State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX H

AN ASSESSMENT OF REGIONAL WATER AVAILABILITY AND DEMAND FOR WATERSHED MANAGEMENT AREA (WMA) 06: UPPER AND MIDDLE PASSAIC, WHIPPANY, AND ROCKAWAY RIVERS

Appendix H:

An Assessment of Regional Water Availability and Demand for Watershed Management Area (WMA) 06: Upper and Middle Passaic, Whippany, and Rockaway Rivers

TABLE OF CONTENTS

AN ASSESSMENT OF REGIONAL WATER AVAILABILITY AND DEMAND FOR WATERSHED MANAGEMENT AREA (WMA) 06: UPPER AND MIDDLE PASSAIC, WHIPPANY, AND ROCKAWAY RIVERS

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EXECUTIVE SUMMARY

Watershed Management Area (WMA) 06 is located in northeastern New Jersey and includes most of Morris County and portions of Essex, Somerset, Sussex, and Union counties. The WMA includes four HUC11s (eleven-digit hydrologic units), which are the basis for water availability and demand

accounting. Defined by its three major rivers (Upper Passaic, Rockaway, and Whippany), this region faces water supply vulnerability, with NJDEP estimates that 50% 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 (Morristown, Parsippany-Troy Hills Township, Livingston Township, Millburn Township, New Providence 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 Sussex County was the only WMA06 county that experienced population decline between 2010 and 2020, and the population of WMA06’s municipalities is projected to grow through 2050. Most WMA06 counties (Morris, Somerset, and Sussex) had unemployment rates and poverty levels below the New Jersey state average, though clusters of socially vulnerable populations in WMA06 were identified in locations including Dover, Victory Gardens Borough, Wharton Borough, Morristown, and Parsippany-Troy Hills Township. WMA06 water withdrawals have declined since the 1990s with predominant water withdrawals used for potable supply purposes, and water users have relied on a roughly even split of surface water and unconfined groundwater sources. While approximately half of WMA06’s public community water systems (PCWSs) reported a decline in potable water demand between 2011-2020, WMA06 PCWS 2050 demand projections indicate that the majority of WMA06 PCWSs will experience less demand than current demand numbers. For the climate change assessment, Morris County was projected to have the largest increase in precipitation among WMA06 counties between 2020-2069. WMA06 was also projected to continue on-going trends of increased groundwater recharge and streamflow in the future, and they were projected to have little to no adverse impacts on regional surface water availability.

While vulnerability in current and/or future water availability was detected across three of four HUC11s in WMA06 (02030103010 (Passaic River Upr (above Pine Bk br), 02030103020 (Whippany River), and 02030103030 (Rockaway River)), several areas within WMA06’s HUC11s were identified as particularly vulnerable.

WMA06 Locations of Concern:

- Livingston Township, Millburn Township, and West Orange Township (HUC11: 02030103010)
- West Caldwell Township, North Caldwell Borough, and East Hanover Township (HUC11: 02030103010)
- Rockaway Township and Denville Township (HUC11: 02030103030)

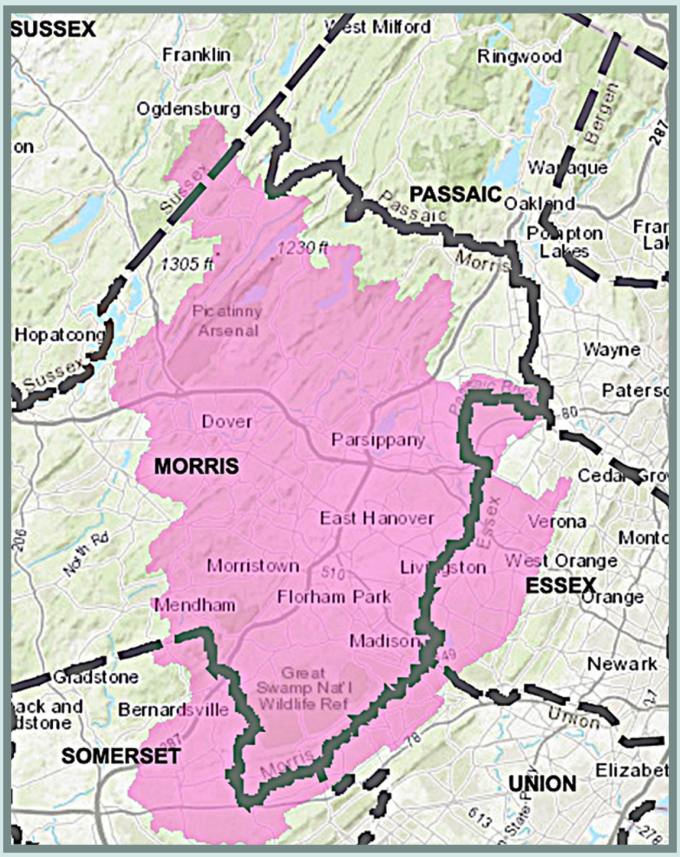
Potential management options are provided that can be implemented across the WMA06 region or be more focused options for specific areas found to have the most significant water supply vulnerability. Management options included updating regional groundwater modeling, use of a water fee/surcharge on end users of Highlands water, protection of aquifer recharge areas, and further assessment of WMA06 PCWSs to meet future regional water demand.

1. INTRODUCTION

Watershed Management Area (WMA) 06 (see Map H1) is located in northeastern New Jersey and includes portions of Morris, Essex, Somerset, Sussex, and Union counties. The WMA06 region includes the upper and middle portions of the Passaic River and two major tributaries (Whippany River and Rockaway River), to where the Passaic River is joined by the Pompton River at Two Bridges (Highlands Council, 2008a). Encompassing a total area of 361 square miles, WMA06 is located in the Highlands and Piedmont physiographic provinces (NJDEP Division of Water Supply and Geoscience [forthcoming]; Town of Morristown Planning Division & Topology, 2020; Tetra Tech, 2020b). This region relies heavily on its groundwater sources for water supply and is characterized by extensive suburban development (Tetra Tech, 2020a).

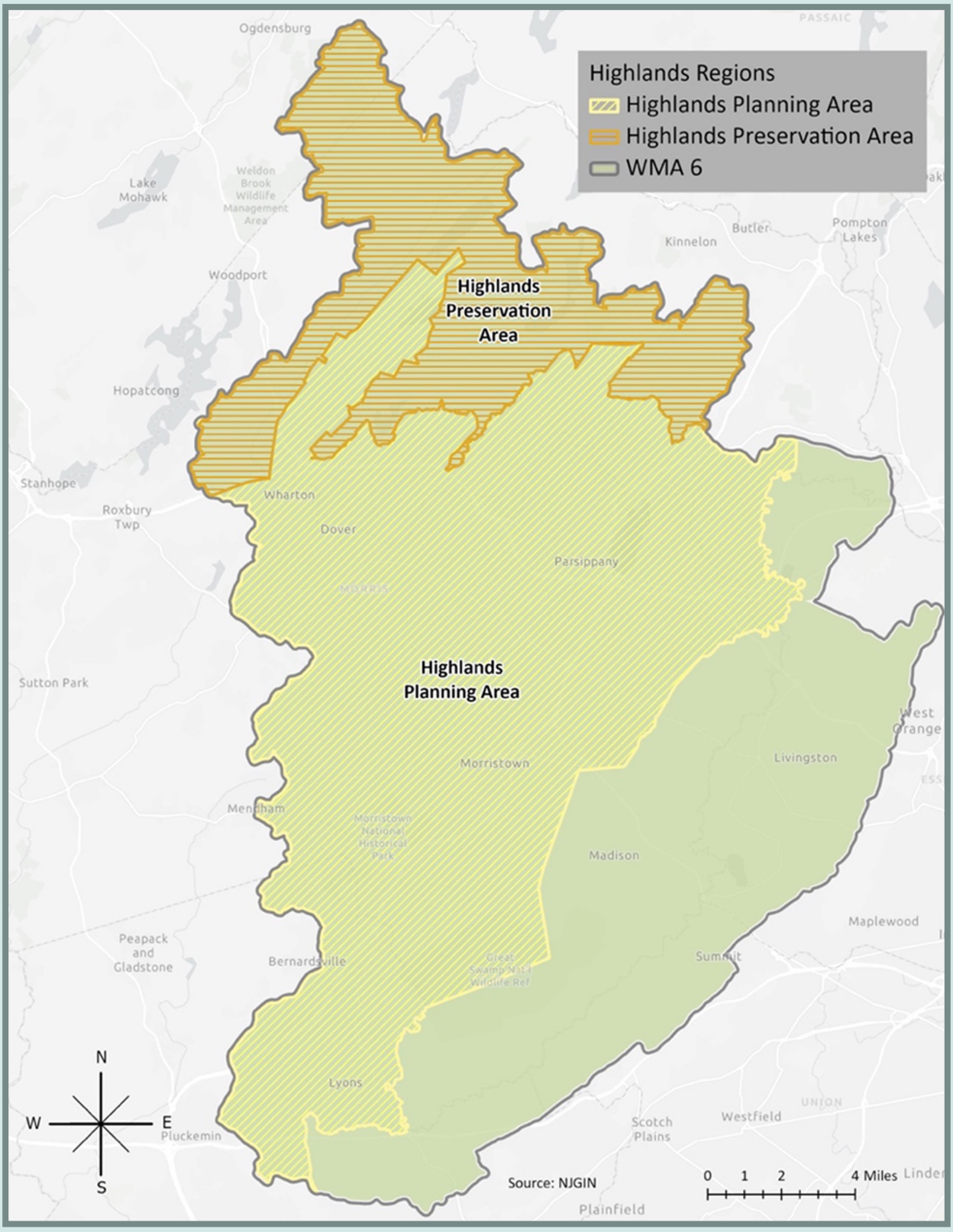
WMA06's land use and economic development is highly reliant on its regional surface water and groundwater sources. The three significant rivers in the region are the Rockaway, Whippany, and Passaic rivers, which are all watersheds within the larger Passaic River Basin (Morris County Planning Board, 2000). WMA06 encompasses the Upper Passaic River Basin, which includes its headwaters in Morris County to its confluence with the Pompton River. The Passaic River forms the boundary between Somerset and Morris counties and later between Morris and Essex counties. This basin drains approximately 987 miles of both North Jersey and Southern New York, including the Highlands Region (Tetra Tech, 2020a). The entire Passaic River Basin spans three WMAs: WMA03 (Pompton, Pequannock, Wanaque, and Ramapo), WMA06, and WMA04 (Lower Passaic and Saddle River).

Regulations for the Highlands Region (see Map H2) and the WMA's large wetlands areas (especially in the Passaic and Whippany river watersheds) present both land and water use restrictions that limit regional development and partially limit water demand. Including parts of seven New Jersey counties, the Highlands Region is a significant drinking water source for New Jersey residents that yields almost 380 million gallons of water daily (Morris County Planning Board, 2013; MCMUA, 2021). Regulations in the Highlands region, especially in the Preservation Area, include water withdrawal limits, new environmental standards, and restrictions on expanding public water and sewer service (Morris County Department of Public Works & Morris County Planning Board, 2018, Highlands Council, 2008b).



Map H.1 Map of WMA06

WMA06's primary groundwater sources are buried valley aquifer systems (Central Passaic Buried Valley Aquifer System and Upper Rockaway River Basin Area Aquifer System), partially developed from the expansion and retreat of glaciers during the Pleistocene Period which are now sole-source aquifers for residents in portions of Morris and Essex counties (Morris County Planning Board, 2000; Morris County Planning Board & Morris County Office of Planning and Preservation, 2020; Amy S, Greene Environmental Consultants, Inc., 2014). These regional buried-valley aquifer systems have withdrawal restrictions, partially in response to earlier modeling research that identified concerns with withdrawal increases (Hoffman, 1989; Nicholson, McAuley, Barringer, & Gordon, 1996). In addition, the sole-source designation of these systems requires the Federal environmental review process to ensure funds are not provided for projects that risk contamination of the aquifer systems (Amy S, Greene Environmental Consultants, Inc., 2010).



Map H.2 Highlands Protection in WMA06

With extensive regional development and New Jersey Department of Environmental Protection (NJDEP) estimates that 50% of WMA06's watersheds have demonstrated water use patterns during peak consumptive/depletive loss years that exceed sustainable surface water availability, examination of WMA06's current water availability and demand and how they may change in the future is critical for ensuring long-term adequate water availability for the region.

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 WMA06 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 WMA06. The second goal is to project how regional water availability and demand 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.

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 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 WMA06's counties and municipalities. Available population projections for WMA06'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 sources were considered for this analysis: (a) Metropolitan Planning Organization (MPO) (provided by the North Jersey Transportation Planning Authority (NJTPA)), and (b) New Jersey Department of Labor (DOL). MPO and DOL population projections were examined and compared with 2020 Census population estimates for WMA06's counties and municipalities to determine which locations are most likely to grow or decline in the future. Municipalities considered most likely to experience 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 WMA06 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 WMA06. This analysis used both GIS and county and municipal documents to consider how WMA06 land use has changed over time and may change in the future. Development strategies suggested by WMA06 county planning boards, 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 WMA06 (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 (eleven-digit Hydrologic Unit Codes, or HUC11s). WMA06 water withdrawals were examined by both source and water use category, discharges (returns) were analyzed by source, and consumptive/depletive use was examined by water use category. Examination of WMA06's 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.

WMA06'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 demand projections for major PCWSs servicing WMA06 were also analyzed to examine their similarities and differences with the WMA06 2050 population projections discussed in Section 4 and their implications for assessing future regional water demand.

2.3 CLIMATE CHANGE ASSESSMENT

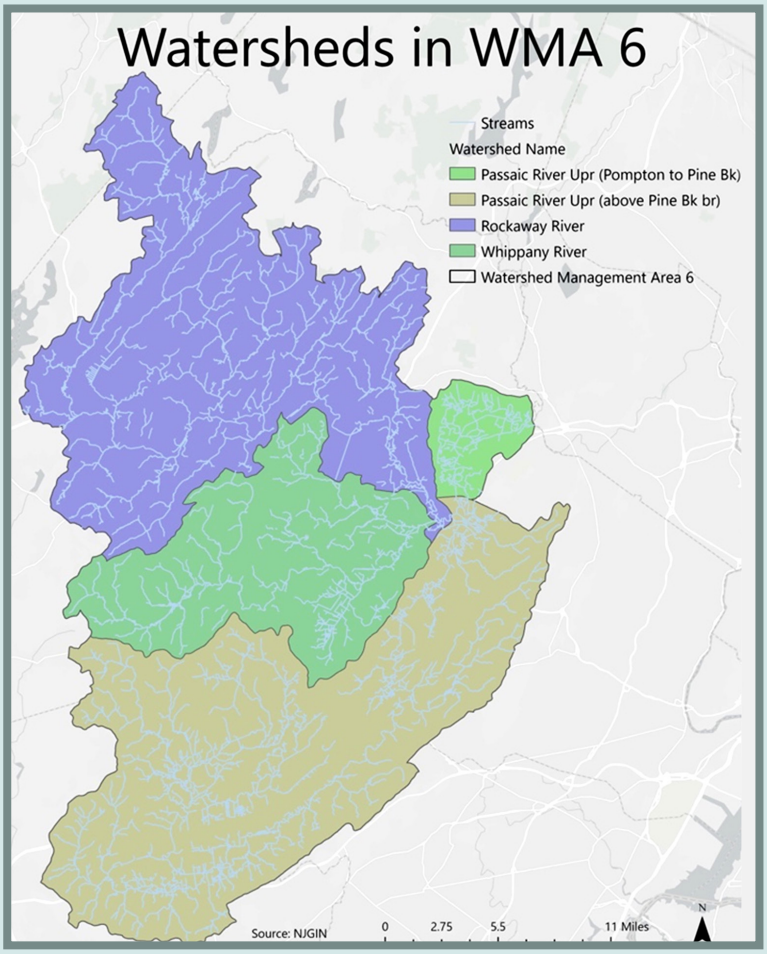
The climate change assessment (Section 9) primarily relied on data provided by NJDEP's DWSG to examine how climate change (temperature and precipitation) is projected to affect regional groundwater recharge, streamflow, and reservoir safe yields. For the examination of regional groundwater recharge, streamflow, and reservoir safe yields, forthcoming NJDEP reports were examined to identify current trends, and NJDEP projections were used to determine anticipated changes due to climate change.

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 (see Section 10). Areas considered to have the highest water supply vulnerability in WMA06 were identified, and management options are proposed that are tailored to address both regional water issues and the specific needs/challenges identified in vulnerable locations.

3. WMA06 WATERBODIES

Map H3 and Table H1 show all of the watersheds (or HUC11s) in WMA06. All four HUC11s are located entirely or partially in the Highlands Region and are subject to Highlands regulations (***All:*** 02030103030; ***Partial:*** 02030103010, 02030103020, 02030103040). All four HUC11s are considered 7Q10 Limited, meaning that the Low Flow Margin calculations (see Chapter 2 of the 2024 Plan) are further limited due to the potential for severe stream flow impacts during very dry periods. The 7Q10 (the lowest flows over a period of seven consecutive days with a 10 percent probability of occurrence) is a standard used in the 2017 New Jersey Statewide Water Supply Plan and Highlands water analyses (Highlands Council, 2008c).



Map H.3 HUC11 Drainage Basins in WMA06

Table H.1 HUC11 Information for Watershed Management Area 06
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)	Highlands	7Q10 Limited	Municipalities
02030103010	Passaic River Upr (above Pine Bk br)	143	349	Partial	Yes	***Morris***: Montville Township, East Hanover Township, Morris Township, Mendham Township, Mendham Borough, Morristown, Florham Park Borough, Harding Township, Madison Borough, Chatham Township, Chatham Borough, Long Hill Township; ***Essex***: Fairfield Township, North Caldwell Borough, Caldwell Borough, West Caldwell Township, Verona Township, Cedar Grove Township, Roseland Borough, Essex Fells Township, West Orange Township, Livingston Township, Millburn Township; ***Somerset***: Bernardsville Borough, Bernards Township, Far Hills Borough, Warren Township, Bridgewater Township; ***Union***: Summit City, New Providence Borough, Berkeley Heights Township
02030103020	Whippany River	70	70	Partial	Yes	***Morris***: Boonton Township, Boonton Town, Denville Township, Mountain Lakes Borough, Parsippany-Troy Hills Township, Randolph Township, Morris Plains Borough, East Hanover Township, Hanover Township, Morris Township, Mendham Township, Mendham Borough, Morristown, Florham Park Borough, Harding Township, Madison Borough
02030103030	Rockaway River	137	206	All	Yes	***Morris***: Jefferson Township, Rockaway Township, Rockaway Borough, Kinnelon Borough, Boonton Township, Boonton Town, Montville Township, Mount Arlington Borough, Roxbury Township, Denville Township, Wharton Borough, Mountain Lakes Borough, Dover, Parsippany-Troy Hills Township, Mine Hill Township, Victory Gardens Borough, Randolph Township, East Hanover Township, Morris Township; ***Sussex:*** Hardyston Township, Sparta Township
02030103040	Passaic River Upr (Pompton to Pine Bk)	12	361	Partial	Yes	***Morris***: Montville Township, Lincoln Park Borough; ***Essex***: Fairfield Township

3.1 SURFACE WATER SOURCES

WMA06 is located in the Passaic River Basin and includes the Upper Passaic, Rockaway, and Whippany watersheds. The largest of these watersheds is the Upper Passaic River watershed, with the Whippany and Rockaway rivers as major watersheds that drain from the Highlands (Tetra Tech, 2020a; Highlands Council, 2008a). The Passaic River headwaters are in Mendham Township, from which the Passaic River flows through a total of 45 municipalities before ultimately emptying into Newark Bay. Within WMA06, the Passaic River flows through or adjacent to municipalities including Bernardsville Borough, Bernards Township, Long Hill Township, Chatham Township and Borough, Livingston Township, Hanover Township, Fairfield Township, and Montville Township. The Passaic River is joined by the Whippany River in Parsippany-Troy Hills Township and the Rockaway River in Pine Brook (Montville Township) (Morris County Planning Board, 2000; Tetra Tech, 2020a). Major tributaries within the Upper Passaic River include Dead River, Black Brook, Penns Brook, Cory's Brook, and Salt Brook. The Salt Brook branches join at the center of New Providence Borough before flowing into the Passaic River and are considered one of the defining features of the municipality (Somerset County Mitigation Planning Committee, 2019; Highlands Council, 2008a; New Providence Open Space Advisory Board, 2006). The Upper Passaic River floods in areas including Lincoln Park Borough, New Providence Borough, and Long Hill Township (Union County, 2016; Tetra Tech, 2020a; New Providence Open Space Advisory Board, 2006; Morris County Planning Board, 2000).

The Rockaway River's tributaries begin in eastern Sparta Township (Sussex County) and travel through Morris County (Tetra Tech, Inc., 2021; Morris County Planning Board, 2000). The Rockaway River flows in a southwesterly then easterly direction through Jefferson Township, Wharton Borough, Dover, Rockaway Borough, Denville Township, and Parsippany-Troy Hills Township, and flows to the Jersey City Reservoir at Boonton (Tetra Tech, 2020a; Morris County Planning Board, 2000; U.S. Army Corps of Engineers New York District & NJDEP, 2008). The Boonton Reservoir serves as a boundary that separates the Upper Rockaway River watershed from the Lower Rockaway River watershed (Gordon, 2002). Parsippany-Troy Hills Township is separated from Montville Township by the Rockaway River, which forms a natural municipal boundary line (Tetra Tech, 2020a). Major tributaries of the Rockaway River include Beaver Brook, Stone Brook, Den Brook, Mill Brook, Burnt Meadow, and Crooked Brook (Highlands Council, 2008a; U.S. Army Corps of Engineers New York District & NJDEP, 2008). The Rockaway River floods in areas including Parsippany-Troy Hills Township, Boonton Town, and Denville Township (Dewberry-Goodkind, Inc., 2006; Morris County Planning Board, 2000).

The Whippany River begins in Mendham Borough and travels in an easterly direction through Morris Township, Morristown, Hanover Township, East Hanover Township, and Parsippany-Troy Hills Township (Morris County Planning Board, 2000). In Hatfield Swamp, the Whippany River joins the Passaic River. The Whippany River is considered a major waterbody in Morristown and drains the northern section of the town (Tetra Tech, 2020a; Colliers Engineering & Design & Hipolit, 2021). Whippany River's watershed includes Intervale Lake, Troy Brook, Rainbow Lakes, Lake Parsippany, West Brook, and Black Brook (Dewberry-Goodkind, Inc., 2006; Highlands Council, 2008a). The Whippany River floods in several areas in WMA06, including East Hanover Township, Morristown, Morris Township, and Parsippany-Troy Hills Township (Tetra Tech, 2020a; Jonathan Rose Companies et al., 2014).

RESERVOIR SYSTEMS AND SAFE YIELD

There are two reservoir systems located in WMA06: (a) Jersey City's Boonton Reservoir System, and (b) New Jersey American Water Company's Passaic System (Canoe Brook), and both have permitted safe yields. Safe yield is defined as the amount of water a system can supply if there is a repeat of the worst drought on record (which is often the drought of the 1960s) (Highlands Council, 2008b). The Boonton Reservoir System is owned by the City of Jersey City, and system operations have been contracted to Veolia. This system consists of two reservoirs: Splitrock and Boonton. Splitrock is located upstream of the Boonton Reservoir and can act as an emergency supply reservoir to the Boonton Reservoir during periods of low storage, drought, or other water supply emergencies. Located in Parsippany-Troy Hills Township, the Boonton Reservoir is considered the main reservoir and is Jersey City's direct source for potable supply (Highlands Council, 2008c; Burgis Associates, Inc., 2011). NJDEP reports this two-reservoir system has a combined storage of 11.3 bg and a safe yield of 56.8 mgd. As of 2008, both reservoirs had a passing flow requirement (5 mgd in Beaver Creek below Splitrock and 7 mgd in the Rockaway River below Boonton) (Highlands Council, 2008c). NJDEP estimates that average withdrawals from the Boonton Reservoir over the last five years were approximately 40 mgd, indicating that system water use was nearing the safe yield threshold, given that peak years will likely be higher.

The New Jersey American Water Company's Passaic System is designed to supply water to locations in northeast New Jersey (Highlands Council, 2008b). This system serves WMA06 locations including Berkeley Heights Township, Bernard Township, Bernardsville Borough, Far Hills Borough, Livingston Township, Millburn Township, New Providence Borough, Summit City, and Florham Park Borough. Municipalities serviced by New Jersey American's Passaic System can receive water from wells in unconfined aquifers and surface water from the Canoe Brook Reservoir System. The Passaic System's Canoe Brook Reservoir system includes three small reservoirs located in the Upper Passaic River Basin that are mainly fed by pumping from Canoe Brook and the Passaic River. NJDEP reports the combined storage of the three reservoirs is 2.84 bg, and the safe yield is 10.8 mgd.

3.2 GROUNDWATER SOURCES: BURIED VALLEY/VALLEY FILL AQUIFER SYSTEMS

The majority of groundwater in WMA06 is drawn from two sole source valley fill aquifer systems: (a) Central Passaic Buried Valley Aquifer System, and (b) Upper Rockaway River Basin Area Aquifer System. Sole Source Aquifers (SSAs) are designated by the U.S. Environmental Protection Agency under regulations provided in the Safe Drinking Water Act of 1974. This designation is provided when: (a) an aquifer system supplies over 50% of the drinking water for the aquifer service area, and (b) there are no economically feasible alternative drinking water sources (Hoffman, 1999; Highlands Council, 2008c; Amy S, Greene Environmental Consultants, Inc., 2014; Amy S, Greene Environmental Consultants, Inc., 2010; Burgis Associates, Inc., 2011). As a result of this designation, additional review of federally-funded projects is required to ensure Federal agencies don't commit funds to projects that risk contamination of these aquifer systems (Amy S, Greene Environmental Consultants, Inc., 2014; Amy S, Greene Environmental Consultants, Inc., 2010; Hoffman, 1999).

Both the Central Passaic Buried Valley and Upper Rockaway River Area aquifer systems have two different aquifer types that are separated by a partially confining unit, partially caused by the expansion and retreat of glaciers during the Pleistocene Period. The first aquifer unit consists of shallow unconfined, unconsolidated rocks in buried valley or valley fill deposits composed of gravel and/or sand, which is considered highly productive and a significant potable supply source in the region (although productivity may vary by location and rock type). These fluvial sand and gravel deposits filled bedrock depressions or river valleys during the retreat of glaciation. These buried valley aquifers are complex and interbedded with clay deposits. An aquifer of consolidated rocks (bedrock) exists throughout WMA06, including below the buried valley aquifers, but it is much less productive and is separated from the buried valley aquifers in some locations by a partially confining layer from glacial lake sediments or relatively tight sediments (Highlands Council, 2008c; Gordon, 2002; Hoffman, 2012; Morris County Planning Board, 2000; Burgis Associates, Inc., 2011). Groundwater and surface water are highly interconnected in this area, as groundwater flows from higher elevations towards valleys, typically flowing from consolidated to unconsolidated deposits before discharging into streams, lakes, or swamps (Highlands Council, 2008c). However, surface water may also flow into the unconfined aquifers.

The Central Passaic Buried Valley Aquifer System is located in Somerset, Essex, Morris, and Union counties. Formerly known as the "Buried Valley aquifer in southeastern Morris and western Essex counties", its notice of approval as an SSA was published in 1980 (Hoffman, 1999). Although it is mostly located in the Piedmont Province, its streamflow source zone extends into the Highlands (Highlands Council, 2008c). The recharge zone for this aquifer includes all of Morristown, Morris Plains Borough, Long Hill Township, Hanover Township, East Hanover Township, Madison Borough, and Florham Park Borough and parts of 19 WMA06 municipalities, and portions of the Passaic, Rockaway, and Whippany rivers all flow into this aquifer's recharge zone (Hoffman, 1999). The Central Passaic Buried Valley Aquifer System is drained by the Passaic River, but during times of extended drought or heavy withdrawals, water can flow from the Passaic River to the aquifer (Highlands Council, 2008c).

The Upper Rockaway River Basin Area Aquifer System was formerly known as the "Unconsolidated Quaternary aquifer in the Rockaway River area, New Jersey" and its SSA notice of approval was published in 1984 (Hoffman, 1999). This aquifer system includes 13 Morris County municipalities that are located in the Rockaway River drainage basin upstream of the Boonton Reservoir. This area includes Boonton Town, Boonton Township, Randolph Township, Dover, Rockaway Township, Wharton Borough, and Roxbury Township (Morris County Planning Board, 2000; Highlands Council, 2008c). The Rockaway River Basin Area Aquifer System follows the ancient Rockaway River path and is currently an important streamflow source

to the Rockaway River system (Morris County Planning Board, 2000; Burgis Associates, Inc., 2011; Highlands Council, 2008c). Along some areas of the Rockaway River, the river will lose water to the aquifer, but in other areas, the Rockaway River gains water from the aquifer. In the Rockaway River watershed, increased groundwater withdrawals upstream have been found to decrease groundwater discharge to the Rockaway River downstream, indicating the highly interconnected nature of the system (Gordon, 2002).

4. DEMOGRAPHIC ANALYSIS

KEY FINDINGS

- Overall, the population of WMA06 municipalities grew from 737,695 to 770,217 between 2010-2020. Among the WMA06 counties (Morris, Essex, Somerset, Sussex, and Union), only Sussex County experienced population decline between 2010-2020.
- While the projection analysis found MPO and DOL projections for WMA06 counties were similar in projecting growth in the WMA06 region, there was some uncertainty in the amount of population growth that would occur in WMA06's primary counties: Morris, Essex, and Somerset.
- Five WMA06 municipalities considered most likely to experience significant population changes (Morristown, Parsippany-Troy Hills Township, Livingston Township, Millburn Township, and New Providence Borough) were selected for further analysis in later sections of the regional assessment as focus municipalities.

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 WMA06's counties and municipalities, respectively. The third component focused on the population 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 analysis.

COUNTY-WIDE ANALYSIS

Table H2 provides demographic information for WMA06's counties and includes state demographic information for comparative purposes. Essex County was found to have the largest population and population density among WMA06 counties; however, only the western-most part of the county is within WMA06, as is true for Union County. Essex, Union, Morris, and Somerset counties all increased in population between 2010-2020, while Sussex County was the only WMA06 county to experience population decline. However, as Sussex County's WMA06 municipalities make up less than 10% of WMA06's total acreage, Sussex County's population decline has a minimal impact on regional growth. Somerset County's growth in population continues an ongoing trend, as Somerset County experienced rapid population growth that was almost double the state growth rate between 2000-2010 (Somerset County Board of Chosen Freeholders, Somerset County Business Partnership, & CEDS Governing Committee, 2013); however, most of the more densely populated areas in the county are outside of WMA06. Despite Sussex experiencing recent population decline, Sussex, along with Morris, Somerset, and Union counties all grew prior to the Great Recession (Tetra Tech, Inc., 2021; Morris County Department of Public Works & Morris County Planning Board, 2018; Somerset County Board of Chosen Freeholders et al., 2013; Union County, 2016).

The economic conditions of WMA06's counties can be seen from examining WMA06 county data for unemployment rate, median household income, and percent poverty. Morris, Somerset, and Sussex were all found to have median household incomes that were above the New Jersey state average. This continues an ongoing trend of Morris and Somerset having some of the highest average incomes in New Jersey (Morris County Department of Public Works & Morris County Planning Board, 2018; Somerset County Board of Chosen Freeholders et al., 2013). Morris, Somerset, and Sussex counties were also found to have percent poverty and unemployment rates that were below the New Jersey state average. While Union had median household income, percent poverty, and percent unemployment rates that were close to the New Jersey state average, Essex County reported significantly higher percent poverty and unemployment rates and a significantly lower median household income compared to the New Jersey state average. This suggests that Essex County is the most vulnerable out of WMA06's counties.

Table H.2 WMA06 County Demographic Information
Sources: 2020 U.S. Census (U.S. Census Bureau, 2021), 2020 ACS 5-year estimate (American Community Survey, 2022a), Bureau of Economic Analysis (2021), NJ Department of Labor and Workforce Development (2022), 2021 ACS 1-year estimate (American Community Survey, 2022b)

County	Essex	Morris	Somerset	Sussex	Union	New Jersey
Land Area (mi^2)	126	461	302	519	103	7,353
2020 Real GDP (Billions of Dollars)	$45	$49	$37	$4	$34	$536
2020 Population Density (per mi^2)	6,850	1,105	1,144	278	5,599	1,263
2010 Census	783,969	492,276	323,444	149,265	536,499	8,791,894
2020 Census	863,728	509,285	345,361	144,221	575,345	9,288,994
Median Household Income	$63,959	$122,962	$124,764	$99,904	$86,764	$89,296
Percent Poverty	15%	6%	5%	6%	9%	10%
Unemployment Rate (May 2021 - not seasonally adjusted)	4%	3%	3%	3%	4%	3%

Several WMA06 counties have developed regional strategies for promoting economic development in WMA06. Morris County has focused on building sector growth in areas including: (a) Healthcare and Social Assistance; (b) Professional, Scientific, and Technical Assistance; and (c) Administrative Support/Waste Management/and Remediation (Morris County Planning Board, 2013). Somerset County was interested in job creation and receiving economic investment from the private sector, and was projecting sector growth in Wholesale Trade, Retail Trade, and Professional, Scientific, and Technical Services (Somerset County Board of Chosen Freeholders et al., 2013). As a part of their strategic development plan, Sussex County was interested in: (a) expanding their tourism and hospitality industry; (b) improving roadways and transit; (c) coordinating with NJDEP to accommodate targeted growth with municipality partnerships; and (d) supporting agriculture businesses by partnering with New Jersey Department of Agriculture (Econsult Solutions Team, 2014).

MUNICIPALITY ANALYSIS

WMA06 includes municipalities in most of Morris County, western Essex County, northern Somerset (Bernards Township, Bernardsville Borough, Far Hills Borough, Warren Township), southeastern Sussex (Hardyston Township, Sparta Township), and western Union County (Berkeley Heights Township, New Providence Borough, Summit City). Similar to the county-level analysis findings, most of WMA06's municipalities grew between 2010-2020, with both Sussex County municipalities experiencing population decline during this time. Twenty-six of 31 Morris County municipalities within WMA06 reported population growth between 2010-2020 (only East Hanover Township, Jefferson Township, Kinnelon Borough, Long Hill Township, and Roxbury Township reported declines), while all of Essex, Somerset, and Union's WMA06 municipalities reported growth. The average percent population growth of WMA06's municipalities between 2010-2020 was 4.7% (U.S. Census Bureau, 2021).

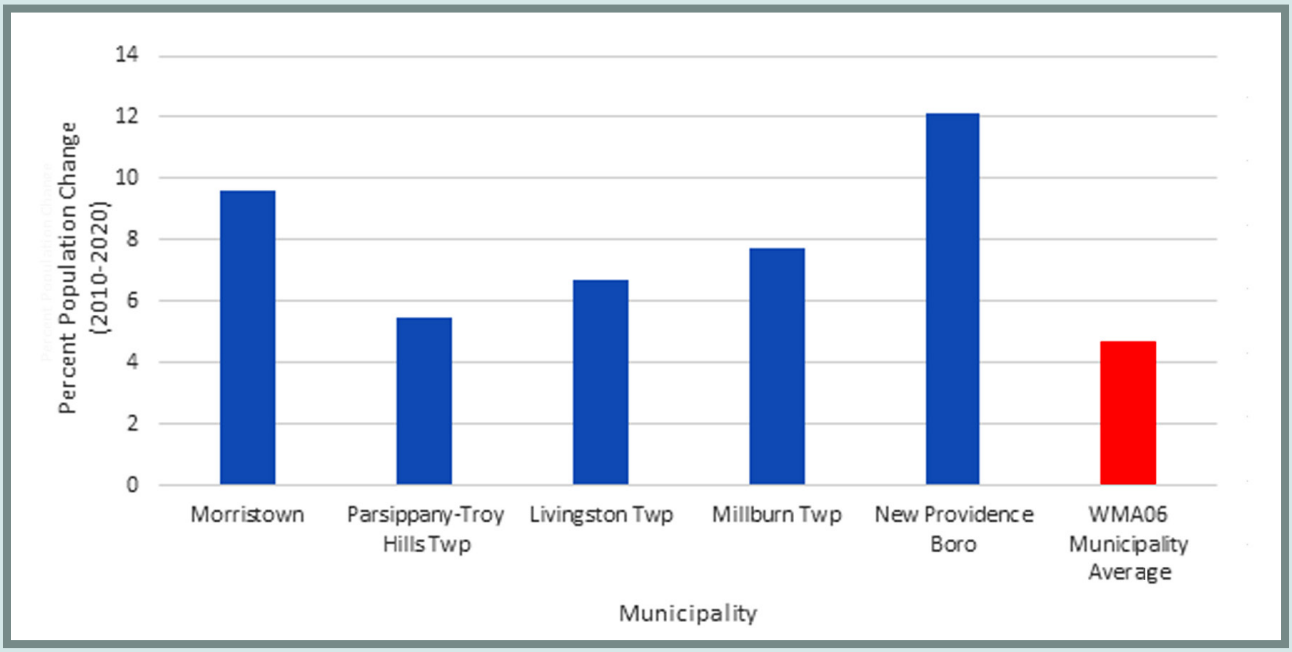


Figure H.1 Percent Population Change in WMA06 Municipalities (2010-2020)

Figure H1 shows the percent population change experienced by the WMA06 municipalities selected as focus municipalities, as compared to the average percent population change of all of the WMA06

municipalities (not of WMA06'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. 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 H1, all of the focus municipalities selected for analysis demonstrated growth between 2010-2020 that exceeded the WMA06 municipality average. While New Providence Borough (which is partially located outside of WMA06) had the largest percent growth (12.2%) among the focus municipalities between 2010-2020, Parsippany-Troy Hills Township experienced the largest total population growth between 2010-2020, growing by 2,924 people. Morristown experienced the second largest percent population change among the focus municipalities (9.6%). Livingston Township and Millburn Township experienced smaller population growth between 2010-2020 (growing by 1,964 and 1,561 people, respectively) (U.S. Census Bureau, 2021).

POPULATION PROJECTION ANALYSIS

Figure H2 shows the MPO and DOL population projections (estimates) for the five WMA06 counties. Both the MPO and DOL population projections were developed prior to the 2020 Census and therefore are based on the 2010 Census data and subsequent annual estimates. The 2020 Census results show significant differences from the earlier modeled results.

With the exception of Sussex County, all WMA06 counties had 2020 Census populations that exceeded their MPO 2020 projections. All WMA06 counties had 2020 Census populations that exceeded their DOL 2020 projections. MPO and DOL projections for WMA06 counties significantly differ in both projected growth estimates and projections of which counties would experience the most growth. For example, for Morris County, the MPO projected a population increase of 13,023 people between 2020-2035, while the DOL projected a population increase of 38,900 people between 2019-2034. Somerset

was similar, with the MPO projecting a population increase of 17,290 people between 2020-2035, and the DOL projecting a population increase of 35,800 people between 2019-2034. For both Morris and Somerset counties, their 2020 Census population numbers were closer to their DOL 2019 projections than their MPO 2020 projections (compare 509,285 with 509,100 and 500,829, and 345,361 with 342,900 and 336,521, respectively) (NJTPA, 2021; DOL, 2014; U.S. Census Bureau, 2021).

Essex County was similar (but in the opposite direction) in that the MPO projected a population increase of 56,472 people between 2020-2035, while the DOL projected growth of 31,800 people between 2019-2034. In comparison, Essex County's 2020 Census population was much higher than both the county MPO 2020 and DOL 2019 projections (compare 863,728 to 800,276 and 808,300 respectively), creating some uncertainty in how much growth Essex County will experience in the future.

As of 2020, Morris County WMA06 municipalities were approximately 55% of the WMA06 total municipal population, followed by Essex (22%) and Somerset (13%) counties. Since the WMA06 municipalities from these three counties make up approximately 90% of WMA06's total municipal population, the projection findings for Morris County, along with Essex and Somerset counties, suggest some uncertainty in how regional population (and potentially water demand) may change in the future (NJTPA, 2021; DOL, 2014; U.S. Census Bureau, 2021).

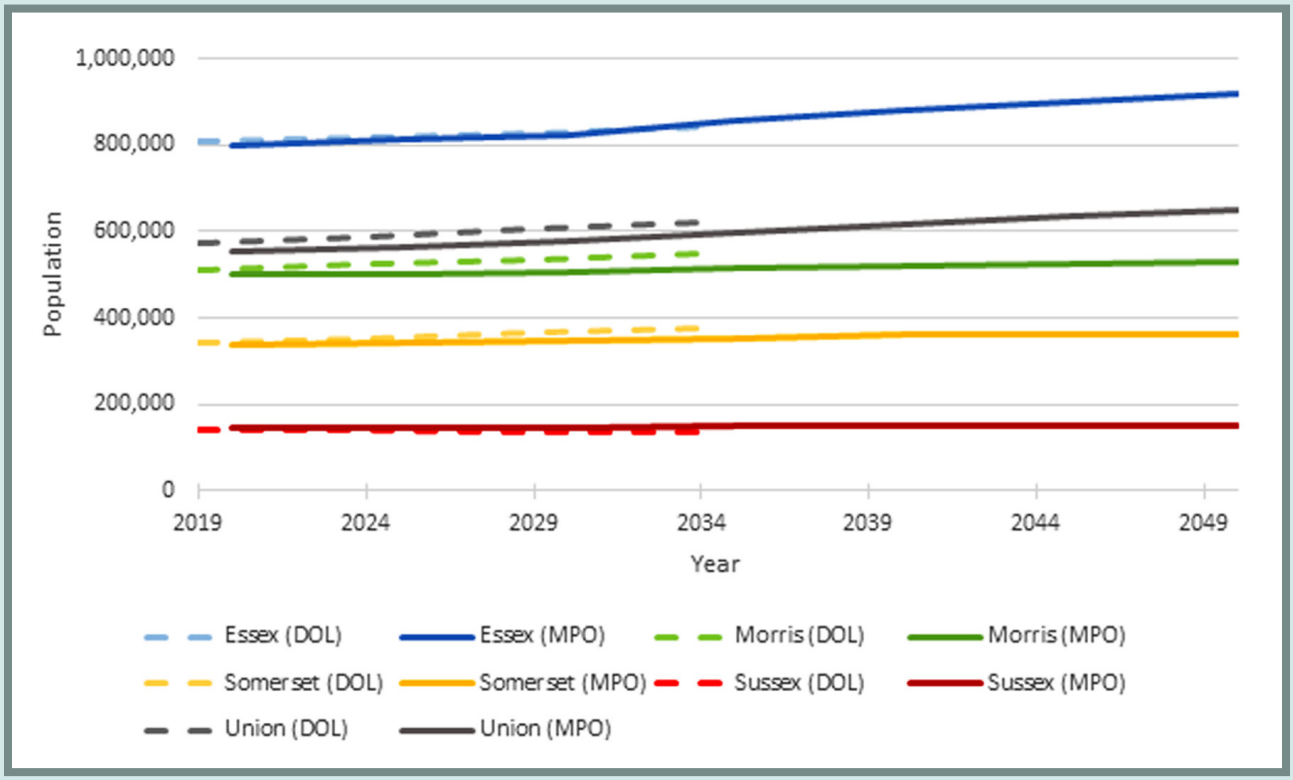


Figure H.2 MPO and DOL Population Projections for WMA06 Counties (2019-2050)

Figure H3a and b demonstrate how the WMA06 focus municipalities were selected for analysis. All of the focus municipalities had 2020 Census populations that exceeded their MPO population projections. In Essex County, population data suggested a potential cluster of future population growth in the adjacent Livingston Township, Millburn Township, and West Orange Township. All three of these municipalities were projected by the MPO to have growth that significantly exceeds the WMA06 municipality average, with West Orange Township projected to have the most significant growth (7,236 person increase between 2020-2050). While both Livingston Township and Millburn Township were selected as focus municipalities, West Orange Township was not since it is primarily located outside WMA06 (primarily located in WMA07 – Arthur Kill) (NJTPA, 2021; DOL, 2014).

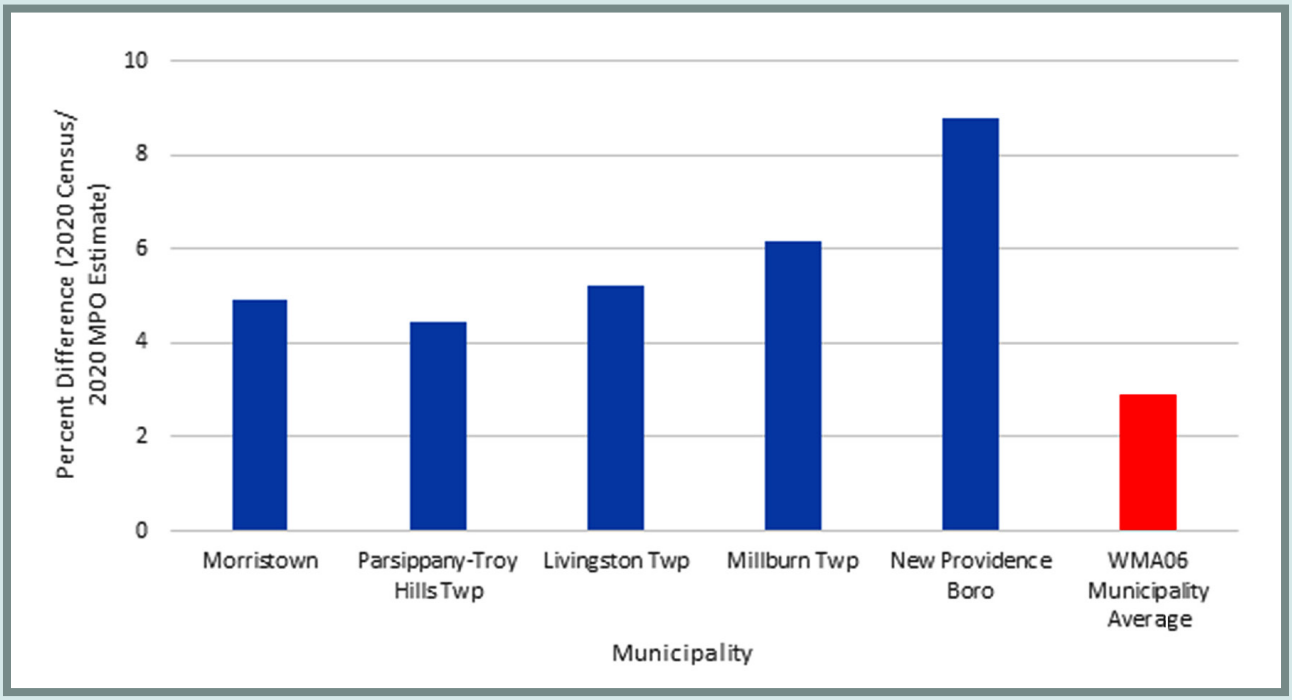


Figure H.3a Percent Difference among WMA06 Focus Municipalities (2020 Census Population/2020 MPO Population Projection)

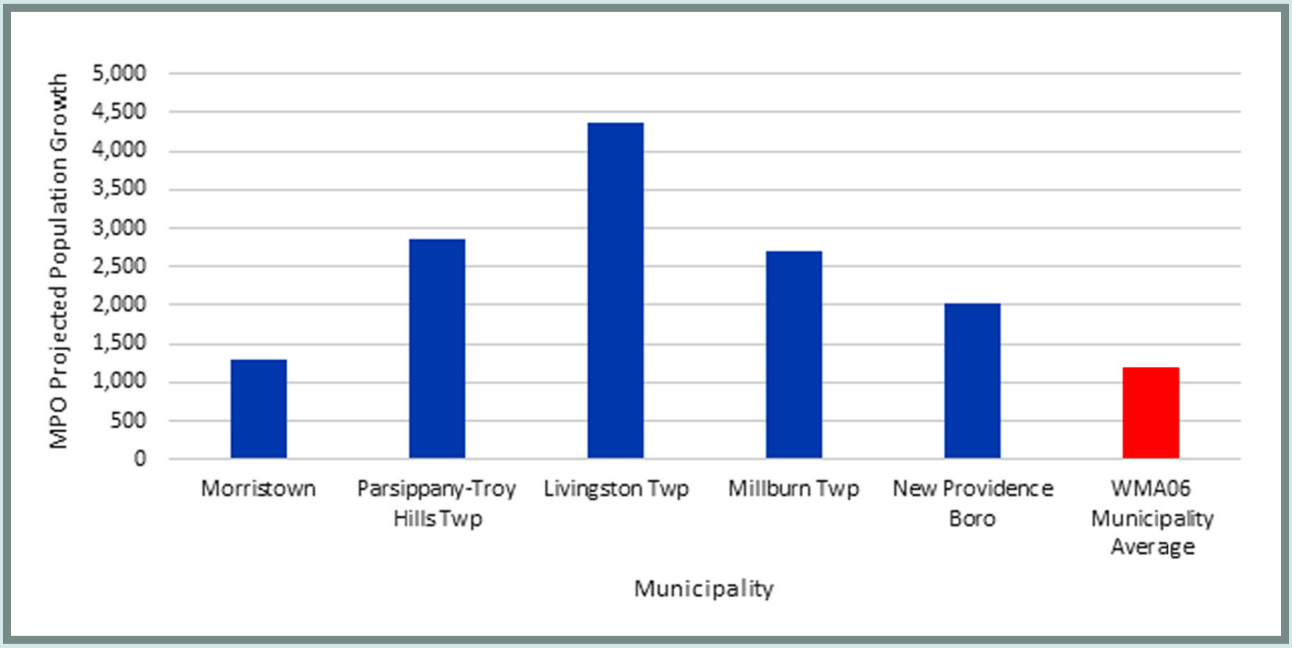


Figure H.3b MPO Projected Population Growth among WMA06 Focus Municipalities (2020-2050)

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 WMA06 region, Essex County was found to have the highest social vulnerability in the region, though this high SVI score may be strongly influenced by municipalities outside of WMA06.
- Although Morris County's SVI score suggests it has low social vulnerability, 17 of its WMA06 municipalities contain Overburdened Communities.
- The WMA06 municipalities with the largest social vulnerability include portions of Morris County's Dover, Victory Gardens Borough, Wharton Borough, and the focus municipalities of Morristown and Parsippany-Troy Hills Township.

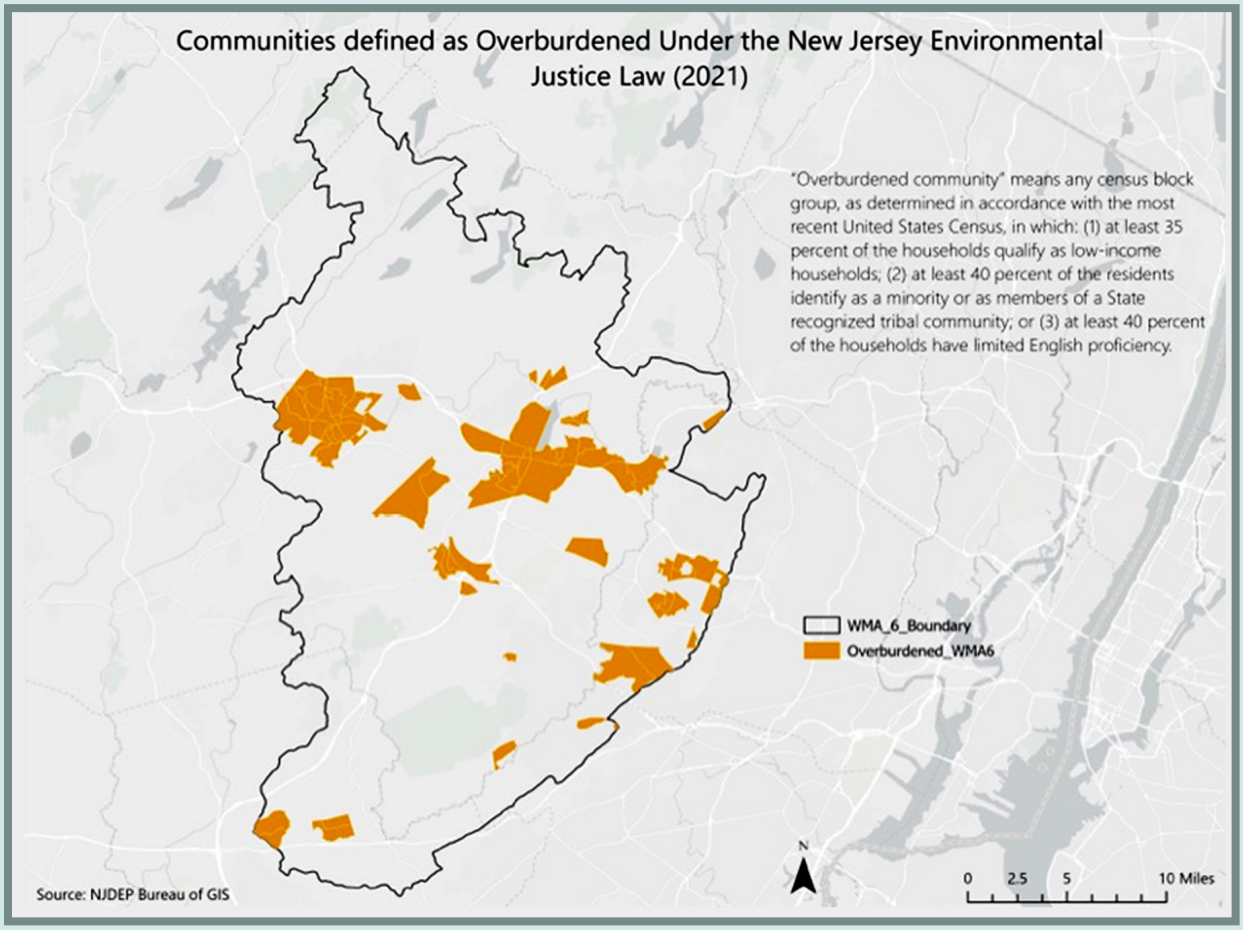
5.1 NJDEP OVERBURDENED COMMUNITIES

Two metrics were used to examine social vulnerability in WMA06: the NJDEP Overburdened Communities and CDC's SVI metrics. On NJDEP's 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)."

Map H4 shows the WMA06 census block groups that are designated as Overburdened Communities. As shown in the map and Table H3, the majority of Overburdened Communities in WMA06 are located in Morris County, followed by Essex County. Four out of the five focus municipalities (Morristown, Parsippany-Troy Hills Township, Millburn Township, and Livingston Township) have census blocks containing Overburdened Communities.



Map H.4 Map of WMA06 Census Blocks Identified as Overburdened Communities

Table H.3 WMA06 Municipalities with Overburdened Communities. Source: NJDEP Office of Environmental Justice, 2022

County	Number of Municipalities with Overburdened Communities	Municipality Name
Morris	17	Boonton Town, Chatham Township, Dover, Florham Park Borough, Hanover Township, Jefferson Township, Madison Borough, Mine Hill Township, Montville Township, Morris Township, Morristown, Parsippany-Troy Hills Township, Randolph Township, Rockaway Township, Roxbury Township, Victory Gardens Borough, Wharton Borough
Essex	7	Caldwell Borough, Cedar Grove Township, Fairfield Township, Livingston Township, Millburn Township, West Caldwell Township, West Orange Township
Somerset	2	Bernards Township, Bridgewater Township
Sussex	0	
Union	1	Summit City

Table H.4 Overburdened Communities in WMA06 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
Morristown	8	340270435001, 340270435002, 340270436021, 340270438023, 340270438011, 340270435003, 340270436022, 340270438021	Minority, Low Income and Minority, Low Income, Minority, and Limited English
Parsippany-Troy Hills Township	27	340270416043, 340270417041, 340270418022, 340270418023, 340270418024, 340270418033, 340270417015, 340270416021, 340270416032, 340270416041, 340270417011, 340270416052, 340270416053, 340270416061, 340270416062, 340270417063, 340270417064, 340270417013, 340270417014, 340270417021, 340270417023, 340270417043, 340270417051, 340270417062, 340270418012, 340270418011, 340270418021	Minority, Low Income and Minority, Minority and Limited English
Livingston Township	10	340130204002, 340130205001, 340130205003, 340130205005, 340130206003, 340130206005, 340130207002, 340130207003, 340130208001, 340130207004	Minority
Millburn Township	9	340130201001, 340130201002, 340130201003, 340130202002, 340130202003, 340130203001, 340130203003, 340130200006, 340130203002	Minority, Low Income and Minority

Table H4 describes the type of vulnerability found in the Overburdened Communities in WMA06's focus municipalities based on NJDEP's definition of Overburdened Community. All of these communities have census block groups with at least 40 percent of the residents identifying as minority. Morristown, Parsippany-Troy Hills Township, and Millburn Township all contain census blocks that have at least 35 percent of the households qualifying as low-income in addition to meeting the definition's minority criteria. Both Morris County focus municipalities, Morristown and Parsippany-Troy Hills, also have census blocks that meet the limited English criteria for NJDEP's Overburdened Community definition.

5.2 SOCIAL VULNERABILITY INDEX (SVI)

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

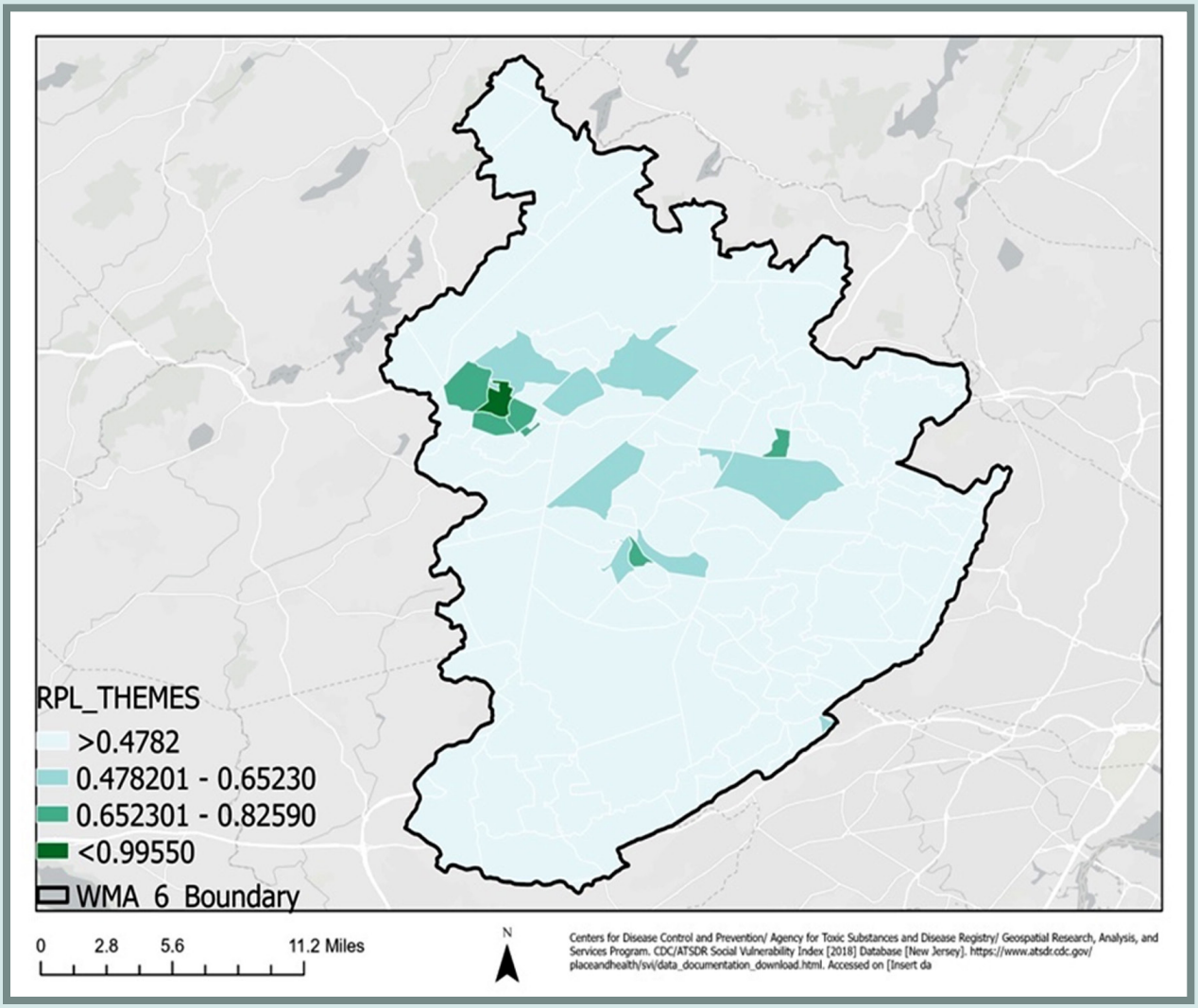
tract receives a rank for each factor, each of the four themes, and overall vulnerability, which can also be aggregated to a county level. SVI percentile rankings are based on a score of 0 to 1, in which census-tracts (or counties) with higher values have greater vulnerability compared to other tracts (or counties). In comparing the two vulnerable community 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. The other two SVI themes (Household Composition and Disability and Housing Type and Transportation) provide additional information about WMA06's socially vulnerable communities (Centers for Disease Control and Prevention Agency for Toxic Substances and Diseases Registry, 2022).

Table H5 provides the percentile ranking values for each of the major SVI categories and the total SVI percentile rankings for each WMA06 county (Also see Map H5). Ranking values are based on a comparison of all New Jersey counties between 0 (lowest vulnerability in the State) and 1 (highest vulnerability in the State). WMA06 has a wide range of SVI scores, with Sussex, Somerset, and Morris counties having relatively low SVI scores, ranking second, third, and fourth lowest in total SVI scores in the state respectively. In addition, these counties also have very low Socioeconomic Status, Household Composition and Disability, and Housing Type and Transportation percentile rankings. The Household Composition and Disability percentile ranking considers single-parent households and the number of citizens aged 65 or older, aged 17 or younger, or with a disability. The Socioeconomic Status category considers citizen income, the number of citizens who are living below poverty level, are unemployed, and/or have no high school diploma. The Housing Type and Transportation percentile ranking 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. The overall scores for Sussex, Somerset, and Morris counties suggest that these counties are the least vulnerable out of the WMA06 counties.

Table H.5 Social Vulnerability Index Percentile Values for WMA06 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
Essex	0.90	0.75	0.85	0.85	0.90
Morris	0.05	0.05	0.45	0.15	0.15
Somerset	0.05	0.10	0.50	0.00	0.10
Sussex	0.15	0.10	0.00	0.00	0.05
Union	0.55	0.45	0.85	0.55	0.60

As shown in Table H5, four out of the five WMA06 counties have relatively high rankings in Minority Status and Language, even among Morris and Somerset counties. This reflects the high resident diversity of the region. While Union County has relatively average SVI scores compared to the rest of the state, Essex County has significantly high SVI scores in all considered categories. Essex County's scores are significantly higher than the other WMA06 counties, which suggests it is the most vulnerable county in the WMA06 region. However, this is a bit of a misrepresentation of WMA06's Essex municipalities, which are less vulnerable compared to areas in the eastern side of the county. Among WMA06 municipalities, the highest SVI scores are located in areas of Dover, Victory Gardens Borough, and Wharton Borough, along with portions of Morristown and Parsippany-Troy Hills Township.



Map H.5 WMA06 Social Vulnerability Index (2018): Overall Municipality Score

5.3 COMPARISON OF OVERBURDENED COMMUNITIES AND SVI FINDINGS

Overall, the SVI and Overburdened Communities results for WMA06 are consistent in identifying the WMA06 locations that are most socially vulnerable. Communities identified as having the highest SVI scores in WMA06 (Dover, Victory Gardens Borough, Wharton Borough, and portions of Morristown and Parsippany-Troy Hills Township) were all found to contain census block groups designated as Overburdened Communities. Also consistent from the comparison of SVI and Overburdened Communities findings was identifying Essex County as the most socially vulnerable WMA06 county. Seven of Essex County's eleven WMA06 municipalities contain Overburdened Communities. As a percent of its total WMA06 municipalities, Essex County has the highest percentage of municipalities containing Overburdened Communities (64%), followed by Morris County (55%).

The finding that 17 of Morris County's WMA06 municipalities contain Overburdened Communities may appear contradictory compared to its SVI findings, which suggested low vulnerability. Because the SVI scores are based on a ranking process, findings for Morris County are interpreted as Morris County has low vulnerability compared to other New Jersey counties (third lowest vulnerability among WMA06 counties and fourth lowest vulnerability among New Jersey counties). However, the Overburdened Communities analysis reveals that Morris 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 WMA06.

6. CURRENT LAND USE

KEY FINDINGS

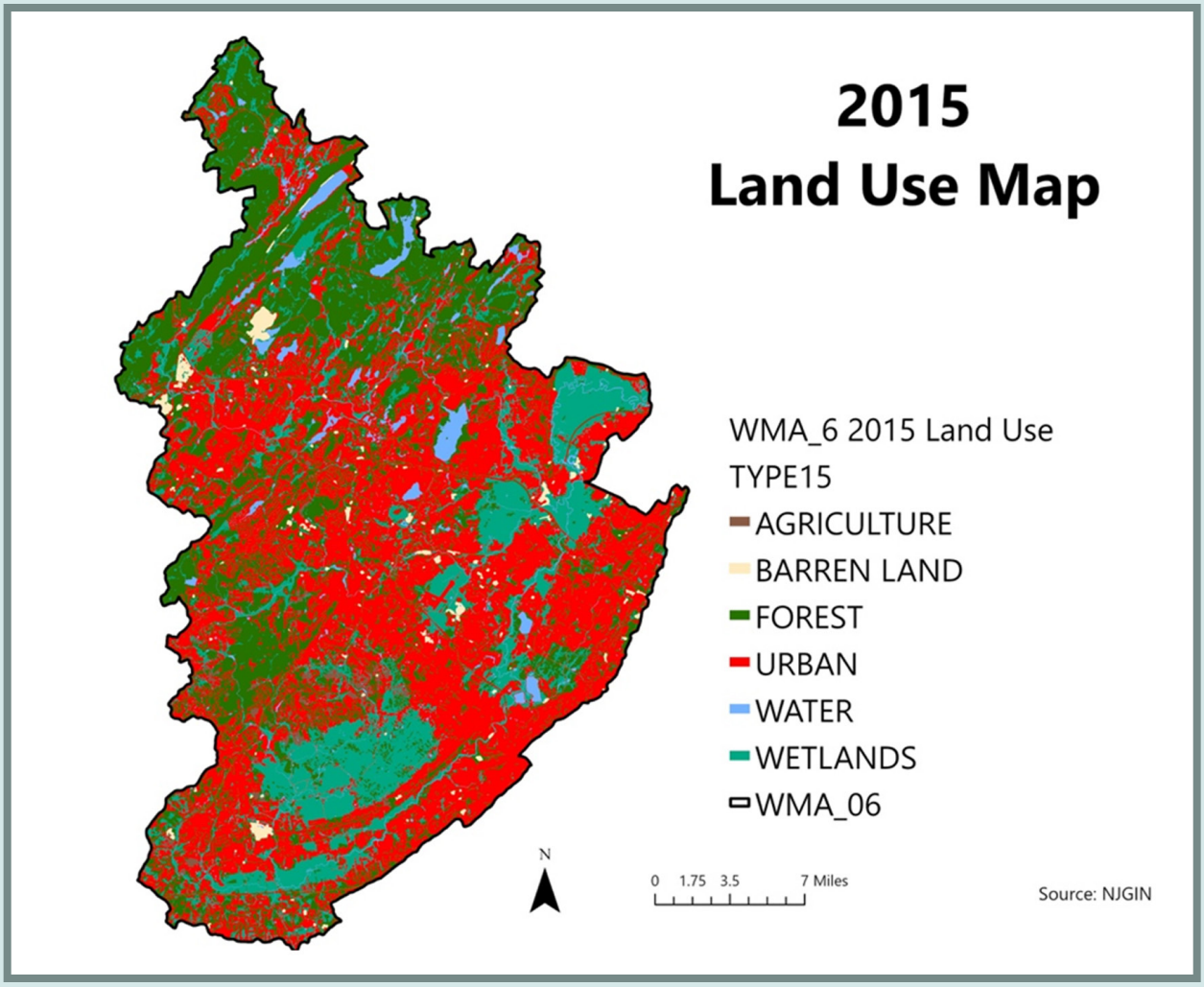
- WMA06 is dominated by urban (32%) and forest (32%) land use/land cover, and is considered heavily developed. Facing regional development limitations from Highlands regulations, development strategies in Morris, Essex, and Somerset counties have focused on urban redevelopment and infill projects.
- A small agricultural presence exists in several WMA06 counties (Morris, Sussex, and Somerset), and WMA06 efforts to preserve open space focus on areas that provide flood protection and aquifer recharge.

Table H.6 Land Use in WMA06 and Focus Municipalities (2015). Data provided by NJDEP Bureau of GIS, 2019

	Urban	Agriculture	Forest	Barren Land	Wetlands	Water
WMA06 Region	32%	1%	32%	1%	17%	3%
Focus Municipalities						
Livingston Township	64%	0%	19%	0%	14%	3%
Millburn Township	64%	0%	22%	0%	7%	6%
Morristown	82%	0%	12%	0%	1%	3%
Parsippany-Troy Hills Township	57%	0%	20%	1%	16%	7%
New Providence Borough	83%	0%	10%	1%	5%	1%

Table H6 provides the 2015 land use data for the WMA06 region and its focus municipalities (also see Map H6). As shown in the table, WMA06 has significant land use/land cover in natural areas, with 2015 reports of 32% forest, 3% water, and 17% wetlands, a significant portion of which is preserved open space. However, these areas are smaller in the focus municipalities. WMA06's highly developed land use is reflected in its reported 2015 regional urban land use percentage, which is 32%. Several significant wetlands areas are located in WMA06 including Passaic-Great Piece, Troy Meadows, Hatfield Swamp, and the Great Swamp. These wetland areas provide stormwater and flood storage and other environmental benefits to the region (Highlands Council, 2008a; Burgis Associates, Inc., 2011; Rutgers Cooperative Extension, 2007).

Despite facing development limits from both Highlands regulations (within the Highlands Preservation Area and conforming municipalities within the Planning Area) and lack of available vacant land, many WMA06 counties have developed strategies to promote development. For example, both Morris and Essex counties' development strategies have focused on redevelopment and infill projects in urban locations (Morris County Department of Public Works & Morris County Planning Board, 2018; Tetra Tech, 2020b). Facing similar issues with little remaining vacant developable land in sewer service areas, Somerset County planners also anticipate that any higher-intensity growth would also be in the form of infill and redevelopment projects (Somerset County Mitigation Planning Committee, 2019); little of the county's WMA06 area is within sewer service areas. Sussex County has focused on preventing suburban sprawl, and is interested in promoting a centers-based land use structure that has higher-density land use near development centers (Morris Land Conservancy & Sussex County Agriculture Development Board, 2008).



Map H.6 WMA06 2015 Land Use Map

6.1 FARMLAND PRESERVATION AND OPEN SPACE

Despite being heavily developed, a small agricultural presence exists in several WMA06 counties. Morris County agriculture is concentrated in the southwest and northern areas of the county (Morris County Planning Board, 2013); the farmland within Washington Township to the southwest is mostly within the Raritan River Basin (WMA08). With estimates Morris County has over 60,000 acres of prime farmland and over 31,000 acres of statewide importance, Morris County's Farmland Preservation Program has preserved over 8,000 acres of farmland as of 2021 (Heyer Gruel & Associates & Morris County Office of Planning & Preservation, 2022). The 2017 Census of Agriculture reported Morris County to have a total of 418 farms and 14,514 acres of agricultural land, far less than the total acreage of prime farmland. The median size of farms was 12 acres, and Morris County's market value of agricultural products sold was $24,824,000 (National Agricultural Statistics Service, 2019a; National Agricultural Statistics Service, 2019b). Known for its production of crops including corn, hay, and livestock, the 2017 Agricultural Census reported Sussex County had 1,008 farms and 59,766 acres of agricultural land; much of this land is outside WMA06. Its median farm size was larger than Morris County's (18 acres), but its market value of agricultural products sold was smaller ($18,226,000) (Morris Land Conservancy & Sussex County Agriculture Development Board, 2008; National Agricultural Statistics Service, 2019a; National Agricultural Statistics Service, 2019b). Somerset County's agricultural industry is considered small, but has strong public support (Somerset County Board of Chosen Freeholders et al., 2013), with approximately 8,300

acres of permanently preserved farmland, part of which is outside of WMA06. All of the WMA06 Somerset municipalities contain small areas of agricultural land use, with a 2019 estimate of 4,168 acres of agricultural land in these municipalities (Somerset County Planning Board, 2022).

WMA06's counties have also made efforts to preserve their open space, which has included a focus on providing flood protection and aquifer recharge. Highlights of WMA06 county efforts to preserve open space are provided below.

- **Morris County:** is highly active in open space preservation and as of 2020, had the largest New Jersey park system with over 18,900 acres. Its open space areas include Morristown National Historic Park and Great Swamp National Wildlife Refuge, both of which are federal facilities (Morris County Planning Board, 2013; Tetra Tech, 2020a). Areas considered high priority for preservation in the county include areas where wellhead protection areas overlap with aquifer recharge areas (MCMUA, 2021).
- **Essex County:** has an extensive park system that as of 2014, included over 7,000 acres of state, county, and municipal open space. Significant open space areas in the county include South Mountain Reservation (1,838 acres), West Essex Park (1,100 acres located along the Passaic River), and Passaic Meadows Macrosite: a NJDEP designated natural heritage priority site located along the Passaic River in Roseland Borough, West Caldwell Township, and Fairfield Township (Hatch Mott MacDonald, 2014).
- **Somerset County:** has a park system that includes over 27 park areas and approximately 14,700 acres. The county's open space preservation strategy includes assisting its municipalities with buyouts of flood-prone residential properties through its Somerset County Municipal Flood Mitigation Funding Program (Somerset County Board of County Commissioners et al., 2022), mostly in the Raritan River Basin.

6.2 NEW JERSEY HIGHLANDS REGION REGULATIONS AND OVERSIGHT

The New Jersey Highlands Region is part of a larger four-state Highlands geological system that spans across 3.5 million acres in New York, Pennsylvania, Connecticut, and New Jersey. The New Jersey Highlands is a 1,343 square mile area that includes all or parts of 88 municipalities in seven counties in northwestern New Jersey (Hunterdon, Warren, Morris, Passaic, Sussex, Bergen, and Passaic) (Highlands Council, 2008b; Tetra Tech, 2020a; Morris County Planning Board, 2013). Considered a significant potable water source for over half of New Jersey's residents, the Highlands Water Protection and Planning Act of 2004 established extensive land use controls in the Highlands Preservation Area, administered by NJDEP, and mandated that the Highlands Council create a Highlands Regional Master Plan (RMP), which established additional land development standards within the region (Highlands Council, 2008b; Tetra Tech, 2020a; Tetra Tech, Inc., 2021; Morris County Planning Board, 2013).

Within the RMP, areas in the New Jersey Highlands region are designated as either Planning Area or Preservation Area. County and municipal conformance to the RMP is mandatory in the Preservation Area and is designed to include lands with the highest ecological value. County and municipal conformance to the RMP is voluntary in the Planning Area. Land is further categorized into three major land use zones: (a) Protection Zones (which focus on protecting the highest quality resources); (b) Conservation Zones (which include significant agricultural lands and associated natural resource lands); and (c) Existing Community Zones (which have fewer natural resource constraints than the first two categories, are more easily served with public infrastructure, and are considered opportune areas for future growth). Restrictions in the Highlands include water withdrawal limits, limits on roadway expansion, restrictions on public water and sewer service extensions, and new environmental standards (Highlands Council, 2008b; Morris County Department of Public Works & Morris County Planning Board, 2018).

Two focus municipalities (Parsippany-Troy Hills Township and Morristown) are located within the Highlands Planning Area. According to the New Jersey Highlands Council website (**New Jersey Highlands Council RMP Conformance Status**), Parsippany-Troy Hills received approval for its petition to the Highlands Council for conformance in 2020. Morristown has not petitioned the Highlands Council for conformance (Highlands Council, 2023).

7. WATER AVAILABILITY AND DEMAND ANALYSIS

KEY FINDINGS

- Overall WMA06 withdrawals have declined since the 1990s, and have been a roughly even split between water withdrawals from surface water and unconfined groundwater sources throughout the considered time period (1990-2020). During this time period, almost all water withdrawals were for potable supply purposes.
- WMA06 HUC11s with the largest average withdrawals between 2016-2020 were 02030103030 (Rockaway River) and 02030103010 (Passaic River Upr (above Pine Bk br). A significant portion of WMA06 water withdrawals from 02030103030 are exported out of WMA06 for potable supply use in Jersey City and municipalities that receive water from the city.
- The largest consumptive/depletive water use in WMA06 between 1990-2020 was for potable supply purposes.
- NJDEP's Low Flow Margin analysis reveals two of four WMA06 HUC11s are unstressed, and the HUC11s with the largest deficits are 02030103020 (Whippany River) followed by 02030103010 (Passaic River Upr (above Pine Bk br)).
- The Upper Passaic, Rockaway, and Whippany rivers have all been found to suffer some water quality impairment, with elevated levels of nutrients including Phosphorus, Sodium, and Lead.

Figure H4a and b show WMA06 water withdrawals from 1990-2020 based on water withdrawal source and water use categories. Water withdrawals were roughly split between surface water sources and unconfined groundwater sources throughout the considered time period (1990-2020). However, overall water withdrawal in the region has declined in recent years, with WMA06 water withdrawals averaging a little over 36,700 million gallons a year (36.7 billion gallons a year) between 2010-2020 (compared to a little over 42,000 million gallons a year between 2000-2009) (NJDEP Division of Water Supply and Geoscience, 2021).

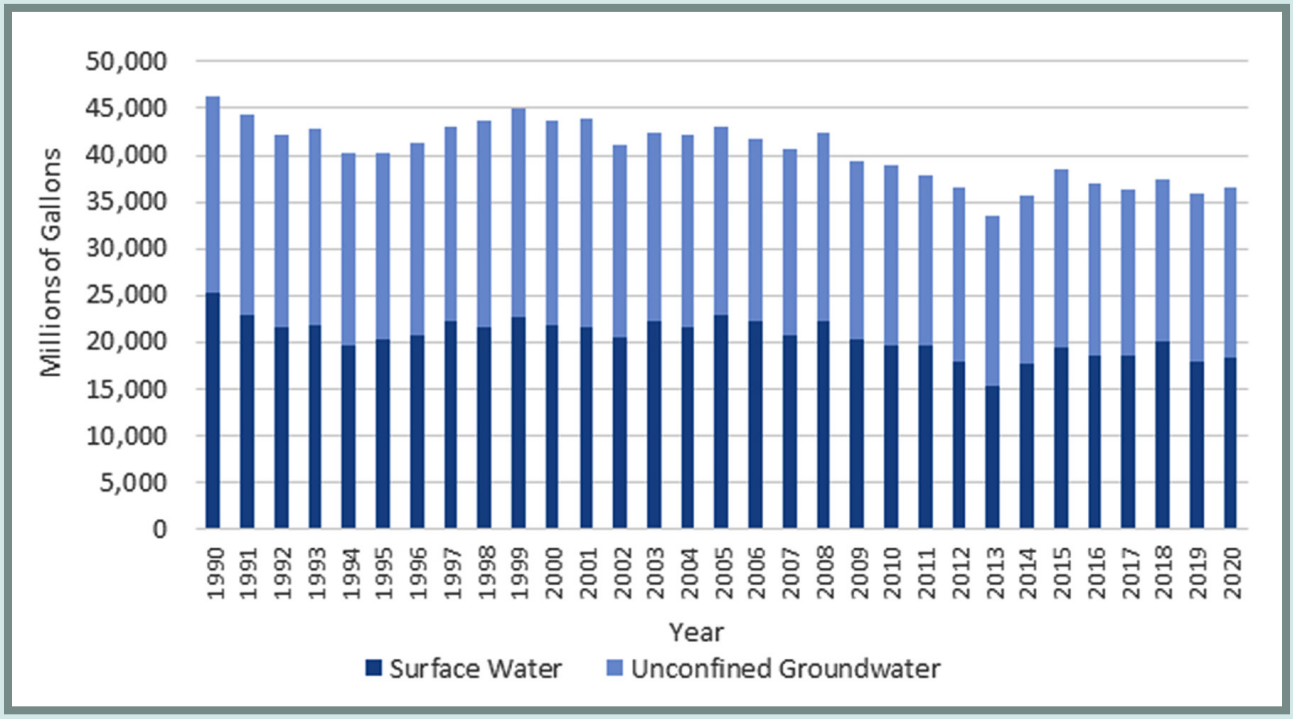


Figure H.4a WMA06 Water Withdrawals by Source (1990-2020)

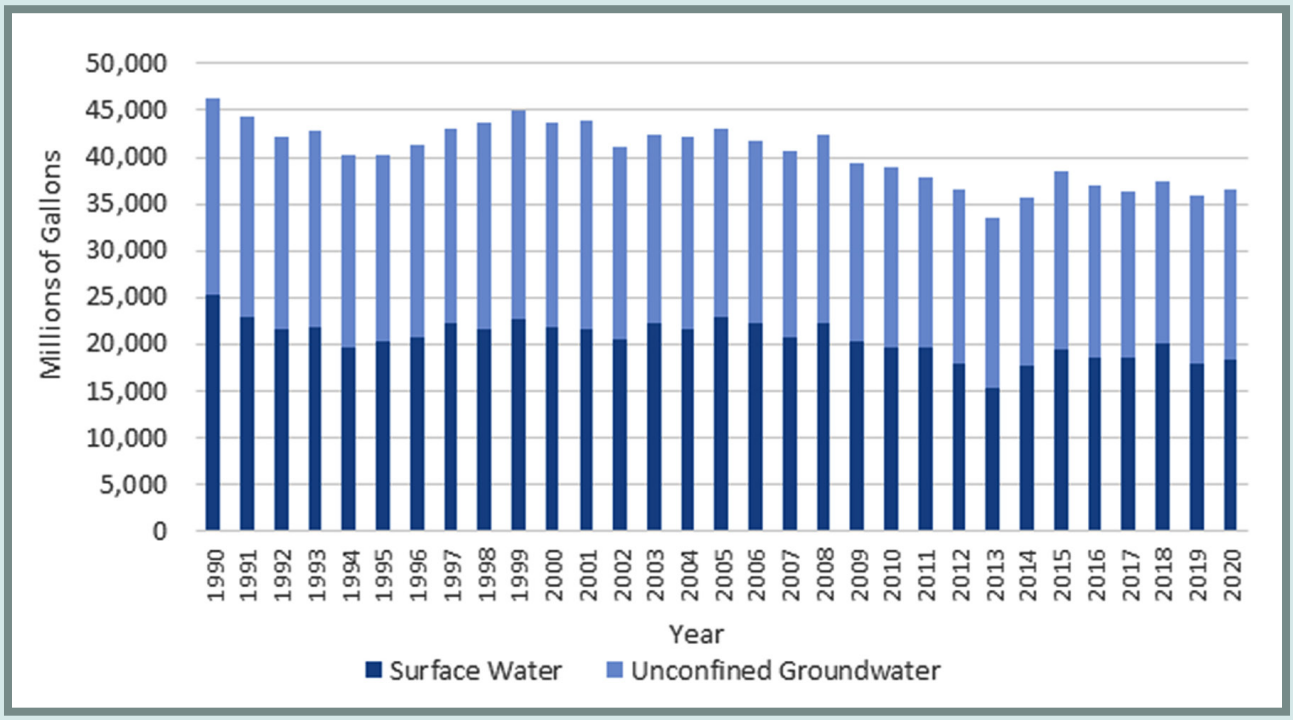


Figure H.4a WMA06 Water Withdrawals by Source (1990-2020)

Water withdrawal by water use category reveals that WMA06 water withdrawals were almost entirely (approximately 97%) for potable supply use throughout the considered time period, with potable supply withdrawals averaging approximately 39,309 million gallons a year. A small amount of water withdrawals was used for agriculture and irrigation and commercial, industrial, and mining purposes in WMA06 (NJDEP Division of Water Supply and Geoscience, 2021).

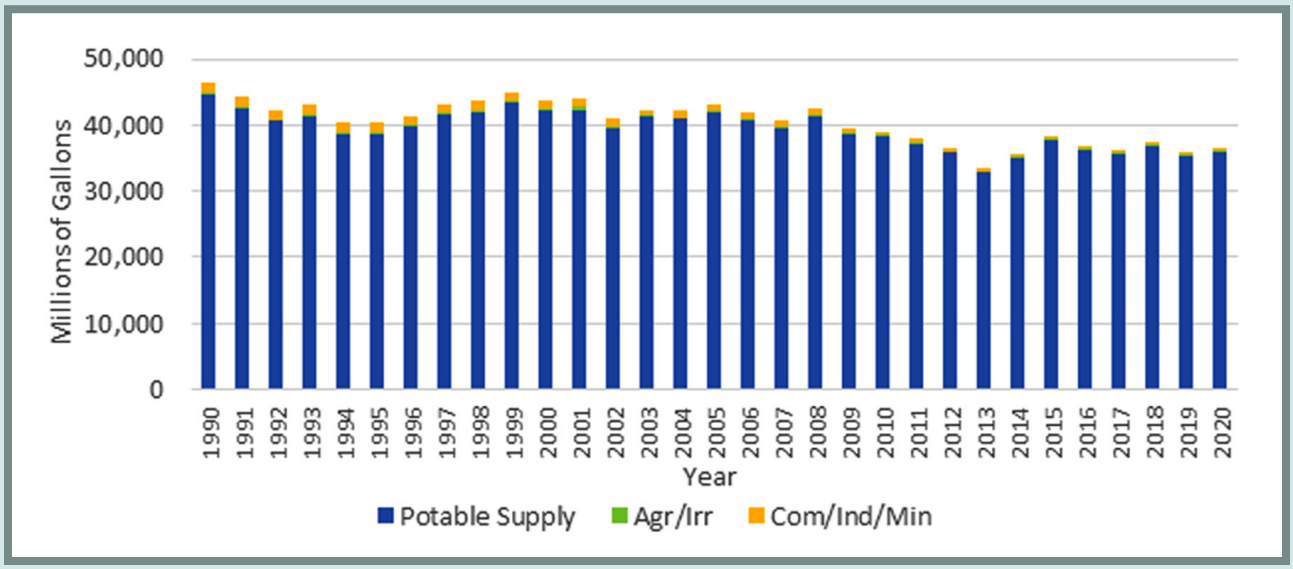


Figure H.4b WMA06 Water Withdrawals by Water Use Category (1990-2020)

Figure H5 shows WMA06 sanitary sewer discharges (returns) to groundwater and surface water resources from 1990-2020. As shown in the figure, WMA06 returns averaged a little over 16,500 million gallons a year between 1990-2020. The average WMA06 water returns between 2010-2020 was approximately 15,864 million gallons a year, which is smaller than the average returns experienced between 2000-2009 (approximately 17,742 million gallons a year). WMA06 returns were almost entirely to surface fresh water sources (average of 99% of total returns between 1990-2020). The largest sources of discharge to surface fresh water sources include Parsippany-Troy Hills STP and Rockaway Valley Regional SA, which were an average of 25.6% and 19.5% of total WMA06 annual discharges from 1990-2020, respectively (NJDEP Division of Water Supply and Geoscience, 2021). Multiple smaller but significant discharges exist in the Whippany River and Upper Passaic River watersheds.

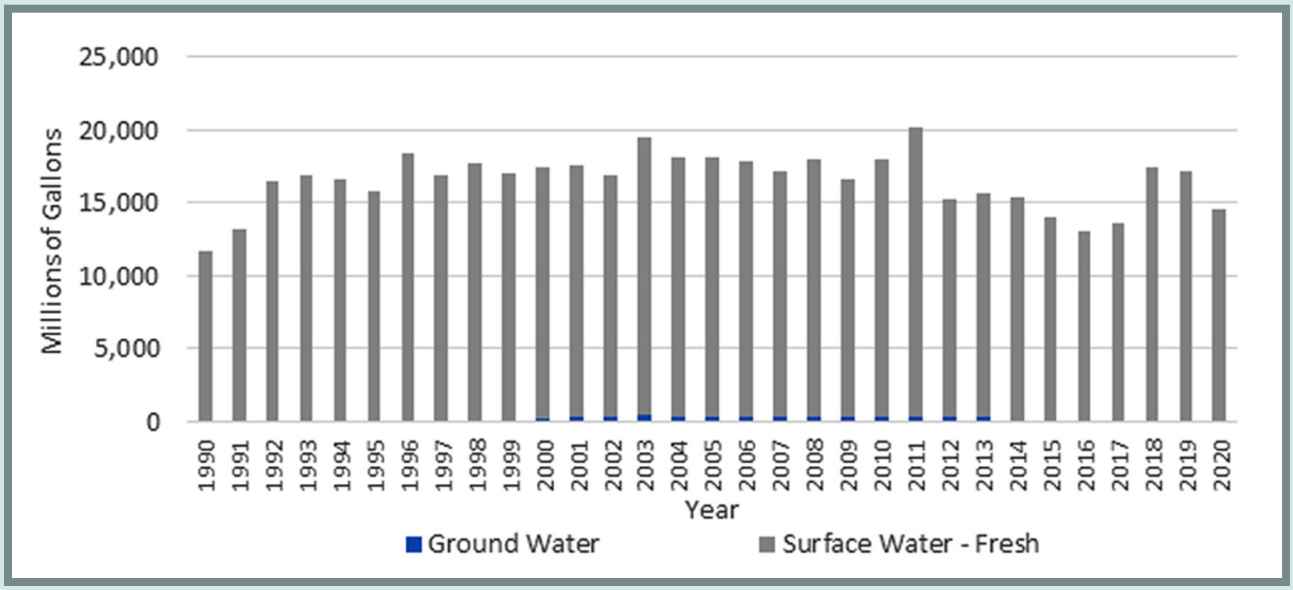


Figure H.5 WMA06 Sanitary Sewer Returns by Source (1990-2020)

7.1 WATER QUANTITY

Figure H6 shows the average water withdrawals for each HUC11 in WMA06 based on water use category between 2016-2020. HUC11 02030103030 (Rockaway River) had the largest average water withdrawal between 2016-2020, which was approximately 19,700 million gallons a year. This water withdrawal, like the water withdrawal for the other WMA06 HUC11s, was almost entirely for potable supply purposes. The HUC11s with the next largest withdrawals were 02030103010 (Passaic River Upr (above Pine Bk br)) and 02030103020 (Whippany River). Both of these HUC11s had average withdrawals of approximately 10,418 and 6,410 million gallons a year for the five-year period, respectively (NJDEP Division of Water Supply and Geoscience, 2021).

Most withdrawals from HUC11 02030103030 (Rockaway River) are from the Boonton (Jersey City) Reservoir and are exported from WMA06 for use by the City of Jersey City and its customers. Between 2016-2020, withdrawals by the City of Jersey City were approximately 78% of all withdrawals in this HUC11. This water withdrawal is also a significant portion of both surface water and total water withdrawals in WMA06. Between 2016-2020, water withdrawals by Jersey City were approximately 82% of WMA06's total surface water withdrawals and 42% of WMA06's total withdrawals (NJDEP Division of Water Supply and Geoscience, 2021). These withdrawals are from reservoir storage, as supported by flows of the Rockaway River including both base flows and runoff. The reservoir is subject to mandatory flow contributions to the lower Rockaway River.

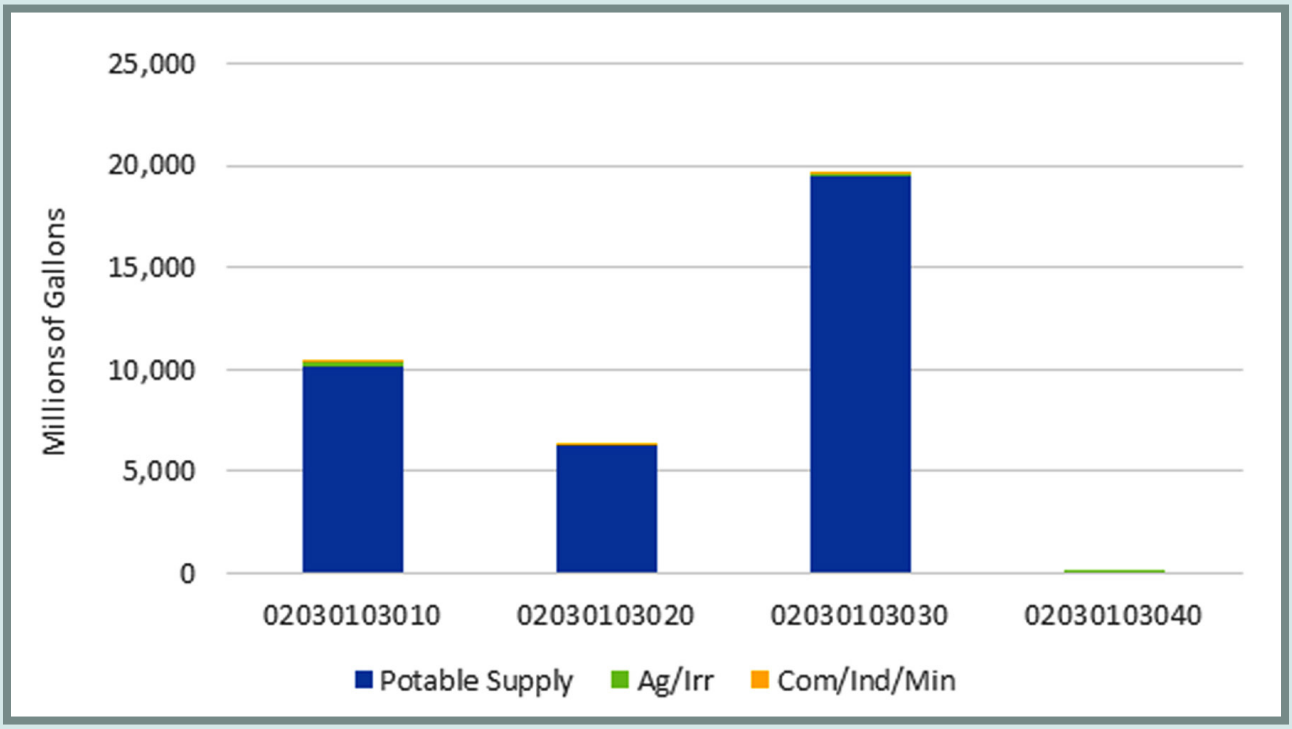


Figure H.6 WMA06 HUC11 Five-Year Average Water Withdrawals by Water Use Category (2016-2020)

Figure H7 provides the annual consumptive water use in WMA06 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. Therefore, Figure H7 reflects the total annual amount of consumptive water use for each water use category in WMA06 between 1990-2020 (NJDEP Division of Water Supply and Geoscience, 2021).

As shown in Figure H7, potable supply had the largest consumptive water use among WMA06's water use categories throughout the considered time period. Total consumptive water use fluctuated between 1990-2020, with an average total consumptive use of approximately 2,898, 3,228, and 2,905 million gallons a year in the 1990s, 2000s, and 2010s respectively. This indicated a rise in consumptive water use between 2000-2009, and a decline in consumptive use after 2010 that reflected similar numbers to those experienced in the 1990s. Potable supply has slightly increased as a percentage of WMA06's total consumptive water use throughout the considered time period. Potable supply was approximately 89%, 90%, and 92% percent of WMA06's total consumptive water use in the 1990s, 2000s, and 2010s, respectively (NJDEP Division of Water Supply and Geoscience, 2021).

Depletive water uses exist where water is removed from its source area and discharged in another HUC11 or tidal waters. The Jersey City withdrawals are 100% depletive, while other withdrawals will have a consumptive water use component with the rest discharged back to the HUC11 as treated wastewater. Depletive water uses are tracked separately.

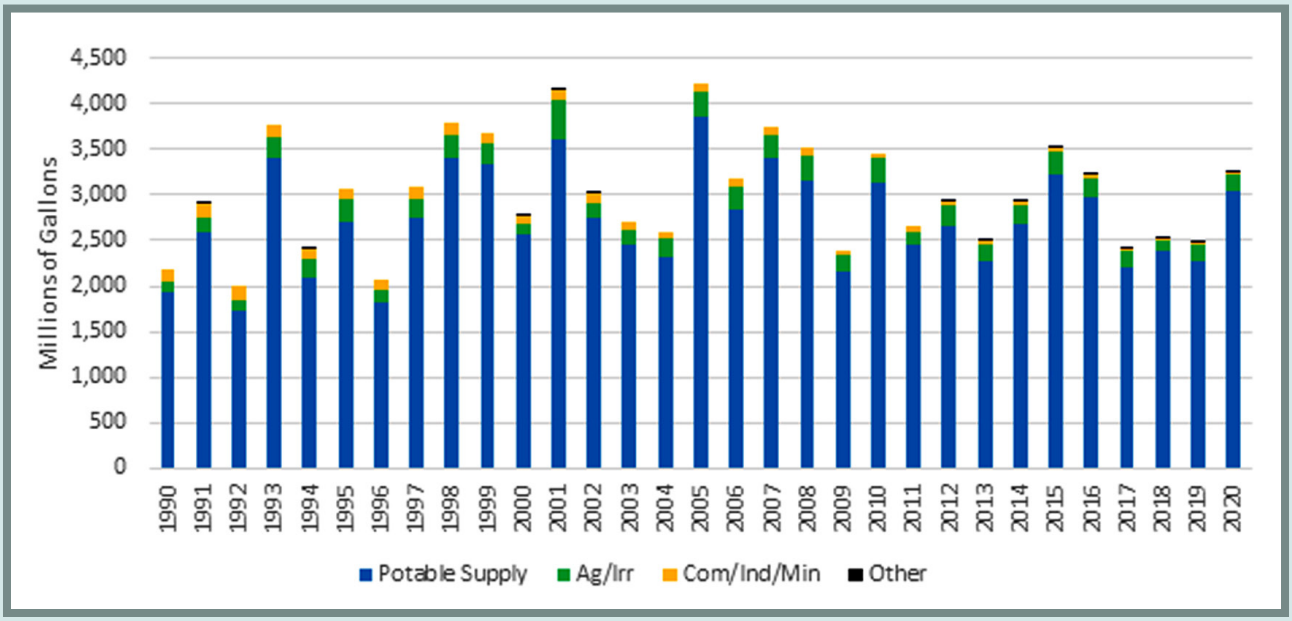


Figure H.7 WMA06 Consumptive Water Use by Water Use Category (1990-2020)

Figure H8 provides WMA06 monthly consumptive water use data by water use category between 2005-2020. Potable supply had the largest consumptive water use among the water use categories, but potable supply consumptive water use in WMA06 has declined since 2015. Average consumptive water use for potable supply was approximately 2,898 million gallons a year between 2005-2015, which declined to approximately 2,574 million gallons a year between 2016-2020. The large peaks for potable supply show the seasonality of consumptive water use for this water use category in which the largest consumptive water use is experienced in the summer months (May-September). Consumptive water use for agriculture/irrigation purposes was also found to have a seasonal effect in which consumptive water use was larger in the summer months. However, this effect was on a much smaller scale (primarily due to the limited agricultural presence in WMA06) (NJDEP Division of Water Supply and Geoscience, 2021).

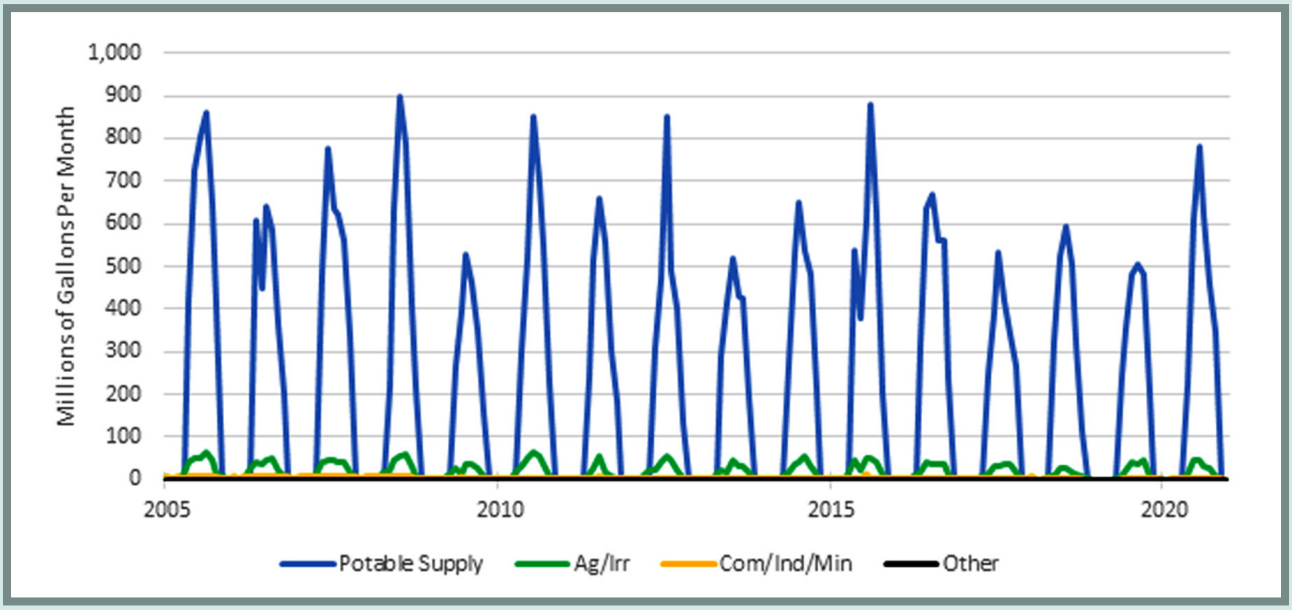


Figure H.8 WMA06 Monthly Consumptive Water Use by Water Use Sector (2005-2020)

LOW FLOW MARGIN METHOD

NJDEP uses the streamflow Low Flow Margin (LFM) method to consider what HUC11s 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 non-reservoir surface waters (reservoir-based systems and confined aquifers are addressed separately). Figure H9a and b show the amount of available water used in each HUC11 during their three-year average peaks in consumptive/depletive loss between 2011-2020. The only HUC11 with net gain in WMA06 (02030103030 – Rockaway River), is indicated in green in both figures. This net gain is primarily due to the Parsippany-Troy Hills STP discharge at the base of the HUC11, representing wastewater not only from the lower Rockaway River watershed but also from the Whippany River and Upper Passaic watershed (including East Hanover). In both figures, any HUC11 with depletive/consumptive loss greater than 100% water available for the watershed is indicated in red and is considered vulnerable or stressed.

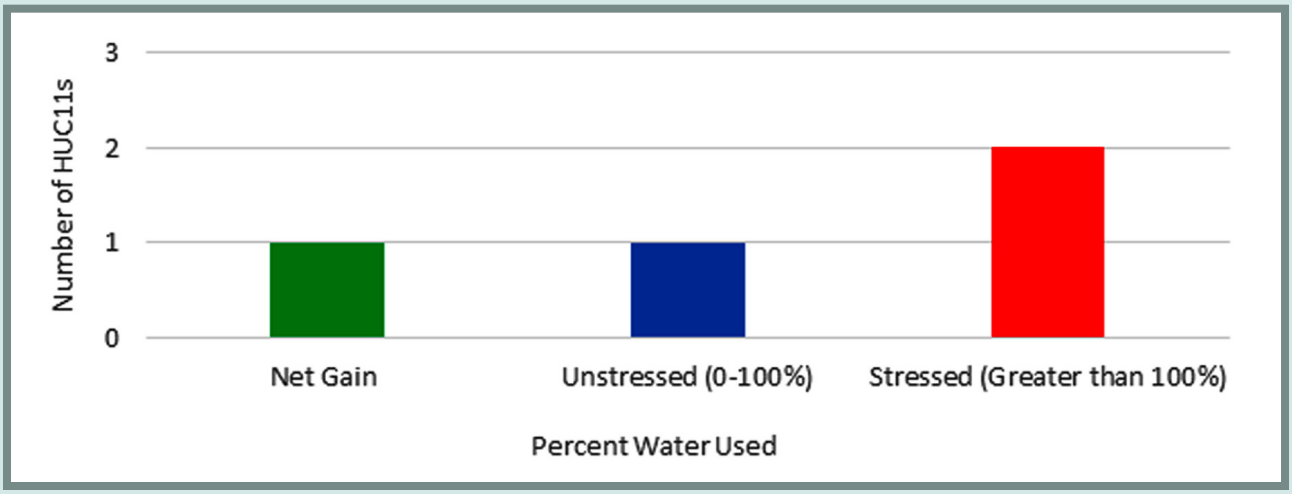


Figure H.9a WMA06 HUC11 Count by Percentage of Total Available Water Used (Three-Year Rolling Average Peak in Depletive/Consumptive Loss between 2011-2020)

As shown in Figure H9b, two out of four WMA06 watersheds are considered unstressed during their respective three-year average peaks in consumptive/depletive loss. The HUC11 considered most stressed in WMA06 is 02030103020 (Whippany River). Of the four HUC11s, potable supply is identified as the largest source of consumptive/depletive loss for three of four HUC11s, including both stressed HUC11s (02030103010 - Passaic River Upr (above Pine Bk br) and 02030103020 - Whippany River) in WMA06. The largest source of consumptive/depletive loss in 02030103030 (Rockaway River) is non-agricultural irrigation (NJDEP Division of Water Supply and Geoscience, [forthcoming]).

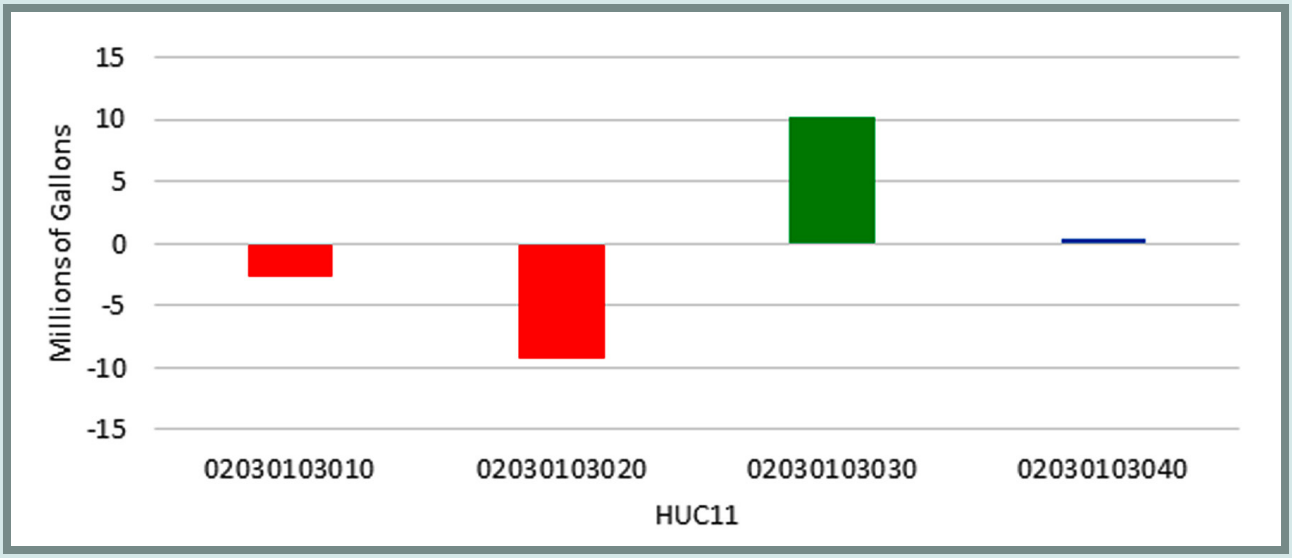


Figure H.9b WMA06 HUC11 Remaining Available Water for Three-Year Rolling Average Peaks in Consumptive/ Depletive Loss (2011-2020)

7.2 WATER QUALITY

Extensive development of WMA06 has contributed to water quality impairment of the Upper Passaic, Rockaway, and Whippany rivers. Highlights of the water quality conditions of WMA06's three major rivers are provided below.

- The Upper Passaic River: traditionally has better water quality than the highly developed and industrialized locations downstream. However, the Upper Passaic River watershed does have water quality concerns. According to NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report, portions of the Upper Passaic River are failing to meet water quality standards in Dissolved Oxygen, Total Suspended Solids, and Total Dissolved Solids. Non-attainment for Total Phosphorus, E. coli, and Arsenic (human health) were detected in multiple locations within the Upper Passaic River watershed. These areas included Slough Brook, Canoe Brook, and several areas of the main Upper Passaic River (such as Snyder to Plainfield Road, Rockaway to Hanover Railroad, and Pine Brook to Rockaway) (NJDEP Division of Water Monitoring and Standards, 2021a; NJDEP Division of Water Monitoring and Standards, 2021b). This region faces challenges from suspected non-point sources including leaking septic systems, urban surface runoff, and lawn and garden chemicals (Morris County Planning Board, 2000).
- The Rockaway River: historically has had good water quality in the Upper Rockaway watershed compared to below the reservoir in Pine Brook (Montville Township). Previous activities on Superfund and other contaminated sites, such as L.E. Carpenter (Wharton Borough) and Sharkey's Landfill (Parsippany Troy-Hills Township), have been suspected of potentially adding industrial contaminants to the Rockaway River (Morris County Planning Board, 2000). More recently, NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report has found that portions of the Rockaway River have excessive E.coli, Arsenic (human health), and Mercury (fish consumption) concentrations (NJDEP Division of Water Monitoring and Standards, 2021a; NJDEP Division of Water Monitoring and Standards, 2021b).

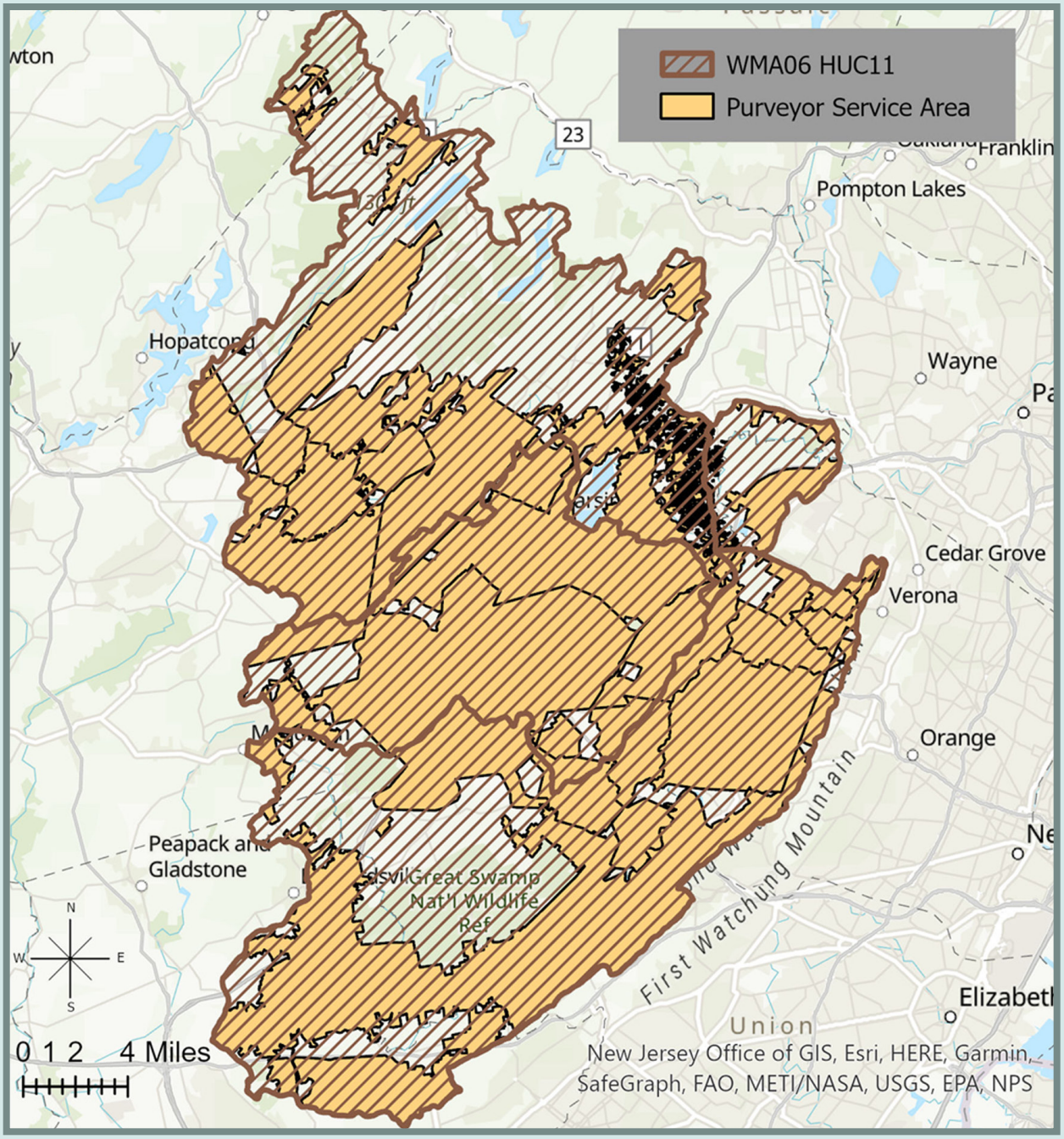
- The Whippany River: also faces pollution from nonpoint sources such as surface runoff, groundwater discharges, and fertilizers, and has been historically found to suffer from contamination from fecal coliform, Phosphorus, inorganic Nitrogen, and Sodium (Tetra Tech, 2020b; Colliers Engineering & Design & Hipolit, 2021; Morris County Planning Board, 2000). Water quality testing of the Whippany River for the NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report shows that portions of the Whippany River suffer from elevated concentrations of Total Phosphorus, E. coli, Arsenic (human health), and Lead (human health) (NJDEP Division of Water Monitoring and Standards, 2021a; NJDEP Division of Water Monitoring and Standards, 2021b). Examination of local waterbodies that enter the Whippany River, such as Lake Parsippany, have been found to have contamination in lake sediments. In response, basins have been created to prevent contaminated sediments from entering the river (Rutgers Cooperative Extension, 2007).

The Central Passaic Buried Valley Aquifer System and Upper Rockaway River Basin Area Aquifer System are vulnerable to contamination through their recharge zones from sources including septic systems and contaminants in streamflow (Amy S, Greene Environmental Consultants, Inc., 2010). Since the unconfined units are often shallow, they may be vulnerable to pollutants such as gasoline, deicing salts, and industrial chemicals (Highlands Council, 2008b). These aquifer systems are also particularly vulnerable to contamination during drought periods and in locations with heavy pumping, as the aquifer will draw water from surface water sources through lake and river sediments (Highlands Council, 2008c). Other sources that pose a risk to contaminate the recharge zones include leaking pipes, accidental spills, pesticides, and vehicle emissions (Amy S, Greene Environmental Consultants, Inc., 2010). There are several Superfund sites upstream, in areas including Denville Township, Dover, Rockaway Borough and Rockaway Township, mostly involving discharges from industrial facilities and gasoline storage tanks.

8. WATER UTILITIES AND WATER INFRASTRUCTURE

KEY FINDINGS

- PCWSs in WMA06 are highly interconnected due to factors including population density and historical development, which allows for the transfer of water between PCWSs.
- Although roughly half of WMA06's PCWSs reported a decline in potable water demand between 2011-2020, the largest increases in potable supply demand were reported for Jefferson Township Water Utility- Lake Hopatcong, Mount Arlington Borough DWP Main, and Denville Township WD.
- WMA06 PCWS 2050 demands projections indicate that the majority of WMA06 PCWSs will experience less demand compared to current demand numbers, with localized differences between PCWSs in different counties and future water use behavior. However, there is some uncertainty with these numbers due to the uncertainty of the population projections for Morris and Essex counties (discussed in Section 4).
- WMA06 PCWS 2050 demands projections also indicate that many PCWSs serving WMA06's focus municipalities will experience demand decline by 2050, suggesting that they will be able to meet future water demands.



Map H.7 Public Community Water System (PCWS) Purveyor Service Areas in WMA06's HUC11s
Source: NJDEP Bureau of GIS

Table H7 shows the public community water systems (PCWSs) that serve over 1,000 people and service the HUC11s in WMA06 (See Map H7 for all PCWS purveyor service areas in WMA06's HUC11s)[1]. Due to factors including high population density and historical development, there are many large PCWSs in WMA06, and they are highly interconnected. In addition to significant WMA06 water withdrawals being exported for use by the City of Jersey City and its customer municipalities, NJDEP reports that many PCWSs within the region also transfer water between each other in bulk transfer agreements, such as from Passaic Valley Water Commission to New Jersey American Water and Southeast Morris County MUA, and from Jersey City to Parsippany-Troy Hills. Regional capability for transferring water between PCWSs in WMA06 has been found to be an effective strategy in regional response to droughts and other water emergencies (NJDEP, Gannett Fleming, & Black & Veatch, 2007).

The largest PCWSs that serve Morris County are Southeast Morris County MUA, Dover WD, and Parsippany-Troy Hills WD. Many of the purveyors in the western part of the county (e.g., Randolph Township) receive water from the Morris County Municipal Utilities Authority (primarily from groundwater in the Raritan River Basin, WMA08), which is responsible for both developing and distributing water supply for county residents (Heyer Gruel & Associates & Morris County Office of Planning & Preservation, 2022). Essex County's largest PCWS is New Jersey American Water. Somerset County has several water service providers including New Jersey American Water – Raritan and New Jersey American Water – Passaic. While roughly half of the listed PCWSs reported a decline in potable water demand, Jefferson Township Water Utility- Lake Hopatcong, Mount Arlington Borough DWP Main, and Denville Township WD reported the largest increase in potable supply demand in WMA06 between 2011 and 2020 (NJDEP Division of Water Supply and Geoscience, 2022a; NJGWS, 2022).

Almost 20% of all major WMA06 PCWSs reported firm capacity deficits. 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). East Hanover Township WD (approximately -0.2 mgd), Sisters of Charity of South Elizabeth (approximately -0.1 mgd), Caldwell WD (approximately -1 mgd), and Roseland WD (approximately -2 mgd) all reported firm capacity deficits. Firm capacity deficits were also reported by Rockaway Borough WD (approximately -0.2 mgd) and North Caldwell WD (approximately -0.3 mgd).

Several major WMA06 PCWSs had either monthly or yearly water allocation permit deficits. Mount Arlington Borough DPW Main reported a deficit for both its monthly (approximately -1 mgm) and yearly (approximately -11 mgy) water allocation permits, while Rockaway Township WD reported a deficit in its yearly water allocation permit (approximately -44 mgy). Rockaway Borough WD reported a monthly water allocation permit deficit (approximately -4 mgm), while North Caldwell WD reported deficits in both its monthly (approximately -11 mgm) and yearly (approximately -205 mgy) water allocation permits (NJDEP Division of Water Supply and Geoscience, 2022b).

[1] Please note that PCWSs with very limited acreage in WMA06 were excluded from the assessment.

Table H.7 Public Community Water Systems in WMA06 Serving 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)
Caldwell WD	NJ0703001	02030103010	-1%	288	304
Essex Fells WD	NJ0706001	02030103010	-9%	180	277
Fairfield WD	NJ0707001	02030103010, 02030103040	5%	489	549
Livingston Township DW	NJ0710001	02030103010	4%	1,435	1,659
NJ American Water- Passaic	NJ0712001	02030103010, 02030103020	-16%	12,445	13,586
North Caldwell WD	NJ0715001	02030103010	-25%	300	374
Roseland WD	NJ0718001	02030103010	-11%	253	282
West Caldwell WD	NJ0721001	02030103010	36%	457	534
Boonton WD	NJ1401001	02030103020, 02030103030	1%	272	293
Chatham WD	NJ1404001	02030103010	13%	324	359
Denville Township WD	NJ1408001	02030103020, 02030103030	36%	736	874
Dover Water Commission	NJ1409001	02030103030	-5%	995	1,085
East Hanover Township WD	NJ1410001	02030103010, 02030103020, 02030103030	31%	694	818
Florham Park WD	NJ1411001	02030103010, 02030103020	12%	377	508
Jefferson Township W U Milton System	NJ1414003	02030103030	-24%	112	136
Jefferson Township Water Utility - Lake Hopatcong	NJ1414011	02030103030	94%	209	268
Fayson Lakes WC	NJ1415001	02030103030	20%	71	84
Lincoln Park WD	NJ1416001	02030103040	-5%	411	507
Madison WD	NJ1417001	02030103010, 02030103020	9%	669	781
Mine Hill WD	NJ1420001	02030103030	-35%	93	148

Purveyor	Purveyor ID	HUC11s Served	Demand Percent Change (2011-2020)	Average Demand (mgy) (2011-2020)	Max Demand (mgy) (2011-2020)
Montville Township MUA	NJ1421003	02030103010, 02030103030, 02030103040	22%	802	870
Sisters of Charity of South Elizabeth	NJ1422001	02030103020	-47%	16	19
Southeast Morris County MUA	NJ1424001	02030103010, 02030103020, 02030103030	6%	3,033	3,198
Mountain Lakes WD	NJ1425001	02030103020, 02030103030	-7%	195	218
Mount Arlington Borough DWP Main	NJ1426005	02030103030	51%	90	111
Parsippany-Troy Hills WD	NJ1429001	02030103020, 02030103030	-2%	2,245	2,422
Randolph Township Public Works Dept	NJ1432003	02030103020, 02030103030	-10%	576	650
Rockaway Borough WD	NJ1434001	02030103030	-42%	338	431
Rockaway Township WD	NJ1435002	02030103030	12%	546	605
AWO&M - Picatinny Arsenal	NJ1435003	02030103030	-22%	226	311
Roxbury Water Company	NJ1436002	02030103030	-19%	352	452
Roxbury Township WD - Skyview*	NJ1436004	02030103030	-100%	18	28
Wharton WD	NJ1439001	02030103030	6%	520	571
Sparta Township WU - Highlands	NJ1918003	02030103030	13%	51	119
NJ American Water - Raritan	NJ2004002	02030103010	1%	35,274	37,257
*Data only available for 2011-2013, 2019					

Table H8 provides NJDEP 2050 projected demands for major WMA06 PCWSs based on the demand projections provided in Appendix D. Four non-peak 2050 projected demands scenarios were considered, 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 service areas in bedrock geology. Optimal water loss scenarios assume that PCWSs will meet a more aggressive water loss standard (25th percentile for the bedrock geology 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 can be expressed as either annual (mgy) or monthly (mgm) data, but is expressed as average daily volumes (mgd) in Table H8. 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, WMA06 PCWSs are anticipated to experience less demand in 2050 compared to current demand numbers, with some more localized differences between PCWSs in different counties and future water use scenarios. Many PCWSs, especially in Morris County, are projected to experience demand decline (indicating more firm capacity available), including Lincoln Park WD, Mine Hill WD, Montville Township MUA, Southeast Morris County MUA, and Parsippany-Troy Hills WD. Other WMA06 PCWSs projected to experience demand decline include Essex Fells WD, New Jersey American Water – Passaic, and Caldwell WD. Some PCWSs had split projections in which demand was projected to increase in non-conservation scenarios and decline in the conservation scenarios. These PCWSs included Fairfield Township WD and Livingston Township DW. Several PCWSs, such as Rockaway Township WD and East Hanover Township WD, are projected to switch from supply surplus to deficit in some 2050 scenarios. North Caldwell WD, which is currently in deficit, is projected to remain in deficit. Some potential concern was also identified for several PCWSs that were projected to be in deficit in some of their 2050 peak demands scenarios (not provided in Table H8). These PCWSs included West Caldwell Township WD, Denville Township WD, East Hanover Township WD, and Rockaway Township WD.

Among the PCWSs servicing WMA06 focus municipalities, almost all of them are projected to have demand decline by 2050. These PCWSs include New Jersey American Water – Passaic (services New Providence Borough, Livingston Township, and Millburn Township), Southeast Morris County MUA (services Morristown), Denville Township WD, and Parsippany-Troy Hills WD (both service Parsippany-Troy Hills Township). Mountain Lakes WD (also services a small part of Parsippany-Troy Hills Township) and Livingston Township DW were both projected to have demand decline in their conservation scenarios and demand increase in their non-conservation scenarios. As mentioned in the previous paragraph, Denville Township WD did have some projected deficit in its 2050 peak demands scenarios. However, overall findings suggest that PCWSs servicing the focus municipalities will be able to meet future water demands assuming no changes in water availability.

Table H.8 WMA06 PCWS 2050 Demands Projections (NJDEP Projections based on Van Abs et al., 2018)
*Red bold text indicates PCWSs in deficit in non-peak 2050 scenarios

				2050 No Conservation Scenario		2050 Conservation Scenario	
Purveyor ID	Purveyor	Average Daily Demand (2020) (mgd)	2020 Deficit/ Surplus (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Wate Loss Scenario (mgd)
NJ0703001	Caldwell WD	0.8	1.1	0.8	0.7	0.7	0.7
NJ0706001	Essex Fells WD	0.4	4.2	0.3	0.3	0.3	0.3
NJ0707001	Fairfield Township WD	1.3	1.6	1.5	1.4	1.3	1.3
NJ0710001	Livingston Township DW	3.9	4.9	4.2	4.0	3.8	3.6
NJ0712001	NJ American Water - Passaic	32.2	62.8	31.4	29.9	28.3	27.0
NJ0715001	**North Caldwell WD**	0.8	0.3	0.8	0.8	0.7	0.7
NJ0718001	Roseland WD	0.7	NA	0.7	0.7	0.6	0.6
NJ0721001	West Caldwell Township WD	1.3	1.5	1.0	1.0	0.9	0.9
NJ1401001	Boonton WD	0.7	1.6	0.8	0.7	0.7	0.7
NJ1404001	Chatham WD	0.9	1.2	0.9	0.9	0.8	0.8
NJ1408001	Denville Township WD	2.2	2.5	2.0	2.0	1.8	1.8
NJ1409001	Dover Water Commission	2.6	3.2	2.2	2.1	2.0	1.9
NJ1410001	**East Hanover Township WD**	1.9	2.2	2.4	2.3	2.1	2.0
NJ1411001	Florham Park WD	1.0	1.4	1.0	0.9	0.9	0.8
NJ1414003	Jefferson Township Water Utility - Milton System	0.3	0.4	0.3	0.3	0.2	0.2
NJ1414011	Jefferson Township Water Utility - Lake Hopatcong	0.6	1.0	0.8	0.7	0.7	0.7
NJ1415001	Fayson Lakes WC	0.2	0.2	0.2	0.2	0.2	0.2
NJ1416001	Lincoln Park WD	1.1	2.0	1.1	1.1	1.0	1.0

				2050 No Conservation Scenario		2050 Conservation Scenario	
Purveyor ID	Purveyor	Average Daily Demand (2020) (mgd)	2020 Deficit/ Surplus (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)
NJ1417001	Madison WD	1.9	2.5	2.0	1.9	1.8	1.7
NJ1420001	Mine Hill Township WD	0.2	0.5	0.2	0.2	0.2	0.2
NJ1421003	Montville Township MUA	2.3	2.8	2.1	2.0	1.9	1.8
NJ1422001	Sisters of Charity of South Elizabeth	0.0	0.1	0.0	0.0	0.0	0.0
NJ1424001	Southeast Morris County MUA	8.4	16.0	7.3	7.0	6.6	6.3
NJ1425001	Mountain Lakes WD	0.5	0.8	0.5	0.5	0.5	0.5
NJ1426005	Mount Arlington Borough DWP Main	0.3	0.3	0.2	0.2	0.2	0.2
NJ1429001	Parsippany-Troy Hills WD	6.1	8.4	5.8	5.5	5.2	5.0
NJ1432003	Randolph Township Water Division	1.6	2.5	1.7	1.6	1.5	1.4
NJ1434001	Rockaway Borough WD	0.8	1.5	0.7	0.7	0.7	0.6
NJ1435002	**Rockaway Township WD**	1.5	1.6	1.8	1.7	1.6	1.6
NJ1435003	USDOD Army Picatinny Arsenal	0.6	2.4	0.6	0.6	0.5	0.5
NJ1436002	Roxbury Water Company	0.9	1.2	1.1	1.0	1.0	0.9
NJ1436004	Roxbury Township WD - Skyview	0.0	0.8	0.0	0.0	0.0	0.0
NJ1439001	Wharton WD	1.4	2.4	1.3	1.3	1.2	1.1
NJ1918003	Sparta Township WU - Highlands	0.1	0.2	0.1	0.1	0.1	0.1
NJ2004002	NJ American Water - Raritan	98.0	178.6	78.7	75.0	72.4	69.0

Similar to WMA06 water supply service areas, expansion of both sewer and septic system use is limited in the region due to Highlands regulations. Highlights on WMA06 county sewer infrastructure are included below.

- Morris County: Major sewerage treatment plants in Morris County include Rockaway Valley Regional Sewerage Authority Sewage Treatment Plant, Morristown Sewer Utility Sewage Treatment Plant, Parsippany-Troy Hills STP, and Florham Park Sewerage Utility (Board of Chosen Freeholders of Morris County, 2014). As of 2019, Morris County had approximately 24 municipal and regional sewage treatment plants serving the county, although Morris County reported that several of their public sewer treatment facilities were at or near their maximum treatment limits (Tetra Tech, 2020a; Morris County Planning Board, 2013).
- Essex County: Since Essex County contains some of the oldest sewerage facilities in the state and most of its municipalities are at or near full build out, county wastewater planning efforts focus on replacing/improving existing wastewater infrastructure and modifying facilities to keep them viable. Existing wastewater facilities that serve WMA06 municipalities include Caldwell Borough STP and Livingston Township STP. In the county's 2014 Wastewater Management Plan, analysis of Essex County's sewer service areas and existing permitted capacity suggested that the county did not require extension to meet future wastewater needs. Residential, commercial, and industrial wastewater flows were not projected to significantly change through 2033, although a small amount of industrial flows were anticipated to shift to residential and commercial flows as abandoned industrial facilities are redeveloped as multi-purpose spaces (Hatch Mott McDonald, 2014).
- Somerset County: Somerset's sewerage facilities servicing WMA06 municipalities include Bernards Township Sewerage Authority's Harrison Brook STP, Bernardsville STP, and Warren Township Sewer Authority (Stage I, II, IV, and V). The county has reported that several of its domestic wastewater treatment plants, such as Harrison Brook STP and Warren Township Sewer Authority's Stage I, II, and V), may face deficit in the future and expansion may be necessary to accommodate growth (Somerset County Board of Chosen Freeholders et al., 2013; Somerset County Mitigation Planning Committee, 2019; Somerset County Planning Division, 2021).

8.1 RELATIONSHIP BETWEEN PROJECTED WATER USE AND DEMOGRAPHIC CHANGES

The findings from the 2050 water demands projections have some disagreement with the MPO and DOL population projections, primarily due to the disagreements between the MPO and DOL population projections discussed in Section 4. A problem with this comparison is that MPO projections are at the county and municipal level, while DOL projections are only at the county level; there is no way to know whether county-level differences result from WMA06 municipalities.

The MPO projects a population growth for Morris County of 27,931 people by 2050, and many of the PCWSs servicing Morris County locations are not expected to experience demand increases or supply deficit in 2050 (Similar findings were found for Somerset County, but since Somerset County WMA06 municipalities are only served by two major PCWSs, primary focus was placed on Morris County). However, Morris County's MPO projection for growth through 2035 is much smaller than the DOL projection (compare Morris County's MPO projection of a population growth of 13,023 people between 2020-2035 and DOL's projection of a population growth of 38,900 people between 2019-2034). While the 2050 demands projections identify some concern with several Morris County PCWSs (such as Denville Township WD, East Hanover Township WD, and Rockaway Township WD), there is some uncertainty with these demand numbers, and Morris County PCWS 2050 projected demand may underestimate demands if the DOL projections are more accurate.

However, Essex County's MPO and DOL projections are opposite to those in Morris County in that MPO projections for Essex County are much higher than its respective DOL numbers. Essex County projects a 120,059 person population increase between 2020-2050 and a 56,472 person increase between 2020-2035, which is much larger than DOL's projection of Essex County to experience a population increase of 31,800 people between 2019-2034. The PCWS demands projections show some agreement with the MPO projections in showing projected deficits for North Caldwell WD and a potential concern for West Caldwell Township WD under peak demand scenarios. However, most projected 2050 demands scenarios for Essex County PCWSs provide little evidence for concern for meeting future water demand, with roughly half of the PCWSs projecting demand decline and several indicating demand may increase or decrease between the non-conservation and conservation scenarios.

Despite the uncertainty in population projections, several regional water demand trends may provide some buffer for the uncertainty. The overall declines in water demand over time may help to offset the effect of increased population growth in the region. Evidence of this was seen in the PCWS 2050 demand analysis as some areas with large projected population growth were not projected to experience demand increase or supply deficit, suggesting an offset between population growth and declining demand. Encouragement of conservation practices may also provide some buffer for uncertainty, as approximately a quarter of WMA06 PCWSs were projected to have demand decline only in their 2050 conservation scenarios. In addition, PCWSs can engage in strategies to improve their surplus/deficit including installation of new infrastructure, engaging in bulk transfer agreements with other PCWSs, making regulatory adjustments to change demand patterns, and identification of new water sources.

9. CLIMATE CHANGE ASSESSMENT

KEY FINDINGS

- Among the WMA06 counties, Morris County is projected to have the largest increase in precipitation across all storm events between 2020-2069.
- WMA06 groundwater recharge is currently higher than the statewide average. Groundwater recharge in WMA06 is projected to increase due to climate change and is not anticipated to pose an immediate threat to future groundwater availability.
- Streamflow in WMA06 is projected to continue to increase due to climate change, and very limited potential was detected for climate change to have adverse impacts on New Jersey surface water availability.
- It is critical to recognize that global and regional climate science is improving, allowing an evolving but better sense of climate change's effects on New Jersey water resources. As such these results need to be periodically reviewed as the data and models evolve.

9.1 GENERAL CLIMATE CHANGE PROJECTIONS FOR THE WMA06 REGION

Climate change in WMA06 is anticipated to follow state-wide trends for temperature and precipitation. Temperature 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.
- 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. Across the state, precipitation increases are anticipated to be higher in Northern New Jersey compared to southern and coastal areas (NJDEP, 2020).

Table H.9 Projected Percent Increase for Precipitation among WMA06 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
Essex	16%	17%	18%	22%	27%	32%
Morris	19%	21%	24%	30%	36%	43%
Somerset	17%	18%	21%	28%	35%	44%
Sussex	19%	19%	21%	24%	28%	33%
Union	17%	18%	19%	24%	29%	35%

Table H9 shows the precipitation projections for WMA06 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, Morris and Sussex counties are projected to have the largest precipitation increase for smaller storm events (two, five, and 10-year storm events), while Morris and Somerset are projected to have the largest precipitation increase for larger storm events (25, 50, and 100-year storms). Since Morris County is projected to have some of the largest increase in precipitation among New Jersey counties, WMA06 is projected to have some of the largest precipitation increase in the state (NJDEP, Northeast Regional Climate Center, & Cornell University, 2023).

9.2 POTENTIAL CHANGES TO WMA06 WATER AVAILABILITY DUE TO CLIMATE CHANGE

CHANGES TO GROUNDWATER RECHARGE

One potential impact of climate change on WMA06 is changes in groundwater recharge. Figure H10 provides forthcoming NJDEP analyses that show modeled average annual groundwater recharge in WMA06 and statewide between 1950 and 2020 using a 30-year rolling average and based on observed daily temperature and precipitation data. A 30-year rolling (or trailing) average – a common metric used to calculate climate parameters - was used to reflect the long-term changes in averages anticipated with climate change. For example, the estimated recharge for 1950 is the average of annual recharge data between 1921-1950. Between 1950 and 2020, the model indicates that average groundwater recharge in both WMA06 and statewide has increased over time. Between 1950 and 2000, WMA06 had a 30-year rolling average annual groundwater recharge of 10.8 inches, while between 2001-2020, WMA06's rolling annual groundwater recharge average increased to 11.3 inches. Statewide, the 30-year rolling average between 2001-2020 was 8.7 inches, which was higher than the average for 1950-2000 (8.0 inches).

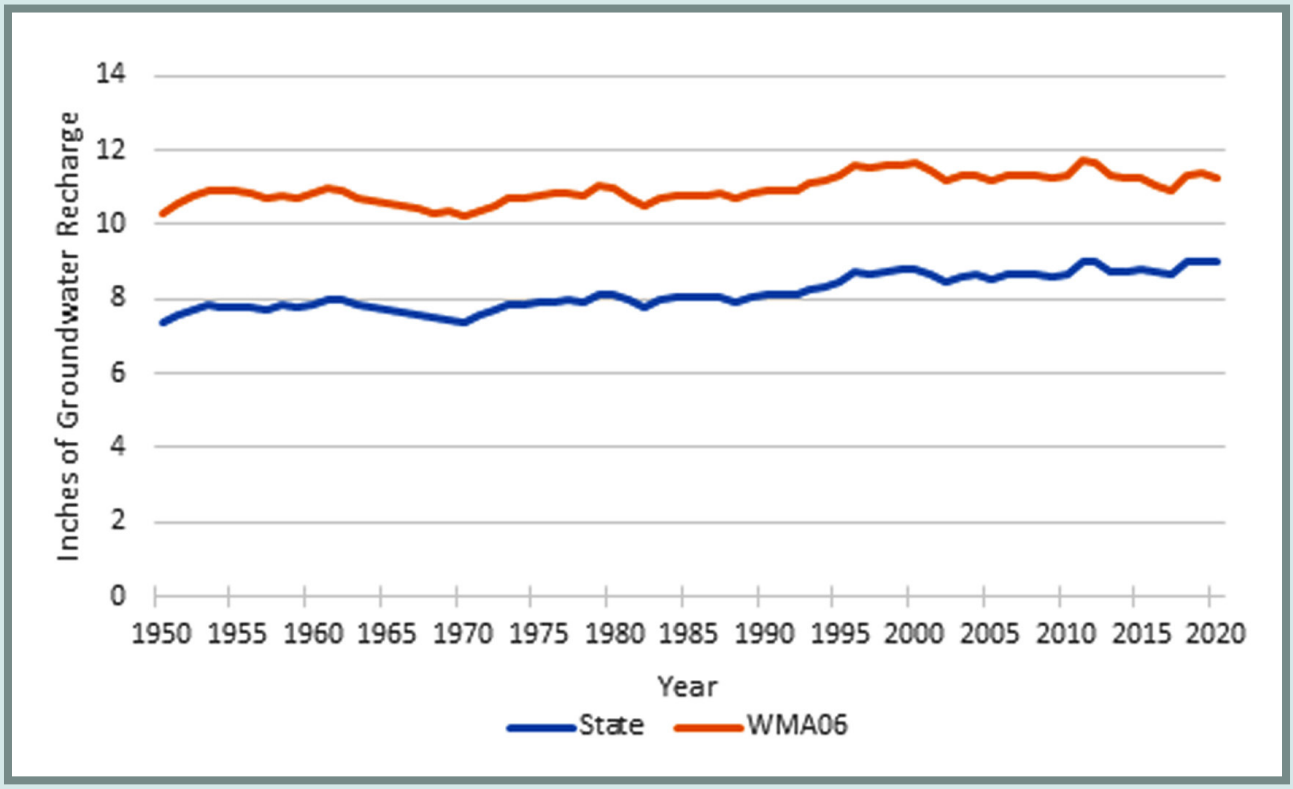


Figure H.10 Comparison of Annual Groundwater Recharge in WMA06 and Statewide with a 30-Year Rolling Average (1950-2020)

WMA06 has also experienced larger annual groundwater recharge compared to the state average throughout the considered time period. For WMA06's rolling average recharge for 2001-2020, WMA06 received approximately 2.6 inches more of groundwater recharge annually compared to the state average. However, state average groundwater recharge has been increasing at a faster rate than in WMA06. As shown in Figure H11, between 1950-2000 and 2001-2020, the 30-year average annual groundwater recharge increased by approximately 0.8 inches statewide, compared to only 0.5 inches in WMA06.

NJDEP DWSG developed projections for state groundwater recharge under nine different climate scenarios (ensembles) for future temperature and precipitation. While only five of nine ensembles forecasted an increase in groundwater recharge from 2020 to 2050, all of the ensembles forecasted more groundwater recharge in 2050 compared to 1980. These research findings suggest that future changes in groundwater recharge do not pose an immediate threat to future groundwater availability.

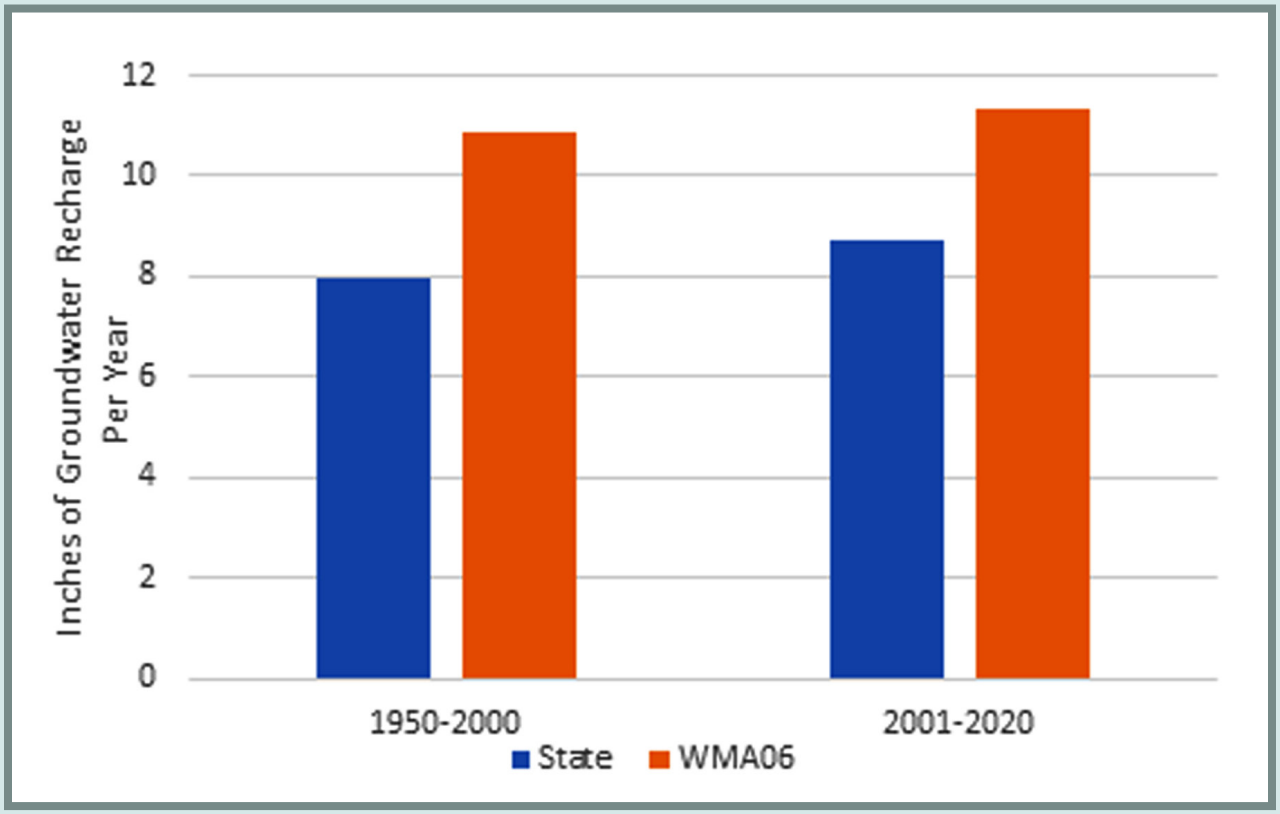


Figure H.11 Comparison of Annual Groundwater Recharge Statewide and in WMA06 with a 30-Year Rolling Average (1950-2020)

CHANGES TO STREAMFLOW

NJDEP DWSG observed that streamflow in WMA06 has also increased, which is consistent with other climate change research. Figure H12 shows the annual estimated naturalized flows in WMA06 between 1951-2019 using a 30-year rolling average. Naturalized flows reflect the streamflow that would have occurred without the presence of the major surface water reservoirs or withdrawals. As shown in the figure, earlier in the time period considered (1951-1980), WMA06's 30-year rolling average flows were lower, with the lowest flows in 1970 (approximately 401 mgd). After 1970, rolling average streamflow in WMA06 gradually increased through 2019. From 1951-2000, WMA06's 30-year rolling average annual naturalized flows were approximately 440 mgd. Between 2001-2019, WMA06's 30-year rolling average annual naturalized flows increased to approximately 466 mgd, reflecting an approximately 6% increase.

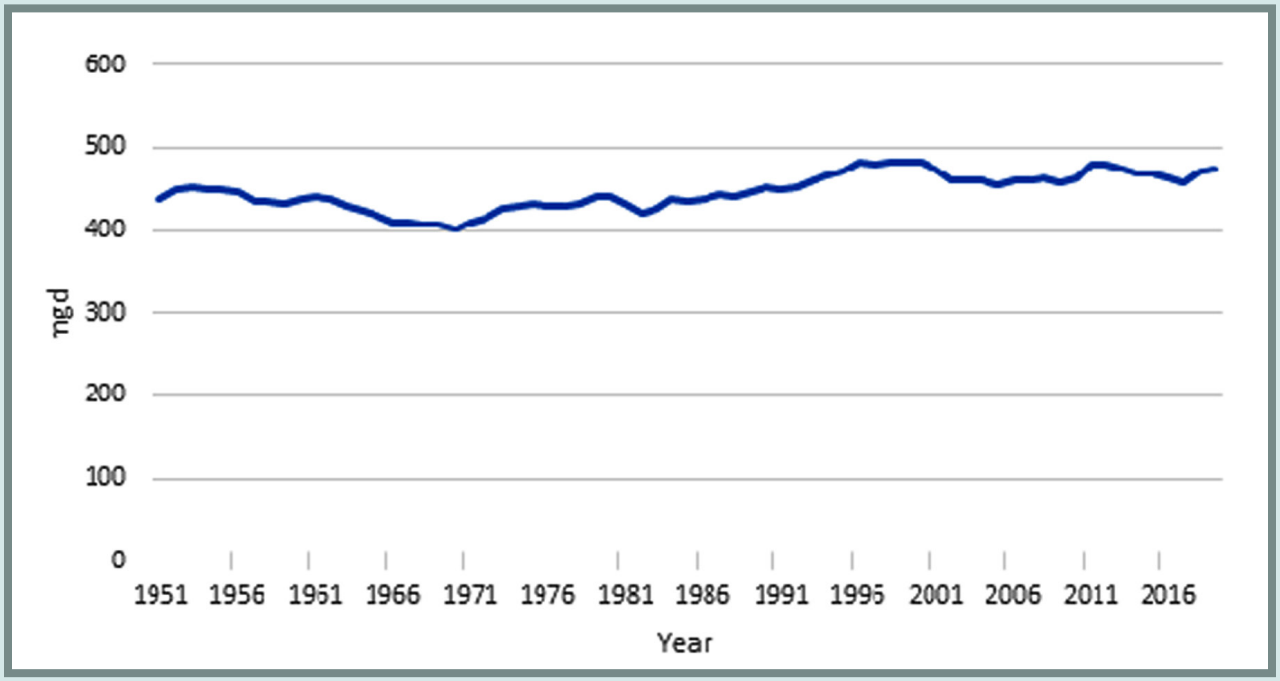


Figure H.12 WMA06 Annual Naturalized Flows with a 30-Year Rolling Average (1951-2019)

The increase in streamflow in WMA06 is anticipated to continue in the future and reflects NJDEP DWSG's overall finding that more annual streamflow is anticipated statewide. Monthly trends are more variable, but more flow is expected in the fall and early winter; the greatest current stresses to water resources are generally in the summer through September, and so a shift in streamflow will have implications for summer stresses. From a water quantity perspective, the projection of increased streamflow is anticipated to be mostly beneficial to reservoirs, which will be discussed in the next sub-section.

CHANGES TO RESERVOIR SAFE YIELDS

A third potential impact of climate change is changes to a reservoir's safe yield. NJDEP examined the potential impacts of climate change to streamflow in reservoir systems. This research involved comparing scenarios of baseline existing operations to assumed climate change scenarios of reduced streamflow over the entire year and increased reservoir system drafts during the spring, summer, and fall seasons. The analysis altered the naturalized flows in order to compare them to the historic ones so that the range of observed variability could be reproduced under an assumed future climate scenario. WMA06's two reservoir systems (Jersey City Rockaway River System and New Jersey American Water Canoe Brook System), were similar to other Northeast New Jersey reservoir systems (such as Wanaque, Hackensack Reservoirs, DeForest Lake (New York), and Pequannock), in which there was very limited potential detected for climate change to have adverse impacts on New Jersey surface water availability. Combined usable storage across these systems during a repeat of the drought of record did not approach zero for any of the scenarios considered, and significant reserve storage was maintained overall. Note that this analysis assumed a simplified change to demand and streamflow and did not consider changes to raw water quality, which may impact a system's ability to treat to drinking water standards or address system resiliency or assessment management concerns. All of these items need to be continually addressed so that safe and reliable drinking water can be delivered to customers.

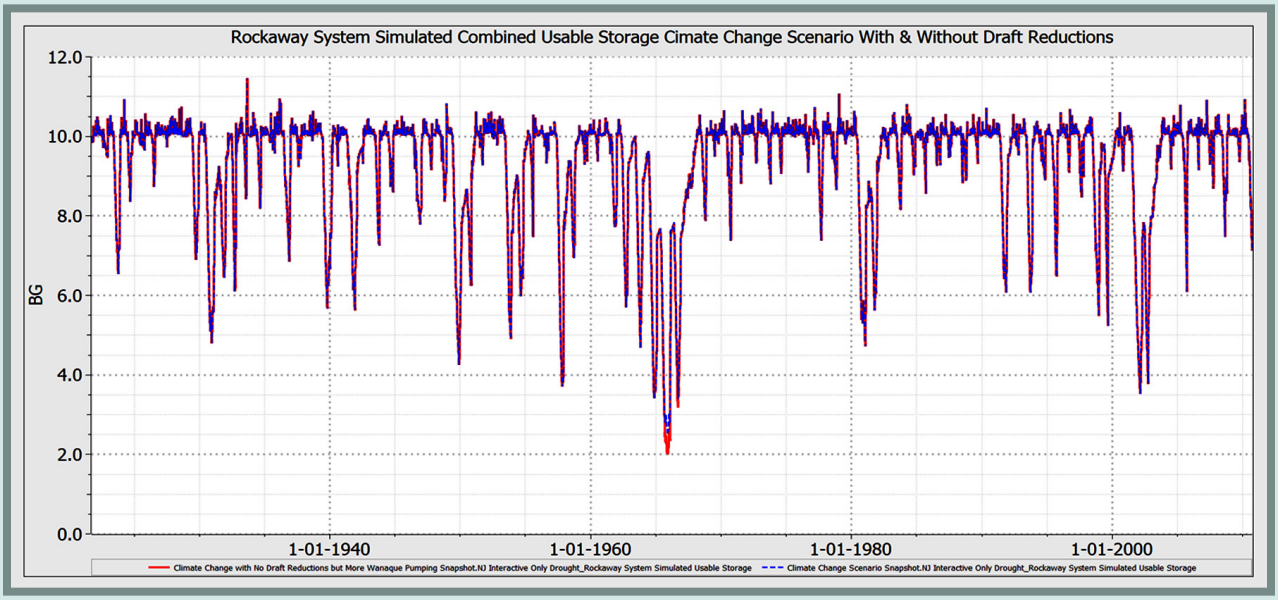


Figure H.13 Rockaway System Simulated Combined Usable Storage Under Climate Change Scenario with and without Mandatory Draft Reductions

Figures H13 and 14 show the simulated combined usable storage for the period of 1930-2010 using the climate change scenarios. No significant impacts on water availability were found for the Jersey City Rockaway River System across all the scenarios considered. However, climate change was found to have a more significant impact on combined usable storage compared to scenarios that eliminated drought draft reductions. For the New Jersey American Water Canoe Brook System, none of the scenarios were found to have a significant impact on combined usable storage, and there were no significant impacts on water availability. However, as a pump storage system, pumpable flows were found to be increasing over time, especially in the fall and early winter.

Although it was found that climate change poses little threat of creating adverse impacts on New Jersey surface water availability, there are other unknown factors that may influence safe yield. As mentioned earlier in this sub-section, water quality changes may have a significant influence on safe yield and surface water availability, but it was not considered in the simulated study.

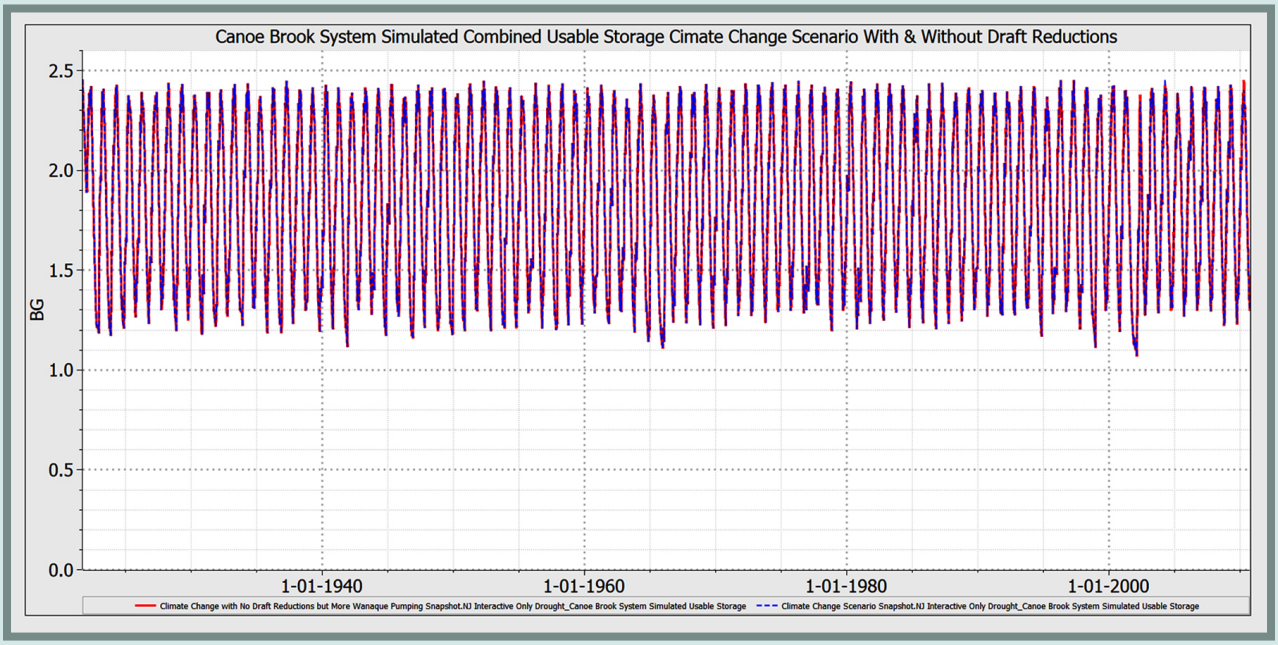


Figure H.14 Canoe Brook System Simulated Combined Usable Storage Under Climate Change Scenarios with and without Mandatory Draft Reductions

10. POTENTIAL MANAGEMENT OPTIONS

Based on the findings from the assessment, WMA06 currently faces water supply vulnerability, which is heightened during periods of drought and has the risk of becoming more severe in the future despite increasing average rainfall and recharge volumes. Since there are only four HUC11s in WMA06, it was not very valuable to rank vulnerability on a HUC11 scale. Many of WMA06's municipalities are located within several different HUC11s, and HUC11 vulnerability differed when considering current and future water supply vulnerability (for example, some HUC11s were found to have more current water supply vulnerability, while others had higher risks for future water supply vulnerability). Included below are some major highlights from the assessment's findings for WMA06's HUC11s, along with some of the locations within the HUC11s found to be particularly vulnerable.

- 02030103010 (Passaic River Upr (above Pine Bk br)): Current and potential future water supply vulnerability was detected as this HUC11 had the second largest LFM deficit in WMA06 during its three-year average in consumptive/depletive loss. It was also found to have the second largest average water withdrawals in WMA06 between 2016-2020. This HUC11 is serviced by several PCWSs that were found to have significant potable supply demand growth between 2011-2020 (West Caldwell WD, Chatham WD, East Hanover Township WD, Florham Park WD, Montville Township MUA), or were found to have demand increase or supply deficit in their 2050 demands projections (West Caldwell WD, East Hanover Township WD, North Caldwell WD). Since this HUC11 contains most of the Essex County WMA06 municipalities, the disagreement of the population forecasts for this county (along with Morris and Somerset counties) adds an additional level of uncertainty in projecting future water availability. Several areas within this HUC11 were found to be particularly vulnerable to face future water availability challenges.
    a. Livingston Township, Millburn Township, and West Orange Township: Although portions of these municipalities are located outside of WMA06, the populations of these three municipalities make up over 60% of the total population among WMA06's Essex County municipalities. All three of these municipalities also outperformed their 2020 MPO population forecasts, suggesting that population growth has been larger than originally projected. Among their PCWSs, Livingston Township DW had slight increases in

potable supply demand between 2011-2020 (approximately 4%), while New Jersey American Water-Passaic experienced demand decline (approximately -16%). Although the 2050 demands projections found that New Jersey American Water-Passaic would experience demand decline, the uncertainty detected among the 2050 population projections makes this region an area to watch. All three of these municipalities contain socially vulnerable populations.

b. West Caldwell Township, North Caldwell Borough, and East Hanover Township: These municipalities were selected due to being within the service areas of North Caldwell WD, West Caldwell WD, and East Hanover Township WD. North Caldwell WD faces current supply deficit and was projected to experience supply deficit in 2050. West Caldwell WD experienced a significant demand increase between 2011-2020 (approximately 36%) and was projected to be in deficit in some of its 2050 peak demand scenarios. West Caldwell Township is considered to be particularly vulnerable as it is serviced by both of these PCWSs and contains socially vulnerable populations. The municipalities serviced by West Caldwell WD are projected to grow by 2,001 people between 2020-2050. Almost all of East Hanover Township's population is serviced by East Hanover Township WD, and this municipality is anticipated to grow by approximately 1,400 people between 2020-2050. East Hanover Township WD's service area is located in three HUC11s (02030103010, 02030103020, 02030103030). This PCWS was found to have one of the largest potable supply demand growths (approximately 31%) among major WMA06 PCWSs between 2011-2020 and was projected to face deficit in some of its 2050 demand scenarios.

- 02030103020 (Whippany River): This HUC11 faces current water supply vulnerability as it was found to have the largest LFM deficit in WMA06 during its three-year peak rolling average in consumptive/depletive loss. Although it was found to have the third highest five-year average water withdrawal in WMA06 between 2016-2020, it includes several PCWSs that experienced significant demand growth between 2011-2020 (Denville Township WD, East Hanover Township WD, Florham Park WD) or were found to have demand increase or supply deficit in their 2050 demands scenarios (Denville Township WD, East Hanover Township WD).
- 02030103030 (Rockaway River): This HUC11 was found to have the potential for future water availability vulnerability. Although this HUC11 was found to have the largest average water withdrawals between 2016-2020, it was found to have a net gain in the WMA06 LFM analysis due to the discharge of treated wastewater from other HUC11s (primarily the Whippany River watershed) at the base of the watershed. However, this HUC11 contains several PCWSs that were found to face either current or future challenges with meeting potable water demand. This HUC11 is serviced by several PCWSs that were found to have significant potable supply demand growth between 2011-2020 (Denville Township WD, East Hanover Township WD, Jefferson Township WU- Lake Hopatcong, Fayson Lakes WC, Montville Township MUA, Mount Arlington Borough DWP Main, Rockaway Township WD, Sparta Township WU- Highlands) or were found to have demand increase or supply deficit in their 2050 demands scenarios (Denville Township WD, East Hanover Township WD, Jefferson Township WU- Lake Hopatcong, Fayson Lakes WC, Rockaway Township WD, Roxbury Water Company). This HUC11 is also where significant water withdrawals are exported out of WMA06 for use in Jersey City and its customer municipalities. Therefore, the HUC11 has both depletive water use and imported water. Two areas within this HUC11 were found to be particularly vulnerable to face future water availability challenges.

  a. Rockaway Township and Denville Township: These municipalities were selected since they are serviced by several PCWSs projected to potentially experience water supply deficit. Rockaway Township was found to be particularly vulnerable since two of its PCWSs show signs of potential future water supply deficit (Denville Township WD and Rockaway Township WD). Rockaway Township is projected to grow by 2,111 people between 2020-2050 and also contains socially vulnerable populations. Denville Township (which also is within the Whippany River watershed) was selected as it contains a significant population serviced by Denville Township WD. The service area of Denville Township WD includes municipalities containing socially vulnerable populations, including Parsippany-Troy Hills Township (a focus municipality) and Randolph Township. Denville Township WD is projected to experience deficit in some of its peak 2050 demands projections, but many of the municipalities in its service area do not have large populations serviced by this PCWS. However, the majority of Denville Township's population is serviced by Denville Township WD, and it is considered their primary PCWS.

10.1 MANAGEMENT OPTIONS

Discussed below are potential management options for the WMA06 region. These options are designed to include both strategies that can be recommended across WMA06 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.

The first management option, updating regional groundwater modeling, is recommended for the entire WMA06 region. Although this region has been a validated area of concern for water availability since the 1980s (Hoffman, 1989; Nicholson et al., 1996), updates to modeling can consider changes to the region (such as population growth, changing water demands, and land use trends) and more recent scientific understanding of the interaction between aquifer underlying bedrock and more-productive unconsolidated units. Earlier modeling efforts, such as those discussed in Hoffman, 2012, made several recommendations for future regional modeling, including: (a) recalibrating modeling to consider data from sources such as field investigations to increase model accuracy, and (b) the development of new modeling that can better account for relationships between aquifers, recharge areas, and discharge areas, and how pumping is regionally distributed. Incorporation of these changes along with additional updates may help provide a more comprehensive understanding of regional water availability.

The second management option, use of a water fee or surcharge on end users of Highlands water for the purposes of preserving lands important to water resources, has been suggested to address the local land use impacts of Highlands regulations that protect water withdrawals exported outside of the Highlands Region. Highlands residents face significant land use restrictions which are designed to protect regional water resources (Highlands Council, 2008b). A fee or surcharge can serve the dual purpose of compensating residents for the restrictions they face and also encourage water conservation among end users. This management option could also be especially beneficial for assisting socially vulnerable communities located within the Highlands since their ability to promote economic development may be limited due to Highlands regulations. Previous legislation on this option (Assembly Bills A2234 and A2603) were proposed in the 2010-2011 New Jersey Legislative Session (Morris County Planning Board, 2013).

The third management option, protection of aquifer recharge areas, also includes protection of regional wetlands and opportunities for flood management. As mentioned earlier in this assessment, WMA06 suffers from significant riverine flooding, particularly along the Rockaway, Whippany, and Passaic rivers (Union County, 2016; Tetra Tech, 2020a; New Providence Open Space Advisory Board, 2006; Morris County Planning Board, 2000; Dewberry-Goodkind, Inc., 2006; Jonathan Rose Companies et al., 2014). Protection of aquifer recharge areas can help the regional water system and mitigate flooding by providing more permeable open space for water to enter the aquifer system. Options to encourage protection of aquifer recharge areas can include:

- Further efforts to delineate groundwater recharge areas: The Highlands Council has delineated groundwater recharge areas in the region, using modeling techniques from NJDEP. However, as of 2018, it was reported that there were no groundwater recharge areas delineated for Essex County (Livingston Planning Department, 2018). Re-evaluation and periodic updating of groundwater recharge areas may be effective in WMA06, particularly since WMA06's Essex County municipalities are less populated compared to some of the larger urban areas located outside the region. The same issue applies to the Union and Somerset County portions of WMA06.
- Coordinating aquifer recharge area protection with existing land conservation and planning efforts: New Jersey is active in acquiring open space properties for environmental purposes. Coordination with existing programs, such as NJDEP's Green Acres and Blue Acres programs, can assist WMA06 county and municipal efforts to prioritize the purchase of open space in recharge areas (NJDEP, 2022; NJDEP, 2023). The Highlands Regional Master Plan also requires protection of major aquifer recharge areas in the Preservation Area and conforming Planning Area municipalities (Highlands Council, 2008b). In addition, aquifer recharge area protection can build off of localized land conservation and planning programs. For example, Livingston Township has its program to acquire land rights for conservation purposes outlined in its 2018 Master Plan. While this approach may face challenges from lack of sufficient funding, streamlining access to grants and partnerships with other conservation organizations

may help to prioritize purchases of properties where potential for aquifer recharge is the highest, such as wetlands (Livingston Planning Department, 2018). Another example is Union County, which has prioritized land use planning to provide open space parkland in flood-prone areas to minimize riverine flood risk. This type of program could potentially be expanded to consider aquifer recharge potential when selecting areas for open space parkland (Union County, 2016).

The final management option, further assessment of WMA06 PCWSs to meet future regional water demand, is recommended for the entire WMA06 region, especially for the identified vulnerable PCWSs. As was found in Section 8, although WMA06's PCWSs are anticipated overall to experience less demand in 2050 compared to current demand numbers, several PCWSs were projected to experience either demand increase or supply deficit in 2050. This presents some concern with meeting future water demands. Planning efforts can be made to further assess WMA06 PCWS potential management options and their feasibility for meeting future demands if they run into deficit (such as identification of alternative water sources, bulk transfers from other PCWSs, existing infrastructure for interconnections between PCWSs, etc.). This assessment can build from earlier NJDEP PCWS research, such as the 2007 NJDEP Interconnection Study (NJDEP et al., 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. 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.

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