State of New Jersey
Department of Environmental Protection

# 2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

# APPENDIX J

## AN ASSESSMENT OF REGIONAL WATER AVAILABILITY AND DEMAND FOR WATERSHED MANAGEMENT AREA (WMA) 17: MAURICE, SALEM, AND COHANSEY RIVERS

# Appendix J:

# An Assessment of Regional Water Availability and Demand for Watershed Management Area (WMA) 17: Maurice, Salem, and Cohansey Rivers

## TABLE OF CONTENTS

# AN ASSESSMENT OF REGIONAL WATER AVAILABILITY AND DEMAND FOR WATERSHED MANAGEMENT AREA (WMA) 17: MAURICE, SALEM, AND COHANSEY RIVERS

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August 2023

## EXECUTIVE SUMMARY

Watershed Management Area (WMA) 17 is located in southwestern New Jersey and includes all of Salem and Cumberland counties and portions of Atlantic and Gloucester counties. The WMA includes 19 HUC11s (eleven-digit hydrologic units), which are the basis for water availability and demand accounting. Defined by its three major rivers (Salem, Maurice, and Cohansey), this region faces water supply vulnerability, with NJDEP estimates that almost 70% of the region has demonstrated water use patterns that exceed sustainable water availability during peak consumptive/depletive loss years. This report assesses water availability and demand for the region during the planning period (2020-2050) based on factors including regional population, social vulnerability, land use patterns, surface water and groundwater availability, demand, and quality, water utilities, and projected climate change impacts. A part of this analysis included a more focused examination of specific municipalities (Carney's Point Township, Salem City, Pilesgrove Township, Vineland City, Bridgeton City, Millville City, Glassboro Borough) identified as most likely to experience either significant growth or decline based on the population analysis; these are referred to as "focus municipalities".

Regional population analysis revealed that only Gloucester County experienced population growth between 2010 and 2020, and Gloucester County is projected to significantly grow in the future. Most WMA17 counties (Salem, Cumberland, and Atlantic) had unemployment rates and poverty levels above the New Jersey state average, with clusters of socially vulnerable populations in locations including Carney's Point Township, Millville City, and Bridgeton City. WMA17 water withdrawals have been relatively stable since 2010 with predominant water withdrawals for commercial/industrial/mining purposes, and water users have relied on a roughly even split of surface water and unconfined groundwater sources. Most of WMA17's public community water systems (PCWSs) reported a decline in potable water demand between 2011-2020, and PCWS 2050 demands projections indicate that roughly half of WMA17 PCWSs will have demand decline. WMA17 communities located along the Delaware River and WMA17's three main rivers (Salem, Maurice, and Cohansey) are projected to be most vulnerable to inundation from sea level rise, with HUC11s 02040206040 and 02040206030 expected to experience the most NJDEP Bureau of Water Allocation and Well Permitting water withdrawal site inundation, followed by 02040206100 and 02040206020. Among the focus municipalities, Bridgeton City, Millville City, and Salem City are projected to have the largest number of Overburdened Community census blocks vulnerable to inundation from sea level rise.

Potential management options are provided that focus on overall WMA17 strategies and more tailored options for specific areas (see below) found to have the most significant water supply vulnerability.

**Hydrologic Unit Code (HUC) 11 of Concern:**

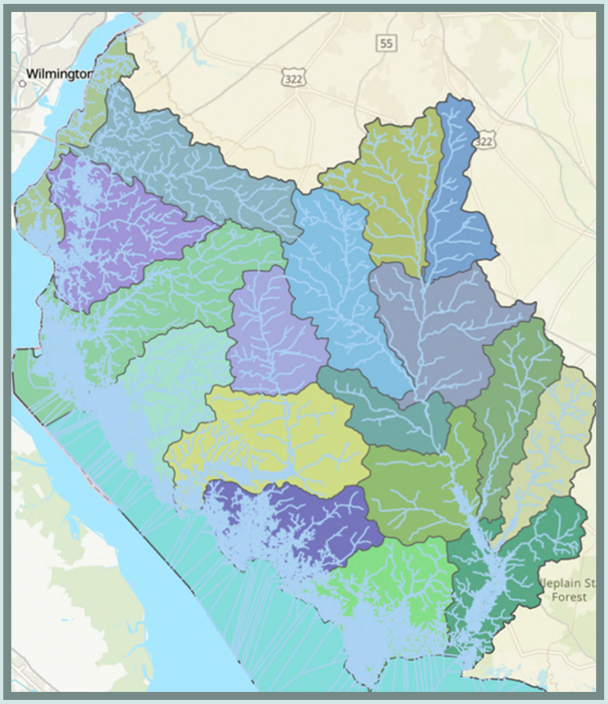
- 02040206030: Salem R (above 39d40m14s)
- 02040206080: Cohansey River (above Sunset Lake)
- 02040206180: Menantico Creek

**Municipalities of Concern:**

- Bridgeton City
- Salem City
- Gloucester WMA17 municipalities

Management options included encouragement of water saving strategies and improving water use efficiency, further assessment of WMA17 PCWSs to meet future regional water demand, investment to protect and restore aquifer recharge, alterations to agriculture BMPs, and investment in resilience and mitigation strategies to reduce/prevent inundation of PCWS service areas from sea level rise.

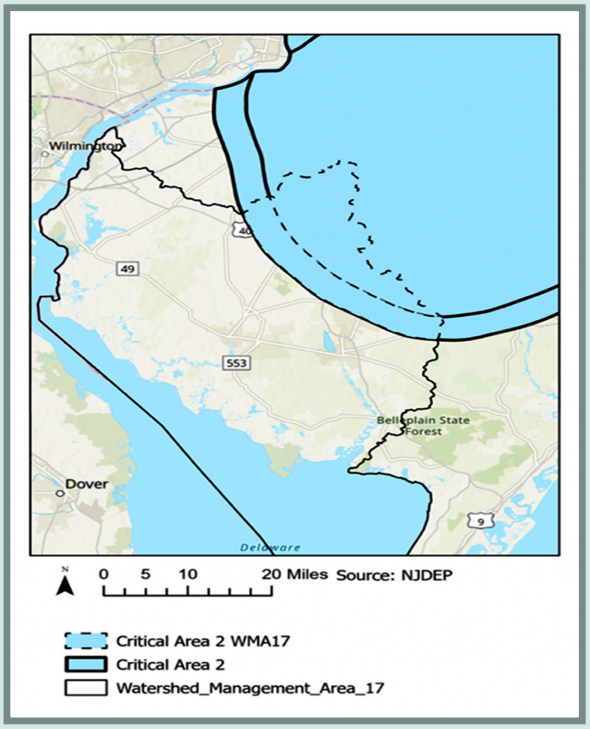
# 1. INTRODUCTION



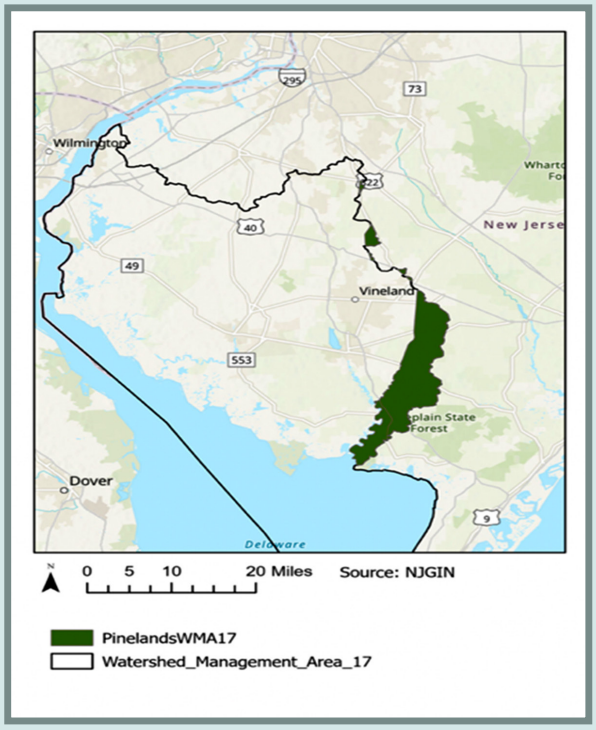

**Map J1.** A Map of WMA17

Watershed Management Area (WMA) 17 is located in southwestern New Jersey and includes all of Salem and Cumberland counties and portions of Atlantic and Gloucester counties. Encompassing a total area of 1,223 square miles, WMA17 is located in the Atlantic Coastal Plain Physiographic Province.

WMA17's land uses and economic development are highly reliant on its regional surface water and groundwater sources. The three major rivers in the region are the Salem, Maurice, and Cohansey rivers, which each drain into the Delaware Bay and River (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; NJ Division of Fish and Wildlife, 2004). Within this region, both the Delaware River and the Maurice River have been designated as critical ecological resources. Located along the western edge of Gloucester, Salem, and Cumberland counties, the Delaware River transitions into Delaware Bay. The Delaware Bayshore Area is considered a Natural Heritage Priority Site and includes critical marshland that increases coastal resilience to storm events (Cumberland County OEM & Stuart Wallace LLC, 2022). The Maurice River is considered a "Scenic Recreational River" within the U.S. National Park Service's Wild and Scenic Rivers Program, along with three of its



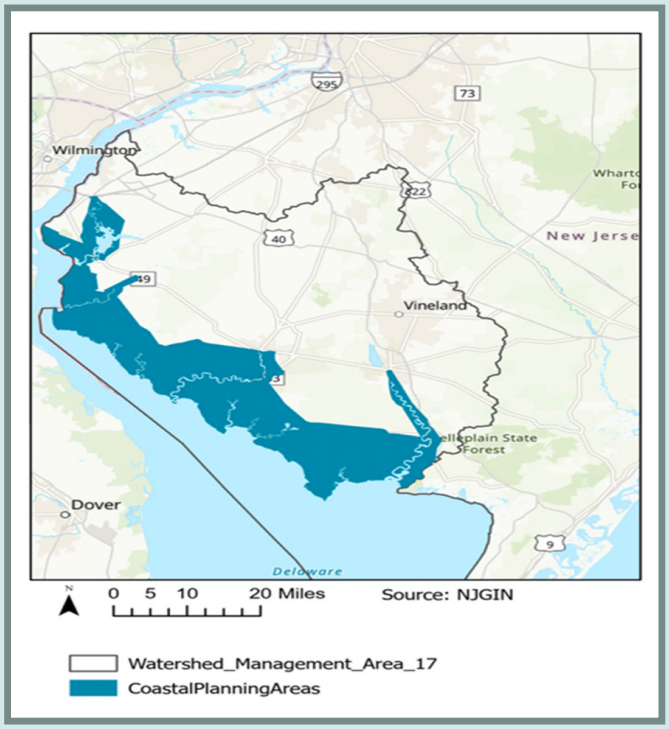

**Map J2.** WMA17 Areas in Water Supply Critical Area 2




**Map J3.** WMA17 Areas Protected by New Jersey Pinelands Protection Act of 1979

tributaries, the Manumuskin, Menantico, and Muskee rivers (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; Tetra Tech, 2022).

Several significant land and water use restrictions from Pinelands Reserve, CAFRA, and Water Supply Critical Area 2 regulations constrain WMA17's development and partially limit its water demand (See maps J2, J3, and J4). Portions of Cumberland and Gloucester counties are located within the Pinelands National Reserve and specifically within the regulatory jurisdiction of the Pinelands Commission, which regulates both land and water use within its boundaries pursuant to the Pinelands Protection Act (Cumberland County OEM & Stuart Wallace LLC, 2022; Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015; Pinelands Commission, 1981). Significant coastal areas of WMA17 are located within Coastal Area Facility Review Act (CAFRA) jurisdiction, which limits land development with regulations that become more stringent the closer the development is to the coast and environmentally sensitive areas (Simone Collins Landscape Architecture & Reed Group, 2011). Also, the majority of Gloucester County is located within the New Jersey Department of Environmental Protection's (NJDEP) Water Supply Critical Area 2, which places restrictions on regional groundwater use in the confined aquifers (Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). With NJDEP estimating that almost 70% of WMA17's watersheds have demonstrated consumptive/depletive water use patterns during peak years that exceed sustainable surface water availability, examination of current regional water availability and demand and how they may change in the future is critical for ensuring long-term adequate water availability for the region.




**Map J4.** CAFRA Coastal Planning Areas in WMA17

### *1.1 GOALS*

This assessment is part of the larger 2024 New Jersey Statewide Water Supply Plan and provides a more detailed assessment of regional water availability and demand in WMA17 for the planning period (2020-2050). This regional evaluation is Step 3 of the Framework for Regional Water Supply Planning and Management that was outlined in the 2024 Plan. It has three main goals. The first goal is to identify current water availability and demand in WMA17. The second goal is to project how water availability and demand in WMA17 may change in the future. The third goal is to identify different potential management options that can be used to reduce regional water vulnerability and deficits in WMA17.

## 2. METHODOLOGY

A multi-prong, multi-scale analysis was conducted to accomplish this assessment's goals. The four main components of this study (demographic analysis, water availability and demand analysis, climate change and sea level rise assessment, and development of potential management options) are described in the following sub-sections.

### *2.1 DEMOGRAPHIC ANALYSIS*

The demographic analysis consisted of three sub-parts: population analysis (Section 4), social vulnerability assessment (Section 5), and current land use analysis (Section 6). The population analysis examined both economic and demographic characteristics of WMA17's counties and municipalities. Existing population projections for WMA17's counties and municipalities for the study planning period (2020-2050) were examined to gather better insight into which locations are anticipated to significantly change in the future. Two population projection data sources were considered for this analysis:

(a) Metropolitan Planning Organization (MPO) (provided by the South Jersey Transportation Planning Organization (SJTPO) and the Delaware Valley Regional Planning Commission (DVRPC)), and (b) New Jersey Department of Labor (DOL). MPO and DOL population projections were examined and compared with 2020 Census population estimates of WMA17's counties and municipalities to determine which locations are most likely to grow or decline in the future. Municipalities considered most likely to experience a significant change in water demand due to population changes were selected for further analysis (referred to as focus municipalities).

The social vulnerability assessment focused on determining which WMA17 locations contained the most vulnerable populations. Social vulnerability was measured using two metrics, NJDEP's Overburdened Communities and the Center for Disease Control and Prevention's (CDC)'s 2018 Social Vulnerability Index (SVI). The identified vulnerable populations were considered throughout the latter sections of the study.

The current land use analysis focused on identifying current land use patterns, land development trends, and initiatives for preserving farmland and open space in WMA17. This analysis used both GIS and county and municipal documents to consider how WMA17 land use has changed over time and may change in the future. Development strategies suggested by WMA17 county planning boards, such as open space advisory committees, agricultural development boards, and economic improvement authorities were also used to consider future development trends and their impact on regional water demand.

### *2.2 WATER AVAILABILITY AND DEMAND ANALYSIS*

The water availability and demand analysis focused on water quantity, water quality (both Section 7), and water utilities and infrastructure in WMA17 (Section 8). The water quantity section focused predominantly on data provided by NJDEP's Division of Water Supply and Geoscience (DWSG) to examine water withdrawal, discharge, and use patterns both regionally and on a smaller watershed scale (referred to as Hydrologic Unit Code (HUC) 11s). WMA17 water withdrawals were examined by both source and water use category, discharges (returns) were analyzed by source, and consumptive use was examined by water use category. Examination of WMA17 surface water vulnerability relied on the NJDEP's Low Flow Margin (LFM) method to determine which HUC11s are most stressed during their largest three-year rolling averages (peaks) of consumptive/depletive water loss. The water quality section examined surface water and groundwater sources using resources including NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report.

WMA17's water utilities and water infrastructure were examined using Public Community Water System (PCWS) data provided by NJDEP and county and municipal water infrastructure documents to assess how regional water demand has changed over time. 2050 water demands projections for major PCWSs servicing WMA17 were also analyzed to examine their similarities and differences with the WMA17 2050 population projections discussed in Section 4 and their implications for assessing future regional water demand.

### *2.3 CLIMATE CHANGE AND SEA LEVEL RISE ASSESSMENT*

The climate change and sea level rise assessment (Section 9) included three sub-sections: (a) general climate change projections for the WMA17 region; (b) potential changes to WMA17 water availability due to climate change; and (c) community vulnerability to sea level rise. General climate change projections (provided by NJDEP's DWSG) for the WMA17 region are provided and projected changes to the region are discussed including inundation of water sources and NJDEP Bureau of Water Allocation and Well Permitting water withdrawal and discharge sites. Community vulnerability to sea level rise was examined by looking at purveyor service areas and Overburdened Communities at risk of inundation from two and five feet of sea level rise.

### *2.4 DEVELOPMENT OF POTENTIAL MANAGEMENT OPTIONS*

Based on the findings from the earlier sections, a list of potential management options was developed based on regional and more localized needs (Section 10). Areas considered to have the highest water supply vulnerability were identified, and management options were proposed that are tailored to address the specific needs/challenges identified in those locations.

## 3. WMA17 WATERBODIES

Table J1 shows all of the HUC11 watersheds in WMA17. Several watersheds (02040206130, 02040206140, 02040206180, 02040206190, 02040206200) are partially located in the Pinelands National Reserve and are subject to Pinelands Commission

regulations. Seven HUC11s are located entirely or partially in Water Supply Critical Area 2 (Full: 02040206120, 02040206130; Partial: 02040206140, 02040206150, 02040206180, 02040206190).

## *3.1 SURFACE WATER SOURCES*

WMA17's surface water sources are provided in Map J5. The Salem River drains the western part of Salem County, and runs 32 miles through Upper Pittsgrove Township, Carney's Point Township, Mannington Meadows, and Salem City before ultimately draining into the Delaware River (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; NJ Division of Fish and Wildlife, 2004). The Upper Salem River Watershed includes portions of Salem County's Woodstown Borough, Upper Pittsgrove Township, and Pilesgrove Township. Agriculture is considered the dominant land use in the Upper Salem River Watershed and includes cropland, pastureland, and orchards (Rutgers Cooperative Extension Water Resources Program, 2012). Major tributaries of the Salem River include Game Creek, Majors Run, and Fenwick Creek.


**Map J5.** A Map of WMA17 Surface Water Sources
Map courtesy of NJDEP

The Cohansey River's headwaters begin in Salem County (north of Bostwick Lake), but the watershed is primarily located in Cumberland County. Draining approximately 20% of Cumberland County, the Cohansey River travels about 27 miles before draining into Delaware Bay. The Upper Cohansey River Watershed has predominantly agricultural land use that includes sod farms, row crops, and nurseries. The Cohansey River is historically responsible for the development of Fairton, Bridgeton, and Greenwich, which remain significant development centers along the Cohansey River. For example, Bridgeton Industrial Park (located in southern Bridgeton City) is located east along the Cohansey River. Below Bridgeton's Sunset Lake Dam, the Cohansey River becomes deeper and navigable until it reaches Delaware Bay. Between Bridgeton and Fairton, the Cohansey River is straight and narrow and has a meandering pattern below Fairton (Cohansey River Planning Committee, 1998). The Cohansey River's tributaries include Harrow Run, Clarks Run, and Parsonage Run, and wetlands are located along the Cohansey River in areas including Fairton, south of Bridgeton, and near the mouth of the river at Delaware Bay (Rutgers Cooperative Extension Water Resources Program, 2011; Cohansey River Planning Committee, 1998).

The Maurice River flows south from Gloucester County to Cumberland County, where it travels through Vineland and Millville and drains into Delaware Bay (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006). Considered Delaware Bay's second largest tributary and the Pinelands National Reserve's western border, the Maurice River drains many of the reserve's forests along with portions of the Delaware Bay Estuary. Designated a National Scenic and Recreational River in 1993, the Maurice River's 35.5 designated miles include 10.5 miles of the main river and 20 miles of its tributaries, including all or parts of the Manumuskin River, Menantico Creek, and Muskee Creek (Sarah Birdsall Planning Consulting, 2017; Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; Simone Collins Landscape Architecture & Reed Group, 2011). The Maurice River Watershed includes approximately 20 major lakes, including its largest lake: Union Lake in Millville City. Millville City includes the north portion of the Maurice River, spanning about four river miles and 11 river miles of its tributary, Menantico Creek (National Park Service, 2001). Tributaries that flow through Vineland to the Maurice River include Muddy Run, Still Run, and Scotland Run (City of Vineland, 2005). The Maurice River receives flow from and contributes to the Kirkwood-Cohansey Aquifer, and its watershed has unconfined aquifer use limits since the eastern Maurice River is located in Pinelands National Reserve and CAFRA protected lands (National Park Service, 2001).

**Table J1.** HUC11 Information for Watershed Management Area 17
Data provided by NJDEP (Snook, Domber, & Hoffman, 2014; NJDEP Division of Water Supply and Geoscience [DWSG], 2021)

| HUC11 | HUC11 Name | HUC11 Area ($mi^2$) | Watershed Area ($mi^2$) | Pinelands | Critical Area 2 | Municipalities |
|---|---|---|---|---|---|---|
| **02040204910** | Delaware Bay (Cape May Pt to Fishing Ck) | 349 | 349 | | | ***Cumberland***: Maurice River Township, Fairfield Township, Greenwich Township, Lawrence Township, Downe Township; ***Salem***: Lower Alloways Creek Township |
| **02040206020** | Pennsville / Penns Grove tribs | 14 | 23 | | | ***Gloucester***: Logan Township; ***Salem***: Oldmans Township, Carney's Point Township, Penns Grove Borough, Pennsville Township |
| **02040206030** | Salem R (above 39d40m14s dam)/Salem Canal | 58 | 58 | | | ***Salem***: Oldmans Township, Carney's Point Township, Pilesgrove Township, Pennsville Township, Mannington Township, Upper Pittsgrove Township, Woodstown Borough |
| **02040206040** | Salem River (below 39d40m14s dam) | 59 | 59 | | | ***Salem:*** Carney's Point Township, Pilesgrove Township, Pennsville Township, Mannington Township, Alloway Township, Salem City, Elsinboro Township, Quinton Township, Lower Alloways Creek Township |
| **02040206060** | Alloway Creek / Hope Creek | 86 | 77 | | | ***Salem***: Pilesgrove Township, Upper Pittsgrove Township, Alloway Township, Elsinboro Township, Quinton Township, Lower Alloways Creek Township |
| **02040206070** | Stow Creek | 55 | 55 | | | ***Cumberland***: Hopewell Township, Stow Creek Township, Shiloh Borough, Greenwich Township; **Salem**: Alloway Township, Quinton Township, Lower Alloways Creek Township |
| **02040206080** | Cohansey River (above Sunset Lake) | 37 | 37 | | | ***Cumberland***: Upper Deerfield Township, Hopewell Township, Stow Creek Township, Shiloh Borough; ***Salem***: Upper Pittsgrove Township, Alloway Township |
| **02040206090** | Cohansey River (below Cornwell Run) | 70 | 107 | | | ***Cumberland***: Upper Deerfield Township, Hopewell Township, Deerfield Township, Stow Creek Township, Shiloh Borough, Bridgeton City, Fairfield Township, Greenwich Township, Lawrence Township |
| **02040206100** | Back / Cedar / Nantuxent Creeks | 51 | 51 | | | ***Cumberland***: Fairfield Township, Lawrence Township, Downe Township |
| **02040206110** | Dividing Creek | 60 | 61 | | | ***Cumberland***: Downe Township, Commercial Township |

| HUC11 | HUC11 Name | HUC11 Area ($mi^2$) | Watershed Area ($mi^2$) | Pinelands | Critical Area 2 | Municipalities |
|---|---|---|---|---|---|---|
| **02040206120** | Still Run / Little Ease Run | 46 | 46 | | All | ***Gloucester***: Washington Township, Glassboro Borough, Monroe Township, Elk Township, Clayton Borough, Franklin Township; ***Salem***: Upper Pittsgrove Township, Pittsgrove Township |
| **02040206130** | Scotland Run | 30 | 30 | Partial | All | ***Cumberland***: Vineland City; ***Gloucester***: Washington Township, Monroe Township, Clayton Borough, Franklin Township; ***Salem***: Pittsgrove Township |
| **02040206140** | Maurice River (above Sherman Ave Bridge) | 57 | 190 | Partial | Partial | ***Atlantic***: Buena Borough; ***Cumberland***: Vineland City, Deerfield Township, Millville City; ***Gloucester***: Franklin Township, Newfield Borough; ***Salem***: Pittsgrove Township |
| **02040206150** | Muddy Run | 58 | 58 | | Partial | ***Cumberland***: Vineland City, Upper Deerfield Township, Deerfield Township; ***Salem***: Upper Pittsgrove Township, Elmer Borough, Pittsgrove Township |
| **02040206160** | Maurice River (Union Lk to Sherman Ave) | 25 | 215 | | | ***Cumberland***: Vineland City, Upper Deerfield Township, Deerfield Township, Millville City, Fairfield Township |
| **02040206170** | Maurice River (Menantico Ck to Union Lk) | 45 | 260 | | | ***Cumberland***: Vineland City, Maurice River Township, Millville City, Fairfield Township, Lawrence Township, Downe Township, Commercial Township |
| **02040206180** | Menantico Creek | 39 | 39 | Partial | Partial | ***Atlantic***: Buena Vista Township, Buena Borough; ***Cumberland***: Vineland City, Maurice River Township, Millville City |
| **02040206190** | Manamuskin River | 36 | 36 | Partial | Partial | ***Atlantic***: Buena Vista Township; ***Cumberland***: Vineland City, Maurice River Township, Millville City |
| **02040206200** | Maurice River (below Menantico Creek) | 49 | 384 | Partial | | ***Cumberland***: Maurice River Township, Millville City, Commercial Township |

## *3.2 GROUNDWATER SOURCES*

The Kirkwood-Cohansey Aquifer is a significant WMA17 groundwater source. Considered the largest contiguous aquifer in the U.S., it is a highly productive aquifer with a 17-trillion-gallon capacity across its multi-county range (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006). As an unconfined (surficial) aquifer, the Kirkwood-Cohansey is composed of permeable sands and gravels and relies on recharge from surface precipitation (Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015; NJ Division of Fish and Wildlife, 2004). The Kirkwood-Cohansey Aquifer is considered Salem County's main groundwater source, providing both potable supply and agricultural irrigation water to WMA17's citizens (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; DVRPC, 2009; Heyer, Gruel & Associates and Michael Baker International, 2018a). The Kirkwood-Cohansey is thought to have abundant water for southern New Jersey but is considered highly vulnerable to risks from contamination from septic systems and surface sources (DVRPC, 2009). Excessive withdrawal may also harm nearby environmental resources, such as the water levels of nearby wetlands (Charles and Nicholson, 2012).

The Piney Point Aquifer is a significant confined aquifer used in WMA17, with significant water withdrawals in Buena Borough (western Atlantic County) and around Bridgeton City (Cumberland County). Flow from the overlying aquifers is a significant source of inflow for the Piney Point Aquifer, while wells and flow to underlying aquifers is a significant source of outflow (Gordon, Carleton, & Rosman, 2021; U.S. Geological Survey, [forthcoming]). Development of the Piney Point Aquifer around Bridgeton in the early 2000s led to significant well water decline in areas of Cumberland County, along with significant water loss experienced around Buena Borough wells. USGS comparisons of water levels in 49 Piney Point wells between 2008 and 2013 found 19 well water levels rose (39%), 7 remained the same (14%), and 23 declined (47%) (Gordon et al., 2021). USGS model simulations of 2040 water loss scenarios identified areas around Bridgeton City and Buena Borough wells to be at risk of experiencing significant water loss from the Piney Point Aquifer in the future (U.S. Geological Survey, [forthcoming]). The onshore part of the 250-mg/L isochlor line – the line used by NJDEP to designate limits of potable water in aquifers – extends from eastern Atlantic County southwest to northern Cape May County (Gordon et al., 2021).

The Potomac-Raritan-Magothy (PRM) Aquifer is considered a significant drinking water source in southern New Jersey, especially in Gloucester and Salem counties. Considered western Salem County's primary water source, it is considered a mostly confined aquifer that provides high quality water that can be used for multiple purposes (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; NJ Division of Fish and Wildlife, 2004; Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). USGS has found the significant sources of inflow and outflow for the Upper and Middle PRM are similar and include inflow from overlying aquifers and recharge and outflow from wells and drains. The Lower PRM has significant inflow from overlying aquifers and outflow from wells (U.S. Geological Survey, [forthcoming]). Within WMA17, Gloucester County, Atlantic County, and portions of eastern Salem County are located in Water Supply Critical Area 2. Established in 1993 to protect the viability of the PRM Aquifer, the Critical Area 2 designation mandated that water withdrawals from the PRM Aquifer within the designated area be reduced by 22% (NJ Division of Fish and Wildlife, 2004; Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). Regional water supply companies are given annual withdrawal limits for PRM extraction, and no pumping increases are allowed (Tetra Tech, 2022). USGS comparisons of 2008 and 2013 Upper, Middle, and Lower PRM well water levels have indicated a recovery of water levels, with reported increases in water levels in 84%, 78%, and 85% of wells for each aquifer layer, respectively (Gordon et al., 2021). However, USGS model simulations of 2040 water loss scenarios for the PRM Aquifer detected risk of water loss in areas near New Jersey American Water (NJAW) Penns Grove (Carney's Point Township), Pennsville Water Department wells, and Chambers Works (Carney's Point Township and Pennsville Township) (U.S. Geological Survey, [forthcoming]). While the Upper PRM's 250-mg/L isochlor line is located in southern Gloucester County in an up-dip direction that faces the Delaware River, the Middle PRM's line bisects Salem County in the west to southern Ocean County in the east (Gordon et al., 2021).

In comparison to the PRM and Kirkwood-Cohansey aquifers, the Mount-Laurel Wenonah (MLW) Aquifer is considered to have less capacity to store and transmit water (NJ Division of Fish and Wildlife, 2004). The MLW Aquifer extends from Monmouth and Middlesex counties in the northeast to Salem County in the southwest (Gordon et al., 2021). According to USGS, significant sources of inflow for the MLW include flow from overlying aquifers and recharge, while significant sources of outflow include flow to the underlying aquifers and drains (U.S. Geological Survey, [forthcoming]). After the creation of Water Supply Critical Area 2 and its restrictions on withdrawals from the PRM Aquifer, the MLW was considered a potential

alternative source and water demand from the aquifer increased (Watt & Voronin, 2006; Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). A USGS analysis comparing 2008 and 2013 water levels from 117 MLW wells indicated increased water levels in 98 wells (84%), 4 wells stayed the same (3%), and decreased water levels in 15 wells (13%) (Gordon et al., 2021). However, USGS model simulations of 2040 water loss scenarios for the MLW Aquifer identified potential risk for significant water loss in Clayton Borough (Gloucester County) and Washington Township (Gloucester County) (U.S. Geological Survey, [forthcoming]). For the MLW Aquifer, the 250-mg/L isochlor line extends about two miles inland in southwestern Salem County (Gordon et al., 2021).

Figure J1 shows the net loss confined aquifer flow in each WMA17 HUC11 in a baseline 2013 scenario and three 2040 water use scenarios. The 2040 water use scenarios are based on the demands projections provided in Van Abs, Ding, & Pierson, 2018, and includes conservation nominal water use, conservation optimal water use, and full allocation water use scenarios. This analysis, provided by USGS in a forthcoming study, shows that net confined aquifer water loss for 2013 was highest in 02040206020, 02040206030, and 02040206120. While the extreme full allocation 2040 scenario indicates the potential for a significant increase in net aquifer flow loss in 02040206020, the other two 2040 scenarios (Optimal and Nominal) in this HUC11 along with the rest of the WMA17 HUC11s, are projected to be relatively similar to the baseline 2013 scenario (U.S. Geological Survey, [forthcoming]).

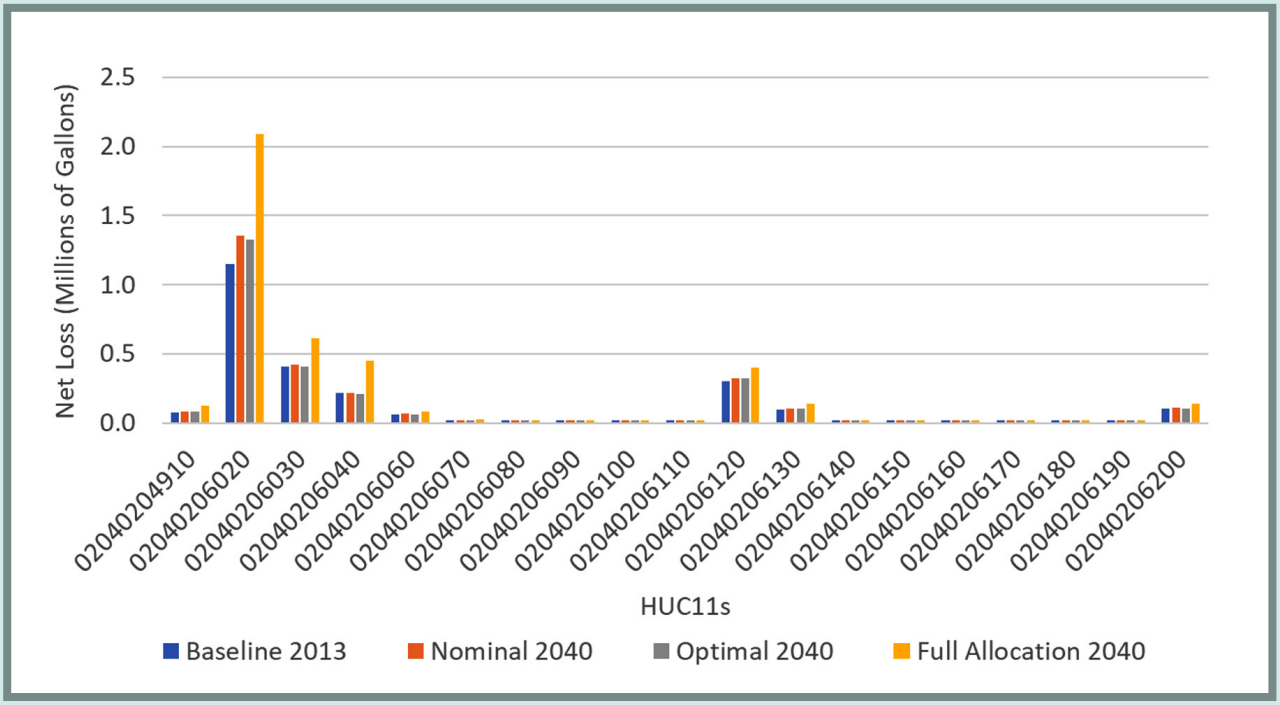



**Figure J1.** Net Confined Aquifer Flow in WMA17 HUC11s
Source: U.S. Geological Survey, [forthcoming]

# 4. DEMOGRAPHIC ANALYSIS

**KEY FINDINGS**

- The overall population of WMA17 municipalities grew slightly between 2010-2020. However, among the WMA17 counties (Atlantic, Cumberland, Gloucester, and Salem), only Gloucester County experienced population growth between 2010-2020.
- The projection analysis found MPO and DOL projections for WMA17 counties were similar in their forecasted time ranges, projecting growth in all WMA17 counties except Salem. Gloucester County is the WMA17 county projected to experience the most population growth.
- Seven WMA17 municipalities considered most likely to experience significant population changes (Carney's Point Township, Salem City, Pilesgrove Township, Bridgeton City, Millville City, Vineland City, and Glassboro Borough) were selected as focus municipalities for further analysis in later sections of the regional assessment.

## *4.1 POPULATION ANALYSIS AND INTRODUCTION TO FOCUS MUNICIPALITIES*

The population analysis consisted of three components. The first two components assessed current demographic and population data for WMA17 counties and municipalities, respectively. The third component focused on the projection analysis, which examined MPO and DOL county and municipality population projections for 2020-2050 and 2019-2034, respectively. Second and third component findings were used to identify the focus municipalities used in the later sections of the assessment.

### COUNTY-WIDE ANALYSIS

Table J2 provides demographic information for WMA17's counties, providing state demographic information for comparative purposes. Gloucester County was found to have the largest population and population density among WMA17 counties and was the only county to experience population growth between 2010 and 2020. This finding continues an ongoing trend of significant growth in Gloucester, as the county experienced a 13% population growth between 2000 and 2010 (Tetra Tech, 2022). Despite experiencing recent population decline, Cumberland, Salem, and Atlantic counties all grew prior to the Great Recession (Simone Collins Landscape Architecture & Reed Group, 2011; Salem County Planning Board, 2016; Heyer, Gruel & Associates and Michael Baker International, 2018a).

The economic challenges experienced by WMA17 counties can be seen from examining WMA17 county data for unemployment rate, median household income, and poverty rate. Similar to the trend with population growth, the only county to have a median household income above the New Jersey state average is Gloucester County. Salem, Cumberland, and Atlantic counties all had unemployment rates above the state average, although these values were improving from the higher rates they experienced at the start of the pandemic in 2020 (New Jersey Department of Labor and Workforce Development, 2022). Salem County's unusually large GDP per capita is likely a result of the nuclear power plants on Artificial Island. The other three counties lag New Jersey. Salem County reported a lagging economy even prior to the COVID pandemic, with estimates the county's total labor force declined from 30,900 to 30,200 between 2017 and 2019 (SJEDD, 2021). Evidence of regional economic challenges are found in Salem City, with reports of vacant buildings and buildings being used for different purposes than originally intended (LPS, 2018). Cumberland County's employment in 2020 was still approximately 6% below its peak in 2005 (Cumberland County Improvement Authority, 2020).

**Table J2.** WMA17 County Demographic Information
Sources: 2020 U.S. Census (U.S. Census Bureau, 2021), 2020 ACS 5-yr estimate (American Community Survey, 2022), Bureau of Economic Analysis, 2021, NJ Department of Labor and Workforce Development, 2022

| County | Atlantic | Cumberland | Gloucester | Salem | New Jersey |
|---|---|---|---|---|---|
| Land Area ($mi^2$) | 556 | 483 | 322 | 332 | 7,353 |
| 2020 Real GDP (Billions of Dollars) | $11 | $6 | $14 | $5 | $536 |
| 2020 Real GDP Per Capita | $40,339 | $36,922 | $47,416 | $78,779 | $57,680 |
| 2020 Population Density (per $mi^2$) | 494 | 319 | 939 | 195 | 1,263 |
| 2010 Census Population | 274,549 | 156,898 | 288,288 | 66,083 | 8,791,894 |
| 2020 Census Population | 274,534 | 154,152 | 302,294 | 64,837 | 9,288,994 |
| Median Household Income | $63,680 | $55,709 | $89,056 | $64,234 | $85,245 |
| Poverty Rate | 14% | 16% | 7% | 14% | 10% |
| Unemployment Rate (May 2021 – not seasonally adjusted) | 5% | 5% | 3% | 4% | 3% |

Despite being hit hard by both the 2008 Great Recession and the COVID pandemic, regional strategies have been developed for promoting economic development in WMA17. The South Jersey Economic Development District identifies several industry sectors as promising for regional economic growth: (a) tourism; (b) agriculture, food processing, and technology; (c) aviation and aeronautical industry; and (d) blue economy, including wind and clean energy (SJEDD, 2021). The fourth identified sector is related to new manufacturing and port facilities in support of Atlantic windfarms off the Jersey Coast and a proposed wind farm project (Ocean 1) in Lower Alloways Creek Township (Salem County) (Cumberland County OEM & Stuart Wallace LLC, 2022). Salem County has expressed interest in building its dominant job force sectors (which include manufacturing, education, and health, along with social service work, retail trade, and nuclear generation), and tourism development (SJEDD, 2021). Similarly, Cumberland County reported in 2020 that they felt their most promising sectors for economic growth were agriculture, education, medicine, and government, which partially aligns with their job growth trends and reported concentrations of talent among residents (Cumberland County Improvement Authority, 2020).

## MUNICIPALITY-WIDE ANALYSIS

WMA17 includes all Salem County and Cumberland County municipalities, portions of seven Gloucester County municipalities (Elk Township, Glassboro Borough, Washington Township, Monroe Township, Franklin Township, Newfield Borough, and Clayton Borough), and parts of two Atlantic municipalities (Buena Borough and Buena Vista Township). Similar to the county-level analysis findings, the 2020 U.S. Census reveals many of Salem, Cumberland, and Atlantic's WMA17 municipalities experienced population decline between 2010-2020; however, the population growth among WMA17's Gloucester municipalities resulted in a slight increase in the overall WMA17 municipality population between 2010-2020. In Cumberland County, only three municipalities grew during this time period, and the only municipality to experience modest population growth was Bridgeton City. Six of Gloucester's WMA17 municipalities grew between 2010 and 2020 (only Franklin Township's population declined) (U.S. Census Bureau, 2021).

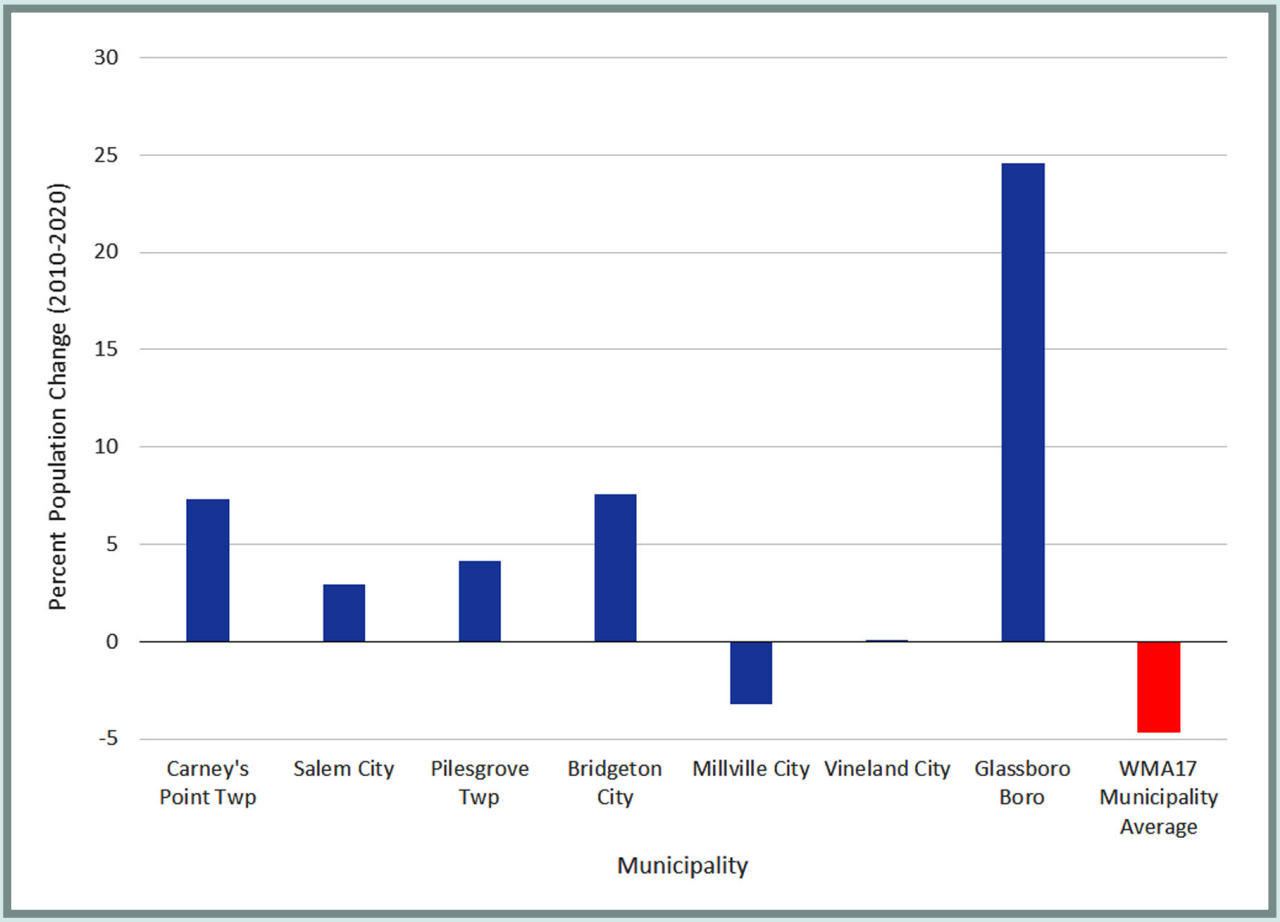



**Figure J2.** Percent Population Change in WMA17 Municipalities (2010-2020)

Figure J2 shows the percent population change experienced by the WMA17 municipalities selected as focus municipalities, as compared to the average percent population change of all of the WMA17 municipalities (not of WMA17's total population). Focus municipalities are municipalities identified as most likely to experience significant population changes (growth or decline) and potentially water demand changes in the future. Since many of WMA17's municipalities declined in population between 2010-2020, focus municipalities were selected based on determining municipalities either currently experiencing significant population changes or are considered the most promising for growth or decline in the future (based partially on the projection analysis in the next sub-section). Identification of focus municipalities was based on factors including municipal percent population changes between 2010-2020, examination of county planning documents, 2020 percent difference between municipal MPO projection and census population (discussed in the next sub-section), and MPO projected municipal growth through 2050 (discussed in the next sub-section).

As shown in Figure J2, many of the focus municipalities selected for analysis demonstrated growth between 2010-2020. Vineland City grew by approximately 56 people, which resulted in a small percent population change that is barely visible in the figure. Glassboro Borough, in particular, experienced the largest population growth between 2010-2020, growing by 4,570 people. Bridgeton City also grew by 1,914 people in this time period. Other municipalities, such as Carney's Point Township, Pilesgrove Township, and Salem City, experienced much smaller population growth between 2010-2020 (growing by 588, 167, and 150 people, respectively) (U.S. Census Bureau, 2021).

## POPULATION PROJECTION ANALYSIS

Figure J3 shows the MPO and DOL population projections (estimates) for the four WMA17 counties. Both the MPO and DOL population projections were developed prior to the 2020 Census, and therefore are based on 2010 Census data and subsequent annual estimates. The 2020 Census results show significant differences from the earlier modeled results.

All four WMA17 counties had 2020 Census populations that exceeded their MPO 2020 projections. The Atlantic and Cumberland 2020 Census populations did not exceed their respective DOL 2019 projections, while both Gloucester and Salem did. Gloucester County is expected to experience the most population growth throughout the forecasted time ranges. The MPO forecasts Gloucester County to grow by 15,293 people by 2035 and by 35,898 by 2050. The DOL forecasts Gloucester County to grow by 20,500 people between 2019 and 2034, which is higher than the MPO forecasted growth between 2020-2035. Cumberland County, despite experiencing population decline between 2010 and 2020, is anticipated to rebound and experience population growth in both its MPO and DOL population projections, with projections to grow by 5,783 people by 2035 and 5,800 by 2034, respectively. Similarly, Atlantic County is forecasted to grow by 6,371 and 6,700 people in its MPO (2035) and DOL (2034) projections, respectively. Salem County is anticipated to decline in population in both its MPO (decline of 6,724 people by 2050 (3,317 people by 2035)) and DOL (3,200 people by 2034) population projections (SJTPO, 2021; DVRPC, 2022; DOL, 2014).

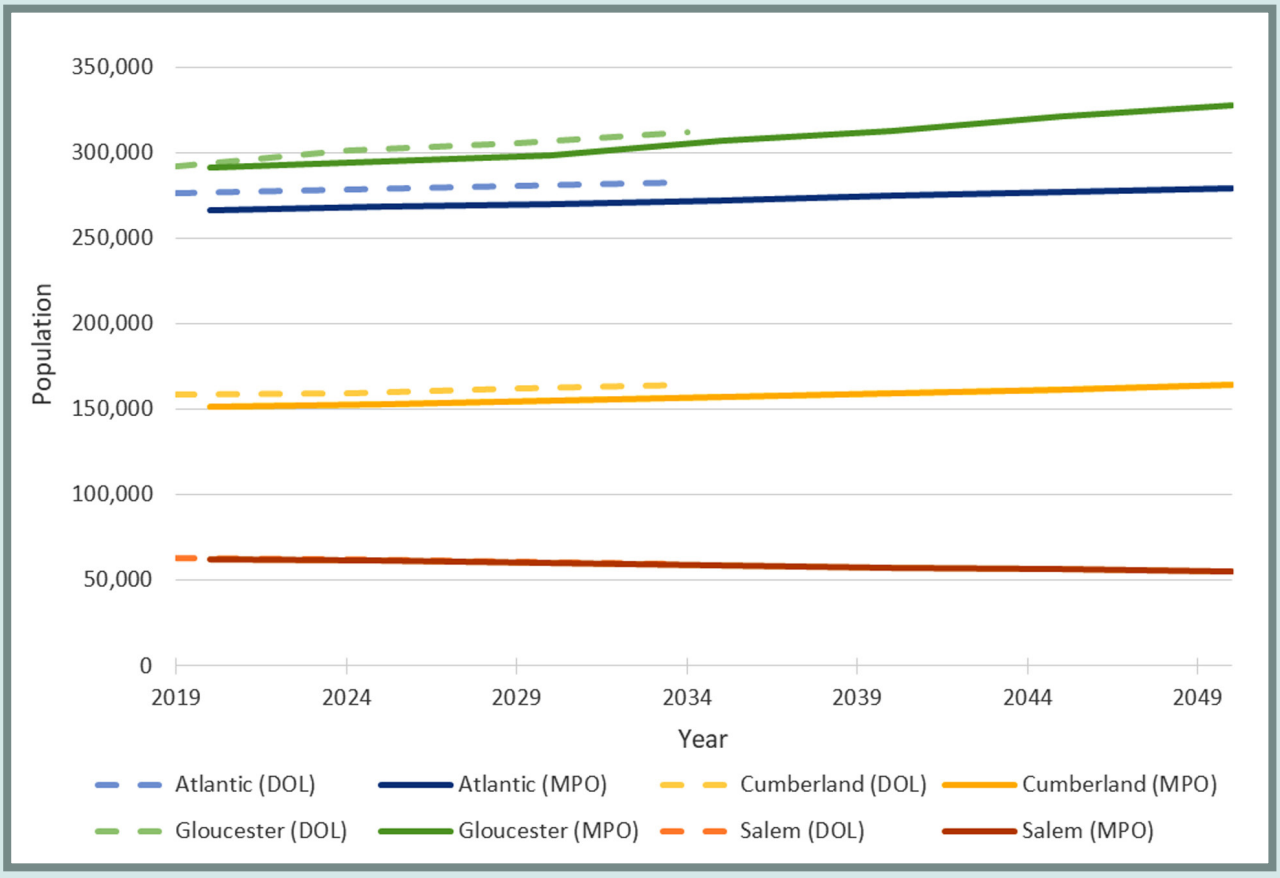



**Figure J3.** MPO and DOL Population Estimates for WMA17 Counties (2019-2050)

The poor outlook for Salem's population growth led to the focus municipalities selected from this county to focus on municipalities expected to experience either growth or the least amount of population loss. Figure J4a and b demonstrate how the focus municipalities were selected for analysis. All of the municipalities selected for analysis had 2020 Census populations that exceeded their 2020 MPO population projections. Vineland and Millville City were also selected since they are projected by their MPO to have the largest population growth among the municipalities selected for analysis (SJTPO, 2021; DVRPC, 2022).

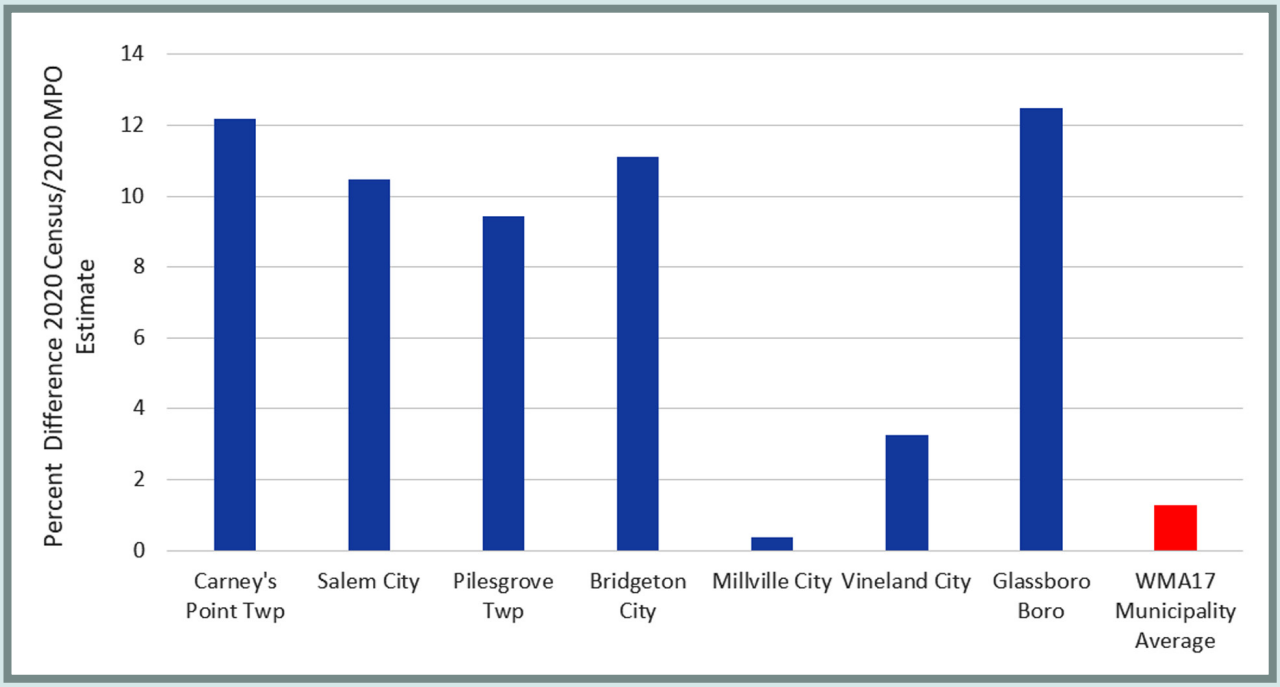



**Figure J4a.** Percent Difference 2020 Census Population/2020 MPO Population Estimate

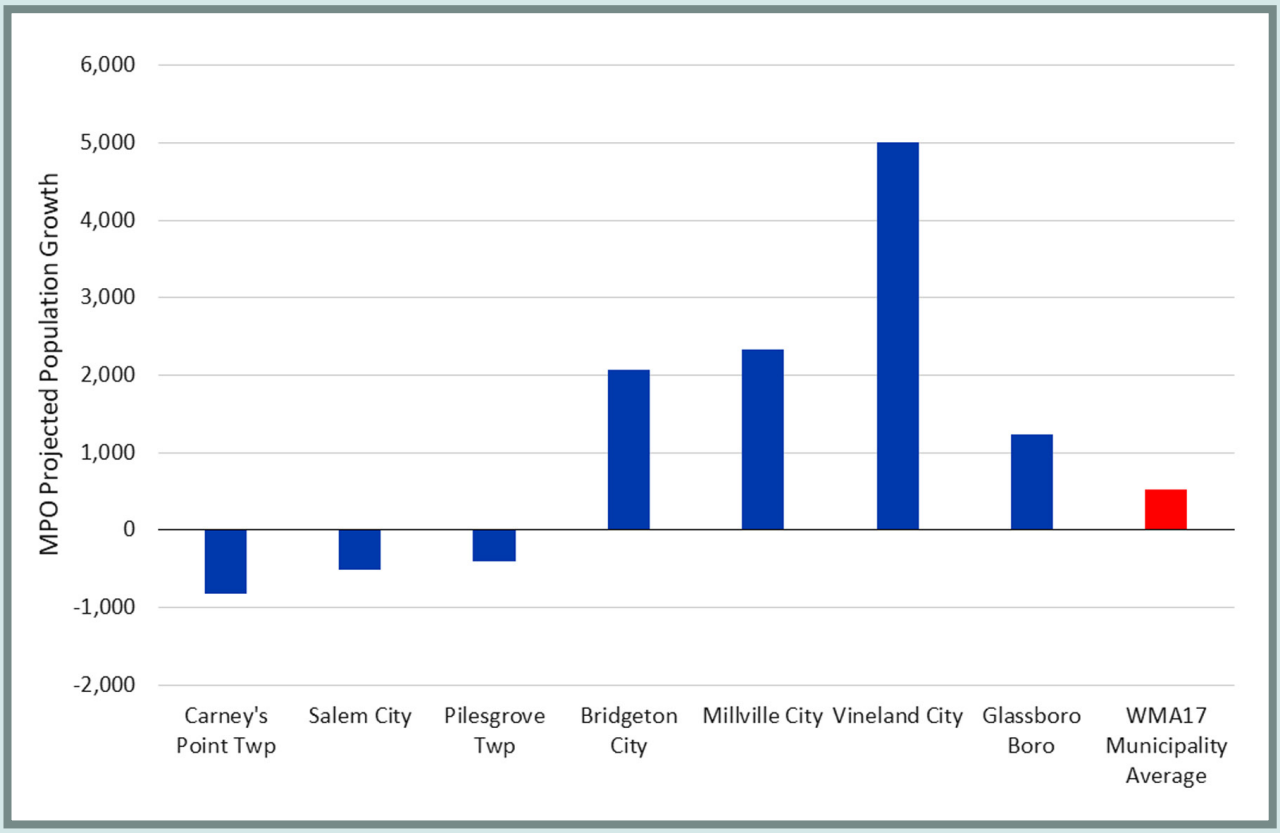


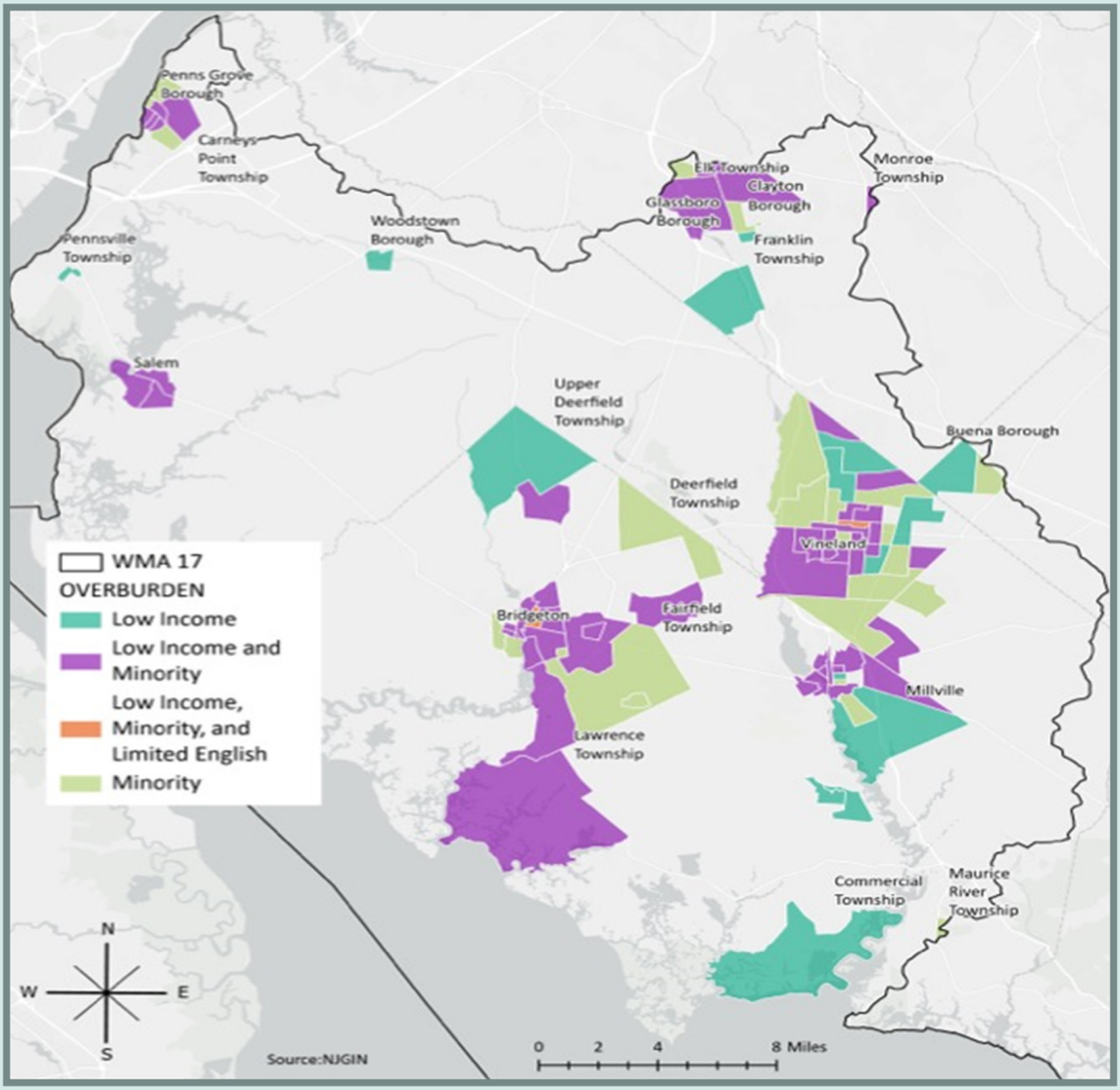

**Figure J4b.** MPO Projected Growth in WMA17 (2020-2050)

## 5. SOCIAL VULNERABILITY

**KEY FINDINGS**

- From examination of NJDEP's Overburdened Communities (as mapped by NJDEP under state law) and the Centers for Disease Control's (CDC's) Social Vulnerability Index (SVI) for the WMA17 region, Cumberland County was found to have the highest social vulnerability in the region.
- Although Gloucester County's SVI score suggests it has the lowest social vulnerability in WMA17, six of seven WMA17 Gloucester County municipalities contain Overburdened Communities.
- The municipalities with the largest social vulnerability include many of the focus municipalities, including Salem County's Carney's Point Township and Salem City and Cumberland County's Millville City, Vineland City, and Bridgeton City.

## 5.1 NJDEP OVERBURDENED COMMUNITIES




**Map J6.** Map of WMA17 Census Blocks Identified as Overburdened Communities

Two metrics were used to examine social vulnerability in WMA17: NJDEP's Overburdened Communities designation and CDC's SVI. On NJDEP's Office of Environmental Justice website (**NJDEP Environmental Justice**), Overburdened Communities are defined as:

"…any census block group, as determined in accordance with the most recent United States Census, in which:

1. at least 35 percent of the households qualify as low-income households (at or below twice the poverty threshold as determined by the United States Census Bureau);
2. at least 40 percent of the residents identify as minority or as members of a State recognized tribal community; or
3. at least 40 percent of the households have limited English proficiency (without an adult that speaks English "very well" according to the United States Census Bureau)."

**Table J3.** Overburdened Communities in WMA17 Counties
Source: NJDEP Office of Environmental Justice, 2022

| County | Number of Municipalities Containing Overburdened Communities | Municipality Name |
|---|---|---|
| **Salem** | 5 | Carney's Point Township, Penns Grove Borough, Pennsville Township, Pittsgrove Township, Salem City |
| **Cumberland** | 9 | Bridgeton City, Commercial Township, Deerfield Township, Fairfield Township, Lawrence Township, Maurice River Township, Millville City, Upper Deerfield Township, Vineland City |
| **Gloucester (municipalities in WMA17)** | 6 | Clayton Borough, Elk Township, Franklin Township, Glassboro Borough, Monroe Township, Washington Township |
| **Atlantic (municipalities in WMA17)** | 2 | Buena Borough, Buena Vista Township |

Map J6 shows the WMA17 census block groups that are designated as Overburdened Communities. As shown in the map and Table J3, Cumberland County was found to have the most WMA17 municipalities with Overburdened Communities, followed by Gloucester County. Almost all of the focus municipalities (Carney's Point Township, Salem City, Bridgeton City, Millville City, Vineland City, and Glassboro Borough) have census blocks containing Overburdened Communities.

**Table J4.** Overburdened Communities in WMA17 Focus Municipalities
Source: NJDEP Office of Environmental Justice, 2022

| Focus Municipality | Number of Census Block Groups Overburdened | Census Block Group Numbers | Overburdened Community Criteria in Census Block Groups |
|---|---|---|---|
| Carneys Point Township | 3 | 340330204001, 340330204002, 340330205001 | Minority, Low Income, Low Income and Minority |
| Salem City | 3 | 340330219001, 340330220001, 340330221001 | Low Income and Minority |
| Bridgeton City | 12 | 340110201001, 340110205021, 340110202002, 340110202001, 340110203001, 340110203002, 340110204001,340110204002, 340110205031,340110205032, 340110206002,340110206003 | Minority, Low Income and Minority, Low Income, Minority, and Limited English |
| Millville City | 13 | 340110302003, 340110304002, 340110305021, 340110301001, 340110302002, 340110302004, 340110302005, 340110303001, 340110303002, 340110303003, 340110304001, 340110304005, 340110305022 | Low Income, Minority, Low Income and Minority |
| Vineland City | 30 | 340110403001, 340110404002, 340110403002, 340110404003, 340110404004, 340110405001, 340110405002, 340110405003, 340110406002, 340110406003, 340110406004, 340110407002, 340110409011, 340110409012, 340110409021, 340110409024, 340110409025, 340110410002, 340110410003, 340110410004, 340110411002, 340110406001, 340110407003, 340110407004, 340110408003, 340110409022, 340110409023, 340110411001, 340110411003, 340110411004 | Minority, Low Income and Minority, Low Income, Minority, and Limited English |
| Glassboro Borough | 5 | 340155014021, 340155014022, 340155014023, 340155014032, 340155014061 | Low Income, Minority, Low Income and Minority |

Table J4 describes the type of social vulnerability found in the Overburdened Communities in WMA17's focus municipalities based on NJDEP's definition of Overburdened Communities. All of these communities had census block groups with at least 40 percent of the residents identifying as minority and/or had at least 35 percent of the households qualifying as low-income households. Two focus municipalities, Bridgeton City and Vineland City, had census blocks in which at least 40 percent of their households identified as having limited English proficiency in addition to meeting the criteria for minority and low-income households.

## *5.2 SOCIAL VULNERABILITY INDEX*

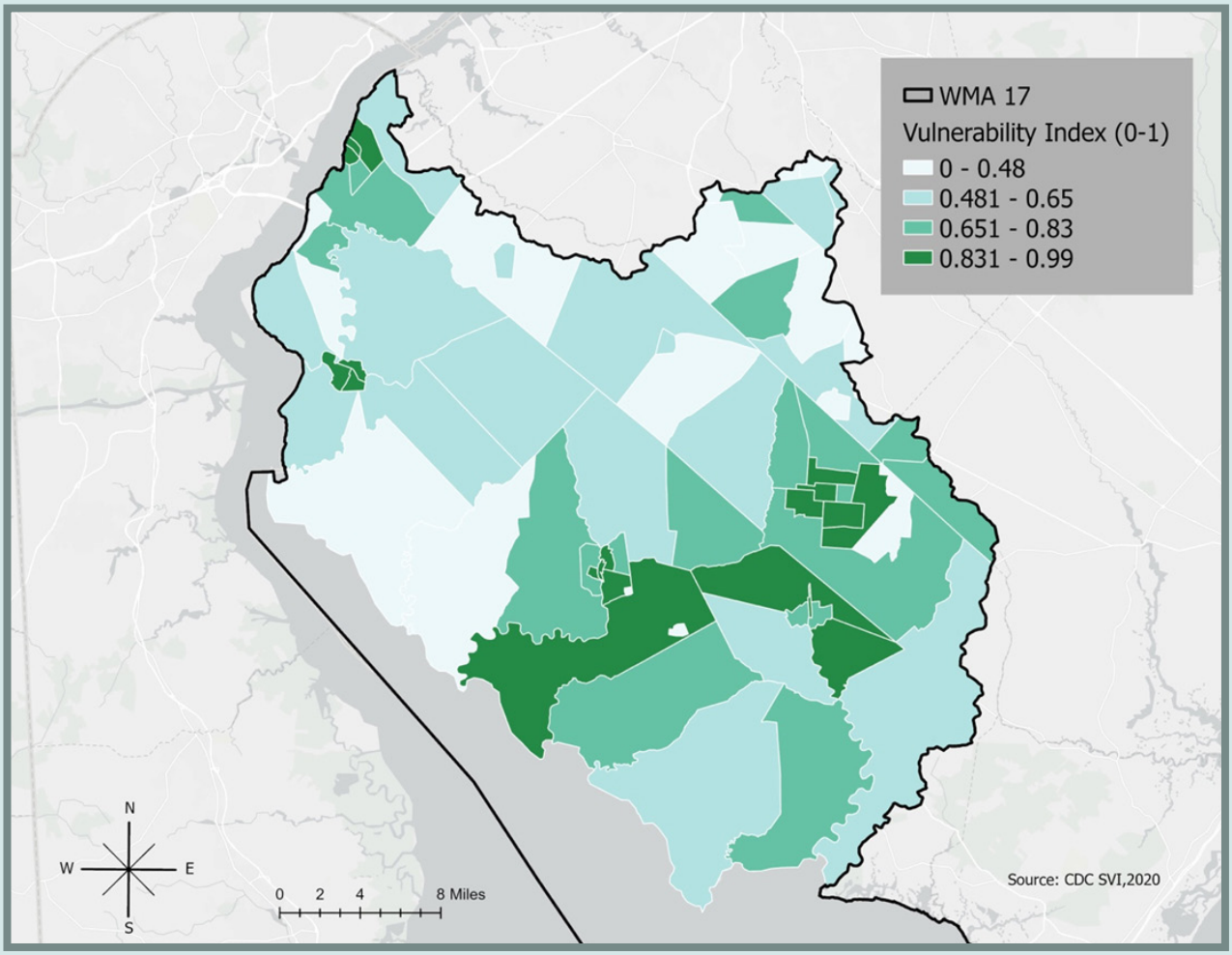
The Social Vulnerability Index (SVI) was originally created by the Agency for Toxic Substances and Diseases Registry's (ATSDR's) Geospatial Research, Analysis & Services Program to help public health officials and emergency responders identify communities most likely to require support after hazardous events. In this index, U.S. Census tracts are ranked against each other on 15 social factors (such as disability and unemployment) that are categorized into four themes (Socioeconomic Status, Household Composition and Disability, Minority Status and Language, and Housing Type and Transportation). Each tract receives a rank for each factor, each of the four themes, and overall vulnerability, which can also be aggregated to a county level. SVI percentile rankings are based on a score of 0 to 1, in which census-tracts (or counties) with higher values have greater vulnerability compared to other tracts (or counties) (Centers for Disease Control and Prevention Agency for Toxic Substances and Diseases Registry, 2022). In comparing the two social vulnerability metrics used in this assessment (Overburdened Communities and SVI), the Socioeconomic Status and Minority Status and Language SVI themes most closely align with the Overburdened Community metric, while the other two themes (Household Composition and Disability and Housing Type and Transportation) provide additional information about WMA17's socially vulnerable communities.

Table J5 provides the percentile ranking values for each of the major SVI categories and the Total SVI percentile rankings for each WMA17 county. These values indicate ranking against all New Jersey counties, in which 0.00 indicates the lowest vulnerability and 1.00 indicates the highest vulnerability in the state. Despite having a relatively high Composition and Disability percentile ranking (a ranking that considers single-parent households and the number of citizens aged 65 or older, aged 17 or younger, or with a disability), Gloucester County's overall SVI percentile ranking is much lower than the other three counties in WMA17. This suggests that Gloucester is the least vulnerable of the WMA17 counties. Salem, Cumberland, and Atlantic counties all have very high Socioeconomic Status percentile rankings. This category considers citizen income, the number of citizens who are living below poverty level, are unemployed, and/or have no high school diploma. Atlantic County and Cumberland County also have very high Housing Type and Transportation percentile rankings. This category considers factors such as the number of citizens living in mobile homes, group quarters, and multi-unit structures, experiencing crowding, and/or have no vehicle. Atlantic and Cumberland counties also have the highest possible Total SVI percentile rankings, suggesting they are the most socially vulnerable counties in WMA17 and the state.

Among WMA17 municipalities, the highest SVI scores were located in many of the focus municipalities. The highest SVI scores were found in Salem City and parts of Carney's Point Township, Bridgeton City, Millville City, and Vineland City, followed by parts of Glassboro Borough. Other WMA17 municipalities, Penns Grove Borough and Fairfield Township, were also found to have some of the highest SVI scores in WMA17 (See Map J7).

**Table J5.** Social Vulnerability Index Percentile Values for WMA17 Counties (2018)
Data courtesy of CDC ATSDR Geospatial Research, Analysis, and Services Program, 2020

| County | Socioeconomic Status Percentile Ranking | Household Composition and Disability Percentile Ranking | Minority Status and Language Percentile Ranking | Housing Type and Transportation Percentile Ranking | Total Social Vulnerability Index Percentile Ranking |
|---|---|---|---|---|---|
| **Atlantic** | 0.95 | 0.80 | 0.65 | 0.95 | 0.95 |
| **Cumberland** | 1.00 | 0.95 | 0.75 | 0.95 | 1.00 |
| **Gloucester** | 0.35 | 0.70 | 0.15 | 0.20 | 0.30 |
| **Salem** | 0.85 | 0.95 | 0.30 | 0.60 | 0.80 |




**Map J7.** Overall SVI Scores in WMA17 (2018)

## *5.3 COMPARISON OF OVERBURDENED COMMUNITY AND SVI FINDINGS*

Overall, SVI and Overburdened Communities results for WMA17 are consistent in identifying the region's socially vulnerable locations. SVI scores identified vulnerability in all or parts of Salem City, Carney's Point Township, Bridgeton City, Millville City, Vineland City, and Glassboro Borough, which all contain census block groups designated as Overburdened Communities. This was also consistent for Penns Grove Borough and Fairfield Township, which were identified as socially vulnerable in both metrics. Also consistent from the comparison of SVI and Overburdened Communities findings was identifying Cumberland County as the most socially vulnerable WMA17 county. Cumberland County's overall SVI score was 1.00, suggesting it is the most socially vulnerable county in the state. This vulnerability was also found in the Overburdened Community analysis, which found that Cumberland County had the most municipalities containing Overburdened Communities among WMA17 counties. Cumberland also contained two focus municipalities (Bridgeton City and Vineland City) with census block groups that met all three criteria for Overburdened Communities.

The finding that six of seven Gloucester County WMA17 municipalities contain Overburdened Communities may appear contradictory compared to its county-level SVI findings, which suggested low social vulnerability. In part, this can be a result of having only a portion of Gloucester County within WMA17. Further examination of the Overburdened Communities in Gloucester County's WMA17 municipalities reveals that the majority of the municipalities with overburdened designation is from meeting the minority criteria followed by the low-income criteria. There were very few municipalities with census

blocks that had multiple criteria met. Since the SVI scores are based on a ranking process, Gloucester County findings are interpreted as Gloucester County is the least vulnerable compared to the other WMA17 counties. However, the Overburdened Communities analysis reveals that Gloucester County contains vulnerable communities regardless of how they compare to communities in other locations. Therefore, the use of the Overburdened Community designation along with the SVI analysis helped to provide a more comprehensive picture of social vulnerability in WMA17.

## 6. CURRENT LAND USE

**KEY FINDINGS**

- WMA17 land use is dominated by water-resource areas (33% Water and 20% Wetlands), and limited, concentrated development of urban areas.
- All four WMA17 counties have a strong agricultural presence and development strategies that aim to prevent the loss of agriculture and open space.

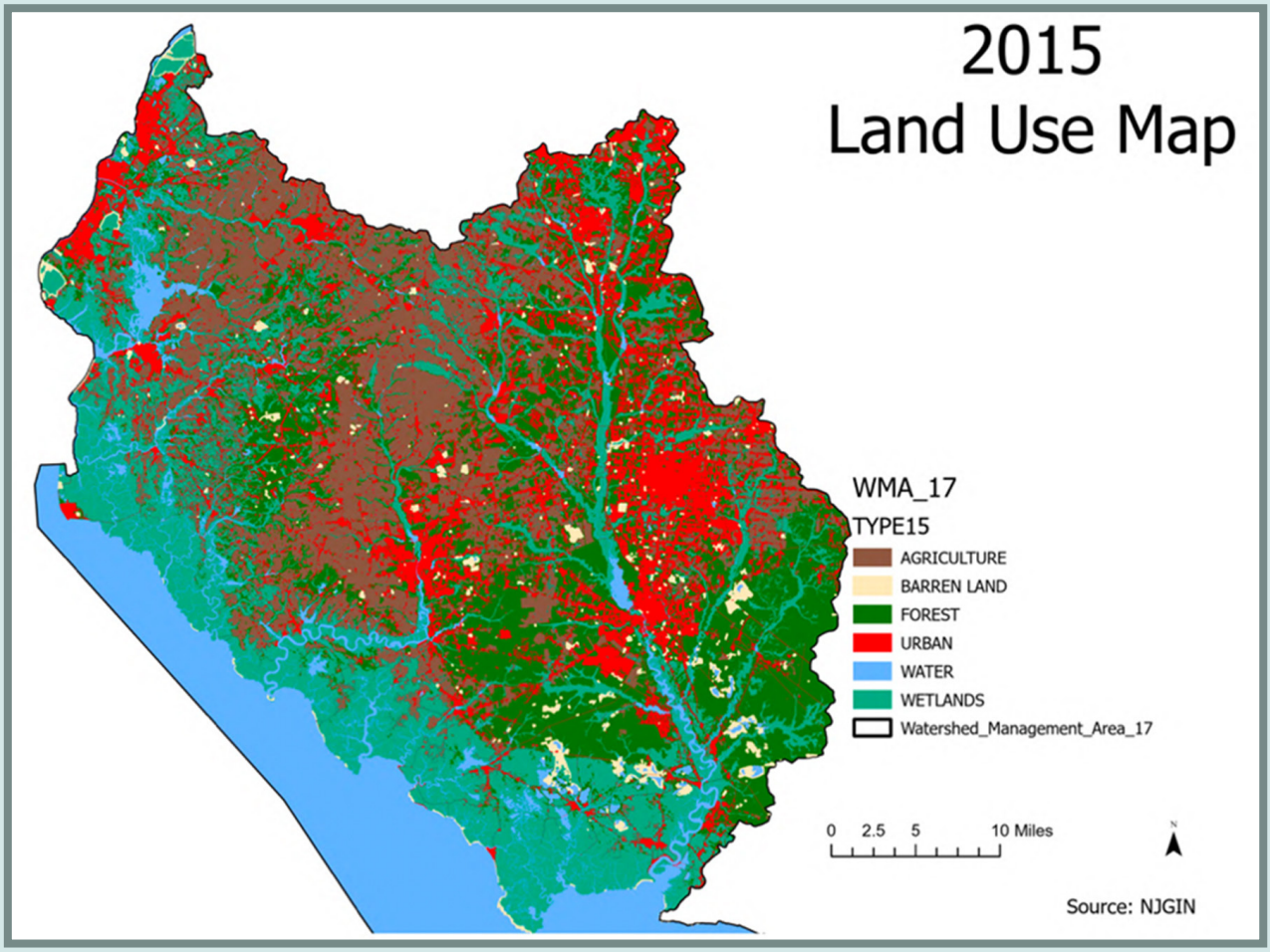
**Table J6.** Land Use in WMA17 and Focus Municipalities
Data provided by DVRPC, 2017, Rutgers Cooperative Extension Water Resources Program (2016a, 2016b, 2016c, 2016d, 2018a, 2014) and NJDEP Bureau of GIS, 2019
*Wetlands value not provided

| Area | Urban | Agriculture | Forest | Barren Land/ Vacant | Wetlands | Water |
|---|---|---|---|---|---|---|
| **WMA17 Region (2015)** | 11% | 18% | 17% | 1% | 20% | 33% |
| ***Focus Municipalities*** | | | | | | |
| **Glassboro Borough (2015)** | 44% | 6% | 40% | 6% | * | 1% |
| **Vineland City (2012)** | 37% | 14% | 33% | 2% | 14% | 1% |
| **Bridgeton City (2012)** | 65% | 2% | 21% | 1% | 6% | 5% |
| **Millville City (2012)** | 28% | 10% | 42% | 1% | 13% | 6% |
| **Salem City (2012)** | 50% | 12% | 4% | 2% | 22% | 10% |
| **Carney's Point Township (2012)** | 26% | 26% | 14% | 2% | 28% | 5% |
| **Pilesgrove Township (2012)** | 13% | 64% | 12% | 10% | 11% | 1% |

Table J6 provides the 2012 and 2015 land use data for the WMA17 region and its focus municipalities (Also see Map J8). As shown in the table, WMA17 has significant land use in open space, with 2015 reports of 17% forest, 33% water, and 20% wetlands land use/land cover, some portion of which has been permanently preserved. The significant portion of land use in the region in wetlands (20%) and water (33%) also demonstrates WMA17's extensive coastal area, which makes development within the region significantly influenced by the Coastal Area Facilities Review Act (CAFRA) along the coastal area. WMA17 regional approaches to concentrate development in already established towns is evident in the reported 2015 regional urban land use percentage, which is only 11%.

All four WMA17 counties have identified development strategies that rely on pre-existing development and infrastructure. Salem County is interested in promoting development in the western part of the county, which has the most population density and the most public water and sewer infrastructure (Salem County Agriculture Development Board & Salem County Open Space Advisory Committee, 2008). Since approximately two-thirds of the county's land has some type of conservation

or development limitation, Cumberland County has anticipated that development will occur in Vineland, Millville, and the adjacent city limits areas of Hopewell, Upper Deerfield, and Fairfield (Cumberland County Improvement Authority, 2020; Simone Collins Landscape Architecture & Reed Group, 2011). Gloucester County residents support the use of development strategies that infill already existing downtown areas of the county due to their concerns about loss of open space (DVRPC, 2015). Atlantic County also has planning goals designed to promote targeted growth in areas with existing infrastructure that are located outside of flood-prone areas and protect agriculture and environmental resources (Heyer, Gruel & Associates and Michael Baker International, 2018a).




**Map J8.** 2015 Land Use Map of WMA17

## *6.1 FARMLAND PRESERVATION AND OPEN SPACE*

WMA17 counties have a strong agricultural presence, and many farmers have adopted water conservation practices, adopted drip irrigation, and implemented other strategies due to increased difficulties to get water allocation permits (Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). Highlights of agricultural productivity in WMA17 counties are included below.

- **Salem County:** contains the agricultural hub, Pilesgrove Township. Known for its productive soils, Salem has strong public support for farmland preservation, despite the sector facing challenges from development encroachment, rising property value costs, and rising production and labor costs (Alaimo Group, 2012; Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; Salem County Agriculture Development Board & Salem County Open Space Advisory Committee, 2008). The 2017 Census of Agriculture reported Salem County to have a total of 781 farms and 98,239 acres of agricultural land. The median size of farms was 25 acres, and Salem County's market value of agricultural products sold was $102,342,000.
- **Cumberland County:** Known for its production of crops including cabbage, herbs, and lettuce, the 2017 Agricultural Census reported Cumberland County had 560 farms and 66,256 acres of agricultural land. Its median farm size was similar to Salem County's (26 acres), but its market value of agricultural products sold was larger ($212,649,000) (National Agricultural Statistics Service, 2019a; National Agricultural Statistics Service, 2019b).
- **Gloucester County:** has some of the most productive farmland in New Jersey and as of 2015, about 20% of the county was used for agricultural operations (Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015).
- **Atlantic County:** includes Buena Borough and Buena Vista Township, which both have a strong economic base for agricultural production (Heyer, Gruel & Associates and Michael Baker International, 2018a).

WMA17 counties have also made efforts to preserve their open space and reduce their impervious surfaces to increase groundwater recharge. Vineland City, Bridgeton City, and Millville City have all reported impervious surface amounts that are considered harmful to their local waterways. According to 2012 NJDEP Land Use/Land Cover data, Bridgeton, Millville, and Vineland reported 26.4%, 9.0%, and 11.4% impervious cover, respectively (Rutgers Cooperative Extension Water Resources Program, 2016b; Rutgers Cooperative Extension Water Resources Program, 2016c; Rutgers Cooperative Extension Water Resources Program, 2016a). In response to these challenges, these locations have been working to preserve open space in areas considered critical for their waterways. In 2018, Vineland was working with Millville to preserve the Menantico Creek corridor, and Vineland has acknowledged the need for continuous monitoring of the Manumuskin River, Maurice River, and Menantico Creek (City of Vineland Planning Board, 2018). Despite facing development pressure in its western areas, Atlantic County's rural areas are dominated by low density development and preserved land, and face Pinelands land use restrictions. As of 2018, Buena Borough had a total of 227.5 acres of municipal parks, and Buena Vista Township had a total of 361.4 acres of municipal parks (Heyer, Gruel & Associates, 2018).

# 7. WATER AVAILABILITY AND DEMAND ANALYSIS

**KEY FINDINGS**

- Overall WMA17 withdrawals have declined since the 1990s and have been a roughly even split between water withdrawals from surface water and unconfined groundwater sources since 2012. After 2010, commercial, industrial, and mining re-established itself as the top water use category for withdrawals, with agriculture/ irrigation and potable supply as smaller, but consistent water use categories.
- WMA17's HUC11s with the largest average withdrawals between 2016-2020 include 02040206110 (Dividing Creek), 02040206030 (Salem R (above 39d40m14s dam)/Salem Canal), and 02040206180 (Menantico Creek). The largest consumptive water use in WMA17 between 1990-2020 was for agricultural/irrigation purposes.
- NJDEP Low Flow Margin data reveals six of 19 WMA17 HUC11s were unstressed during their three-year rolling averages of peak depletive/consumptive loss. The HUC11s with the largest deficits were 02040206080 (Cohansey River above Sunset Lake), 02040206150 (Muddy Run), and 02040206180 (Menantico Creek).
- The Salem, Maurice, and Cohansey rivers have all been found to suffer some water quality impairment, with elevated levels of nutrients including Phosphorus and Lead.

Figure J5a shows WMA17 water withdrawals from 1990-2020 based on water withdrawal source. Water was withdrawn predominantly from surface water sources in the 1990s, which were on average 55% of total withdrawals. A significant decline in surface water withdrawals led to the majority of water withdrawals in WMA17 to come from unconfined groundwater sources after 2002. This decline was due in large part to a mining company ceasing surface water withdrawals between 2002 and 2003 (Hanson Aggregates, a firm specializing in sand, gravel, and crushed stone). Dominant use of unconfined groundwater sources persisted throughout the early 2000s, and ultimately changed to a roughly even split between water withdrawals from surface water and unconfined groundwater sources after 2012 (NJDEP Division of Water Supply and Geoscience, 2021).

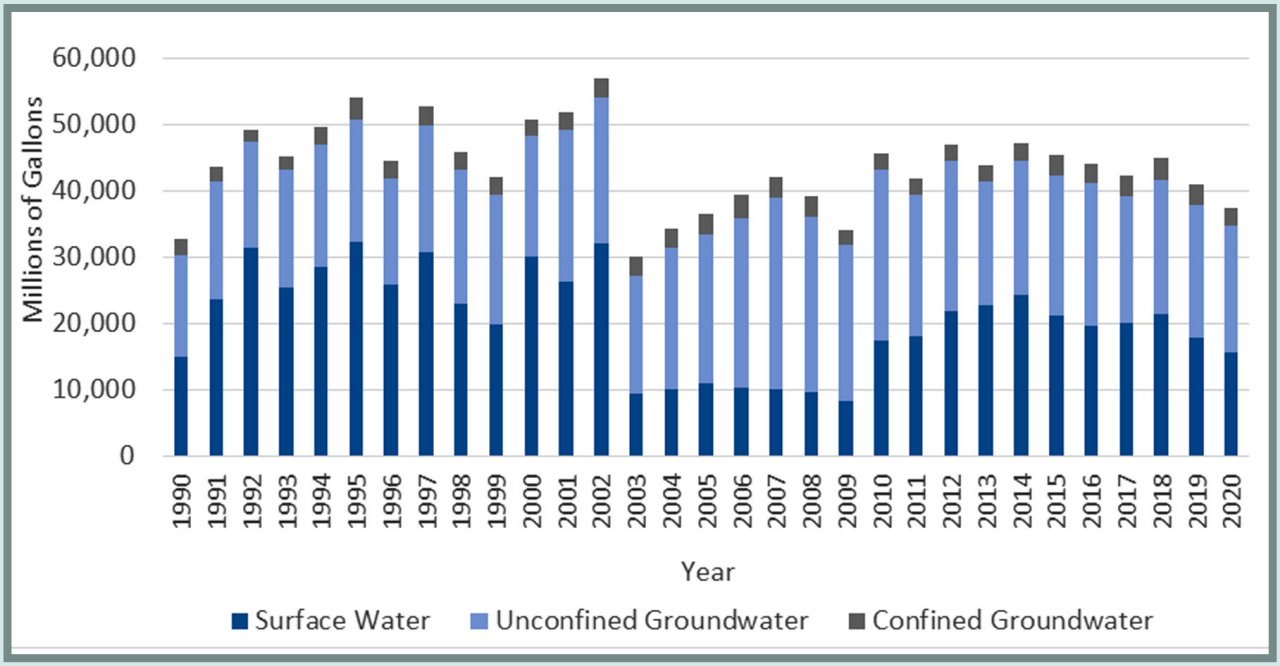



**Figure J5a.** WMA17 Water Withdrawals by Source (1990-2020)

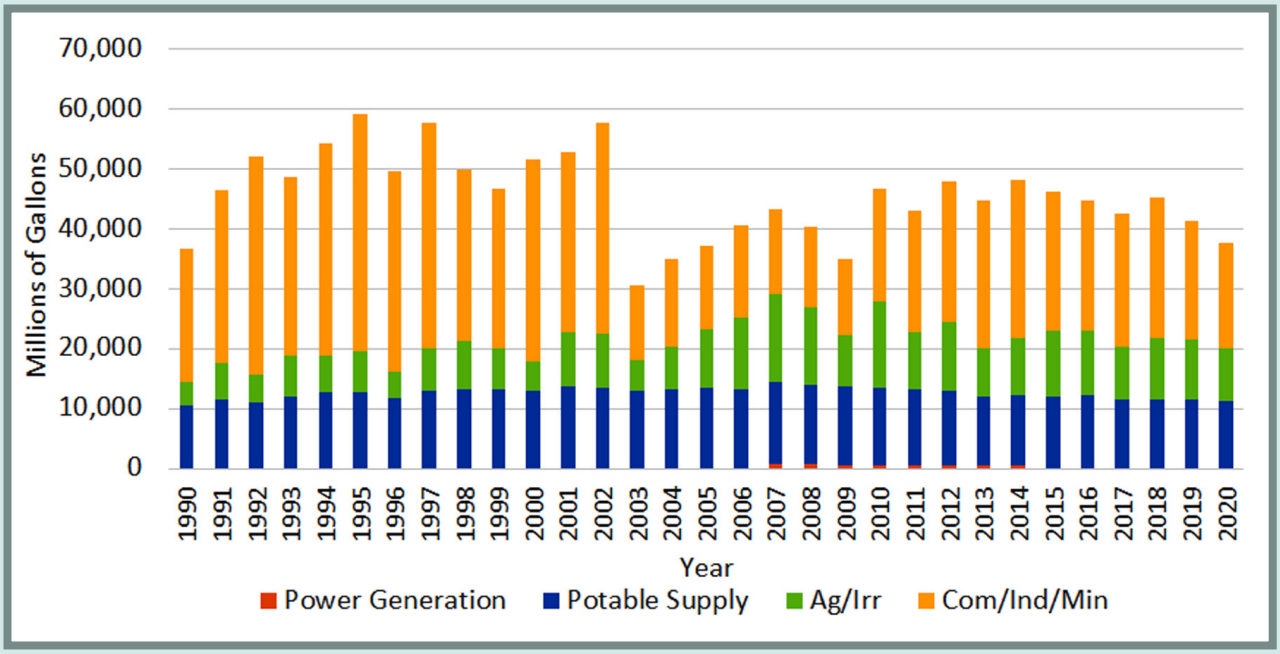



**Figure J5b.** WMA17 Water Withdrawals by Water Use Category (1990-2020)

As shown in Figure J5b, WMA17 water withdrawals were primarily for commercial, industrial, and mining purposes throughout the 1990s. On average, commercial, industrial, and mining withdrawals were 63% of total WMA17 withdrawals during this period, with approximately 72% of these withdrawals used for mining and 28% used for industrial purposes. Significant decline in water withdrawals after 2003 led to water withdrawals for potable supply and commercial, industrial, and mining purposes to be very similar and dominant withdrawal categories between 2003-2009. After 2010, commercial, industrial, and mining re-established itself as the top water withdrawal water use category, although water withdrawals for both potable supply and agriculture and irrigation remained significant water use categories through 2020. It should be noted that the Salem Nuclear Generation facilities use water directly from the Delaware River, as use not reflected in these graphs as this withdrawal does not affect WMA17 water availability (NJDEP Division of Water Supply and Geoscience, 2021).

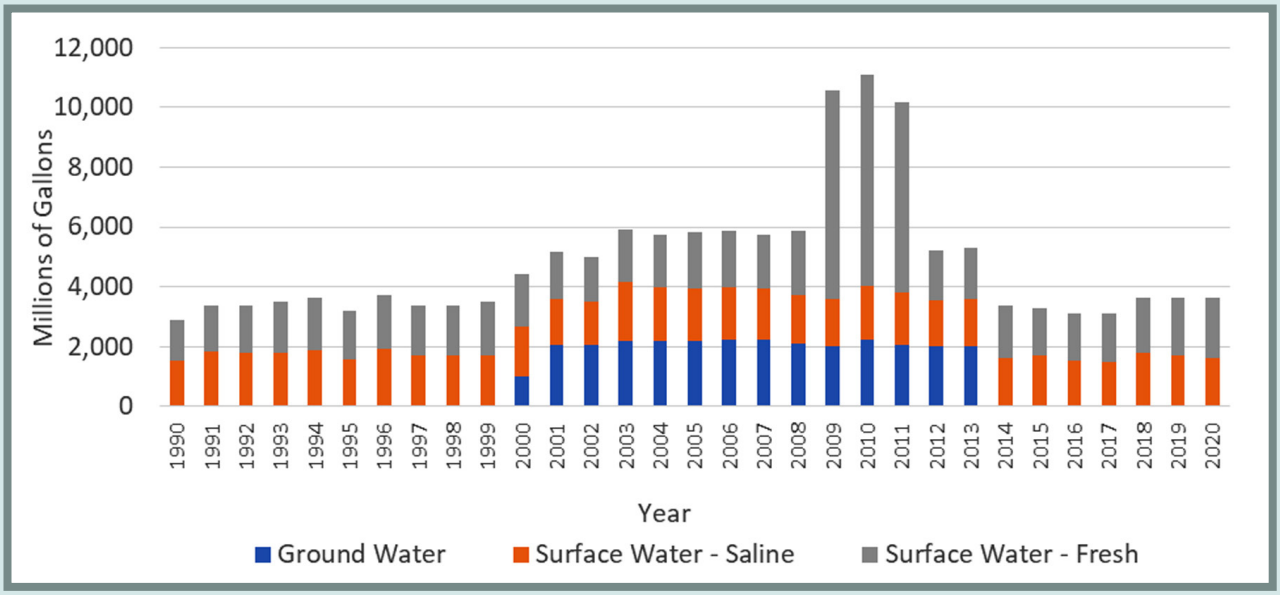



**Figure J6.** WMA17 Sanitary Sewer Returns by Source (1990-2020)

Figure J6 shows WMA17 sanitary sewer discharges (returns) to groundwater and surface water sources from 1990-2020. Throughout the 1990s and from 2014-2020, WMA17 discharges were only to surface water sources, which were a roughly 50/50 split to surface saline water and surface fresh water sources. Between 2000 and 2013, WMA17 discharged to groundwater sources, which varied between 19% and 41% of WMA17's total discharges in a given year. Almost all of these groundwater discharges (approximately 97%) were from Landis Sewerage Authority, serving the Vineland area. Between 2009 and 2011, WMA17's discharges to surface fresh water sources grew significantly, becoming slightly less than two-thirds of the WMA's total discharges. This sudden spike in discharges to surface fresh water sources was due to short-term discharges from the chemical manufacturing site, Dupont Chamber Works (now Chemours Chambers Works), and Seabrook Brothers & Sons Inc. (a food and vegetable processing company) during this time period (NJDEP Division of Water Supply and Geoscience, 2021).

## *7.1 WATER QUANTITY*

Figure J7 shows the average water withdrawals for each HUC11 in WMA17 based on water use category between 2016-2020. The HUC11, 02040206110 (Dividing Creek), had the largest average water withdrawal between 2016-2020, which was slightly less than 9,400 million (9.4 billion) gallons. This water withdrawal was almost entirely for commercial, industrial, and mining purposes, with mining making up the majority (approximately 82%) of total withdrawals in this 5-year period. The HUC11s with the next largest average withdrawals were 02040206030 (Salem R (above 39d40m14s dam)/Salem Canal) and 02040206180 (Menantico Creek). While 02040206030's water withdrawals were predominantly for commercial, industrial, and mining purposes, 02040206180's water withdrawals were largely split between agricultural and irrigation (approximately 34% of average withdrawals) and commercial, industrial, and mining purposes (approximately 47% of average withdrawals). Both of these HUC11s had average withdrawals of approximately 4,476 and 3,673 million gallons for the five-year period, respectively (NJDEP Division of Water Supply and Geoscience, 2021).

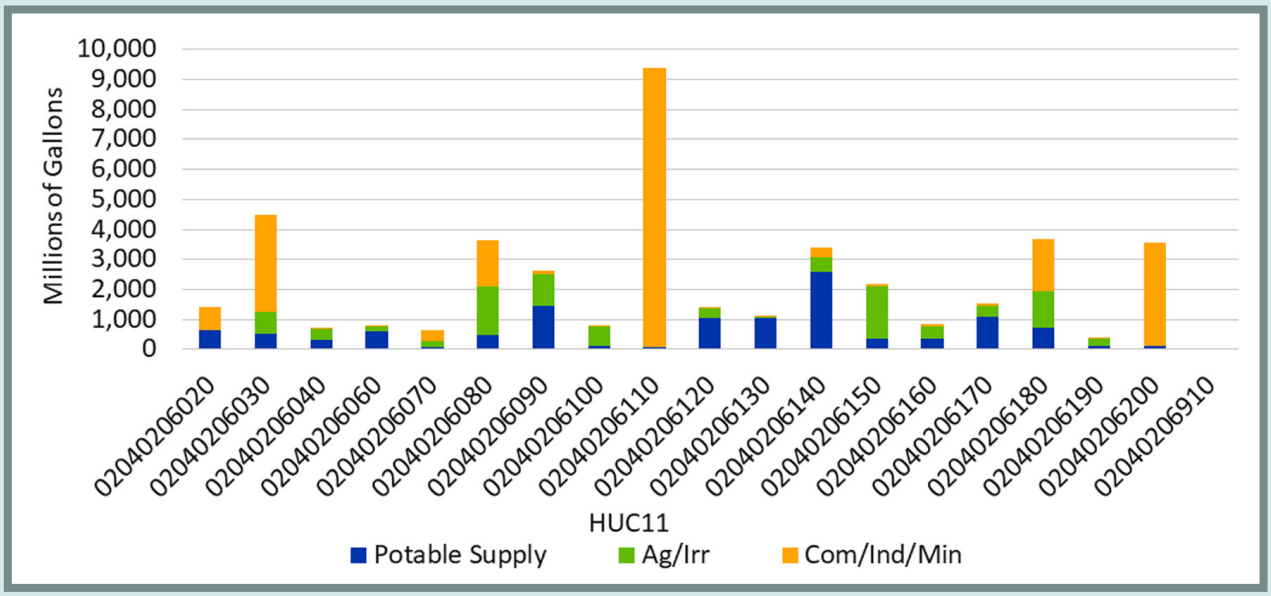



**Figure J7.** WMA17 HUC11 5-Year Average Water Withdrawals by Water Use Category (2016-2020)

Figure J8 provides the annual consumptive water use in WMA17 by water use category between 1990-2020. Consumptive water use is considered water that is removed from a water source, used, and ultimately lost (often through evapotranspiration processes), which can vary by water use category (since a different percentage of water evaporates for different water uses) and in different seasons. This water use is different than depletive water use, in which water is removed from its source area and discharged in another HUC11 or tidal waters (depletive water uses are tracked separately). Therefore, Figure J8 reflects the total annual amount of water lost to each HUC11 for each water use category in WMA17 between 1990-2020 (NJDEP Division of Water Supply and Geoscience, 2021).

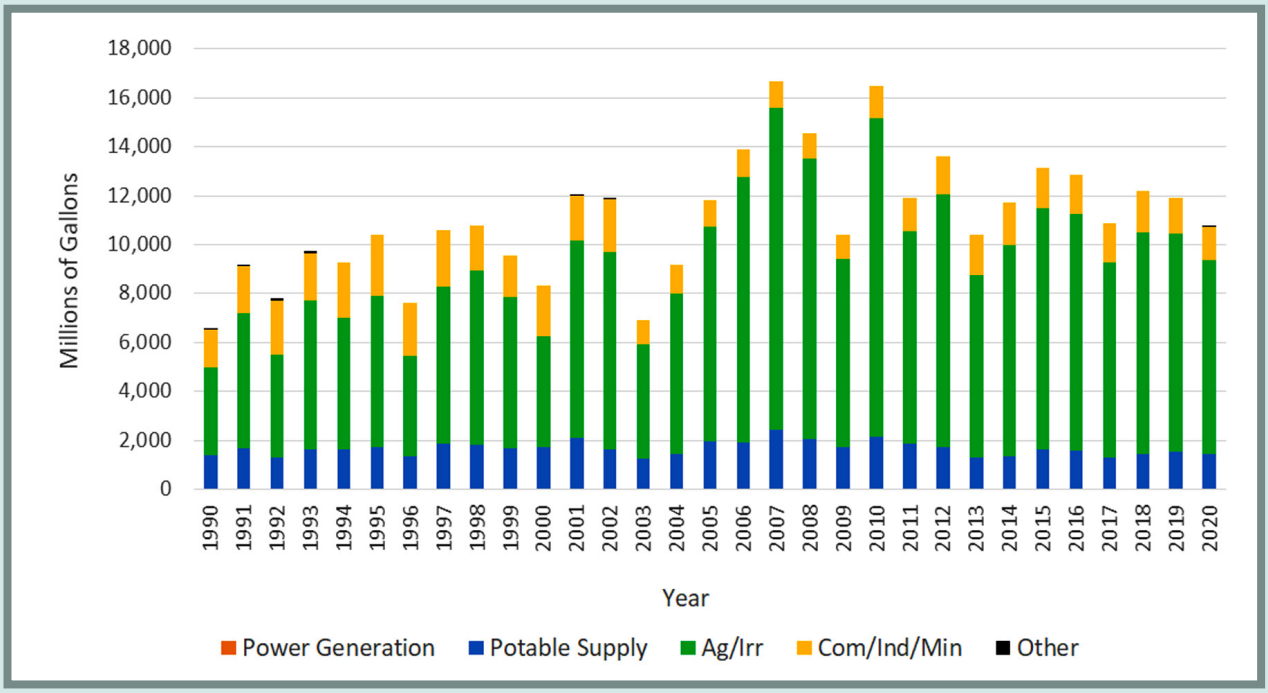



**Figure J8.** WMA17 Consumptive Water Use by Water Use Category (1990-2020)

As shown in Figure J8, consumptive water use in WMA17 experienced a gradual increase and decline in the time period considered. WMA17 had an average consumptive water use of approximately 9,127 million gallons a year (9.127 billion gallons a year) in the 1990s, which increased to 12,012 million gallons a year between 2000-2010, and declined to 11,938 million gallons a year between 2011-2020. Agriculture and irrigation (Ag/Irr) had the largest consumptive water use among WMA17's water use categories throughout the considered time period. Water use for the agriculture/irrigation category was almost entirely for agricultural purposes (approximately 98% between 1990-2020). In comparison to the other water use categories, most water used for agriculture evaporates with almost all of its withdrawn water being consumed (evaporated) in the summer months. Agricultural consumptive water use as a percentage of total WMA17 consumptive water use has increased over time, with agricultural consumptive water use being approximately 58% of WMA17's total consumptive water use in the 1990s and approximately 72% of WMA17's total consumptive water use between 2000-2020 (NJDEP Division of Water Supply and Geoscience, 2021).

Figure J9 provides monthly consumptive water use data for WMA17 by water use category between 2005-2020. Similar to the overall consumptive water use for WMA17, agriculture/irrigation had larger consumptive water use between 2005-2010 (approximately 10,818 million gallons a year) compared to 2011-2020 (approximately 8,838 million gallons a year). The large peaks for agriculture/irrigation show the significant seasonality of consumptive water use for this water use category, in which the largest consumptive water use is experienced in the summer months. Agriculture/irrigation experienced its highest peaks in July 2007 (approximately 3,311 million gallons) and July 2010 (approximately 3,021 million gallons) (NJDEP Division of Water Supply and Geoscience, 2021).

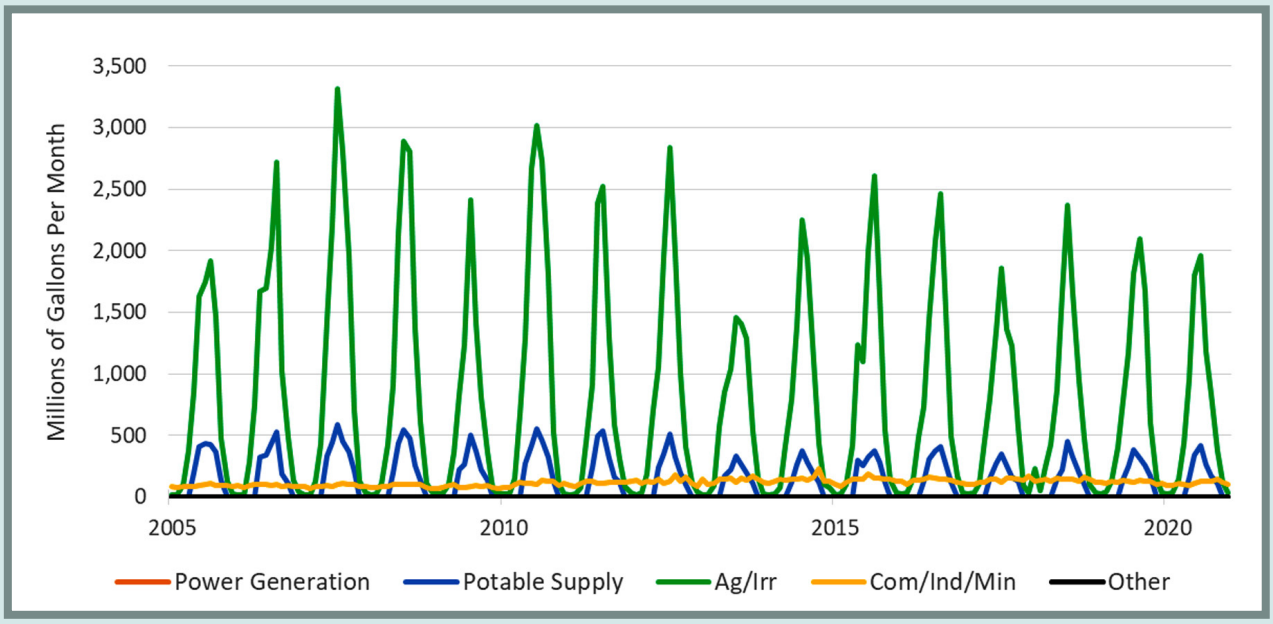



**Figure J9.** WMA17 Monthly Consumptive Use by Water Use Sector (2005-2020)

In comparison, consumptive water use for potable supply in WMA17 also experienced seasonal peaks in summer months, but on a much smaller scale. Overall consumptive water use for potable supply has also declined over time, with potable supply having an average consumptive water use of approximately 2,039 million gallons a year between 2005-2010 and 1,524 million gallons a year between 2011-2020. Consumptive water use for commercial/industrial/mining purposes did not show a seasonal effect and had consistent consumptive water use throughout the year. However, consumptive water use for this water use category increased gradually over time, with an average consumptive water use of approximately 1,109 million gallons a year experienced between 2005-2010 and 1,574 million gallons a year experienced between 2011-2020 (NJDEP Division of Water Supply and Geoscience, 2021).

## LOW FLOW MARGIN METHOD

NJDEP uses the streamflow Low Flow Margin (LFM) method to consider what HUC11s are or may be stressed based on their largest three-year running average (peaks) in consumptive/depletive water loss, regarding use of the unconfined (surficial) aquifer and surface waters (confined aquifers are addressed separately). Figure J10a and b show the amount of available water used in each HUC11 during their peak three-year average loss intervals between 2011-2020. In both figures, the only HUC11 with net gain in WMA17 (02040206020-Pennsville/Penns Grove tribs), is indicated in green in both figures. Any HUC11 with depletive/consumptive loss greater than 100% water available is indicated in red and is considered potentially vulnerable or stressed.

As shown in the figures, six out of 19 WMA17 watersheds are considered unstressed (although two HUC11s have such little water remaining, it is barely or not visible in Figure J10b). Within WMA17, the agriculture and irrigation water use category was identified as the largest source of consumptive/depletive loss, which was identified in 11 of 19 HUC11s. Potable supply was the second largest source of consumptive/depletive loss among WMA17 HUC11s (found in four HUC11s). Of the 13 stressed HUC11s, nine HUC11s had agriculture and irrigation as their largest source of depletive/consumptive loss (compared to three HUC11s for potable supply).

Notice that the negative HUC11s in Figure J10b are more negative than the positive HUC11s are positive, indicating WMA17's vulnerability to stress during periods of peak water loss. The HUC11s considered most stressed are 02040206080 (Cohansey River above Sunset Lake) and 02040206150 (Muddy Run), followed by 02040206180 (Menantico Creek) and 02040206030 (Salem R(above 39d40m14s dam)/Salem Canal). The agriculture and irrigation water use category was the largest source of consumptive/depletive loss for all four of these HUC11s (NJDEP Division of Water Supply and Geoscience, [forthcoming]). However, as discussed in the 2024 Plan, the tracking of agricultural demands has been an ongoing issue, with the potential for both overcounting and undercounting of water withdrawals and of consumptive losses.

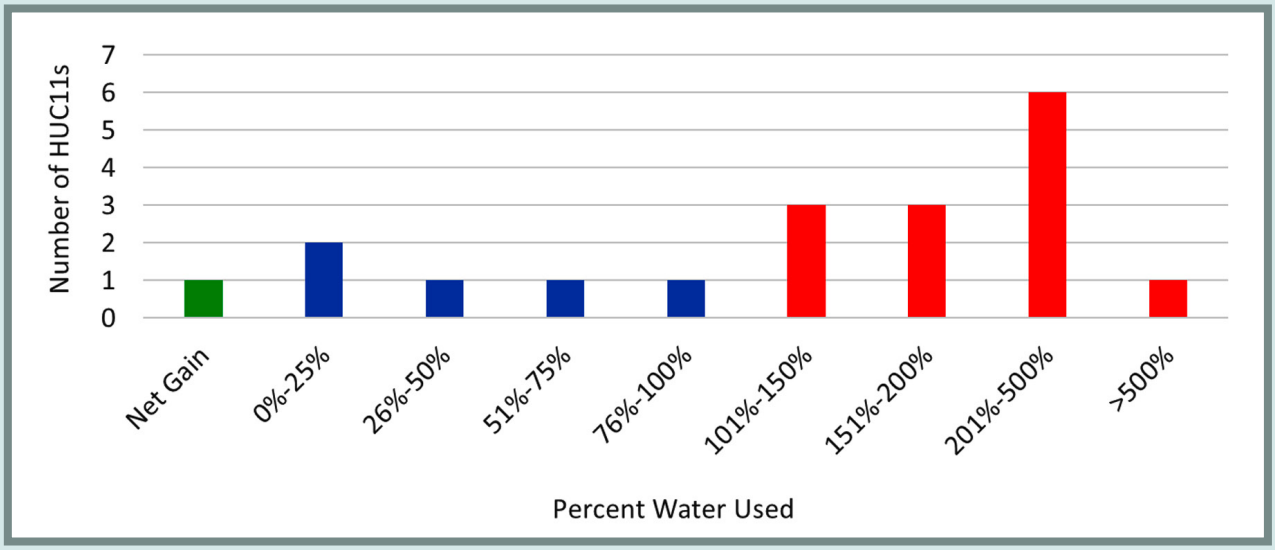



**Figure J10a.** WMA17 HUC11 Count by Percentage of Total Availability Used (Rolling Average Three-Year Peak in Depletive and Consumptive Loss 2011-2020)

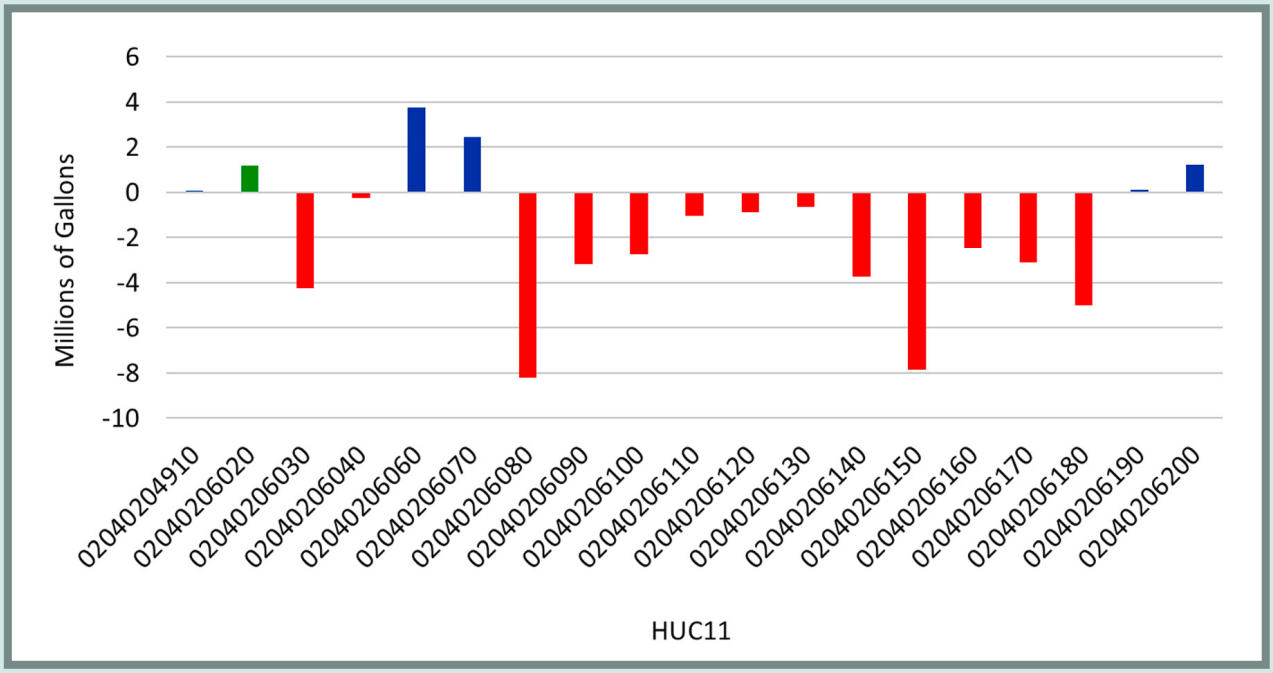



**Figure J10b.** WMA17 HUC11 Remaining Available Water for Rolling Average Three-Year Peak in Depletive and Consumptive Loss (2011-2020)

## *7.2 WATER QUALITY*

Water quality degradation of WMA17 surface water sources has occurred, which poses a threat to both regional surface water and groundwater sources. The regional water system is highly interconnected, in which the water quality of the surface water system is connected with the unconfined groundwater system (NJ Division of Fish and Wildlife, 2004). Sources of surface water contamination can include: (a) deforestation/development; (b) urbanization; (c) agricultural operations; (d) municipal and industrial wastewater discharge (point source); (e) artificial channelization; (f) upstream impoundments; (g) drought conditions; and (h) leaking septic systems (Sickels & Associates, Inc., 2021; NJ Division of Fish and Wildlife, 2004; Rutgers Cooperative Extension Water Resources Program, 2012; Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006). Information about the water quality of WMA17's three major rivers are provided below.

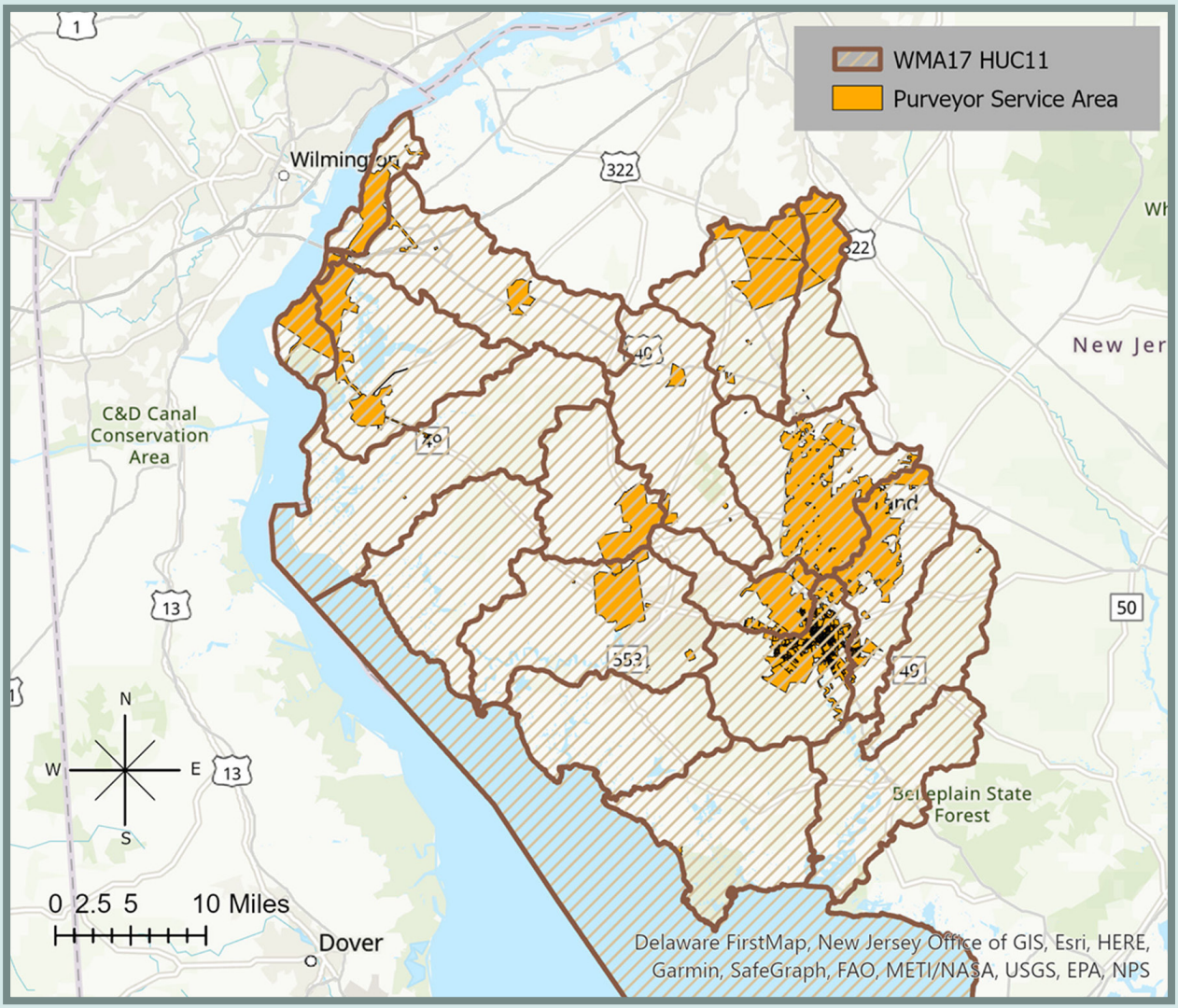
- **Salem River:** According to NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report, the Salem River is failing to meet water quality standards in Dissolved Oxygen (DO), pH, Total Phosphorus, Total Suspended Solids, turbidity, Arsenic, and *E. coli*. Salem River tributaries have also been found to suffer from impairment. For example, Majors Run has been found to suffer from excessive fecal coliform levels (NJDEP Division of Water Monitoring and Standards, 2021a; NJDEP Division of Water Monitoring and Standards, 2021b).
- **Maurice River:** The Maurice River has been found to be severely impaired with high concentrations of Mercury, coliform bacteria, Arsenic, and Lead. Parts of the Maurice River also have excessive levels of E. coli and Arsenic (NJDEP Division of Water Monitoring and Standards, 2021a; NJDEP Division of Water Monitoring and Standards, 2021b).
- **Cohansey River:** The Cohansey River (particularly its headwaters) is considered highly vulnerable to contamination, and a Watershed Restoration Plan has been adopted to reduce its fecal coliform, Lead, and Phosphorus concentrations (Salem County Agriculture Development Board & Salem County Open Space Advisory Committee, 2008; Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006). Water quality testing of the Cohansey River for the NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report shows that the Cohansey River suffers from elevated levels of Total Phosphorus and fecal coliform (NJDEP Division of Water Monitoring and Standards, 2021a).

Groundwater sources in WMA17 also face water quality risks, especially in its recharge areas. Since the Kirkwood-Cohansey Aquifer is recharged from percolation by precipitation, risks to the aquifer include contamination from agricultural chemicals, illegal dumping, chemical spills, and septic systems. However, one benefit for the Kirkwood-Cohansey Aquifer is that, unlike the PRM Aquifer, which has heavily developed recharge areas, most of its recharge area is not developed. Since the PRM Aquifer has an overlying clay layer to protect it, it is considered less vulnerable to contamination than the MLW Aquifer (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; NJ Division of Fish and Wildlife, 2004). However, water withdrawals and sea level rise both increase concerns of saltwater intrusion into WMA17's aquifers.

## 8. WATER UTILITIES AND WATER INFRASTRUCTURE

**KEY FINDINGS**

- Although most of WMA17's PCWSs reported a decline in potable water demand between 2011-2020, the largest increases in potable supply demand were Pennsville Township WD, New Jersey American Water – Logan, and Clayton Borough WD.
- WMA17 PCWS 2050 demands projections indicate that roughly half of WMA17 PCWSs will have decreased demand, but several PCWSs, such as Bridgeton City WD and Washington Township MUA, are anticipated to experience demand increases in 2050.
- WMA17 PCWS 2050 demands projections also suggest that some PCWSs servicing WMA17 Gloucester municipalities may face difficulties in meeting 2050 demand, with demands exceeding current PCWS capacity. While almost all Salem County PCWSs are projected to experience demand decline in 2050, PCWSs servicing Cumberland County municipalities are projected to have a mix of demand increase and decline.




**Map J9.** Public Community Water System (PCWS) Purveyor Service Areas in WMA17's HUC11s
Source: NJDEP Bureau of GIS

Table J7 shows the public community water systems (PCWSs) that serve over 1,000 people and service the HUC11s in WMA17 (See Map J9 for all PCWS purveyor service areas in WMA17's HUC11s). The listed PCWSs that serve Salem County include New Jersey American Water-Penns Grove, Pennsville Township WD, Woodstown WD, and Salem WD. Cumberland County's PCWSs include Upper Deerfield Township WD, Bridgeton City WD, Millville WD, and Vineland Water & Sewer Utility. Gloucester County is serviced by several PCWSs including Washington Township MUA, Glassboro Borough WD, Clayton Borough WD, Logan Township MUA, Monroe Township MUA, and New Jersey American Water - Logan. While most of the listed PCWSs reported a decline in potable water demand, Pennsville Township WD, New Jersey American Water – Logan, and Clayton Borough WD reported the largest increase in potable supply demand between 2011 and 2020 (NJDEP Division of Water Supply and Geoscience, 2022a; NJGWS, 2022). Of the PCWSs, Clayton Borough WD reported a firm capacity deficit (approximately -0.1 mgd); firm capacity represents the ability of a utility to provide water with its largest unit out of production (e.g., the largest well in a wellfield) (NJDEP Division of Water Supply and Geoscience, 2022b).

Table J8 provides NJDEP 2050 projected demands for WMA17's major PCWSs based on the demand projections provided in Appendix D. The table provides four 2050 projected demands scenarios, which include nominal and optimal water loss scenarios under a No Conservation and Conservation scenario. Nominal water loss scenarios assume that 2050 water losses will be the same as current median PCWS water losses for the Coastal Plain region. Optimal water loss scenarios assume that PCWSs will meet a more aggressive water loss standard (25th percentile for the Coastal Plain region). No Conservation scenarios assume that recent per capita demands remain stable through 2050, while Conservation scenarios assume a 10% reduction in per capita demands. Surplus/Deficit refers to limitations of an Allocation Permit or Water Use Registration minus the sum of demand recorded based on water use records plus demand projected for approved projects. Often, this data is expressed as either annual (mgy) or monthly (mgm) data, but it is expressed as average daily volumes (mgd) in Table J8. Negative surplus/deficit values indicate a shortage in diversion privileges or available supplies through bulk transfer agreements (NJDEP Division of Water Supply and Geoscience, 2022b).

Overall, roughly half of WMA17's PCWSs are projected to have demand decline (indicating more available firm capacity), and only one PCWS (Fairview Manor Mobile Home Park) is anticipated to experience deficit by 2050. WMA17 PCWSs projected to experience demand increases include Bridgeton City WD, Washington Township MUA, and Monroe Township MUA. Potential concern was identified for Monroe Township MUA, since deficit was detected in one of its 2050 peak demands scenarios (not listed in Table J8). Demand decline was projected for many PCWSs servicing Salem municipalities, including Salem WD, New Jersey American – Penns Grove, Woodstown Borough WD, and Elmer Borough WD. These findings align with the findings from Section 4's population projections section, which projects Salem County's population to decline through 2050.

**Table J7.** Public Community Water Systems in WMA17 Servicing More Than 1,000 People and the HUC11(s) They Serve
Data provided by NJDEP DWSG (NJDEP Division of Water Supply and Geoscience, 2022a; NJGWS, 2022)

| Purveyor | Purveyor ID | HUC11s Served | Demand Percent Change (2011-2020) | Average Demand (mgy) (2011-2020) | Max Demand (mgy) (2011-2020) |
|---|---|---|---|---|---|
| NJ American Water- Penns Grove | NJ1707001 | 02040206020, 02040206030 | -15% | 407 | 504 |
| Pennsville Township WD | NJ1708001 | 02040206020, 02040206030, 02040206040 | 28% | 357 | 427 |
| Woodstown WD | NJ1715001 | 02040206030 | -11% | 128 | 137 |
| Salem WD | NJ1712001 | 02040206040, 02040206060 | -9% | 324 | 361 |
| NJ American Water- Logan | NJ0809002 | 02040206020 | 13% | 404 | 439 |
| Upper Deerfield Township WD | NJ0613004 | 02040206080, 02040206090, 02040206150, 02040206160 | -38% | 156 | 207 |
| Bridgeton City WD | NJ0601001 | 02040206090 | -7% | 1,094 | 1,200 |
| Fairton Federal Correctional Institution | NJ0605004 | 02040206090 | 1% | 68 | 75 |
| Monroe Township MUA | NJ0811002 | 02040206120, 02040206130 | -0.3% | 893 | 945 |
| Glassboro Borough WD | NJ0806001 | 02040206120 | -26% | 638 | 711 |
| Clayton Borough WD | NJ0801001 | 02040206120, 02040206130 | 8% | 201 | 234 |
| Harding Woods MPH | NJ1710001 | 02040206120 | -5% | 25 | 29 |
| Washington Township MUA | NJ0818004 | 02040206120, 02040206130 | -12% | 1,447 | 1,714 |
| Vineland Water & Sewer Utility | NJ0614003 | 02040206130, 02040206140, 02040206160, 02040206170, 02040206180 | -22% | 2,662 | 3,054 |
| Buena Borough MUA | NJ0104003 | 02040206140, 02040206180 | -10% | 182 | 198 |
| Newfield WD | NJ0813001 | 02040206140 | -30% | 55 | 78 |
| Millville WD | NJ0610001 | 02040206140, 02040206160, 02040206170, 02040206180, 02040206200 | -10% | 1,176 | 1,291 |
| Elmer Borough WD | NJ1702001 | 02040206150 | -18% | 45 | 51 |
| United Mobile Homes of Vineland | NJ0614005 | 02040206180 | 0.4% | 31 | 41 |

**Table J8.** WMA17 2050 PCWS Demands Projections (NJDEP projections based on Van Abs et al., 2018)
*Red bold text indicates PCWSs in deficit in non-peak 2050 scenarios

| Purveyor ID | Purveyor | Average Daily Demand (2020) (mgd) | 2020 Deficit/ Surplus (mgd) | 2050 No Conservation Scenario | | 2050 Conservation Scenario | |
|---|---|---|---|---|---|---|---|
| | | | | Nominal Water Loss Scenario (mgd) | Optimal Water Loss Scenario (mgd) | Nominal Water Loss Scenario (mgd) | Optimal Water Loss Scenario (mgd) |
| **NJ1707001** | NJ American - Penns Grove | 1.1 | 2.2 | 0.9 | 0.8 | 0.8 | 0.8 |
| **NJ1708001** | Pennsville Township WD | 1.1 | 1.6 | 0.9 | 0.8 | 0.8 | 0.7 |
| **NJ1715001** | Woodstown Borough WD | 0.3 | 0.5 | 0.3 | 0.3 | 0.2 | 0.2 |
| **NJ1712001** | Salem WD | 0.8 | 1.0 | 0.7 | 0.7 | 0.6 | 0.6 |
| **NJ0809002** | NJ American - Logan | 1.2 | 1.8 | 1.1 | 1.0 | 1.0 | 0.9 |
| **NJ0613004** | Upper Deerfield Township WD | 0.4 | 1.1 | 0.4 | 0.4 | 0.4 | 0.4 |
| **NJ0601001** | Bridgeton City WD | 2.9 | 4.1 | 3.5 | 3.3 | 3.1 | 3.0 |
| **NJ0605004** | Fairton Federal Correctional Institution | 0.2 | 0.4 | NA | NA | NA | NA |
| **NJ0811002** | Monroe Township MUA | 2.4 | 4.0 | 2.9 | 2.8 | 2.7 | 2.5 |
| **NJ0806001** | Glassboro Borough WD | 1.7 | 3.6 | 1.6 | 1.6 | 1.5 | 1.4 |
| **NJ0801001** | Clayton Borough WD | 0.6 | 0.9 | 0.6 | 0.6 | 0.6 | 0.6 |
| **NJ1710001** | Harding Woods MPH | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **NJ0818004** | Washington Township MUA | 3.8 | 6.0 | 4.3 | 4.1 | 3.8 | 3.7 |
| **NJ0614003** | Vineland Water & Sewer Utility | 6.8 | 10.0 | 7.2 | 6.9 | 6.5 | 6.2 |
| **NJ0104003** | Buena Borough MUA | 0.5 | 0.7 | 0.5 | 0.5 | 0.5 | 0.4 |
| **NJ0813001** | Newfield Borough WD | 0.1 | 0.5 | 0.1 | 0.1 | 0.1 | 0.1 |
| **NJ0610001** | Millville WD | 3.1 | 5.0 | 3.1 | 3.0 | 2.8 | 2.7 |
| **NJ1702001** | Elmer Borough WD | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| **NJ0614005** | **Fairview Manor Mobile Home Park** | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 |

Within the WMA17 region, areas already possessing sewer infrastructure are established areas and areas prioritized for future growth (Heyer, Gruel & Associates and Michael Baker International, 2018a). Typically, WMA17 locations with public water service also have approved sewer service (DVRPC, 2009; Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). Information on WMA17 county sewer infrastructure is included below.

- **Salem County:** Seven wastewater treatment facilities serve Salem County, and in 2016, they provided 11 Salem municipalities with wastewater services. To meet future wastewater management demands, the following Salem municipalities were projected to require new or expanded capacity to meet demand: (a) Carney's Point Township; (b) Oldmans Township; (c) Elmer Borough; and (d) Pittsgrove Township (Sickels & Associates, Inc., 2016).
- **Cumberland County:** has six facilities that provide sewer service. The largest of these providers are Landis Sewerage Authority, Millville Sewer Utility, and Cumberland County Utilities Authority (DVRPC, 2009). Areas within Cumberland County that have sewer service are the north central portion of the county in Vineland, Bridgeton, and Millville.
- **Gloucester County:** has two distinct sewer service areas of the Gloucester County Utility Authority (GCUA): (a) Consolidated District, and (b) Non-consolidated District. Serving about 80% of the county's population as of 2013, the GCUA Consolidate District service areas include all or parts of 16 Gloucester County municipalities. The GCUA Non-consolidated District includes most of Gloucester County's farmlands and includes all or part of 15 municipalities; most of this area does not have installed sewer collection systems, which are confined to developed areas (Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015).

## *8.1 RELATIONSHIP BETWEEN PROJECTED WATER USE AND DEMOGRAPHIC CHANGES*

While some findings from the 2050 PCWS water demands projections align with findings from the population projections discussed in Section 4, the 2050 demands projections provide evidence that regional PCWSs will overall be able to meet future demand. One potential concern identified in Section 4 was that Gloucester County was projected to experience significant population growth through 2050. Several PCWSs projected to have future demand increase, such as Washington Township MUA and Monroe Township MUA, service some of Gloucester's WMA17 municipalities. These PCWSs were projected to have a remaining capacity of approximately 21% and -4% (indicates deficit) in their peak demand across all 2050 scenarios (including peak scenarios), respectively. One PCWS (Clayton Borough WD) servicing Gloucester's Clayton Borough had split projections. Split projections indicate a PCWS had projected demand increase and decline among its 2050 Non-conservation and Conservation scenarios, respectively. However, as there are several PCWSs servicing Gloucester County municipalities that are projected to have demand decline (New Jersey American-Logan, Glassboro Borough WD, Newfield Borough WD), it is likely that even if potential deficits arise in the future, alternative supplies could be available to meet future demand through interconnections. In addition, potential strategies for PCWSs to improve their surplus/deficit include installation of new infrastructure, engaging in bulk transfer agreements with other PCWSs, emphasizing demand reductions during peak periods (e.g., summer months), making regulatory adjustments to change demand patterns, and identification of new water sources.

Many of the PCWSs projected to experience demand decline service Salem municipalities, while PCWSs servicing Cumberland municipalities had a mix of projected demand increase and decline. This aligns with the expected population decline projected for Salem County and small population growth projected for Cumberland County through 2050. PCWSs with projected demand decline that service Salem municipalities include Salem WD, New Jersey American – Penns Grove, Pennsville Township WD, Woodstown Borough WD, and Elmer Borough WD. These PCWSs (with the exception of Pennsville Township WD and Elmer Borough WD) service the focus municipalities, Carney's Point Township, Pilesgrove Township, and Salem City. Among the PCWSs servicing Cumberland County municipalities, projections included demand decline for several PCWSs, including Newfield Borough WD and Millville WD, and demand increase for Bridgeton City WD. Several PCWSs servicing Cumberland municipalities, such as Upper Deerfield Township WD and Vineland Water & Sewer Utility were split between projecting demand increase and decline among their 2050 Non-conservation and Conservation scenarios, respectively. While there is some uncertainty about future demand among PCWSs servicing Cumberland County municipalities, the overall findings for PCWSs servicing Salem and Cumberland counties suggest that the water supply provided by these PCWSs should be adequate to meet future water demand in 2050.

# 9. CLIMATE CHANGE AND SEA LEVEL RISE ASSESSMENT

**KEY FINDINGS**

- Among the WMA17 counties, Atlantic County is projected to have the largest increase in precipitation across different storm events between 2020-2069.
- Projections of WMA17 water withdrawal and wastewater discharge site inundation for 2050 and 2100 suggest HUC11s 02040206040 and 02040206030 will experience the most facility inundation, followed by 02040206100 and 02040206020. The majority of withdrawal permit sites projected to be inundated with two and five feet of sea level rise are used for agricultural purposes.
- WMA17 communities located along the Delaware River/Bay and WMA17's three main rivers (Salem, Maurice, and Cohansey) are projected to be most vulnerable to inundation from sea level rise. While Salem Water Department is projected to experience the most inundation of its service area among major PCWSs servicing WMA17, the focus municipalities, Bridgeton City, Millville City, and Salem City are projected to have the largest number of Overburdened Community census blocks vulnerable to inundation from sea level rise.

## *9.1 GENERAL CLIMATE CHANGE PROJECTIONS FOR THE WMA17 REGION*

Climate forecasts in WMA17 are anticipated to follow state-wide trends for temperature and sea level rise. Temperature, sea level rise, and precipitation projections for 2050 are included below.

- **Temperature:** Statewide temperatures are projected to increase between 4.1 to 5.7 degrees Fahrenheit by 2050. Winters are anticipated to warm faster (compared to the other seasons), and summers are expected to become hotter.
- **Sea Level Rise:** Statewide sea levels are projected to rise between 1.4 and 2.1 feet by 2050. "Sunny day flooding" is anticipated to occur more frequently, and hurricanes, Nor'easters, and other extreme weather events are projected to increase in severity and frequency.
- **Precipitation:** Overall, New Jersey is projected to receive 4 to 11% more precipitation by 2050. Larger rainfall events are anticipated to increase in frequency, and fall and spring seasons are projected to become wetter (NJDEP, 2020).

**Table J9.** Projected Percent Increase for Precipitation among WMA17 Counties (Moderate RCP 4.5 Scenario for 2020-2069)

| | 2-Year Storm | 5-Year Storm | 10-Year Storm | 25-Year Storm | 50-Year Storm | 100-Year Storm |
|---|---|---|---|---|---|---|
| **Atlantic** | 18% | 17% | 19% | 23% | 26% | 30% |
| **Cumberland** | 16% | 16% | 16% | 19% | 23% | 28% |
| **Gloucester** | 16% | 16% | 17% | 19% | 22% | 26% |
| **Salem** | 17% | 18% | 19% | 21% | 22% | 24% |

Table J9 shows the precipitation projections for WMA17 counties for different level storm events provided by the **New Jersey Extreme Precipitation Projection Tool**. These numbers reflect the upper likelihood for projected precipitation increases, representing a 17% chance that precipitation will increase more than the value shown. As shown in the table, Atlantic County is projected to have the largest precipitation increase among WMA17 counties. Among the three remaining counties, Salem County is projected to have a greater precipitation increase during smaller rain events compared to Cumberland and Gloucester counties, while Cumberland and Gloucester are anticipated to have more precipitation increase during larger rain events compared to Salem (NJDEP, Northeast Regional Climate Center, & Cornell University, 2023).

## *9.2 POTENTIAL CHANGES TO WMA17 WATER AVAILABILITY DUE TO CLIMATE CHANGE*

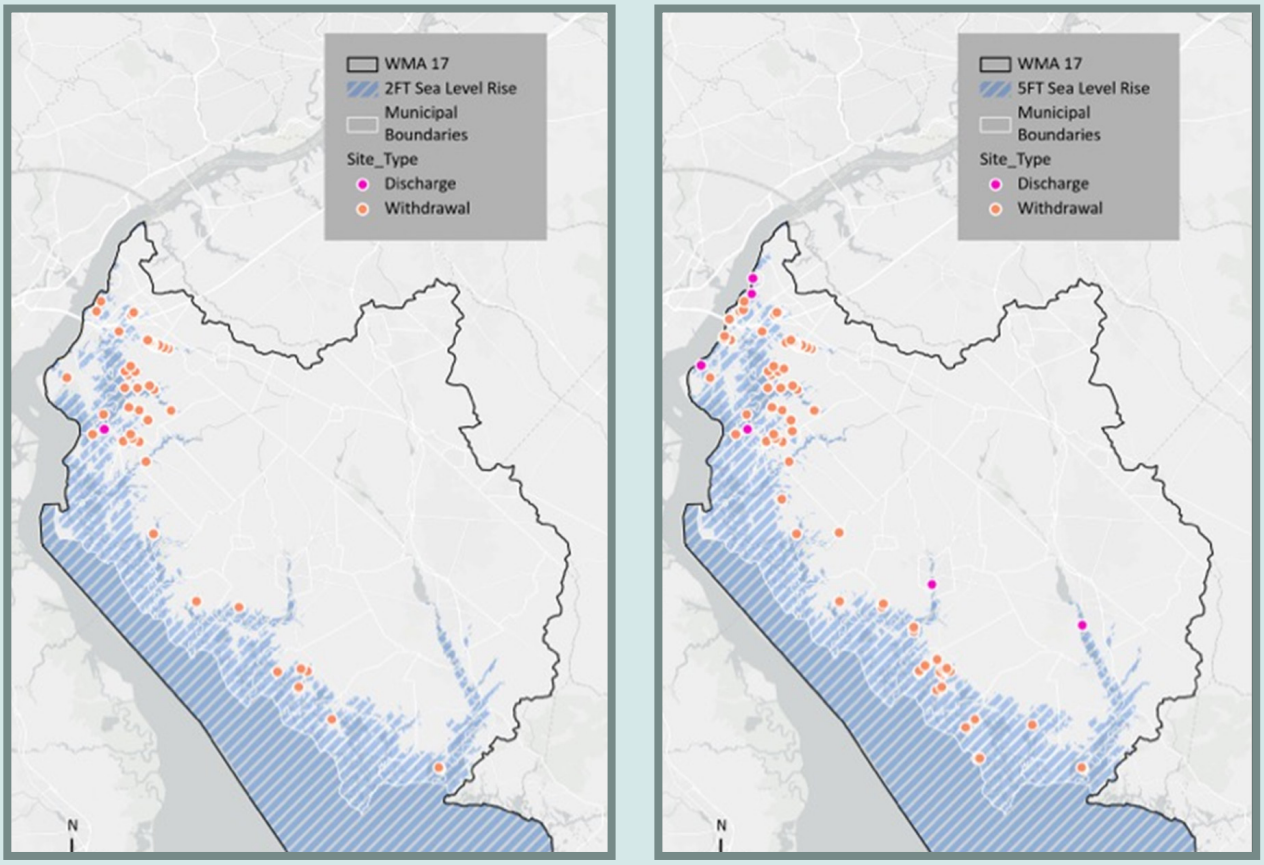
### INUNDATION OF WMA17 AQUIFERS

Inundation of unconfined aquifer systems in the WMA17 region is one critical concern resulting from sea level rise. Research conducted by NJDEP's DWSG finds a two foot increase in sea level would most significantly impact the Kirkwood-Cohansey Aquifer system, with approximately 31,500 acres of the aquifer being directly inundated by sea water. However, with two and five feet of sea level rise, approximately 83,000 and 98,000 acres of the Kirkwood-Cohansey's outcrop (recharge) area would be inundated, respectively. The two and five feet standards are used in the 2024 Plan to approximate a high-end measure of likely sea level rise for 2050 and 2100, respectively (less than a 17% chance of sea level rise exceeding the height indicated).

Inundation of confined aquifer outcrop (or recharge) areas also provides a risk for WMA17 fresh water sources to be infiltrated with sea water. Two confined aquifers at risk in WMA17 include the Magothy (Upper PRM Aquifer) and Potomac (Lower PRM Aquifer) formations. DWSG projects that approximately 8,100 acres of the Magothy Formation and 5,200 acres of the Potomac Formation's outcrop areas will be inundated with two feet of sea level rise.

### WMA17 SITE INUNDATION FROM SEA LEVEL RISE

Sea level rise also poses the risk of WMA17 water withdrawal and wastewater discharge sites becoming inundated with salt water. According to DWSG, unconfined wells with direct connections to the surface would immediately experience inundation from two feet of sea level rise. Confined wells can also face the risk of direct inundation of sea water from the actual wellhead (vertical migration).




**Map J10.** WMA17 Withdrawal and Discharge Sites Projected to be Inundated with 2ft and 5ft of Sea Level Rise

The DWSG database, New Jersey Water, identifies withdrawal and return sites (such as intake pipes, withdrawal wells, discharge sites, and surface water withdrawal sites) used for potable supply, agricultural, industrial, and commercial purposes that are projected to be inundated with two and five feet of sea level rise (see Map J10). However, the New Jersey Water sites provided here may not match with those provided in the NJDEP permit/regulatory database.

As shown in Map J10, all WMA17 permitted sites projected to be inundated in these scenarios are located in Salem and Cumberland counties. With two feet of sea level rise, Salem has many more withdrawal sites that are inundated compared to Cumberland County (37 compared to 9). However, more Cumberland County sites become inundated with five feet of sea level rise than in Salem (Cumberland's inundated permit sites increase to 26 while Salem's increase to 49).

Table J10 shows the number of WMA17 withdrawal and discharge sites that are projected to be inundated with two and five feet of sea level rise. Based on New Jersey Water database data, the WMA17 HUC11s anticipated to experience the most inundation are 02040206040 and 02040206030, with both HUC11s projected to experience significant site inundation with two feet of sea level rise. 02040206100 is also anticipated to have a significant increase in sites inundated with five feet of sea level rise. HUC11s, 02040206020 and 02040206110, are anticipated to experience minimal site inundation with two feet of sea level rise, but have increases in inundation of permitted sites with five feet of sea level rise.

Figure J11 shows which WMA17 municipalities are projected to experience the most withdrawal site inundation with two and five feet of sea level rise. As shown in the figure, Mannington Township is expected to experience the largest number of sites inundated, followed by the focus municipality, Carney's Point Township, and Lawrence Township. PCWSs in Salem City and Pennsville Township have withdrawal sites projected to be inundated with two and five feet of sea level rise, respectively. Another focus municipality, Pilesgrove Township, is projected to have minimal withdrawal site inundation with sea level rise.

**Table J10.** WMA17 Withdrawal and Discharge Sites Inundated by HUC11 (2ft and 5ft of Sea Level Rise)

| HUC11 | Number of Sites Inundated (2ft) | Number of Sites Inundated (5ft) |
|---|---|---|
| ***Withdrawal Sites*** | | |
| **02040206020** | 3 | 7 |
| **02040206030** | 14 | 17 |
| **02040206040** | 18 | 22 |
| **02040206060** | 1 | 2 |
| **02040206070** | 1 | 2 |
| **02040206090** | 2 | 4 |
| **02040206100** | 4 | 14 |
| **02040206110** | 1 | 5 |
| **02040206200** | 2 | 2 |
| ***Discharge Sites*** | | |
| **02040206020** | 0 | 4 |
| **02040206040** | 1 | 1 |
| **02040206090** | 0 | 1 |
| **02040206170** | 0 | 1 |

Several focus municipalities are also projected to have discharge site inundation with two and five feet of sea level rise. Discharge sites for sewer treatment facilities in Carney's Point Township, Millville City, and Bridgeton City are projected to be inundated with five feet of sea level rise, with facilities in Salem City becoming inundated with two feet of sea level rise, complicating the discharge process by backing treated wastewater up the pipelines. Inundation of WMA17's PCWS purveyor service areas with two and five feet of sea level rise will be discussed in the next sub-section.

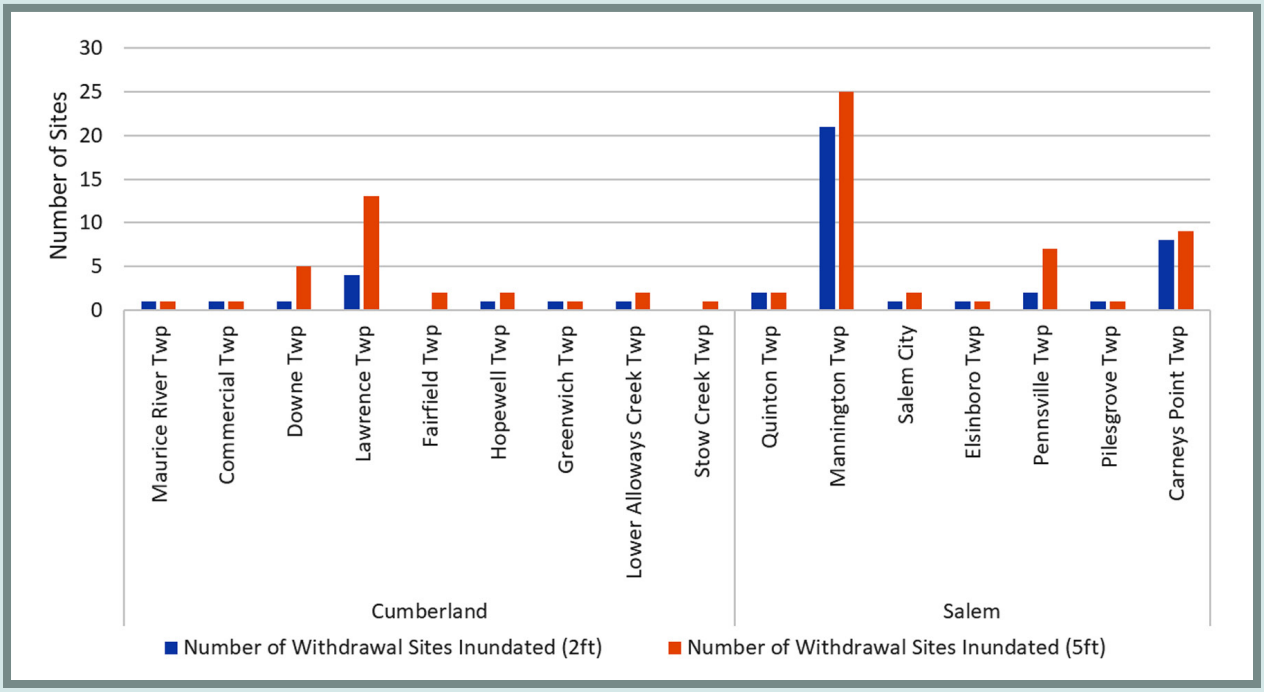



**Figure J11.** The Number of Withdrawal Sites in WMA17 Inundated with 2ft and 5ft of Sea Level Rise

Figure J12a and b show the water use group information of the withdrawal sites that are projected to be inundated with two and five feet of sea level rise. As shown in the pie charts, withdrawal sites projected to be most significantly inundated with two and five feet of sea level rise are sites dedicated to agricultural use. Approximately 83% and 75% of projected inundated withdrawal sites are dedicated to agricultural use in the two and five feet sea level rise scenarios, respectively. Withdrawal sites for commercial/industrial purposes was the next largest use group to be inundated with two and five feet of sea level rise, although the number of inundated sites for this use group decreased as a percentage of total inundated sites in the five feet scenario (compare 15% to 13%). While inundation of withdrawal sites dedicated to potable supply are projected to be minimal with two feet of sea level rise, the number of sites inundated increases from one to nine with five feet of sea level rise.

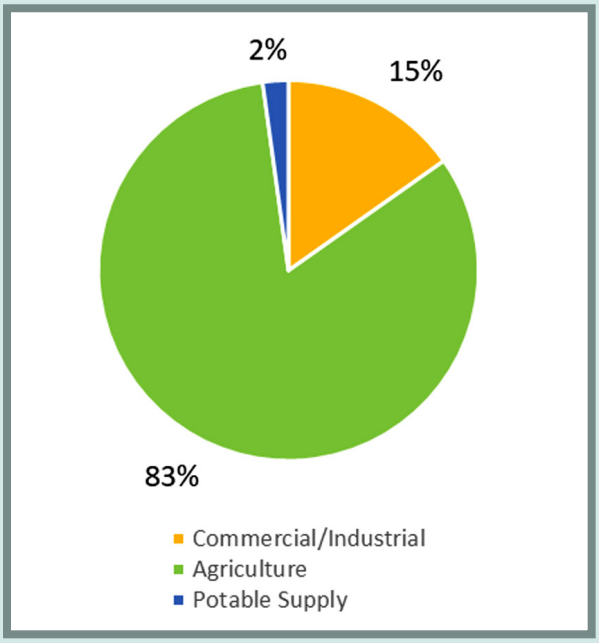



**Figure J12a.** WMA17 Withdrawal Site Inundation by Use Group (2ft of Sea Level Rise)

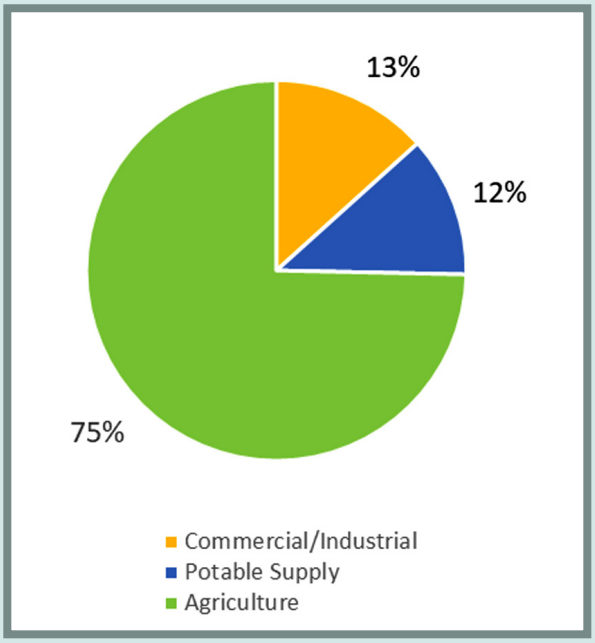
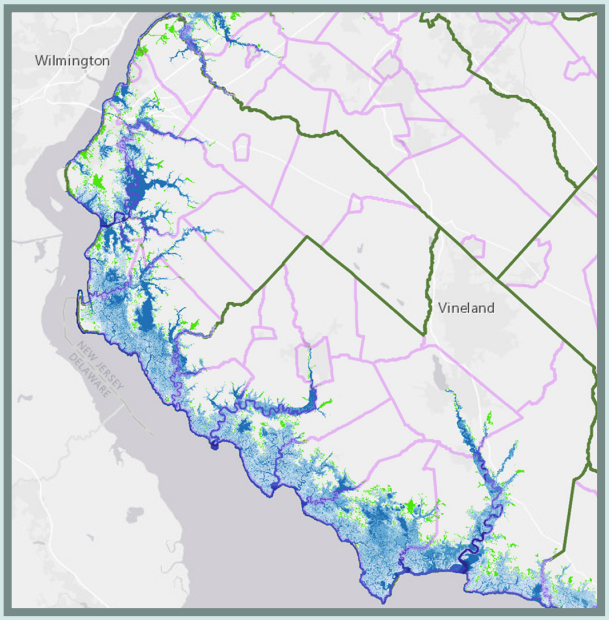


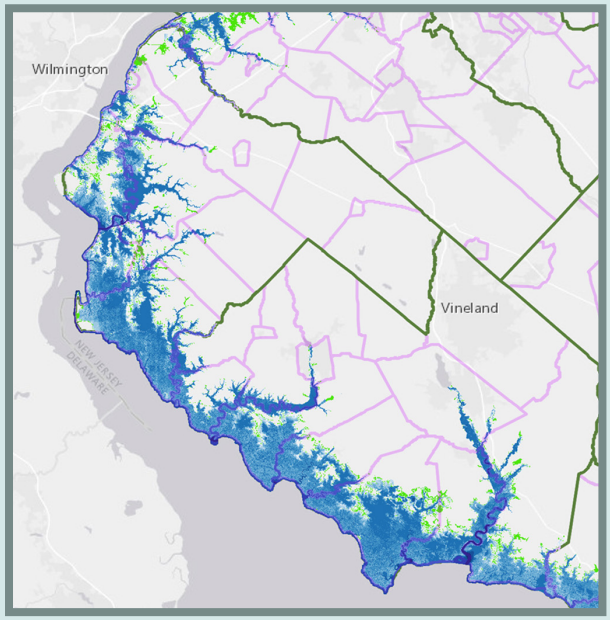

**Figure J12b.** WMA17 Withdrawal Site Inundation by Use Group (5ft of Sea Level Rise)

## *9.3 WMA17 COMMUNITY VULNERABILITY TO SEA LEVEL RISE*

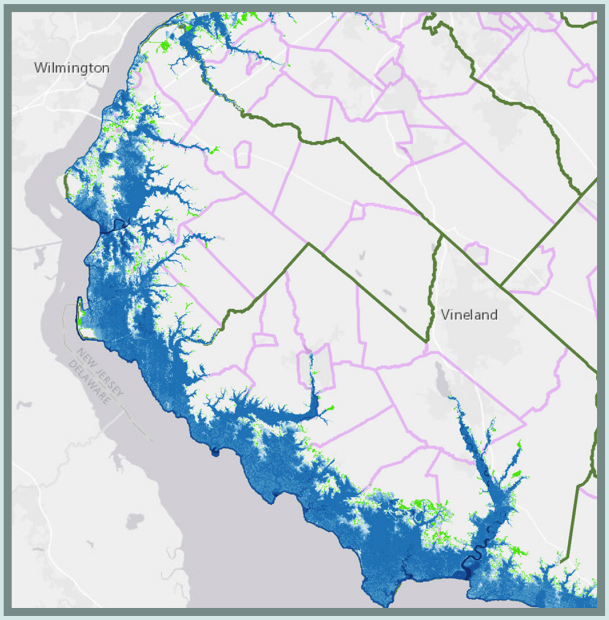
Since WMA17 is partially coastal in nature, sea level rise is anticipated to remove a significant portion of Cumberland County's low-lying land area located along Delaware Bay. The anticipated loss of tidal wetlands to open water is expected to create a threat to both the sustainability and resilience of the Delaware Bayshore (SJEDD, 2021; Simone Collins Landscape Architecture & Reed Group, 2011). However, WMA17 municipalities along the Delaware Bay and its tributaries are anticipated to experience additional risk from flooding, coastal erosion, and storm surge (Cumberland County OEM & Stuart Wallace LLC, 2022; Tetra Tech, 2022).

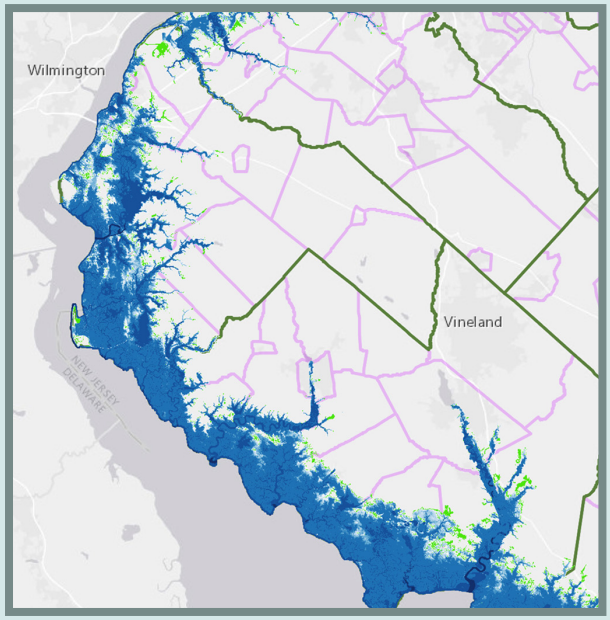
Map J11a and b show different scenarios for projected sea level rise within the WMA17 region provided by NJFloodMapper (Rutgers Center for Remote Sensing and Spatial Analysis, 2017). FloodMapper measures both sea level rise and the metric, Total Water Level (a comprehensive measure that considers sea level rise (permanent inundation), high tide flooding, and extreme coastal flooding). The maps on the left in both figures show projected permanent inundation of the WMA17 area, reflecting two feet of sea level rise for 2050 and five feet of sea level rise for 2100. The maps on the right show flood event water levels for the WMA17 region with two and five feet of sea level rise and a two-year flooding event, respectively. Two-year flooding event is defined as a precipitation event having a 50% NOAA Annual Exceedance Probability (likelihood of exceeding a certain amount of precipitation at least once in any given year); inundation would be higher with larger coastal storm surge. As shown in the maps in blue and green, the most significant inundation is anticipated in municipalities located along the Delaware River/Bay and along WMA17's three main rivers (Salem, Maurice, and Cohansey), where saltwater can more readily move inland. Community vulnerability to sea level rise is greater than projected in the maps on the left as more widespread and severe inundation is anticipated with storm flooding events (reflected in the maps on the right).



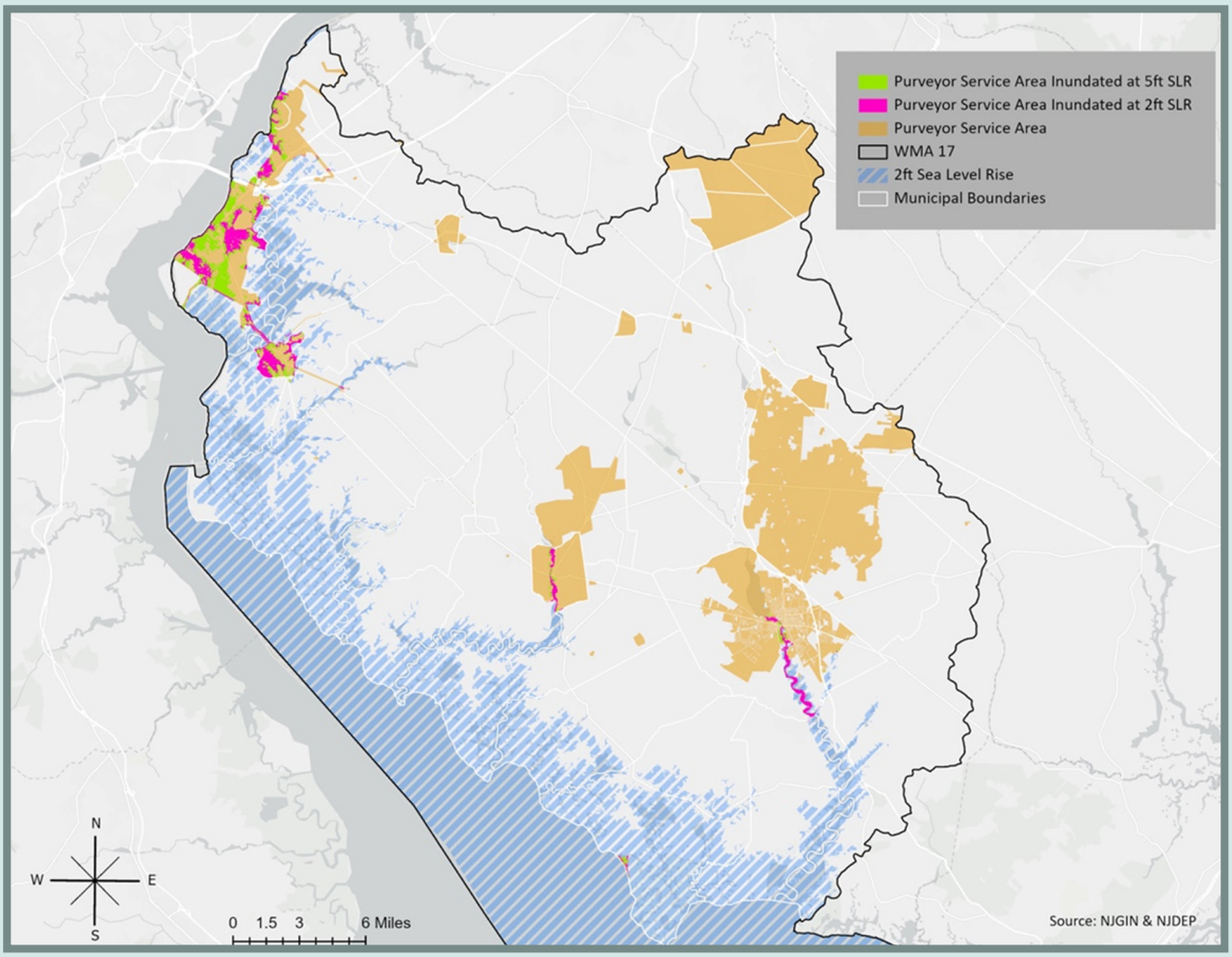

**Map J11a.** (Left) Map of the WMA17 Region with 2ft of Sea Level Rise (2ft TWL); (Right) Map of the WMA17 Region with 2ft of Sea Level Rise and a 2-Year Flooding Event (4ft TWL)




**Map J11b.** (Left) Map of the WMA17 Region with 5ft of Sea Level Rise (5ft TWL); (Right) Map of the WMA17 Region with 5ft of Sea Level Rise and a 2-Year Flooding Event (7ft TWL)

Inundation of WMA17's PCWS purveyor service areas from sea level rise is one community threat to regional water availability. Map J12 shows the major WMA17 PCWS purveyor service areas projected to be inundated with two and five feet of sea level rise. The major PCWSs projected to have inundation of their service areas include Upper Deerfield Township WD, New Jersey American – Penns Grove, Pennsville Township WD, and several PCWSs located in focus municipalities (Bridgeton City WD, Millville WD, and Salem WD).




**Map J12.** Projected Inundation of Major WMA17 PCWS Service Areas with 2ft and 5ft of Sea Level Rise

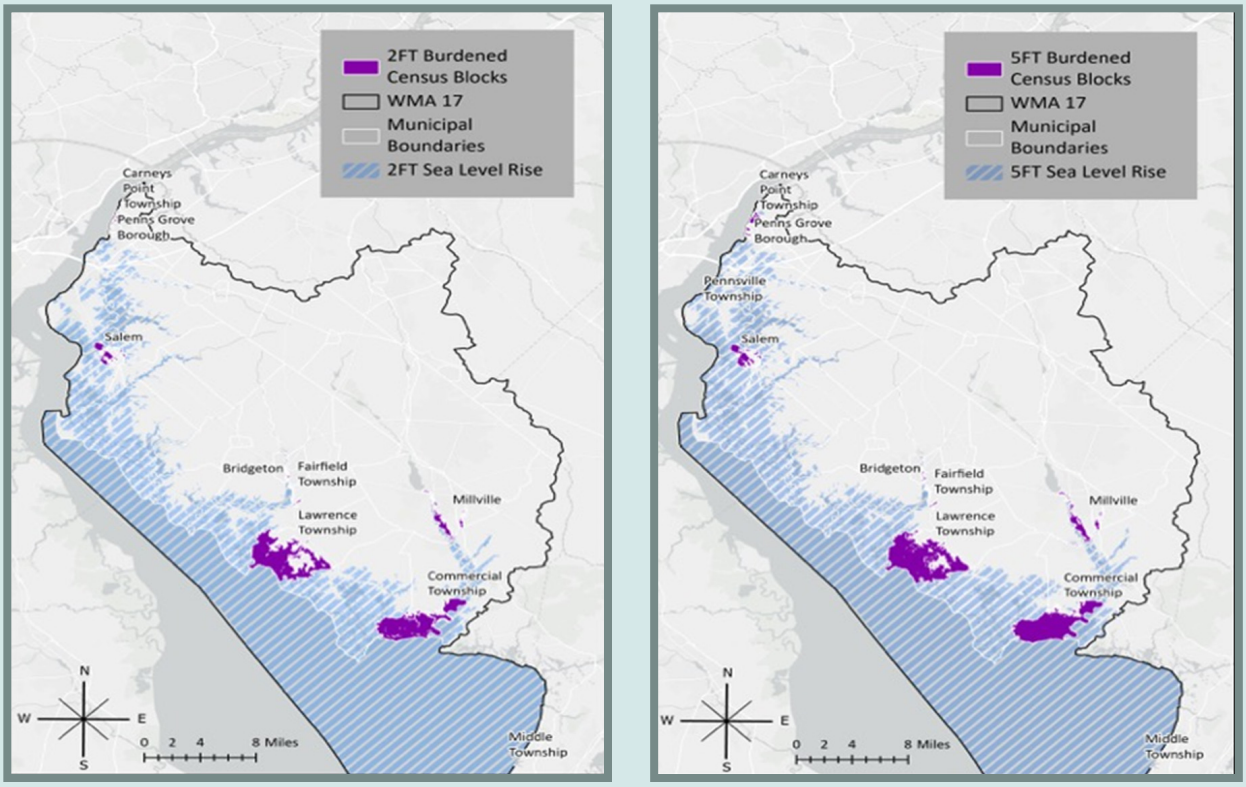
Table J11 provides the projected percent inundation of major WMA17 PCWS service areas with two and five feet of sea level rise. As shown in the table, the major WMA17 PCWS projected to have the most inundation of its service area is Salem WD, with over 40% and 60% of its service area projected to be inundated with two and five feet of sea level rise, respectively. Salem WD services HUC11s containing several focus municipalities including Carney's Point Township, Pilesgrove Township, and Salem City. Pennsville Township WD is also projected to have inundation of its service area, with projections of almost a quarter of its service area being inundated with two feet of sea level rise. Pennsville Township WD also services HUC11s containing several focus municipalities (Carney's Point Township, Pilesgrove Township, and Salem City) and Gloucester County's Logan Township. Bridgeton City WD and Millville WD are both projected to have minimal inundation of their service areas. However, these PCWSs service HUC11s containing Millville City, Bridgeton City, Vineland City, along with several Gloucester County municipalities (Franklin Township and Newfield Borough).

**Table J11.** Major WMA17 PCWS Purveyor Service Areas Projected to be Inundated with 2ft and 5ft of Sea Level Rise
Data provided by NJDEP DWSG

| Purveyor ID | Purveyor | Percent Inundated (2ft of Sea Level Rise) | Percent Inundated (5ft of Sea Level Rise) |
|---|---|---|---|
| NJ0610001 | Millville WD | 5% | 6% |
| NJ1707001 | NJ American - Penns Grove | 14% | 25% |
| NJ1708001 | Pennsville Township WD | 24% | 57% |
| NJ1712001 | Salem WD | 42% | 62% |
| NJ0601001 | Bridgeton City WD | 6% | 9% |

Map J13 shows the NJDEP's Overburdened Community census blocks in WMA17 that are projected to be inundated with two and five feet of sea level rise. All of the WMA17 Overburdened Community census blocks projected to be inundated with two and five feet of sea level rise are located in Salem and Cumberland counties. Areas projected to have the most census block inundation with both two and five feet of sea level rise include Penns Grove Borough, and the focus municipalities, Bridgeton City, Millville City, and Salem City. Almost all of the census block groups (11 of 14 for two feet of sea level rise; 16 of 19 for five feet of sea level rise) projected to be inundated from these municipalities meet both the low income and minority criteria of the Overburdened Community definition.

Table J12 provides the Overburdened Community census block groups in WMA17's focus municipalities projected to be inundated with two and five feet of sea level rise. As shown in the table, the focus municipality containing the most Overburdened Community census blocks at-risk from sea level rise is Bridgeton City, followed by Millville City and Salem City. As the majority of the at-risk census blocks are projected to be inundated at two feet of sea level rise, early action to protect these communities and their vulnerable populations is critical as the majority of sea level rise impacts to these communities are projected to occur sooner (by 2050) rather than later (by 2100).




**Map J13.** WMA17 Overburdened Community Census Block Groups Inundated with 2ft and 5ft of Sea Level Rise

**Table J12.** Overburdened Community Census Block Groups in WMA17's Focus Municipalities Projected to be Inundated with 2ft and 5ft of Sea Level Rise

| Focus Municipality | Number of Census Block Groups Inundated (2ft of Sea Level Rise) | Census Block Groups Inundated (2ft of Sea Level Rise) | Number of Census Block Groups Inundated (5ft of Sea Level Rise) | Census Block Groups Inundated (5ft of Sea Level Rise) |
|---|---|---|---|---|
| Carneys Point Township | 1 | 340330204002 | 1 | 340330204002 |
| Salem City | 3 | 340330219001, 340330220001, 340330221001 | 3 | 340330219001, 340330220001, 340330221001 |
| Bridgeton City | 5 | 340110201001, 340110206003, 340110202001, 340110203001, 340110205031 | 7 | 340110201001, 340110202001, 340110202002, 340110203001, 340110205031, 340110205032, 340110206003 |
| Millville City | 3 | 340110302002, 340110303002, 340110305021 | 4 | 340110301001, 340110302002, 340110303002, 340110305021 |

## 10. POTENTIAL MANAGEMENT OPTIONS

Based on the findings from the analysis, WMA17 currently faces water supply vulnerability, which is heightened during periods of drought and has the risk of becoming more severe in the future with climate change, sea level rise, and population change. Included below are some of WMA17's locations found to be the most vulnerable, along with some of the major highlights from the assessment's findings for these areas.

- **02040206030 (Salem R (above 39d40m14s dam)/Salem Canal):** includes two focus municipalities (Carney's Point Township and Pilesgrove Township) and includes areas Salem County planners identified as most promising for growth. This HUC11 had the second highest five-year average water withdrawal by water use category
  and fourth most negative remaining available water value for its three-year rolling average in peak depletive/consumptive loss in WMA17. One of its PCWSs, Pennsville Township WD, reported the largest demand increase between 2011-2020 among larger WMA17 PCWSs (28%). This HUC11 was found to have the second largest number of projected withdrawal sites inundated with two and five feet of sea level rise, with significant site inundation in both Mannington Township and Carney's Point Township.

- **02040206080 (Cohansey River (above Sunset Lake)):** includes both Upper Deerfield Township and Hopewell Township, which were identified by Cumberland County planners as areas that had potential to experience future growth. Out of the WMA17 HUC11s, 02040206080 had the fourth highest five-year average water withdrawals by water use category, and was first in most negative remaining available water for its three-year rolling average in peak depletive/consumptive loss. As sea level rise was not identified as a significant widespread concern for this HUC11, primary vulnerability for this HUC11 is from potential population growth and meeting future water demands.

- **02040206180 (Menantico Creek):** includes two focus municipalities (Vineland City and Millville City), which were both identified as promising areas of growth in Cumberland County. Partially located in Water Supply Critical Area 2, this HUC11 had the third highest five-year average water withdrawals by water use category and third most negative remaining available water value for its three-year rolling average in peak depletive/consumptive loss. Among the focus municipalities, Millville City had the second largest number of Overburdened Community census blocks projected to be inundated from sea level rise.

- **Bridgeton City:** USGS reported significant water declines in the Piney Point Aquifer around Bridgeton City wells, which was anticipated to become worse in different 2040 water loss scenarios. The Piney Point Aquifer is experiencing some decline based on well water level changes, which may result in challenges for Bridgeton if its population grows as projected. Bridgeton also faces potential vulnerability from sea level rise, as Bridgeton City was found to have the largest number of Overburdened Community census blocks that would be inundated by sea level rise among the focus municipalities.

- **Salem City:** Among the focus municipalities, Salem City was found to have the third largest number of Overburdened Community census blocks projected to be inundated with two and five feet of sea level rise. Its major PCWS, Salem WD, was also projected to have almost half of its purveyor service area inundated with two feet of sea level rise – the largest inundation among major PCWSs servicing WMA17.

- **Gloucester County WMA17 Municipalities:** Gloucester County was anticipated to experience the most population growth out of the four WMA17 counties, with an MPO projected population growth of 12,977 among its WMA17 municipalities between 2020-2050. Several major PCWSs that service HUC11s containing WMA17 Gloucester municipalities were projected to have demand increase or experience deficit by 2050.

Table J13 shows potential management options for the WMA17 region. This table is designed to include both strategies that can be applied across WMA17 and more focused strategies that can address specific localized needs. While only a few areas were highlighted in the region, these management options can be implemented in similar regional locations facing similar challenges. This section is designed to serve as a flexible blueprint for management options since each area will differ on strategies that best address their individual water supply challenges and should be monitored closely and updated as new research and data become available.

**Table J13.** Potential Management Options for WMA17

| Vulnerable WMA17 Area | Encouragement of Water Saving Strategies and Improving Water Use Efficiency | Further Assessment of WMA17 PCWSs to Meet Future Regional Water Demand | Investment to Protect and Restore Aquifer Recharge | Alterations to Agriculture BMPs | Investment in Resilience and Mitigation Strategies to Reduce/Prevent Inundation of PCWS Service Areas from Sea Level Rise |
|---|---|---|---|---|---|
| **02040206030** | Yes | Yes | Yes | No | Yes |
| **02040206080** | Yes | Yes | No (monitor to prevent future recharge losses) | Yes | No |
| **02040206180** | Yes | Yes | Yes | Yes | Yes |
| **Bridgeton City** | Yes | Yes | Yes | No | Yes |
| **Salem City** | Yes | Yes | Yes | No | Yes |
| **Gloucester WMA17 Municipalities** | Yes | Yes | No (monitor to prevent future recharge losses) | No | No |

The first management option (Encouragement of Water Saving Strategies and Improving Water Use Efficiency) is applicable for the entire WMA17 region and for this reason is labeled yes for all of the vulnerable WMA17 areas. Encouragement of water saving strategies can ensure water is available for both current citizens and regional goals for development. This was argued in Salem County's 2014-2017 Economic Strategic Plan, which argued that water conservation, re-allocation, and recycling are critical for ensuring water supply is available for new businesses and industry (Salem County & Salem County Improvement Authority, 2019). Encouragement of strategies promoting water use efficiency can be applied on both a local (installation of water efficient plumbing, smart irrigation systems, etc.) and regional (encouraging use of existing water supply and sewer infrastructure) scale. Efficiency in water use has been found to be associated with population density, as lower density residential water demands have been found to be higher compared to more populated areas (Van Abs et al., 2018). Recommendations for using pre-existing infrastructure, such as water and sewer, were found in planning documents for all four WMA17 counties (Simone Collins Landscape Architecture & Reed Group, 2011; Heyer, Gruel & Associates and Michael Baker International, 2018a; Cumberland County Improvement Authority, 2020; Salem County Planning Board, 2016; DVRPC, 2015) and can be critical for balancing water demands and protecting environmental resources subject to Water Supply Critical Area 2, Pinelands Commission, and CAFRA regulations.

The second option (Further Assessment of WMA17 PCWSs to Meet Future Regional Water Demand) is recommended for all WMA17 PCWSs and is labeled yes for all of the WMA17 vulnerable areas identified in Table J13. As was found in Section 8, despite roughly half of WMA17's PCWSs being projected to experience demand decline, several PCWSs were projected to experience demand increase and have potential concerns in meeting future water demands. Planning efforts can be made to further assess WMA17 PCWS potential management options and their feasibility for meeting future demands if they run into deficit (such as bulk transfers from other PCWSs, existing infrastructure for interconnections between PCWSs, identification of alternative water sources, etc.). This assessment can also build from earlier NJDEP PCWS research, such as the 2007 NJDEP Interconnection Study (NJDEP, Gannett Fleming, & Black & Veatch, 2007). Specific focus can be placed on identifying PCWSs that are most isolated (in terms of connecting to other PCWSs and their purveyor service areas) and contain socially vulnerable populations in their service areas, and developing potential strategies if those PCWSs face deficit. Collaboration with PCWSs can strongly assist in these efforts and provide early identification of potential problems for PCWSs to respond to deficit, which may help to streamline regional response to deficit if it occurs in the future.

Investment to protect and restore aquifer recharge can be an option for urbanized locations in HUC11:02040206030, HUC11:02040206180, Bridgeton City, and Salem City, especially since urbanized locations such as Vineland City, Bridgeton City, and Millville City have been found to have impervious surface amounts that are considered harmful to their local waterways. Although it is not recommended for HUC11:02040206080 and Gloucester's WMA17 municipalities to invest to decrease impervious surfaces at this time, it is recommended that these locations proactively mitigate impervious surface development and the loss of aquifer recharge areas in the future. Actions that can be used to reduce impervious cover could include (but are not limited to): (a) de-paving; (b) use of permeable pavement systems; (c) rain garden/bioretention system installation; (d) rainwater harvesting; and (e) use of bioswale, planter boxes, and stormwater planters (Rutgers Cooperative Extension Water Resources Program, 2018b). To protect groundwater sources, regional growth and land use decisions should be closely monitored (NJ Division of Fish and Wildlife, 2004). In cases where development does occur, strategies to minimize impervious surfaces can be used, such as disconnecting runoff flow over impervious surfaces, maximizing natural drainage and vegetation, protecting areas with water quality benefits or areas vulnerable to erosion, minimizing land disturbance, and providing vegetated open-channel conveyance systems (Sickels & Associates, Inc., 2021).

Alterations to agricultural Best Management Practices (BMPs) is suggested for HUCs 02040206080 and 02040206180, which were each found to have agriculture and irrigation as a significant water withdrawal water use category over a five-year period (2016-2020) and their largest water use loss group during their respective three-year rolling averages in peak depletive/consumptive loss. Working with farmers is essential to protect regional water availability and provides one of the best opportunities for ensuring adequate open space that can be used for aquifer recharge. Several options for improving agricultural practices could include implementing strategies to increase overall participation in BMPs and improving water monitoring of agricultural lands. For example, farmers that sign up for BMPs or implement new water monitoring strategies could receive priority access to irrigation water (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006). Such an approach can also be used to determine acceptance and quantity permitted in water allocation permits.

Investment in resilience and mitigation strategies to reduce/prevent inundation of PCWS service areas from sea level rise is recommended for all PCWSs in all the identified vulnerable WMA17 areas with the exception of HUC11:02040206080 and the more inland Gloucester WMA17 municipalities. Certain locations were identified as particularly vulnerable to sea level rise, such as Salem City and 02040206030's Carney's Point Township, and PCWSs in these locations should be prioritized in these management strategies. Increasing shoreline resilience may be critical for PCWSs with service areas in coastal areas as most of the WMA17 coastal municipalities along the Delaware River and Bay are anticipated to experience the most severe inundation from sea level rise. Some regional efforts are already underway that may decrease WMA17 PCWS vulnerability to climate change, including: (a) the promotion of wetlands protection; (b) working with FEMA, State of New Jersey, and Army Corps of Engineers to mitigate flooding in coastal areas; (c) helping to target funding for storm surface barriers and beach replenishment including living shoreline approaches; and (d) identifying pump station locations and flood mitigation strategies (SJEDD, 2021). Another potential project to decrease regional vulnerability to sea level rise is to restore and stabilize the mouth of the Maurice River – which may help decrease future inundation of Millville WD's purveyor service area. This proposed project intends to dredge the channel and includes establishing breakwaters and an oyster reef (NJ Delaware Bayshore Council, 2019).

PCWS strategies could also be developed in tandem with repeated monitoring and updating of county Multi-Hazard Mitigation reports. At the time of this assessment, all four WMA17 counties had Multi-Hazard Mitigation reports that considered county and municipality infrastructure risk from factors such as flooding, sea level rise, and severe weather events. Analysis tools from these documents, such as ranking of hazards and potential displaced populations calculations, are critical for determining the most vulnerable areas and can serve as a foundation for building strategies to improve regional resilience against climate change (For examples, see Cumberland County OEM & Stuart Wallace LLC, 2022 and Tetra Tech, 2022). PCWSs can have a critical role in hazard assessment and formulation of mitigation strategies related to water and sewer infrastructure and assist in regional collaboration to prevent hazards. These efforts should also include close collaboration with identified vulnerable populations in these locations. Areas, such as Bridgeton City, Millville City, and Salem City, each have vulnerable populations that face significant threats from sea level rise inundation and should be kept updated as new data and research on climate change become available.

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