nursery stock should be watered by any efficient means.
- Recommendation: Where a source of non-potable water exists at the location of use it should be used in lieu of potable water in a conservative manner.
- "Established" means planted 1 year or more. "Newly-planted" means planted less than 1 year.

Golf Courses and Athletic Fields

- Use of potable water should be limited to between the hours of 5 p.m. and 9 a.m. for tees, greens, and fairways to prevent damage.
- Watering of grass or clay courts and athletic fields should be limited to between the hours of 5 p.m. and 9 a.m.
- Water conservation measures and the use of drought best management practices should be used to reduce water use.
- All facilities' drought management plans shall be finalized, submitted to DNREC, and readied for implementation.
- Recommendation: Where a source of non-potable water exists at the location of use it should be used in lieu of potable water and may be applied to any part of the facility in a conservative manner.

Miscellaneous Uses

- Water shall be served in public establishments only at the customer's request.
- Use of potable water for washing private vehicles is permitted only by the use of a bucket and a hose with a flow-control nozzle.
- The use of potable water for washing paved surfaces is prohibited, except for sanitation.
- Watering required in earthworks projects for erosion and sediment control shall be done under plans approved by the prevailing governmental agency.

NOTICE: Individual water providers have the authority to impose more restrictive limits for demand management purposes.

Mandatory Water Use Restrictions for Drought Emergency

Lawn and Turf Watering (including residential, commercial, institutional, and government uses)

- The use of potable water for watering of "established" lawns and turf is prohibited.
- The following uses of potable water are permitted, only to the minimum extent necessary to prevent damage:
  - Use of potable water for "newly-planted" turf areas shall be limited to between the hours of 5 p.m. and 9 a.m. by any efficient means and in a conservative manner.
  - Landscaping work over 10,000 square feet, in progress or under contract as of the declaration of drought emergency, may be watered by any efficient means and in a conservative manner.
  - Pesticides may be watered-in within 2 days of application using the recommended rate and only between the hours of 5 p.m. and 9 a.m.
  - Newly-installed irrigation systems may be tested by the contractor up to 10 minutes per zone and a sign on the premises shall be displayed stating testing is occurring.
  - Where a source of non-potable water exists at the location of use it must be used in lieu of potable water in a conservative manner.
  - Diversions from sources of public water supply for non-potable uses may be restricted.
- "Established" means planted for more than 1 year. "Newly-planted" means planted less than 1 year.

Landscape Plant Watering (including residential, commercial, institutional, and government uses)

- The use of potable water for watering of "established" landscape plants is prohibited.
- The following uses of potable water are permitted, only to the minimum extent necessary to prevent damage:
  - New landscape plants may only be watered manually or with soaker hoses, and only between the hours of 5 p.m. and 9 a.m. with the user in attendance.
  - Pesticides may be watered-in within 2 days of application using the recommended rate, and only between the hours of 5 p.m. and 9 a.m. Newly-installed irrigation systems may be tested by the contractor up to 10 minutes per zone and a sign on the premises shall be displayed stating testing is occurring.
  - Nursery stock may be watered by any efficient means for only 2 periods per day totaling no more 6 hours, with no more than 10 minutes of syringing of stressed plants between the hours of 12 noon and 3 p.m.
  - Where a source of non-potable water exists at the location of use it must be used in lieu of potable water in a conservative manner.
  - Diversions from sources of public water supply for non-potable uses may be restricted.
- Exceptions:
  - Self-supplied public gardens may be watered conservatively by any efficient means and only to prevent damage.
  - Irrigation bags or similar devices may be used for trees and other individual plants.

    - Commercial watering is permitted beyond one year after planting if required by the applicable contract.
- "Established" means planted for more than 1 year. "Newly-planted" means planted less than 1 year.

Golf Courses and Athletic Fields

- All facilities' drought management plans as submitted to DNREC shall be implemented.
- Use of potable water is allowed between the hours of 5 p.m. and 9 a.m. and only to prevent damage to tees and greens.
- Watering of grass or clay courts and athletic fields is allowed only between the hours of 5 p.m. and 9 a.m. to maintain playability.
- Where a source of non-potable water exists at the location of use it must be used in lieu of potable water and may be applied to any part of the facility in a conservative manner.
- Diversions from sources of public water supply for non-potable uses may be restricted.
- Exception: Daytime syringing for heat sensitive grasses is permitted to prevent damage

Miscellaneous Uses

- Water shall be served in public establishments only at the customer's request.
- The use of potable water for non-commercial washing of private vehicles is prohibited.
- The use of potable water for washing paved surfaces is prohibited, except for sanitation.
- Opening of hydrants or flushing of water mains is prohibited, except for public protection purposes and shall be performed only by authorized personnel.
- The use of potable water for filling of swimming pools is prohibited except for filling of therapeutic pools or to prevent structural damage to new pools.
- The use of potable water for topping off swimming pools is permitted only to the extent necessary to maintain proper filtration.
- The use of potable water for fountains and ornamental pools is prohibited unless they are supporting fish or plants.
- Watering required in earthworks projects for erosion and sediment control shall be done under plans approved by the prevailing governmental agency.
- Where a source of non-potable water exists at the location of use it must be used, when appropriate, in lieu of potable water in a conservative manner.
- Diversions from sources of public water supply for non-potable uses may be restricted.
- Exception: Use of potable water is allowed for the production of food, fiber, nursery stock, sod, flowers, livestock, and poultry.

NOTICE: Individual water providers have the authority to impose more restrictive limits for demand management purposes.