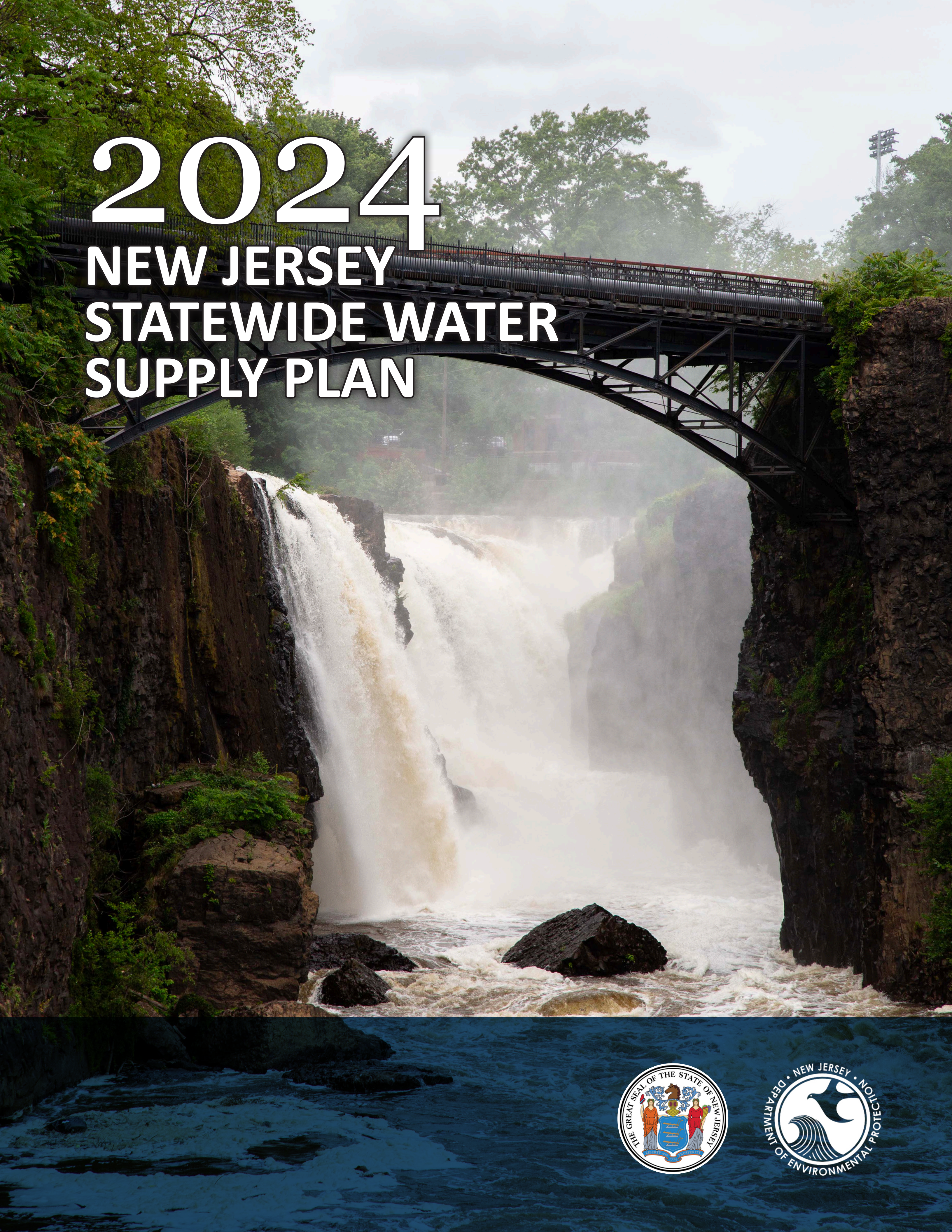
2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN



THE GREAT SEAL OF THE STATE OF NEW JERSEY

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

Acknowledgements

This update of the New Jersey Statewide Water Supply Plan, hereinafter referred to as the "Plan", represents a major advance in the state's protection of water resources and planning for future needs. Its publication is made with sincere thanks to Governor Phil Murphy, Lieutenant Governor Tahesha Way and Department of Environmental Protection (DEP) Commissioner Shawn LaTourette for their leadership and dedication to the stewardship of New Jersey's precious water resources.

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Finally, numerous staff throughout DEP provided insightful comments on this report that helped in its drafting. The editorial staff greatly appreciates all the input that was shared.

DEP also received considerable help in formulating this plan from current and former members and advisors of the Water Supply Advisory Council. This is a volunteer group of professionals in the water resources field that is established under the Water Supply Management Act of 1981 specifically to advise DEP on the water supply plan and other water supply resource issues. Council members and advisors at the time of Plan drafting included the following:

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DEP held four stakeholder sessions during the initial drafting of this plan. We would like to thank the attendees of these meetings for their valuable feedback and generous donation of their time.

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Executive Summary

New Jersey's water resources are essential public assets, held in trust for the people by the State Commissioner of Environmental Protection, and critical to the health, safety, economic wellbeing, recreational and aesthetic enjoyment, and general welfare of all New Jersey residents. The State's 9.3 million residents, $800 billion economy, and diverse ecosystems depend upon a clean, secure, and resilient water supply in order to meet daily needs, expand economic opportunities, enhance standards of living, improve public health, and restore the natural environment. Thus, the New Jersey Legislature, through the Water Supply Management Act (N.J.S.A. 58:1A et. seq), charged the Commissioner and our Department of Environmental Protection (DEP) with ensuring that water resources are planned for and managed as a common resource to provide an adequate supply and quality of water for present and future generations of New Jerseyans and to protect the natural environment of the waterways of the State.

With DEP oversight and support, public and private water supply managers have worked to successfully balance the needs of the state's residents, businesses, and environment and ensure that there is the necessary quantity and quality of water, when and where it is needed. However, new and increasing water supply challenges demand renewed commitment to New Jersey's progressive water supply planning and management approach. Among these challenges are water management risks stemming from our rapidly changing climate and its rising sea levels, warmer temperatures, and unprecedented precipitation variability; aging infrastructure in both small and large and urban and rural water systems; emerging water contaminants, including such as synthetic chemicals like per- and polyfluoroalkyl substances; and the occurrence of harmful algal blooms that endanger water supplies.

A coastal community and natural vegetation located in Brigantine, New Jersey.

In recent years, New Jersey has repeatedly faced a confluence of water resource challenges that have tested our infrastructure and the responsive capacity of our institutions. During the summer of 2022, extremely low precipitation and streamflow led the DEP to declare a Drought Watch, the first in more than six years. During the same period, aging infrastructure failed, resulting in massive water main breaks (two of which impacted more than 700,000 residents); water systems were required to confront supply sources contaminated with per- and polyfluoroalkyl substances (PFAS); and rampant harmful algal blooms (HABs) were worsened by extremely warm temperatures and intense precipitation. One such HAB broke records for duration, and its toxin levels threatened the water supply of 800,000 residents. The difficulties continued into 2023, with four months experiencing near record temperatures, the wettest December on record, continued infrastructure failures, and water systems struggling to remedy PFAS contamination.

The combination of these challenges has severely tested the resilience of New Jersey's water resources and their management and has proved especially vexing for the State's most vulnerable, underserved, and overburdened communities. As such conditions are expected to persist or worsen in the years ahead, the DEP and public and private water supply managers must carefully administer planning, regulatory, investment, and incident response initiatives. Conscious of these challenges and informed by multiple points of analysis, this 2024 New Jersey Statewide Water Supply Plan (Plan) identifies immediate, near-term, and long-term actions necessary to ensure that water supplies remain viable for current and future generations.

The Delaware and Raritan Canal at Swan Creek located in Lambertville, New Jersey.

This constitutes the third major Plan since the enactment of the Water Supply Management Act; it presents updated water supply data, adds several new points of analysis, and reflects the most current and best available science. It builds off of previous plans, and utilizes important DEP science, data, policy, and regulatory developments to assess resources and redefine critical actions and next steps.

Since the last Water Supply Plan revision in 2017, significant progress has been made in characterizing existing climate change impacts and projecting the magnitude and timing of continuing climate changes to better define how they will impact the State and its water resources. The challenges are great and evolving, but work contained in this Plan provides the assessments and establishes the processes to enable public and private water supply managers to continue to meet the water needs of New Jersey's residents, economy, and environment. The 2024 Plan concludes that, under normal conditions and in most regions, the State has sufficient quantities of water to meet current and reasonably anticipated future needs. However, the continued availability of water resources and their readiness for use is dependent upon intentional and consistent actions to conserve, bolster, and actively manage public and private water supplies. In short, New Jersey is well-positioned to address its water supply challenges as long as the State, together with the multitude of water supply managers and water system owners undertake continuous actions to mitigate the risks of climate change, aging infrastructure, and emerging contaminants, including through the actions and policy supports identified here.

In meeting the seven key requirements of the Water Supply Management Act, this Plan identifies ground and surface water supplies and quantifies their current and projected demands; makes recommendations for improvements or additions to water supply facilities, for agricultural and aquacultures use; identifies policy supports necessary to protect source waters; and identifies land preserved for water supply purposes and administrative changes to improve ground and surface water quantity and quality.

In addition to addressing these key requirements, this Plan also includes a summary of the State's drought monitoring and response, a water conservation strategy, DEP's first meaningful review of climate change implications for statewide water supply and detailed actions to help address this challenge, an analysis of potential water availability losses due to contamination by contaminants of emerging concern, including the PFAS suite of chemicals and others such as 1,4 dioxane, and a review of how water supply issues intersect with environmental justice concerns. In addition to supporting comprehensive management while capturing the diversity of water supply issues faced in different parts of New Jersey, this Plan offers assessments and recommendations from both a statewide and regional perspective, and provides guidance for state and regional water supply decision-makers.

Rapids on the Batsto River at Wharton State Park located in Hammonton, New Jersey.

To ensure that New Jerseyans continue to have an ample, reliable, and safe quantity and quality of water now and in the future, this Plan identifies the following action areas:

- **Hydrologic Data, Monitoring, Models, and Assessments:** The availability of long-term and real-time hydrologic datasets are critical pieces of information the DEP uses to quantify trends, characterize current conditions, and to build and calibrate models. This information is used to ultimately make informed decisions and to update future water supply plans.
- **Climate Change - Water Availability Research and Modeling:** This Plan and its recommendations benefit from the availability of sound and reliable climate change science. This science continues to evolve, and DEP will remain committed to monitoring new developments, with a particularized focus on the regional and local impacts of climate change upon New Jersey and its natural resources. As new and additional climate change data becomes available, it will be utilized to improve DEP water supply models and monitoring methods to more effectively mitigate and manage climate change impacts to water resources.
- **Climate Change - Infrastructure Resilience Recommendations:** DEP develops recommendations and establishes criteria to improve the resilience of water infrastructure and mitigate the adverse impacts of climate change upon the State's water supply, including through actions to reform relevant DEP policies, protocols, statutes, or regulations pertaining to water infrastructure assessments and modifications.
- **Regional and Statewide Water Supply Planning and Protection:** Water supply planning is a critical element to ensure that the State continues to have adequate supplies of acceptable quality to meet all current and future needs, and to balance human uses with ecological needs. Regional and statewide planning is adaptive and evolves as new information becomes available or issues emerge. The Plan prioritizes regions of New Jersey where future planning efforts should be focused.

- **Water Policy Modernization:** DEP is obligated and empowered to improve and protect water supply resources and water system infrastructure to ensure water availability and the delivery of safe drinking water to homes and businesses. In some cases, the federal and state laws and regulations that give rise to these obligations are fit for modernization to better position the State and its water providers to confront new and evolving water supply challenges.
- **Asset Management and Resilience:** Maintenance and improvement of infrastructure is key to effective and successful water supply management, and critical to ensure the State has access to clean and plentiful drinking water. Proper asset management can reduce water incidents and emergencies, limit disruptions to customers, and reduce long-term costs.
- **Policies and Priorities for Efficient Water Use:** The Plan identifies key policy priorities for the DEP as it continues to regularly re-evaluate new technologies and research to ensure the responsible and efficient use of the State's water resources.
- **Public Outreach:** DEP is committed to continuing public education and engaging with people and communities we serve on key water supply issues and initiatives.

New Jersey residents, communities, businesses, and institutions are as connected and interdependent as the water resources we share, and each of us must be careful stewards of this precious, finite resource. As public and private water supply managers work to implement the measures identified in this Plan in the years ahead, DEP stands as a partner to every community, water system, business, institution, and member of the public we serve. As DEP does its part to discharge the recommendations made here, the Department will closely monitoring new developments and update this Plan periodically to ensure that the most up-to-date data and best available science are utilized to address our water supply needs and challenges.

Together, we will ensure that current and future generations of New Jerseyans have access to a clean, secure, and resilient supply of water.

Pedestrian Bridge over Delaware River at Bulls Island Recreation Area, Stockton NJ.

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Chapter 1: Introduction

For over a century, public and private water supply managers, have worked to balance the water needs of New Jersey residents, businesses, and environment to ensure that there is the necessary quantity and quality of water when and where it is needed for current and future populations. This is a core mission of the New Jersey Department of Environmental Protection (DEP) and the primary goal of the New Jersey Statewide Water Supply Plan (Plan).

New Jersey has historically seen itself as a water-rich state with a relatively even distribution of precipitation over the seasons, especially as compared to other parts of the United States that experience water scarcity. New Jersey is also the most densely populated state in the nation, which places intense demands on our water resources, requiring thoughtful water supply planning and proactive management. New Jersey's water supply reservoirs are comparatively small and, during droughts, these and other water resources can become stressed. Our shallow groundwater in unconfined or surficial aquifers can serve an excellent water supply purpose, yet this resource is critical to healthy stream flow that in turn supports ecosystem health and downstream water supplies. The deep groundwater in New Jersey's confined aquifers can serve as a prolific water supply, but this vital resource can be stressed by excessive withdrawals and, in some areas, by saltwater intrusion. While water supply managers have ably navigated these needs and limitations in years past, emerging challenges—especially those exacerbated by our changing climate—present new and unprecedented levels of additional stress for our State's water resources

Pakim Pond located in Brendan T. Bryne State Forest in the New Jersey Pinelands.

Since the last Plan revision in 2017, significant progress has been made in characterizing existing climate change impacts and projecting the magnitude and timing of continuing climate change impacts. This 2024 Plan is part of a statewide effort to better identify the adverse impacts of climate change and plan adaptation measures. The challenges are great and evolving, but work is underway to provide the assessments and to establish the processes that will enable public and private water supply managers to continue to meet the water supply needs of its residents, economy, and environment.

In New Jersey, the waters of the state are owned by the people – all residents, both current and future - and are held in trust by the State for their benefit. The State government manages these waters on behalf of the people, through the Water Supply Management Act (N.J.S.A. 58:1A), which empowers DEP to allocate water resources to various needs through a formal process that ensures the demands are reasonable, that other water users are protected, and that the demands do not unduly diminish environmental quality. New Jerseyans have a reasonable expectation that statewide water supply resources will be sufficient to meet existing and future needs through both a planning and a regulatory process.

As directed by the Water Supply Management Act, DEP prepares and routinely updates a New Jersey Statewide Water Supply Plan that analyzes relevant water supply data, examines growth projections, evaluates risks, and identifies policy supports necessary to overcome water supply challenges and ensure that New Jersey's present and future water resource needs can be satisfied. The first Plan was adopted in 1982, and major revisions followed in 1996 and 2017, with intermittent updates between revisions. This Plan constitutes the third major revision of the Plan; it presents updated water supply data, adds several new points of analysis, and reflects the most current and best available science. This Plan is to be revised and updated in five years (2029), consistent with the requirements of the Water Supply Management Act, but components may be updated prior as DEP intends this Plan to be a dynamic, living document: the data within will be updated on an ongoing basis as new information and analyses become available and scientific methods are refined and incorporated.

Several chapters of this Plan provide information and analyses that correspond to the multiple charges of the Water Supply Management Act, as follows:

CHARGE	CHAPTER AND SUMMARY
Identification of existing Statewide and regional ground and surface water supply sources, both interstate and intrastate, and the current usage thereof.	Chapters 2 and 4: New Jersey receives considerable precipitation, has significant ground and surface water sources, and sufficient storage capacity. Additionally, historic investments in water supply storage, transmission infrastructure, and interconnections have proven to be advantageous to the State for both normal and periodic drought and water emergency conditions, generally.
Projections of Statewide and regional water supply demands for the duration of the plan.	Chapter 4: Presents projections and includes forecasts for Public Community Water System (PCWS) demands to the year 2050, with the methodology and detailed results in the corresponding appendix. This Plan takes the additional step of providing conservative estimates of excess or shortfalls by Watershed Management Area (WMA). Results are presented in a regional, resource-specific manner making its usefulness in a site-specific manner limited, as water availability is a function of all water resources in a specific area and potential of site-specific resource limitations.
Recommendations for improvements to existing State water supply facilities, the construction of additional State water supply facilities, and for the interconnection or consolidation of existing water supply systems, both interstate and intrastate.	Chapters 5, 6, 7, and 8 present various strategies and recommendations, the implementation of which must be carefully planned based on sound scientific data and thoughtful analyses.
Recommendations for the diversion or use of fresh surface or ground waters and saline surface or ground waters for aquaculture [agricultural] purposes.	Chapters 5 and 6 include discussions of demand for these uses and guidance for future use, both on a statewide-basis and for specific WMAs.
Identification of policy supports that provide for the maintenance and protection of watershed areas.	Chapter 5 describes ongoing efforts to protect vital watersheds and potential avenues for expansion or enhancement of the Source Water Area Protection planning process.

CHARGE	CHAPTER AND SUMMARY
Identification of lands purchased by the State for water supply facilitates that are not actively used for water supply purposes.	Chapter 5 and Appendix L present this inventory and provide recommendations as to the future use of these lands for water supply purposes.
Administrative actions to ensure the protection of ground and surface water quality and supply sources.	Chapter 5 provides an overview of water resource protection and planning efforts and approaches for appropriate actions.

In addition to meeting these charges, this Plan also includes:

- a summary of New Jersey's drought/emergency strategies in Chapter 7, including active monitoring, management area designations and authorities to act in the event of a water supply emergency (this includes "lessons learned" from extreme weather events, including the multiple named tropical storms and numerous extreme precipitation events exacerbated by climate change as well as the historic and recent droughts and 'flash drought' extreme dry periods);
- a comprehensive statewide water conservation strategy, presented in Chapter 5 (Increasing Water-Use Efficiency);
- the first extensive review of climate change implications for water supply in New Jersey (Chapter 3), regarding water availability and the resilience of water supply systems, along with a discussion of managing water supplies in the face of uncertainty from droughts, climate change, severe weather events, energy costs, development patterns and demand trends (Chapter 7);
- an analysis in Chapter 2 of potential water availability losses due to contamination by contaminants of emerging concern, including the PFAS suite of chemicals and others such as 1,4 dioxane; and
- a review of ways in which water supply issues raise or address concerns for environmental justice and overburdened communities, in Chapter 5.

This Plan promotes improved asset management, targeted investment in existing infrastructure and new projects that will improve the interconnection and operability of existing water supply assets. Investment in water infrastructure is also needed to enhance the ability of systems to withstand and quickly recover from loss of service (e.g., water main breaks) caused by adverse conditions such as extreme weather events and unexpected water supply emergencies.

Challenges identified in this Plan include, but are not limited to:

- shifts in residential populations, energy production and industry base, making projections based on historic trends more difficult;
- growth of consumptive water use;
- potential implications of climate change for water availability, water quality and water system resilience;
- the need for better integration of water supply issues with environmental justice concerns, such as the potential for surface water and ground water quality issues affecting overburdened communities with limited financial capacity to ensure the best protections for public health;
- finished water losses from aging transmission infrastructure;
- the need for asset management and for water systems to invest in water supply infrastructure and associated funding challenges;

- additional costs attributed to water systems associated with increasing water quality improvement needs;
- risks from times of drought and unpredictable weather and the impact to water supplies and demands; and
- the time and resources necessary to fully implement the identified policy supports.

Through active and thoughtful water supply management, New Jersey is well-positioned to overcome these challenges, expand economic opportunities and improve standards of living—each dependent upon on safe and secure water supplies—and better protect and improve its water resources. As described in this plan, a key to such positive outcomes is to increase water use efficiency through conservation and effective management. Another key is to ensure that water systems continually invest in their infrastructure and consistently apply sound asset management practices that factor in changing risks profiles, including those resulting from aging infrastructure and emerging risks such as climate change. In doing so, New Jersey's water systems will become equipped with the decision-making tools necessary to prioritize the replacement of antiquated infrastructure and make priority-based decisions on investments in new infrastructure.

East Point located on the Delaware Bayshore near the mouth of the Maurice River.

This Plan concludes that, while facing new and increasing water supply challenges, New Jersey has sufficient quantity of water to meet current and reasonably anticipated future needs in most regions of the state, but the continued availability and transferability of water is dependent upon intentional and consistent actions to conserve, bolster, and actively manage public and private water supplies, including through improvements to the policy supports identified in this Plan. In some regions (the Lower Raritan-Passaic region and the Southwestern region including WMA 17), there is concern that current or projected demands may exceed long-term available water resources during drought conditions; however, as discussed in this Plan, further analysis is necessary to better characterize these concerns.

The impacts of climate change upon New Jersey's water resources demands the continuous attention and vigilance of public and private water supply managers. DEP provides an initial evaluation of the impacts of climate change upon water supplies as part of this Plan and, while these initial analyses do not indicate severe impacts to water supply in the short-term, it is critical to acknowledge the improving accuracy of the climate change projections, including for future precipitation, temperature, and sea-level rise conditions—each of which carry serious implications for water supply. These improved projections and their associated water supply impact assessments may alter these findings and will likely require additional actions in the years ahead. As such, this Plan must be updated on a periodic basis to ensure that the most up-to-date data and best available science are utilized to make recommendations and address any newly identified concerns.

Members of the public expect that their increasing water supply needs will be readily met. Ensuring that these expectations are met will be challenging but must be considered a top-priority for the overall health and well-being of New Jersey's residents and businesses. This Plan is expected to serve as a key tool for DEP and various government agencies to inform enhanced management of one of New Jersey's key assets, its water supply.

In accordance with the Act, preparation and revisions of the Plan were conducted in consultation with many entities, including but not limited to the Water Supply Advisory Council, which includes a wide variety of water interests, the Highlands Water Protection and Planning Council, the Pinelands Commission, the New Jersey Water Supply Authority, the New Jersey Infrastructure Bank, the Department of Agriculture, the New Jersey Environmental Justice Advisory Council, and many other water interests through a Water Supply Plan Stakeholder Advisory Group. A new website for the Plan (**NJSWSP website**) was also developed which provided additional opportunities for the public to participate in the planning process. In addition, in accordance with the Act, DEP released a draft version of the proposed Plan in February of 2024, collected public comment through April of 2024, held two public meetings during the public comment period both online and in person, and invited written comments on the draft Plan, all to allow additional public comment. All submitted comments have been evaluated and, where appropriate and practicable, changes were made to the Plan.

The general structure of the following NJSWSP chapters is as follows:

Executive Summary

Chapter 1: Introduction

Chapter 2: Statewide Water Supply Availability

Chapter 3: Climate Change Impacts to Water Availability

Chapter 4: Statewide Water Demands and Balances

Chapter 5: Water Resource Protection and Planning Efforts

Chapter 6: Regional Planning for Deficit Mitigation and Avoidance

Chapter 7: Managing Uncertainty: Drought, Resilience and Sustainability

Chapter 8: Recommendations and Action Items

Appendices: A series of twelve technical reports and other informational documents that provide detailed analyses, results, and issues in support of this NJSWSP.

Chapter 2:
Statewide Water Supply Availability

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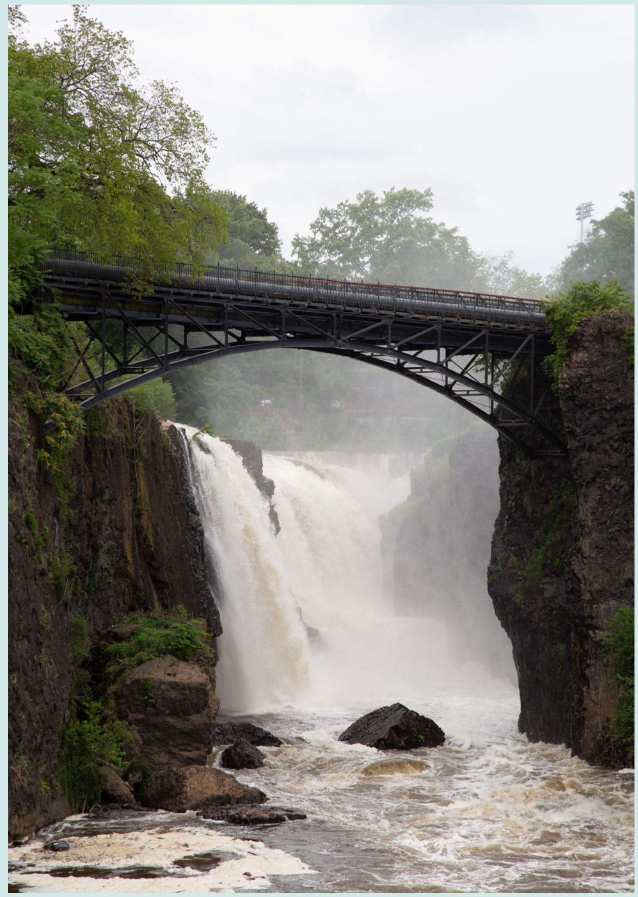
OVERVIEW

Understanding where water supplies are adequate or inadequate to address current and future demands requires clear analysis of both natural water availability, water quality and the built infrastructure (e.g. reservoirs) necessary to store water. The analysis of current and future water supply availability has five components:

1. **Natural water-resource availability:** A quantification of how much water can be withdrawn without causing adverse impacts. This is a function of water availability from three different sources:
   - surface-water reservoir supply systems;
   - unconfined aquifers and associated streams; and
   - confined aquifers.

Additional limits on natural water resource availability can also occur due to uncertainties with measurements or from water quality requirements which permanently or temporarily reduce availability.

2. **Administratively approved availability:** A quantification of the water that can be withdrawn in compliance with current DEP permits. In scenarios for water demands, these are the "full allocation" volumes.
3. **Current and future water demands:** The volume of water currently used and estimates of what will be needed to meet residential, commercial, industrial, agricultural and other demands, either self-supplied or through public water systems. These demands are projected for all uses and geographic areas to ensure adequate supplies.
4. **Future impacts to natural water-resource availability:** Impacts include, but are not limited to, climate change impacts to supply and quality, new and emerging contaminants, and development and land use changes.
5. **Water balance analysis:** An accounting of the extent to which currently available supplies are sufficient or not sufficient to meet current and future needs.



The Great Falls of the Passaic River located in the Paterson Great Falls National Historic Park in Paterson, New Jersey. Paterson is considered America's first planned industrial city and was built centered around the Great Falls.

This chapter focuses on the first two issues described in Figure 2.1, while Chapter 3 addresses climate change and water supply and Chapter 4 addresses current and future demands and water balances. The general intent since the 1981 Water Supply Management Act is that DEP should ensure that new or modified water allocations and certifications do not impact existing water uses or environmental resources, based on available knowledge. Ideally, approvals should remain within the total water availability for a resource, but legacy approvals and lack of complete information are constraints to effective decision-making; the planning process provides an approach for addressing such issues. More information is available in the supporting documentation listed at the end of this chapter.

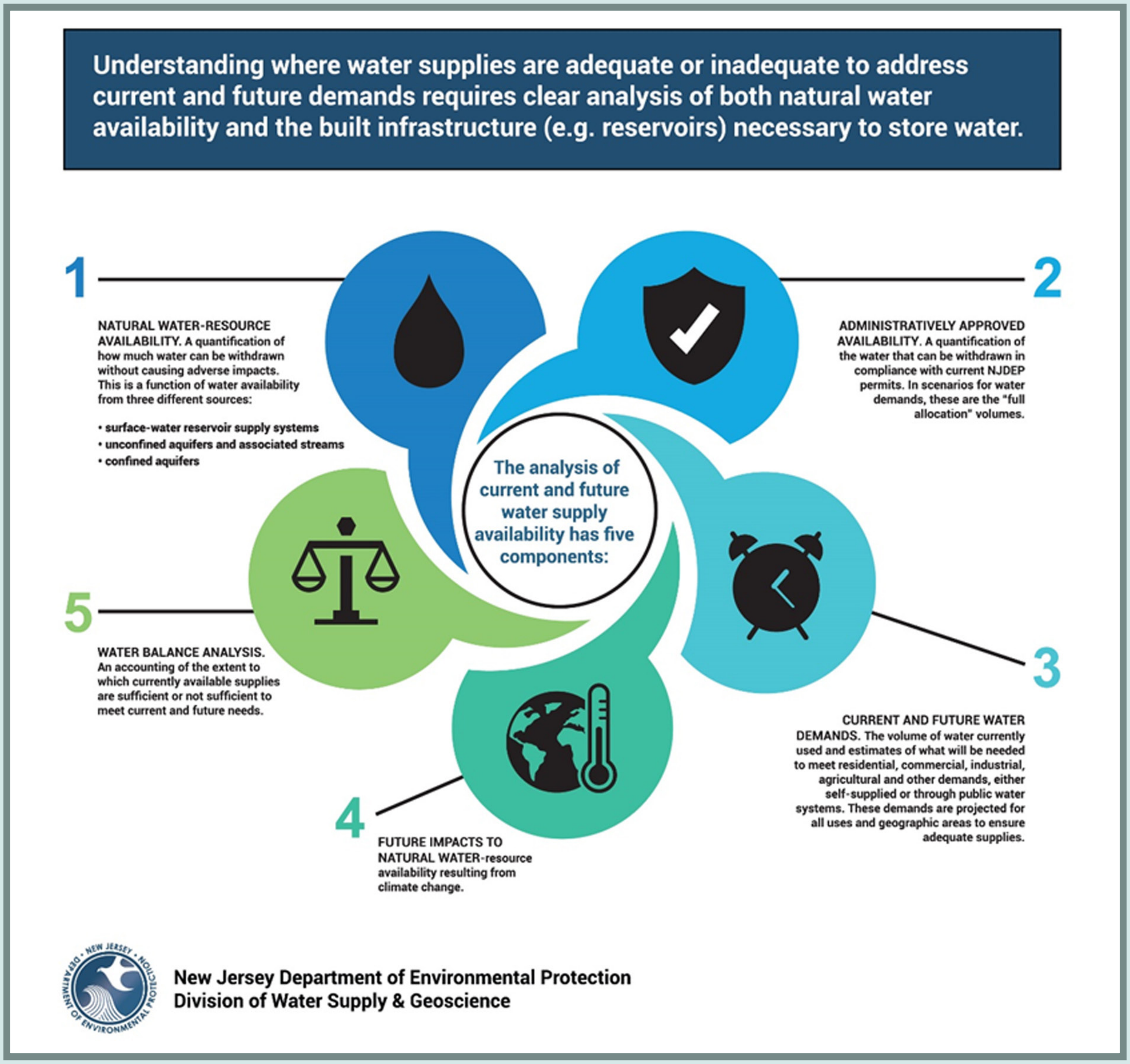


Figure 2.1 Infographic showing steps completed to develop the water availability analyses conducted in this plan.

The goal for water supply planners is to establish strategies to ensure that water supplies, as well as necessary water supply infrastructure, are in place and coordinated to meet anticipated future demands. The planning process addresses both the need to ensure that water supplies are sufficient and the need to ensure that demands are not excessive, through efficient and effective water uses. However, the Plan is not intended to, and cannot comprehensively address every issue related to water supply. It does not address individual water allocation, certification or registration requests or expectations, as they are addressed through the Water Allocation permit process. These permit decisions, however, must be consistent with the overall guidance of the Plan. It also does not address items regulated by the federal Safe Drinking Water Act and New Jersey Safe Drinking Water Act, though the Plan does evaluate issues related to the protection of untreated water resources (i.e., source water protection) and the potential loss of water supplies to contamination. Finally, the Water Supply Management Act specifically requires that no DEP actions, which includes the Plan, "shall be inconsistent with the provisions of the "Pinelands Protection Act," P.L.1979, c.111 (C.13:18A-1 et seq.), ... the "Highlands Water Protection and Planning Act," ... or the Highlands Regional Master Plan." Therefore, these regions are addressed in a different manner than the rest of the state. Ultimately, this revision of the Plan is intended to be a major step forward in how DEP will evaluate statewide water availability in the future.

NATURAL WATER RESOURCE AVAILABILITY

Fresh water is withdrawn from many sources in New Jersey, each with differing characteristics which contribute to how withdrawals affect other users and the environment. Ultimately all water is connected via the hydrologic cycle. However, for planning purposes the DEP defines three unique but interconnected categories of water sources: (1) surface-water reservoirs with a defined safe yield; (2) stream and river intakes and unconfined aquifers; and (3) confined aquifers. While hydrologic connections exist between each of them, this Plan treats them as distinct categories of sources to allow for use of existing models and methods, including confined aquifer groundwater, reservoir, and groundwater recharge models, to better define how much is available and can be used. The 2017 Plan used a similar approach. Where potential or existing water deficits are identified in a region with more than one of these water supply resources, region-specific analyses can evaluate the interconnection among resources to provide a more robust availability analysis. Note that the confined aquifers as discussed in this document refer to the coastal plain confined aquifers, but not to any smaller or locally confined aquifers that occur outside of the coastal plain physiographic province. Note that surface water is often summarized as “SW” throughout this plan and should not be confused with stormwater. Groundwater is often summarized as “GW” with unconfined and confined abbreviated as “uncon” and “con”, respectively.

SURFACE WATER SUPPLY RESERVOIR SYSTEMS

Surface water supply reservoir systems are built to store raw (untreated) water accumulated during relatively wet periods for use when supplies may not be as plentiful. The construction of major water supply reservoir systems in New Jersey began in the 19th century, with many of the major urban areas building reservoirs in rural areas during the 1890s and early 1900s. Another spate of reservoir construction occurred in the post-war era of the 1950s and 1960s to supply the expanding population of New Jersey, especially in suburban areas, and in response to the severe 1960’s drought, often referred to as the drought of record, which reduced the amount of water that systems were previously believed to be able to provide. The largest of these were Round Valley and Spruce Run Reservoirs, the state’s largest and third largest in storage. The final major reservoirs were constructed around 1990, Monksville and Manasquan, to address needs in north Jersey and Monmouth County, respectively. The major water supply reservoirs are shown in Figure 2.2 and described in Table 2.1. The state’s reservoirs are primarily located in the northern and central regions, including a few relatively small ones located in northern New Jersey and the northern coastal plain region. Most of the coastal plain region of southern New Jersey is too flat for major reservoirs.

Round Valley Reservoir located in Round Valley State Park in Lebanon, New Jersey. This reservoir is considered the largest reservoir in New Jersey and can hold up to 55 billion gallons of water at full capacity.

On-stream reservoirs are built across the path of a stream or river where the topography is favorable to impound water. The total amount of water an on-stream reservoir can provide for water supply is a function of the flows entering the reservoir from the upstream watershed, the capacity of the impoundment, and required releases. Most New Jersey reservoirs are of this type. Examples include Spruce Run Reservoir in Hunterdon County, Boonton Reservoir in Morris County, and Swimming River in Monmouth County.

Off-stream reservoirs generally are built on relatively smaller streams that can be dammed to form a large storage pool. They are then filled primarily by pumping from a larger stream or river nearby. Round Valley Reservoir, in Hunterdon County, and Point View Reservoir in Passaic County are examples of this type of reservoir.

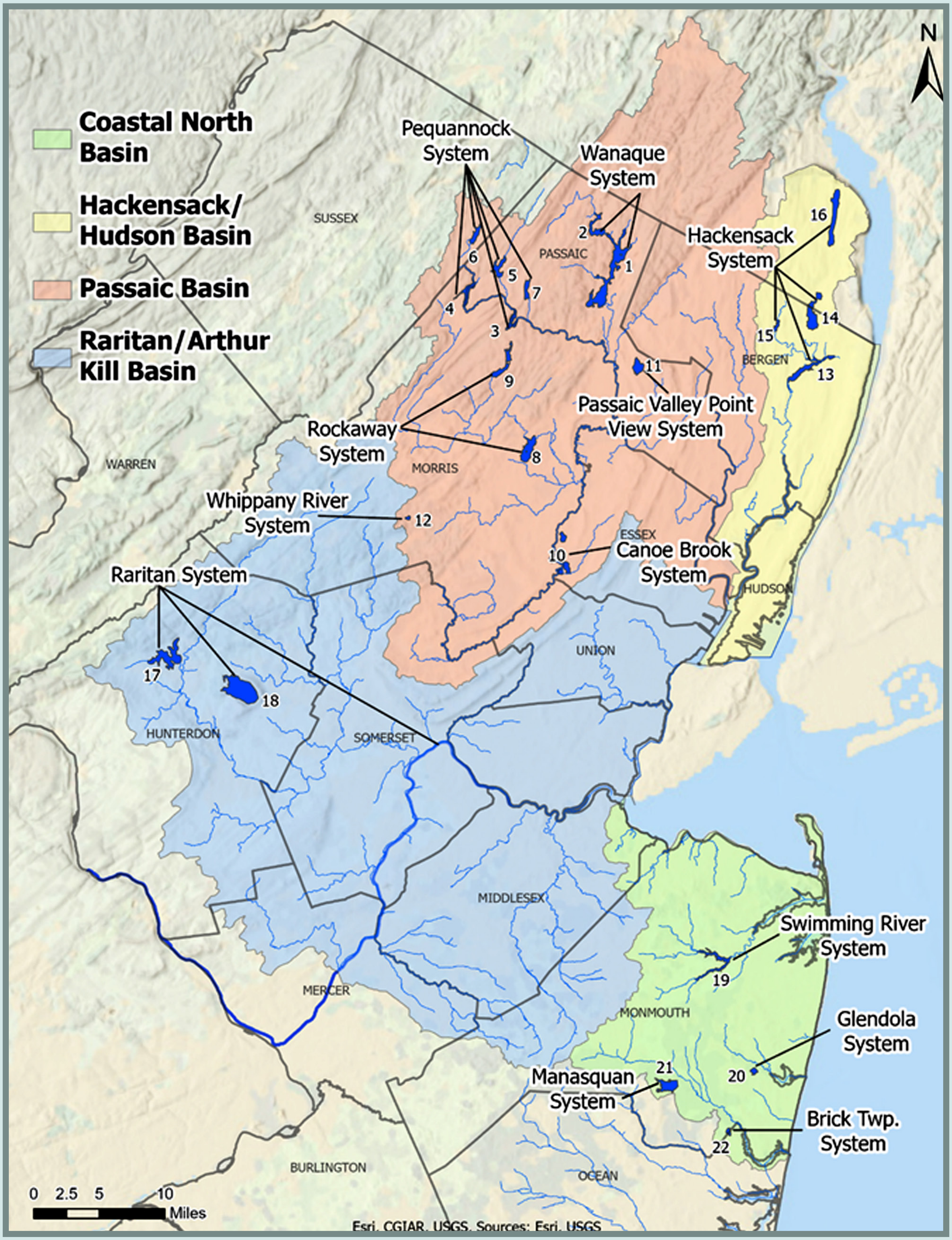


Figure 2.2 Major Surface Water Supply Reservoir Systems.

Table 2.1 Major Surface Water Supply Reservoirs that Serve New Jersey

Map ID Reservoir Name (approximate year completed)	Reservoir Owner	Usable Storage (bg)	Water Source
Wanaque System			
1. Wanaque (1927)	North Jersey District Water Supply Commission (NJDWSC)	29.49	Wanaque River; pumping from Pompton River (co-owned by Veolia North America) and Ramapo River
2. Monksville (1987)	NJDWSC	6.86	Wanaque River
Pequannock System			
3. Charlotteburg (1961)	City of Newark	2.41	Pequannock River
4. Oak Ridge (1892)		3.91	Pequannock River
5. Clinton (1892)		3.51	Clinton Brook
6. Canistear (<1900)		2.41	Pacock Brook/Pequannock River
7. Echo Lake (natural)		1.60	Macopin River
Rockaway System			
8. Boonton (1904)	City of Jersey City	7.10	Rockaway River
9. Split Rock (1948)		2.90	Beaver Brook
Canoe Brook System			
10. Canoe Brook #1, 2 & 3 (1900-1958)	NJ American Water (NJAW)	2.45	Canoe Brook/Passaic River
Passaic Valley Point View System			
11. Point View (1964)	Passaic Valley Water Commission (PVWC)	2.85	Pumping from Pompton River
Whippany River System			
12.Clyde Potts Reservoir (1930)	Southeast Morris County MUA (SMCMUA)	0.4	Whippany River
Hackensack System			
13. Oradell Reservoir (1921)	Veolia North America (formerly SUEZ)	3.27	Hackensack River
14. Lake Tappan (1966)		3.85	Hackensack River
15. Woodcliff Lake (1905)		0.87	Pascack Brook
16. Lake DeForest (1956)		5.37	Hackensack River
Raritan System			
17. Spruce Run (1964)	NJ Water Supply Authority (NJWSA)	11.0	Spruce Run and Mulhockaway Creek
18. Round Valley (1960)		55.0	Pumping from South Branch of the Raritan River
19. Delaware & Raritan Canal (repurposed 1950s)		n/a	Delaware River
Swimming River System			
20. Swimming River (1901)	NJAW	1.8	Swimming River
Glendola System			
21. Glendola (1965)	NJAW	0.9	Shark River/Jumping Brook
Manasquan System			
22. Manasquan (1990)	NJWSA	4.7	Timber Swamp Brook (direct), Manasquan River (pumping)
Metedeconk System			
23. Brick Township (2005)	Brick Township MUA	0.9	Pumping from Metedeconk River

Table 2.2 Safe yield and demand for Major Surface Water Supply Reservoirs that serve New Jersey

Reservoir System	System Owner	Permitted Safe Yield (mgd)	Current Average Annual Demand (mgd)
Wanaque System	NJDWSC	148*	106
NJ Hackensack System	Veolia NA	126.5*	94
Pequannock System	City of Newark	49.1	25
Rockaway System	City of Jersey City	56.8	40
Canoe Brook System	NJAW	10.8	7
Passaic Valley System	PVWC	75	48
Raritan System	NJWSA	241	176
Swimming River System	NJAW	25	23.3
Glendola System	NJAW	5.7	3.7
Manasquan System	NJWSA	30	23.7
Metedeconk System	Brick Twp MUA	17	8.1
TOTAL		**784.9**	

**Reflects shared ownership of the Wanaque South Project*

Finally, the yield of some on-stream reservoirs is increased by replenishing it with pumping from another water source. For example, the Wanaque Reservoir dams the Wanaque River, but water can be added to the Wanaque Reservoir through large pump intakes on the Ramapo River near the confluence of the Pompton and Passaic Rivers; the latter also provides water to Oradell Reservoir in Bergen County. Appendix B has information on the major surface water supply reservoir systems in New Jersey.

The safe yield of a reservoir system is the volume of water the reservoir system can routinely supply during a repeat of the driest conditions yet experienced. For New Jersey, this "drought-of-record" is often, but not always, the multi-year drought of the mid-1960s. A reservoir system's safe yield is a function of the water flowing into the reservoir, the infrastructure available to store and pump that water, and the operating rules which govern reservoir operation, such as requirements for the reservoir to provide downstream flows. If the reservoir is modified by increasing its storage, its operating rules change, or release requirements change, then the safe yield may change. Refer to the DEP's Guidance Manual for Estimating the Safe Yield of Surface Water Supply Reservoir Systems for more information (DEP, 2011).

To address the complexities of reservoir system operations and interconnections, the DEP determined that a computational model was necessary. The model was developed in a software program called RiverWare which was created by the University of Colorado's Center for Advanced Decision Support for Water and Environmental Systems (CADSWES). The model has been developed and added to over the years and is used for planning, permitting, and drought preparedness.

In addition to the major surface water supply systems mentioned in the tables and paragraphs above, it is also important to identify the Delaware River as a major potable supply source for the state. Both the City of Trenton and the NJ American Delaware System Delran intake are major sources of potable supply that withdraw directly from the river. Additionally, the Delaware and Raritan Canal's (part of the Raritan System) primary source of water is the Delaware River. In addition to natural runoff, flows are augmented by reservoir operation governed by a complex set of flow management agreements overseen by the Delaware River Basin Commission. Merril Creek Reservoir is the only reservoir located in NJ used to manage flows in the basin. More details on DRBC can be found in Chapter 5 and throughout this Plan.

SURFACE WATERS AND UNCONFINED AQUIFERS

An unconfined groundwater aquifer (also referred to as a water-table aquifer) interacts with the soils and surface waters above it. Water recharges the unconfined groundwater aquifer through the overlying soil, beyond the root zone of plants.

Groundwater in some areas may not exist in sufficient quantity or quality to be usable as drinking water supply or for other purposes. Where groundwater levels are high relative to a nearby surface water body, groundwater moves toward the surface water (Figure 2.3a). Where groundwater levels are low relative to the surface waters, leakage from the surface water can recharge the unconfined groundwater aquifer.

Groundwater withdrawals from an unconfined aquifer can capture part of the water movement from groundwater to surface water (Figure 2.3b) or even reverse the flow direction and induce leakage (Figure 2.3c). The result is a reduction in stream flow, similar to a direct withdrawal from a stream but with a slower impact on flows. Therefore, when calculating water availability, withdrawals from unconfined aquifers are combined with withdrawals from surface-water intakes (other than those supported by reservoir storage).

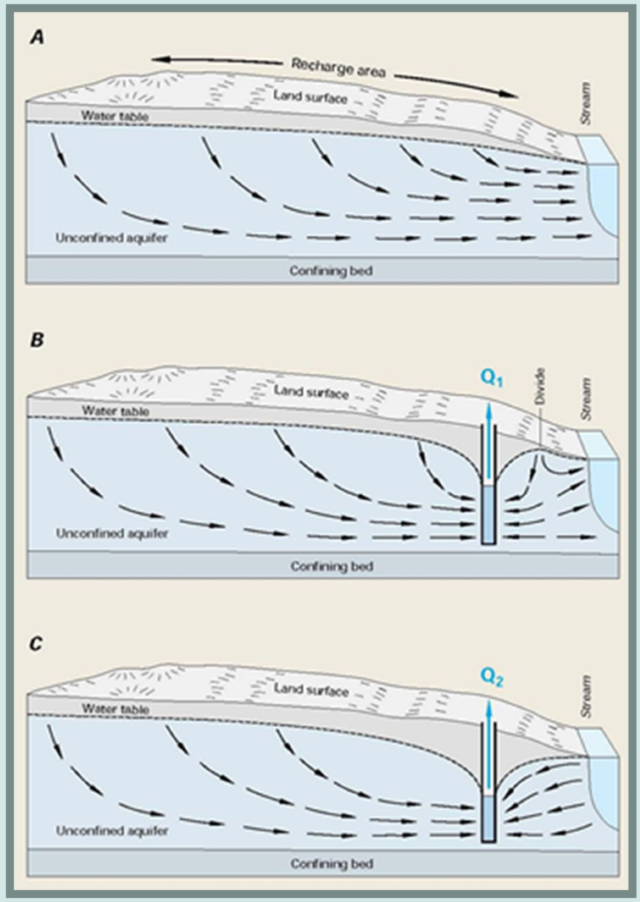


Figure 2.3 Unconfined Groundwater and Stream Flow: (a) natural conditions; (b) diverted by a pumping well; and (c) as diverted by a pumping well with induced stream leakage (modified from Winter et al., 1999).

Availability is determined via calculation of net withdrawals (total withdrawals minus returns) which are then compared to how much water can be removed from the stream without creating unacceptable ecological impacts. Understanding how much water can be withdrawn without damaging aquatic ecosystems for each watershed in the state would require lengthy and expensive field studies. Therefore, a methodology was developed for New Jersey application that relies on available science, flow monitoring, and statistical analysis. This methodology, the Stream Low Flow Margin method (referred to interchangeably as LFM or low flow margin), is used to estimate the amount of water that can be withdrawn sustainably (Domber et al., 2013) for each 11-digit Hydrologic Unit (HUC 11; comprised of one or more closely aligned watersheds). The 2017 Plan was the first statewide application of the LFM approach. The LFM approach is also used in the Highlands Regional Master Plan (adopted in 2008), with modifications to address statutory goals for that region. The LFM is defined as the difference between the median September flow and the 7Q10 flow at the lowest elevation of each drainage basin. September was selected because it is typically the driest month of the year in New Jersey. The 7Q10 flow represents the annual minimum 7-day average flow with a 10% occurrence probability and is frequently used as a low flow statistic. HUC11 subwatersheds (HUC11s) or drainage basins are used as the geographic basis for analysis in this Plan update (Hoffman & Pallis, 2009). There are 151 HUC11s in New Jersey ranging in size from about 2,000 to 90,000 acres. The HUC11 was chosen to balance data and analysis limitations with spatial resolution needs. Using a larger unit, such as a HUC 8 or WMA, could cause impacts of withdrawals on ecosystems to be masked. The HUC11 was chosen as the appropriate delineation for a statewide screening method with the possibility of analysis at a finer scale where potential ecological detriments are identified, such as a HUC11 that is shown as having large net losses. Examination of the results at a smaller scale can provide a clearer sense of which parts of the larger watershed are more or less stressed, and why. The Highlands Regional Master Plan, which is focused on a smaller region, uses HUC14 subwatersheds as a smaller area of focus. DEP anticipates adjusting the LFM method to analyze availability by HUC12, to improve alignment with more recent national work on drainage area and watershed delineations. This would allow for analysis at a finer scale as there are 275 HUC12s within the New Jersey state border compared to 151 HUC11s.

The larger portion of the low flow margin (the difference between the September median and 7Q10 flow) is reserved to support aquatic ecosystems within the HUC11. The remainder is available for routine human use that is not returned to the same watershed (e.g., consumptive and depletive water losses). This Plan uses 25% of the LFM as a planning threshold of excessive depletive and consumptive water loss, with the remaining 75% for ecological maintenance and provision for downstream flows. If there is more net water loss than this threshold, a HUC11 is considered to have limited additional supplies, at least at a preliminary level. In these areas, further analysis is warranted. The hydrogeologic setting of any particular HUC11 is complicated and site-specific analysis is typically required to determine whether a diversion is sustainable or not, through the permitting or planning processes or both. Chapter 4 provides more detailed information on how the results are used in planning. In addition, the LFM results are used within the water allocation regulatory process as one of multiple considerations in whether new or increased allocations should be approved.

A fundamental assumption of the LFM approach is that the same planning threshold is appropriate for all waters outside of the Highlands region, which has special statutory authorities and expectations to protect sensitive aquatic ecosystems. Since adoption of the 2017 Plan, DEP has conducted additional research to update the streamflow database used to derive the LFM and has recalibrated the LFM approach. The results of these analyses are used in this version of the Plan, based on the LFM approach with a 25% planning threshold. DEP compared results of the LFM approach at 25% to another approach, the New Jersey Hydroecologic Alteration Tool (NJHAT, modeling software for determining Ecological Limits of Hydrological Alteration, or ELOHA, Poff et al., 2009), for multiple watersheds across the state in a range of hydrogeologic settings that had sufficient data for the NJHAT analysis (Domber et al., 2013); DEP concluded that generally the LFM approach at 25% would protect ecosystems from excessive withdrawals at the HUC11 level (i.e., not including potential site-specific impacts from withdrawals). The reanalysis confirmed use of the 25% threshold (see Table 2.3) and did not result in major changes to the LFM approach. Therefore, this Plan relies on the use of the 25% planning threshold with additional constraints in situations where the results would reduce flows to surface water supply reservoir systems, imply withdrawals exceeding the 7Q10 flows, and other factors. These additional constraints are intended to avoid flow reductions that would put water supplies and aquatic ecosystems at risk.

Hamden Pump Station operated by the New Jersey Water Supply Authority in Clinton Township, New Jersey. This station allows water to be moved from the Raritan River into Round Valley Reservoir.

Table 2.3 Calibration of the stream low flow margin method using NJHAT

ID	Gage Number	Name	Baseline Period	Drainage Area (mi2)	Stream Type Classification	Stream Flow Reduction (CFS)	Stream Flow Reduction (MGD)	* September Median (MGD)	* 7Q10 (MGD)	Stream Stat Violation	LFM Difference of 7Q10 and September Median (MGD)	** Percent of LFM
1	01464000	Assunpink Creek @ Trenton	1923-1956	91	A	3.891	2.51	26.5	7.97	DL4	18.53	14%
2	01410150	East Branch Bass River near New Gretna	1978-2005	8.11	D	0.581	0.38	7.11	4.17	DL4	2.94	13%
3	01440000	Flatbrook near Flatbrookville	1923-2005	64	A	4.9	3.17	13.57	4.75	ML6	8.82	36%
4	01411000	Great Egg Harbor River @ Folsom	1925-1970	57.1	B	5.5	3.55	28.44	14.01	FH10/DL1	14.43	25%
5	01408000	Manasquan River @ Squankum	1931-1956	44	A	3.5	2.26	21.97	10.83	ML8	11.14	20%
6	01409400	Mullica River near Batsto	1957-2005	46.7	B	6	3.88	25.85	9.39	ML4	16.46	24%
7	01457000	Musconetcong River near Bloomsbury	1921-1972	141	B	9	5.82	67.86	29.57	DL1	38.29	15%
8	01379000	Passaic River near Millington	1921-1979	55.4	A	2.5	1.62	9.51	1.81	ML5	7.7	21%
9	01443500	Paulins Kill @ Blairstown	1921-1975	126	A	11.5	7.43	34.9	10.59	ML7	24.31	31%
10	01477120	Racoon Creek near Swedesboro	1966-2005	26.9	C	2	1.29	10.99	4.75	ML4/ML6/ML8	6.24	21%
11	01384500	Ringwood Creek near Wanaque	1934-1978	19.1	C	0.85	0.55	2.13	0.24	ML5	1.89	29%
12	01380450	Rockaway River @ Main Street @ Boonton	1937-1959	116	A	14	9.05	38.78	9.61	ML6	29.17	31%
13	01465850	South Branch Rancocas Creek @ Vincentown	1961-1975	64.5	B	3.6	2.33	19.35	5.75	DL1	13.6	17%
14	01396500	South Branch Raritan River near High Bridge	1918-1970	65.3	A	4.5	2.91	29.73	14.24	ML4	15.49	19%
15	01408500	Toms River near Toms River	1928-1963	123	B	8.5	5.49	73.68	42.93	DL1	30.75	18%
16	01411300	Tuckahoe River @ Head of River	1969-2005	30.8	C	1	0.65	10.99	4.65	ML5	6.34	10%

17	01409280	Westecunk Creek @ Stafford Forge	1979-1988	15.8	D	3.5	2.26	14.28	8.67	ML8/FH3	5.61	40%
18	01381500	(1) Whippany River @ Morristown	1921-1952	29.4	C	2.5	1.62			ML4	5.153	31%
19	01398000	Neshanic River @ Reaville	1930-1962	25.7	A	0.3	0.19	1.55	0.12	ML6	1.43	14%
20	01409500	Batsto River @ Batsto	1927-2005	67.8	B	9.5	6.14	43.95	26.14	ML9	17.81	34%
21	01467000	N. Branch Rancocas near Pemberton	1921-2005	118	B	10	6.46	53	22.3	ML3	30.7	21%
22	01399500	(2) Lamington River near Pottersville	1921-1950	32.8	C	2.875	1.86			ML4	7.7	24%
23	01396660	(3) Mulhockaway Creek @ Van Syckel	1977-2005	11.8	C	0.6	0.39			ML7	1.9	20%
24	01386000	West Brook near Wanaque	1934-1978	11.8	C	0.45	0.29	1.94	0.38	ML6/FL1	1.56	19%
											Average =	**23%**

(1)- From area ratio of Whippany River HUC11 02030103020 LFM Analysis (69.9 mi2 and 12.2 LFM)
(2)- From area ratio of downstream gage 01399780 flow stats (99 mi2 and 23.2 LFM)
(3)- From area ratio of downstream gage 01396700 flow stats (20.5 mi2 and 3.26 LFM) DL1: Annual minimum daily flow. (cfs)
DL4: Annual Minimum of 30-day moving average flow. (cfs)
ML3: Mean or median (user choice) of March of minimum flow values. Determine the minimum flow for each March over the entier flow record. (cfs) ML4: Mean or median (user choice) of April of minimum flow values. Determine the minimum flow for each April over the entier flow record. (cfs) ML5: Mean or median (user choice) of May of minimum flow values. Determine the minimum flow for each May over the entier flow record. (cfs) ML6: Mean or median (user choice) of June of minimum flow values. Determine the minimum flow for each June over the entier flow record. (cfs) ML7: Mean or median (user choice) of July of minimum flow values. Determine the minimum flow for each July over the entier flow record. (cfs)
ML8: Mean or median (user choice) of August of minimum flow values. Determine the minimum flow for each August over the entier flow record. (cfs)
ML9: Mean or median (user choice) of September of minimum flow values. Determine the minimum flow for each September over the entier flow record. (cfs) FH3: High Flood pulse count. (number of days/year)
FH10: Flood frequency. (number of events/year) FL1: Low flood pulse count. (number of events/year)
*September Median and 7Q10 Flows were obtained from New Jersey Geological Survey Technical Memorandum 13-3, Domber, S., Snook, I., Hoffman, J.L., 2013, “Using the Stream Low Flow Margin Method to Assess Water
**The “Percentages” column is the Stream Flow Reduction divided by the “Difference of 7Q10 and September Median”.

After documentation of the stream low flow margin method in the New Jersey Geological and Water Survey (NJGWS) Technical Memorandum 13-3 (TM13-3) and initial implementation in the 2017 Plan, efforts were made to explore whether adjustments to the method were necessary. NJGWS contracted USGS to perform a recent flow trends study to inform possible changes. Stream statistics, including but not limited to 7Q10 low flows and September median flows, were compared between two time periods: 1950-1979 and 1990-2019. Results of the study were mixed, with only the September median flow statistic displaying a significant difference on a statewide basis. A general increase, though not always statistically significant, in flow statistics was observed at many of the study sites in northern New Jersey, while results in the south were a mix of both increases and decreases. It is possible that these changes in streamflow are related to the changing climate, a topic which is covered in detail in Chapter 3 of this document. Further research is needed to address recent flow trends and climate change as it relates to the method.

It was determined that several modifications to the low flow margin method were needed to more accurately reflect the complex hydrogeologic and hydrologic relationships that exist within a drainage basin, and to better identify regions that may be experiencing hydrologic stresses and require further investigation or action by the DEP. Those changes are outlined below. Unless specifically noted, the method components are the same as defined in **TM13-3**.

- Water use data period:
  - Water use data through 2020 was used. The last Plan update used data from 2000-2015.
  - 2011-2020 was used to determine peak use due to general statewide stabilization of trends in water use over that period.
- Peak use representation:
  - Peak use will be selected from the three-year period with the highest average net water loss from 2011-2020. Previous Plan updates used the single year with highest loss.
  - The change is designed to reflect the complexity of unconfined groundwater storage and corresponding base flows, as a single year may not accurately represent current peak use conditions.
- Saline discharges:
  - Saline discharges will no longer be incorporated into remaining available water calculations since it requires significant investment before it can be reused. Volumes are still tracked in the summary data tables.
- Additional considerations:
  - Upstream stressed HUC- Highlights any HUC11 that is downstream of another that has been identified as stressed.
  - In a stressed WMA- Net loss was subtracted from total availability for each WMA in the same manner that is carried out on a HUC11-by-HUC11 basis. If a WMA is identified as stressed, all HUC11s within are flagged for a potential availability limitation.

DEP is considering further model improvements to ensure that the results accurately reflect in-situ ecologic/aquatic observed conditions. Additionally, it is also open to consideration of alternative approaches that come from relevant research either in New Jersey or elsewhere. The LFM approach improvements under consideration are:

- application of the New Jersey Hydrologic Alteration Tool (i.e., ELOHA model) to additional sites and updates of previously studied sites using new data and projections that incorporate climate change impacts;
- shifting from analysis at the HUC11 watershed level to the HUC12 subwatershed level; and
- consideration of climate change impacts on water availability.

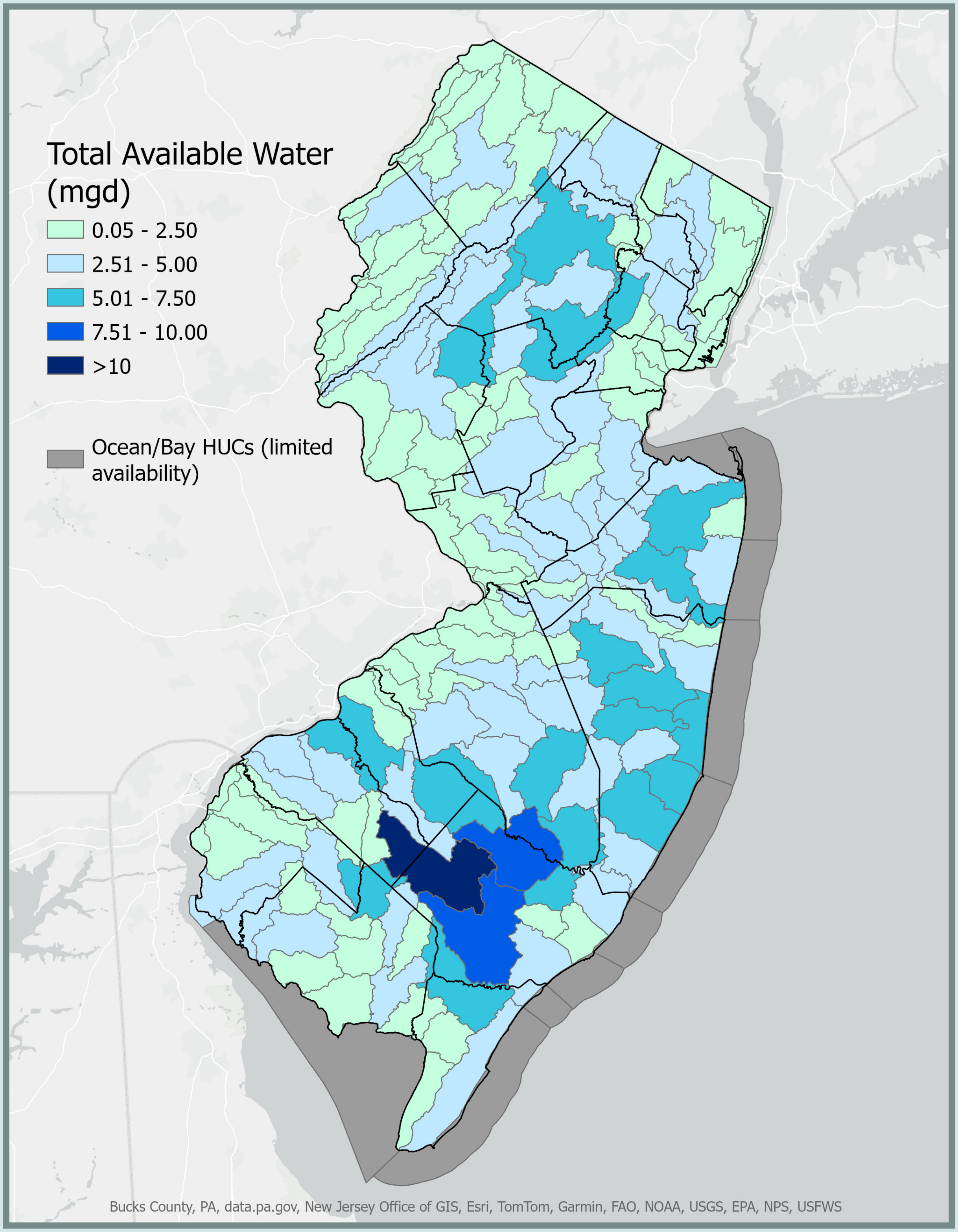


Figure 2.4 shows the estimated amount of water available for consumptive and depletive water uses from the unconfined aquifer and surface water system of each HUC11 (in mgd). This does not include the estimate of surface water reservoir safe yields or yields from confined aquifers.

CONFINED AQUIFERS

In New Jersey confined aquifers underlie much of New Jersey's Coastal Plain. These aquifers are separated from unconfined aquifers and each other (except where they intersect with the surface in their recharge areas, called outcrop areas) by one or more geologic units that hinder the vertical movement of water (Figure 2.5). Withdrawals from them do not have an immediate effect on the unconfined aquifers and surface waters above them. Groundwater modeling indicates that confined aquifer pumping can increase the amount of water leaving the watershed where the confined aquifer outcrops and becomes unconfined. This is referred to as leakage. For this reason, leakage to and from the confined aquifer is a factor accounted in the low flow margin (LFM) method discussed above.

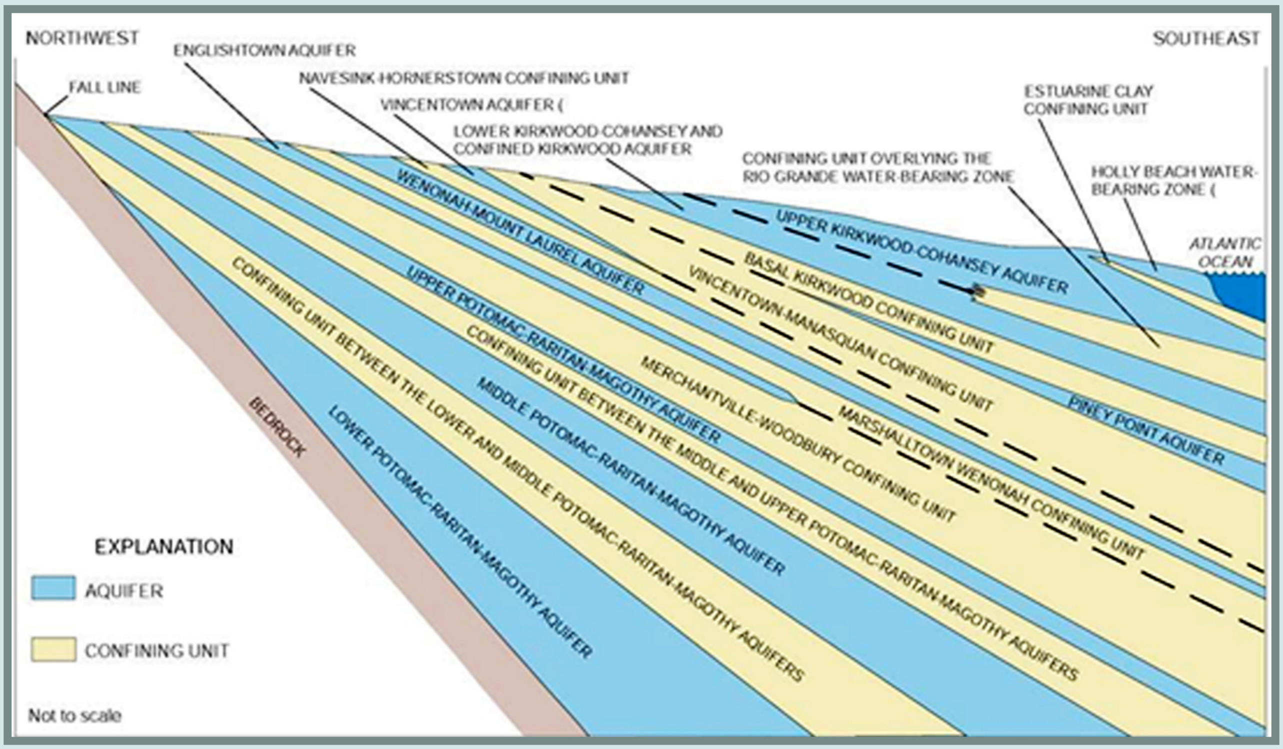


Figure 2.5 Generalized Cross Section of New Jersey's Coastal Plain Aquifer System (from Charles et al., 2011).

Confined aquifers can also experience leakage to and from overlying and underlying confined aquifers, based on differences in the water pressure within each aquifer. These leakages are important factors in confined aquifer models. Confined aquifers also can interact with saline waters along the coastal areas, such that excessive pumping of the confined aquifer can induce saltwater intrusion toward the wells. The focus of this Plan, as with prior plans, is on the major coastal confined aquifers. Some confined aquifers exist in non-coastal areas, but they tend to be geographically limited and closely related to surrounding unconfined aquifers.

Confined aquifers are a significant water supply source for southern New Jersey, providing the majority of potable water supplies to users in the State's coastal plain. Steadily increasing use of these aquifers has caused progressive declines in water levels in some areas and saltwater intrusion in others. Hydrogeologic analysis of the Coastal Plain confined aquifer systems has revealed the interconnected nature of the individual aquifers and their eventual hydraulic connection to water table systems. Due to this interrelationship, new diversions from most confined aquifers draw water from an overlying or underlying aquifer and/or the water table system. This emphasizes the need for a comprehensive, regional water supply planning perspective in assessing the potential impacts of developing additional supplies.

DEP and USGS have conducted cooperative research to upgrade and update the confined aquifer models. Based on this research, USGS provided water balances for each confined aquifer, with consideration of recharge from outcrop areas, movement across the confining layers to and from the confined aquifer, water withdrawals from the aquifer and three scenarios for future demands from existing wells, two based on scenarios from Van Abs et al. (2018) and one using full water allocations; the last is considered a "maximum stress" test that is unlikely to be realized in the foreseeable future. The results are detailed in Appendix C.

WATER AVAILABILITY UNCERTAINTIES

No method of water availability analysis is perfect. The purpose of the Plan is to understand water availability to a level that allows for effective planning and management of water resources. The DEP continues to learn and improve its methods to ensure policy is based on the best available and most up to date scientific understanding of water resource issues. This will, in turn, lead to a more rigorous research agenda regarding specific water resources that are stressed, appear to be stressed, or are critical resources and warrant better baseline knowledge. Several areas of potential uncertainty exist that are acknowledged here but are considered within acceptable levels for planning purposes. Further research will help reduce these uncertainties over time, for later inclusion in the planning process.

1. **Monitoring versus modeling**: Modeling is a critical analytical tool that uses available data and knowledge of system processes to estimate current conditions and project future changes. All models are simplifications of reality and are heavily dependent on available data. New Jersey has a robust water monitoring network and is one of the most well developed in the nation, but even so there are data gaps that must be acknowledged. Additional stream flow and aquifer level monitoring stations and an increased knowledge of geology in specific areas would improve model development.
2. **Changes in climate conditions:** Though there is a good understanding of overall climate change impacts, the specific seasonal and annual variability is still uncertain as well as longer term conditions (i.e., beyond 2050) conditions. Planning can incorporate this uncertainty through the use of risk analysis. For example, if no significant water availability stresses occur under a suite of probable scenarios, then any uncertainty is manageable. If, on the other hand, a major increase in stress is possible under a scenario that has a significant chance of occurring, the planning should incorporate and address that risk. Research results to date are discussed in Chapter 3. Real time or quasi-real time monitoring and periodic reassessments are key activities that can decrease uncertainty and ensure that the DEP has adequate time to address emerging issues.
3. **Hydrologic modifications:** In a similar vein, it is well understood that water resource infrastructure development and alterations may affect hydrologic systems (e.g., beneficial reuse of treated wastewater, water supply interconnections). Land development and redevelopment will affect demands. However, the specific locations and impacts of these changes over the next 30 years or more cannot be specified at this time. New Jersey is currently updating its Statewide Development and Redevelopment Plan and future WSPs will utilize the State Plan resources available. As with climate change, the use of scenarios is the best approach for determining whether potential modifications of hydrologic conditions and water demands pose significant risk.
4. **Local natural resource limitation and or permit conditions on regional resources:** The analysis used in this Plan is based on large-scale planning units, such as confined aquifers, reservoir systems and HUC11s. The water availability results for the confined and unconfined aquifers may not reflect local limitations on withdrawals. Where water is withdrawn is important. For example, the same volume of confined aquifer withdrawal will have different impacts depending on whether the well is close to or distant from saline water. Reservoir safe yields can change based on downstream flow requirements. Unconfined aquifer withdrawals may be restricted due to wetlands protection, effects on nearby wells, etc. Therefore, what is available regionally may not be available where it is needed locally. In situations where regional studies indicate stresses, local supplies may be available depending on specifics of the request. In these cases, additional modeling, assessment, and studies may be required to confirm that the local supply is sustainable and will not exacerbate the regional issue.
5. **Regional and watershed/aquifer water availability interactions:** One of the more difficult analytical issues is that the three major categories of water availability (reservoir systems, unconfined aquifers, confined aquifers) interact. Reservoirs rely heavily on groundwater discharges to streams that flow into the reservoirs, and therefore the safe yields can be reduced by upstream aquifer withdrawals. As noted in the confined aquifer discussions, the overlying unconfined aquifers can be a source of recharge to the confined aquifer, or vice versa,

depending on local conditions. These natural and induced inter-flows are important to modeling, which is best performed for specific regions where there is a current or future concern.

6. **Infrastructure-related inter-flows:** Water transfers through water and wastewater infrastructure are tracked in the various water availability models to the extent possible. These transfers may occur between HUC11s (e.g., upstream to downstream, downstream to upstream, between unconnected river basins), from freshwater resources to ocean wastewater discharges, and through Managed Aquifer Recovery systems. Beneficial reuse of treated wastewater, either directly or indirectly, can alter water availability calculations as well. As one interesting example of water transfers, New Jersey American Water constructed a finished water pipeline that transfers water from the Passaic Valley Water Commission (PVWC) up basin to the Morristown and Millburn areas of Morris and Union Counties. After use of this water by the consumers, the resultant wastewater is treated and discharged back into the river where it is available for other downstream users, including the PVWC facility. Much of the flow in the lower Passaic River during low flow periods is supplied by treated sanitary wastewater discharges.
7. New Jersey is also a party to the Delaware River Basin 1954 Supreme Court decree ("Decree") that resolved litigation among the Delaware River Basin states and New York City. The Decree, among other things, ensures that out-of-basin water diversions by New York City and New Jersey do not adversely affect water supplies basin-wide and requires certain compensating and "excess" releases from New York City's Delaware River Basin reservoirs. The five parties to the Decree (the four Delaware River Basin states and New York City) periodically negotiate modifications to an operating agreement, which can affect water availability for New Jersey. Additional information about the Decree and the operating agreement (known as "FFMP") is included in Chapters 3, 5, 6, and 8 of this Plan.
8. **Water quality constraints on supply:** Historic water quality problems have forced public community water systems to abandon supplies, such as Newark's decision to stop using the Passaic River locally around the turn of the 20th century, and build reservoir systems in the Pequannock watershed. Other urban areas did likewise. In the 1980s, recognition and establishment of water quality criteria for volatile organic chemicals (VOCs) and other industrial contaminants resulted in advanced treatment of some wells, but also in the abandonment of other wells due to decisions that the use of alternative supplies was preferable than use of the existing supply, due to concerns about either treatment viability or excessive costs. This issue was assessed in the 1996 Plan. Currently, new maximum contaminant levels (MCLs) for several PFAS chemicals and anticipated MCLs for other compounds will likely force consideration of treatment viability and costs relative to the abandonment of supplies and use of alternatives. While the contaminated resources will still exist and may in the future be usable if cost-effective treatment becomes available, abandonment of these supplies could represent a local reduction in water availability. The next section summarizes ongoing research on these issues.

All of these considerations create some uncertainty in water availability calculations that must be addressed in the planning process.

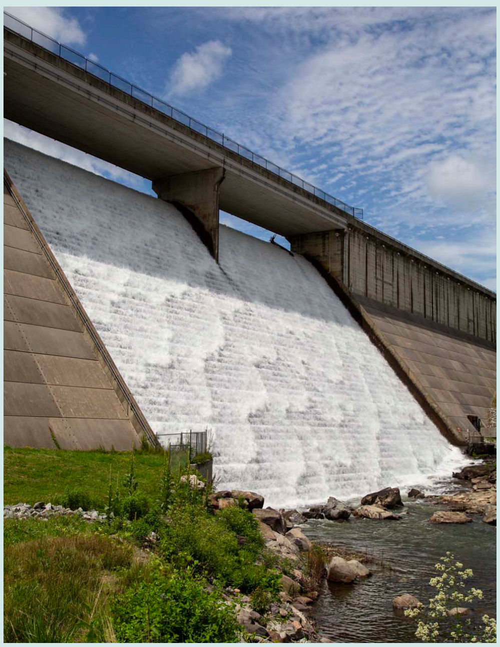
POTENTIAL WATER LOSSES TO CONTAMINATION

The sections above discuss water supply availability from a quantity perspective, which has been the typical focus of earlier water supply plans in New Jersey. The connection between supply and quality has always been made, but this Plan broadens those links and addresses specific water quality issues- especially those impacting drinking water. Water is only truly available if it is available in the necessary volumes and of the appropriate quality. While effective water treatment technologies exist which ensure water meets the necessary health standards for its intended use, there are limits including time requirements to design and build new technologies; very real cost constraints to install, operate and maintain those treatment processes; and space/land use limitations for some water systems. The state is currently experiencing challenges as water utilities are required to comply with the existing New Jersey MCL standards for three PFAS contaminants, while reacting to the proposed EPA MCLs which are much lower than the current New Jersey MCL standards. The lower and expanded federal standards recently proposed for this suite of chemicals are anticipated to impact more water systems statewide and exacerbate the challenges New Jersey is already experiencing.

To further expand the scope of this Plan, the following section uses the existing (but ultimately limited) safe drinking water quality data to evaluate the distribution of PFAS throughout the state and quantifies the potential threat on unused but available drinking water supplies from PFAS or other contaminants. An overview of the already significant amount of treatment the state's water utilities are already implementing is covered in Chapter 5. While this section focuses on PFAS, the overall issue of new MCLs or emerging contaminants has the potential to have similar impacts to water supplies and cost of water. For example, increasing trends in chlorides, primarily from road salt applications, have been noted and are a concern due to the extreme difficulty and cost of removing it. 1,4 dioxane and cyanotoxins are other examples.

STATEWIDE PFAS WATER SUPPLY ANALYSIS

Per- and polyfluoroalkyl substances (PFAS), including perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), and perfluorononanoic acid (PFNA), have been regulated in New Jersey's drinking water via a maximum contaminant level (MCL) since 2018 for PFNA and 2020 for PFOA and PFOS. The unique substances that fall under the PFAS umbrella can be referred to as analytes.



Monksville Reservoir located in Long Pond Ironworks State Park in the New Jersey Highlands. The reservoir and state park are considered great spots for fishing, hiking, and wildlife watching.

On certain occasions, the discovery that a public water system's finished water violates the MCL for PFAS has resulted in at least a temporary loss of water supply while installing new or updating existing treatment technology. In these cases, systems may choose to switch to alternate water sources, including purchased water from neighboring purveyors. This presents a concern that certain systems or water sources may face increasing demands on a temporary or permanent basis due to loss of supply in affected systems found to violate newly adopted water quality standards.

To explore the problem from a water supply planning perspective, NJGWS performed an analysis of statewide reported PFAS sample results to highlight regions or sources of water where levels have been elevated. It is important to note that the maps and charts that follow include, in addition to more recent data, PFAS sample data that was collected prior to the introduction of the New Jersey MCL and in some cases, prior to the installation of treatment. "Hot spots" on the maps do not represent water systems that are in violation of PFAS MCLs, but instead highlight areas with elevated density of PFAS samples of higher concentrations. Additionally, risk analysis was conducted to show how systems that rely on surface water sources could be stressed by demands associated with neighboring systems responding to PFAS MCL violations, which tend to have a greater impact to groundwater sources, and requiring purchased water to replace sources.

The DEP chose to explore the impacts of PFAS on water supply due to their presence as a relatively new threat and the availability of sample data. However, there are other emerging contaminants, such as 1,4-dioxane, that may have similar impacts on supply.

Figures 2.6 and 2.7 are heat maps developed from singular PFAS sample detection data that was submitted to the Bureau of Safe Drinking Water for required monitoring purposes from 2019 to 2022. While samples were collected before 2019, and for a portion of 2023 when this chapter was drafted, these years were selected due to the significant number of data points and their geographic spread. The data are point-of-entry samples, collected after raw water traveled through the existing drinking water treatment processes. While not ideal data, as some systems may have had existing treatment for other reasons which also removed PFAS, this is the best statewide potable water dataset available to the DEP. It should be noted that a single sample result in excess of an MCL does not denote a violation by the water system (which is determined based on a running annual average). Note that the concept of a heat map has multiple uses and the concept discussed in this Plan is not related to temperature.

A heat map is a depiction of the relative density of plotted points. In this case, the points represent PFAS samples, and a weight is applied via the analyte concentration so that samples with higher concentrations have a greater effect on the occurrence density pictured in the maps. These maps were produced using ESRI's heat map symbology which relies upon the kernel density method, described in detail by Silverman (1986). For each point, a surface is produced with the highest value at the location of the point and decreasing values at increasing distance from said point, eventually reaching zero at the search radius selected by the user. The weighting field, which in this case is sample concentration, is the number of times the value is counted for the surface associated with each point. Surfaces overlap where points are located near one another, and the values of the overlapping surfaces are summed. The result is the occurrence density, symbolized in yellow, orange, and red on the maps. It is important to note that the heat maps and occurrence density areas are NOT representative of in situ water quality PFAS concentrations, but rather show areas where occurrences are more likely. We accept there may very well be other areas not identified in the maps which also have PFAS contamination present, but which were not mapped by this specific process. While other PFAS sample data sets exist, such as the ambient groundwater monitoring network and samples associated with the site remediation program, this analysis was focused on drinking water and therefore relied upon finished water samples. Figure 2.6 organizes sample data by analyte and each individual map includes all samples for the given analyte from 2019 to 2022. There are very few locations where a significant density of high concentration PFNA samples occurs, and there is significant overlap in PFOS and PFOA "hot spots." In Figure 2.7, sample data for different analytes are combined and arranged on a year-to-year basis. Changes over time in the position and intensity of "hot spots" may be caused by water sources going offline, the addition of new treatment processes, or other reasons. Some water systems have stopped using water sources temporarily, added new treatment to eliminate contaminants, and begun to distribute water from those sources again. This could contribute to a reduction in occurrence density of samples with elevated PFAS concentrations.

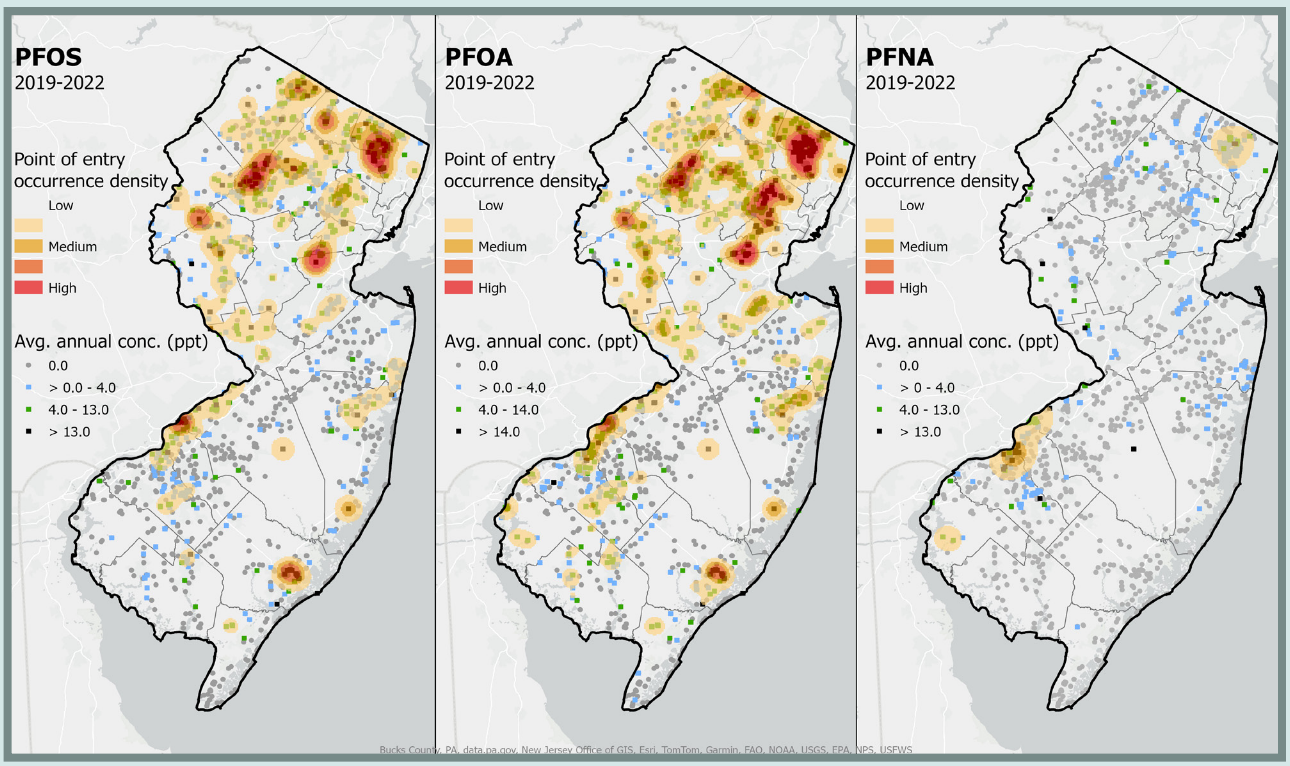


Figure 2.6 Heat maps, developed based on kernel density method with weighting for sample concentration, show the areas where the occurrence of elevated samples has been more or less dense. Sample points are symbolized to highlight the New Jersey MCLs (13 or 14 ng/L or parts per trillion(ppt)) and the proposed EPA MCLs (4 ng/L or ppt). Note: Symbology for sample points is different in the PFNA map because the proposed EPA MCL for PFNA is folded into a Hazard Index for PFAS that is not sampled for in New Jersey.

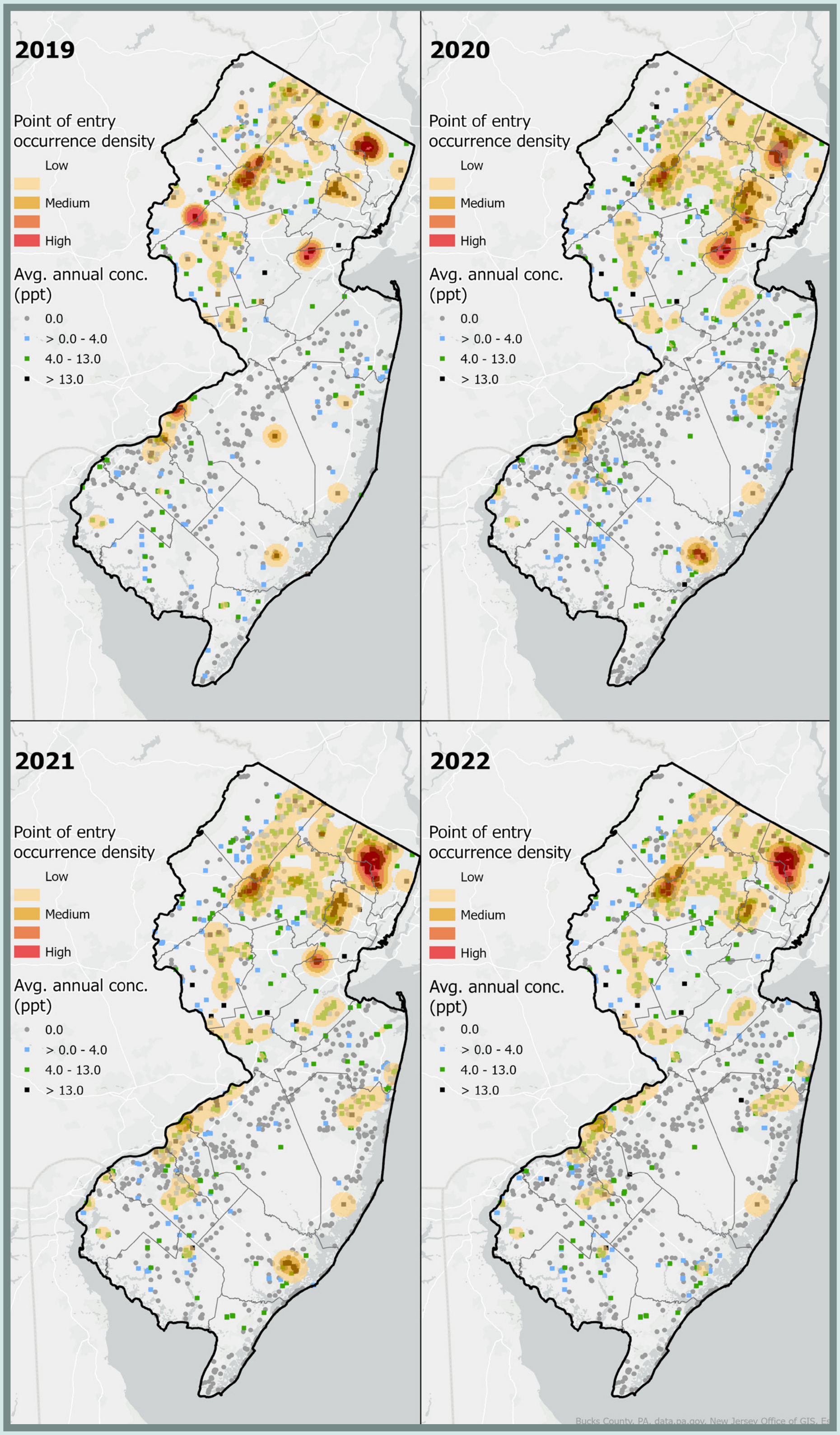


Figure 2.7 Heat maps, developed based on kernel density method with weighting for sample concentration, combining occurrence density for the three PFAS analytes (PFNA, PFOS and PFOA) currently regulated by a NJ drinking water MCL, organized by year from 2019-2022. Sample points are symbolized to highlight New Jersey MCL's for which the 13 ng/L (ppt) value was chosen due to the fact that applies to two out of the three substances. A single EPA MCL of 4 ng/L (applies to PFOA and PFOS) was included in the symbology.

A primary goal of this PFAS analysis was to determine which raw water sources are more likely to be contaminated by these substances. The maps above provide geographic context for statewide PFAS sampling, but do not connect the results to water source. The box and whisker plots that follow display the same sampling data expanded to include all PFAS samples available at the time this chapter was developed, spanning 2013 to 2023.

Figure 2.8 shows the components of a box and whisker plot. The box area represents the spread of values between the 25th and 75th percentiles, also known as the interquartile range (IQR). Within the IQR, the central line is the median and the X represents the average value. The “whiskers” extend to 1.5 multiplied by the IQR, beyond which all values are identified as outliers.

Relatively few samples exceed the New Jersey MCL (13 ng/L) for PFNA, which is shown in Figure 2.9. The boxes for the water resources are barely visible because the IQR for each is very close to zero. The IQR and average value for samples taken from PRM water sources stand out but do not approach the New Jersey MCL, although a number of outlier samples exceed it. While these are noted as statistical outliers on a box and whisker plot, they are treated no differently than other sample results in the process of evaluating water quality.

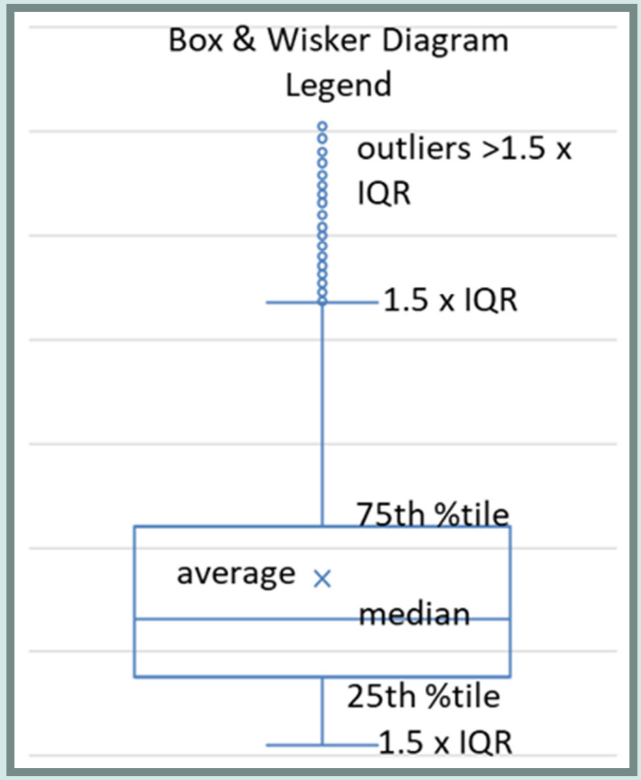


Figure 2.8 Description of box and whisker plots displayed in following figures. IQR refers to the interquartile range, represented by the box which includes data points for the middle two quartiles.

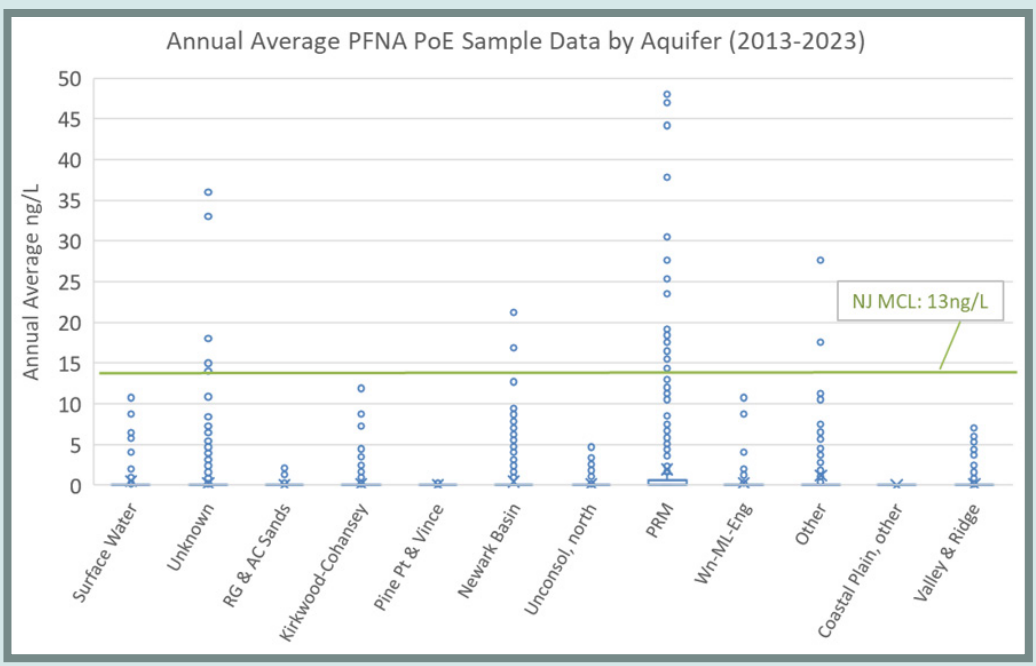


Figure 2.9 Box and whisker plot showing PFNA sample results, organized by aquifer. The green line represents the New Jersey MCL for PFNA which became effective in 2019.

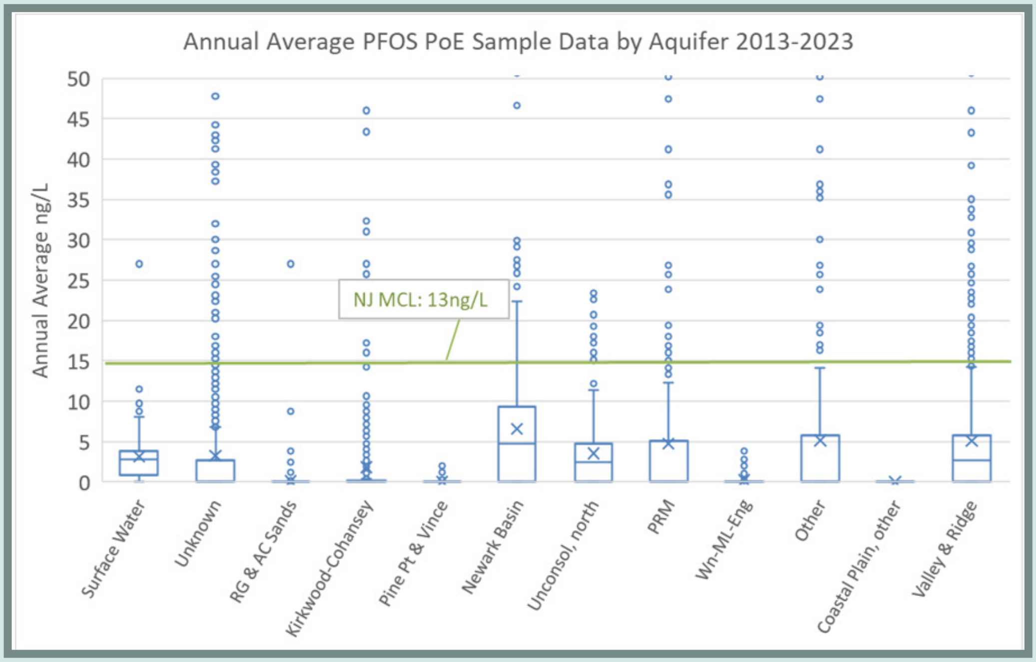


Figure 2.10 Box and whisker plot showing PFOS sample results, organized by aquifer. The green line represents the New Jersey MCL for PFOS which became effective in 2020.

When compared to the previous box and whisker plot for PFNA, Figure 2.10 displays a relatively more significant presence of PFOS. However, only the Newark Basin sampling data shows an upper boundary above the New Jersey MCL and none of the water resources' IQRs reaches that threshold. The 75th percentile of sample data for the unconsolidated aquifers in northern New Jersey, the PRM aquifer and the Valley and Ridge aquifer system reaches or just exceeds 5 ng/L. This is relevant due to the proposed EPA MCL for PFOS of 4 ng/L. A number of samples pictured as outliers exceed the New Jersey MCL.

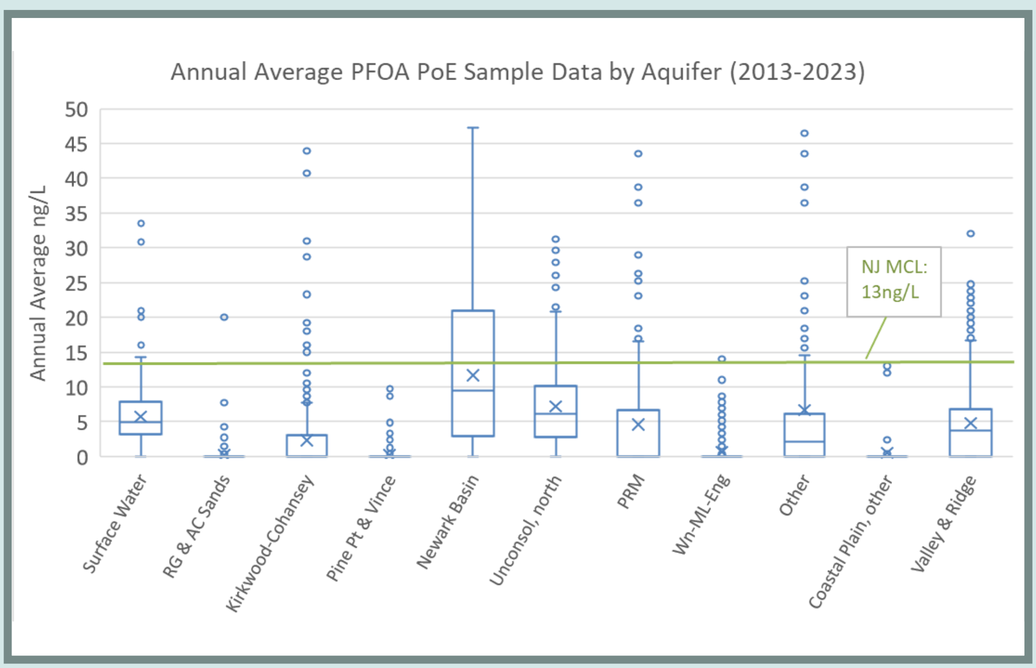


Figure 2.11 Box and whisker plot showing PFOA sample results, organized by aquifer. The green line represents the New Jersey MCL for PFOA which became effective in 2020.

Figure 2.11 shows that, for most water resources, samples for PFOA are returning higher concentrations than the other two analytes. A significant amount of the IQR for Newark Basin samples is above the New Jersey MCL and the associated median and average are close to the threshold. IQRs for the unconsolidated aquifers in northern New Jersey, the PRM aquifer, and the Valley and Ridge aquifer system are higher than for PFOS. Surface water samples display higher concentrations than for PFOS or PFNA and the median and average for these are above the proposed EPA MCL of 4 ng/L. Average sample concentrations for the Newark Basin, the unconsolidated aquifers in northern New Jersey, the PRM aquifer, and the Valley and Ridge aquifer system are at or above the proposed EPA MCL. For most water resources on the chart, there are fewer points identified as outliers and broader IQRs than for the other analytes, suggesting that sample concentrations are more tightly clustered.

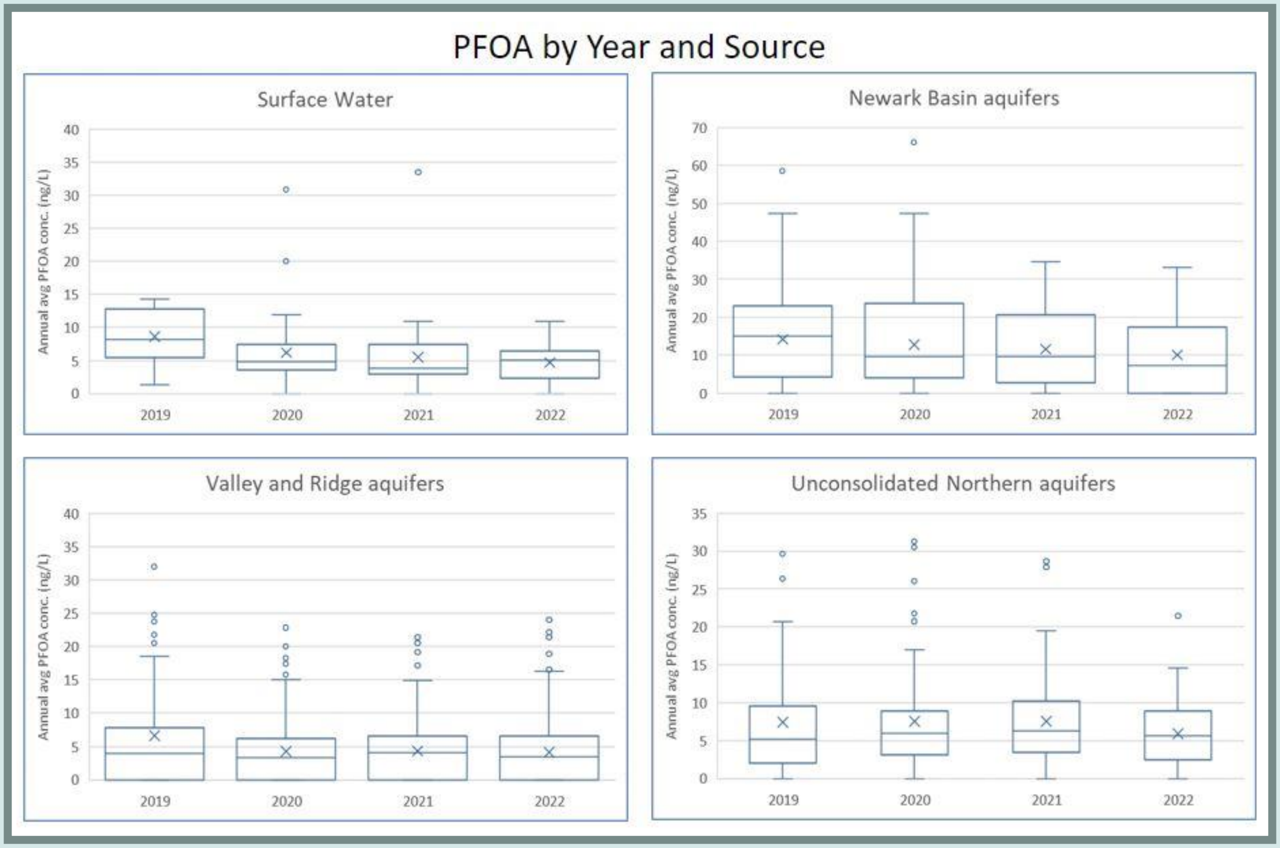


Figure 2.12 Box and whisker plots for PFOA only from 2019-2022, organized by select aquifers.

Figure 2.12 shows the change in PFOA sample concentration over time for four selected water resources. Surface water shows the most noticeable change, with median and average concentration dropping after 2019, and a tightening of the IQR for 2020-2022. The IQR for Newark Basin samples decreases less but the median and mean drop below the New Jersey MCL. Samples from the Valley and Ridge aquifer system and the unconsolidated aquifers in northern New Jersey exhibit minimal change.

Overall, PFOS concentrations are lower than PFOA in the selected water resources (Figure 2.13). Surface water samples show a decrease similar to what was observed for PFOA, and by 2020 the entire IQR, median, and average are below 5 ng/L. The box and whisker for samples collected from Newar Basin aquifer sources is skewed by two data points with extremely high concentrations, but IQRs, medians, and average for all four years are below the New Jersey MCL. Concentrations for the unconsolidated aquifers of northern New Jersey decreased from 2020 to 2022 while those for the Valley and Ridge aquifer system remained very stable.

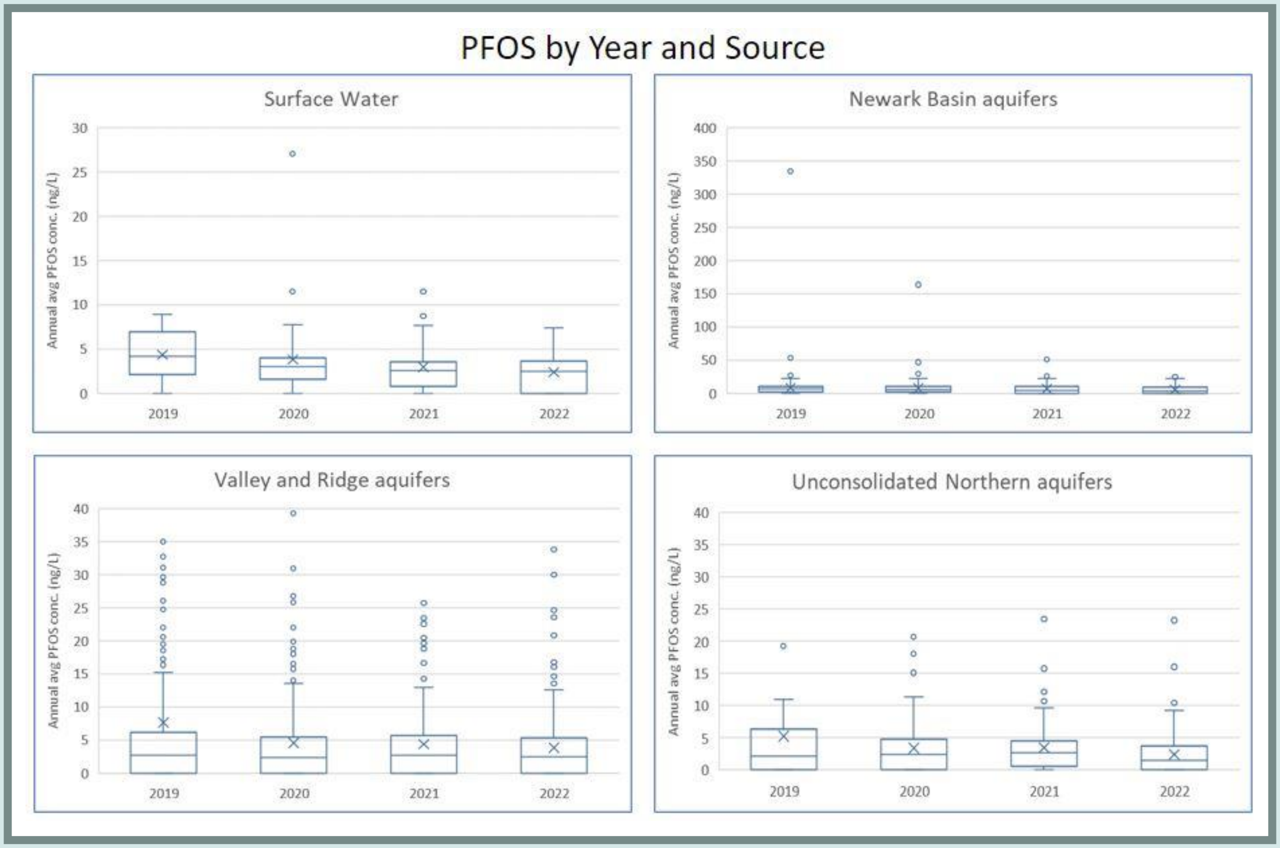


Figure 2.13 Box and whisker plots for PFOS only from 2019-2022, organized by select aquifers.

Figures 2.9 to 2.11 show data for the three analytes, PFNA, PFOS, PFOA, binned by water source. It is clear that the presence of PFAS is not uniformly distributed among sources, with some more frequently returning samples at or above the state's MCL. Samples for four highly relevant water sources that returned a significant number of high concentration values were arranged by year and analyte in Figures 2.12 to 2.13. Changes over time may have occurred for a variety of reasons, some of which are mentioned previously in relation to Figure 2.6. The availability of statewide raw water sample data available to the DEP would enhance these analyses.

PCWS VULNERABILITY ASSESSMENT

The impacts of PFAS and other emerging contaminants are still being realized and are ultimately difficult to predict, but temporary or permanent source losses have occurred and will continue to pose challenges for public water systems in the future. To identify water systems where loss of groundwater sources due to contamination could exceed available supplies, the DEP conducted a vulnerability assessment. The assessment method focused on the major surface water systems in New Jersey (who are common, temporary, or permanent "go to" suppliers of water), their interconnected neighbors, and simulated the loss of sources and the increased need for transfers. Unconfined groundwater loss was simulated in percent breaks, to determine the degree of loss that would result in a surface water system exceeding their assigned public water system deficit/surplus estimates as determined by the Division of Water Supply and Geoscience. Assumptions include that the system in question and its neighbors experience unconfined groundwater loss at the same thresholds, and that the surface water system will transfer water to its neighbors to account for their loss. For the purposes of this assessment, a system's neighbors are defined as systems that are geographically adjacent or that have purchased water from or sold water to the system in question. Demands used were developed for the Surplus/Deficit Analysis completed in January 2023. Systems that would not be able to meet demands in the instance of 100% loss of unconfined groundwater supply are described as potentially vulnerable in Figure 2.14. As deficit/surplus results are periodically updated these results may change and therefore should be periodically updated to identify systems that continue to show vulnerability over multiple reassessments.

Surface water sources can also contain PFAS, HABs or other contaminants which can reduce supplies of the surface water systems, either permanently or temporarily. This analysis only covers the groundwater loss and use of surface water, but it could be expanded to include the loss of any source of water. It is closely linked to the finished water storage waiver issue covered in Chapter 7.

This assessment only simulates loss of unconfined groundwater and the potential impacts on interconnected systems as a response to PFAS-caused supply challenges, but the method could be applied to other water resources. For example, temporary loss of surface water supplies is possible - and has occurred already - as a result of harmful algal blooms (HABs). A similar vulnerability assessment could be carried out in the future to analyze collective risk related to HABs or other contaminants. Although it is unknown what future issues will be posed by emerging contaminants, water supply vulnerabilities can be explored using this analytical approach

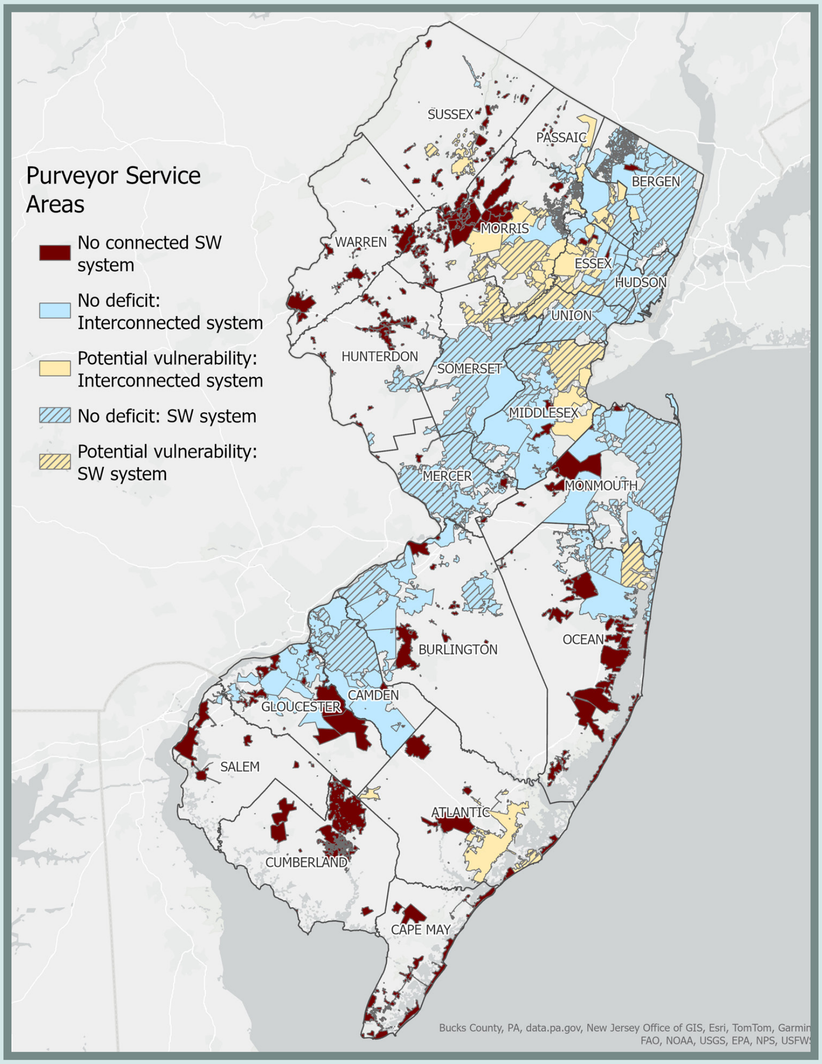


Figure 2.14 Statewide map with systems symbolized based on the groundwater vulnerability assessment. Systems where 100% loss of unconfined groundwater could cause a supply deficit are identified as potentially vulnerable. Major surface water systems are symbolized with cross hatching. Within the legend surface water is abbreviated as SW.

INFRASTRUCTURE DEVELOPMENT RISKS

Technologies developed to facilitate the installation of infrastructure like Horizontal Direction Drilling (HDD) create opportunities but also present risks if not properly managed and regulated. HDD can allow for utilities to run necessary infrastructure through highly sensitive environments without disturbing the surface areas along the route. While HDD minimizes the percent surface area disturbance and avoids disturbance of highly sensitive environments, the potential effects of Inadvertent Returns (IR) can be consequential. Based on reviews of HDD projects and related studies, HDD activities carry a potential risk to groundwater as well as to surface water supplies through the IR of fugitive drilling muds and fluids which become a source of pollution in groundwater, surface water/sediments, and or the ecologically sensitive area that was intended to be unharmed through this alternate process. Currently New Jersey has no regulatory requirement pertaining to the HDD activities, unlike the N.J.A.C. 7:9D regulations which oversee and regulate the installation of conventional vertical wells. Recent studies (Peters et al., 2014) and documentations of unsuccessful HDD activities show that unintended IRs pose potential risks to groundwater, surface water, and ecological areas. It is recommended that the oversight and proper regulatory management of HDDs throughout the process of planning, construction, installation, and decommissioning should be considered to prevent potential impacts and minimize risks.

SUMMARY

Natural vegetation located along the Green Bank Bridge in Mullica Township, Atlantic County. The bridge crosses over the Mullica River, connecting Atlantic and Burlington counties.

A clear analysis of natural water availability and the built infrastructure necessary for water storage is needed to understand where water supplies are adequate or inadequate to address both current and future demands. This chapter aims to address that need by providing an overview of natural water resource availability and administratively approved availability throughout New Jersey. Although not evenly distributed throughout the state, total natural water resource availability (including reservoirs) is an estimated 1,791 mgd, with surface water reservoir systems, unconfined aquifers and associated streams, and confined aquifers providing 785 mgd, 387 mgd, and 619 mgd, respectively.

DEP relies on the use of both the stream Low Flow Margin method and confined aquifer models to help estimate statewide water availability. Since the 2017 Plan, the DEP made adjustments to the stream Low Flow Margin method to more accurately reflect hydrogeologic and hydrologic relationships and to better identify regions potentially facing hydrologic stress. Adjustments to this approach included the incorporation of more recent water use data, alterations in how peak use is represented in analysis methods, and the removal of saline discharges from remaining available water calculations. The DEP and USGS have also worked collaboratively to improve the estimation of water availability in confined aquifers by upgrading and updating confined aquifer models to provide water balances for each confined aquifer in the New Jersey Coastal Plain. However, analytical estimations of water availability in confined aquifers – as with estimations of unconfined aquifer and surface water availability – will always have some uncertainty. DEP will continue to work to reduce uncertainty in its approaches to estimate water availability.

This chapter also focused on examining the potential impacts that water quality issues may have on available supply, including an analysis of the threat to drinking water posed by the presence of PFAS. An examination of PFAS sampling results showed that exceedances of current New Jersey MCLs are not uniformly distributed. Some water resources, such as the Newark Basin and the Valley and Ridge aquifers, appear more likely to return a sample with a high concentration of one of the three PFAS analytes- PFNA, PFOS, and PFOA. A PCWS vulnerability assessment was also conducted to identify water systems where a loss of groundwater sources due to contamination could stress available supplies.

While the DEP explored the impacts of PFAS on water supply due to their presence as a relatively new threat, other emerging contaminants, such as 1,4-dioxane, have the potential to have similar impacts on supply. By considering major surface water systems and their interconnections, this chapter identified systems that may be vulnerable if temporary or permanent unconfined groundwater source losses occur in the future due to PFAS-caused supply issues. The DEP is committed to continuing to monitor PFAS and other contaminants that may influence New Jersey water supply availability and improving analyses as statewide raw water sample data becomes more available.

Two specific areas DEP intends to target related to its research approach to estimate statewide water availability include:

- continuing its ongoing research to further refine the Low Flow Margin method by determining: (a) how climate change may influence recent flow trends; and (b) how to more accurately reflect ecologic/aquatic observed conditions in-situ; and
- further evaluation of strategies to reduce uncertainty in water availability estimations based on the use of periodic reassessments, and further research on the geology of specific locations and the use of real time or quasi-real time monitoring.

Chapter 3:
Climate Change Impacts to Water Availability

TABLE OF CONTENTS

OVERVIEW

The earth is warming and 2023, exacerbated by the onset of El Niño conditions in the Pacific Ocean, was globally the hottest year on record. In 2023, New Jersey has seen its warmest January since at least 1895, while February and April had average temperatures among the five highest for those months over the same time period. To date the state has also experienced multiple weeks of hot and dry conditions ended abruptly by intense precipitation events. This extreme variability appears to be occurring more frequently and is one of the forecasted effects of a changing climate. It is well documented that New Jersey is not immune to the impacts of climate change and is in fact already facing significant direct and indirect consequences, some of which are more severe than those experienced in most other regions of the country and the world. The 2020 New Jersey Scientific Report on Climate Change communicated that sea-levels are rising and temperatures are increasing at a greater rate in New Jersey than other parts of the Northeast region and the world. It also reports that precipitation is increasing, with annual precipitation increasing by 7.9% over the long-term average in the last 10 years alone. Additionally, storm events producing extreme precipitation have increased by 71% over the last 50 years. The 2020 New Jersey Scientific Report on Climate Change found that sea-levels are expected to rise approximately one to two feet by 2050 and two to five feet by 2100; precipitation may increase 4% to 11% by 2050; and temperatures are expected to increase by another 4.1°F to 5.7° F by 2100 (NJDEP, 2020).

These climate drivers -- sea-level rise, increasing temperatures, and increasing precipitation -- have direct and indirect impacts to the state's natural and built water supplies and can lead to critical water supply stresses. While more rainfall can result in more streamflow into reservoirs, peak streamflow can stress aquatic and drinking water quality and floods can inundate critical infrastructure. More precipitation can lead to more groundwater recharge, but warmer temperatures can result in longer growing seasons, and more evapotranspiration and large storm events can result in more runoff (potentially carrying contaminants into surface water) and less groundwater recharge. Warmer temperatures can also increase water demands; including potable, agricultural and power generation. Sea-level rise will force saltwater into unconfined aquifers and estuaries and cause wells and intakes to become salty permanently or periodically during droughts. Climate change is and will continue to be the major driver of water availability issues for the state.

This chapter represents the first major evaluation of climate change implications for water availability and water demand within a Plan. The findings included in this Plan were developed using reliable climate change science and technically sound modeling efforts by the DEP. As the science of climate change impacts on water resources evolves, the DEP will monitor and incorporate new developments. This chapter captures current, well-established knowledge of climate trends and is focused on screening-level-type evaluations. It builds on the climate science and forecasts outlined in the DEP's 2020 Scientific Report on Climate Change and incorporates information from the Rutgers State of the Climate reports and other research. Updates to this Plan will be developed over time and as appropriate. This evaluation is primarily used to identify data gaps and uncertainties, priority topics needing further investigation, and initial assessments of magnitude and severity of impacts to New Jersey's water supplies. This analysis is the start of an ongoing scientific, policy and regulatory process that must continue to use the best available science and modeling techniques.

A revetment and shorefront community located in Brigantine, New Jersey. Sea level rise poses a risk to critical infrastructure and water resources located in New Jersey's coastal areas.

OVERVIEW OF CLIMATE SCIENCE

As documented by the 2020 New Jersey Scientific Report on Climate Change (NJDEP, 2020), climate change is occurring and will continue to occur. Three major climate change effects which will impact water availability are evaluated in this Plan: temperature change, precipitation change, and sea level rise. Each has the potential to modify water availability and water demands in different ways. The major climate change drivers and potential impacts to New Jersey can be viewed via the **Climate Change in New Jersey: Impacts and Effects web product** which includes useful maps and graphics.

TEMPERATURE

Increasing temperatures can shift precipitation types (e.g., snowfall to rainfall), increase evapotranspiration rates, increase soil moisture deficits, increase the intensity of storms, and increase and extend water demands. Generally stated, New Jersey temperatures have been rising year-round, but especially in the winter, and faster than the global average.

New Jersey temperatures are increasing faster than the rest of the Northeast, by 3.5°F since 1895, and are projected to increase by 4°F to 10°F through the year 2100 (under moderate and high emission trends, respectively), with winters warming faster than annual averages (Shope et al., 2023). Figure 3.1 shows the five warmest and coolest months (compared to the average) on record from 1895 through 2022, with a clear trend from cooler months in the early 1900s to warmer months in the 21st century.

Global Climate Models (GCM) provide various scenarios for future conditions, depending on greenhouse gas emission trends, and downscaling these models for use in a small state or even the Mid-Atlantic region is an important next step. Shope et al. (2023) note that "this warming trend is expected to accelerate with further climate change". These GCMs are reasonably

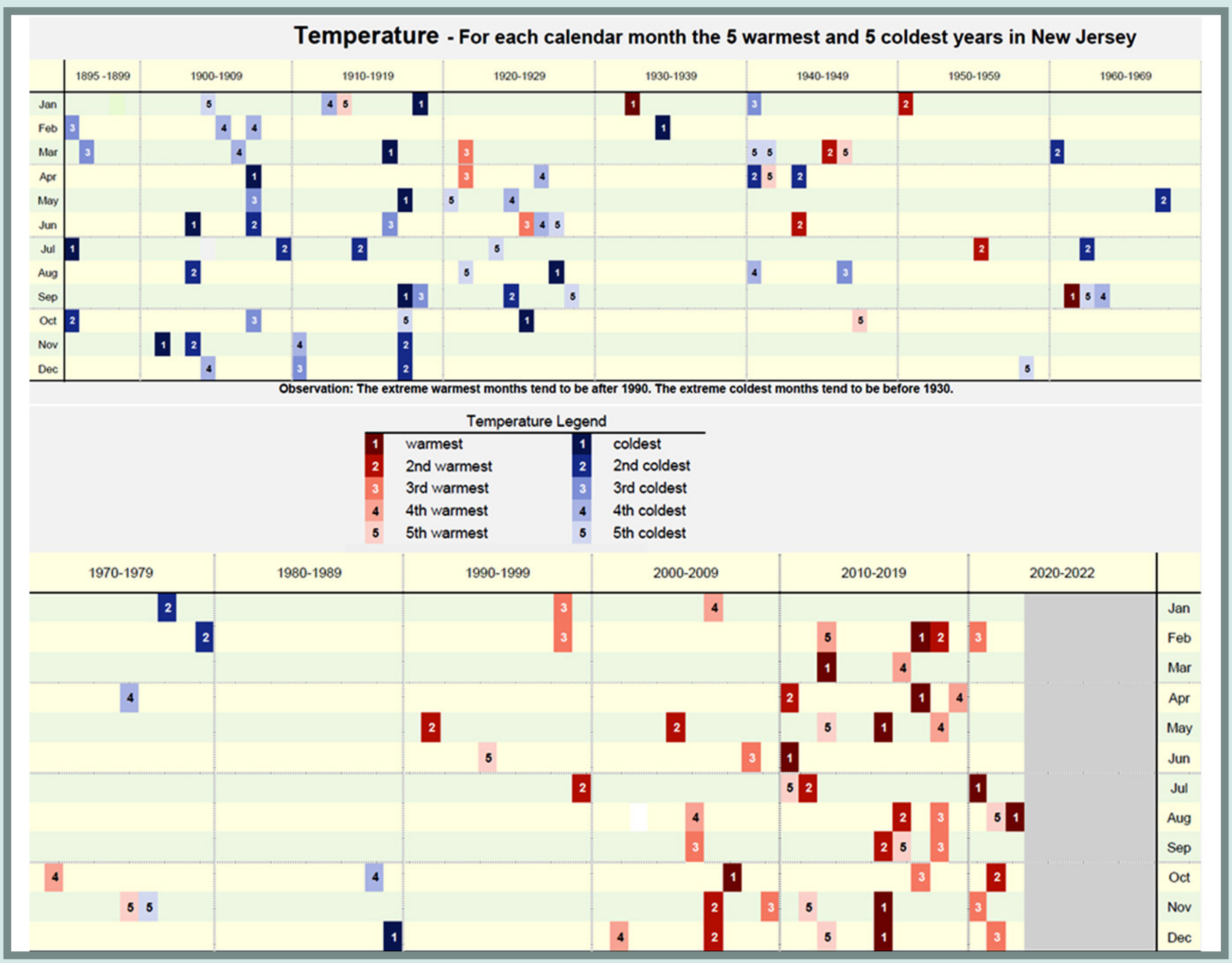


Figure 3.1 New Jersey's Extreme Temperature Months, 1895-2022 (Rutgers/NJDEP-NJG&WS, 2023).

good at predicting annual average temperatures at a global-regional scale. However, daily, monthly, and seasonal temperature changes can significantly impact water demands and influence drought conditions, so it is critical that modeling capability be expanded and improved to better forecast and plan at state-specific spatial and more finite temporal scales.

PRECIPITATION

Precipitation above all else drives water availability and the timing and magnitude of it is critical in determining water supply impacts. Extreme events can provide a lot of runoff into reservoirs but it can also cause flooding and negatively impact water quality or water supply infrastructure. Lack of precipitation beyond normal amounts can lead to drought, stress aquatic resources, and reduce water available for consumption. Precipitation in New Jersey has increased roughly 7% since the early 1990s (Figure 3.2). It is evident in Figure 3.2 that precipitation patterns often demonstrate variability when examined year-to-year or by location. This variability can make it difficult to directly attribute all of the recent increases to climate change, but there is an increasing trend in precipitation in which climate change is the driving factor. Looking to the future, the 2020 New Jersey Scientific Report on Climate Change states annual precipitation in New Jersey is expected to increase by 4% to 11% by 2050 (Horton et al., 2015).

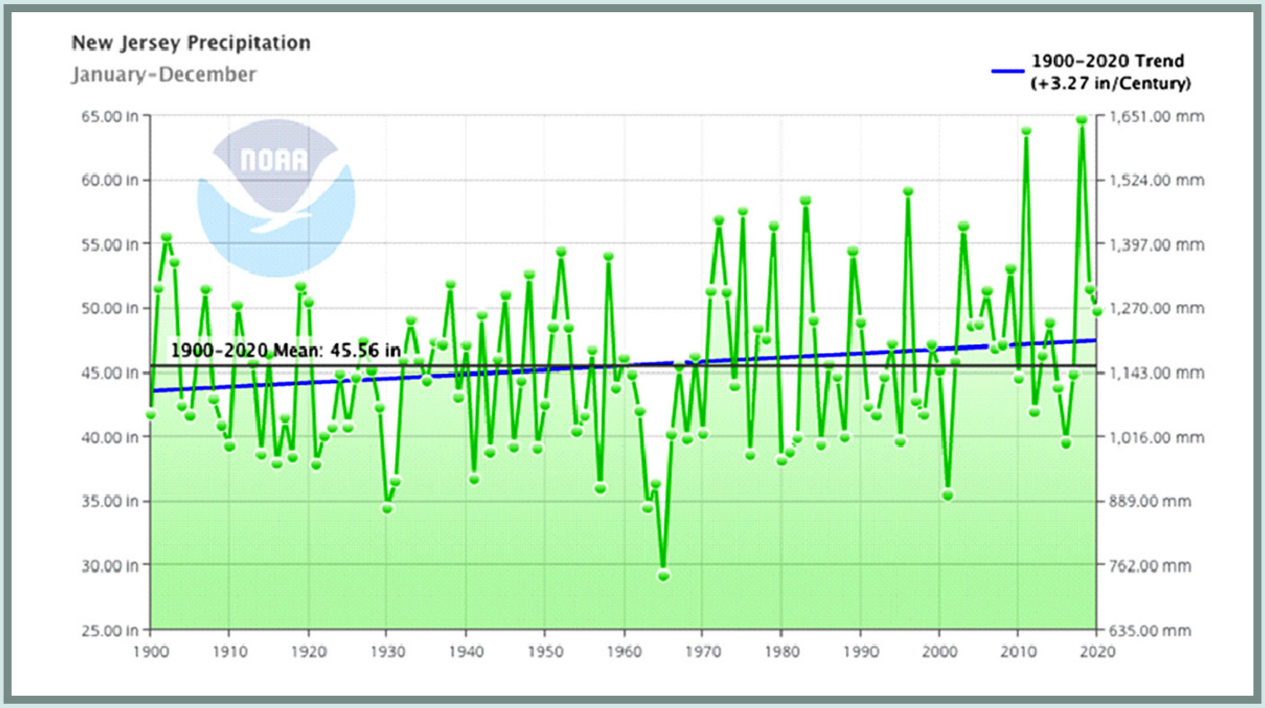


Figure 3.2 New Jersey Annual Average Precipitation 1900-2020 (NOAA National Centers for Environmental Information).

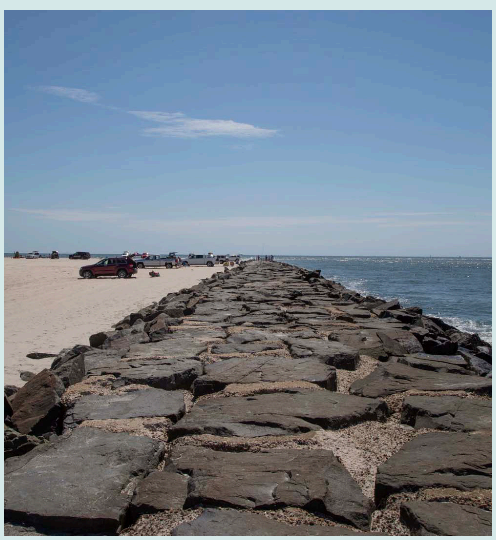
EXTREME PRECIPITATION

The increase in annual precipitation totals observed since the 1990's is generally not concerning from a water supply standpoint. More precipitation means more available water, which is typically a favorable condition. However, over recent decades some locations have exhibited a tendency for an increasing percentage of annual precipitation to occur during larger precipitation events. Instead of annual precipitation totals building though numerous small-scale events, more and more often extreme events comprise a greater percentage of the annual total. To visualize how New Jersey will be impacted by the increased intensity of extreme precipitation events throughout the next century DEP commissioned the creation of the **New Jersey Extreme Precipitation Tool**. With larger scale precipitation events comes elevated risks of flooding and flood-related damage (e.g., existing infrastructure). Recent projections indicate that the intensity of precipitation events in New Jersey will continue to increase and that changes will be greater in the northern part of the state than the southern and coastal areas (DeGaetano, 2021).

Additionally, the extreme 24-hr rainfall will increase by about 5–15% and despite increasing rainfall annually, rising temperatures and increases to water demand and evaporation will likely increase the likelihood of drier soil conditions overall (DeGaetano, 2021). In addition, the frequency and intensity of short-term, very dry to drought conditions are likely to increase (Shope et al., 2023). The juxtaposition of short, intense precipitation events and flashy hot, dry periods, and how the two phenomena influence each other, create significant challenges for water supply managers, who must determine the impacts to supply not necessarily over an annualized period, but over relatively short time scales.The ability to make assessments seasonally, monthly, or even weekly becomes more important. Thus, additional development of higher resolution, more time-sensitive, models is needed. Similar variability may develop across the state at different rates and intensities, further complicating the situation. Research conducted as part of this Plan has predominantly focused on the annual time step and the next step is to apply GCMs via downscaling to address these critical issues.

TEMPERATURE AND PRECIPITATION NEXUS

Temperature and precipitation, and more specifically the combination of both, are closely linked with hydrologic and water supply conditions in New Jersey. In the southwestern United States, data and GCMs show the high probability of long-term reductions in precipitation and increasing temperatures resulting in severe water availability reductions. The same cannot be said for New Jersey. While warmer temperatures lead to longer growing seasons and higher water demands, increases in annual precipitation equate to more available water. Short-term (weekly, monthly, seasonal and year-to-year specific) variability in these two quantities can have significant impacts on water supply conditions in the state at any time. Neither the GCMs nor the long-term weather forecast models are accurate enough yet to predict when these unique combinations of hot and dry will occur. This is further complicated by the fact that the time of year is an important factor in determining their hydrologic impact. Hot and dry weather in the spring can increase forest fire risk or complicate agricultural practices, and hot and dry weather in the summer can increase demands and stress water supplies. It is the latter, the hot and dry in the summer, that at least anecdotally appears to be occurring more frequently. The occurrence of these short, but severe events, sometimes referred to as ‘flash droughts’, can cause different types of droughts (refer to Chapter 7) to emerge and require the development of specific indicators and metrics to more reliably determine when they are occurring and improved research to determine their recurrence interval.



A rocky shoreline located in Brigantine, New Jersey. Rocks can help to reduce sand erosion and protect against storm surge in coastal areas.

SEA LEVEL RISE

Sea-level rise in New Jersey is affected by at least three different factors. One is global and regional ocean level rise due to warming of the oceans (expansion) and increased ice melt. The second is movement of the earth’s crust in New Jersey, where the northern area is slowly rebounding from removal of the ice sheet weight from the last glaciation and the southern area is sinking (a process known as isostatic rebound). The third is historic reduction of groundwater pressure in coastal confined aquifers, which can result in land subsidence.

Rising sea levels can temporarily or permanently turn fresh water sources salty, inundate water supply infrastructure, and make ‘normal’ flood events even more devasting. New Jersey has already been disproportionately affected by the apparent rate of sea-level rise with projections in New Jersey being more than two times the global average (NJDEP, 2020). Gauge heights in several locations within New Jersey illustrate this rise (Figures 3.3 a-c). As part of its evaluation, Rutgers determined that sea-level has risen 18.2 inches from the year 1911 at Atlantic City (Shope et al., 2023) compared to the average of 7.6 inches globally over a similar time period. For the more recent 40-year period from 1979 through 2019, sea-level has risen 8.2 inches at Atlantic City, compared to an average of about 4.3 inches globally (Shope et al., 2023). Sea level has risen by an average rate of approximately 0.2 inches per year along New Jersey’s coast while the global average has been about 0.1 inch per year.

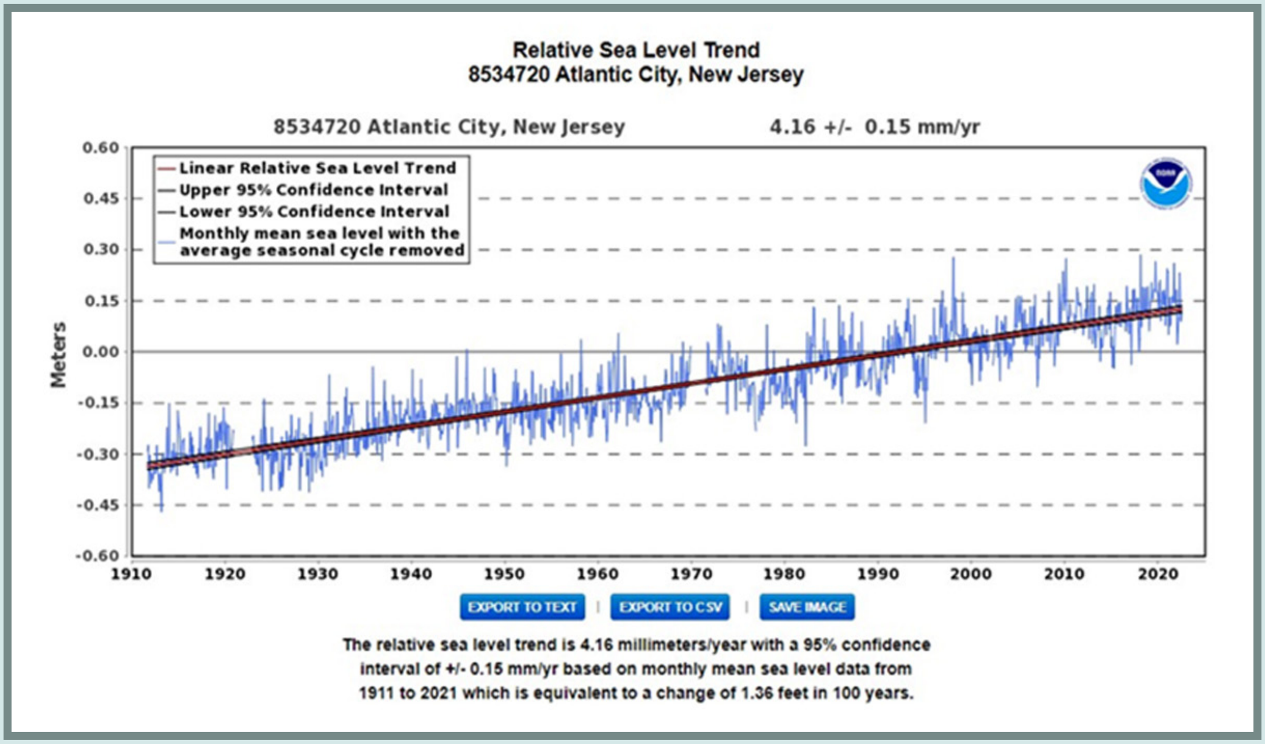


Figure 3.3a Sea level Trend for Atlantic City (NOAA).

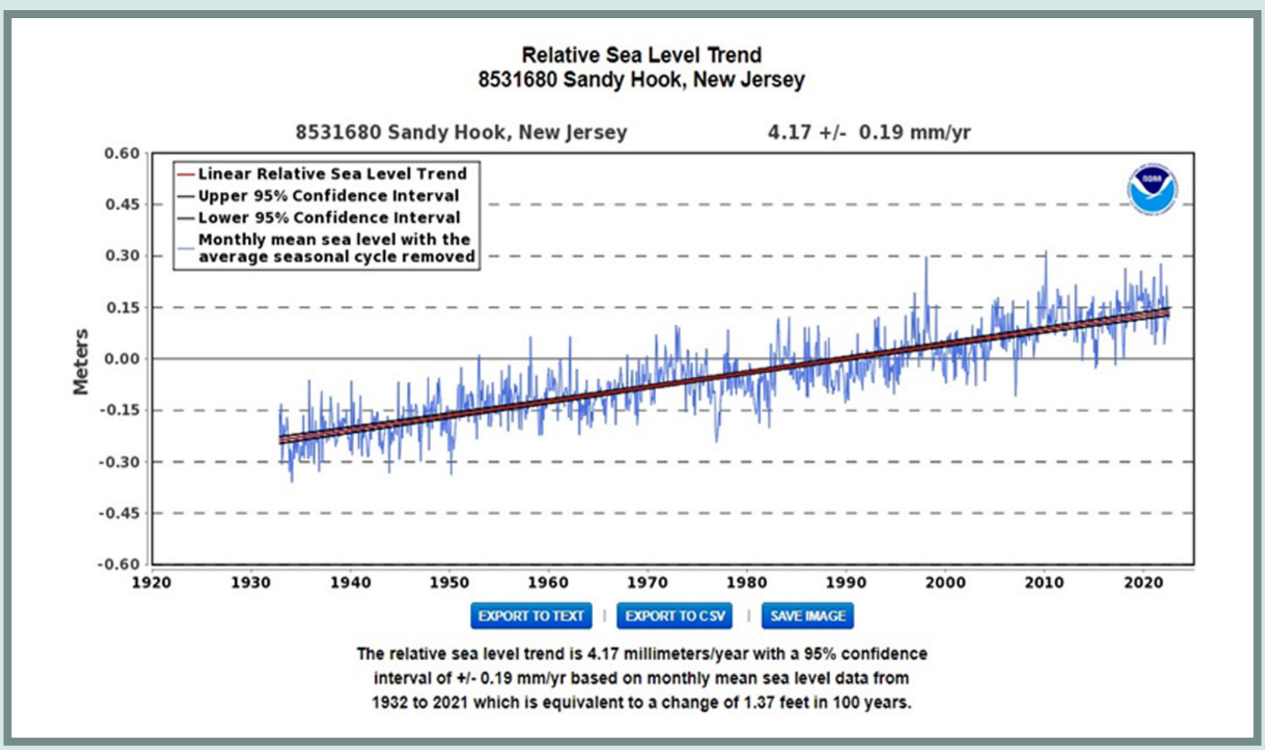


Figure 3.3b Sea level Trend for Sandy Hook (NOAA).

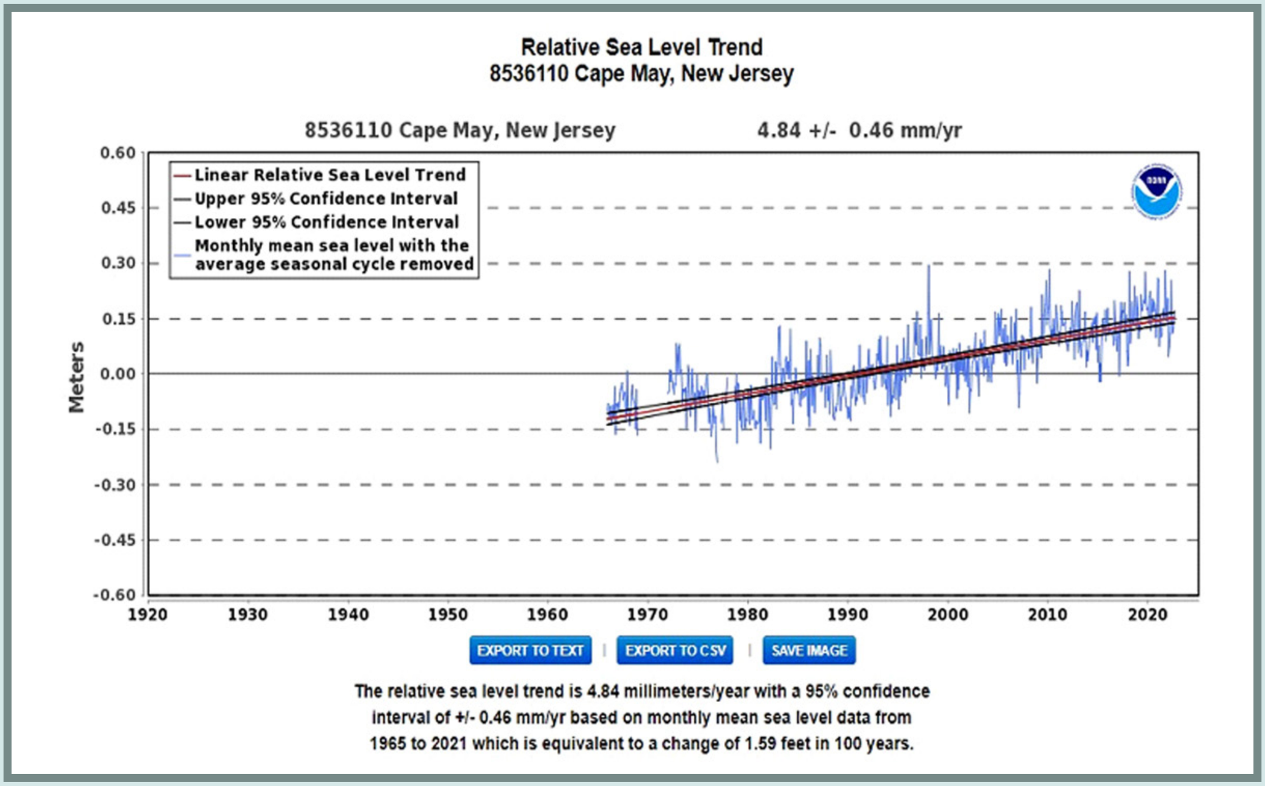


Figure 3.3c Sea level Trend for Cape May (NOAA).

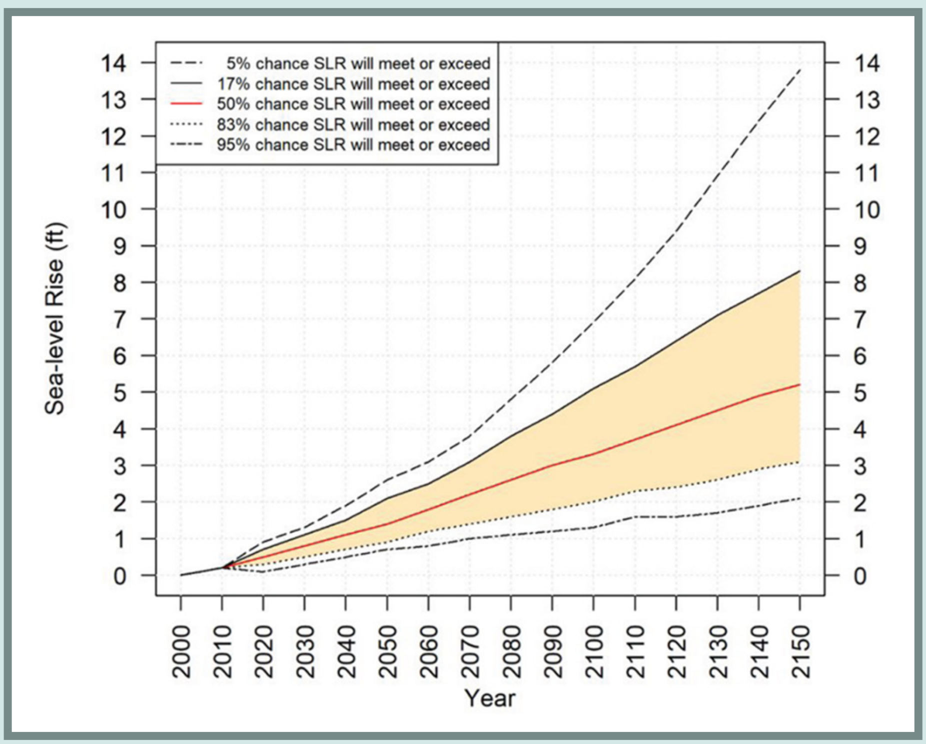


Figure 3.4 Diagram of Sea-Level Rise Projections Curve Under Moderate Emissions Scenario *(Kopp et al., 2019). There is a 50% chance that sea-level rise will exceed the level displayed by the red line, and a 66% chance that sea-level rise levels will be between the solid black line and the dotted black line (i.e., tan area). (As shown in NJDEP, 2020.)*

The rate of sea-level rise has been accelerating in recent decades and is expected to further accelerate through this century (Shope et al., 2023). Sea-level rise in New Jersey is projected to increase from levels experienced in the year 2000 by up to 1.1 feet by 2030, 1.4 to 2.1 feet by 2050 (50% and 17% probability, respectively), and 3.3 to 5.1 feet by 2100 due to climate change using a moderate emission scenario (NJDEP, 2020), as shown in Figure 3.4 for a set of probability curves.

The most recent Rutgers report notes that the rate of sea-level rise from 2050 through 2100 is more dependent on future greenhouse gas emissions, stating: "In a low emissions scenario, projected sea-level rise at 2100 is expected to be 1.7–4.0 ft compared to the year 2000. Under a high emissions scenario, sea level is projected to rise 2.3–6.3 ft." (Shope et al., 2023).

CLIMATE CHANGE IMPACTS RELEVANT TO NJ WATER SUPPLY

The pervasive nature of climate change will impact the state's water supplies in several ways. First, sea level rise (SLR) may increase saltwater intrusion of coastal aquifers and estuaries, or it may inundate coastal wells and other critical water treatment and distribution infrastructure. Second, changing precipitation patterns, especially the increase in large events, which lead to flooding can damage water supply infrastructure or impact raw and finished water sources. Additionally, changing precipitation combined with increased temperatures may alter surface water safe yields and groundwater recharge and aquifer dependable yields. These changes may also lead to worse and/or more frequent drought periods. Third, climate change may alter surface and ground water quality (Aziz, 2023) which can lead to increased treatment times and costs. This would include warmer water temperatures increasing the likelihood of harmful algal blooms (HABs) caused by cyanobacteria which has become more and more of a problem over the last decade. Fourth, altered water use patterns may result, especially in outdoor water uses such as agricultural and non-agricultural irrigation. The relationship between climate change, water resource impacts, and specific impacts to water supply is complicated. A schematic showing these relationships is shown in Figure 3.5. The current scientific evidence and issues regarding these issues are discussed in this section.

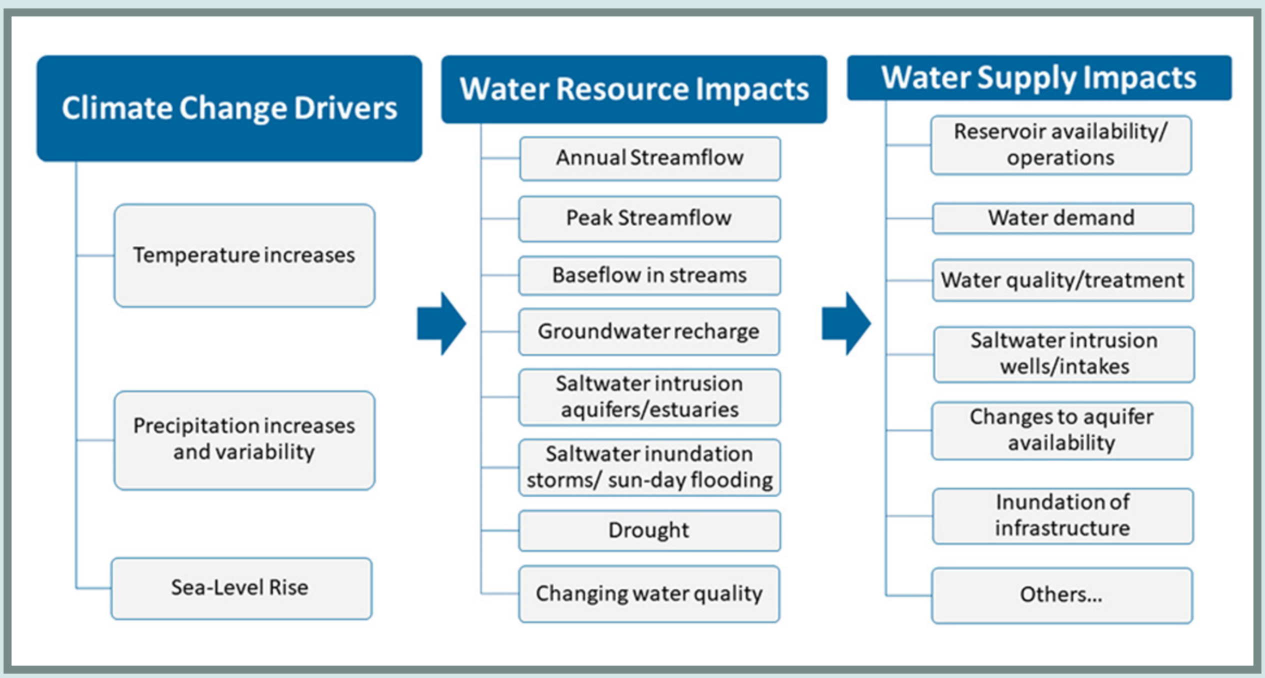


Figure 3.5 Shows flow from climate change drivers to potential impacts to water supply.

COMPLEXITIES OF WATER RESOURCES AND CLIMATE CHANGE

Past conditions are no longer good indicators of future conditions, and predicting the future is complicated by the interaction of multiple climate change impacts, each with its own pattern and trends. Therefore, the implications for water supply and demands are not straightforward. For example, increased precipitation can increase water supply, especially for our larger reservoir systems, but increased dry periods would stress supplies, especially for smaller reservoirs and shallow aquifers. Increased storm intensity can overwhelm soil capacity for infiltration, resulting in a greater percentage of precipitation going to runoff rather than aquifer recharge, but that effect may be offset by increasing precipitation overall. Total groundwater recharge may be reduced by the longer growing season (where water needs of plants reduce infiltration beyond the root zone), but recharge may be increased by more precipitation coming as rainfall during milder winters. Any of these patterns may also change as the relative change in precipitation and temperature shifts.

Another uncertainty is whether climate change will raise the potential for increasingly severe droughts in New Jersey, and whether they could result in a new worse drought of record. A related question is whether the potential for more frequent but less severe droughts will stress water resources in ways not previously seen. In other words, is the multi-year dry period the most limiting factor for future supplies, or will a shorter, but more severe dry period or a combination of smaller droughts in close proximity be the new drought of record?

Regarding water demands, warmer temperatures mean longer growing seasons and increased demands for lawn and agricultural irrigation, exacerbated by more dry periods during the growing season. Intense storms may be less useful for crops than long periods of milder rainfall. To the extent that irrigation occurs during dry summer periods, increased water supply stresses will occur at the driest time.

An overhead agricultural irrigation system at Tuckahoe Turf Farms in Hammonton, New Jersey. Climate change may increase water demands for agricultural irrigation by extending growing seasons and increasing the frequency of dry periods during the growing season.

Water supplies are highly dependent on the seasonal and total amounts of runoff (supporting reservoir storage), groundwater recharge (supporting aquifer storage), and movement of groundwater into surface waters to support stream flows (supporting reservoir storage and aquatic ecosystems). Researchers must therefore understand the extent to which conditions have already changed (and whether the changes are accelerating), the potential for conditions to change into the future, and how the various changes for individual variables will affect water supplies. On the demand side, researchers must understand how climate change has altered and may alter water demands, as changing demand patterns and intensity could reduce reservoir safe yields and aquifer sustainability.

Climate change is increasing variability and uncertainty and leading to new weather extremes. Certain combinations of these weather events can cause major water supply impacts. These new extremes are difficult to plan for as there are no historical analogs that can be used as examples. When two or more of these extreme events occur simultaneously, they are referred to as “black swan events” and can be thought of as situations where compounding events caused by weather extremes, such a HAB occurring during a drought, may test water supply systems in ways never imagined. However, water supply managers should not be deterred from prudent planning as inaction would be an unfortunate and costly response to uncertainty. Rather, managers can look to past instances where water supply conditions were put under great strain, be they due to extreme weather conditions or the inability for existing infrastructure to adequately perform, and see that one of the best defenses against severe events is the maximization of flexibility within a water system. The ability to quickly move water from one source to another via well designed and protected infrastructure is vital in these situations.

SEA-LEVEL RISE AND RESULTING IMPACTS

Sea-level rise will have the largest impact along the New Jersey coastline and especially in southern coastal areas along the Jersey Shore and Delaware Bay and estuary. Three major impacts are discussed in this section: confined aquifers, unconfined aquifers, and water supply wells.

Changes in sea level can affect the groundwater flow system by altering the extent and location of the freshwater-saltwater interface within the New Jersey Coastal Plain aquifers in several ways. This interface is where the freshwater portion of the confined or unconfined aquifers are met by more saline waters that are associated with the sea. Changes to the location of this interface are caused by a combination of factors including aquifer recharge rates (both natural and as affected by land uses), water withdrawal rates, and sea-level rise (both natural and as affected by climate change).

As a general approach to characterize and assess sea-level rise in this Plan, the two-foot and five-foot increases are used as the basis for 2050 and 2100 assessments, respectively. These estimates are generally consistent with DEP's Sea-Level Rise Guidance document from June 2021 assuming a moderate emission scenario. It is critical to note that this guidance document outlines a more evolved process to select an appropriate SLR estimate that factors in risk tolerance, project lifespan, and geographic location, among other factors, when assessing a specific project. DEP's guidance also recommends considering the 2100 horizon. However, other key aspects of this Plan (such as the water demand forecasts) focus out to 2050 only. Since the Plan is required to be updated every five years and many of the climate change-water supply impacts assessments are new, many of the analyses are limited to the 2050 period. Where appropriate, the 2100 time period is considered in this Plan. DEP will enhance existing water availability models and leverage expanded knowledge of SLR for future updates, and will consider current policies, procedures, guidance, and longer forecast periods.

UNCONFINED AQUIFERS

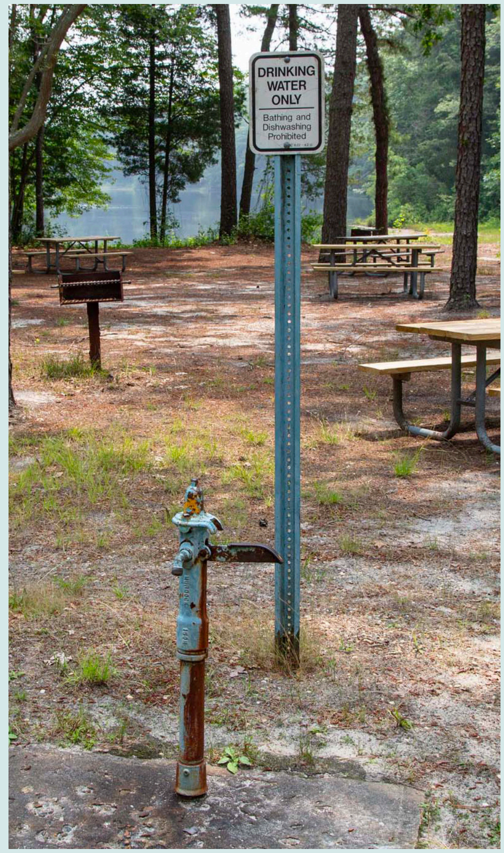
The shallow coastal aquifers are at greatest risk of sea-level rise impacts. Sea-level rise translates directly to a movement of saline water over currently dry lands. The more the saline waters move inland, the greater the loss of recharge area and the greater the potential for movement of saline waters into groundwater. Dissolved salts make saline water denser causing it to sink beneath freshwater, so rising sea levels can push it further inland under fresh groundwater. The shallower the slope of a land area, the greater the in-land penetration of saline waters from sea-level rise. For example, a slope of one foot per thousand feet means that one foot of sea-level rise will equate to the inland movement of saline waters one thousand feet. Southern portions of the Jersey Shore and much of the Delaware Bay shoreline in Cape May, Cumberland and Salem counties typically have very shallow slopes from the water's edge. Combined with the effects of storm surges, large areas can be placed at risk as can be seen in Figure 3.6, adapted from the New Jersey Climate Change Resource Center's NJFloodMapper tool.

Figure 3.6 Delaware Bay Inundation, (L) Current and (R) 2-Foot Sea-Level Rise (NJCCRC).

CONFINED AQUIFERS

The nature of the freshwater-saltwater interface over the past 84,000 years is described in reports completed by Pope and Gordon (1999), Meisler et.al. (1985 and 1989), and Spitz (1998). These studies detailed the location of salty groundwater in both onshore and offshore areas in the Northern Atlantic Coastal Plain and the effects of eustatic sea-level changes (i.e., based on the global volume of ocean water) on the location of this freshwater-saltwater interface within the aquifers.

Greater degrees of heterogeneity within the coastal plain sediments would cause the freshwater flow system to extend farther offshore. Simulations using decreasing hydraulic conductivity in the sediments offshore suggest that the saltwater interface zone in the adjacent Continental Shelf in southern New Jersey is not in equilibrium with present sea level and most likely represents sea levels that were 50 to 100 ft below present sea level. Meisler et.al. (1984) concluded that the freshwater-saltwater interface is not in equilibrium with present sea level due to the influence of significantly lower sea levels that have occurred in the more recent geologic past and that the current interface is moving landward in response to the geologic changes in sea level from 71,000 years ago. More recent studies of sea level during the last glacial age indicate that the lowest sea levels were in the range of 120 to 135 meters (394 to 443 feet) below current global levels (Lambeck et al., 2014). As sea level began to increase from 71,000 years ago to the present, the freshwater-saltwater interface began moving landward. The saltwater interface transition zone is currently moving slowly landward and upward in response to the most recent rise in sea level with the estimates of lateral water particle velocity at a rate of about 0.2 miles per 10,000 years (Meisler, 1989).



A drinking water only sign located next to a hand pump in Brendan T. Bryne State Forest in the New Jersey Pinelands.

Pope and Gordon (1999) examined more recent changes and scenarios related to sea level using the SHARP modeling program to simulate flow between freshwater and saltwater sources for scenarios representing past eustatic conditions and future groundwater withdrawals on the location of the saltwater interface. The SHARP model is a quasi-three-dimensional, finite-difference model that simulates coupled freshwater and saltwater flow separated by a sharp interface which is used to represent the difference in chloride concentration between fresh and salty water (Essaid, 1990). This model was used to represent the hypothetical seaward extent of which the chloride concentration is equal to or greater than 10,000 milligrams per liter in the New Jersey Coastal Plain aquifers.

Simulations were used to estimate the location and movement of the interface for several scenarios; geologic sea-level changes for the past 84,000 years, pumping impacts within the aquifers from predevelopment time and the potential impact of future withdraws through the year 2040. No future sea-level rise scenarios were simulated as part of this study, but the model simulations do provide a description of the location and movement of the salt-water interface during historical sea-level changes and water-use increases. At the end of the USGS simulation for this time period, the freshwater-saltwater interface was moving geologically up-dip from the rise in sea level beginning 18,000 years ago to sea level in 1896, which represents the sea level elevation at the first point of accurate measurement specific to New Jersey. Since that time to the end of the study, the saltwater interface has been moving landward in response to sea level rise. However, the current saltwater interfaces for most confined aquifers used in coastal regions in New Jersey are located tens of miles offshore.

These modeling studies verify that the movement of the freshwater-saltwater interface is most influenced by large scale, geologic changes in sea level resulting from changes in glaciation. These past geologic sea-level changes indicate that a relative 2-ft increase in sea level by 2050 would not significantly reduce the source of fresh groundwater within the confined aquifers in the New Jersey Coastal Plain by saltwater displacing freshwater. The modeling also concluded that the movement of the saltwater interface is not overly sensitive to stresses on the groundwater flow system resulting from increased groundwater withdrawals from the Coastal Plain aquifers. While sea-level rise over the next 50 years does not appear to substantially exacerbate the risk, additional research should be conducted to confirm these findings. Similar findings for 2100 estimates of sea-level rise would also be true. Periodic monitoring and reassessment are still required to ensure that the most up to date projections and groundwater models are utilized to confirm these conclusions.

It is critical to note that aquifers which are currently experiencing or expected to experience saltwater intrusion in the short-term will still need to be actively managed and monitored. Refer to Chapter 6 for a discussion of these areas/aquifers and how DEP is managing them.

POTENTIAL IMPACTS TO NEW JERSEY'S AQUIFERS

Shallow, unconfined aquifers, including outcrop areas of confined aquifers, would be the first immediate threat to a direct rise in sea level and landward inundation. New Jersey Geological and Water Survey (NJGWS) staff used the DEP Sea Level Rise Inundation Depth Grid (NJDEP, 2021) for 2-ft and 5-ft sea-level rise to analyze the potential impacts to New Jersey's aquifers from the direct inundation of sea water for the year 2050 and 2100 SLR conditions, respectively. The Depth Grids were generated by DEP's Bureau of GIS based on the National Oceanic and Atmospheric Administration's (NOAA) mean higher high water (MHHW) surface. Grids were then superimposed over existing GIS coverages including aquifer outcrop areas and public supply well locations to provide an analysis into the immediate impacts from sea water inundation. The immediate and principal impact of a 2 or 5-foot increase in sea level on New Jersey's aquifers would occur in the unconfined aquifer systems of the Coastal Plain. The unconfined Kirkwood-Cohansey (K-C) aquifer system would suffer the greatest harm, as it covers a very large portion of the Coastal Plain of New Jersey. Based on the analysis, approximately 77,400 acres of the K-C aquifer would be directly inundated by sea water from a 2-ft sea level rise (Figure 3.7). The impacted regions are located along coastal areas and tidal waterways along the Atlantic Ocean, Delaware Bay and tidal Delaware River. This inundated area would also provide a direct pathway for the migration of sea water towards freshwater sources used by existing unconfined wells, which are numerous in these regions (see Tables 3.1 and 3.2).

Confined aquifers with outcrop areas, where a water bearing layer nears the ground surface and can be recharged directly by precipitation, which extend to these mapped inundated areas would also create a direct pathway for the infiltration of sea water into fresh water sources. The confined aquifer outcrop areas that would be initially affected by inundation include the Magothy and Potomac Formations. They run parallel to the Delaware River and the aquifers currently exhibit some degree of hydraulic connection with the river. The 2-ft SLR would inundate approximately 9,000 acres of the outcrop area of the Magothy and 5,100 acres of the Potomac Formations (Figures 3.8 and 3.9 respectively). Again, any inundation of salt water at these outcrop areas would provide a direct pathway for salty water to migrate towards fresh water sources, aggravating any current salt-water intrusion that currently exists. Groundwater flow direction in these aquifers has historically been controlled by the large cone of depression due to previous over pumping that led to the declaration of Water Supply Critical Area 2 and the imposition of regulatory controls on, and reductions of, confined aquifer use. This large cone of depression has shifted flow from predevelopment when groundwater discharged to the river to the current flow pattern of inland and down dip flow in these units. The inundation of brackish water from a 2-ft or 5-ft SLR increase would provide a pathway for salty water to migrate towards pumping centers due to the increased particle velocities created by large cones of depression. The area with the greatest cone of depressions in both the Magothy Formation (Upper PRM Aquifer) and Potomac Formation (Lower PRM Aquifer) is currently located within inland Camden County between Lindenwold and Pine Hill.

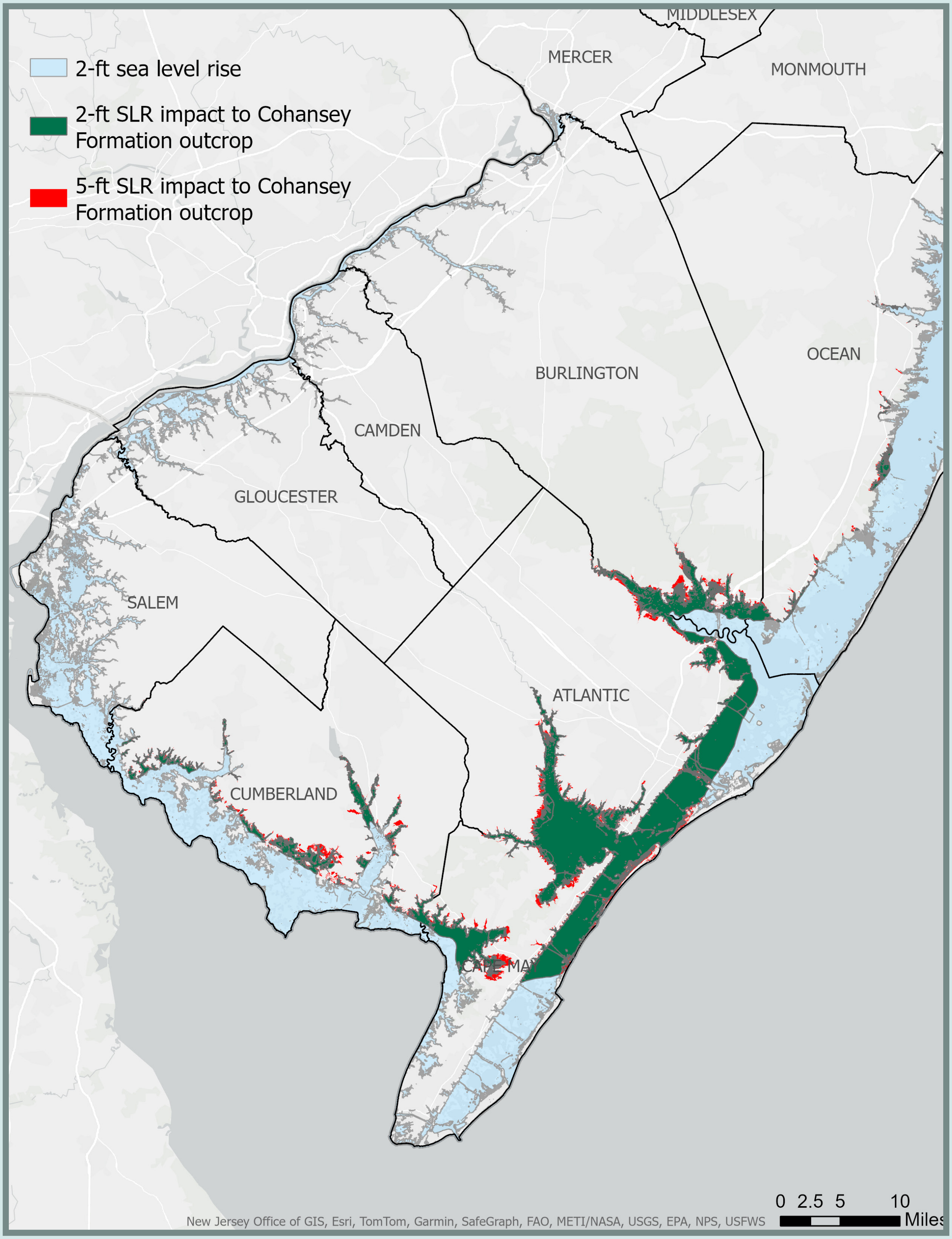


Figure 3.7 Inundation area impacting Cohansey Formation outcrop for 2-ft and 5-ft of sea level rise.

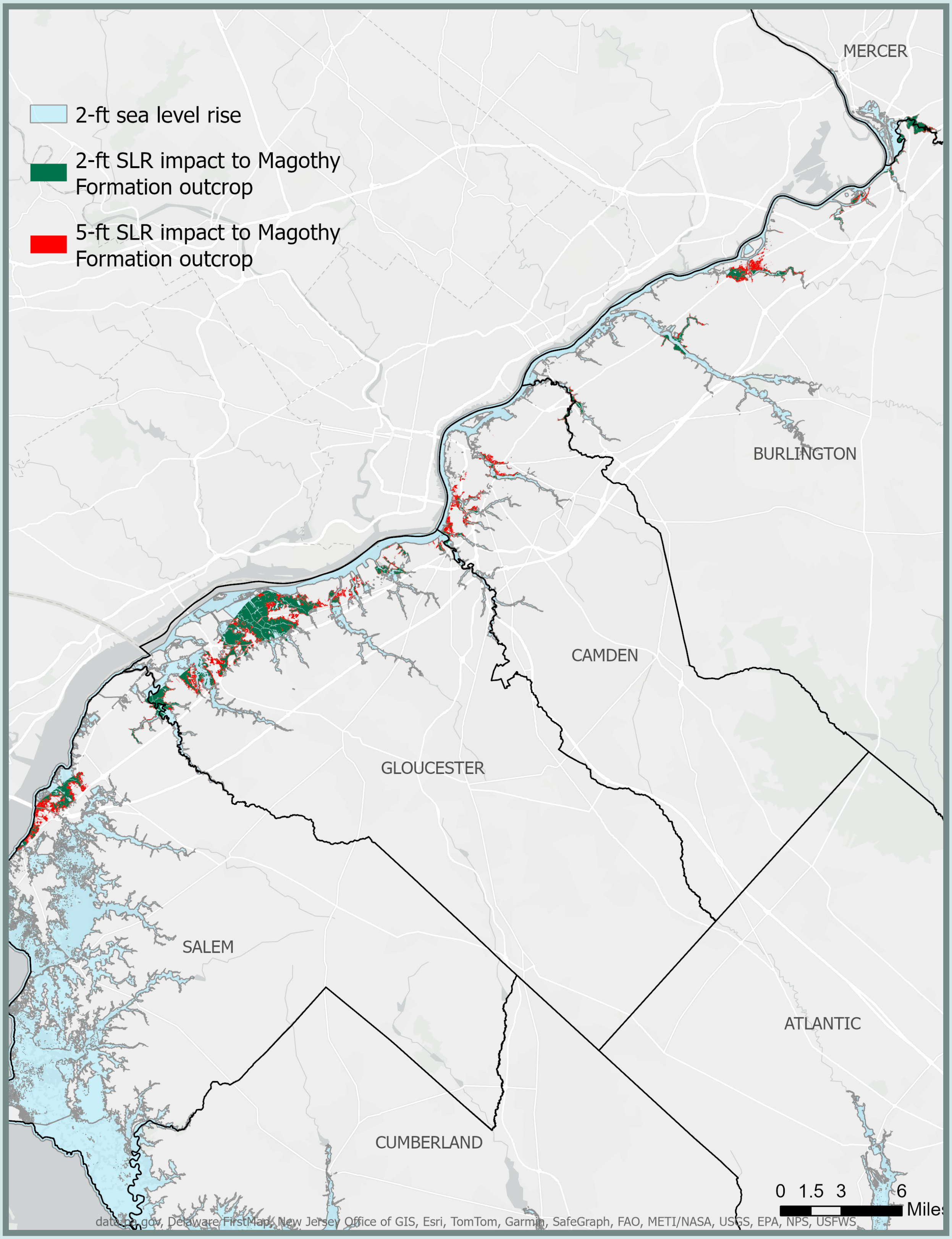


Figure 3.8 Inundation area impacting Magothy Formation outcrop for 2-ft and 5-ft of sea level rise.

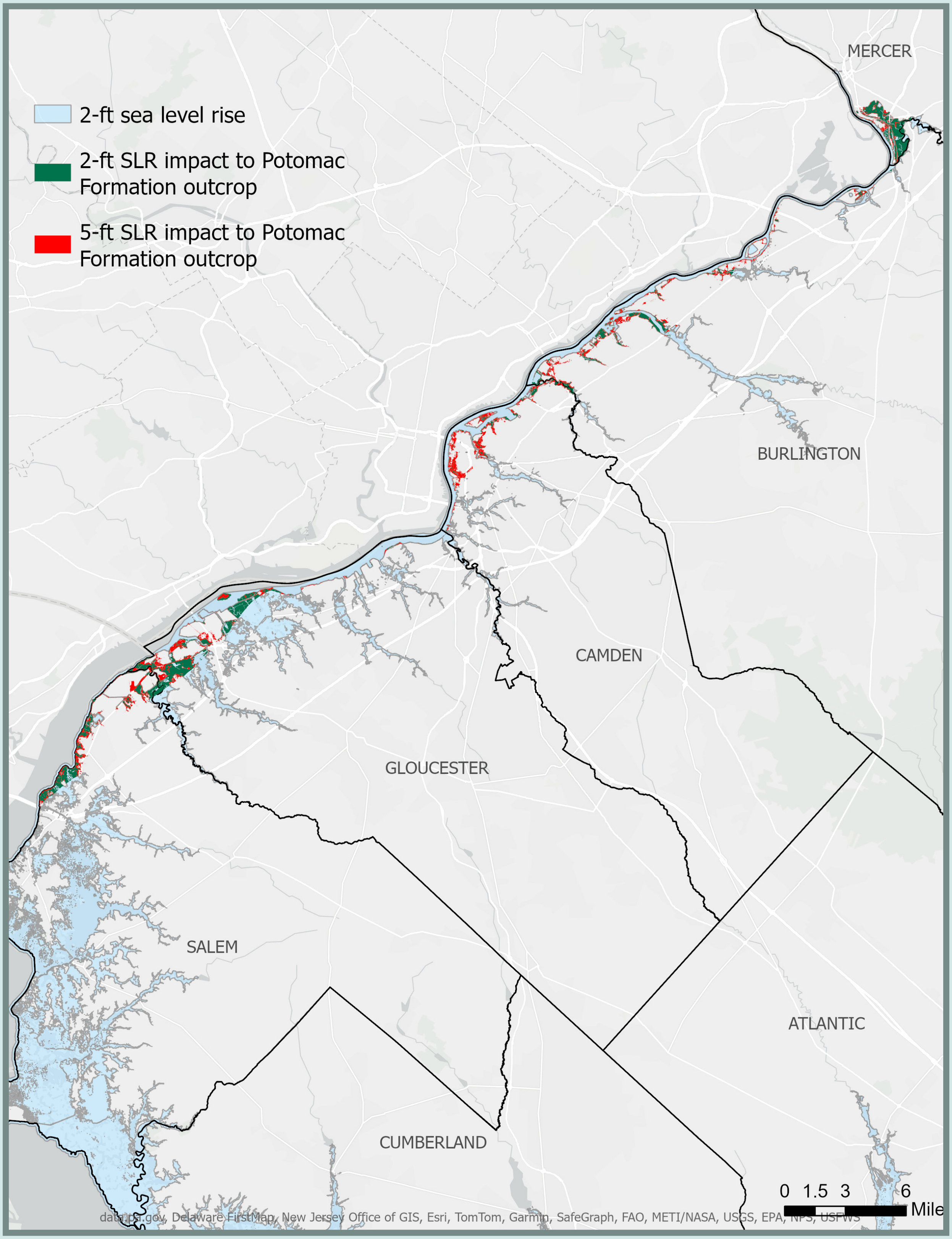


Figure 3.9 Inundation area impacting Potomac Formation outcrop for 2-ft and 5-ft sea level rise.

POTENTIAL IMPACTS TO EXISTING WELLS AND INTAKES

The immediate impact from a two- or five-foot sea level rise impact would be to unconfined wells with a direct connection to the surface. However, confined wells would also be prone to direct inundation of sea water from the wellhead, which could provide a pathway for vertical migration of salty water to deeper confined and not-salty water.

Confined aquifers along New Jersey's Atlantic coastal regions currently contain significant volumes of freshwater with the saltwater front located miles offshore. Salt-water intrusion in coastal aquifers from the projected SLR for 2050 does not appear to be a factor due to the location of the saltwater interface and the previous modeling study results. The USGS modeling studies concluded that increasing pumping by 30 percent to simulate potential 2040 withdrawal volumes would have little impact on the position of the current salt-water interface within New Jersey aquifers. For example, the 10,000 mg/l chloride line for the Atlantic City 800 ft sand aquifer is currently mapped more than 30 miles offshore. Therefore, no barrier island confined aquifer wells along the Atlantic coast are likely to be at risk if the wellheads themselves are not subject to inundation, but other areas with saltwater intrusion remain a concern.

A water pipeline located in the Paterson Great Falls National Historic Park in Paterson, New Jersey.

Existing regional groundwater flow models could be used to simulate areas where salty water may be a concern by using advective transport to further analyze what areas outside of the 2050 projection may be prone to salt-water migration. These models could also be used to look at future water demands and existing cones of depression impacts on the 2-ft SLR inundated areas. Areas that are currently dealing with saltwater intrusion within New Jersey such as Cape May County would need to evaluate the additional impact that a 2-ft SLR will have on their groundwater resources.

The potential for 5-ft of SLR by 2100 puts many wells, in both confined and unconfined aquifers, at risk. Figure 3.10 highlights the threat for confined aquifer potable supply wells along the barrier islands and shows that there is also significant risk to surface water intakes and unconfined groundwater wells near the Delaware Bay and River. In Figure 3.11, the withdrawal sites are symbolized by use group. Impacted wells for agricultural use are clustered along the Delaware Bay and River while those along the Atlantic coast are more likely to be used for potable supply. The number of wells that are within the 2- and 5-foot areas are summarized by their source of water in Table 3.1 and by their use of water in Table 3.2. Although they are not displayed on the maps or tables, the NJGWS water use database, NJWaTr, estimates that 18878 domestic wells would be inundated by 5-ft of SLR.

Table 3.1 Number of Wells Within the 2- and 5-foot Sea-level Rise Zones by Source of Water.

Source of Water	2-ft SLR		5-ft SLR	
	Well count	Volume (mgd)*	Well count	Volume (mgd)*
Confined	23	7	132	29
Unconfined	35	2	140	10
Surface	70	21	100	40
Unknown	0	0	1	0
Total	128	30	373	79

Table 3.2 Number of Wells Within the 2- and 5-foot Sea-level Rise Zones by Use of Water.

Use of Water	2-ft SLR		5-ft SLR	
	Well count	Volume (mgd)*	Well count	Volume (mgd)*
Agriculture	70	2	100	3
Commercial	3	0	5	0
Industrial	27	19	70	32
Irrigation (non-ag)	10	0	33	0
Mining	0	0	5	6
Potable supply	18	9	158	38
Power generation	0	0	2	0
Total	128	30	373	79

*Annual volumes (2016-2020) were averaged for each site then summed by use type.

Although outside the scope of the current Plan, future vulnerability analyses can be conducted to examine the potential risk of SLR-related water supply problems due to aquifer loss and increased stress on surface water supply systems. For example, a similar vulnerability analysis approach used to create Figure 2.14 can be updated to include potential saltwater inundation from sea level rise.

Water supply is much more than wells and intakes and consideration needs to be given to the entire withdrawal-transfer-treatment-delivery infrastructure network. While detailed location data for finished water infrastructure does not reside in one master GIS database, DEP identified approximately 340 finished water storage tanks, standpipes or similar structures associated with public community water systems within the 2-ft sea level rise zone. These structures range in size from 1,000 gallons to over 10 million gallons and total over 500 million gallons of combined storage. These supplies are key assets and ensure that drinking water can be delivered during peak demand periods or when treatment is offline. Additional data should be compiled to identify pump stations, treatment plants and other critical water supply infrastructure threatened by sea-level rise or freshwater flooding. The data and subsequent analysis are needed so DEP can identify an action plan and prioritize next steps.

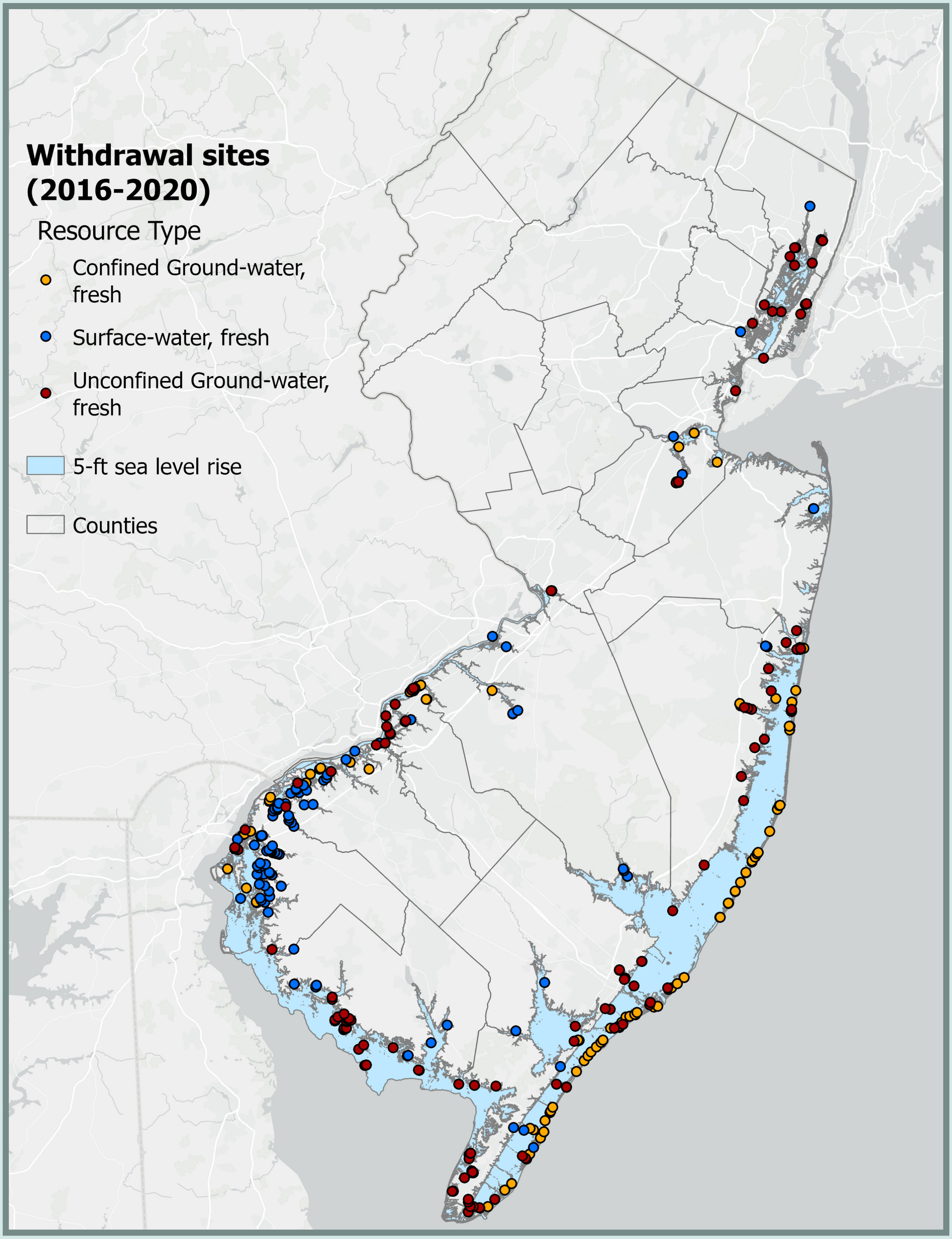


Figure 3.10 Water withdrawal sites inundated by 5-ft of SLR, symbolized by resource type.

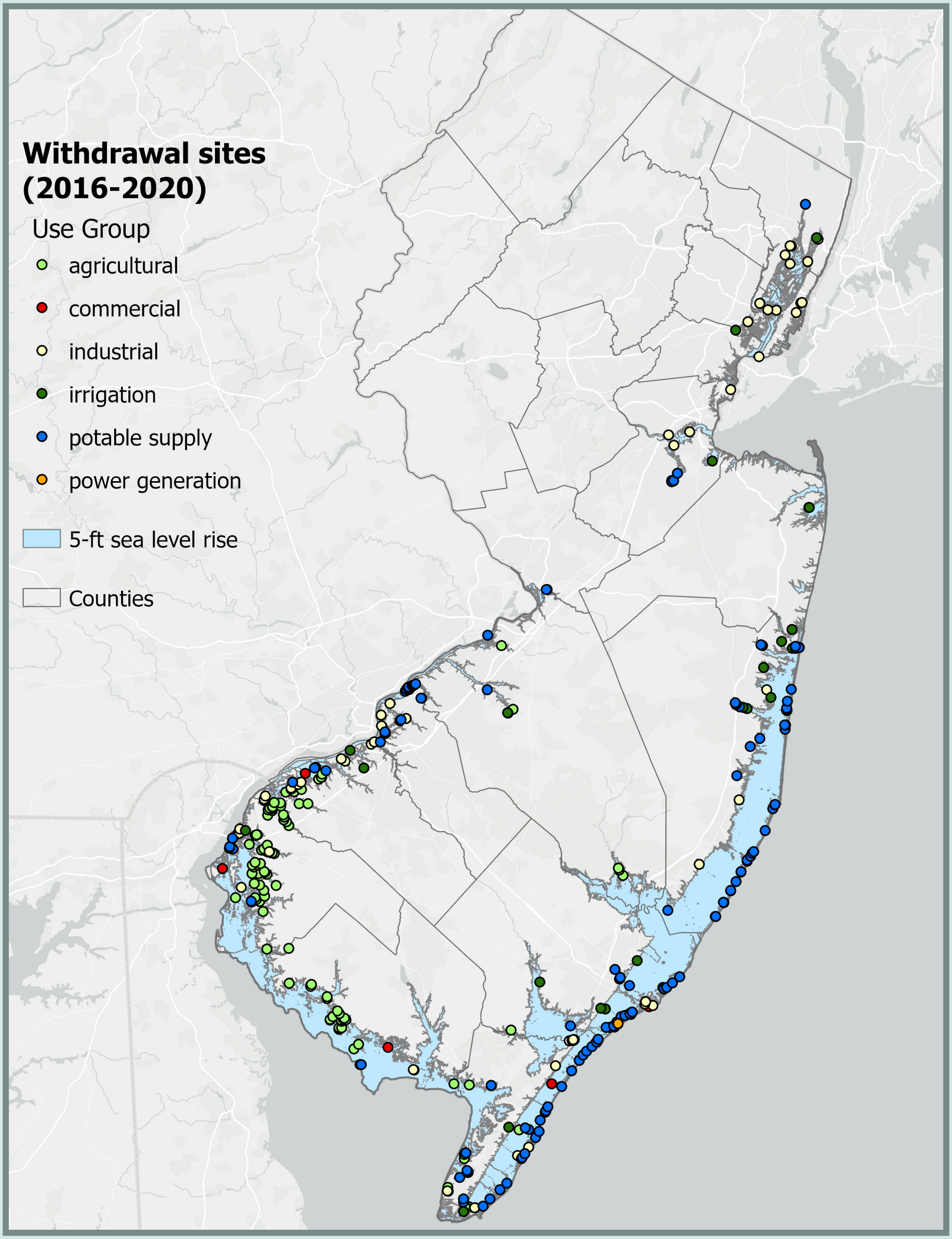


Figure 3.11 Water withdrawal sites inundated by 5-ft of SLR, symbolized by use group.

POTENTIAL IMPACTS TO DELAWARE RIVER WATER SUPPLIES

The surface waters of the Delaware River Basin support multiple New Jersey water systems including the City of Trenton, the New Jersey Water Supply Authority's Delaware and Raritan Canal, New Jersey American Water Company's Delran intake, and a host of smaller surface water users. Diversions through the Delaware and Raritan Canal are currently limited by regulations of the Delaware River Basin Commission (DRBC) and are included in the adaptive water resource management agreement known as FFMP (see Chapter 5, Regional Water Resource Agencies and Interstate Waters). The New Jersey American Water Company's Delran intake is located in the Delaware River Estuary and vulnerable to potential saltwater intrusion during low flow conditions. During the 1960's drought of record, salt water came very close to impacting the Philadelphia water intake and would have impacted the New Jersey American Delran intake if it had been built and in operation at the time. In 1983, the DRBC established a flow objective at Trenton, New Jersey to support freshwater inflows to the Delaware Estuary for salinity management. The DRBC calls for water releases from basin reservoirs to meet the Trenton flow objective. The goal is to help keep the location of the 250 mg/L chloride concentration line, an indicator of salinity intrusion, downstream of the potable intakes at Delran and City of Philadelphia. More information can be found on the websites of the Delaware River Basin Commission and the United States Geological Survey's Office of the Delaware River Master.

At the time of publication of the Water Supply Plan in 2024, the Delaware River Basin Commission was conducting studies to determine whether the salinity management measures then in effect would be adequate to protect the drinking water intakes from salinity intrusion considering the effects of climate change. As sea level rises, saltwater will migrate further upstream, requiring additional management actions to offset this effect (Figure 3.12). In response to the combination of sea level rise and the potential for increased drought intensity and thus low flows, the basin's flow objectives may need to be modified. In addition, the available water for releases may not be adequate, and more storage or changes to basin reservoir operations may be needed. It is important to evaluate the Delaware River Basin flow and drought management regulations and agreements (see Chapter 5) to ensure that the tradeoffs between reservoir storage (both upper and lower Delaware Basin), ecologic and recreational needs, and saltwater management for drinking water are thoroughly understood.

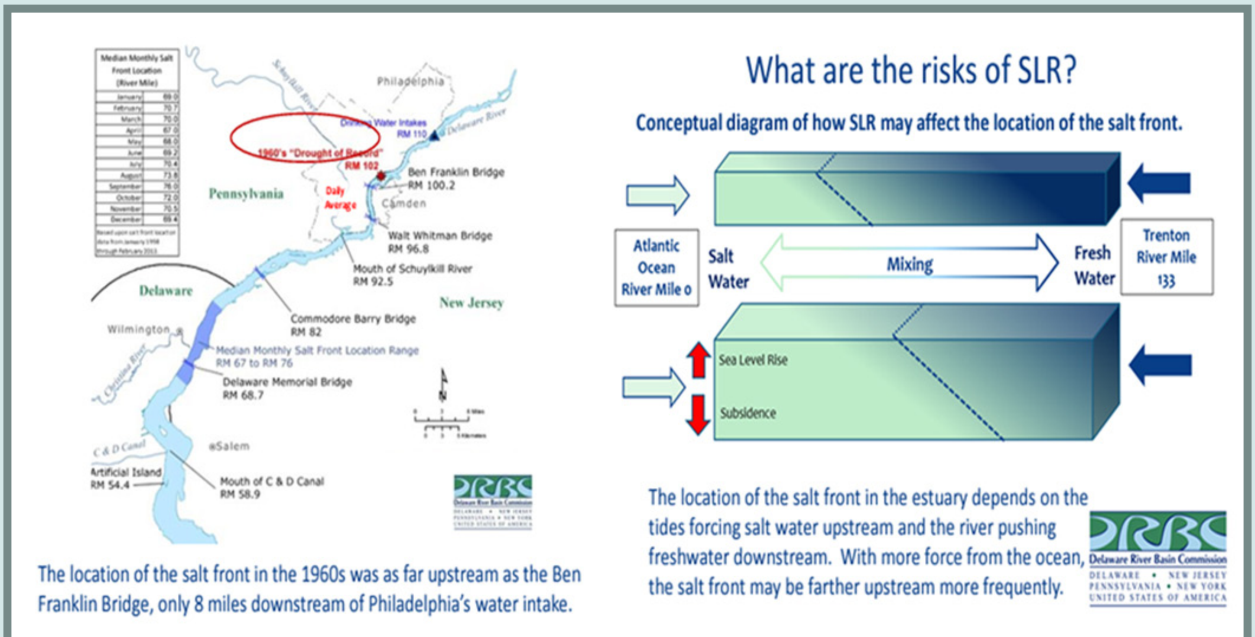


Figure 3.12 Conceptual Impacts of Sea Level Rise on the Delaware River Salt Front (DRBC).

THREATS TO OTHER SURFACE WATER SUPPLY INTAKES

As with the Delaware River salt front, other surface water systems may be vulnerable to sea-level rise. One example is the Forge Pond intake of Brick Township Municipal Utility Authority (BTMUA), on the Metedeconk River in Ocean County. With an increase in sea level of 3 feet (either permanently or through a combination of sea-level rise and storm surge), saline water could penetrate from Barnegat Bay into and beyond Forge Pond (Figure 3.13). BTMUA has been evaluating options for protection of its public water supply intake. DEP is currently developing a RiverWare model of the water supply system (wells, reservoirs, and intakes) that will be incorporated into the larger New Jersey Model which can be used to assess impacts to safe yield from modified operations. Note this RiverWare model does not simulate sea-level rise so additional assessment(s) will be needed.

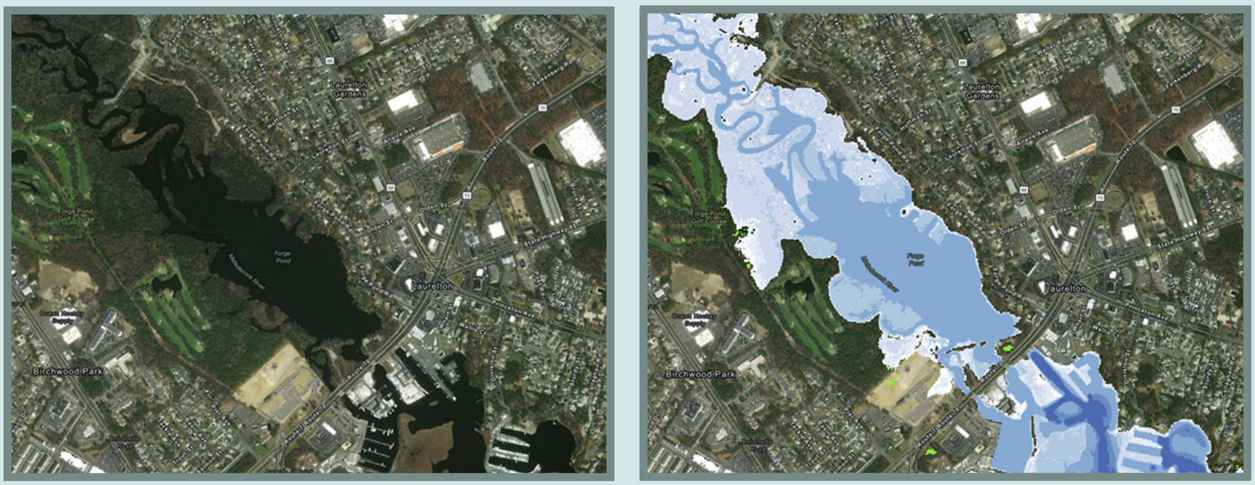


Figure 3.13 Forge Pond Area, (a) Current Sea Level and (b) 3-foot Sea-Level Rise (NJCCRC).

Other Atlantic Ocean/Barnegat Bay systems which could be impacted by sea-level rise include the lower Atlantic City Reservoir and Swimming River Reservoir where sea-level rise and increased flood elevations from storm surges could cause significant problems at the dams. These issues should be further evaluated and monitored over time.

CHANGING PRECIPITATION AND TEMPERATURE PATTERNS

Precipitation across New Jersey has already been impacted by climate change. More precipitation is falling on average over the year, more of that precipitation coming in fewer but larger events, and more variability is occurring over the year and from year-to-year. The effects of these changes on water supply are assessed in the sections below.

POTENTIAL IMPACTS TO SURFACE WATER RESERVOIR SYSTEM SAFE YIELDS

NJGWS staff conducted preliminary research on possible changes to surface water supply reservoir system safe yields and pumping requirements in the Passaic/Hackensack and Raritan systems, all of which have been modeled using the RiverWare software in conformance with DEP Safe Yield Guidance Manual (NJDEP, 2011). Refer to Chapter 2 for details on the systems and definition of safe yield. The model is being expanded to include the Coastal North region systems and similar assessments will be possible when those updates have been completed. The assessment included two components.

First was an assessment of stream flow changes in ten watersheds where human impacts (other than climate change) were limited, to determine whether the flows, averaged over rolling 30-year periods, changed at the annual or monthly levels. In general, annual stream flow are increasing and monthly streams flows appear to have increased somewhat in the fall and early winter (especially October and December) and decreased somewhat in the late winter and early spring over the periods-of-record (see Figure 3.14). The results are variable across the state, with the north appearing to have more water on an annual basis. For on-stream reservoirs this shift in flows, assuming spring flows are not well-below normal, and demand is not excessive, is not expected to affect safe yields as the systems are designed to fill and spill annually. Use of models, such as the New Jersey RiverWare Model, to forecast seasonal storage using observed conditions can inform decision making and provide DEP additional advanced information to determine if actions are needed.

In theory, the same is true for reservoir pumped storage, where a shift to more pumpable flows in the fall and early winter should offset lower pumpable flows in the late winter and spring. However, since pumped storage systems need to be actively managed to turn pumps on and off at the correct times (and don't simply capture runoff as run-of-river systems do) there is an element of increased water supply risk for these systems. In order to prevent unnecessary risk, reservoir operators and DEP oversight will continue to monitor real-time conditions and decision making, develop climate change adjusted pumping guidance curves, and evaluate the need to modify pumping equipment and permit conditions. Water quality will also be factored into the analyses.

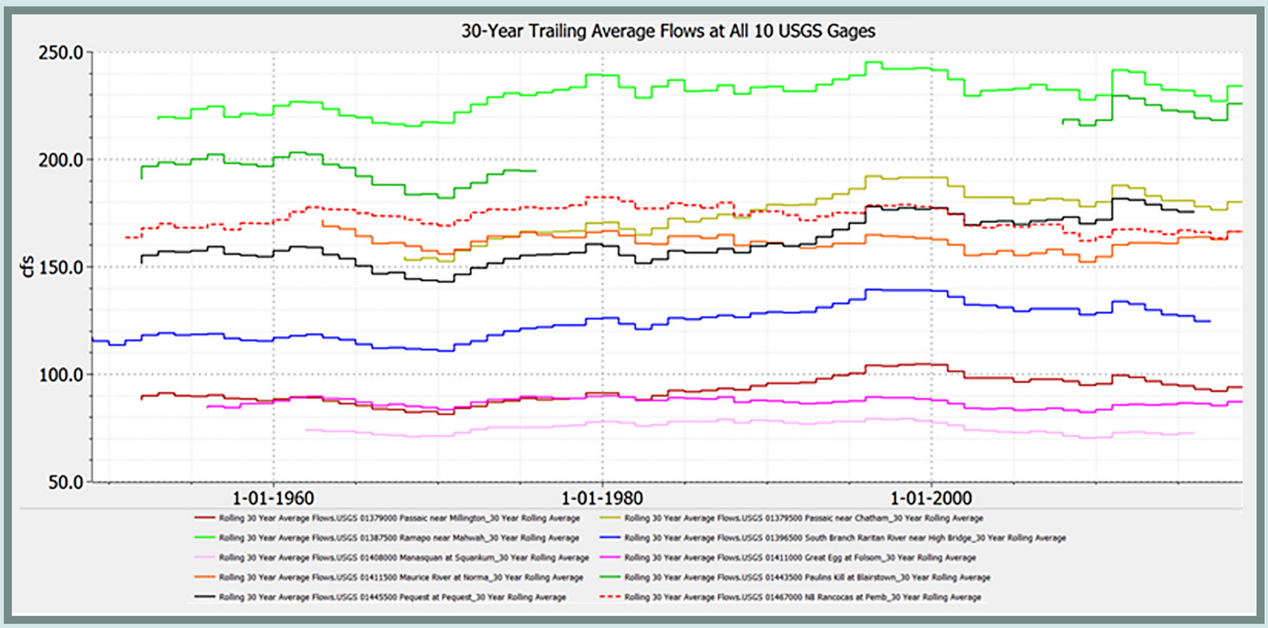


Figure 3.14 30-Year Trailing Average Stream Flows at 10 Selected USGS Gauging Stations (NJDEP).

Second, the models were used to assess how safe yields might change due to future changes in drafts and stream flows related to climate change. The analysis used a theoretical what-if climate change scenario of reduced stream flows and increased reservoir system drafts during the spring, summer, and fall seasons, with variations on reservoir operation and pumping approaches to simulate a range of management options. In general, the assessment showed an increased probability that the reservoir systems reach drought emergency status, with the most significant effects for the Wanaque System and the Hackensack System, which are interlinked through the Wanaque South Pumping Station project. Under the theoretical scenario, the probability of drought status more than doubled, which is a significant impact. However, all systems had adequate storage to meet drafts and did not run out of water. Implementation of passing flow and effective draft reductions are key tools that proved to be effective management options.

The methods and tools used in this assessment depend heavily on statistical and model analyses of observed hydrologic data and, in some cases, current data is not available. Rapidly developing climate change impacts may not become apparent in observed hydrologic data until significant impacts are already occurring. Improved methods of forecasting future stream flows are needed along with continued funding of existing (or expanded) real-time monitoring networks and analysis of the data collected. Additionally, the model does not yet include all of the state's surface water supply reservoir systems. Future expansions are underway to address these limitations.

As stated at the beginning of this chapter, the analyses conducted as part of this Plan only provide a foundation of the climate change risks to water supply. Additional evaluation needs related to surface water system concerns include:

- the risk of flood events exacerbated by climate change- both precipitation and sea-level rise storm related impacts to infrastructure and treatment (events may induce increased levels of contaminants via New Jersey's numerous superfund sites);
- the emergence of new drought types- such as the quick onset, severe, but short duration 'flash drought' and the probability of a new, more severe longer-term drought of record;
- the apparent increased occurrence of HABs which threaten drinking water operations- both treatment and quantity related impacts;
- increased potential for pathogens in warmer waters; and
- increased dependency on surface water systems in areas of aquifer salinization.

Responses to these events and other unknown issues that will likely arise depend on the continued support and analyses of real-time hydrologic monitoring networks and evaluation of data, the foundation of which is integral to continued support of climate research in identifying and mitigating emerging risks.

EXTREME PRECIPITATION EVENTS AND POTENTIAL IMPACTS TO WATER-SUPPLY INFRASTRUCTURE

A water release at Spruce Run Reservoir in Clinton, New Jersey. This reservoir is considered one of the first water supply facilities to be constructed and operated by the state.

More precipitation is falling in larger storm events and thus larger events are becoming more frequent. In other words, what was once considered the "100-year storm", or a storm with a 1% likelihood of occurring on an annual basis, is now an event that occurs more frequently. These larger precipitation events mean more flooding which can impact and disrupt water-supply infrastructure. There are too many examples to list individually, but they cover the gamut of major treatment plants, pump stations, and uncovered finished water reservoirs getting inundated or nearly inundated by flood waters, large and small watermains being washed out, and general disruption of service. Climate change forecasted for the state will only further exacerbate these issues. Many of these issues can be addressed through robust contingency planning and assessment by the system owner and via regulatory programs that acknowledge floods will get worse and occur more frequently.

IMPACTS TO UNCONFINED AQUIFER RECHARGE

Two aspects of surficial aquifer (unconfined groundwater) recharge are climate related. First is the impact on surficial aquifers along the shoreline, where sea level rise can inundate new areas with saltwater. This issue has been discussed above. The second issue is the amount of precipitation that infiltrates beyond the root zone to become groundwater, including aquifer storage. These unconfined groundwaters are critical to direct withdrawals, as baseflow to streams to support overall streamflow and as recharge to underlying confined aquifers.

NJGWS has investigated changes in groundwater infiltration and aquifer recharge in response to climate change through a Land Phase Model (LPM), which "uses the logic of a soil-water budget and readily available data to estimate a variety of outputs, including groundwater recharge (GWR), on a daily timestep" (Domber et al., 2022). This 300-meter grid model builds on the earlier GSR-32 groundwater recharge model (Charles et al., 1993). The LPM provides updated and more detailed outputs for recharge, runoff, simulated evapotranspiration, soil water deficits and other factors than GSR-32, which provided only the average annual normal and drought recharge estimates. GSR-32 results were used in the 1996 Plan to define groundwater availability on a watershed management area basis. As the model is relatively new, the daily results were aggregated up to annual results and calibrated to the GSR-32 results. Only the annual results are utilized in this Plan. DEP is currently working on additional model enhancements that once verified will be used in later analyses.

The first notable result from the LPM is that groundwater recharge has been for the most part rising since 1950 (based on 30-year rolling averages) in both northern and southern New Jersey, with the averages increasing from roughly 12 and 12.5 inches to 14 and 15+ inches per year, respectively. Precipitation is increasing faster than potential evapotranspiration (PET). While these are regional averages and specific watersheds will have varying results, the overall result is increased recharge, which reduces the stresses of water withdrawals from shallow aquifers. The NJGWS study notes that while the model calibrates well to available streamflow data on an annual basis, additions and adjustments will allow for calibration to daily hydrographs, expanding water supply planning applications. A second-generation model is currently in development.

NJGWS also used the LPM to develop nine climate change scenarios using combinations of low, medium, and high changes in temperature and precipitation, through the year 2050. All nine scenarios forecast more groundwater recharge in 2050 than in 1980, statewide, and only two scenarios forecast a decrease from 2020 to 2050, while five scenarios forecast increases and two forecast stable conditions. The results shown in Figure 3.15 are 30-year rolling average groundwater recharge estimates which smooth the year-to-year variability and better shows long-term trends.

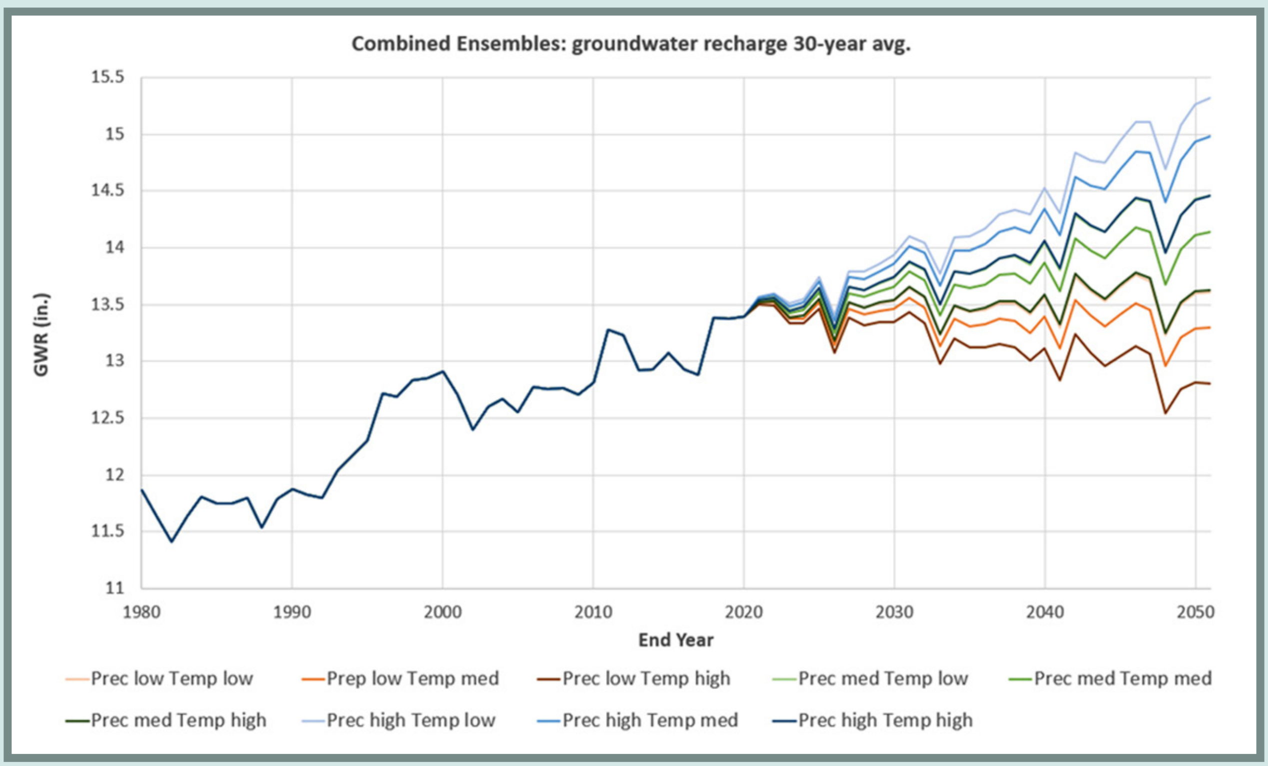


Figure 3.15 Groundwater Recharge Estimates Using 30-Year Rolling Averages (NJGWS).

The scenarios simulating 2021 through 2050 groundwater recharge were based on a combination of three temperature assumptions and three precipitation assumptions for a total of nine possible scenarios. They are low temperature with low, medium, and high precipitation, medium temperature with low, medium and high precipitation, and high temperature with low, medium and high precipitation. In order to account for normal daily, seasonal and yearly variability, the daily time series of temperature and precipitation from 1990 to 2020 was adjusted by the values listed in Table 3.3 and then appended to the 2020 dataset to generate a 2021 through 2050 timeseries for use in the LPM. To account for the observed temperature and precipitation changes which had already occurred over the 1990 to 2020 period, each daily temperature and precipitation adjustment was increased by the fixed 30-yr net value. This adjustment ensured that 1990 data (which then used as the 2021 data) was increased by the change which had already occurred in addition to the per year change assumed. For example, a 1990 temperature value of 15 0C was increased by 0.558 (0.54+0.018) to estimate a 2021 temperature and a 1991 value of 15 0C was increased by 0.576 (0.54+0.018+0.18) to estimate a 2022 temperature for the low scenario. The individual year results are shown as 30-year rolling averages in Figure 3.16 for 1920 through 2050.

Table 3.3. Temperature and precipitation changes assumed in the 2050 groundwater recharge analysis

Scenario	Temperature change		Precipitation Change	
	30-yr Net	Per Year	30-yr Net	Per Year
Low (L)	0.54 ^{0}C	0.018 ^{0}C	4%	0.13%
Medium (M)	0.75 ^{0}C	0.025 ^{0}C	7.5%	0.25%
High (H)	1.11 ^{0}C	0.037 ^{0}C	11%	0.367%

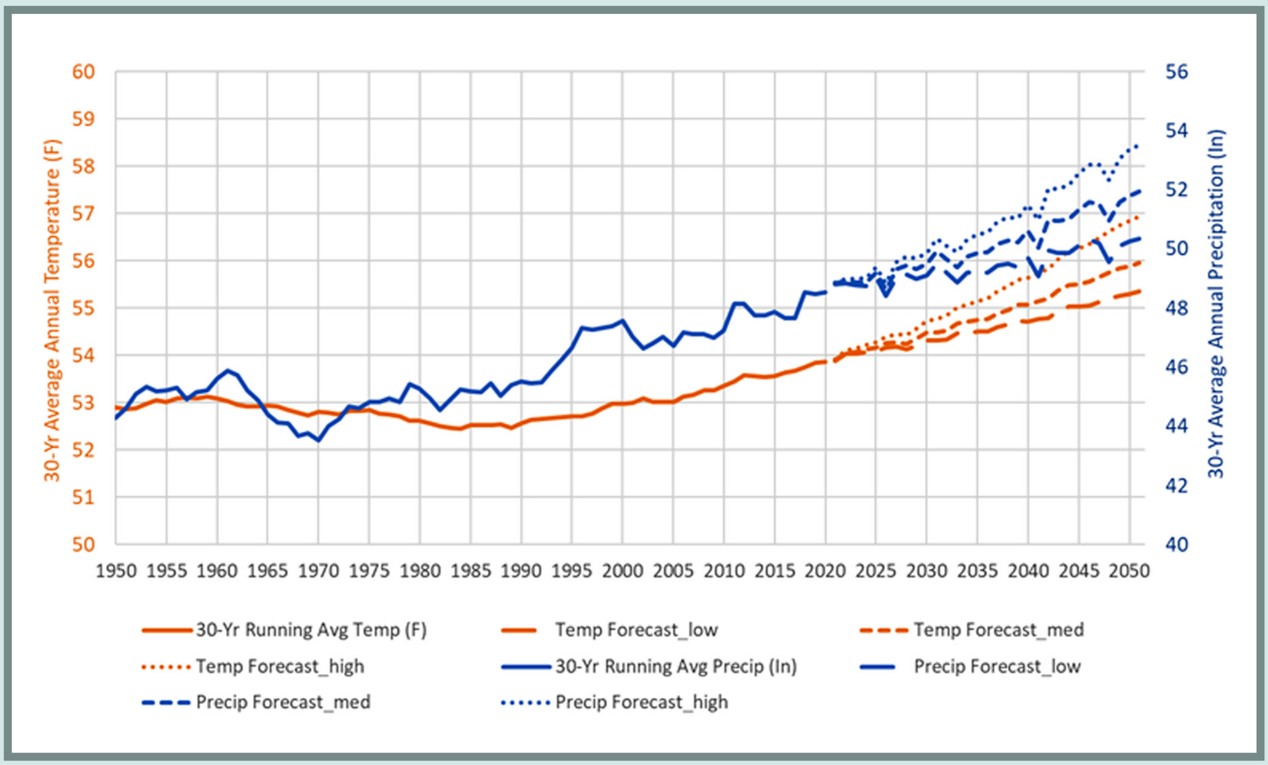


Figure 3.16 30-year rolling average precipitation and temperature data 1920 through 2020 and forecasts for 2021 through 2050. This data was used to generate PET and groundwater recharge (shown in Figure 3.15 above).

IMPACTS TO CONFINED AQUIFER RECHARGE

The primary impact of climate change on confined aquifer recharge relates to groundwater infiltration within the outcrop areas of the confined aquifers, which will be affected in the same manner as for unconfined aquifers. Most confined aquifers outcrop in southwestern New Jersey. Confined aquifers also receive recharge from overlying aquifers, where the same question of aquifer recharge will be of interest.

WATER QUALITY IMPACTS

Climate change has implications for water quality, in all waters but especially in surface waters. Increasing atmospheric temperatures can modify surface water chemistry. The increasing percentage of precipitation that comes during intense rainfall events will tend to increase stormwater flows, pollutant runoff from the land surface, erosion of stream beds (with attendant release of sediment and soil phosphorus), and potential exposure of contaminated soils in riparian areas. As noted in the New Jersey Scientific Report on Climate Change (NJDEP, 2020), increased water temperature, nutrient loads and total dissolved solids increases the potential for lower oxygen levels and an increase in cyanobacteria blooms.

Water treatment in Veolia's Haworth Water Treatment Plant in Haworth, New Jersey.

Climate change driven impacts to water quality are not limited to surface water. A 2023 report released by the DEP's Division of Science and Research (Aziz, 2023) conducted an extensive literature review and concluded that the effects of climate change are likely to cause ephemeral and long-term impacts on groundwater quality driven by modifications of hydrogeological processes, including precipitation, groundwater recharge, discharge, storage, and seawater intrusion. These modifications would influence biogeochemical reactions and the ultimate chemical fate and transport of contaminants and are likely to drive the variability of both anthropogenic and geogenic contaminants.

Initial work here suggests that these water quality changes will not likely reduce total water availability in New Jersey, but they may result in more expensive and intensive needs for source water protection and drinking water treatment and may cause temporary or permanent losses of supply if treatment is not feasible or takes time to install (i.e. limiting supply). Refer to Chapter 2 for a discussion of how new and emerging contaminants can contaminate water supplies and Chapter 5 for additional information on drinking water quality treatment and protection actions.

HARMFUL ALGAL BLOOMS (HABS)

Cyanobacterial blooms (or HABs) are excessive growth of cyanobacteria, which are caused by sunlight, warm temperatures, and increased nutrients. HABs can make people, pets, and wildlife sick from either the cyanobacteria cells themselves or from the cyanotoxins they sometimes produce. With a warming climate, there has been an increase of HABs globally. HABs In New Jersey have been increasing in occurrence since the state's HAB Response program began in 2017, and many have impacted New Jersey's water supply sources. In 2022, there were 65 documented occurrences in New Jersey. Of those, some were in surface waters upstream of water supply intakes, such as Greenwood Lake (upstream of Monksville and Wanaque reservoirs), Spruce Run Reservoir and Carnegie Lake/Millstone River. Though the largest concern with HABs is water quality, they can also have direct impacts to supply when additional supplies are used to attempt to move water or push "HAB water" away from intakes. For example, in the summer 2022, the state had just entered into a drought watch when the Millstone River experienced a severe 9-mile long HAB that threatened a major drinking water intake. Due to the extreme health risk associated with cyanotoxins, the presence of the HAB at the intake could have resulted in a "do not drink" advisory for almost 800,000 people. Therefore, the New Jersey Water Supply Authority released 5 billion gallons of water beyond normal operations to limit the impact of the HAB to the intake. Work has been done and continues to be done to help water systems prepare how to handle a HAB, for example, the development and implementation of cyanotoxin management plans, and work that the Drinking Water Quality Institute is doing to develop recommended standards for cyanotoxins in drinking water.

While surface water quality and HAB response monitoring is ongoing and will continue, a key question will be how to determine the most important causes of water quality problems and identify proactive, source water protection approaches. Ongoing actions such as the new, issued on December 1, 2022 and effective January 1, 2023, NJPDES permits for Municipal Separate Storm Sewer Systems (MS4s), which require development of Watershed Improvement Plans, will help address these issues by reducing nutrient inputs. Proper septic system management is also key, especially for lakefront communities.

DEMAND MODIFICATIONS

At this point, it is difficult to project the impacts of climate change on water demands, as future conditions remain uncertain. However, the state would benefit from expanded research in the following areas:

- Indoor water demands (e.g., bathing, cooking, toilets, clothes washing) are unlikely to change significantly with increased outside temperatures.
- Increased outdoor temperatures will drive higher water demands for lawn and agricultural irrigation, especially given forecasts for more frequent summer dry periods. While these increased demands cannot currently be predicted, one option would be to analyze demands in more southern states along the eastern seaboard, with the assumption that as New Jersey's future summers shift to being more like their current summers, water demands will shift in a similar way.
- Agricultural irrigation demands may change also due to crop selection, toward crops that are more tolerant of higher summer peak temperatures. Likewise, lawn grass seed selections may change to those that are more temperature and drought tolerant, including from cool-season turfgrass species such as Kentucky bluegrass and tall fescue (Grande, 2004; Goatly, 2008) to warm season grasses such as Bermudagrass, which is mentioned as being very well adapted for the hot climates (e.g., Piedmont areas) in Virginia (Goatly, 2008) and Georgia (Waltz, 2020).
- Increased outdoor temperatures may also drive an increase in urban outdoor water demands associated with recreation, street tree maintenance, and heat island reduction. Southwestern states and Mediterranean nations use misting technology to cool public spaces (e.g., school yards, shopping areas) in hot and dry climates; such cooling techniques may find use in New Jersey as summer peak temperatures increase. However, these water demands are not likely to be a major factor in total urban water demands.
- A more localized issue relates to temporary or permanent dislocation of water demands in areas that are damaged by coastal and riverine floods. For example, the New Jersey Shore is experiencing post-Sandy redevelopment, with varying effects on year-round populations. Of the 62 municipalities in Monmouth, Ocean, Atlantic and Cape May counties that lost population between 2010 and 2020, nearly all were coastal communities. Of the 63 municipalities that gained population, most were non-coastal communities but there were some notable coastal and back bay exceptions, such as Red Bank and Absecon (US Census, 2010; US Census, 2020). These population shifts may represent a flux between rental and year-round properties. The question is whether sea level rise will hasten a shift from year-round properties in high-hazard locations, or the loss of developed properties entirely in areas that are badly damaged by coastal storm surge that is exacerbated by sea level rise. It is important to note that sea level rise will increase damages even if coastal storms are no more severe than in the past, as the storm surge will start from a higher base, damaging more properties more severely.

CLIMATE CHANGE INITIATIVES FOR WATER SUPPLY

Climate change has and will continue to impact New Jersey's water supplies in a multitude of short-term and long-term ways. Some may be well understood, and others may be unknown. DEP is committed to increasing its knowledge of climate change impacts on water supplies through continued monitoring, research, and modeling efforts. These efforts will require continuous reevaluation and refinement of future climate conditions and sea levels, and advancement of water supply models.

The concept of stationarity, where the past can be assumed representative of the future, is no longer applicable. While historic droughts and water supply emergencies can still be used as planning scenarios, these events need to be reevaluated in light of climate change and likely projections of future conditions. For example, what will a repeat of the 1960s multi-year drought look like in 2050? Will it be drier or longer or will other factors such as demand increases become important drivers of risk? In order to be prepared for these uncertainties, DEP should continue to utilize an ongoing and adaptive process that monitors, researches, models, implements, and revises. This established practice can be adapted to address future climate conditions.

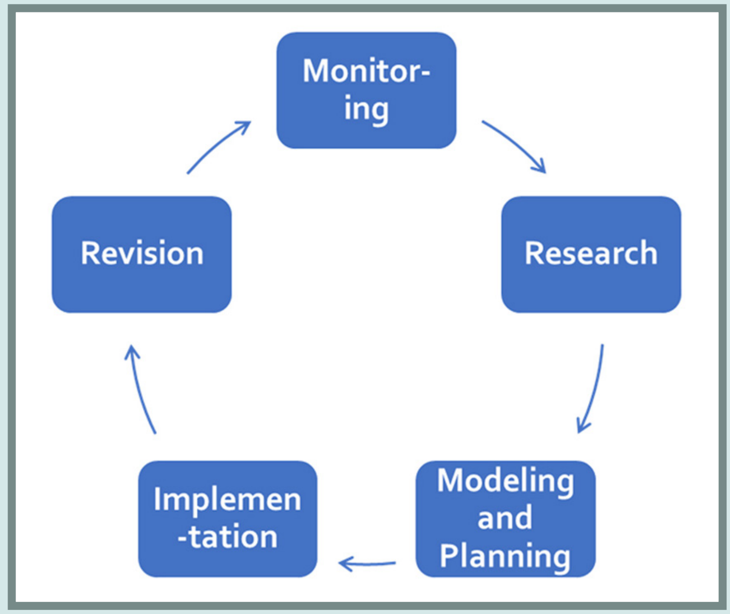


Figure 3.17 NJDEP overall strategy to address climate change impacts on water supply.

- **Monitoring:** Real-time or near-real-time climate and hydrologic data needs to be collected and assessed. This information can be used to confirm forecasts and calibrate models in addition to informing day-to-day water supply operations (as well as meet a range of other DEP and stakeholder needs). Monitoring data could also include event or system specific observations so the resulting data could be used to inform next steps (also known as lessons learned).
- **Research:** Research needs to be conducted and updated to better define what future climate will look like in New Jersey and to specifically define drought and water demands. This could include improved downscaling of global climate model outputs for the New Jersey region.
- **Modeling:** Models need to be developed, calibrated, and improved to quantify the effects of climate change on water supplies. This could include improved streamflow forecasts to use in reservoir models, advancing the land phase model used for the Plan update, or expanding saltwater intrusion models both in the confined and unconfined aquifers to better assess where impacts to potable aquifer might occur.
- **Implementation:** While no one model or tool is perfect, action typically occurs when data, models and experts agree.
- **Revision:** Periodic reviews and updates of all of these steps should be made so that course corrections can be implemented if needed. That is why this Plan considers future needs well beyond the five-year plan renewal cycle.

SUMMARY

Climate change is here and impacting New Jersey in direct and indirect ways and it will continue to impact the state's water supplies. While it is difficult to pin a specific event solely on climate change, it is apparent that climate change and specifically, sea-level rise along with increases in both temperature and precipitation are contributing to water supply impacts now and moving forward.

The increase of large precipitation events has been observed and is projected to increase during this century. The state has experienced numerous situations where extreme precipitation events have directly impacted water utilities. This list is long and includes events such as the flooding of Passaic Valley Water Commission's New Street uncovered finished water reservoir with untreated runoff resulting from the foot of rain which fell during the remnants of Hurricane Ida, and the repeated 'near misses' at New Jersey American's Raritan Millstone and Canal Road Treatment Plants during Hurricane Irene (2011) and Ida (2021) (both plants had been hardened after Hurricane Floyd caused extensive damage to both facilities in 1999).

A beach located in Ocean City in Cape May County, New Jersey.

Rising temperatures, especially heat waves during the summer can lead to unusually high water demands. When these demands are coupled with aging infrastructure, water mains are stressed and breaks can occur. Each year thousands of water main breaks occur. Most are small and do not cause major outages, but some breaks are very damaging. One example occurred in Newark when a 36-inch main broke in August of 2022, the warmest August in New Jersey from 1895 to 2022 (see Figure 3.1), resulting in the complete loss of pressure in the area served by the Pequannock treatment plant. This caused loss of water at the taps and/or boil water advisories, affecting over 200,000 people in Newark, Belleville, Bloomfield, and Nutley, including four hospitals. The main break was so large that it also resulted in a vehicle being swallowed by a sinkhole at the break site. Another example occurred in October of 2022 when the North Jersey District Water Supply Commission (NJDWSC) experienced an issue with a drainage valve on one of its major water transmission lines (72-inch diameter) in Nutley, which caused flooding of the roadway and nearby homes. A potential water service loss was narrowly avoided to 539,000 residents. Anecdotally, summer demands for many systems appear to be increasing. However, it is difficult to accurately determine heat is the primary cause. Multiple factors could be implicated, including residential water use changes caused by office and school closures during the Covid-19 pandemic and the regionalization of supplies due to source contamination.

Sea-level rise coupled with warming air and ocean temperatures increases the likelihood and severity of Hurricanes, Nor'easters, and other ocean driven events. Super Storm Sandy caused major damage to water supply infrastructure- primarily to finished water networks. The storm hit New Jersey in late October bringing with it a large storm surge which damaged critical electrical infrastructure in turn impacting utility's ability to treat and purvey water through the event. While it is difficult to predict exactly where and when these types of events may occur, it is vital for water systems to keep emergency management plans up to date and perform regular testing and maintenance on all interconnections. In the wake of Sandy and other recent adverse weather events, the DEP developed new guidance to ensure that critical repairs, reconstruction, new facilities, and operation/maintenance enhanced resilience of critical infrastructure. The documents address Auxiliary Power, Flood Protection, Emergency Response/Planning and Asset Management. These documents and guidance protocols can be found at the **DEP Asset Management website**. In addition, communication between DEP, State and Federal disaster relief groups and water supply systems will be integral in these situations.

The initial assessments conducted as part of this Plan are preliminary and do not address all the known water supply issues related to climate change. Those that were conducted suggest that, from a statewide annual average perspective, climate change has resulted in increasing available water for New Jersey. This assumes that the climate forecasts used in the assessments and water resource models are reasonably accurate, demands remain approximately stable, water quality impacts are manageable, and existing infrastructure and sources are maintained. Droughts will continue to occur and may worsen, extreme precipitation events will periodically threaten critical water supply infrastructure, and rising sea-levels will threaten low lying areas and water supply infrastructure.

At this time, it appears that sea level rise impacts will be felt most notably in unconfined aquifers near the current shoreline, inundating both recharge areas and existing wells. The outcrop areas of confined aquifers are likewise at risk in these areas, but the deeply confined portions of these aquifers off the Atlantic coastline, that are not already dealing with saltwater problems, are unlikely to see any significant new risk.

The inland unconfined aquifers have been experiencing increased recharge overall, however that trend may reverse if temperature driven evapotranspiration exceeds increased recharge. These unconfined aquifers are critical supplies for direct withdrawals and for flow to surface waters, as most annual average surface water flows are dependent on the movement of groundwater to streams (base flow) in all but the most intensively developed areas. Unlike surface waters, monitoring of groundwater at a regional scale is difficult. This issue will need a directed research approach to assess ongoing changes.

Safe yields of surface water reservoir systems are not anticipated to be substantially affected by climate change over the duration of this Plan according to current, preliminary modeling analysis conducted to date. Pumped storage reservoirs systems are likely to be most sensitive to changes in the magnitude and timing of streamflow. Further research on potential streamflow changes will be important for improved modeling of future scenarios. While the surface water reservoir systems are expected to have a sufficient volume of water, water quality degradation from increased mobilization of pollutants from more intense rainfall events is expected to impact water supplies. Additionally, combinations of events, aka black swan type events, where multiple limitations or stresses occur simultaneously are possible and can severely limit supplies.

It is critical to recognize that:

- This Plan and its recommendations benefit from the availability of sound and reliable climate change science.
- Though current models cannot predict specific conditions in a specific season in the future, further science and research is expected to improve the accuracy and availability of such tools.
- This Plan's water availability impact evaluations were preliminary and need to be continued and enhanced to confirm findings.
- Raw and finished water transfers will still be needed.
- More research is needed to characterize future drought frequency, duration, and severity, with increased occurrence of flash drought-like events likely.
- Existing saltwater problem areas still need to be assessed and actively managed.
- Water quality impacts (e.g. HABs) were not quantified but are anticipated and need to be evaluated. The effects on supplies could be significant.
- Sea-level rise will impact unconfined potable aquifers and outcrop areas, and will inundate wells and related infrastructure. Infrastructure hardening or relocation is likely to be needed.
- Saltwater will move further upriver and more often potentially impacting lower elevation dams, intakes and reservoirs.
- Future demands are likely to change in response to a changing climate (e.g. longer growing seasons or hotter summers).
- Laws, regulations, and policies and procedures will need to be updated more frequently to address the evolving science.

In summary, climate change has already impacted the state and its water supplies, and it will continue to impact the state in new and unique ways. While the initial assessments conducted as part of this Plan suggest that the state's water supply quantity is adequate to meet needs on a whole, there is more work that needs to be conducted to ensure that this outcome is achieved. In addition to the immediate policy and regulatory actions identified, modeling capabilities for forecasting long-term impacts must be augmented, source water protection to prevent or mitigate increased water quality problems such as HABs must be improved, and climate change-water supply assessments must be refined and expanded.

Two specific areas DEP intends to target related to climate change include:

- continued evaluation and monitoring of climate change implications for statewide water availability and demand as the science of climate change impacts on water resources and available data evolves in the future (i.e. use updated sea level rise estimates, improved water availability models, and longer forecast periods); and
- further analysis of data gaps, uncertainties, and topics requiring further investigation identified in this chapter. Examples of potential topics for further analysis include:
    - the limitations of downscaling to consider more localized water supply impacts over shorter-time scales (i.e. weekly, monthly, seasonally);
    - the need for periodic monitoring and reassessment to confirm that sea level rise over the next 50 and 100 years does not substantially exacerbate the risk of the movement of the saltwater interface; and
    - the need for further monitoring analyses by DEP oversight and reservoir operators to determine optimal approaches for operating pumped reservoir storage systems in response to climate change.

Chapter 4:
Statewide Water Demands and Balances

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OVERVIEW

New Jersey withdraws an average of 750 billion gallons of fresh water each year, based on 2016-2020 data. About 70 percent of total water withdrawals come from surface water. This water supports a variety of uses -- potable supply, power generation, commercial/industrial/mining, and both agricultural and non-agricultural irrigation. Some of this water is returned to its original source, but some does not, going to either consumptive or depletive losses.[1]

Each use sector consumes a different percentage of water, and this percentage varies from summer to winter and between types of uses. For example, power generation using once-through cooling processes consumes only a very small percentage of water it uses, while evaporative cooling processes use far less water but evaporate most of it. Agricultural use in the growing season consumes almost all of the water it withdraws, though water used for cranberry harvesting is mostly non-consumptive.

Water withdrawals can also result in the transfer of water from one place to another (known as a depletive use since it is depleted from the original water resource); for example, wastewater discharges to fresh waters are often not to the source surface water or aquifer; what is a depletive water loss to one water resource may be an additional supply in another and is tracked as such. However, roughly 70 percent of all treated wastewater effluent in New Jersey is discharged to saline waters (e.g., oceans, bays, estuaries), making it unavailable for further use. The combination of consumptive and depletive water uses has a major impact on the state's water resources.

Water withdrawals and use vary both spatially and temporally across the State. Power generation uses of surface water declined sharply from 2005 to 2011 as electricity generation shifted from coal fire powered plants to natural gas and renewable energy and more efficient cooling systems were implemented. (Note: coal-fired power plants are no longer active in New Jersey). Statewide total water withdrawals (excluding power generation) have decreased by an average of 3.8 billion gallons per year (bgy) over the 30-year study period (1990-2020). The decline is due primarily to reduced demands in the commercial/industry/mining sectors. At the same time, potable supply withdrawals have varied from 400 to 450 bgy through the entire period with no discernible trend, despite a major increase in population (from 7.7 million in 1990 to 9.3 million in 2020, a 20% increase).

Irrigation at Specca Farm in Bordentown, New Jersey. Agricultural water use is almost entirely consumptive for most crops during the growing season.

Consumptive use related to water supply withdrawals, however, have increased. The consumptive use trend reflects, in part, increased potable supply uses (from public water systems and private wells) for water-intensive recreational uses and lawn/garden irrigation, and for agricultural irrigation practices. Total consumptive losses varied between 55.6 and 98.5 bgy for the study period with over half of the losses coming from the potable supply sector alone. Consumptive losses are rising at a rate of slightly more than half a billion gallons per year (this excludes trends associated with the power generation use sector).

1 Consumptive loss means water is removed from the water supply resource (ground or surface water), used, and lost to the atmosphere, generally through evapotranspiration. Depletive loss means the withdrawal of water from a water supply resource where the water, once used, is not discharged to the same water supply resource in such a manner as to be useable within the same watershed (e.g., exported out of the watershed); it may be available for use elsewhere in the state if discharged to fresh waters. These terms are used throughout this NJSWSP.

Within any sub-region of the State, different and even converse trends may be observed. A larger amount of water withdrawal can be sustained without adverse environmental impacts if the water remains in useable form within the original source watershed and/or there is a significant volume of available water. On the other hand, a smaller amount of water loss in places with limited water availability may be unsustainable. Chapter 2 discusses the approach used to estimate available water. This chapter discusses both water demands and how they affect net water availability for the three categories of water resources.

New water data are continually submitted to DEP; the related water demand forecasts and availability can change in response to the new data. As such, DEP routinely updates its water data, periodically revises its water availability and forecast analyses, review the results, and incorporate policy and/or regulatory changes, if necessary, in response to the continually evolving information. This important work informs both annual monitoring of water demands throughout the state and future updates to the Plan.

NEW JERSEY WATER SOURCES

There is one water cycle, but for the sake of planning and accounting purposes, water is assigned to one of three sources: surface water, unconfined groundwater and confined groundwater. The DEP's planning and permitting authority is on fresh (not saline) water, however as water resources become limited and sea-level rise continues to impact sources that were previously fresh, some saline diversions, however minimal, are included here. It is also important to note that there are some users of saline water such as the nuclear power generating and aquaculture facilities, but they are not the focus of this Plan, and their volumes are not accounted for in the following discussions.

DATA SOURCES

New Jersey has a long history of monitoring water withdrawals and use. The current monitoring and reporting system stems from the 1981 Water Supply Management Act and corresponding Water Supply Allocation Permits rules (N.J.A.C. 7:19) and the Agricultural, Aquacultural, and Horticultural Water Usage Certification rules (N.J.A.C. 7:20A). The Water Allocation regulations require quarterly water use reporting for monthly water withdrawals with sources having the pump capacity to withdraw 100,000 gallons per day (gpd) or more of fresh water, or 50,000 gpd in the Highlands Preservation Area. The agricultural regulations require annual reporting of monthly water withdrawals for sources that have the pump capacity to withdraw 100,000 gallons per day (gpd) or more of fresh water.

The water use characterization summarized in this chapter originates from the withdrawal data reported by water allocation permittees as well as agricultural water usage certification and water usage registration holders. It also includes supplemental data such as private domestic well withdrawal estimates. Sources include:

- Water Allocation Permits, Water Use Registrations, Agricultural Water Usage Certifications, Agricultural Water Usage Registrations;
- Safe Drinking Water public community systems and bulk transfer of potable water between systems;
- NJ Pollutant Discharge Elimination System sanitary sewer surface water and groundwater (>2,000 gpd) discharges; and
- private domestic well withdrawal estimates by census block group with region-specific per capita water use rates and household density information developed from US Census, well permit datasets, and DEP commissioned reports.

The data and analyses in this chapter are taken from information in the New Jersey Water-Transfer Data Model (also referred to as NJWaTr or NJ Water). This database contains information on sites of water withdrawal, use, and discharge quantities associated with each site on a monthly basis, and linkages between the sites. The NJWaTr water use characterization data presented here cover the period 1990 through 2020 and represents the best data available to assess water use and estimate water availability in New Jersey (Tessler, 2003). Note that the data used in the work may differ from the DEP's regulatory water use datasets.

DATA UNCERTAINTIES

New Jersey has a robust data system for water withdrawals, based on decades of record keeping. However, as with every type of measurement, there are inherent uncertainties in measuring water withdrawals, depending on the type of use and whether the withdrawals are measured by calibrated meters, by estimates based on pump capacity, or by indirect methods. The uncertainties may range from minor to significant. Where a water resource is identified as having a major surplus of net available water, uncertainties in withdrawal measurement are unlikely to be a major factor. However, where a major water stress is identified, having more accurate withdrawal data will be critical.

Water Allocation Withdrawals: Non-agricultural withdrawals in water allocation permits are required to provide monthly data on withdrawals. These data are based on meter readings at the water source, and they are considered accurate within the limits of the meters, assuming periodic calibration and proper recording and reporting. The monthly data are periodically reviewed for discrepancies that indicate a data problem. Another potential issue is whether some water withdrawals that should have water allocation permits are not yet regulated. Again, this issue is unlikely to create a significant data problem statewide or regionally but may be of concern in stressed areas, as missing withdrawals can make a situation look better than it is. Finally, industrial and commercial demands can vary significantly from year to year, based on changes in manufacturing processes, mining operations, and seasonal recreational demands. These shifts can complicate demand analyses and forecasts.

Agricultural Withdrawals: Several issues exist regarding agricultural withdrawals. First, agricultural withdrawals are heavily influenced by crop selection, soils, precipitation levels and patterns, and temperature levels and patterns, all of which can vary greatly from year to year, season to season. These variables make analysis of water resource impacts and projections of future demands difficult. The second issue is data uncertainty. Current DEP regulations only require that agricultural withdrawals under agricultural water usage certifications be documented and reported. When meters are not employed by the certification holder to measure water withdrawal, regulations require the use of rated pump capacity multiplied by the hours of operation. Recent research by DEP and partners has compared these values against meter readings through a voluntary field trial. The general result is that the normal method (pump capacity multiplied by hours of operation) tends to exceed meter readings, especially for higher volumes (more than 2 million gallons per month). The study did not analyze causality, but the results might reflect differences between pump capacity ratings (based on free- flowing water) versus reality, where the pump is pushing water through a distribution system, which could slow the flow of water. While further tests would be useful, the research indicates that available reports on major agricultural withdrawals may overstate actual flows.

An overhead agricultural irrigation system at Tuckahoe Turf Farms in Hammonton, New Jersey.

Another potential complication with agricultural withdrawals is understanding the extent to which irrigation water is returned to either the same or another water resource. Irrigation ideally provides only sufficient water to support plant growth, but some irrigation systems may result in water infiltration past the root zone, constituting groundwater recharge. The NJ Water Tracking System estimates the percentage of agricultural withdrawals that are lost to evapotranspiration, but these are general assumptions, not site-specific measurements, due to the high cost of such field research.

Water Returns: Not all potable water withdrawals reach customers. Inevitably, each public community water system (PCWS) will have some water losses from pipelines, with some of 25% or more. In some locations, these losses may result in groundwater recharge to aquifers, while in others, the water is lost to public use entirely. It is not feasible to measure the extent to which PCWS water losses result in recharge. In most areas this will not be a major factor, but it could be in some deficit regions. However, while unaccounted-for water may be reported to be between 15-25% in some cases, this calculation does not distinguish between real losses (i.e. water lost due to leakage) or apparent losses (i.e. water lost due to billing, metering, or systemic data handling errors). In its proposed rulemaking to codify the Water Quality Accountability Act (WQAA), the DEP intends to incorporate requirements for applicable PCWS to conduct and submit an annual AWWA Water Loss Audit. Once the DEP begins to collect and analyze this data, it would be easier to characterize the extent to which different regions may be experiencing returns to aquifers due to leakage, or other causes. 70% of all treated wastewater effluent is discharged to saline waters, representing a 100% consumptive/depletive water use.

Self-supplied residential household and irrigation demands: New Jersey has many households (roughly 10% of the total population) with private domestic wells to meet all potable water demands, including outdoor uses. No metered data are available for these sources, therefore, a model is used to estimate total demands from private domestic wells based on well permitting and drilling records maintained by DEP, the population not residing within PCWS service areas, multiplied by an average per household demand. Additionally, an unknown number of additional households have private irrigation wells, while the indoor uses are supplied by a PCWS. Statewide withdrawals for this situation are likely very small but locally they may be measurable. As with agricultural withdrawals, the underlying data uncertainties will not be problematic where water resources are not stressed or where private wells represent a small portion of total withdrawals.

SOURCES OF WATER

New Jersey withdraws fresh water from one of three sources: surface water, and both confined and unconfined aquifers. Figure 4.1 shows annual total surface water, unconfined aquifer and confined aquifer withdrawals for the period 1900-2020. On average, New Jersey obtains 8% of its water from confined aquifers, 18% from unconfined aquifers, and 74% from surface water sources. Total withdrawals for all purposes have declined more than 25% from 1990 to 2020; most of the decline is surface water. Figure 4.5a below also shows the proportion of water sources geographically across New Jersey's five water regions.

Spring House located along the Delaware and Raritan Canal in Titusville, New Jersey.

The summary of water withdrawals by source is complicated by two factors. First, surface water is stored in reservoirs when incoming surface water flows are high during wet periods; storage levels decline when drier conditions prevail. These withdrawals typically do not lower streamflows excessively because DEP requires minimum stream passing flows (discharges from the dam to the river) to be maintained. Second, unconfined aquifers are hydraulically connected to the streams. Water may flow into the streams (called baseflow) or from the stream (recharging the groundwater but decreasing streamflow) depending on relative water levels. These factors complicate estimating how much water is available for use now and in the future. This issue is discussed in more detail in Chapter 2.

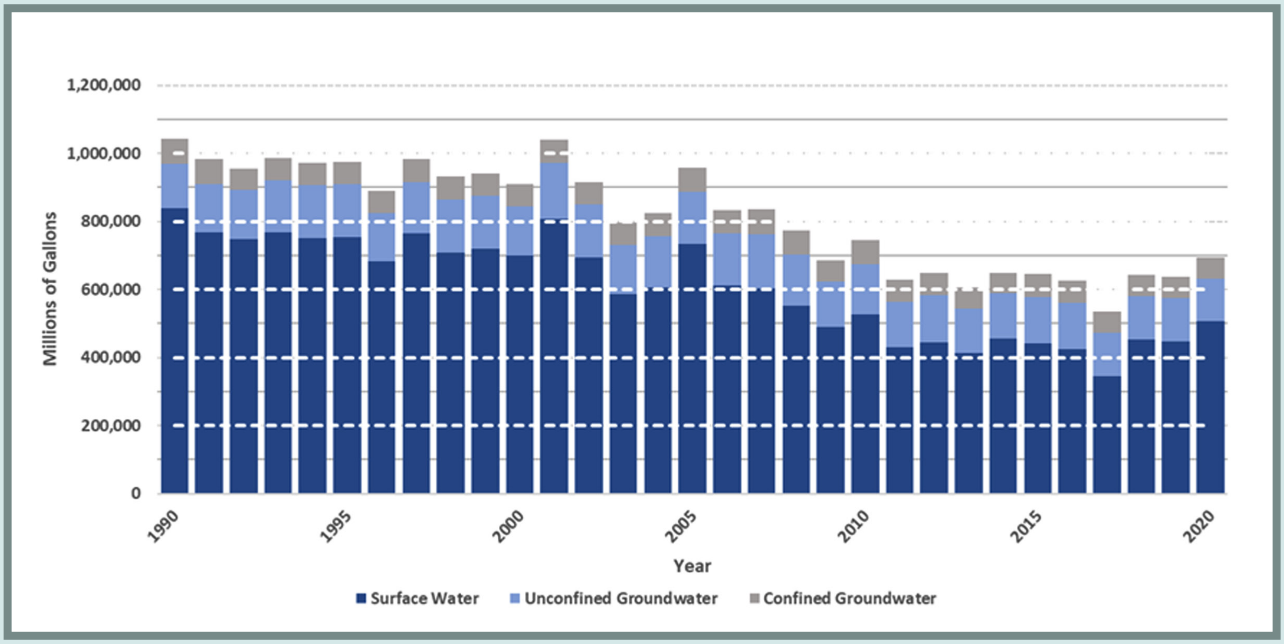


Figure 4.1 Annual Statewide Source of Water Withdrawal, 1990-2020.

WATER WITHDRAWALS AND USE

Reported water withdrawals do not necessarily equal water uses so they are treated separately. The main example of this is water that is withdrawn to fill up a water supply reservoir, but which is not diverted to a potable water public supply treatment plant and then customers until later when it is actually needed. In most other cases, such as water withdrawn from a well or intake for irrigation purposes, it is used immediately so withdrawal will equal use (at least on the monthly timescale that data is reported/estimated on in the state). These differences are typically observed when data is compared at the site scale, but one example of this difference in the Plan is in the reported totals in Figures 4.5a and 4.5b for the Passaic water region.

STATEWIDE WITHDRAWALS

Figures 4.2, 4.3 and Table 4.1 show annual withdrawal volumes from 1990 - 2020 by water use sector. As shown in Figure 4.1, annual water withdrawals in New Jersey peaked at over one trillion gallons in 1990, but overall withdrawals have decreased in the last few years to 700 billion gallons in 2020. The changes are partially the result of a shift by power generators to natural-gas powered stations (which use less water than coal-powered stations). This shift is a function of economic forces and is likely to remain as additional energy comes from renewable sources; the last coal-fired facility in New Jersey closed in 2022. The conversion to renewable energy sources may require the temporary (construction dewatering, etc.) or long-term use of water but it is anticipated that total water use will still be significantly less.

Withdrawals for power generation, attributable to only fourteen individual users in 2020[2], represent approximately one-half of all water used statewide in some years, primarily through 2005. Since most of this type of water use is neither depletive nor consumptive (in other words, it is a non-consumptive use that is not transferred from the source watershed), water used for power generation is sometimes removed from the withdrawal summaries, such as in Figure 4.3 and 4.8.

[2] In 2020, two of the 14 power generation users are specifically hydropower generators. These two hydropower users represent over 90% of the total power generation withdrawal. The withdrawal, use and discharge occur at essentially the same location with minimal consumptive loss associated with it.

Agricultural water withdrawals summarized here and throughout this Plan include traditional agricultural uses like irrigation of crops, plants and animals, frost protection, and cranberry harvesting, as well as other horticultural uses as identified in the Agricultural, Aquacultural and Horticultural Water Usage Certification Rules (N.J.A.C. 7:20A). New Jersey law (N.J.S.A. 58:1A-1 et seq.) specifically exempts saltwater diversions from DEP regulation, therefore aquacultural activities in salt water or any saltwater diversion used for cooling or other purposes is not included in these summaries (see N.J.A.C. 7:19 – 1.4). As sea-levels rise, climate changes and water treatment technologies improve, New Jersey may need to revisit this exemption.

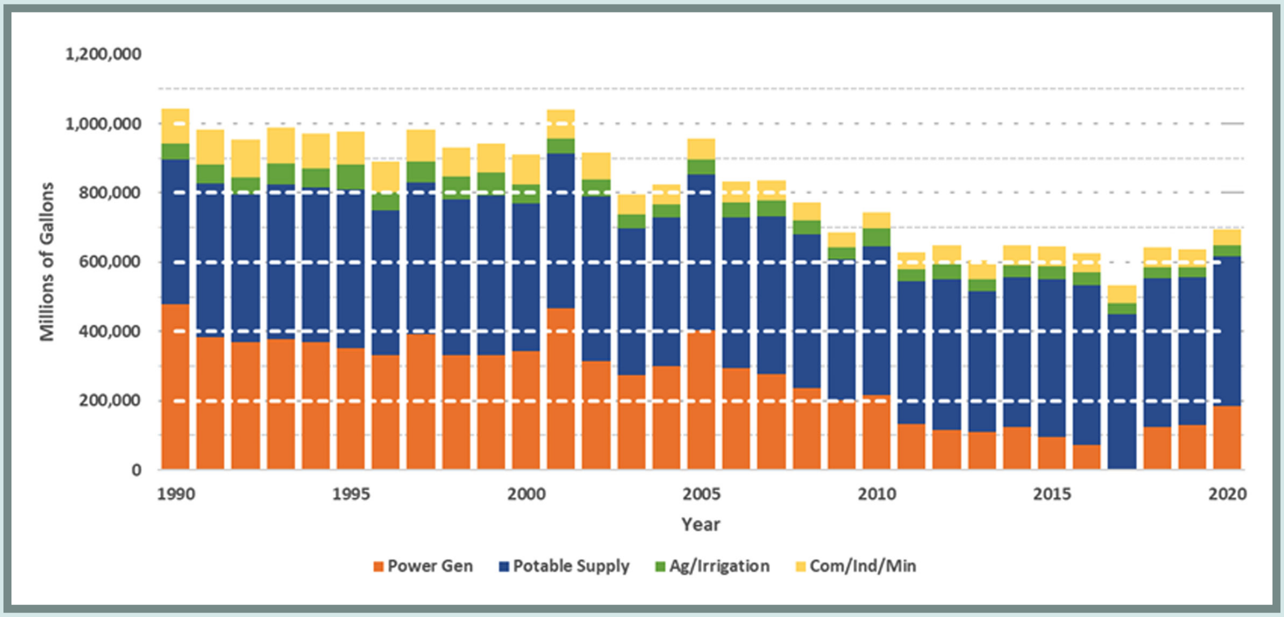


Figure 4.2 Water Withdrawals by Use Sector, 1990-2020.

Potable water withdrawals include both self-supplied potable sources and withdrawals by public community water systems. These public community water systems often have a mix of residential, industrial, commercial and irrigation use components (especially for larger systems) which vary between water systems. All withdrawals by public community water systems are considered potable supply because many systems do not have the ability to distinguish the exact use. DEP began requiring an estimate of residential demands under the Water Quality Accountability Act, which will allow for better differentiation of water demands in future iterations of this Plan. As Figure 4.4 shows, of the 220 PCWS reporting this value (as of September 16, 2022), 77 reported that residential demands were 90% or more of their total demands and 151 reported values of 70% or more. Only 16 PCWS reported that residential demands were less than 50% of total billed demands. Most small PCWS were created to serve primarily residential areas and would tend to have the highest percentages of residential demand. Large PCWS serve a mix of residential, industrial, commercial, and public customers and therefore will have somewhat lower percentages of residential demands. For example, Newark, Passaic Valley Water Commission and Camden City all reported values between 40% and 50% residential demand.

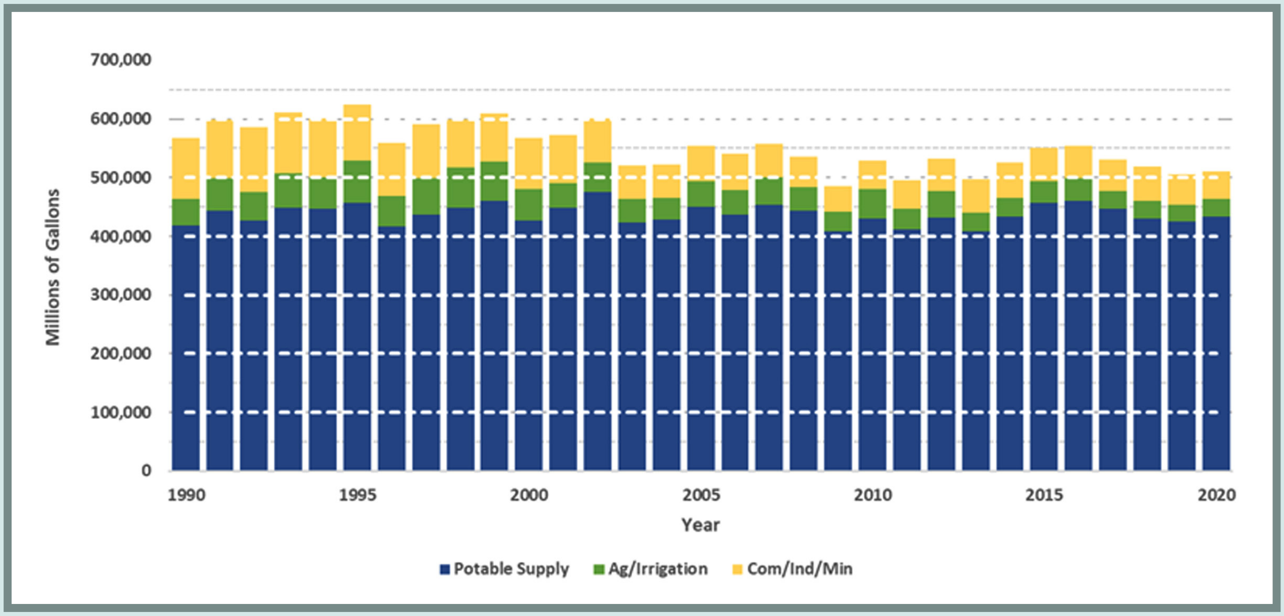


Figure 4.3 Water Withdrawals by Use Sector, 1990-2020, excluding power generation.

Statewide water withdrawals vary from year to year and from sector to sector (Figures 4.5 and 4.6, Table 4.1) primarily in response to weather conditions but also due to changes in economics and public policies. Annual withdrawals of water, excluding power generation, ranged from 485 billion gallons (bg) in 2009 to 624 bg in 1995, with an average of 553 bg. Potable supply accounted for the majority of non-power generation use, 79% on average. Combined commercial/industrial/mining use made up another 13%, while agriculture and irrigation are 8% of average use.

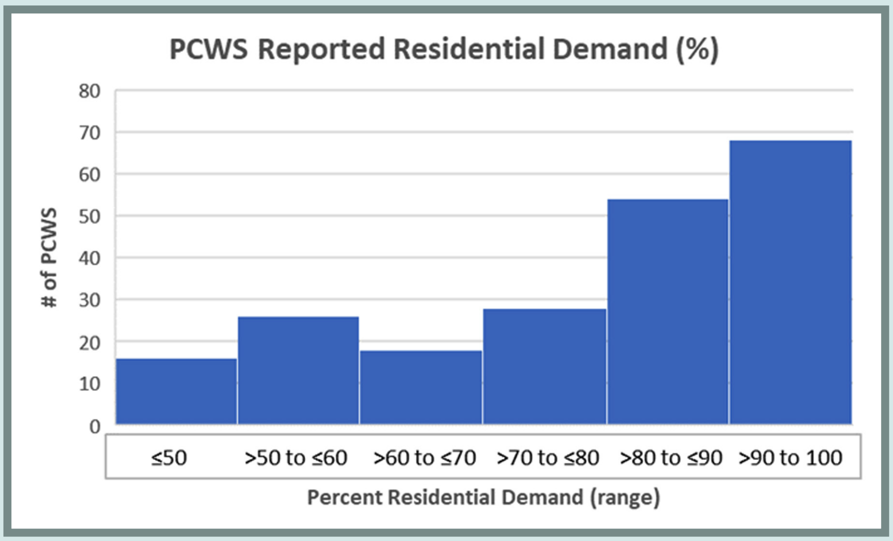


Figure 4.4 Residential Demands as a Percentage of Total PCWS Demands.

Table 4.1 Annual Water Withdrawals by Water Use Sector, in millions of gallons

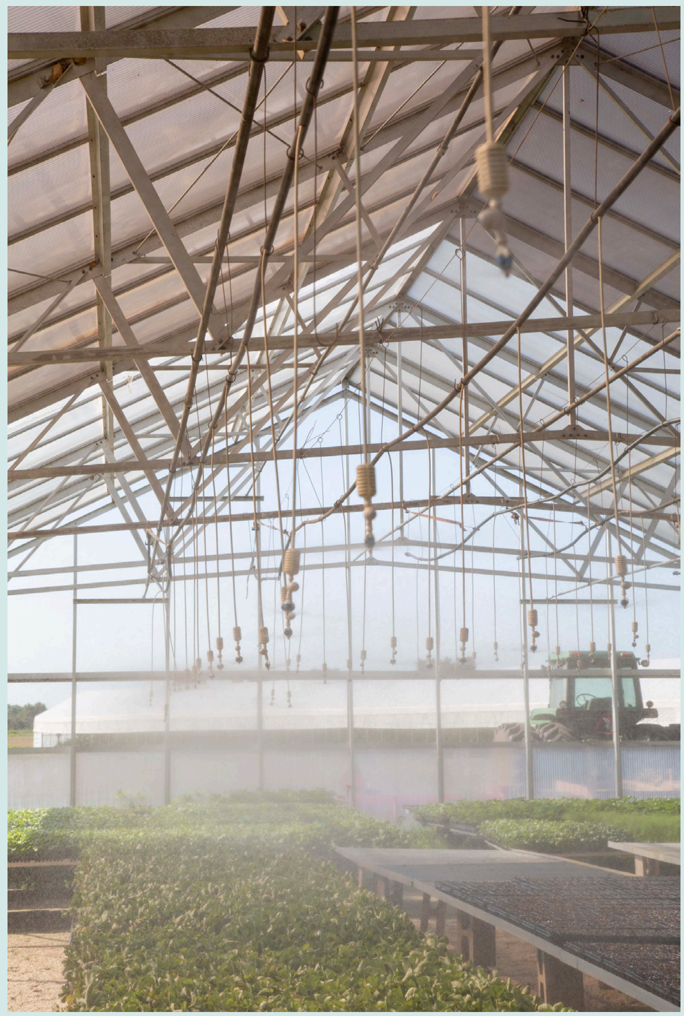
Water Use Sector								
Year	Agricultural	Commercial	Industrial	Irrigation	Mining	Potable Supply	Power Generation	Total Withdrawals
1990	44,658	459	75,307	2,090	26,521	417,652	477,355	1,044,043
1991	52,135	534	70,250	3,033	29,418	443,656	383,202	982,229
1992	45,933	497	70,267	2,543	39,698	427,572	367,699	954,209
1993	54,193	620	70,485	3,896	32,684	448,997	376,575	987,450
1994	49,390	557	63,029	3,384	38,273	446,933	369,511	971,077
1995	67,851	596	52,250	4,155	41,747	457,552	351,934	976,086
1996	48,438	617	51,937	2,684	38,061	416,810	331,985	890,532
1997	58,718	473	47,857	4,343	43,881	436,202	392,357	983,832
1998	62,981	554	46,722	4,772	36,248	448,631	332,256	932,163
1999	62,033	300	46,425	4,490	34,785	460,598	333,018	941,649
2000	49,696	525	50,075	3,655	36,036	427,154	343,483	910,623
2001	35,860	554	46,115	6,506	35,925	448,296	466,088	1,039,343
2002	45,912	492	36,080	4,352	39,030	475,129	314,050	915,046
2003	36,044	508	42,090	4,418	13,484	423,197	275,039	794,779
2004	31,312	569	42,558	5,107	13,889	429,117	300,830	823,382
2005	37,033	608	43,780	7,005	14,681	450,430	402,970	956,508
2006	36,723	581	39,179	6,097	20,830	436,550	293,733	833,692
2007	38,794	431	38,859	6,944	18,164	454,341	277,490	835,024
2008	34,660	429	36,211	6,297	14,712	443,447	236,396	772,151
2009	28,364	477	33,081	4,203	10,356	408,918	200,603	686,001
2010	44,123	359	30,512	7,103	16,508	429,971	215,230	743,806
2011	29,274	401	29,368	5,297	19,511	412,231	131,597	627,679
2012	38,072	472	32,420	5,773	22,748	432,534	116,950	648,969
2013	26,627	471	33,230	5,359	23,234	408,749	108,607	606,277
2014	27,610	387	32,845	5,432	25,518	433,059	124,415	649,266
2015	30,097	243	34,780	6,812	21,263	457,430	94,101	644,725
2016	31,554	496	36,007	6,604	18,462	460,683	71,150	624,957
2017	24,601	472	33,398	5,027	19,604	446,877	4,171	534,150
2018	25,376	493	36,332	4,524	21,766	430,898	123,273	642,662
2019	23,691	329	37,143	5,043	15,077	424,634	131,295	637,212
2020	24,734	526	35,876	5,199	11,442	433,324	183,951	695,051

Figure 4.5a shows the average annual reliance on each source of water withdrawn in New Jersey's five Water Regions, based on data from 2016 to 2020. Water Regions are compiled from entire Watershed Management Areas, which in turn are compiled from HUC11s. The size of the pie chart is proportional to the volume of the withdrawal. The data show the regional variations in source of water and in water demands. The amount of water withdrawn does not necessarily equal the amount of water immediately used. This is particularly true for the potable supply sector where water may be withdrawn one month, stored, and then used several months later. One example is pumped water (sometimes referred to as pumped storage) used to fill a reservoir. In this case water is withdrawn from a river and pumped into a reservoir, where it is stored until it is directly or indirectly withdrawn at a later time into the potable water treatment plant. From here the water is treated and sent into the distribution system for use by its customers. Three reservoirs are almost entirely dependent on pumped storage: Round Valley, Manasquan and Brick Township, while the Wanaque and Oradell reservoirs are augmented by pumped storage. Managed Aquifer Recharge (MAR, aka Aquifer Storage and Recovery) is another example of delayed use, where water is temporarily stored in an aquifer and later retrieved for use.

Figure 4.5b shows the average annual water use by sector in each of New Jersey's five Water Regions based on data from the 2016 to 2020 period. The size of the pie chart is proportional to the volume of the water used and may be different than the size of the corresponding withdrawal chart, Figure 4.5a. This is the result of stored potable water withdrawal which are used later and from the movement of water from one water region where it is withdrawn to another water region where it is used.

For both Figures 4.5a and b, the larger circles in Northeast New Jersey (the Passaic Region) reflects the large population; nearly all the water withdrawals are for potable supply (similar to the Raritan Region). The Upper Delaware Region, however, has similar water demands despite its much lower population. Comparison of the two figures shows that a major demand in that region is for power generation, in part related to a pumped storage hydroelectric facility in the region. The Lower Delaware Region also is distinct from the others, with a sizeable share of demands within the Commercial/Industrial/Mining and agricultural sectors.

Water use trends, similar to withdrawal trends, vary from month to month as well as year to year. In New Jersey, water use typically peaks during the summer when outdoor and irrigation/agricultural demands are high. Figure 4.6 shows statewide average monthly use for the 2016-2020 period. February is the month with the lowest average withdrawals, 36.9 billion gallons, and July the greatest, 53.3 billion gallons. (This summary excludes withdrawals for power generation.)



An indoor spray irrigation system located at Specca Farm in Bordentown, New Jersey.

Water withdrawal data, aggregated by HUC 14 and municipality, is available to the public via the **New Jersey Water Withdrawal Data Summary Viewer**. Withdrawals can be viewed by use group or source type and can be filtered geographically by selecting one or more HUC14s or municipalities.

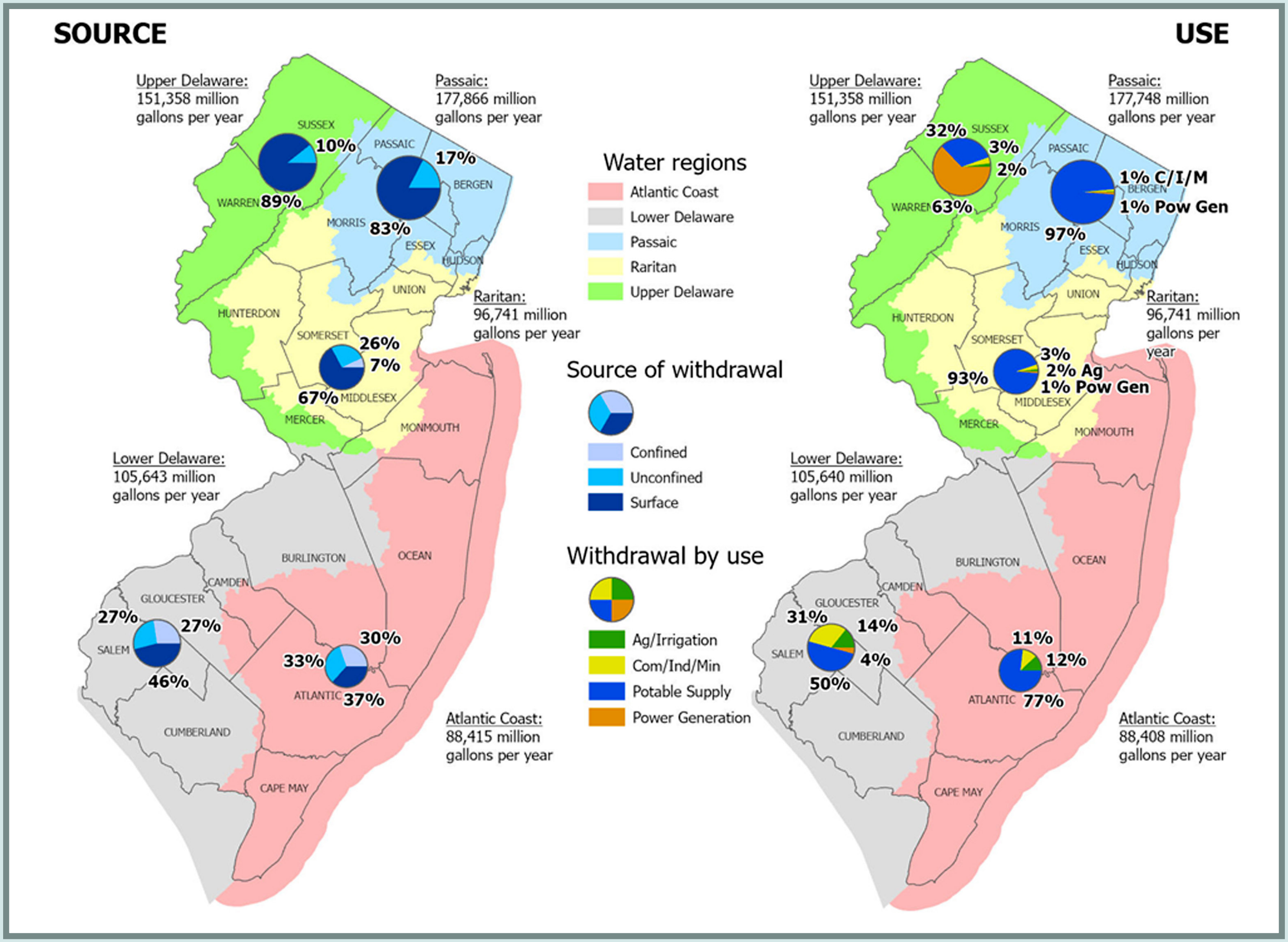


Figure 4.5a Average annual source of water withdrawal, by water region, 2016 - 2020 (millions of gallons).

Figure 4.5b Average annual use of water, by water region, 2016-2020 (millions of gallons).

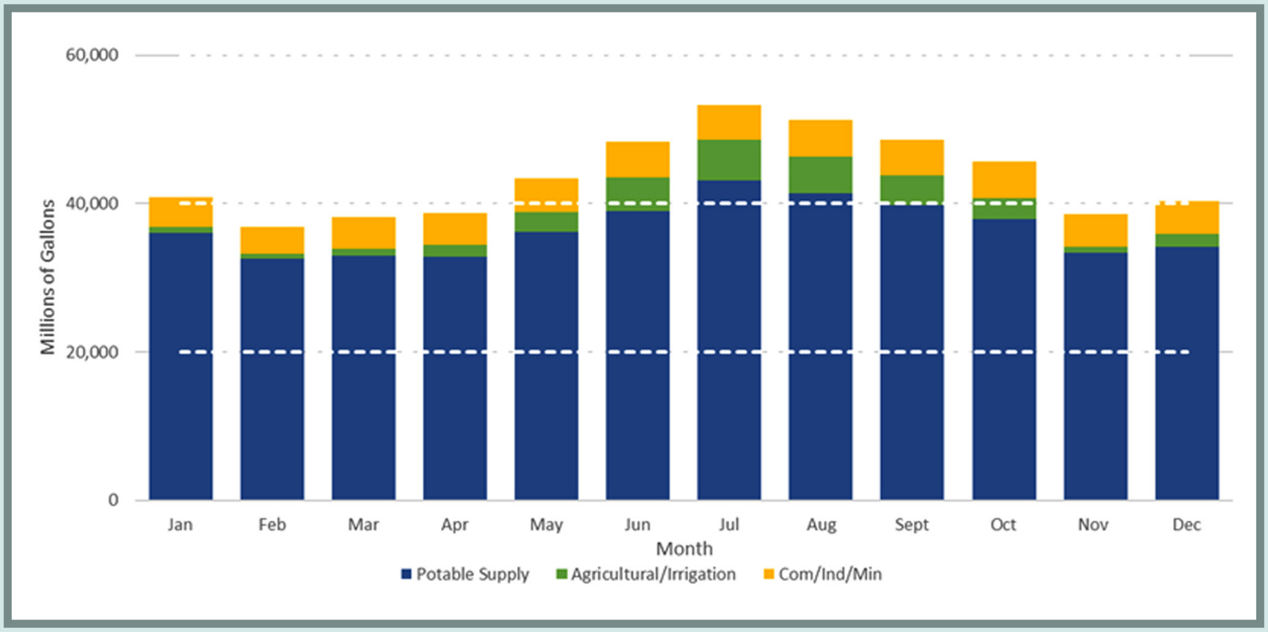


Figure 4.6 Statewide Average Monthly Use by Sector, 2016-2020

CONSUMPTIVE AND DEPLETIVE USES

Total withdrawal and total use can be somewhat misleading when it comes to determining hydrologic impacts, because not all water use results in a consumptive or depletive loss to the basin; some is returned to the same water resource and is available for new uses. Hydrologic impacts are a function of many site-specific and regional factors and include the consumptive or depletive loss associated with one or more withdrawals, the seasonal withdrawal pattern, and the hydrogeology and water budget of the watershed. Figure 4.6 shows statewide annual consumptive water use by sector for the period 2016 to 2020. Consumptive losses rarely can be directly measured, but rather are based on research results (e.g., for agricultural and non-agricultural irrigation practices), a comparison of water withdrawals to discharges of treated wastewater effluent, and a comparison of growing season and non-growing season demands. While the estimates are based on strong data, regional and local variations may exist in the accuracy of results. Therefore, the estimated consumptive losses need to be used carefully in water availability analyses.

Based on the estimates for the period 1990-2020, consumptive loss associated with potable use has increased on average by about 333 million gallons a year. Consumptive loss due to agricultural and non-agricultural irrigation has increased by 166 million gallons a year. The values in both cases primarily reflect increased irrigation demands for agriculture and landscapes. On the other hand, consumptive loss associated with commercial, industrial, and mining uses has decreased by 150 million gallons a year. The net amounts to an average annual increase in consumptive loss of 349 million gallons a year.

Consumptive use varies from year-to-year based upon temperature, precipitation and changing demand patterns (e.g., agricultural or lawn irrigation practices or population growth), but the general trends observed in Figure 4.7 indicate that consumptive use is generally increasing over the period of record.

Figure 4.8 is a comparison of the estimated statewide non-consumptive and consumptive water use for each water use sector for the period 1990-2020. Note that the y-axis scales on the four subgraphs vary considerably. For example, non-agricultural irrigation is largely consumptive, but the total consumptive use by non-agricultural irrigation is far smaller than that of Potable Supply even though the consumptive portion of public supply use is small percentage wise. Figure 4.9 summarizes total average use over the period 2016-2020 by water use sector (a) and consumptive losses attributable to those user groups (b). Potable supply total use accounted for 82% of the total use, but 64% of the consumptive loss. Agricultural and non-agricultural irrigation accounted for 7% of the total use, but 30% of the consumptive loss.

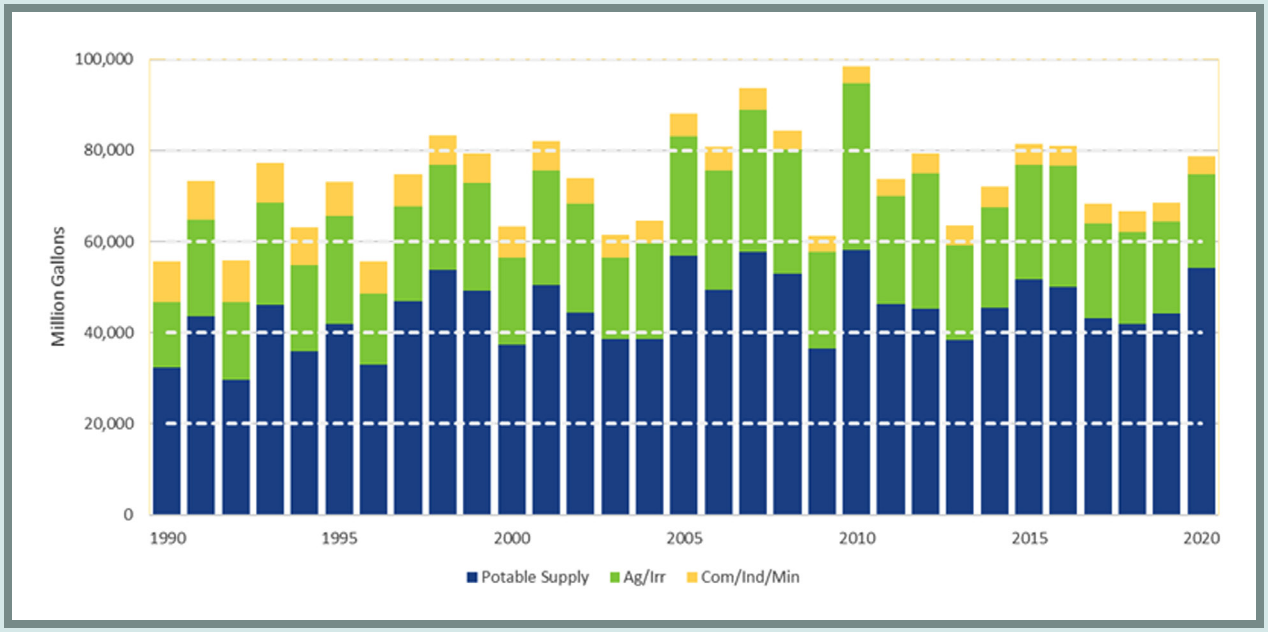


Figure 4.7 Statewide Annual Consumptive Water Loss from All Use Sectors Except Power Generation (1990 –2020).

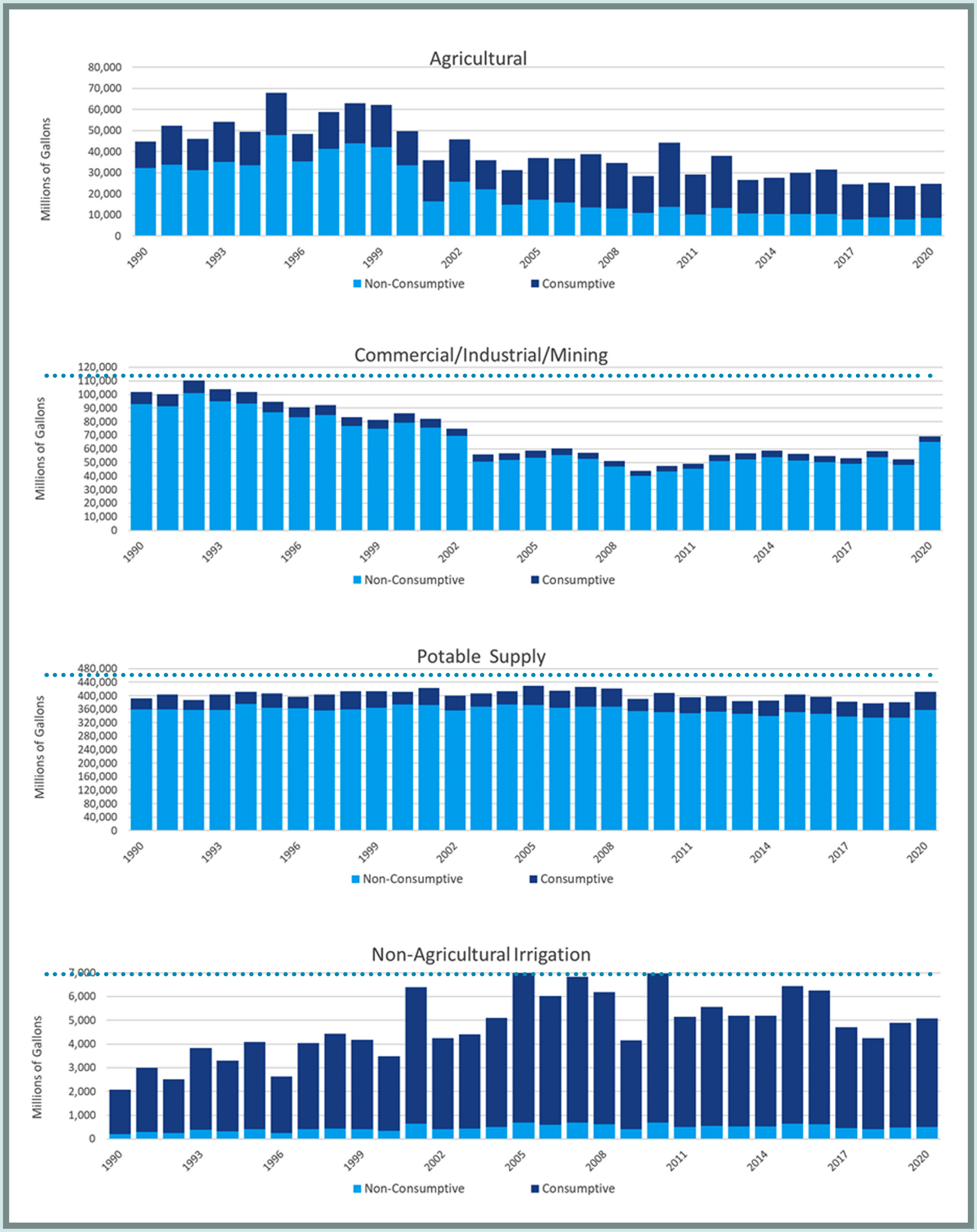


Figure 4.8 Statewide Water Withdrawals and Consumptive Use by Water Use Sector, 1990-2020.
(Note: The vertical axis scale varies significantly in magnitude between graphs.)

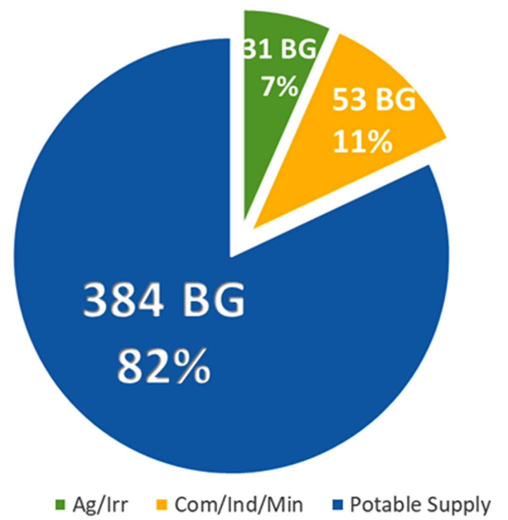


Figure 4.9a Average total water use by sector (billions of gallons and % of total), 2016-2020.

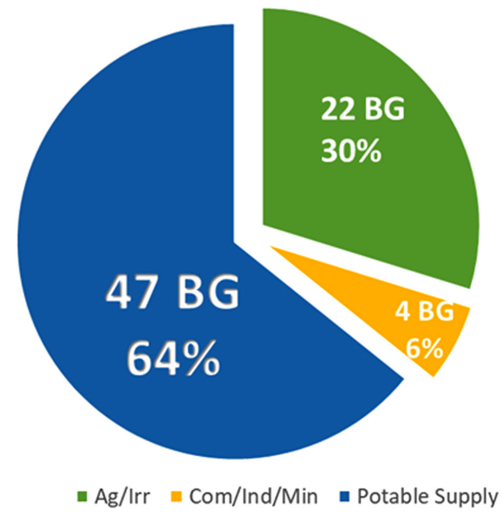


Figure 4.9b Average consumptive losses by sector (billions of gallons and % of total), 2016-2020.

The Wanaque Reservoir located along the Wanaque River in Wanaque and Ringwood, New Jersey. In addition to being located in the New Jersey Highlands, the Wanaque River is a tributary of the greater Passaic River watershed, which includes areas in both New York and New Jersey.

Depletive water uses are more difficult to map, but the NJWaTr database does track the movement of water from its source to its discharge point. In many cases, depletive uses are caused by the movement of water from a reservoir to a distribution system downstream or in another watershed entirely. In other cases, water is withdrawn from aquifers and then discharged to either fresh surface waters or to saline waters. Roughly 70% of all treated wastewater from sewage treatment plants is discharged to saline waters, leaving only 30% discharged to fresh waters where it can be used for ecological support or human purposes. As such, depletive water uses are much larger than consumptive water uses statewide, but the relative importance of consumptive and depletive water uses vary greatly from watershed to watershed.

The robust nature of the NJWaTr database allows for the tracking of water from withdrawal to use and ultimately its return to the natural system. Figure 4.10 combines this data into one Sankey diagram illustrating both the movement and magnitude of water that result as demand is met during an average year in New Jersey.

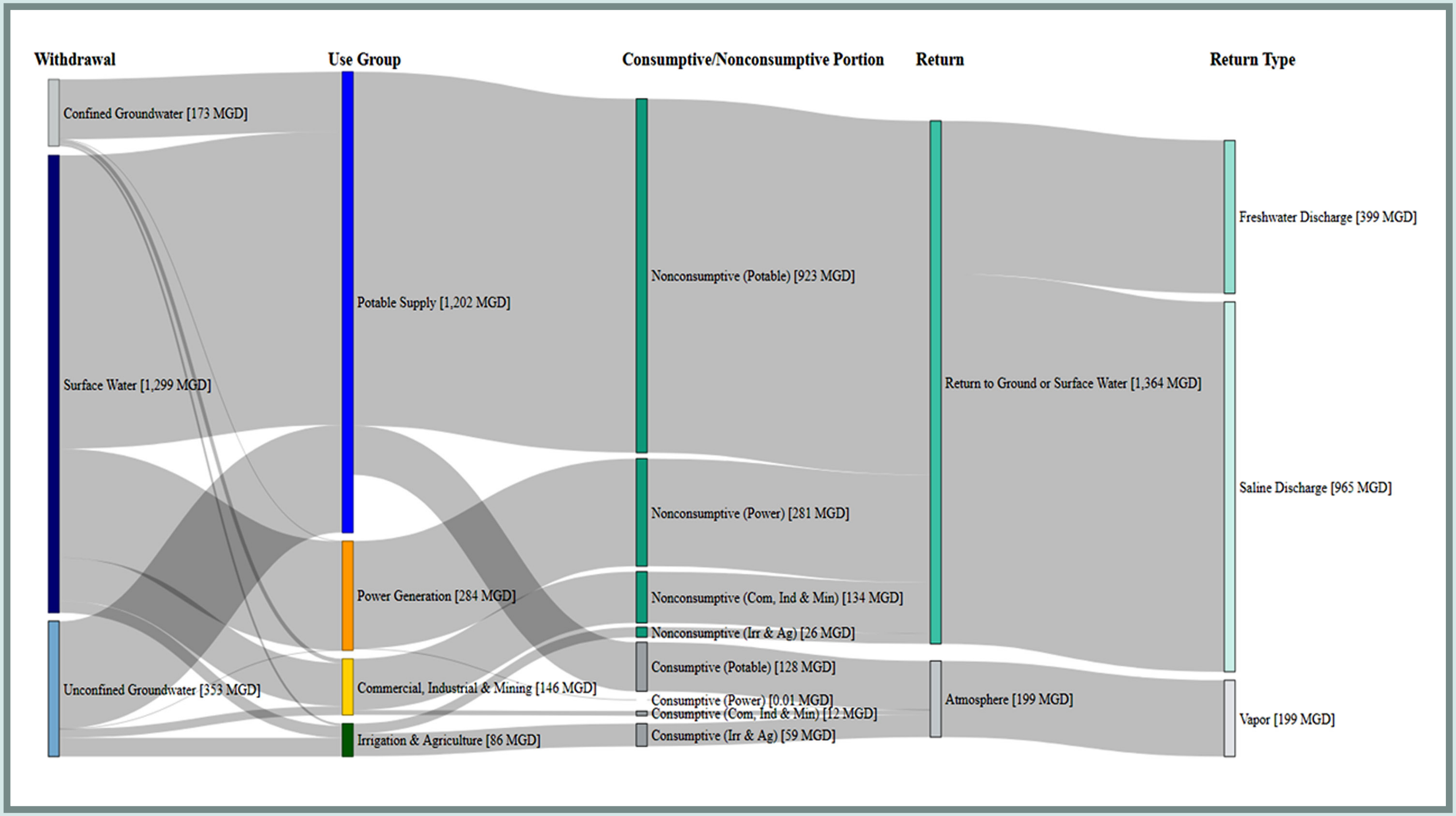


Figure 4.10 Sankey diagram displaying how statewide water withdrawals are distributed by use group and ultimately either returned via discharge or lost to the atmosphere. Displayed data is based on annual average using 2016-2020 and represented in million gallons per day (mgd).

POTABLE SUPPLY USE

Potable supply consists of the water provided by New Jersey's public water systems and individual private wells. Water use by this sector represents 384 bg statewide total and 64% of consumptive use (excluding power generation). Figure 4.11 illustrates monthly statewide potable consumptive and non-consumptive use for the study period. The data show that overall non-consumptive use remains relatively constant, and that year-to-year variability is driven primarily by changes in consumptive water use, primarily driven by outdoor water uses.

Oradell Reservoir managed by Veolia Haworth in Haworth, New Jersey. Reservoirs help to meet statewide needs for potable supply, which is the most significant water use in New Jersey.

Another important factor associated with potable supply water use is population. According to the U.S. Census Bureau, New Jersey's population increased more than 19.7%, from 7.76 million people in 1990 to 9.29 million in 2020. This increase in population and the associated water demand has been tempered by reductions in non-residential (i.e., commercial/industrial) water use and reduced residential demands from the integration of low-flow plumbing fixtures in new construction and the replacement of old appliances and plumbing fixtures with new water efficient versions. Figure 4.12 shows gross total per capita use rates for potable supplies (i.e., total demand for all public supply uses divided by total population, not just the residential demand component). Use varies annually, but the data clearly show a general downward trend in statewide per capita use rates. However, the per capita demands vary greatly among public community water systems, depending on several critical factors, including but not limited to: (a) the mix of residential, industrial, commercial and public facility land uses; (b) geographic location; and (c) system water losses.

From a difference perspective, Figure 4.13 shows per capita consumptive use in the potable supply sector, where the trend, though variable, is certainly not decreasing and possibly slightly increasing. The variability is driven, in part, by normal precipitation and temperature variations. The trend is driven, in part, by increases in outdoor water use for non-potable purposes such as landscape irrigation and recreation. And from the likely extension of the peak demand season due to the warmer temperatures New Jersey has and will continue to have.

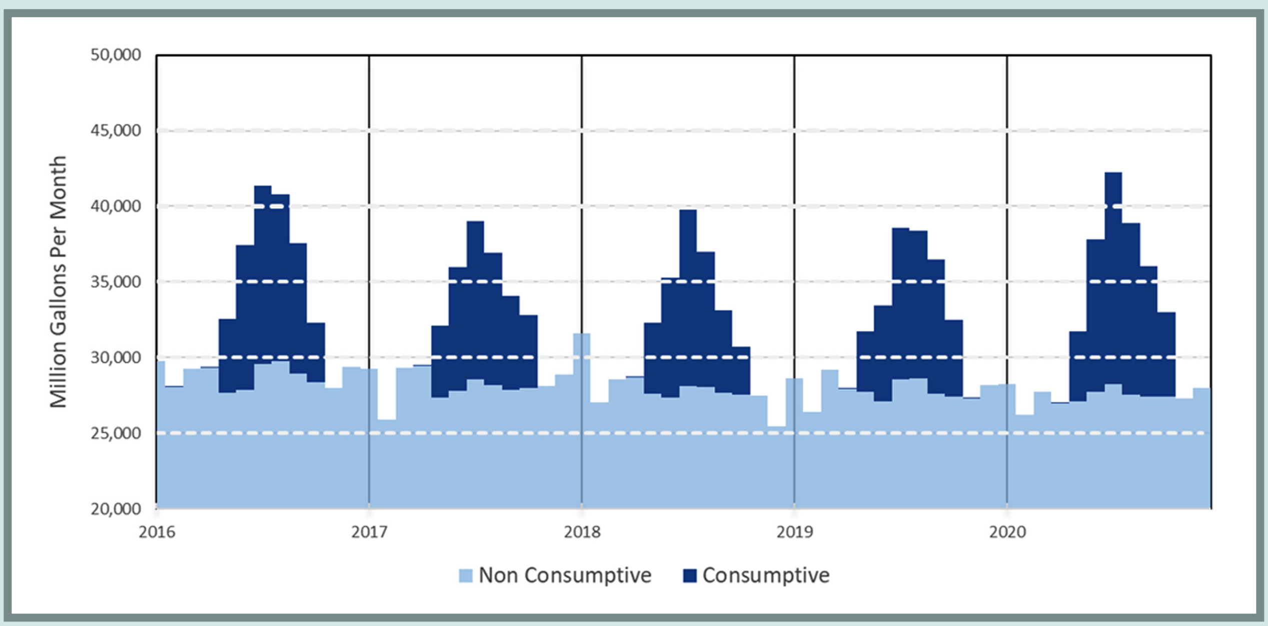


Figure 4.11 Statewide Monthly Consumptive and Non-Consumptive Potable Supply Use, 2016-2020.

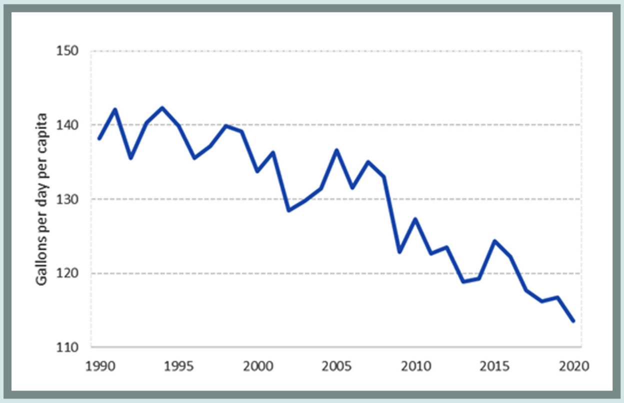


Figure 4.12 Gross Potable Supply Demands Per Capita, 1990 to 2020.

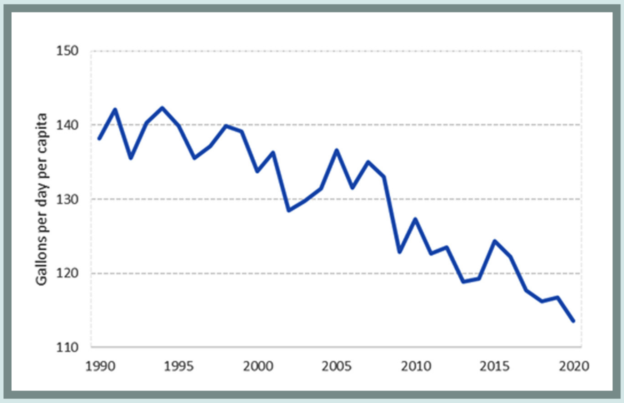


Figure 4.13 Potable Supply Consumptive Use Per Capita, 1990 to 2020.

ESTIMATING FUTURE WATER NEEDS

Forecasts of future water needs play an important role in water supply planning. DEP commissioned a report from Rutgers University to estimate 2040 demands for 584 public community water systems (PCWS); the report was published in 2018 (Van Abs et al., 2018). The report provided a detailed statewide assessment of residential per capita water demands and how they differ geographically and seasonally, based on monthly household demand data representing 45% of all residential customers in New Jersey. It also included the first statewide analysis of water losses based on available data from DEP and the Delaware River Basin Commission (DRBC). A spreadsheet model provided multiple demand scenarios based on different levels of residential conservation and water loss reduction.

While results differed among the PCWS, the statewide demands under the conservation scenarios were more than 10% lower than the "business as usual" scenario. The largest 37 PCWS, which supply 80% of all residential customers, emphasize the importance of analyzing individual systems, as 26 showed flat or declining demands under the best Conservation scenario, while 11 showed increasing demands. Of those with increasing demands, some are isolated systems with few options for additional supplies through interconnections, while others are in highly interconnected regions.

For the Plan, the Rutgers model was updated to estimate demands for the year 2050. The new analysis incorporates much of the 2040 model, especially the per capita residential demands, with the following updates:

- population projections using recent (though pre-2020 census) models from New Jersey's Metropolitan Planning Organizations (MPOs), the North Jersey Transportation Planning Agency, the Delaware Valley Regional Planning Commission, and the South Jersey Metropolitan Planning Organization;
- updated water loss analyses using more current information from DEP and DRBC;
- updated PCWS service area maps from DEP;
- updated analyses of the split between residential, commercial and industrial demands for PCWS;
- updated analyses of seasonal demands in coastal PCWS with large tourist water demands; and
- comparison of the demand scenarios to current available water supplies, based on water allocation permits and contracts as tracked through the DEP Water Deficit/Surplus Analysis system.

The detailed methodology and results are provided in Appendix D – 2050 Forecast Water Demands for Public Community Water Systems. The following discussion summarizes the results.

POPULATION PROJECTIONS

The MPO projections are based on pre-2020 census population estimates, which introduces some differences between the MPO estimates for 2020 and the 2020 census results. Statewide, the MPOs projected 8.94 million people for 2020, but the 2020 census population is 9.28 million, 3.7% higher. The MPO projections to 2050 show a state population of 10.05 million, an increase of 12.4% from the 2020 MPO estimate, but only 8.3% above the 2020 census population. The median difference for all municipalities is 3.6% (average of 5%), while the median for the largest 50 municipalities (based on 2020 size) is 4.4% (average of 5.2%). Table 4.2 provides examples of the population differences for the largest 10 municipalities. The differences range from 2% in Woodbridge Township to 32.6% for Lakewood Township. These differences create some uncertainty in the analysis of future water demands, but there are no other municipal population projections to the year 2050. Therefore, the MPO values are used in this Plan for planning purposes, with the expectation that during the next few years each MPO will update its projections using the 2020 census, at which point the PCWS water demand forecasts can likewise be updated. It is important to note that the PCWS demand forecast scenarios are based on percent population changes between 2020 and 2050; the method uses 2020 and 2050 MPO values, providing a sufficiently robust percentage change, even though the 2020 MPO starting point is different from the 2020 census.

Table 4.2 Largest 10 Municipalities: Population Estimates and Projections

Municipality	County	2020 Census Population	Percent Change 2010-2020	% Difference (2020 Census/ 2020 MPO Estimate)	2020 MPO Population Estimate	2050 MPO Population Estimate
NEWARK CITY	Essex	311,549	12.4	8.4	286,551	334,773
JERSEY CITY	Hudson	292,449	18.1	9.8	265,127	387,098
PATERSON CITY	Passaic	159,732	9.3	5.2	151,568	179,976
ELIZABETH CITY	Union	137,298	9.9	5.0	130,593	158,829
LAKEWOOD TWP	Ocean	135,158	45.6	32.6	97,381	118,710
EDISON TWP	Middlesex	107,588	7.6	5.7	101,651	108,805
WOODBRIDGE TWP	Middlesex	103,639	4.1	2.0	101,572	111,356
TOMS RIVER TWP	Ocean	95,438	4.6	2.5	93,106	111,843
HAMILTON TWP	Mercer	92,297	4.3	5.8	87,093	88,912
TRENTON CITY	Mercer	90,871	7.0	8.9	83,148	85,861

PCWS WATER LOSSES

The water loss analyses were completely updated for this Plan, using new years of data from the DRBC (all of which used the Water Loss Audit v.5 of the American Water Works Association) and a major new data set from DEP. For both data sets, the years 2018 and 2019 were used to reflect pre-pandemic patterns. The detailed results are provided in Appendix E– New Jersey Assessment of Water Losses for Public Community Water Systems.

Statistical analyses provided new insights. First, analysis confirmed that the DRBC and DEP data could be used in combination, representing 234 PCWS (with DRBC data being used for any PCWS that also reported data to DEP). Second, the analysis showed that PCWS with service areas located primarily in bedrock geology had significantly different results than PCWS in the coastal plain. With the new data, there was no statistically significant difference between the small, medium and large PCWS in each region; PCWS results are therefore combined by region. The statistically significant differences between the Bedrock and Coastal Plain water losses provide a basis for different planning targets in the two regions.

In all cases, the real water losses will be slightly lower. Using the DRBC data set, which provides estimates of real, apparent and total water losses, real water losses comprise the vast majority of total water losses (average of 85.5% and median of 94%). Table 4.3 shows the results for Water Losses (Real plus Apparent) and a Real Losses result that assumes real water losses are 90% of all water losses.

Table 4.3 Median and 25th Percentile PCWS Water Losses

Water Loss Metric	Median Bedrock % Water Loss	Median Coastal % Water Loss	25th Percentile Bedrock % Water Loss	25th Percentile Coastal % Water Loss
All Losses	17.0	12.0	13.0	8.1
Real Losses	15.3	10.8	11.7	7.3

The median results are used as an indicator of what the median utility currently achieves regarding water losses. The 25th percentile results are used as an indicator of what PCWS with robust asset management programs can achieve regarding real water losses. The consistent differences between PCWS in the two geophysical areas indicate that PCWS in the Bedrock Provinces may have a long-standing potential for higher real water losses, which will be a factor in 2050 water withdrawals in those areas.

RESIDENTIAL, INDUSTRIAL AND COMMERCIAL (RIC) DEMANDS

While many small PCWS only have a single customer category (usually residential), larger systems will have a mix of residential (single family and multi-family), industrial, commercial and public facilities customers. Public facilities are included in the commercial category as similar in nature though not ownership. Estimates of residential, industrial and commercial (RIC) demands for all PCWS are feasible using a combination of (a) service area distribution among the three major land use categories, and (b) specific RIC data from some PCWS.

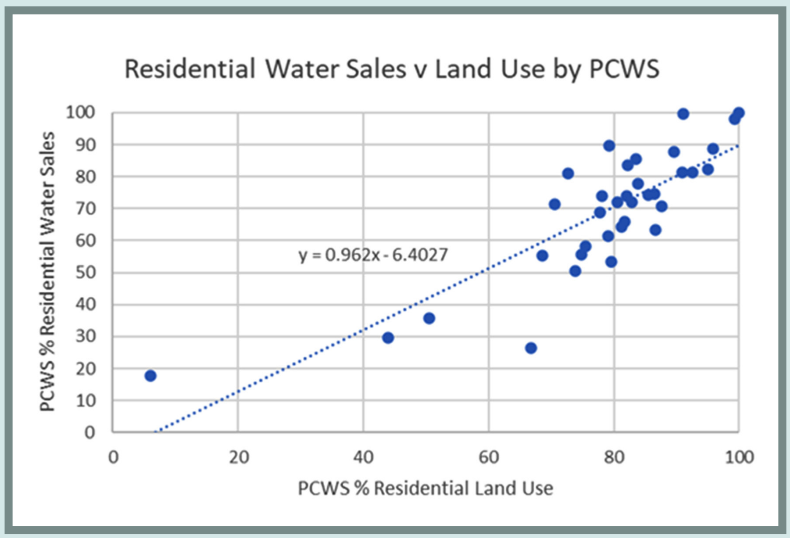


Figure 4.14 Percent PCWS Residential Demands Relative to Residential Land Use (n=210).

The new analysis includes recent demands by customer category from 35 PCWS, allowing for a better estimation of RIC demands using extrapolations based on land use distributions. RIC data were received from NJ American Water (multiple systems), Evesham Township MUA, East Brunswick, Ridgewood, Passaic Valley Water Commission, Sayreville, South Brunswick, and Washington Township (Gloucester County) MUA. Earlier data provided by Newark were also used.

In addition, DEP received 2019-2021 residential demand information (as a percentage of total billed demands) from 210 PCWS as part of the Water Quality Accountability Act reporting process. While a few of the reported values are questionable, most results can be used as part of the analysis. Figure 4.14 shows the results for all 210 PCWS that provided results, compared to the percentage of their developed service area (i.e., excluding forests, wetlands, open waters and parks) in residential land use.

The combined data allowed for improved estimates for residential, industrial and commercial (including public facility) demands across all PCWS. Reported data were used where available. The reported information was used to develop relationships between land use coverage in the PCWS service area and sector demands, which were then applied to the remaining PCWS. The full analysis is provided in Appendix F– Estimating New Jersey Residential, Industrial and Commercial Demands by PCWS.

SEASONAL DEMAND ANALYSIS FOR COASTAL AND NON-COASTAL PCWS

Most PCWS have somewhat higher summer-season demands (June through September) than for the rest of the year, reflecting outdoor water demands such as landscape irrigation. However, some PCWS have a very different pattern of demands that reflect major population shifts during the summer tourist season, where resident populations can jump sharply. For this reason, these tourism centers need to be identified and treated differently in the modeling process than other PCWS. Based on a review of monthly demand data for 464 PCWS from DEP's NJ Water Tracking (NJWaTr) database, the median ratio of summer to non-summer demands for non-coastal PCWS (407 systems) is only 1.2, indicating a 20% increase in the summer. Coastal PCWS were defined as those with over 50% of their service area within one mile of the coast along the Jersey Shore (Monmouth, Ocean, Atlantic and Cape May counties), and were further subdivided into Barrier Island and Non-Barrier Island PCWS. The latter group (24 systems) show a significantly higher median ratio of summer to non-summer demands, of 1.55. However, the Barrier Island PCWS (33 systems) show a markedly higher ratio, of 3.17, indicating that the summer demands are three times the non-summer demands. Figure 4.15 shows the results for the four PCWS categories.

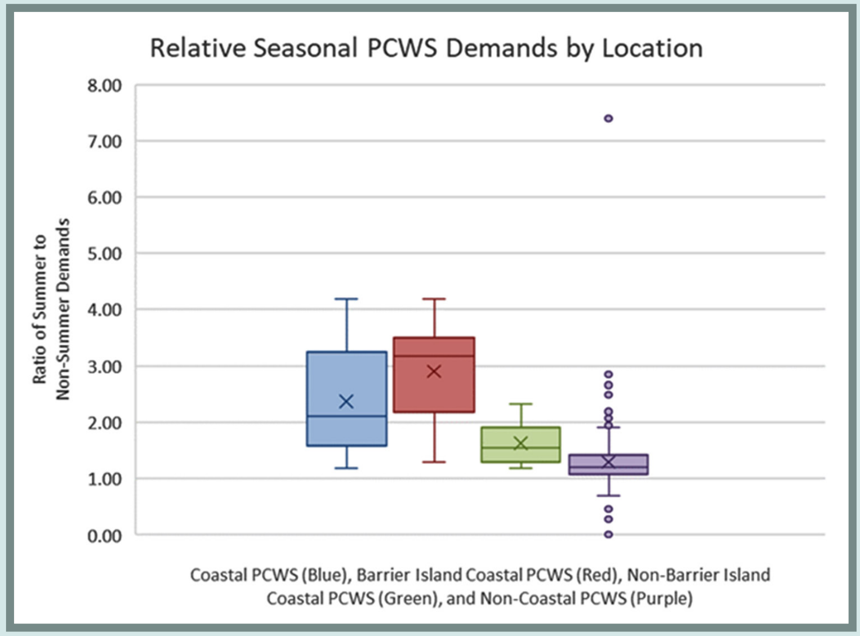


Figure 4.15 Seasonal Demand by PCWS Category.

Even within the Barrier Island systems, the results differ a great deal. Table 4.4 shows the summer and non-summer average demands for key tourism-focused PCWS. Atlantic City, which has a year-round tourism industry (casinos), has a ratio of only 1.3, close to the non-coastal median. Avalon, on the other hand, has a summer demand more than four times its non-summer demands.

2050 PCWS DEMAND SCENARIO RESULTS

The final step in the PCWS demand projections is to use the results of the analyses discussed above to create a new demands model for the year 2050. Full results are available in Appendix D- 2050 Forecast Water Demands for Public Community Water Systems. The model has the following general structure:

1. **2020 Demands:** For each of the 583 PCWS in DEP's Deficit/Surplus Analysis spreadsheet, use the peak annual demands and the 2016-2020 annual average demands to estimate four demand components: total water losses, residential demand, commercial demand, and industrial demand. Separate commercial and industrial demands were only available from PCWS that supplied the relevant information (35 PCWS). For the other PCWS, commercial and industrial demands were combined and calculated by subtracting residential demands and water losses from theannual value. For each PCWS, summer and non-summer total demands are calculated based on the seasonal analysis discussed above.

PCWS (>1 MGD Annual Average Demand)	Summer Average Demand (mgd)	Non-Summer Average Demand (mgd)	Ratio of Summer to Non-Summer Demands
Atlantic City MUA	10	7.8	1.3
Wildwood Water Dept	6.3	2.5	2.6
NJ American Water Co	4.7	1.5	3.2
Brigantine Water Dept	2.8	1.1	2.6
Lower Twp MUA	2.0	1.2	1.7
Cape May Water & Sewer Utility	2.0	0.95	2.1
Margate Water Dept	2.2	0.84	2.6
Ventnor City Water & Sewer Utility	1.7	0.98	1.7
Avalon Water & Sewer Utility	2.2	0.54	4.2

Table 4.4 Summer and Non-Summer Demands for Barrier Island Coastal PCWS (>1 mgd Annual Average)

2. **2050 Demands, Static Per Capita Demands:** This analysis projects water demands to the year 2050 assuming no change in residential per capita demands; total residential demands change by the percentage population change, either higher or lower. Commercial demands also change by percentage population change, based on the assumption that changes in residential populations and commercial land uses are closely correlated, with the commercial land uses reflected sources of jobs and retail sales for the nearby population. Industrial demands are assumed to be unchanged, as there is no viable approach for estimating changes in industrial production. Only 50 PCWS have service areas with industrial land use greater than 10%. In some cases, those industrial land uses will have minimal water demands relative to land area (e.g., warehousing) while in other cases the water demands will be large (e.g., beverages).

   Water Loss Scenarios: This analysis also includes three scenarios for water losses.

   a. The first uses the current water loss percentage, where available, or the median water loss rate for either coastal or bedrock areas where a PCWS-specific rate is not available.
   b. The second applies the median water loss percentage to all PCWS (“Nominal Loss”).
   c. The third applies the 25th percentile water loss percentage (“Optimal Loss”) to all PCWS.

   There is no specific method for projecting water losses, as each PCWS will have its own assessment management approach and will differ in customer base, land use patterns, infrastructure age, etc. Using the three percentages (current, median and 25th percentile) provides a way of assessing potential impacts if a specific PCWS remains at current levels or moves toward the median or 25th percentile (either up or down from current levels). These scenarios reflect the potential for PCWS to either reduce or increase their water loss rates.

3. **2050 Demands, Declining Per Capita Demands:** This analysis also projects PCWS demands to the year 2050, but assuming that residential and commercial conservation will reduce demands by 10% from the prior analysis. This assumption differs from the more detailed approach used in the 2018 model for the year 2040, which evaluated potential residential demand changes based on land use density and recent per capital demands. However, the per capita demands are now somewhat less current and the projection has been extended from 2040 to 2050. Using a single value of 10% conservation over the period from 2020 to 2050 provides insight into potential water savings. It also allows the model to be modified to any desired percentage to test scenarios. The three water loss scenarios are used for this also.

The analysis was performed for all 583 PCWS listed in the DEP Deficit/Surplus Analysis spreadsheet (current as of June 2022). Of these, three systems are excluded from the discussion below because they do not have their own service areas, but rather provide bulk treated water to other PCWS that are included in the analysis. Of the 580 PCWS remaining, 541 have available data for peak demands, and 552 have available data for 2016-2020 annual average demands. The statewide results for all PCWS with data are shown in Table 4.5. The largest 10 PCWS account for 50% of the total 2016-2020 average demands, the largest 64 PCWS account for 80%, and the largest 118 PCWS account for 90%.

The 2050 results for the largest 10 PCWS (by 2016-2020 average demands) are shown in Table 4.6. Compared to the statewide average growth between 2020 and 2050 of 12.4%, Jersey City MUA has a high rate of expected growth at nearly 33%. Several systems have expected population changes at roughly the statewide average, but others, such as Trenton Water Works (serving four municipalities) are projected to experience no growth or slight reductions in population.

Table 4.5. 2020 Statewide Water Demands

D/S Total Limits (mgd)	D/S Peak Annual Demand (mgd)	NJWaTr 2016-2020 Average Demand (mgd)
1,986	1,338	959

The relationship between the 2016-2020 average demands (used as the 2020 base) and the various 2050 scenarios primarily reflects a combination of population and water loss changes. For example, some systems show a major drop between 2020 and 2050, despite increasing population, indicating that reaching the median (nominal) or 25th percentile (optimal) water loss rates would decrease demands significantly. In other cases, the current water losses are not greatly different from the nominal water losses used in the scenarios, and so population change will be the major factor. All of the largest ten PCWS are in bedrock geology service areas, except for New Jersey American Water-Coastal North. For the bedrock PCWS, the nominal water loss is 17%; for coastal plain PCWS, the nominal water loss is 12%.

The most optimistic scenario for annual average water demands is the last, where a 10% reduction in residential and commercial demands is assumed along with optimal water losses (13% for bedrock and 8.1% for coastal plain). In this scenario, for the largest 10 PCWS, the only PCWS with projected demands greater than the 2020 baseline is Jersey City. Given that older systems will have a harder time meeting the optimal water loss scenario, it is likely that 2050 demands will be higher. Figure 4.16 shows the percent change in average annual demand based on a comparison of this scenario to 2016-2020 average annual demand. Due to the optimistic nature of the scenario applied, some systems show significant decreases in demand. Smaller systems that project to experience population growth may be on the opposite end of the spectrum, showing significant percent increases in demand.

Table 4.7 provides similar information but with 2020 peak demands compared to the equivalent scenarios. Again, Jersey City MUA stands out as the only PCWS among the largest 10 that has projected peak demands exceeding the 2020 baseline across all scenarios. It is also the only one of the 10 where a peak demand scenario for 2050 exceeds the total limits of the PCWS as determined by DEP (56.8 mgd, from its two reservoirs). In total, 22 PCWS have at least one scenario (generally a peak demand scenario) that exceeds the PCWS total limits. In some cases, the PCWS already purchases water from other systems with sufficient capacity to meet their needs, but in others the PCWS is entirely reliant on local sources and therefore would face greater difficulties in expanding supplies. A few PCWS have one or demand scenarios that would only come into play if their current water loss rates increased to the median for their region; these systems currently have low water loss rates.

None of the scenarios should be viewed as predictions. Rather, they provide a suite of possibilities showing the relative effects of population change, asset management effectiveness and water use efficiency. By linking these demand scenarios to specific water withdrawals, it is feasible to evaluate whether one or more scenarios would involve an excessive withdrawal from a resource, based on water allocation permits, safe yield models, or aquifer models.

Table 4.6. 2050 Water Demand Projections from 2016-2020 Average Demands for Largest 10 PCWS Systems

PCWS System			Population	NJWaTr	2050 No Conservation Scenario		2050 Conservation Scenario	
PWSID #	**County**	**Name**	**% CHANGE 2020-2050**	**2016-2020 Average Demand (mgd)**	**Nominal Water Loss Scenario (mgd)**	**Optimal Water Loss Scenario (mgd)**	**Nominal Water Loss Scenario (mgd)**	**Optimal Water Loss Scenario (mgd)**
NJ0238001	Bergen	Suez Water New Jersey - Haworth	11.8	104	111	105	99	94
NJ2004002	Union	New Jersey American Water - Raritan System	11.0	98	79	75	72	69
NJ0714001	Essex	Newark Water Department	10.9	53	42	41	40	38
NJ1605002	Passaic	Passaic Valley Water Commission	13.0	48	53	51	48	46
NJ1345001	Monmouth	New Jersey American Water - Coastal North	-1.4	39	36	35	33	31
NJ0712001	Essex	New Jersey American Water - Passaic Basin	5.1	32	31	30	28	27
NJ0906001	Hudson	Jersey City MUA	32.9	31	41	39	36	35
NJ0327001	Burlington	New Jersey American Water - Western Division	-0.7	28	28	27	25	24
NJ1111001	Mercer	Trenton Water Works	-0.1	26	25	24	23	22
NJ1225001	Middlesex	Middlesex Water Company	6.4	20	23	22	21	20
TOTALS (Largest 10 PCWS, representing 50 percent of total 2016-2020 average statewide demands)				**480**	**469**	**448**	**426**	**406**
TOTALS (Largest 64 PCWS, representing 80 percent of total 2016-2020 average statewide demands)				**763**	**771**	**736**	**698**	**666**
TOTALS (All PCWS) NB: Many very small systems lack available information on current and therefore projected demands				**957**	**977**	**933**	**883**	**843**

Table 4.7. 2050 Water Demand Projections from 2016-2020 Peak Demands for Largest 10 PCWS Systems

PCWS System			Population	Deficit/ Surplus	2050 No Conservation Scenario		2050 Conservation Scenario	
PWSID #	County	Name	% CHANGE 2020-2050	Peak Annual Demand (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)
NJ0238001	Bergen	Suez Water New Jersey - Haworth	11.8	103	109	104	98	93
NJ2004002	Union	New Jersey American Water - Raritan System	11.0	141	114	108	105	100
NJ0714001	Essex	Newark Water Department	10.9	76	62	59	58	55
NJ1605002	Passaic	Passaic Valley Water Commission	13.0	84	94	89	85	81
NJ1345001	Monmouth	New Jersey American Water - Coastal North	-1.4	47	44	42	39	38
NJ0712001	Essex	New Jersey American Water - Passaic Basin	5.1	36	36	34	32	31
NJ0906001	Hudson	Jersey City MUA	32.9	49	64	61	57	55
NJ0327001	Burlington	New Jersey American Water - Western Division	-0.7	43	43	41	39	37
NJ1111001	Mercer	Trenton Water Works	-0.1	29	27	26	25	23
NJ1225001	Middlesex	Middlesex Water Company	6.4	41	47	45	42	40
TOTALS (Largest 10 PCWS, representing 50 percent of total 2016-2020 average statewide demands)				**650**	**637**	**608**	**579**	**553**
TOTALS (Largest 64 PCWS, representing 80 percent of total 2016-2020 average statewide demands)				**964**	**972**	**928**	**880**	**841**
TOTALS (All PCWS) NB: Many very small systems lack available information on current and therefore projected demands				**1203**	**1220**	**1165**	**1104**	**1054**

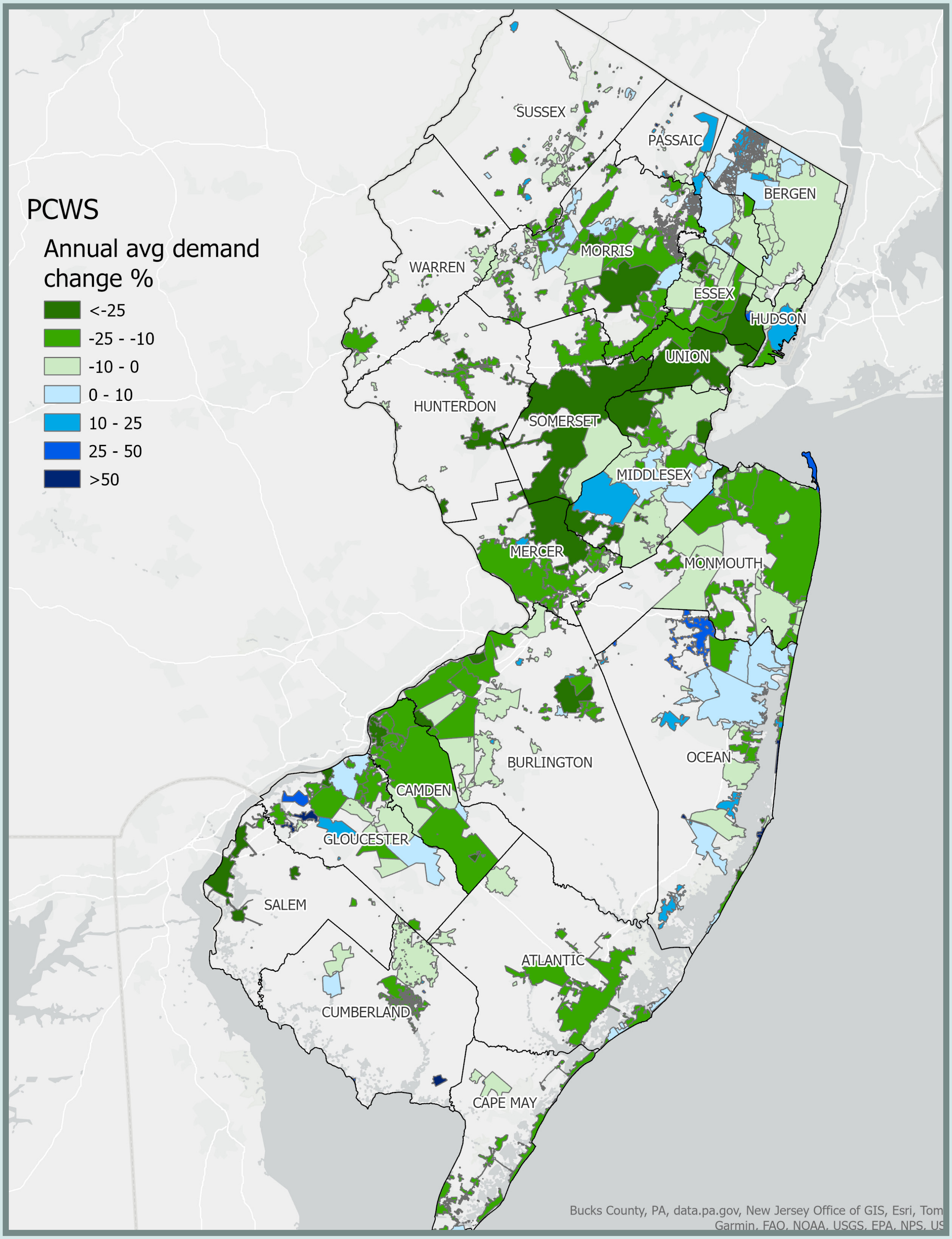


Figure 4.16 Percent change from current (2020) annual average demands to projected (2050) demands based on the optimal water loss scenario.

IMPACTS AND SHORTFALL ANALYSIS

Natural resource availability from New Jersey's three primary resources (surface water supply reservoirs, streams and unconfined aquifers, and confined aquifers), was quantified and then compared to current and future demand to determine net resource availability. These results were also compared to the administrative availability. Each resource has a specific set of concerns and limitations and are discussed below. The results of the three individual analyses are combined in the sections below and summarized in Table 4.8. In general, New Jersey is a water rich state, but it is also densely populated; therefore, regional and sub-regional shortfalls do occur, and water-supply droughts and emergencies periodically occur. Potential climate change driven impacts on water availability create additional uncertainty, but initial assessment conducted for this Plan update shows that supplies will remain the same or slightly increase (but more work is needed to conform these findings). The information contained below is meant to be used for water resource management and needs to be used in conjunction with the established permitting/regulatory process.

UNCONFINED GROUNDWATER AND SURFACE WATER

The withdrawal of water from the surface water and unconfined aquifer system reduces streamflow. This is a function of water depletion due to depletive and consumptive water loss within the HUC11, balanced by any water gains from imports to the HUC11. The net loss is then compared to the low-flow margin, an estimate of the amount of water that can be lost from the surface water and unconfined aquifer system without creating unacceptable ecological impacts (see Chapter 2 for more details). The results are provided by HUC11 as a starting point for analysis of existing and future water demands, but they are not definitive. The availability of water supply from unconfined and surface water may be additionally constrained by the following:

- wetlands and ecologically sensitive areas affected by existing or proposed wells;
- watersheds where the withdrawal of 25% of the Low Flow Margin represents an unacceptable level of streamflow reduction during low-flow periods (e.g., the 7Q10);
- interference or new or increased withdrawals with other water users;
- contamination and other water quality issues; or
- restrictions as a result of the Highlands Act, Highlands Regional Master Plan and Highlands Preservation Area Rules (N.J.A.C. 7:38).

After documentation of the stream low flow margin (LFM) method in NJGWS Technical Memorandum 13-3 and initial implementation in the 2017 Plan, it was determined that several modifications were needed to more accurately reflect the complex hydrogeologic and hydrologic relationships that exist within a drainage basin, and to better identify regions that may be experiencing hydrologic stresses and require further investigation or action by the DEP. Those changes are outlined below. Unless specifically noted, the method components are the same as defined in TM13-3.

- Water use data period:
    - The 2017 Plan used data from 2000-2015.
    - The 2011-2020 period is used in this Plan to determine peak use due to stabilization of trends in water use over that period.
- Peak use representation:
    - Peak annual use will be selected from the three-consecutive year period with the highest average net water loss from 2011-2020 with the last year used to indicate the multi-year period. The 2017 Plan used the single recent year with highest loss.
    - The change is designed to reflect the complexity of unconfined groundwater storage and corresponding base flows, and that a single year may not accurately represent current peak use conditions. DEP recognizes that some aquifer areas may respond more quickly to withdrawals during dry periods; this issue is addressed through the water allocation permit process.

- Discharges to saline waters:
    - o These discharges will no longer be incorporated into remaining available water calculations since such discharges have very different hydrologic impacts on the watershed. These volumes are still tracked in the summary data tables as potential future resources.
- Additional considerations:
    - o Upstream stressed HUC: Highlights any HUC that is downstream of another that has been identified as stressed.
    - o In a stressed WMA: Net loss was subtracted from total availability for each WMA in the same manner that is carried out on a HUC-by-HUC basis. If a WMA is identified as stressed, all HUCs within are flagged for a potential availability limitation.

The following charts depict water loss by HUC11 from the unconfined groundwater and surface water (aka non-reservoir) sources only and how different uses impact overall water loss. For each chart, the coastal areas are shown in gray (Ocean/Bay HUCs) and as having limited availability because any treated wastewater effluent cannot be reused once discharged, as discussed above. In addition, for Figures 4.17, 4.19 and 4.21(a) and (b), the Highlands Region is whited out as the Highlands Council's planning water resource planning policies in the Highlands Regional Master Plan have primacy, pursuant to 2004 amendments to the Water Supply Management Act.

- **Figure 4.17** shows the estimated amount of unconfined groundwater and surface water lost from each HUC11. Of 151 HUC11s, eight indicate more than 10 mgd of net loss, but many HUC11 show losses from 0-3 or 3-10 mgd. The areas showing highest gains (3-10 or more than 10 mgd) have major freshwater discharges of treated wastewater effluent, generally from regional systems that draw their water from other HUC11(s). The largest such flow is the Camden County Municipal Utility Authority discharge (dark blue), which is allocated to a HUC11 but technically located at the base of the HUC11 and very near a freshwater tidal reach of the Delaware River estuary.
- **Figure 4.18** shows the unconfined groundwater and surface water use responsible for the greatest water loss in each HUC11. In this case "Primary Loss" means the largest source of consumptive/depletive water loss, which may or may not be a majority of the consumptive/depletive loss in the HUC11. Potable supply demands are the most frequent source of primary loss, but agricultural demands are more common in the southern area.
- **Figure 4.19** shows what the amount of unconfined groundwater and surface water loss would be if withdrawals were diverting at the full rate within water allocation permits and agricultural use certifications. The results in this chart are similar to those of Figure 4.17, but more severe in several cases and should be considered a worst case but very unlikely scenario.
- **Figure 4.20** shows the water use type responsible for the greatest amount of unconfined groundwater and surface water lost at full allocation. In this case, there is a major shift from Figure 4.18, showing far more HUC11 where potable supply demands would be the primary loss.
- **Figure 4.21a** was determined by subtracting peak water loss between 2011-2020 (Figure 4.17) from available water (Figure 2.4), which results in the remaining volume of water than can be depletively and/or consumptively lost from each HUC11. Areas shown as "limited availability" have net losses that exceed the LFM amounts available, and therefore are a potential concern and targets for additional analysis and planning (see Chapter 8: Regional Planning for Deficit Mitigation and Avoidance).
- **Figure 4.21b** shows the amount of water remaining for use from the unconfined groundwater and surface water sources only in each HUC11 assuming full allocation withdrawal. This chart should be considered a "worst case" analysis, as in many if not most cases, the full allocation level of existing permits is unlikely to be achieved. As many regions are dominated by potable supply demands, the earlier analysis of 2050 PCWS demands is relevant, showing the most PCWS are likely to have reduced, not increased, demands. Still, this chart is another factor in selecting regions for further analysis and planning.

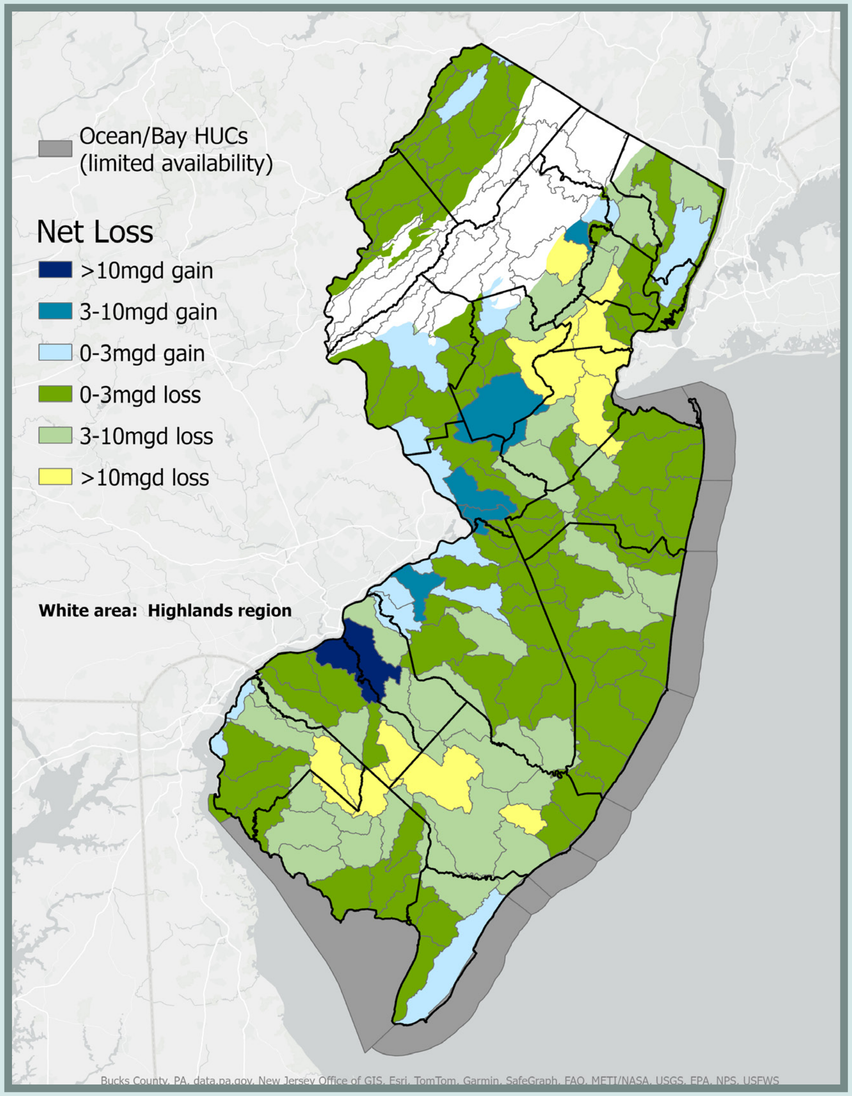


Figure 4.17 Depletive and consumptive loss from unconfined groundwater and surface water sources at peak use rates used in analysis.

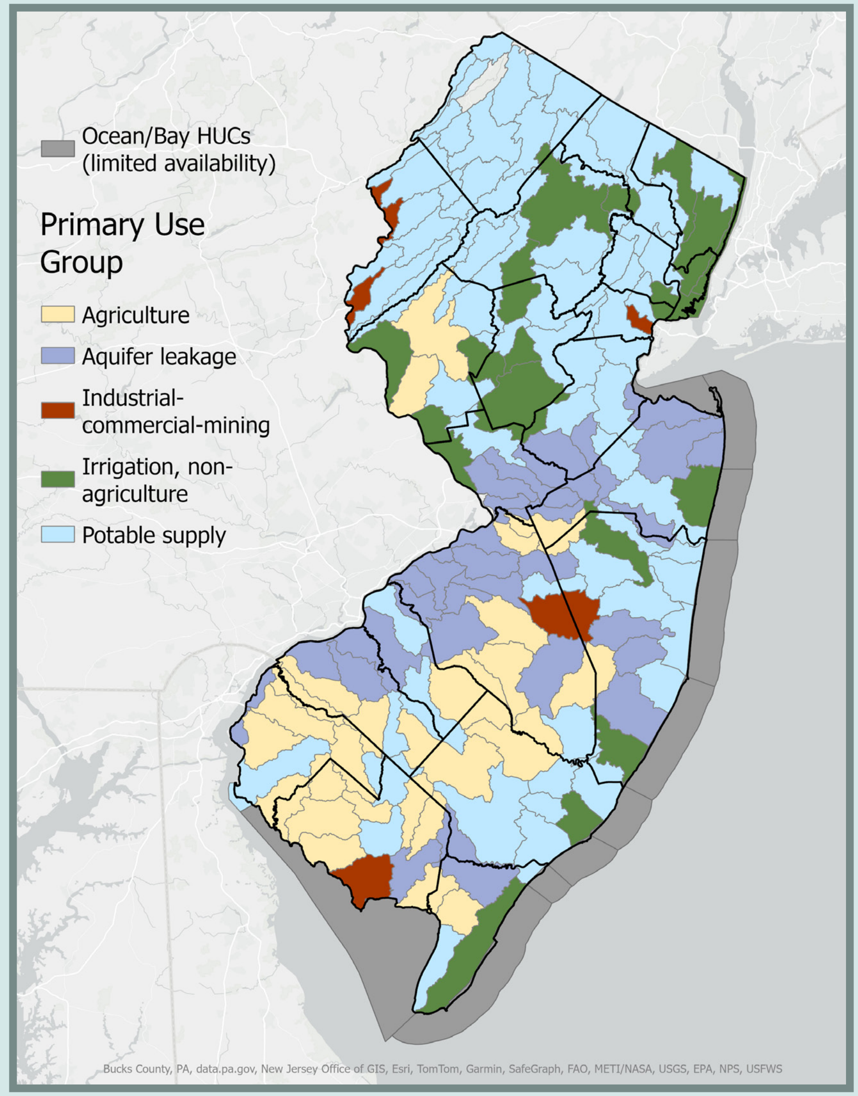


Figure 4.18 Primary causes of depletive and consumptive loss at peak use rates used in analysis.

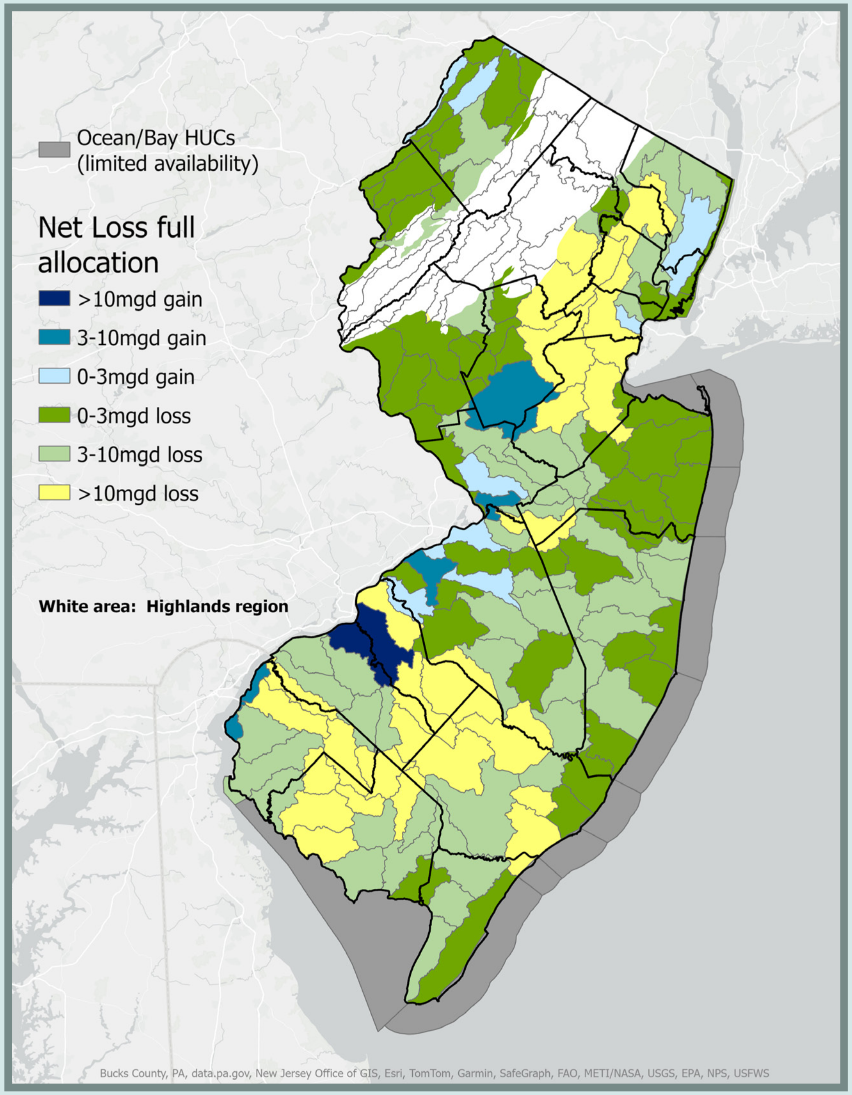


Figure 4.19 Depletive and consumptive loss from unconfined groundwater and surface water sources at full allocation use rates as of 2020.

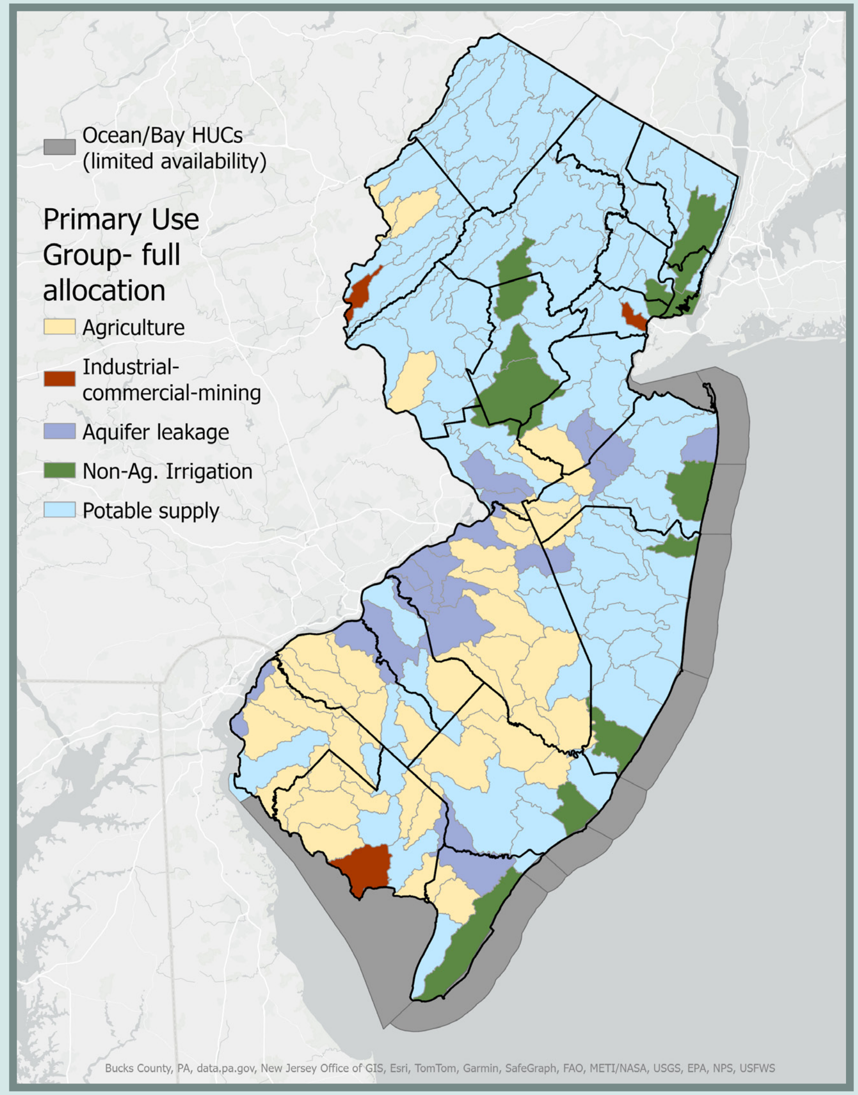


Figure 4.20 Primary causes of depletive and consumptive loss at full allocation use rates as of 2020.

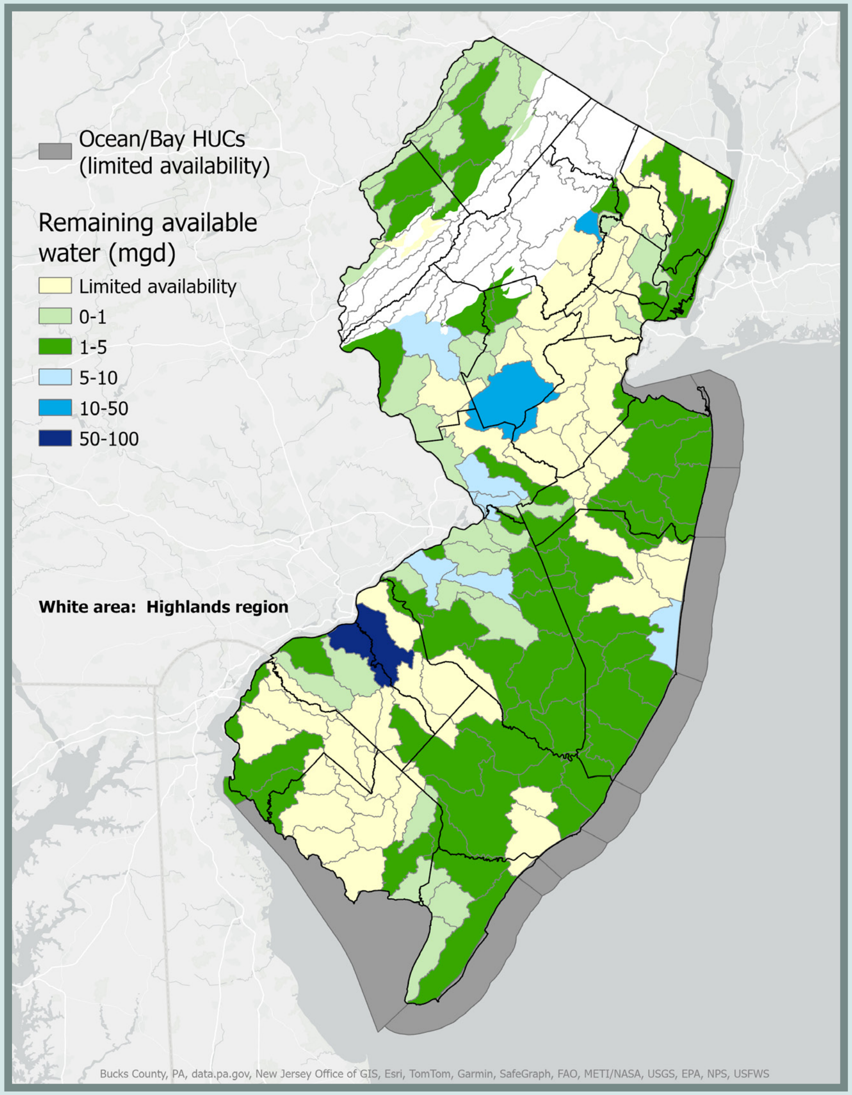


Figure 4.21a Remaining available unconfined groundwater and surface water for depletive and consumptive use by HUC11 at peak current use rates.

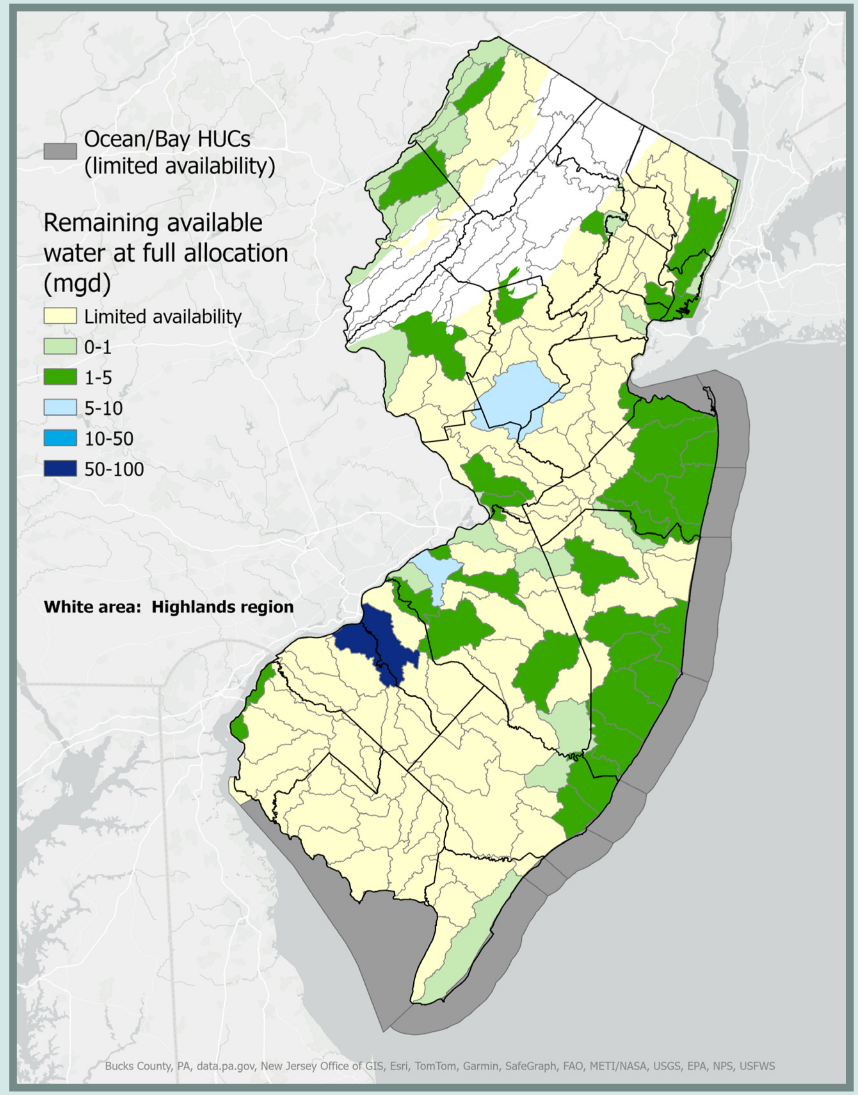


Figure 2.21b Remaining available unconfined groundwater and surface water for depletive and consumptive use by HUC11 at full allocation use rates.

CONFINED AQUIFERS

The future availability of water supply from the confined aquifers is constrained by a number of factors, including:

- **Water Supply Critical Areas:** Due to significant historic depletion, allocations in both Critical Areas (Figure 4.22) were significantly reduced starting in the 1980s by revisions to the Water Supply Management Act. This resulted in a rebound in groundwater levels over the following decades. Additional withdrawals from certain designated Critical Area aquifers are not allowed, except in accordance with the Act.
- **Saltwater intrusion:** The threat of saltwater intrusion in estuarine, seaward and bayward margins of aquifers where salty water is present or in proximity limits additional withdrawals. Pumping is usually restricted in these areas in order to not exacerbate the problem.
- **Depleted water levels:** Additional withdrawals are discouraged where groundwater levels are declining and not stabilizing.
- **Surface Water:** Near outcrop areas, confined aquifer drawdowns may migrate up-dip and affect groundwater levels under wetlands and surface waters. This potential impact may limit additional withdrawals in some areas.
- **Interference:** Increased withdrawal levels may create significant drawdowns in existing wells. In some areas this prevents DEP from approving significant additional groundwater withdrawals.

For these reasons, the assumption of this Plan is that no appreciable additional withdrawals will be feasible from the confined aquifers, though localized supplies may be available and the reconfiguration of wellfields to reduce the risk of saltwater intrusion may also result in additional supplies. Final determinations will be made during the water allocation permit review process when specific aquifer, location and volumes details can be accurately assessed.

SURFACE WATER SUPPLY RESERVOIR SYSTEMS

DEP limits the amount of water that the owner of a surface water supply reservoir system can contract to deliver to the safe yield. Safe yield that has not been committed (contracted) to a user) represents the volume of water available to supply future demand increases. Table 4.8 provides the permitted reservoir safe yields. As discussed in Chapter 3, ongoing and future safe yield modeling will need to take into consideration the potential changes due to climate change, hydrologic modifications, demand pattern, etc., potentially resulting in long-term modifications of the safe yields. While the DEP reviews all contracts for the sale and purchase of water, it is the individual PCWSs who initiate these contracts.

Table 4.8 Safe Yield and Current Demand of the Major Surface Water Supply Reservoirs

Reservoir System	System Owner	Permitted Safe Yield (mgd)	Current Average Annual Demand (mgd)
Wanaque System	NJDWSC	148*	106
NJ Hackensack System	Veolia NA	126.5*	94
Pequannock System	City of Newark	49.1	25
Rockaway System	City of Jersey City	56.8	40
Canoe Brook System	NJAW	10.8	7
Passaic Valley System	PVWC	75	48
Raritan System	NJWSA	241	176
Swimming River System	NJAW	25	23.3
Glendola System	NJAW	5.7	3.7
Manasquan System	NJWSA	30	23.7
Metedeconk System	Brick Twp MUA	17	8.1
TOTAL		**784.9**	

**Reflects shared ownership of the Wanaque South Project*

ADMINISTRATIVELY APPROVED WITHDRAWALS

The Water Supply Management Act recognizes that the water resources of the State are essential to the health, safety, economic welfare, recreational and aesthetic enjoyment, and general welfare, of the people of New Jersey. To protect these resources, the Legislature granted DEP authority to plan and manage water supplies as a common resource to meet State, regional and local water needs. The Act directs DEP to administer a regulatory program that manages the State ground and surface water supplies to safeguard quantity and quality, thereby protecting public health and safety as well as the natural resource itself. To that end, DEP adopted the Water Supply Allocation Permits Rules (N.J.A.C. 7:19), and the Agricultural, Aquacultural and Horticultural Water Usage Certification Rules (N.J.A.C. 7:20A), which together establish a uniform water allocation permit program that sets standards for diversions, and includes provisions related to planning, project review, monitoring, reporting, and enforcement.

The water allocation permitting program is administered by DEP's Division of Water Supply & Geoscience (DWSG). As of mid-2021, DWSG managed 578 active water allocation permits, 728 water use registrations, 717 agriculture water usage certifications, and 141 agricultural water usage registrations. Note that these permit counts will fluctuate as the DEP is actively reviewing, revising and canceling unused permits frequently. The rules require that applicants for a diversion provide sufficient information and analysis to show that the diversion will not:

- exceed the natural replenishment or safe yield;
- adversely impact other users or natural resources;
- increase the rate of saltwater intrusion;
- lead to the spread of groundwater contamination; or
- increase drawdown in a Water Supply Critical Area (see Figure 4.22) unacceptably.

New allocation permits and increases of existing allocation permits are approved or denied on a case-by-case basis. Each application goes through an extensive process including a pre-application meeting(s), an extensive technical report, preparation of a water conservation and drought management plan, site inspections, aquifer testing (if applicable), staff review, public notification and comment, and a public hearing (if requested). New or increased diversions regulated through registrations and/or certifications follow a comparable process that is defined by their specific regulation guidelines. In addition, permits and certifications being reviewed during the renewal application process are examined for compliance to permit requirements and water usage. If a facility has consistently used substantially less water than they are allocated and cannot justify the need for part or all of that remaining supply, then DWSG may reduce the allocation upon renewal. On the other hand, if a facility does not appear to have enough water for future growth, the DWSG will notify the facility that they need to obtain additional supply

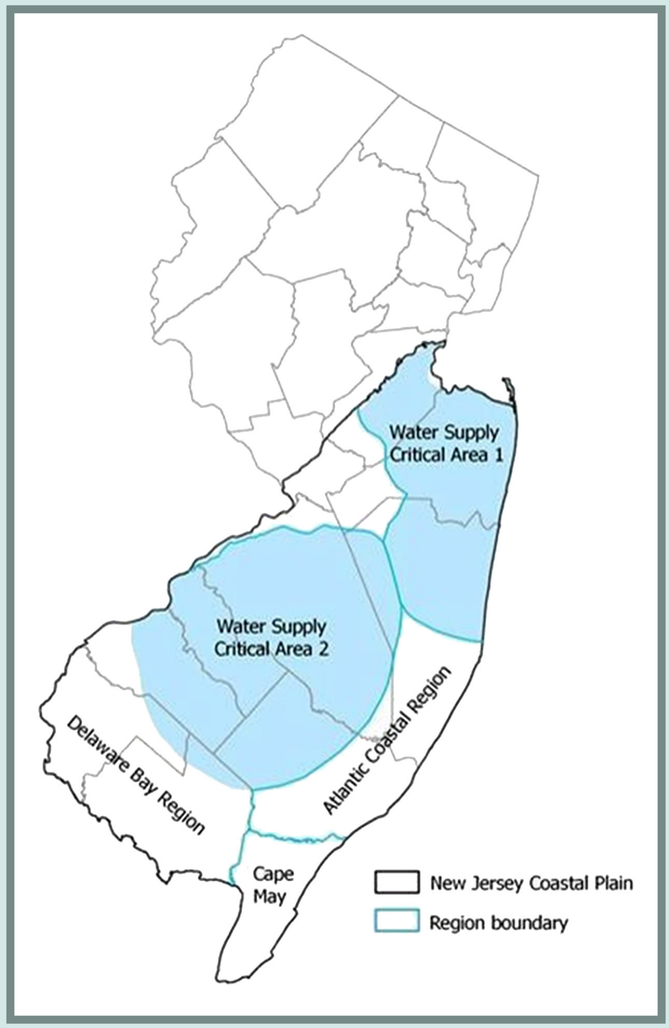


Figure 4.22 Water Supply Critical Areas of New Jersey.

via permit modification (e.g., new source, additional allocation from an existing source, bulk purchase contract from another water allocation permittee), reduce demands, or both.

To ensure sustainability of all diversions and prevent the impacts described above, the DWSG sets controls on allocations, which include:

- limits on the volume of water that may be withdrawn on a monthly and annual basis;
- precise identification of sources from which water may be diverted;
- defined uses of the diversion and effective term limit;
- specific monitoring and reporting requirements;
- passing flow requirements, if appropriate;
- contingency plans and/or mitigation requirements for adverse impacts, if appropriate; and
- review of any contracts a water supplier has entered in for sale or purchase of water on a non-emergency basis to ensure all water demands can be met.

The monthly and annual diversion limits in a water allocation permit represent administratively approved water availability. Each permit application is evaluated to determine if the sustainability requirements set forth in the rules are met. Some of the permit-wide limits are further managed with source or water resource-specific limits (e.g., well field, intake, type of use or aquifer-specific limits). The sub-permit limits do not necessarily equate to permit-wide limits but rather are designed to allow permittees the flexibility to best manage their individual demands or resource constraints. As of mid-2021 there were 5,773 mgd of surface water allocations, 1,170 mgd of unconfined groundwater allocations, and 619 mgd of confined groundwater allocations, for a total of 7,563 mgd, a drop of roughly 10% from the values reported in the 2017 Plan, in part due to changes in the analytical approach[3]. These source-specific limits reflect availability constraints which, in some cases, are different than the permit-wide allocation limits granted in water allocation permits. They provide a more accurate estimate of the resource-specific withdrawal limits of each allocation. Thus, these source-specific results are used in this analysis.

WATER ADMINISTRATIVELY AVAILABLE FOR PUBLIC WATER SYSTEMS

Water used for potable supply must also meet the requirements of the Safe Drinking Water Act (N.J.S.A. 58:12A-1 et seq.) and implementing rules (N.J.A.C. 7:10). These rules require that each purveyor meet a minimum firm capacity, which is defined as pumping and/or treatment capacity (excluding coagulation, flocculation, and sedimentation) available to meet peak daily demand when the largest pumping station or treatment unit is out of service. In other words, firm capacity is the volume of water a purveyor can reliably deliver when its largest source or facility is offline.

The currently allocated water volume needs to be considered along with projected future demands. Figure 4.23 shows the deficit between the allocated amount of potable water and the estimated potable water needs by community water systems based solely on demands resulting from the 2050 PCWS demands analysis. Results show areas of the State with surplus or deficit supplies in relation to currently (2022) approved potable supply, not natural resource capacity. This assessment, when combined with the natural resource limitations, provides an overview of the status (i.e., surplus or deficit) of areas of approved potable water supplies.

[3] Note that water withdrawal permits are often issued with one or more permit allocation sub-limit(s) on a subset of sites (e.g., multiple well fields under a single permit), or where a monthly limit is not equal to one-twelfth of the annual limit. This makes specific quantification of resource-specific allocation totals difficult. The Department improved its method to calculate these limits after the 2017 plan was released so some of the differences between the two plans may be explained by the different methodologies used. Ultimately, permittees must adhere to the limits contained in each permit.

The analysis identifies those water systems that appear to have adequate approved allocations and system capacity to satisfy future projected population growth. Water systems surplus or deficit (as of January 2023) is compared to 2050 demand that incorporated expected changes in population as well as possible changes to the rate of water conservation and water loss (Van Abs et al., 2017). Four scenarios were selected from this report and the 2050 demand data was gathered for each scenario for each purveyor. The four scenarios that were selected for this analysis are as follow:

1. **CNWL** = Conservation-Nominal Water Loss Scenario assumes water conservation rate trends continue and that water loss rates are equal to the current state median rates.
2. **NCNWL** = No Conservation-Nominal Water Loss Scenario assumes that the current rates of conservation are static and that water loss rates are equal to the current state median rates.
3. **NCOWL** = No Conservation-Optimal Water Loss Scenario assumes that the current rates of conservation are static and that that all systems achieve water loss rates equivalent to the current 25th percentile for systems in New Jersey that had reported via water audits at the time of the report.
4. **COWL =** Conservation-Optimal Water Loss Scenario assumes that water conservation rate trends continue and that all systems achieve water loss rates equivalent to the current 25th percentile for systems in New Jersey that had reported via water audits at the time of the report.

Figure 4.23 displays a scenario in which water conservation practices continue to reduce overall system demands and where water systems are assumed to move towards optimization of water loss by mitigating leakage. Table 4.9 shows the number of systems in 2050 that will be in deficit if new sources are not brought online or if historic demands are not reduced.

Table 4.9 2050 Available Water Summary

Water Availability	Scenario			
(mgd)	CNWL2050	COWL2050	NCNWL2050	NCOWL2050
< 0	68	58	95	83
0 to 5	397	406	372	383
5 to 10	10	11	8	10
10 to 50	9	9	9	9
50 to 100	1	1	1	1
No Data Available	118	118	118	118

As the public water system deficit/surplus analysis is updated with revised demand and/or allocation volumes these results will change. While the usefulness of this assessment for a case-by-case analysis is somewhat limited, it is extremely useful for statewide planning with respect to targeted economic growth, optimization of existing infrastructure, identification of infrastructure needs, and development of additional sources of supply. However, to be protective of resources and provide for sustainable and reliable supply into the future, this analysis should also be considered in conjunction with the natural capacities of the resource. Refer to Appendix K for more detail on this analysis.

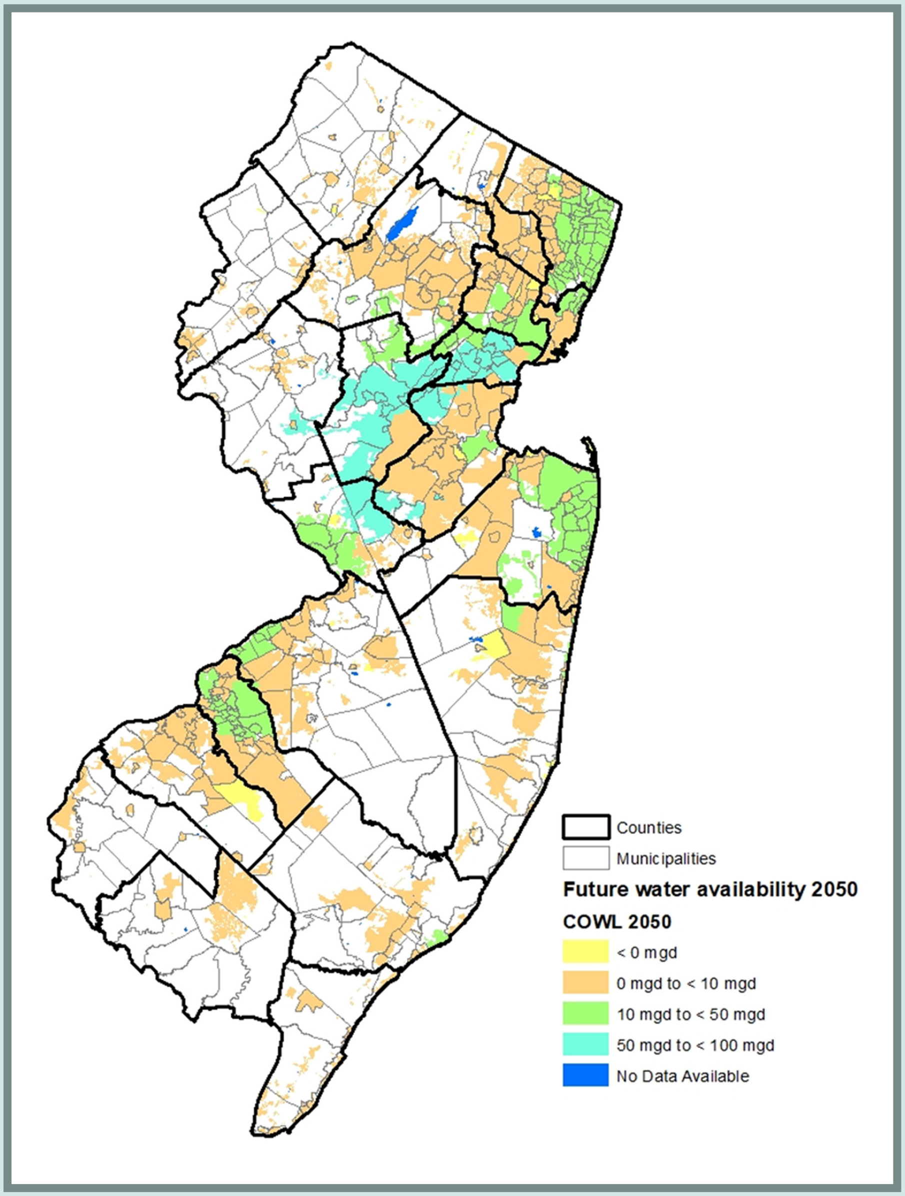


Figure 4.23 Water Administrative Availability for Public Water Systems: Results show areas of the State with surplus or deficit supplies in relation to currently approved water allocation permits for potable supply, not natural resource capacity. Results are plotted based on best available service area mapping; white spaces represent areas not part of this analysis which are generally self-supplied private domestic users. This assessment, when combined with the natural resource limitations, provides an overview of the status (i.e., surplus or deficit) of areas of approved potable water supplies. Based on the 2050 PCWS Demand Analysis and December 2022 system data available at: **DEP Public Water Systems**.

* *https://www.nj.gov/dep/watersupply/pws.html*

STATEWIDE WATER AVAILABILITY SUMMARY

The results discussed in this chapter are summarized by Watershed Management Areas (WMAs) in Table 4.10 and below. These summaries of water use and availability reflect the “big picture” of water availability throughout the State. Note that there are many complexities that are not accounted for in these WMA summaries. For example, confined aquifer boundaries do not follow surface watershed (HUC11) boundaries. At the larger WMA scale these confined vs. unconfined aquifer differences are less significant, however they may be important when a site-specific analysis is conducted. Similar boundary issues also come in to play with demand and supply since water can be piped across long distances from where it is available to where it is needed. The summaries reflect supply and demand in each WMA and does not account from the transfer of water across watershed management area boundaries. This is especially significant in WMAs 3, 4, 5, 6, 7, and 9.

Future water availability is assumed to remain the same for this analysis. The overall findings of the climate change water availability evaluations summarized in Chapter 3 indicated that no major short-term changes to water supply are anticipated. This may change as the data and models are improved.

Table 4.10 summarizes water availability for all 20 WMAs. The availability analysis includes the following factors: surface water from reservoirs (safe yield), unconfined aquifer and non-reservoir surface water based on sustainable ecological planning thresholds, and confined aquifer availability based on regulatory limits. Each availability analysis recognized and accounted for the hydraulic linkages between the resource categories, but the total identified availability estimates were based on each individual resource (e.g., reservoir system, unconfined or confined groundwater wells). The actual volume of water available to any specific subregion is a function of the total of all the water resources present in that area combined with any site-specific resource limitations.[4] This table also shows net demand from each of these resources and remaining availability. Statewide, total resources are estimated to be 1,791 mgd, and net demand to be 1,349 mgd. Surface water reservoir systems, unconfined aquifers and associated streams, and confined aquifers each provide 785 mgd, 387 mgd, and 619 mgd of availability respectively. Table 4.10 also shows an estimated change in potable demand ranging from a decrease of 20 mgd to an increase of as much as 113 mgd by 2050.

Spruce Run Reservoir located in Clinton, New Jersey. Spruce Run is the third largest reservoir in New Jersey (after Round Valley and Wanaque).

The table also shows how much water is estimated to be available from three different, currently unused sources: treated wastewater currently discharged to saline waters (619 mgd), enhanced potable conservation methods[5] (42 mgd), or unbuilt water supply projects[6] that currently reserved for future consideration (283 mgd).

Table 4.10 shows that total current demands exceed sustainable thresholds WMAs 7, 15 and 17. Results also show that sustainable thresholds are exceeded for the unconfined groundwater and non-safe yield surface water diversions in WMAs 6, 7, 9, 15 and 17, but that the safe yield and confined aquifer resources, where present, have available supplies. Accounting for 2050 demands doesn't increase the WMA that exceed sustainable thresholds. The majority of these deficits can be attributed to outdoor water uses and depletive losses (i.e., wastewater transfers to large regional treatment plants that discharge to the ocean and/or bay). This highlights the importance of using water more efficiently and minimizing exports.

The summaries of water use and availability in Table 4.10 are helpful in that they combine the multiple, detailed, resource-specific availabilities in a comprehensive manner. However, their usefulness in identifying appropriate water supply management options at a site-specific or even watershed level is somewhat limited. For example, to develop the WMA

4 Availability in a given area is a complex function of several factors. For example, administrative availability is associated with a permit and its designated use, while safe yield is related to a water system and its network of interconnections. Unconfined groundwater and surface water are derived at the watershed (HUC11) scale. Confined aquifer availability is a function of aquifer extent, groundwater divides, and critical area boundaries. Due to the nature of this information (i.e., differing or overlapping boundaries and differences in scale), summarizing water availability for any one geographic area in New Jersey is complicated.

5 The potable conservation method assumes that one-third of 2016-2020 average annual potable supply consumptive use can be saved via water conservation and that water then becomes available for new or deficit offsetting potable uses.

6 WMA 6 projects include one or more finished water interconnections to transfer water from the NJ American's Raritan Basin system to the Passaic Basin system, WMA 7 projects include transfers of water from WMA 9 via the Virginia Street interconnection or similar, WMA 9 projects includes multiple projects like the confluence pump station, Kingston Quarry and Six Mile Run Reservoir, WMA 12 projects include transfers from WMA 9 via the South River Basin Pipeline or similar type of transfer, and WMA 18 projects include expansion of the Delran surface water treatment plant or similar intake.

summaries, unconfined groundwater and surface water availabilities for each HUC11 watershed were combined into one total. The water available to any one new diversion is highly dependent on the location of the new diversion, the location of the HUC11 with the availability, and available infrastructure and resources to move water to the desired location. In addition, the underlying cause of a deficit in a WMA may result from a specific type or volume of use that can be modified, or from an allocation that will never be fully used. Also, site-specific details may limit the availability of a proposed diversion in a WMA with a surplus (e.g., adverse interference with other users and limited water availability at the site because of in-situ aquifer conditions).

To ensure sustainable water supplies, DEP will continue to review detailed data and demonstrations of alternative region-specific sustainability thresholds. DEP considered the results of the Highlands Regional Master Plan (RMP) process to define

Table 4.10 Natural Resource Availability, Demands, Remaining Availability, 2050 Estimates, and Options.

WMA#	WMA Name	Natural Resource Availability (mgd)			Current Demand (mgd)			Remaining Availability (mgd)				Net Demand 2020-2050		Options for Additional Water Supply (mgd)		
		Reservoirs	Unconf GW and SW	Conf GW (sub to revision)	Reservoirs	Unconf GW and SW	Conf GW	Reservoirs	Unconf GW and SW	Conf GW	Net	Low End (mgd)	High End (mgd)	Ocean/ bay sewer discharges	Potable conservation savings	Unbuilt water supply projects
1	Up Del		30			7			24		24	-0.3	1.5		0.5	40
2	Wallkill		6			3			4		4	-0.2	0.2		0.2	
3	P-P-W-R	197	8		131	8		66	0		66	-3	-1		1.1	
4	Low Pas-Sad	75	9		48	7		27	2		29	-9	12		4.5	
5	Hack-Hud-Pas	127	6		94	2		33	4		36	-15	7	82	5.6	
6	U/M P-W-R	68	15		47	16		21	-1		19	1	9		2.6	30
7	Arthur Kill		6			17			-11		-11	9	24	303	2.8	20
8	N/S Raritan		21	0		8	0		13	0	13	1	3		3.3	
9	L Rar-Sou-Law	241	13	51	176	36	45	65	**-23**	6	48	2	15		3.2	135
10	Millstone		8	15		0	9		8	6	14	2	6		0.3	
11	Cen Del		8	4		-1	3		9	2	11	1	5		1	
12	Monmouth	61	21	69	51	5	64	10	16	5	31	1	8	139	5	23.2
13	Barnegat Bay	17	54	140	8	31	126	9	23	14	46	-8	1	47	3.7	
14	Mullica		39	10		22	6		17	4	21	0	0		0.4	
15	Gr Egg Harbor		36	49		45	46		-9	3	-6	-2	3	28	1.5	
16	Cape May		7	28		2	28		4	1	5	-2	0	16	0.4	
17	Mau-Sal-Coh		47	31		82	20		-35	12	-23	-1	2	4	1.2	
18	Low Del		24	147		-40	165		64	-18	46	1	11		3	35
19	Rancocas		19	40		-3	30		22	10	32	0	3		1.1	
20	Ass-Cro-Doc		10	34		-12	20		22	14	37	1	4		0.4	
TOTAL		**785**	**387**	**619**	**555**	**234**	**560**	**230**	**152**	**59**		**-20**	**113**	**619**	**42**	**283**

available water supply in the Highlands Region. Future water allocation and safe drinking water permit decisions, for new or modified permits as well as renewals, will be made consistent with the adopted Highlands rules (N.J.A.C. 7:38) and the Highlands RMP. DEP also will continue to work with the Pinelands Commission to ensure water allocation decisions meet Pinelands Comprehensive Management Plan (CMP) objectives.

Notes for Table 4.10:

- The information summarizing Statewide Water Availability is extensive, and the Tables have been divided to properly fit the format of this document. Refer to Appendix A for additional details.
- All volumes are in millions of gallons per day (mgd).
- Columns that are blank are due to the fact that the identified resource for each region are not available there. Columns with a “0“ indicate regions where that resource is present but not currently a viable supply.
- The total resource availability is based on the best available analysis using the combined sum of the amount of water available from unconfined sources of supply and surface waters based on the stream low flow margin method, the approved safe yields of existing reservoir systems, and the total permitted allocations in the confined aquifers.
- Remaining Availability is WMA-specific, and it is not appropriate to include a total sum for the entire state.
- Net demand is based upon the peak use of the resource for each HUC11 between 2011 and 2020. Not all HUC11s may have the same peak year.
- The remaining availabilities are not summed statewide because a large loss in one WMA does not offset a surplus in another WMA. Similarly, a large loss in one resource does not mean that a new source may be added (assuming all permitting requirements are met) which utilizes another source in the same WMA which has availability.
- The 2050 water demand estimates include the water purveyor needs assessment discussed earlier in this chapter and that self-supplied commercial, industrial, mining, power and agricultural water uses will remain the same.
- Increases in the resource availability may occur for reservoirs if new infrastructure is built and permitted and in confined aquifers depending upon the specific location and construction of a new source.
- Ocean and bay discharges are not included as part of the stream low-flow margin availability, since the waters are ‘lost’ to the freshwater system; instead, these discharges are separated to indicate their reuse.

Figures 4.24-4.29 summarize key values from Table 4.10 and add spatial context to the information. In Figure 4.24, natural availability, demand, and remaining availability (balance) are summed by water region. Water regions are combinations of WMAs grouped by shared hydrography. The amount contributed to availability and demand by each of the three resource types, reservoir, unconfined groundwater and surface water, confined groundwater, varies by region, as do totals. For each of the five regions, natural availability is greater than demand, resulting in positive balances and no deficits.

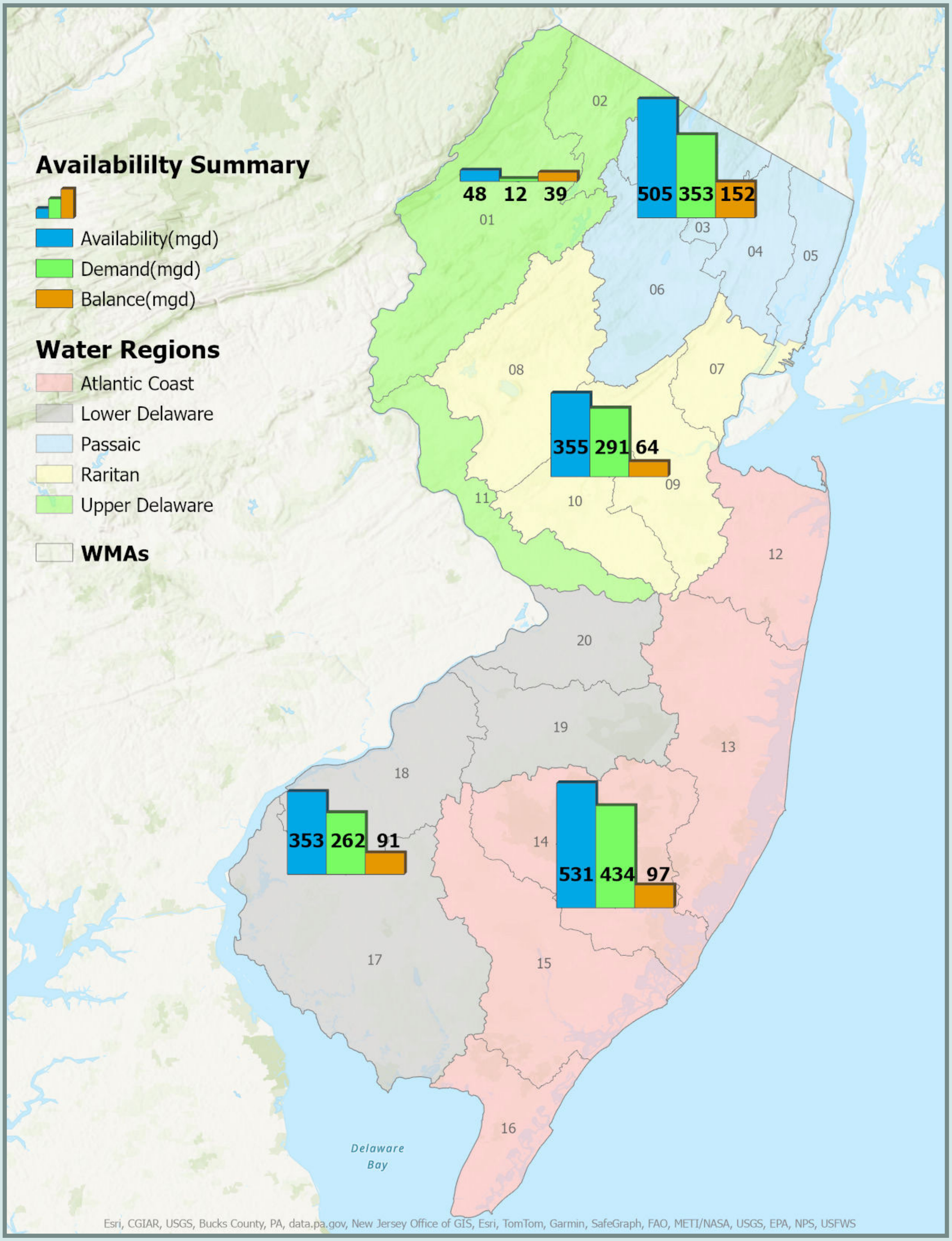


Figure 4.24 Shows WMA natural availability, demand, and remaining availability (balance) collapsed to water region.

Figures 4.25-4.29 contain the availability data from Figure 4.24 but display it in greater detail. Each chart depicts the summary for a single Water Region and breaks down the availability, demand, and balance data by WMA. Within each WMA, the amount of water contributed by reservoirs, unconfined groundwater and surface water, and confined groundwater is shown. In some cases, there is a deficit for a given resource, most frequently unconfined groundwater and surface water, in a WMA denoted by a negative value in the balance column. However, Figure 4.24 shows that when data is summarized by Water Region, no deficits are present. A negative value in the demand column occurs when water returns for a given resource are larger than the withdrawals.

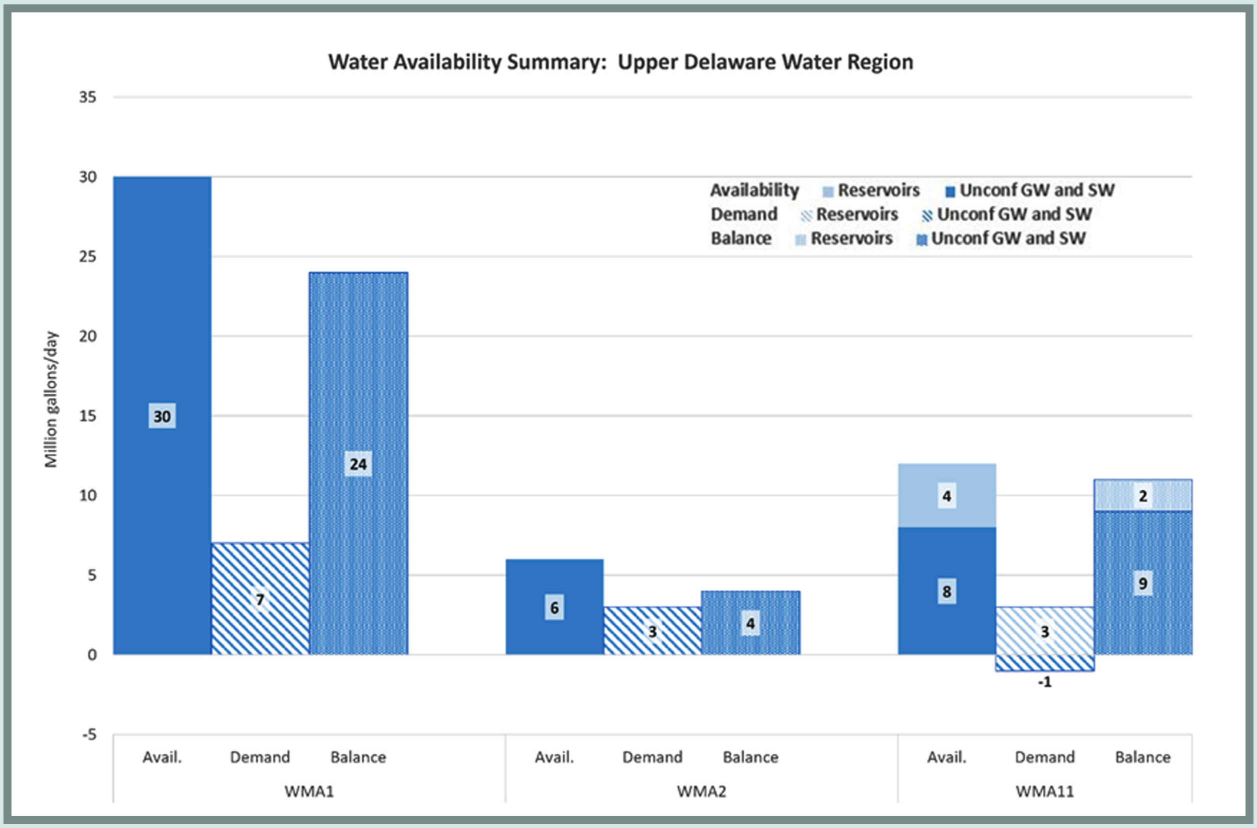


Figure 4.25 Water availability summary for the Upper Delaware Water Region availability, demand, and the resulting balance for each WMA in the region are categorized by resource.

The Upper Delaware Water Region is comprised of three WMAs within which, unconfined groundwater and surface are the primary resources. As shown in Figure 4.25, none of these WMAs holds a negative balance, due in large part to relatively low demands.

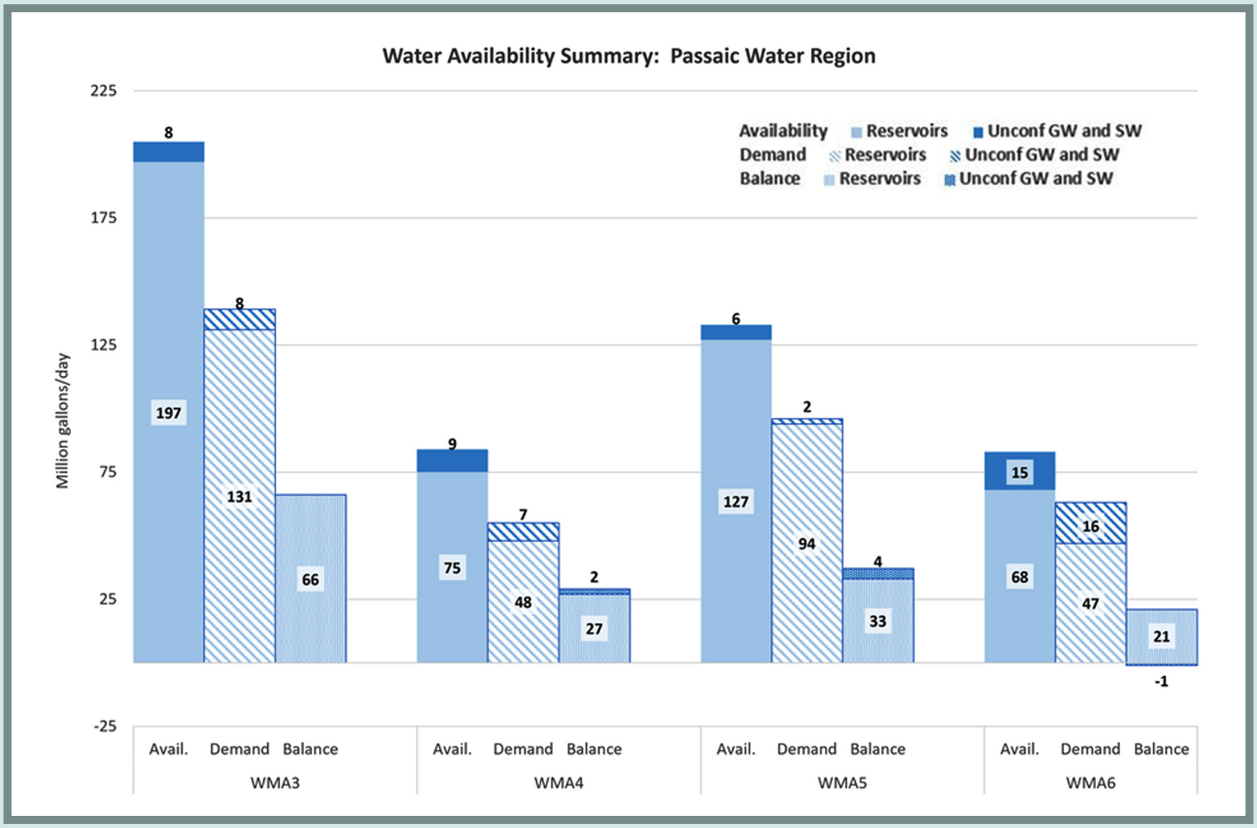


Figure 4.26 Water availability summary for the Passaic Water Region availability, demand, and the resulting balance for each WMA in the region are categorized by resource.

Reservoirs serve as the primary resource for the Passaic Water Region's four WMAs, although there is some unconfined groundwater and surface water use as well. All WMAs have positive balances for reservoirs, and in WMA 6 unconfined groundwater and surface water demand is slightly higher than availability.

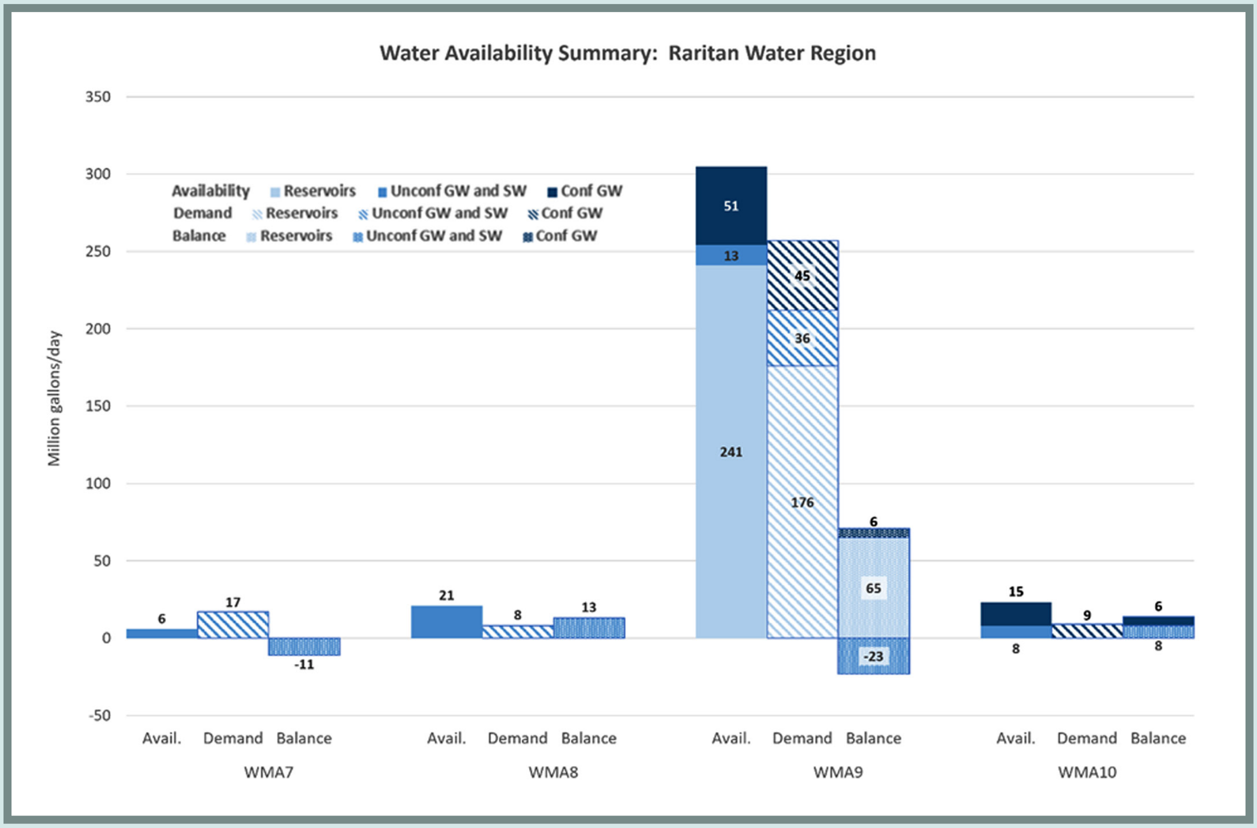


Figure 4.27 Water availability summary for the Raritan Water Region availability, demand, and the resulting balance for each WMA in the region are categorized by resource.

The Raritan Water Region contains four WMAs, of which WMA 9 has the greatest availability and demand, dominated by reservoir supply. Demand for unconfined groundwater and surface water outweighs availability in WMAs 7 and 9.

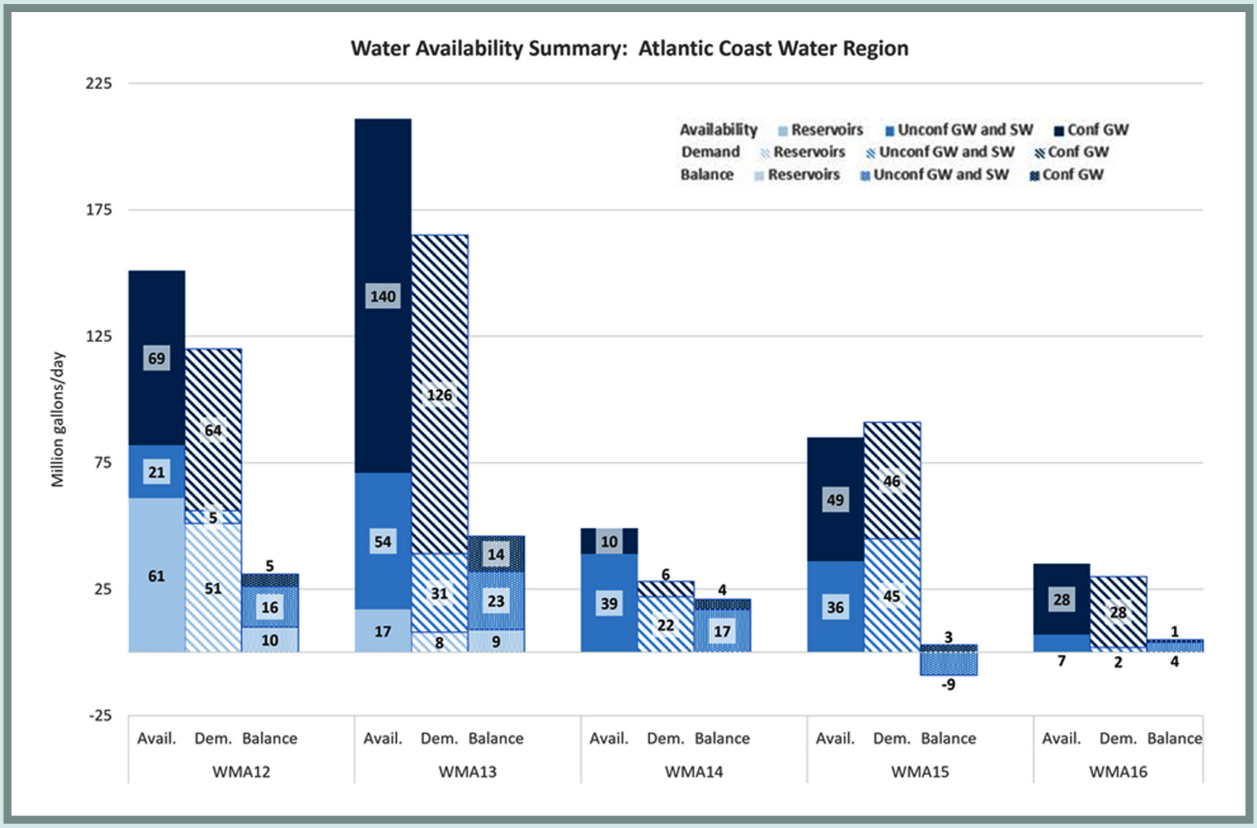


Figure 4.28 Water availability summary for the Atlantic Coast Water Region availability, demand, and the resulting balance for each WMA in the region are categorized by resource.

The Atlantic Coast Water Region shows significant use of all three resources with a greater reliance on confined groundwater than the other Regions. WMA 15 has a negative value for balance in the unconfined groundwater and surface water category.

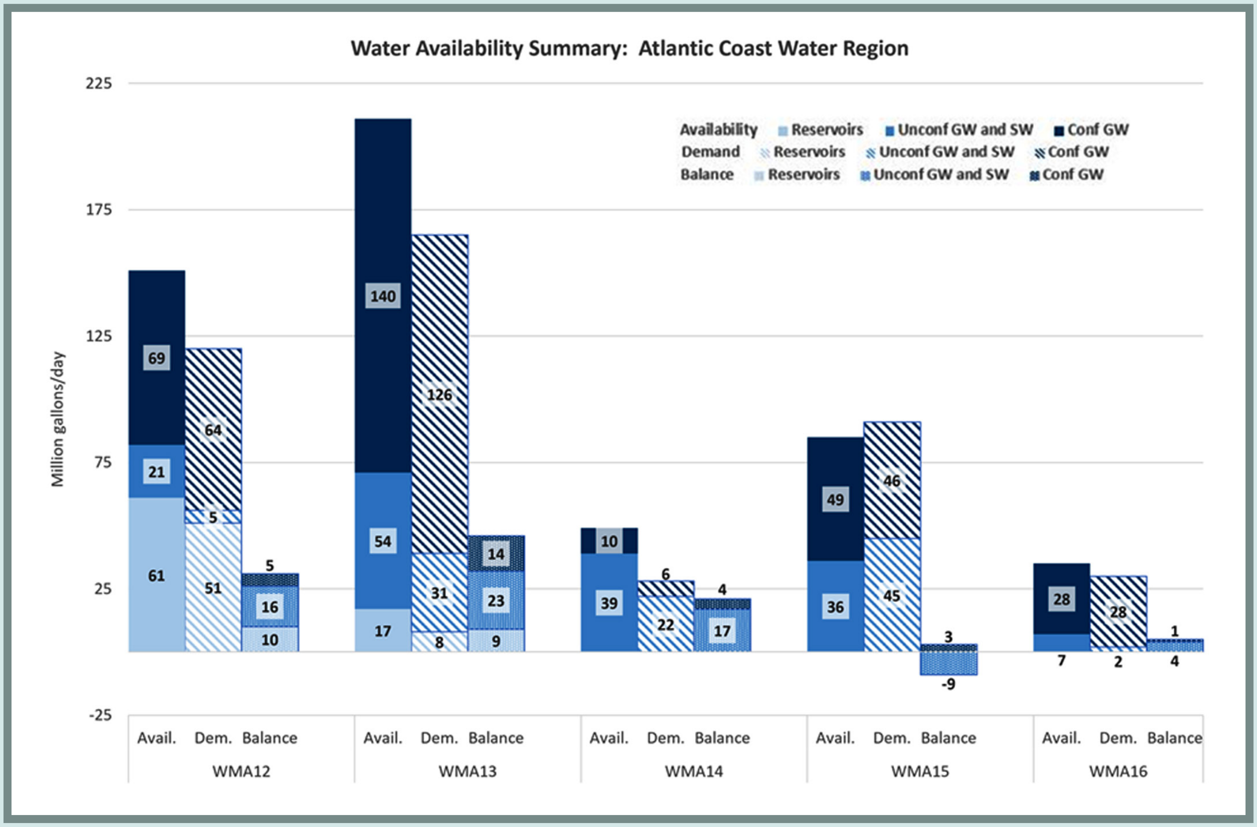


Figure 4.29 Water availability summary for the Lower Delaware Water Region availability, demand, and the resulting balance for each WMA in the region are categorized by resource.

In the five WMAs in the Lower Delaware Water Region, unconfined groundwater and surface water and confined groundwater are the relied-upon resources. Negative balances occur for unconfined groundwater and surface water in WMA 17 and for reservoirs in WMA 18.

SUMMARY

The analyses for water resources suggest current water resources are sufficiently available however, in light of changing climate several regions need to be further assessed and monitored to ensure that the stresses under full allocation scenarios are not realized. Some resources either are or may be stressed currently, based on preliminary information (e.g.,the LFM approach) or detailed models (e.g., confined aquifers, reservoir safe yields). The relative demands by use category vary widely; no single approach will be useful in all regions. In many areas, more detailed information will be needed to verify water stresses. However, in some of these regions, the calculated stresses are so high that a high level of scrutiny is required to reduce consumptive and depletive losses from current uses and likely to restrict increased demands; this step has been taken already in several regions, as discussed in Chapter 6 on regional planning.

The detailed water assessments and potential management options are covered in the following chapters and provide a framework to inform future decisions regarding water supply. Users looking for availability at a specific location should be aware that site-specific conditions may be more limiting than the WMA-wide analysis might indicate.

Two specific areas DEP intends to target related to statewide demands and balances include:

- continued efforts in its proposed rulemaking to codify the Water Quality Accountability Act to require applicable PCWSs to conduct and submit an annual AWWA Water Loss Audit; and
- further actions to decrease uncertainty in current water balance estimation methods, including:
    - monitoring and updating statewide water data;
    - reviewing alternative region-specific sustainability thresholds; and
    - periodic updating of water availability and forecast analyses.

Chapter 5:

Water Resource Protection and Planning Efforts

TABLE OF CONTENTS

OVERVIEW

The DEP has the primary responsibility for managing New Jersey's water resources. This includes the protection of water supplies and quality, allocation to users, infrastructure regulation and financial assistance, and the assurance of safe drinking water. Due to this broad responsibility, DEP has focused its efforts on comprehensive water resources management -- a holistic approach to managing the State's water resources from the perspective of supply, quality, standards, and monitoring. DEP operates under both general and specific legislative authorities and under defined principles and priorities (**About DEP website**).

This chapter details how DEP comprehensively manages New Jersey's water resources and notes areas where future work will expand on current approaches. Key items addressed include program areas devoted to the protection of New Jersey's water resources, water efficiency and conservation strategies, and water system resilience and asset management. These areas directly relate to discussions of environmental justice in water resources. This is a new topic area for this Plan building off New Jersey's recently passed Environmental Justice Laws, some of the most progressive in the nation. This chapter includes an analysis of environmental justice concerns as they relate to water supply in overburdened communities and sets up the necessary groundwork for ways in which DEP can continue to address environmental justice in water resource management and drinking water protection.

Whitesbog Village Historic Site located in Brendan T. Byrne State Forest in the New Jersey Pine Barrens.

The Division of Water Supply and Geoscience's safe drinking water program's function and mandate is also covered in this chapter, along with a statewide assessment of the water systems operating throughout New Jersey, the latter being a new topic not previously covered in past water supply plans. DEP recognizes that water quality can have serious impacts to overall supplies. Some of the ways in which DEP performs continuous monitoring and assessment of New Jersey's water resources are also described here and noted as vital areas for continuous efforts.

Finally, the waters of New Jersey are managed by several regional water resource agencies in addition to but with similar missions to those of DEP. These include the Delaware River Basin Commission, the Pinelands Commission, and the Highlands Council. The permitting and planning practices of these agencies are detailed to provide an expansive view of water resources management occurring throughout the state.

This Plan, and specifically this chapter, outlines the range of actions DEP is actively undertaking to ensure an adequate supply of properly treated water is available throughout New Jersey. DEP will continue to focus on safeguarding source water, addressing threats to drinking water quality and infrastructure, and furthering its commitment to environmental justice in water resources. Lastly DEP would like to note that the New Jersey Office of Planning Advocacy has recently initiated a process to update the State Plan, last released in 2001. The State Plan has cross acceptance procedures to coordinate water supply and other state plan actions across numerous state agencies. DEP is a participant in the cross-acceptance process to ensure coordination between the policies of the State Plan and the Plan. More information can be found here: **Office of Planning Advocacy State Plan website**.

Topics found in this chapter relate to other areas of the Plan where additional detail can be found. Readers are encouraged to visit the following:

- Climate change impacts that relate to many of the concepts covered in this chapter are explored in Chapter 3.
- Greater detail regarding many planning and policy efforts can be found in Appendix L.
- Water allocation regulations and permitting programs are discussed throughout this Plan, specifically in Chapter 2 (overall program), Chapter 4 (statewide water availability), and Chapter 6 (regional issues).

PROTECTING NEW JERSEY'S WATER RESOURCES

DEP has taken significant steps to improve the protection of New Jersey's water resources, including source water assessment and protection, land preservation, improved surface water quality standards and regulations related to water supply, point source pollution controls and stormwater management. DEP continues to be actively engaged in the management of the State's drinking water sources for both quantity and quality. Historically, the primary purpose of the New Jersey Statewide Water Supply Plan was to focus on the quantity of available water, both current and future needs. DEP recognizes that the supply of adequate safe and reliable water cannot be fully assessed by evaluating quantity alone and has greatly expanded its analysis of drinking water quality and water supply infrastructure in this Plan. To understand the State's vulnerabilities, the Plan must consider the impacts of aging infrastructure, emerging contaminants, and climate change. These factors are significant in determining the future water supply conditions for New Jersey.

WATER QUALITY REGULATORY PROGRAMS

The quality of the water resource is an equally important component and DEP has numerous programs devoted to preserving and restoring the water quality of New Jersey's aquatic resources. In general, New Jersey's water quality has been improving since the 1970s, mainly due to DEP's focus on achieving better wastewater treatment and focus on non-point source pollution. The net impact of this improvement is effectively summarized in the most recent version of the New Jersey Integrated Water Quality Assessment Report series, available at **Water Quality Assessment**. These reports "provide effective tools for maintaining high quality waters and improving the quality of waters that do not attain their designated uses." They show not only the ways in which the DEP has sought to implement improvements from point source controls, but also areas of potential concern where the long-term trends point toward increasing nonpoint source pollutant concentrations, including nutrients that can trigger harmful algal blooms (cyanobacteria blooms) and chloride levels from road salts, that are related to the long-term trend of suburban and exurban development.

Water quality monitoring, assessment, and restoration is an ongoing process. The DEP has rules and regulations to help protect and improve water quality, including:

- Discharges of Petroleum and Other Hazardous Substances (N.J.A.C. 7:1E);
- Coastal Zone Management Rules (N.J.A.C. 7:7);
- Freshwater Wetland Protection Act Rules (N.J.A.C. 7:7A);
- Stormwater Management Rules (N.J.A.C. 7:8);
- Standards for Individual Subsurface Sewage Disposal Systems (N.J.A.C. 7:9A);
- Surface Water Quality Standards (N.J.A.C. 7:9B);
- Ground Water Quality Standards (N.J.A.C. 7:9C);
- Well Construction and Maintenance; Sealing of Abandoned Wells Rules (N.J.A.C. 7:9D);
- Private Well Testing Act Rules (N.J.A.C. 7:9E);
- Safe Drinking Water Act Rules (N.J.A.C. 7:10);
- Flood Hazard Area Control Act Rules (N.J.A.C. 7:13);

- Water Pollution Control Act Rules (N.J.A.C. 7:14);
- Pollutant Discharge Elimination System Rules (N.J.A.C. 7:14A);
- Underground Storage Tank Rules (N.J.A.C. 7:14B);
- Sludge Quality Assurance Rules (N.J.A.C. 7:14C);
- Water Quality Management Planning Rules (N.J.A.C. 7:15);
- Water Supply Allocation Permits (N.J.A.C. 7:19);
- Agricultural, Aquacultural and Horticultural Water Usage Certification (N.J.A.C. 7:20A);
- Industrial Site Recovery Act Rules (N.J.A.C. 7:26B) and Remediation Standards (N.J.A.C. 7:26D);
- Pesticide Control Code (N.J.A.C. 7:30);
- Highlands Water Protection and Planning Act Rules (N.J.A.C. 7:38);
- Green (and Blue) Acres Program (N.J.A.C. 7:36); and
- Site Remediation Rules (N.J.S.A. 58:10 et seq).

SOURCE WATER ASSESSMENT PROGRAM

In 2004, as a requirement of the 1996 Amendments to the Safe Drinking Water Act, DEP, in conjunction with the United States Geological Survey (USGS), performed source water assessments for all public community water systems (PCWS) and public non-community water systems (PNCWS), to predict the susceptibility of source water to contamination. While many regulatory programs were in place to protect the quality of drinking water, the results of the Source Water Assessment Program (SWAP) were designed to provide planning opportunities to: (1) determine the source water assessment area of each ground and surface water source of public drinking water; (2) develop an inventory the potential contamination sources within the source water assessment area; (3) determine the public water system source's susceptibility to regulated contaminants; and (4) to incorporate public education and participation. Source water assessment reports for each of the approximately 600 community water systems and 3,545 non-community water systems were completed and released on the **SWAP website**. These reports provide information on the potential vulnerability of each of the water system's sources to the following contaminant categories: nutrients (nitrates), pathogens, pesticides, volatile organic compounds (VOCs), inorganics (metals), radionuclides/radon, and disinfection by-product precursors. See Figure 5.1 for a map of surface water source areas.

As part of the Source Water Assessment Program, DEP also developed well head protection areas (WHPA) for **PCWS** and **PNCWS** water supply wells. Well head protection areas are calculated in accordance with the **Guidelines for Delineation of Well Head Protection Areas in New Jersey** and delineate the horizontal extent of ground water captured by a well pumping at a specific rate over a two-, five-, and twelve-year period. The well head protection areas provide a critical component of the source water assessment and protection activities as well as the basis for focusing efforts of the state's groundwater protection strategy. These resources require periodic update to reflect new or modified sources or the improved location of existing wells. Additionally, improved hydrogeologic properties will change the extent of each well's WHPA. Periodic revision of these areas is also required.

The reports and supporting documents are available to the public by searching for water systems at: **SWAP Reports & Summaries**. While some systems have changed names or ownership over time, the reports still have value, but ultimately should be updated on a periodic basis to reflect current data, policies and issues.

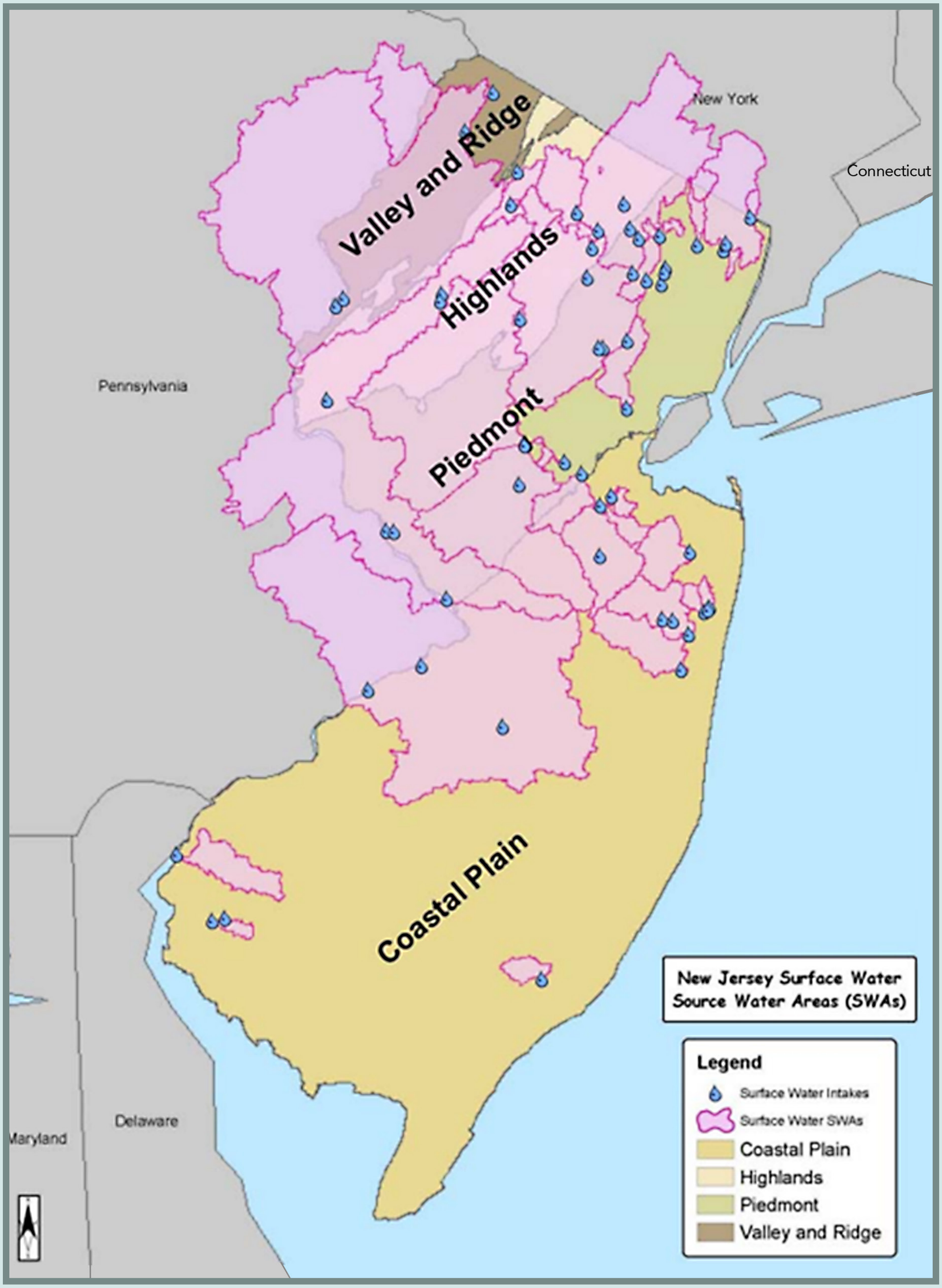


Figure 5.1 Surface water source water areas from the 2004 New Jersey Source Water Assessment Program Statewide Summary report.

These Source Water Assessments highlighted the importance of regulating land use activities in order to protect sources of potable supply for both ground and surface water resources. As part of its larger drinking water quality protection efforts, DEP is developing an expanded and more integrated Source Water Assessment process. This process will utilize updated potable source location data, consider recently added MCLS, emerging contaminants (e.g., chloride and sodium from winter salting applications), and take advantage of the improved GIS utilities that are now available to the DEP. The revised program is also envisioned to integrate the goals of the SWAP into some of the established water quality protections programs that are active in the DEP. These may include the C1 waters designation, the Integrated Water Quality Assessment Report, Water Quality Management Plans, or the State Plan. For example, the source water assessment plans may identify a water system that serves less than 100,000 people which would benefit from C1 designation and its associated regulatory protections. In such cases the revised SWAP could inform C1 designation criteria so any drinking water system that could benefit from upstream land use and wetland protections could benefit from the program. There are also potential C1 designation restrictions which can limit a water utility's ability to repair, expand or enhance infrastructure (such as changes needed to meet new MCL standards or to make infrastructure more resilient to the threats from climate change, or simply to maintain and repair critical infrastructure) that can be addressed by this enhanced SWAP process. Additionally, the program could identify specific drinking water quality parameters or metrics that could be used to define non-degradation criteria. Similarly, the SWAP may identify surface watershed or groundwater recharge areas that need to be considered when Water Quality Management Plans are amended. Details of the enhanced SWAP are forthcoming.

CATEGORY ONE (C1) WATERS

The Surface Water Quality Standards (SWQS) at N.J.A.C. 7:9B require that any water bodies that are designated as Category One (C1) waters be protected from any measurable change in water quality because of their exceptional ecological, recreational, water supply, or fisheries resources significance. Through these regulations, C1 designation provides additional protection to water bodies that help prevent water quality degradation and discourage development where it would impair or destroy natural resources and environmental quality. The maintenance of water quality is important to all residents, particularly to the many communities that depend upon surface waters for public, industrial, and agricultural water supplies, recreation, tourism, fishing, and shellfish harvesting. The **C1 Story Map** and some of its infographics provide details on the C1 designation and its evolution since inception in 1981.

Both the 1996 and 2017 New Jersey Statewide Water Supply Plans proposed a better integration of New Jersey's SWQS with surface water supply management, including an evaluation of the surface water use designations and water quality criteria with respect to their adequacy to protect surface water supplies. As discussed above, this Plan is also recommending further integration.

As of April 2020, DEP had designated around 7,400 stream miles and 12,374 acres of lakes and reservoirs as C1 waters. Most of these designations were made in 1985 based on State and Federal parks, wildlife management areas, and trout production waters. Between 1985 and 2002, only streams upgraded to Fresh Water Two (FW2) trout production, achieved C1 designation. In 2002, DEP began an intensive effort to identify additional waters that warranted enhanced protections afforded by this designation. Starting in 2002, DEP expanded the C1 designation criteria to include waters of "exceptional ecological significance" and of "exceptional water supply significance." A 2008 rule added 686 miles of C1 waters (mostly for exceptional water supply significance), and in 2020 DEP adopted new C1 designations affecting 600 miles of streams (mostly for ecological significance).

The designation of these waters as C1 is a preventive measure aimed at protecting waters that are ecologically exceptional and/or drinking water sources. Land use and wastewater infrastructure decisions associated with C1 waters are required to meet the anti-degradation policies specified in the SWQS. This preventive strategy serves to substantially enhance protection for one-half of the State's drinking water supplies. DEP is working to re-evaluate the criteria for designating C1's under water supply significance.

For more information pertaining to C1 Waters, please see the Division of Water Monitoring, Standards, and Pesticide Control web site at: **C1 Waters**.

WATER QUALITY MANAGEMENT PLANNING (WQMP)

The Water Quality Management Planning (WQMP) rules, N.J.A.C. 7:15, implement the Water Quality Planning Act (WQPA), N.J.S.A. 58:11A-1 et seq., whose purpose is to maintain and, where attainable, restore the chemical, physical, and biological integrity of the surface and ground water resources of the State. The WQMP rules are one component of the State's water quality continuing planning process (CPP) required by Sections 201, 208 and 303 the Federal Water Pollution Control Act, 33 U.S.C. §§ 1251 et seq. (33 U.S.C. §§ 1281, 1288, and 1313), commonly known as the Clean Water Act (CWA), as well as the State WQPA and the Water Pollution Control Act (WPCA), N.J.S.A. 58:10A-1 et seq. The CPP is intended to integrate and unify water quality management planning processes, assess water quality, establish water quality goals and standards, and develop a Statewide implementation strategy to achieve the water quality standards. The WQMP rules provide a framework to integrate wastewater planning with existing permitting programs. They also provide the framework to identify the anticipated municipal and industrial waste treatment needs and any gaps in providing capacity in the future. More information is at **Water Quality Management Planning Program**.

Currently, the WQMP process does not take into consideration water supply availability when making decisions. This review was previously completed but was subsequently ceased due to rule change. Disconnecting water quality decision making from water supply can lead to water resource management problems. DEP should work to re-implement water supply reviews into WQMP decision making processes.

WETLANDS IMPACTS REVIEW IN ALLOCATION PERMITTING DECISIONS

Following a 2009 Appellate Division decision regarding an appeal of amendments to the rules for Agricultural, Aquacultural, and Horticultural Water Usage Certification at N.J.A.C. 7:20A, DEP determined it would cease its cross-programmatic review (pursuant to the rules for Water Supply Allocation Permits at N.J.A.C. 7:19; Water Resource Management and Watershed and Land Management) of impacts to wetlands stemming from proposed diversions greater than 100,000 gallons per day. Since it is well documented that water diversions located outside of wetlands and transition areas have the potential to adversely impact wetlands, including groundwater dependent flora and fauna, DEP will explore legal and regulatory options for restarting and formalizing a cross-programmatic review process.

WATER USE EFFICIENCY AND CONSERVATION

Improving water use efficiency and decreasing water waste is one of the most cost-effective and environmentally sound planning methods to decrease water resource demands. Increasing water efficiency improves DEP's water management approach in several ways. First, it helps to improve statewide capacity for responding to future uncertainties, such as changes in population, the potential for hotter, more erratic weather, and increased outdoor water use and consumptive water losses. Second, water efficiency and conservation methods can help to reduce the need for future additional expenditures for treatment, distribution, and storage infrastructure by decreasing future water supply needs. Third, water not needed due to improved efficiency and conservation ensures more water is available for ecological and recreational use, along with the potential for storage for future use. Finally, water efficiency and water loss management support energy efficiency throughout the entire water and wastewater supply chain, thus supporting New Jersey's Energy Master Plan.

DEP continues multiple initiatives to increase water efficiency with the goal of averting future water emergencies and potential needs for water use restrictions or other costly measures during drought or other emergency conditions. Initiatives taken by DEP can be categorized as both demand/source management and statewide water conservation strategies, which are described below with greater detail provided in Appendix L.

DEMAND/SOURCE MANAGEMENT

A key feature of the New Jersey Statewide Water Supply Plan is to curtail water waste and extend New Jersey's water supplies into the future, reserving high quality waters through both source and demand management. This approach ensures that DEP can pursue water conservation and efficiency strategies by targeting the state's largest water uses.

Two trends were detected in statewide water demand and use analyses that guided the discussion of current DEP water conservation actions in the next sub-section. The first trend is the decrease in statewide water demand for power generation. This is primarily due to the closing of coal-fire power generation plants, which use more water, and replacing them with gas-fired plants equipped with more efficient cooling technologies (with the larger statewide goal of switching to renewable sources of power such as offshore wind). The second trend is the more critical issue of increasing consumptive water losses, which has primarily occurred in the public water supply and non-agricultural irrigation sectors. Specifically, these water uses include activities such as outdoor lawn/landscape irrigation, recreation, and household maintenance, which tend to be highest during peak summer months when water natural resource and treated drinking water supplies are usually the most stressed.

STATEWIDE WATER CONSERVATION STRATEGIES

Six categories of current DEP actions to promote statewide water conservation were used to form DEP potential policy options discussed in Appendix L. These actions primarily target the potable supply sector, specifically the outdoor "non-essential" or "non-potable" uses such as lawn/landscape watering, which was identified as the single greatest source of State consumptive water loss. Agricultural demands are also discussed, since they can stress local water supplies in locations where agricultural irrigation is a significant portion of demands. Each of the six categories of current DEP actions to promote statewide water conservation are provided below.

- **Public Education and Outreach:** DEP has developed and implemented different approaches to inform the public about water supply issues, drought management, and water conservation and efficiency strategies- **DEP Water Conservation**. Examples of water conservation programs DEP has implemented include the **New Jersey Water Savers** program and the **Water Champions** program. DEP also continues to promote statewide water conservation and efficiency through involvement in the Sustainable Jersey program and the Environmental Protection Agency's (USEPA) WaterSense program. Tailored programs may also need to be developed to address community or region specific issues; e.g. OBCs or vacation/shore communities

- **Reduce Non-revenue Water Losses and per Capita Water Usage:** Non-revenue water (previously referred to as unaccounted-for water) refers to water withdrawn from a source by a purveyor and is not accounted for as being delivered to customers in a measured amount. This water contributes to overall water loss – a critical problem as greater water losses increase the amount of water withdrawn from reservoirs, rivers, and aquifers, placing greater stress on these resources. Since April 2017, DEP has worked to monitor water loss data through an electronic portal, including larger systems that are interconnected and serve at least 1,000 people. In addition, DEP regulations subject New Jersey public water systems to water loss requirements and expectations and use a metric that considers all types of non-revenue water, whether real (i.e., system leakage, etc.) or apparent (i.e., meter errors, theft, etc.). DEP is also encouraging the use of a more detailed system of measurement, the Water Audit program of the American Water Works Association (AWWA) (more information is available at **DRBC Water System Audits**), which the Delaware River Basin Commission (DRBC) requires for all public water suppliers in the Delaware River Basin. At this time, DEP does not require AWWA audits to be submitted by most systems outside of the DRBC's authority. However, pending rulemaking from DEP to fully implement the Water Quality Accountability Act (WQAA) would require approximately 300 PCWSs to complete the American Water Works Association water loss audit. This increase in access to water loss data would improve DEP's ability to identify systems with excessive water losses.

- **Reduce Excessive Outdoor Water Use:** Residential and commercial landscaping contributes to the increased consumption of potable water supplies, especially during the peak use growing season. It increasingly strains surface and groundwater water resources, drinking water treatment, and infrastructure capacity. DEP employs several different strategies to reduce excessive outdoor water use.

    - **Residential Irrigation Water Scheduling and Use of Smart Irrigation Controllers:** DEP has partnered with Sustainable Jersey to create an Outdoor Water Conservation model ordinance for municipal consideration. This ordinance recommends a two-day-per-week water schedule, with an exception for properties with Smart irrigation controllers. While historically many water utilities have used every-other-day watering restrictions, in practice this tends to result in increased water usage than if restriction were not in effect. Instead, two-day per week restrictions tend to result in the desired demand reductions, while still affording residents some flexibility in maintaining their outdoor landscaping. This ordinance is promoted as a Priority Action Item in the Sustainable Jersey program, under the **Water Conservation Ordinance Action**.

- **Agricultural Irrigation System Technologies:** DEP is working to better understand water use measurements of agricultural irrigation and promote the lowest quality water for intended use. DEP in collaboration with the U.S. Geological Survey, New Jersey Department of Agriculture, and Rutgers Agricultural Experiment Station developed a pilot project to compare irrigation volumes using standard estimation methods (calculation-based method) versus two types of flow meters. Agricultural water use issues and the results of this study are also discussed in Appendix L and Chapter 6 for regions where it is the dominant water use.

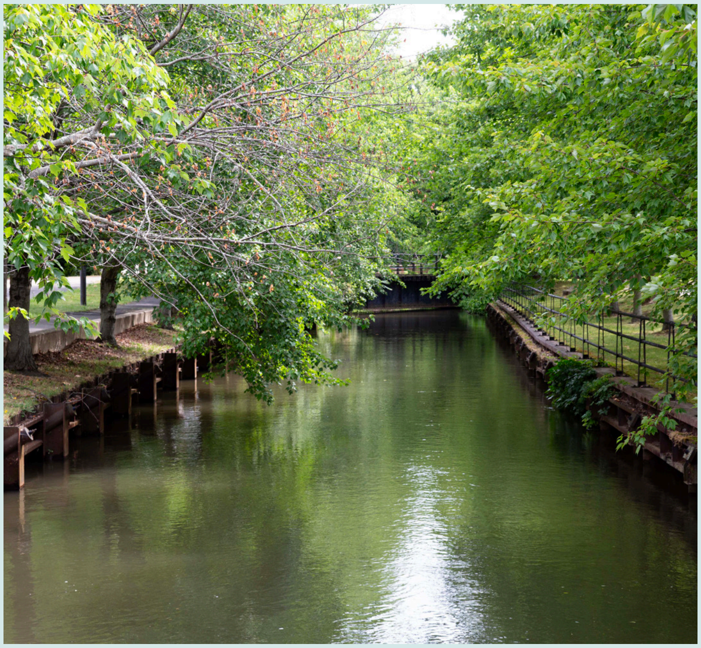
- **Residential Rainwater Harvesting:** DEP also works with the Watershed Ambassadors program to continue a residential rainwater harvesting program (rain barrels and rain gardens) that was begun in 2000. Designed to promote the lowest quality water for intended use, to date over 2500 rain barrels have been built and distributed statewide. Each barrel mitigates approximately 1400 gallons per year for a total of 3.5 million gallons annually statewide.

- **Rate-making and Billing:** Water conservation-minded rate structures are designed to motivate consumers to decrease excess water usage. However, while conservation rate structures can be effective to reduce water demands, improperly set rates may lead to unexpected demand changes that can positively or negatively affect water supplier revenue. The Board of Public Utilities (BPU), the New Jersey Department of Community Affairs (NJDCA), municipal systems, and privately owned purveyors (a) evaluate water conservation rates and water pricing systems that encourage water conservation, and (b) allow for a recovery of conservation program costs through water sales. Potential conservation rate structures that can be used include block rates, seasonal rate structures, and decoupling rate structures. DEP supports the efforts of these agencies in their evaluation and application of these rate structures wherever prudent. Additionally, prior to instituting conservation rate structures it is also important that affordability be considered with respect to income in the service area. Specifically, potential impacts to overburdened communities should be assessed. In some of these communities' rates may already be high when viewed in comparison to average income and institution of conservation rates could potentially exacerbate this situation.

- **Indoor Plumbing and Appliances:** Encouraging high efficiency household appliances can help decrease future potable water demands. Potential ways of increasing indoor plumbing efficiency include the adoption of advanced meter technology, the use of home water audits, and the development of plumbing retrofit ordinances and programs. In 2021, Governor Phil Murphy signed into law **P.L. 2021, c. 464**, establishing minimum efficiency standards for several types of residential and commercial appliances. This law applies to appliances such as spray sprinkler bodies, toilets, urinals, faucets, and showerheads. Additional information about this is available **here**.

- **Reclaimed Water for Beneficial Reuse (RWBR):** "RWBR involves taking what was once considered waste product, giving it a specialized level of treatment and using the resulting high-quality reclaimed water for beneficial use. In other words, the reclaimed water is used to replace or supplement a source of groundwater or potable water" (DEP, 2005). The importance of RWBR as a water management tool first emerged during the drought conditions of 1999 and the subsequent 2002 drought event. RWBR in New Jersey continues to gain ground as a viable and attractive water source alternative for specific purposes to help meet future water demands. RWBR applications must be sent to the DEP for approval, to ensure among other things, RWBR does not divert critical streamflow waters necessary for the health of aquatic ecosystems. DEP increasingly advocates for the use of RWBR as a drought mitigation strategy and long-term water supply management tool, particularly for highly consumptive, non-potable purposes. DEP will study further revisions to the DEP Water Allocation Rules to discourage new or increased non-potable, highly consumptive allocations, except as possible sources of back-up emergency supplies to RWBR. To promote RWBR, DEP has instituted financial assistance programs to assist the financing of new infrastructure and additional treatment requirements for RWBR projects. More information regarding RWBR can be found at the **DEP RWBR website**.

WATER SYSTEM RESILIENCE AND ASSET MANAGEMENT


The Delaware and Raritan Canal (Feeder Canal) in Mercer County.

A critical challenge of statewide water management planning is ensuring water systems can provide sufficient water during and after emergencies, such as water main breaks and severe weather events and the ability to adapt to challenges that arise as the result of climate change. The Water Quality Accountability Act of 2017 (WQAA) was adopted in response to aging water infrastructure and final recommendations by the New Jersey Joint Legislative Task Force on Drinking Water (2018). The WQAA establishes a formal framework for the asset management requirements for applicable water systems, which includes both treatment and delivery components. In addition to ensuring water systems ability to maintain and invest in their systems to guarantee the delivery of safe drinking water, it is key that systems be able to provide an adequate volume of water to their customers during emergencies, including drought. This may require both internal and external resources and strategies, such as adequately functioning system interconnections, access to proper storage, conjunctive water use, Managed Aquifer Recharge (MAR), and substitution of water resources. Exploration of new or potential expanded sources of supply may also assist PCWS to reduce the potential stress of meeting future water demand. Success in meeting these challenges hinges on proper investment by each system. This includes but is not limited to ensuring proper rate structure is in place, the use of bonds, and taking advantage of low interest loans such as those available through the Drinking Water State Revolving Fund where feasible.

DEP WATER SYSTEM RESILIENCE ACTIONS

Different categories of current DEP actions related to improving statewide water system resilience are provided below. Examples of resilience include preparedness, maintenance, and regular capital investment to address current conditions as well as those expected with future climate conditions. Each of these topics and potential management options associated with them are discussed in greater detail in Appendix L. Additional information and analysis related to water supply climate resilience is covered in Chapter 3.

- **Promote Water System Resilience and Emergency Planning:** To promote water system infrastructure resilience after Superstorm Sandy, DEP required water systems to submit their Emergency Response Plans (ERPs) in accordance with N.J.A.C. 7:19-11.2. Guidance was developed to enhance the development of the ERPs around four major themes (Flood Protection, Asset Management, Emergency Management Planning and Preparedness, and Auxiliary Power), to ensure that future rehabilitation, repair, and construction of systems are conducted “safer, stronger, and smarter”. DEP will continue to work with the drinking water sector to ensure it is prepared for extreme weather, implementing asset management, and dealing with emergencies.
- Additionally, in the summer of 2021, DEP required all surface water systems to submit addendums to their ERP’s and include Cyanotoxin Management Plans to assess systems vulnerabilities and better prepare them in the event a HAB impacted their system.
- **Emergency Agreements between Purveyors**: DEP will also continue to monitor emergency agreements between purveyors. Emergency agreements allow systems to respond to either a potential for temporary system failure (e.g., a treatment plant issue or well failure) or meet a temporary need for water supply (e.g., drought). Existing

Water Allocation rules at N.J.A.C. 7:19-6.9(g) (Operation of Interconnections) require DEP to provide approval of all emergency agreements. Additional approval by DEP must be provided through a water contract review application under N.J.A.C. 7:19-7 for interconnection operation agreements proposing routine purchase/sale or guaranteed firm capacity supplement.

- **Water Supply System Interconnections:** DEP continues to implement prioritized recommendations from the **2007 Statewide Interconnection Study**. DEP continues to use existing interconnected water systems to mitigate and avoid the negative impacts of drought and other water shortages, and is using the New Jersey River Model, Water Supply Management Decision Support Tool (WSMDT), and other equivalent tools to ensure data is kept current and to evaluate and facilitate proactive transfers. Recently, DEP has worked with the North Jersey District Water Supply Commission and Veolia Hackensack to modify normal operations of the Wanaque aqueduct to reduce the frequency of drought in the Northeast region.
- **Surface Water Reservoir System Modeling:** To determine the amount of water that can be routinely provided during a repeat of the drought of record, many reservoir-based water systems have developed safe yield models. Examples of two models developed to update safe yield estimates include one developed by the New Jersey Water Supply Authority for the Raritan System (uses the RiverWare modeling platform) and one by the North Jersey District Water Supply Commission for the Wanaque/Monksville System. DEP developed a water availability model using RiverWare for the Hackensack/Passaic/Raritan River Basins, which is used in water allocation reviews. DEP will expand its current model to address all surface water systems, including scenarios for finished water transfers and potentially to water quality issues. DEP will also continue to develop computer models to simulate water availability under different assumptions for regional and inter-regional water system groups.
- **Implementation of Water Conservation and Drought Management Plans:** Pursuant to N.J.A.C. 7:19-6.5(a)3, all water allocation permit holders are required to submit updated Water Conservation and Drought Management Plans (WCDMP). DEP will continue to enforce the requirements of existing rules to ensure that updates are accurate and implementable, and that drought management and response plans are up to date. DEP will also evaluate and review the efficacy of amending Water Allocation rules at N.J.A.C. 7:19-2.2(i) to enhance current WCDMP forms with a new water audit and water loss program that includes best management practices and reporting requirements and is compatible with Delaware River Basin Commission requirements.
- **Restructuring Water Allocation Regulations:** Water supply emergency management procedures should continue to be streamlined to reorganize and consolidate existing rules that direct water supplies management during a water emergency, including the prioritization and restriction of water uses. DEP is currently considering amendments to the existing rules (N.J.A.C. 7:19) to reflect amendments to the Water Supply Management Act, provisions of the Highlands Water Protection and Planning Act, and the enactment of the Environmental Enforcement Enhancement Act. DEP is also considering proposed amendments to simplify the water emergency surcharge schedule, incorporate stakeholder input, increase flexibility, modernize and simplify business processes, and create consistency across DEP programs.
- **General "Overdraft" Provisions:** DEP will work with water supply purveyors to ensure that seasonal water and overdraft provisions are supported by safe yield models and guaranteed contracts between water purveyors but will make sure this does not adversely impact purveyors' abilities to meet demands.
- **Competing Needs – System Investment and Water Affordability:** In many cases, rates will need to rise to provide sufficient revenue for maintenance and capital improvements, which includes both personnel and structural assets. As a result, customers may be assessed increases to their bills, which can be financially stressful for lower-income households and businesses. For this reason, affordability will be an ongoing concern for many New Jersey areas and may potentially harm drinking water utilities that face strong opposition to rate increases, despite their asset management and improvement needs. DEP will continue to work to help mitigate affordability concerns.

INTERCONNECTIONS, CONJUNCTIVE USE, MANAGED AQUIFER RECHARGE, AND SOURCE SUBSTITUTION

Water supply systems can employ a variety of strategies to help reduce their vulnerability to drought and other seasonal shortages. These strategies include system interconnections, conjunctive use, managed aquifer recharge, and substitution of water sources. A description of each management strategy is included below, with further detail provided in Appendix L.

- **Water Supply System Interconnections:** The transfer of water between systems for routine or seasonal water supplies can offset supply risk and optimize the use of regional water resources (separate from emergency transfer issues). The 2007 Statewide Interconnection Study also confirmed that interconnections are a valuable tool for alleviating regional drought conditions. However, while interconnections add to overall system reliability and resilience, it is important that the transferred water meets water quality standards, and that the resilience of the sending system is not harmed by the transfer. DEP will continue to work with purveyors to ensure any such problems are prevented or minimized. This includes evaluating and working to ensure that major interconnections between large systems such as those located in the northeast are functioning and/or constructed if not available or that alternative and adequate supplies can be delivered to customers if a major pipeline from one purveyors treatment plant to the distribution area fails.

  Related to this are PCWS without interconnections to neighboring systems or those geographically isolated and not able to interconnect. For these situations, the system needs to ensure that it has its own plans in place for any type of water supply emergency, i.e., drought or infrastructure failure. This could include alternative power supplies, emergency wells and intakes, adequate finished water storage, and plans in place to ensure that water quality is maintained. DEP will continue to work to identify these systems and work to ensure that appropriate plans are in place and that infrastructure is maintained.

- **Conjunctive Use of Multiple Water Supply Sources:** Conjunctive use can improve overall water supply reliability by providing several resources that can be strategically employed and rested based on different conditions, such as drought, peak seasons, or other water shortages. For example, a system may divert water from an unconfined aquifer during times of high availability and then rely on confined aquifers when temperatures, water use, and sparse precipitation could more adversely affect surface water sources. There are a variety of forms of conjunctive use including combined use of different surface water and confined and unconfined groundwater sources.

- **Managed Aquifer Recharge (MAR):** MAR is the process of pumping excess allocation waters into underlying aquifers for storage and future recovery. Although previously referred to as Aquifer Storage and Recovery (ASR), DEP prefers the term MAR as it covers multiple operational permutations that can go into these types of projects, one of which is ASR. MAR projects involve injected water first being treated to meet drinking water Maximum Contaminant Levels (MCLs) prior to being pumped underground, and revised review procedures were developed to meet Ground Water Quality Standards, N.J.A.C. 7:9C (GWQS). With the potential to provide water stored during off-peak periods to meet peak demands, combat drought conditions, and manage saltwater intrusion in Areas of Critical Water Supply Concern and Cape May County, DEP will continue to support the use of MAR where appropriate. The Division of Water Quality (DWQ) in coordination with the Division of Water Supply and Geoscience (DWSG) developed comprehensive review procedures for MAR projects to safeguard drinking water supply, maintain compliance with the Safe Drinking Water Act, and protect groundwater quality. DWQ is currently working to obtain information from existing MAR operations statewide to ensure consistent permitting for all MAR operations through the issuance of an individual NJPDES DGW permit.

- **Water Source Substitution:** A shift in water sources by a water supply system can reduce an existing stress in certain circumstances, like saltwater intrusion or contamination. However, water supply systems may face limitations in using this strategy due to cost and must ensure that substitutions don't generate new problems.

POTENTIAL NEW AND EXPANDED SOURCES OF SUPPLY

As discussed throughout this Plan, some New Jersey water supply resources have confirmed or face the possibility of current or future stresses where water withdrawals may increase saltwater intrusion, stress stream ecosystems, or simply exceed sustainable supplies, if they are not properly managed. DEP's Water Allocation program is responsible for ensuring water allocation permits protect water source integrity and water users. Past planning efforts have identified some capital projects as potential future water supply resources, for both source and finished waters. Along with the new or expanded projects, some of which are discussed below, it is critical that current assets are managed, maintained, exercised, repaired, etc. (which is discussed in detail in the WQAA and asset management topics throughout this Plan). Additionally, when new projects are built, long-term management plans and adequate financing must be included in operation and maintenance plans and budgets. The focus of this section is on the Northeast and Central Drought regions because of their large populations, older infrastructure, and previously identified projects. Additional details for other regions and general strategies are described in more detail in Appendix L.

- **Northeast Drought Region:** Within the Northeast Drought Region, P.L. 2005, c.349 appropriated $53 million dollars from the 1981 Water Supply Bond Fund, specifically, $30 million was appropriated for drought mitigation to enhance interbasin transfers, specifically the Virginia Street Interconnection/Pumping Station. However, 2017 regional stakeholder meetings between affected parties and DEP to determine the relevance of this project. The results of the stakeholder meeting, as well as additional DEP initiatives are outlined below:
    - **Virginia Street Interconnection and Belleville Pumping Station:** The Virginia Street Interconnection/Pumping Station, located in Newark, is limited in size and has limited resources devoted to operation and maintenance. The 2007 Interconnection Study identified the Virginia Street Interconnection as a critical water supply asset with opportunity for inter-basin transfers between the City of Newark, New Jersey American Water (NJAW) – Raritan system, and the North Jersey District Water Supply Commission (NJDWSC). To reach its full design capacity, the NJAW-Raritan and Newark systems require improvements to transmission capabilities and a new pumping station is needed at the Belleville Reservoir site. DEP will work with purveyors to assess the utility of these improvements and will work with Central and Northeast drought region water suppliers to develop a strategy to make the Virginia Street Interconnection/Pumping Station fully functional and automated with the necessary enhancements.
    - **Additional Water Infrastructure Options:** The 2007 Interconnection Study also found that additional enhancements to critical water supply infrastructure in the Passaic and Hackensack basin would greatly increase the region's ability to address water supply emergencies such as infrastructure repair and drought. Examples of additional enhancements include: (a) the preservation of the full operational capacity of Newark's Cedar Grove Reservoir in a manner that meets EPA and DEP's uncovered finished water reservoir safe drinking water requirements, and (b) the expansion of the Chittenden Road interconnection to include the North Jersey District.
    - **Coordinated Operations:** Modeling and assessment conducted by DEP show that the coordinated operation of the larger surface water supply systems in the northeast and central regions can greatly increase resilience and decrease the frequency of system stress. One primary example of this is the use of the Wanaque Aqueduct which transfers water from NJDWSC sources to the Oradell Reservoir operated by Veolia. Modeling conducted by DEP and both utilities showed that coordinating operations and delaying water transfers reduced simulated drought days over the period-of-record and increased overall safe yield of the two systems. Recent events suggest that real-world benefits were achieved. The potential exists for other shared and coordinated operations to increase resilience, but additional modeling, new finished water interconnection and infrastructure, and cost sharing agreements would need to be designed and implemented.
    - **Uncovered Finished Water Reservoirs:** In 2006, the Federal Safe Drinking Water Act regulations required existing open finished storage reservoirs to be covered to prevent contamination or to provide for 4-log virus removal, 3-log Giardia inactivation, and 2-log Cryptosporidium inactivation treatment by April 1, 2009. There are only 20 uncovered finished water reservoirs (UFWR) still in use in the United States, 5 of which are in the State of New Jersey, with the major ones located in northeastern New Jersey. While they represent critical sources of finished water supply (often close in proximity to demands), they also pose unique water quality risks. For example, PVWC's New Street Reservoir was inundated by untreated runoff from the remnants of Hurricane Ida in 2021 requiring a multi-week boil-water advisory. DEP will continue to actively work to reduce risks posed from these sources and ensure that all drinking water quality standards are met while preserving critical finished water supplies. These actions apply to UFWR throughout the state such as the one utilized by Trenton Water Works.

- **Central Drought Region:** The Eastern Raritan Basin Water Feasibility Study, the 1996 Plan, and the 2017 Plan identified several projects in the Raritan River Basin that can be used to increase the safe yield of the New Jersey Water Supply Authority (NJWSA) within the Raritan Basin and the Central Drought Region.
  - **Kingston Quarry Reservoir:** One project under consideration is the Kingston Quarry Reservoir. It was initially proposed by Trap Rock Industries as a reclamation plan for their rock quarry once operations cease. It is envisioned as two large water storage pool areas located at an elevation below the Canal that would store unused Delaware and Raritan Canal flow and/or high flows from the Millstone River for eventual release back into the canal during low-flow periods. This project is considered a viable strategy only if legal issues related to the operation, land, and necessary storage volumes are met at the required time of transference. As of 2023, this operation quarry is still being actively used, DEP and NJWSA will consider engaging a consultant to research next steps to pursue the Kingston Quarry Reservoir project.
  - **Confluence Pumping Station:** Confluence Pumping Station is a second project for the Central Drought Region that can provide additional safe yield of approximately 50 million gallons per day (mgd) in the NJWSA Raritan System. This project would entail replacing an existing release pipeline from Round Valley Reservoir to the South Branch of the Rockaway Creek that is currently used for releases from Round Valley. The new pumping station would construct a new pipeline from this existing discharge point on the Rockaway Creek to the confluence of the North and South branches of the Raritan and pumping station (in the pool formed by the Headgate dam) would supply water from downstream to the reservoir. Although this project is currently not being actively pursued, it is assumed to be one of several priority projects if additional safe yield is needed. Recent announcements by the DEP's Office of Natural Resource Restoration outlining plans to remove the Headgate dam complicate the development of the project if it is needed in the future.
  - **Additional Opportunities:** Additional opportunities for the Central Drought Region include: (a) the application of a multi-day average passing flow scheme to meet the requirements of New Jersey Statute NJSA 58:1B-1 et seq., and (b) bolstering the interconnection of water supply systems between the Central (Raritan River Basin) and Coastal North Drought Regional systems. The use of a multi-day averaged passing flow scheme would also allow the New Jersey Water Supply Authority to reduce over releases since there would be additional time to balance out under releases over the next several days.
- **Finished water-supply interconnections:** Multiple reports, modeling exercises and staff experiences have shown that maintenance, use and expansion of finished water-supply interconnections are critical to address water supply emergencies, both short-term (i.e. water main breaks) or long-term (i.e. drought, loss of source, or water quality treatment limitation). This recommendation applies throughout the state to both small and large water systems.
- **Retention of Previously Acquired Water Supply Properties:** Although they are not presently figured in near-term capital water supply development, DEP will ensure the Six Mile Run Reservoir and Hackettstown Reservoir as well as other identified properties remain preserved for future water supply purposes.
- **Advanced Treatment Technologies:** Advanced treatment technologies may also be used to develop new sources of water supply. Implementation of RWBR can be used as a water supply source for existing and new non-potable purposes. DEP will assess and consider proven treatment technologies to convert "non-potable" water supply sources to "potable sources."

As issues emerge and water supply conditions evolve, specific priority projects may change. Future Plans and plan updates will document any new projects.

ADEQUATE ASSET MANAGEMENT

Increasing water supply resilience requires adequate asset management of water supply systems and infrastructure. This includes estimating infrastructure needs, maintaining infrastructure, and a determination of how infrastructure will be financed. DEP offers several programs to assist in these efforts, including its rules and guidance provided in its Asset Management Policy program and Capacity Development program. Each of these aspects of asset management and DEP's existing programs to assist in these efforts is discussed below, with greater detail provided in Appendix L.

- **Water Quality Accountability Act:** The Water Quality Accountability Act (WQAA), P.L. 2017, c. 133 (WQAA), enacted on July 21, 2017, established new requirements for purveyors at certain PCWS to improve the safety, reliability, and administrative oversight of water infrastructure. The WQAA became effective on October 19, 2017. Additionally, on November 8, 2021, amendments to the WQAA were signed into law as P.L. 2021, c. 262. These changes enhance the cybersecurity requirements of the WQAA, among others. The Act applies to PCWS with more than 500 service connections (approximately 1000-1500 residents, for PCWS that primarily serve residential customers); approximately 300 water systems in New Jersey are regulated under the WQAA. Further information on the program is available from **DWSG WQAA**.

  The WQAA requires purveyors to create and implement an asset management plan designed to inspect, maintain, repair, and renew its infrastructure consistent with standards established by the American Water Works Association. Asset management plans must be developed and must include annual identification of critical infrastructure repair and restoration or replacement projects for the next three years. Submittal of the asset management plans to DEP is not required by the WQAA, but the plans must be available for DEP review when requested. Purveyors must annually submit a Capital Improvement Report, which must outline their capital projects completed pursuant to their asset management plans, and identify projects planned up to 10 years in the future. Over time this allows for a comparison of anticipated versus actual expenditures, water system performance, and other technical, managerial, and financial capacity indicators. In addition, the Act also specifies a frequency for routinely testing valves and fire hydrants, compliance aspects of drinking water regulations, and cybersecurity programs.

  It should be noted that the WQAA only applies to public water systems and has no obligations for wastewater utilities. While there are different regulatory and management obligations between the different utilities, service disruptions and environmental impacts

(***Top***) Hamden Pump Station operated by the New Jersey Water Supply Authority in Clinton Township, New Jersey; (***Bottom***) Infrastructure located in Veolia's Haworth Water Treatment Plant in Haworth, New Jersey.

caused by aging and deteriorating infrastructure have major societal impacts. Additionally, many purveyors subject to the WQAA also own and operate wastewater utilities. This has created some confusion and uncertainty as different sides of a water utility's "shop" may have unequal regulatory obligations. Additionally, there are a handful of cases where large, regional water suppliers may pump and treat water on a wholesale basis to other utilities which may have to comply with the WQAA, but do not have enough direct individual customers to be subject to the WQAA themselves.

- **Estimating Infrastructure Needs:** Several existing reports have evaluated New Jersey's drinking water systems infrastructure and estimated the potential cost of addressing its infrastructure needs. In its "2021 Report Card," The American Society of Civil Engineers New Jersey Chapter gave New Jersey a "C-" (mediocre) grade for its drinking water infrastructure (see **New Jersey Infrastructure Report Card** and **New Jersey Infrastructure Report Card Summary**) and identified over $8.6 billion in total drinking water need. Moreover, the USEPA's 7th Drinking Water Infrastructure Needs Inventory released in April 2023 estimated that $12.2 billion in capital investments will be needed over the next 20 years to update, install, and replace New Jersey's drinking water infrastructure (See **EPA 7th Drinking Water Infrastructure Needs Survey and Assessment**).
- **DEP Asset Management Policy Program:** DEP promotes responsible asset management and adequate infrastructure reinvestment, which are essential to ensuring long-term integrity of water system assets and the sustainable supply of safe drinking water to customers. DEP encourages asset management through both rules and ensuring permit requirements. Guidance documents are also available to assist with clarifying permit requirements and to ensure best management practices for governing water system maintenance, operation, and management. Detailed information about asset management can be found at DEP's Asset Management webpage: **DEP Asset Management**.
- **Maintaining Infrastructure:** Starting in 2008, the New Jersey Clean Water Council (CWC) has conducted public hearings focused on water-related environmental infrastructure (including drinking water), regarding objectives, needs, financing, and management in the State. The need for greater attention on asset management was identified as a recurring theme at these hearings, including adequately funding related assets on a sustainable basis. Based on the recommendations developed from these hearings, DEP developed asset management guidance focused on: (a) a routine asset condition assessment; (b) a programmed and preventive maintenance system; and (c) a procedure to evaluate life-cycle cost impacts of repair or replacement decisions.
- **Securing Infrastructure and Critical Assets:** Ensuring that water supplies and their associated infrastructure are physically secure (in addition to cyber secure) is a key element in providing New Jerseyans with safe and adequate supplies. The distributed nature of water supply sources (both wells and reservoirs), treatment plants, and distribution networks creates unique risks for the DEP, water utilities, and local governments, and the residents they serve. For example, some of the state's largest reservoirs, such as Spruce Run, Round Valley, and Monksville, allow recreation and include private property on the shoreline. While this situation creates unique recreational opportunities, it also creates additional security risks. Another example is aqueducts, canals and large pipelines that run long distances from water sources to demand centers which require additional resources to monitor. Many of these have been in existence for almost a century and the public and local governments often overlook their significance. In light of these risks, the DEP will continue to require and expand, where necessary, the physical security requirements defined in N.J.A.C 7:19 2.14 and N.J.A.C 7:10-11.6.
- **DEP Capacity Development Program to Identify Problem Systems:** DEP administers the Capacity Development (CapDev) program to try to identify and quantify individual system problems related to potential infrastructure needs and financial shortfalls in developing and maintaining infrastructure. Originally a mandate of the 1996 Federal Safe Drinking Water Act (SDWA) amendments, it is a tool to identify specific water systems with technical, managerial, and financial (TMF) deficits and provide the tools needed to overcome their shortcomings and attain long-term system viability. Every three years the CapDev program identifies a list of non-compliant water systems that require assistance to resolve TMF issues based on input from DEP's Compliance and Enforcement section and county health departments. More information on this program is available at: **DWSG Capacity Development Program**.

- **Infrastructure Financing:** Providing safe drinking water requires heavy capital investment, and the costs of building environmental infrastructure are often placed on ratepayers and taxpayers. In partnership with the New Jersey Infrastructure Bank (I-Bank), DEP promotes the use of the New Jersey Water Bank, which implements the Clean Water and Drinking Water State Revolving Funds (SRFs). The NJ Water Bank provides low-interest financing for Technical Assistance and Capital Improvement projects to keep costs to the public as low as possible. The I-Bank was originally created by legislation enacted in 1986 to establish an independent State authority to manage efficient and low-cost financing for environmental infrastructure projects. In addition to administering the SRFs, the NJ Water Bank has recently been able to enhance its funding capacity due to the enactment of the Bipartisan Infrastructure Law (BIL). Due to this influx of funding, DEP also initiated the **Water Infrastructure Investment Plan (WIIP)**, which highlights available low-cost funding to eligible borrowers, defray maintenance costs, and improve New Jersey's water infrastructure for its ratepayers. DEP's Bureau of Water System Engineering also jointly manages the Drinking Water State Resolving Fund (DWSRF) with the DEP's Municipal Finance and Construction Element and the New Jersey I-Bank.

ENVIRONMENTAL JUSTICE AND WATER SUPPLY

Robert Bullard suggests that "Environmental justice embraces the principle that all people and communities have a right to equal protection and equal enforcement of environmental laws and regulations." (Bullard, 2023). Many current regulatory frameworks fail to fully meet this expectation; extensive research shows that land uses causing environmental harm are strongly associated with overburdened communities. The USEPA states that "[e]nvironmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies," (EPA, 2023). This definition combines results and procedural approach. The New Jersey Environmental Justice Law (N.J.S.A. 13:1D-157) does not define environmental justice, per se, but rather includes a statement of purpose: "The Legislature further finds and declares that no community should bear a disproportionate share of the adverse environmental and public health consequences that accompany the State's economic growth…".

In accordance with the Environmental Justice Law, DEP has mapped the extent of overburdened communities (OBCs), defined by the criteria below, as census block groups with:

1. at least 35 percent low-income households; or
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.

The total population of OBCs mapped by DEP is nearly 4.8 million, more than half of the state's population. (See: **What are Overburdened Communities?**). These areas are shown in the EJMAP (**Where Are New Jersey's Environmental Justice Communities?**).

While environmental justice addresses essentially all aspects of environmental policy, the focus here is on implications regarding water supply and the relationships between affordability, asset management and resilience. This Plan takes the first steps to identify these relationships and outlines the major areas where additional research and action is needed.

OVERBURDENED COMMUNITIES AND PUBLIC WATER SYSTEMS

Using the mapping of OBCs, PCWS service areas, and recent research on the affordability of drinking water and wastewater utilities (Van Abs et al., 2021), it is possible to identify PCWSs that are entirely or largely within OBCs, their service area populations, the percentage and population of households that may face water and sewer utility costs that pose affordability concerns (using a combination of utility costs and household incomes), and whether the PCWSs face water supply constraints that may compromise existing or future supply of water to customers. Of the 584 PCWSs analyzed, 24 PCWSs with total populations of more than 1.3 million have at least 70 percent of their service area in OBCs. Of this population, roughly 300,000 people are in households that may face affordability concerns, ranging from 11 to 43 percent of the households served in each system.

Not all OBCs are the same. Many PCWSs with a high percentage of OBCs serve historic urban centers and were built during times of relative wealth, mostly as major industrial centers (e.g., Camden, Jersey City, Newark), but in the post-World War II period saw a major reduction in wealth.[1] Several of these urban PCWSs face projected reductions in water demands from 2020 to 2050, which will reduce revenue and therefore increase the costs per gallon of system operation, maintenance and asset management for the system's customers. In other cases, significant growth is anticipated, which will provide additional revenue but may also stress the PCWS's ability to meet water demands. In addition to historic urban centers there are newer PCWSs, serving major post-war suburban areas that also face similar issues.

Table 5.1 provides a summary of PCWS with high percentages of OBCs. Figure 5.2 shows one general and four specific maps and summary data showing the relationship between selected PCWSs and OBCs.

Ensuring that all residents are able to afford perhaps their most essential utility, water, remains a challenge for the PCWSs that serve low-income communities. PCWSs must ensure there is adequate revenue to support needed investment to maintain reliable, safe water service throughout their entire service area, but some low-income residents may face challenges in being able to continue to afford their water bill as rates are expected to increase in the future. This challenge became much more apparent during the COVID-19 pandemic, when many residents in New Jersey fell into arrearages as a consequence of non-payment for their water bills. For investor-owned water utilities alone, BPU identified approximately 142,000 residential customers who were in arrearages for their water bills in May 2022, representing approximately $42 million in unpaid bills (**BPU May 2022 Arrearages for Posting**). Shutoffs were suspended for the duration of the pandemic, allowing customers the flexibility to defer paying water bills to pay for other essential costs. However, the experience did illustrate how many residents are economically vulnerable and face the possibility of being unable to pay for their water bills. This scenario creates a ripple effect where the PCWS which serves the community may not generate sufficient revenue, resulting in said utility being unable to initiate necessary capital improvements, or even fund routine maintenance work, to maintain reliable water service. This problem was temporarily addressed in New Jersey via the Low-Income Household Water Assistance Program (LIHWAP), administered by NJDCA, which used federal dollars to help cover that resource gap, particularly for residents who were hardest hit by the COVID-19 pandemic. However, the federal funds supporting LIHWAP have since been exhausted, meaning that LIHWAP is not currently able to deploy additional resources to support New Jersey's neediest residents. Given the reliance on LIHWAP support to offset water utility costs, it is recommended that similar initiatives are evaluated and implemented.

[1] Newark is a good example of this pattern. In the late 1800s, Newark was wealthy enough to purchase 35,000 acres of land in rural areas of Morris and Passaic counties and build five reservoirs for its **Pequannock Watershed** system, providing high-quality source water. After peaking at nearly 450,000 residents, Newark's population declined to less than 275,000. Newark has nearly one-third of its households with incomes below the federal poverty line. Only in recent years has Newark's population begun to increase, to roughly 300,000 in 2023.

Table 5.1 PCWS with High Percentages of Overburdened Communities

PWSID	PCWS Name	% Over-burdened Community	Estimated 2018 PCWS service area population	Estimated % HH* below affordability baseline threshold	Estimated Population of HH* below affordability baseline threshold	Projections
NJ0705001	East Orange Water Commission	100%	64,404	27.7%	17,865	Demand declining
NJ1216001	Perth Amboy Dept of Municipal Utilities	100%	51,854	32.6%	16,887	Demand stable or declining
NJ0408001	Camden City Water Department	100%	44,726	60.7%	27,152	Demand declining
NJ0102001	Atlantic City MUA	100%	38,260	49.6%	18,983	Demand declining
NJ0717001	Orange Water Department	100%	30,405	32.1%	9,748	Demand declining
NJ0338001	Willingboro MUA	100%	33,086	13.8%	4,580	Demand stable, supply sufficient
NJ0714001	Newark Water Department	99%	279,082	34.8%	97,138	Growth expected, demand declining
NJ1111001	Trenton Water Works	99%**	217,000	26.0%	56,420	Demand declining, supply available
NJ2004001	Liberty Water Company c/o NJ American	98%	128,124	31.4%	40,294	Demand growth, supply available
NJ0701001	Belleville Township Water Department	98%	33,005	11.0%	3,619	Demand stable, supply constrained
NJ1215001	North Brunswick Water Department	97%	41,922	15.2%	6,379	Demand stable, supply sufficient
NJ1221004	South Brunswick Township	96%	43,835	11.4%	4,991	Major growth, supply available
NJ1214001	New Brunswick Water Department	94%	56,012	43.3%	24,269	Demand declining
NJ1808001	Franklin Township (Somerset County)	93%	62,261	18.7%	11,618	Demand growth, supply sufficient
NJ0906001	Jersey City MUA	92%	261,687	24.7%	64,735	Major growth, peak supply constrained?
NJ0901001	Bayonne City Water Department	89%	65,325	24.4%	15,911	Demand growth, supply sufficient
NJ0614003	Vineland City Water and Sewer Utility	88%	51,488	22.4%	11,555	Demand growth, supply constrained?
NJ1409001	Dover Water Commission	86%	26,319	23.9%	6,301	Demand declining
NJ2013001	Veolia (Rahway)	82%	29,380	22.1%	6,501	Demand declining
NJ1205001	Edison Water Company	82%	44,156	12.5%	5,533	Demand stable, supply sufficient
NJ1225001	Middlesex Water Company	80%	203,772	16.1%	32,833	Demand declining
NJ1605002	Passaic Valley Water Commission	79%	306,902	31.0%	95,130	Demand declining
NJ0424001	Merchantville Pennsauken Water Commission	76%	44,192	21.1%	9,338	Demand stable to declining
NJ0702001	Bloomfield Water Department	74%	48,890	11.8%	5,757	Demand declining
NJ1219001	Sayreville Borough Water Department	70%	44,251	17.1%	7,557	Demand growth, sufficient supply

*HH means households
**The 99% value for Trenton Water Works' percent OBC was calculated based on the city's municipal boundary although the system also provides water to communities outside of the boundary.

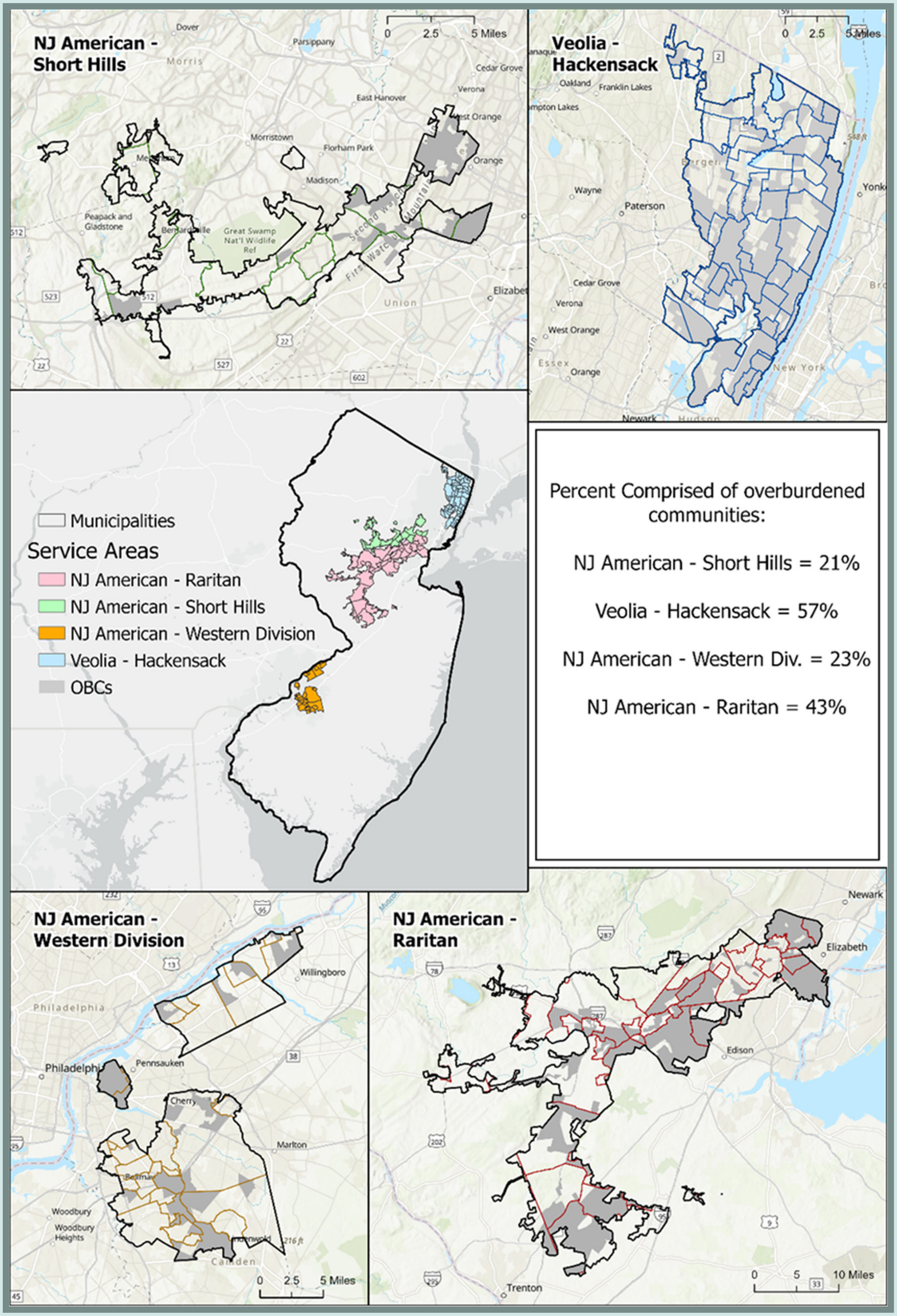


Figure 5.2 Maps and summary data showing relationship between selected PCWSs and OBCs.

The importance of interconnections between water systems to promote resilience is well attested to in this Plan. Systems that lack these connections have fewer options in responding to loss of supply, which could occur for a variety of reasons, and face greater risk of failing to provide adequate quantities of water with the necessary quality to customers. Where water systems serve OBCs, these risks may be compounded. Table 5.2 summarizes systems lacking interconnections where OBCs comprise the majority, by land area, of the service area, suggesting the potential for increased difficulties in financing future investment into water system redundancy. Systems that serve smaller populations will have fewer customers to fund system improvements and may need access to financial assistance programs. One example is the presence of PFAS contamination anticipated to be found throughout the state and New Jersey's (and potentially the lower EPA) MCL criteria necessitating the installation of additional and costly treatment requirements.

Water systems were categorized and counted based on the classes defined in NJSDWA Rule 7:10-15.4. Systems without interconnections are defined here as those that did not record a water transfer or interconnection between 2011 and 2020. This is a preliminary analysis which could lead to a more specific study of communities that may or may not face water supply-related risks.

Table 5.2 Non-interconnected water systems where the majority of service area is comprised of OBCs.

PCWS	Class 1 (Pop. 25 to 999)	Class 2 (Pop. 1,000 to 9,999)	Class 1 (Pop. 10,000 to 49,999)	Class 1 (Pop. 50,000 or more)
System Counts	27	13	1	0

OVERBURDENED COMMUNITIES AND PRIVATE WELLS

There are also numerous overburdened communities outside of PCWS service areas; these communities rely on private wells for household and business water supplies. Figure 5.16 shows OBCs outside of PCWS service areas and includes HUC11s with potential water availability limitations. Where private wells suffer from contamination or loss of supply due to groundwater declines, the stresses on the OBCs will be exacerbated. Stresses from contamination may be felt more acutely in some ways by lower income, lower density, and more rural OBCs served predominantly by private wells. As lower income private well owners may not have the financial resources, or education to fully appreciate the importance of system maintenance and regular testing for not only contaminants with acute health effects (E. Coli or Nitrate), but also chronic (e.g. Arsenic) or emerging contaminants (e.g. PFAS or 1,4-dioxane), these individuals may be more susceptible to exposure to these health effects via their drinking water. Even if an individual in an OBC is able to obtain the financial resources to conduct such a test, they may struggle further to either install treatment for the contaminant(s) of concern, connect to a municipal water supply, or else switch to bottled water. These options are costly, and limited resources outside of New Jersey's **Spill Fund** are available. Additionally, the fundamental challenge of owning and adequately maintaining an aging drinking water well remains costly. Lower income residents may lack the financial capital to pay the cost for a licensed well driller to replace a failing drinking water well, and needy residents may resort to hiring unqualified, or unlicensed individuals to meet their potable water needs. DEP's Technical Assistance Funding program may be able to assist in some instances. More information is available at the DEP **WIIP Technical Assistance Request website**.

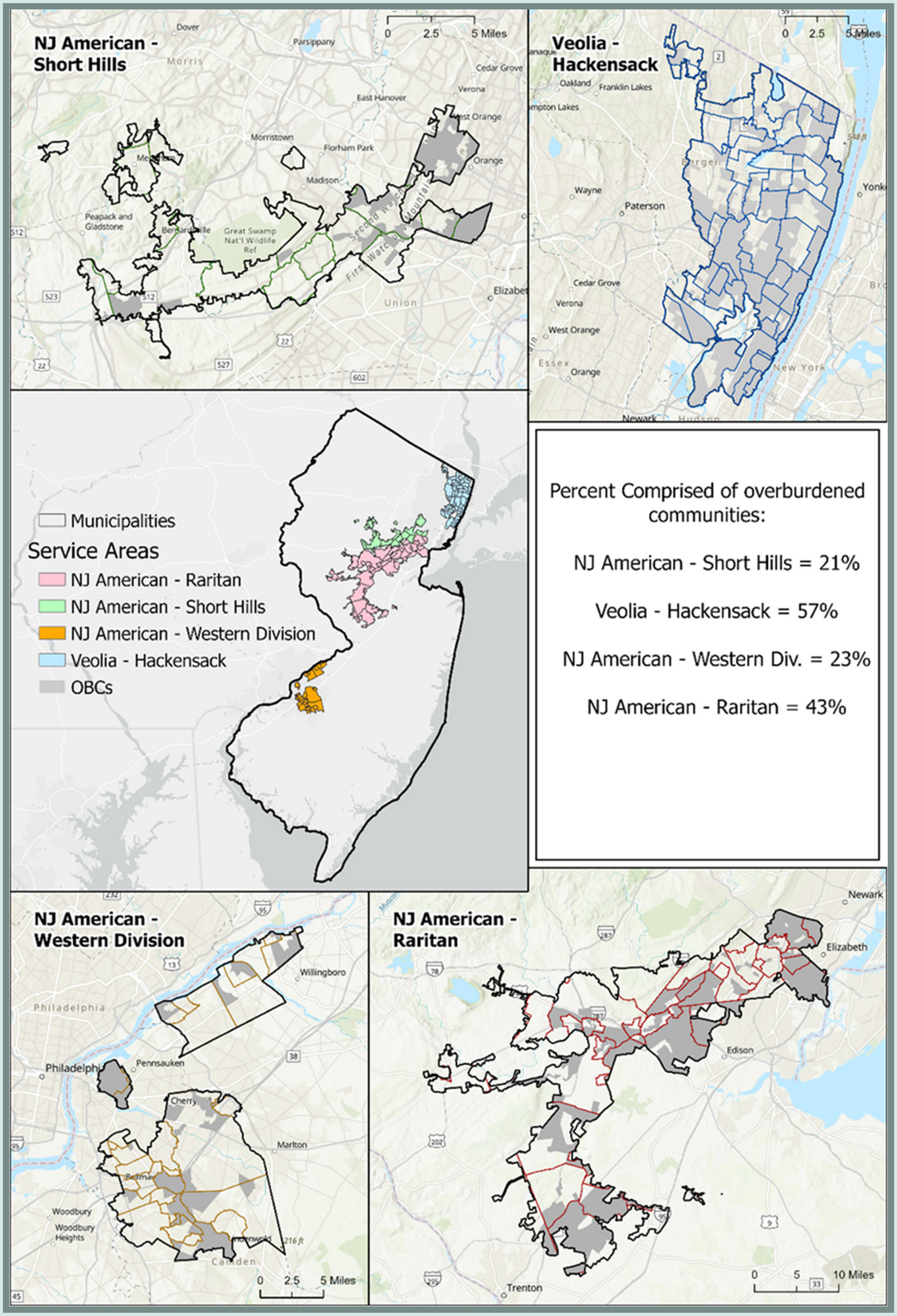


Figure 5.2 Maps and summary data showing relationship between selected PCWSs and OBCs.

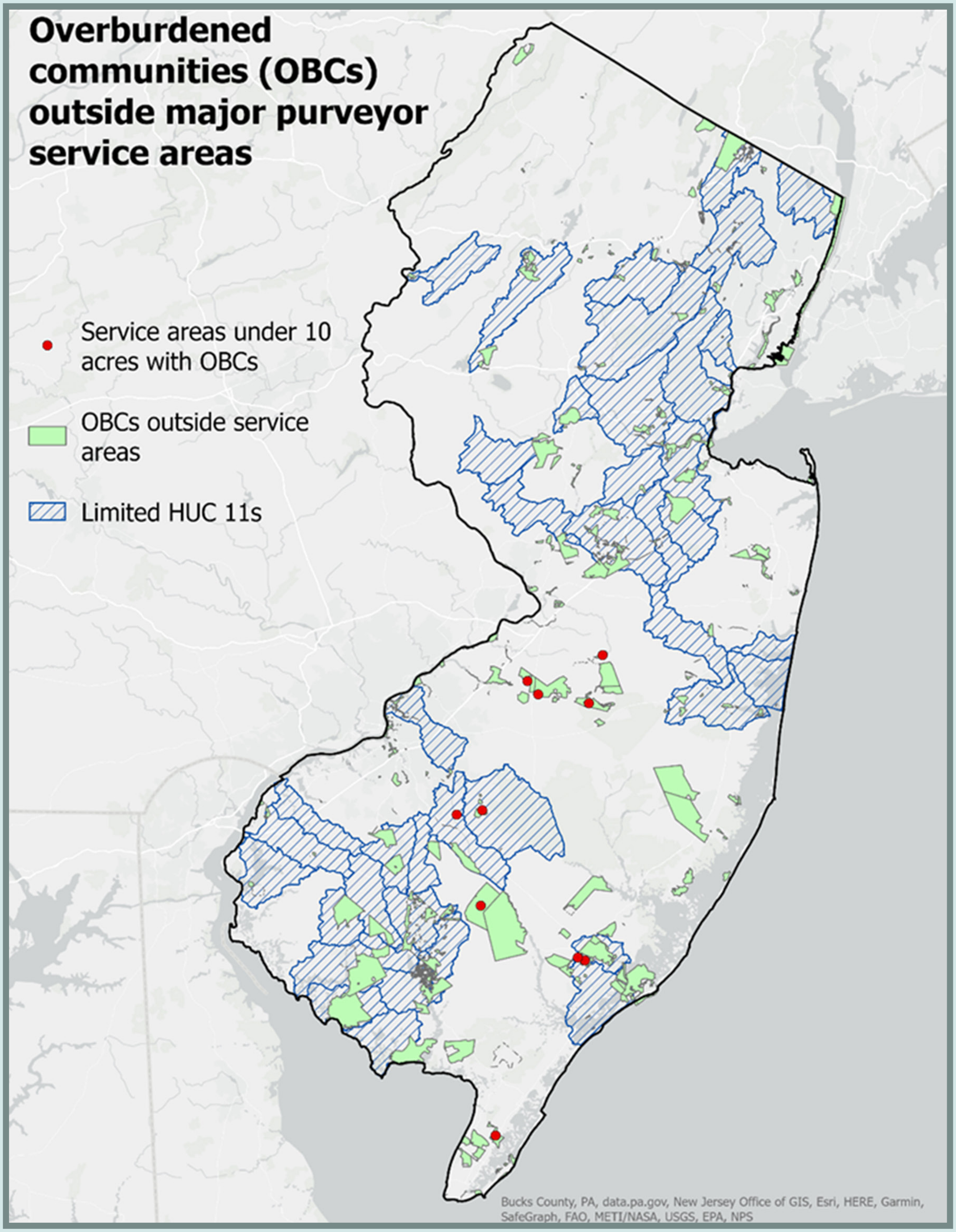


Figure 5.3 Overburdened communities outside of PCWS service areas and HUCs with potential unconfined aquifer availability limitations.

ENVIRONMENTAL JUSTICE RECOMMENDATIONS

- DEP should support legislative efforts to explore the establishment of a permanent LIHWAP program across New Jersey. Additional efforts could be made at the federal level. By providing support for low-income residents to consistently be able to afford water bills, this can avert the need for water shutoffs as well as provide the buffer needed for PCWSs to establish the rates necessary to fully fund the needs of their water infrastructure. This would also ensure that even low-income customers are able to afford water service as rates increase in the future. The legislature should consult with the NJDCA and BPU to identify possible parameters of a permanent LIHWAP, and lessons learned from implementing the temporary program to ensure that eligible homeowners would be aware of the program, that PCWSs would be supportive and accepting of these funds, and that the program would be sustainable to support residents' needs.
- The DEP should consider working with the New Jersey Department of Health (NJDOH), NJDCA and local and county health to sponsor additional research into the scope of financial need for low-income private well owners.
- While any resident served by a private well is subject to the health risks associated with a contaminated, or failing well, these concerns are exacerbated within OBCs due to the historic challenges experienced by these communities. To alleviate the financial burdens which may accompany the ownership of a private well or small PCWS (such as mobile home parks or similar types of isolated systems), DEP should support legislative efforts to explore the establishment of a revolving funding source that provides low- or no-interest loans or grants to eligible homeowners to ensure support is accessible to residents in need for the replacement of failing drinking water wells due to age, or installation of treatment for naturally occurring contaminants (or human-made where a responsible party is not apparent). This fund could be operated in a revolving fashion and modeled after the highly successful State Revolving Funds for both Drinking Water and Clean Water.

PROTECTING DRINKING WATER

DEP implements the New Jersey Safe Drinking Water Act (NJSDWA) and has been granted primacy for implementing the federal Safe Drinking Water Act by the USEPA. Most provisions of these laws are focused on ensuring the treatment and delivery of drinking water that meets federal and state standards to customers of public water systems. Ensuring safe drinking water, however, does not rely solely on treatment. Rather, it uses a multi-barrier approach that starts with protection of the water source, as a treatment system will be more successful if the incoming source waters are of high quality. Poor quality source waters increase the treatment technology needed, the cost of treatment, and the potential for treatment difficulties. It is for this reason that the SWAP was developed and integrated with ongoing regulatory programs that protect water sources. The following sub-sections discuss DEP efforts to ensure safe drinking water through the implementation of the Safe Drinking Water Program including the Lead and Copper Rule, and the Water Quality Accountability Act.

SAFE DRINKING WATER PROGRAM

DEP's Division of Water Supply and Geosciences is responsible for regulating and guiding the proper operation of public water suppliers in New Jersey, in compliance with the NJSDWA (N.J.S.A. 58:11 et seq. and N.J.S.A. 58:12A-1 et seq.) and the NJSDWA Rules (N.J.A.C. 7:10). The suppliers are responsible for treated or delivered drinking water quality, system operations, finished drinking water storage, water pressure, etc., and submitting regular compliance reports to the DEP. Many of these reports, including information on the system's licensed operators, reported water quality sampling, water system violations, and other relevant data, are available to the public at the New Jersey Drinking Water Watch web page: Drinking Water Watch. Although customers are directly notified of any violations in applicable public notices and their annual consumer confidence reports, **Drinking Water Watch** increases the accessibility of this data to the public. DEP also collaborates with the NJDOH and local health boards on implementation of the Private Well Testing Act (N.J.S.A. 58:12A-26) and Private Well Testing Act Rules (N.J.A.C. 7:9E), which require testing of private wells upon sale or transfer of residential property.

DEP is responsible for working with drinking water utilities in the event of water contamination issues, including water main breaks and water pressure problems that might require drinking water advisories and the response to acute public health threats (e.g., E. Coli), to achieve compliance with all regulatory requirements as quickly as possible. One of the best ways of ensuring compliance is to prevent problems from developing in the first place; DEP operates a Capacity Development Program by promoting effective technical, managerial, and financial capacity for all water utilities, through technical assistance and training and funding (see **DEP-DWS&G Capacity Development Program**). DEP also conducts research to identify potential drinking water issues and develop new or revised Maximum Contaminant Levels (MCLs) or treatment techniques for drinking water contaminants.

SAFE DRINKING WATER PROGRAM NEXT STEPS

As mentioned above, under N.J.A.C. 7:10, a permit is required to be obtained from DEP by PCWS (and PNCWS that serve Federal or State facilities) for the construction or modification of drinking water infrastructure and treatment. While permits are issued for new or modified components or processes, there is no permit or approval issued by DEP for the overall operation of a water system regulating its management and maintenance.

Some water systems take a proactive approach to ensuring their system is properly managed and maintained. These systems may take a variety of measures such as:

- the development of Operation & Maintenance manuals that are routinely referenced and adhered to by personnel employed by the water system;
- ensuring sufficient staffing, including the appropriate licensed individuals;
- taking extra steps not required by regulation or permitting requirements, such as routinely inspecting and maintaining assets (e.g. water storage tanks); and
- maintaining accurate records of operations, maintenance activities and system disruptions.

However, not all systems are proactive and it's possible that a water system may comply with delivering water that meets drinking water standards at key regulatory compliance points (e.g., at the point of entry to the water system) but deliver water that degrades prior to reaching the customer's tap due to poor maintenance or management of the water system overall. Other water systems may struggle to meet drinking water standards due to the lack of robust operational and maintenance standards.

Therefore, DEP has started to explore the feasibility of the issuance of Water System Operation Permits to specify conditions of proper water system management and maintenance. Other states including Alabama, California, Iowa, South Carolina, Vermont and Virginia currently issue these types of permits to their regulated community. The conditions that could be included in these types of permits would result in higher quality water to customers and result in fewer violations of drinking water standards. DEP seeks to enhance its existing authority to issue such permits. DEP will assess, with stakeholder input, whether these types of permits should be issued and if so, whether conditions should be standard for each system, or if conditions should vary based on system size and type or other factors.

Roughly ten percent of New Jerseyans rely on private wells (about 400,000 homes) and as such the homeowners are the primary agent responsible for ensuring adequate water quality (See **New Jersey Private Well Information**). Many homeowners rely on private companies to test and treat their water and DEP is exploring the possibility of certification and licensing requirements for installers of treatment systems within the home. New Jersey homeowners that self-supply potable water via a private domestic well or who are publicly served but desire secondary treatment may opt to install point-of-entry (POE) or point-of-use (POU) treatment devices in their home. Currently, there are no certification or licensing requirements for individuals who install POE or POU treatment devices in homes in New Jersey. Although there are reputable and experienced companies within the state, there are some which lack the knowledge and expertise to provide the correct treatment units that effectively and safely reduce contaminants of concern. Due to this lack of professional certification or licensing, a potential gap exists which could result in residents receiving ineffective, or in some cases, actively detrimental treatment systems which could introduce new health risks to homeowners and their families. A statewide certification program for residential POE or POU systems would ensure quality of service and provide confidence for New Jersey residents that the treatment they pay for is effective in providing the advertised goals and is properly installed to not cause further harm. Such a certification program would need to be designed to align with relevant requirements for licensed plumbers. As an analogue, there is an existing radon treatment professional certification program in New Jersey that can serve as a model for the proposed certification. The radon program originated within DEP in the 1980s, but became mandatory in 1991, and now maintains certifications for about 900 individuals and 35 businesses.

LEAD AND COPPER RULE

Lead is a pollutant that is rarely found in source water withdrawn from the streams, reservoirs, and aquifers of New Jersey. It is commonly found when drinking water chemically reacts with the lead pipes and plumbing fixtures when moving from a water treatment plant to the end user, most often in the service lines between the water mains and a customer meter. However, premise plumbing, older fixtures, and solder, can also contribute to lead in drinking water. DEP's Lead Team has worked with a wide variety of industry and other stakeholders to ensure that the Federal Lead & Copper Rule (LCR) requirements are fully being implemented in New Jersey and to create guidance to support the New Jersey Board of Education rules that require sampling for lead in water in New Jersey schools. As a result, the State Legislature adopted and the Governor signed legislation in 2021 requiring that all PCWS replace all lead service lines within 10 years. This legislation predated but will support the implementation of federal LCR requirements for lead service line replacements. The New Jersey safe drinking water requirements for lead will be updated as necessary in response to federal LCR requirements as they change. More information is at **Lead in Drinking Water.**

RESILIENCE, SUSTAINABILITY, AND CLIMATE CHANGE

As discussed in Chapter 4, current trends in water availability modeling indicate that surface water safe yields face limited changes through the year 2050 and surficial aquifers in many but not all HUC11 areas may see increased water availability. Indoor residential water demands are likely to continue to decline, a long-standing trend that will not be affected by climate change. However, outdoor water demands are likely to continue to increase, as temperatures increase and the growing season lengthens, and periodic dry spells become more frequent. Flood events are likely to become more frequent and severe as annual precipitation increases and storms become more intense. Finally, sea level rise will put more developed lands and some coastal plain wells at risk.

Beach erosion control structure near East Point in Cape May County.

These findings are important to environmental justice. As discussed earlier in this chapter, PCWS resilience is dependent upon the ability to respond and adapt to environmental forces. Sustainability of a PCWS depends heavily upon the ability to charge rates that reflect the true cost of water supply, so that the PCWS assets are well maintained. Any PCWS with a high proportion of lower-income households will have difficulties raising rates to pay for good asset management in normal times. When disasters strike, a PCWS could both lose revenue and face disaster related disruptions and response costs, not all of which will necessarily be eligible for reimbursement by state and federal disaster recovery funds.

Sea level rise could result in the loss of service area, through a forced move of customers and demolition of development that cannot be protected cost-effectively. While many areas along the Jersey Shore coast have high-value developments, there are areas along the shores of the Arthur Kill, Newark Bay, Hackensack Meadowlands, Hudson River, Raritan Bay, Delaware Bay, and tidal Delaware River that have concentrations of low-income households. These areas face greater difficulties in attracting funds for risk-reduction projects that protect development. This is especially true for federal funds that require project benefits that exceed costs, a difficult test when development values are low. The loss of service area will result in lower revenues along with the need to address abandoned infrastructure. Conversely, there may be some situations where rebuilding elements of the water supply infrastructure, while doable and where funds may be available, simply does not make sense in the larger context of community sustainability and long-term climate change impacts. With the support from **New Jersey's Interagency Council on Climate Resilience**, DEP released the New Jersey Climate Change Resilience Strategy (NJDEP, 2021) and continues to expand guidance which can be found at the **DEP Climate Change website** to help governments, utilities, and communities make informed decisions.

Finally, many PCWS in New Jersey will face additional costs for treatment of recent and upcoming MCLs for toxic and carcinogenic substances such as PFAS chemicals, 1,4 dioxane and others, along with the costs of removing lead service lines as required by state law. Therefore, the long-term ability of PCWS to sustain operations and to respond to external disasters is lower when their customer base faces high affordability stresses. There is no permanent state or national program to assist customers so that PCWS can set rates at viable levels without harming their customers.

STATEWIDE SAFE DRINKING WATER ASSESSMENT

To comply with the NJSDWA, public water suppliers apply a variety of treatments prior to finished water reaching customers. The figures and tables below serve as a high-level assessment of these processes, displayed in both statewide summary form and mapped to provide geographic context. While emerging contaminants are a concern, and are addressed in detail in Chapter 2, this section serves to communicate some of the many actions that are currently taken to ensure residents of New Jersey have access to continuous supplies of safe drinking water. The analysis underlines how water from different sources and geographic areas must be treated differently. A complete understanding of the current steps undertaken to provide the residents of the state with safe drinking water is useful in planning for future water supply needs. For the following tables and figures note that some water systems rely on wells that are so close to surface water sources that they are considered groundwater under direct influence (GUDI). These wells were categorized as groundwater for the purposes of this assessment. The number of active water systems and the treatment processes they apply are subject to change. The data used to generate the figures and tables below was generated in March 2023.

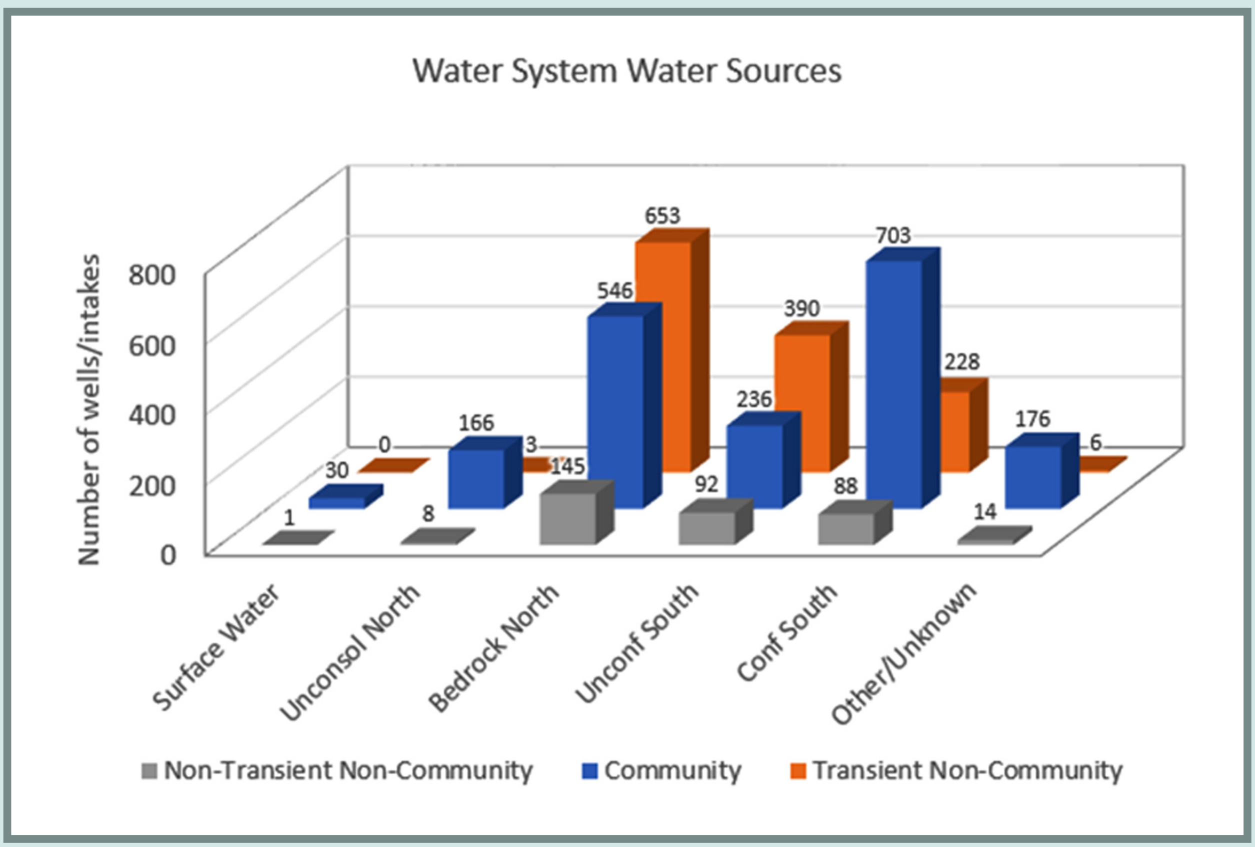


Figure 5.4 Shows number of wells/intakes associated with water systems in the water sources listed.

For this assessment the potable water sources were broken out in the following categories. Surface water includes any intake on a river or reservoir. “Unconsol North” refers to the unconsolidated aquifers located in the Newark Basin, Highlands and Valley and Ridge physiographic provinces and includes primarily sand and gravel aquifers associated with glacial outwash or post-glacial fluvial deposits. “Bedrock North” refers to wells screened in competent bedrock in the Newark Basin, Highlands and Valley and Ridge physiographic provinces. “Unconf South” refers to the unconfined aquifers of the Coastal Plain physiographic province with the most common one being the Kirkwood-Cohansey aquifer. “Conf South” refers to the confined aquifers of the Coastal Plain physiographic province and includes the Potomac-Raritan-Magothy, the Atlantic City 800-ft Sand, and the Wenonah-Mount Laurel aquifers, among others.

Table 5.3 (**Top**) Shows the number of public water systems (by PWSID and including CWS, NTNC and TNC) that apply the treatment objectives listed. Many systems apply more than one objective resulting in total values summing to more than total number of systems.

(**Bottom**) Shows total number of systems that apply some treatment and total that do not treat. Note that the “no treatment’ systems are still required to monitor water quality and install treatment if necessary. Some of these systems may also be purchasing all their water from a system that does treat its water. This analysis did not account for that situation.

Number PWSIDs	Percentage PWSID Statewide	Treatment Objective
1,239	34.6%	DISINFECTION
767	21.4%	CORROSION CONTROL
720	20.1%	SOFTENING (HARDNESS REMOVAL)
685	19.1%	PARTICULATE REMOVAL
684	19.1%	IRON REMOVAL
213	5.9%	INORGANICS REMOVAL
175	4.9%	ORGANICS REMOVAL
146	4.1%	TASTE / ODOR CONTROL
86	2.4%	RADIONUCLIDES REMOVAL
54	1.5%	MANGANESE REMOVAL
53	1.5%	OTHER
14	0.4%	DISINFECTION BY-PRODUCTS CONTR
2,485	69.4%	**PWSID - Treatment of some kind**
1,096	30.6%	**PWSID – Monitoring, but no treatment**
3,581	100.0%	**Total PWSID**

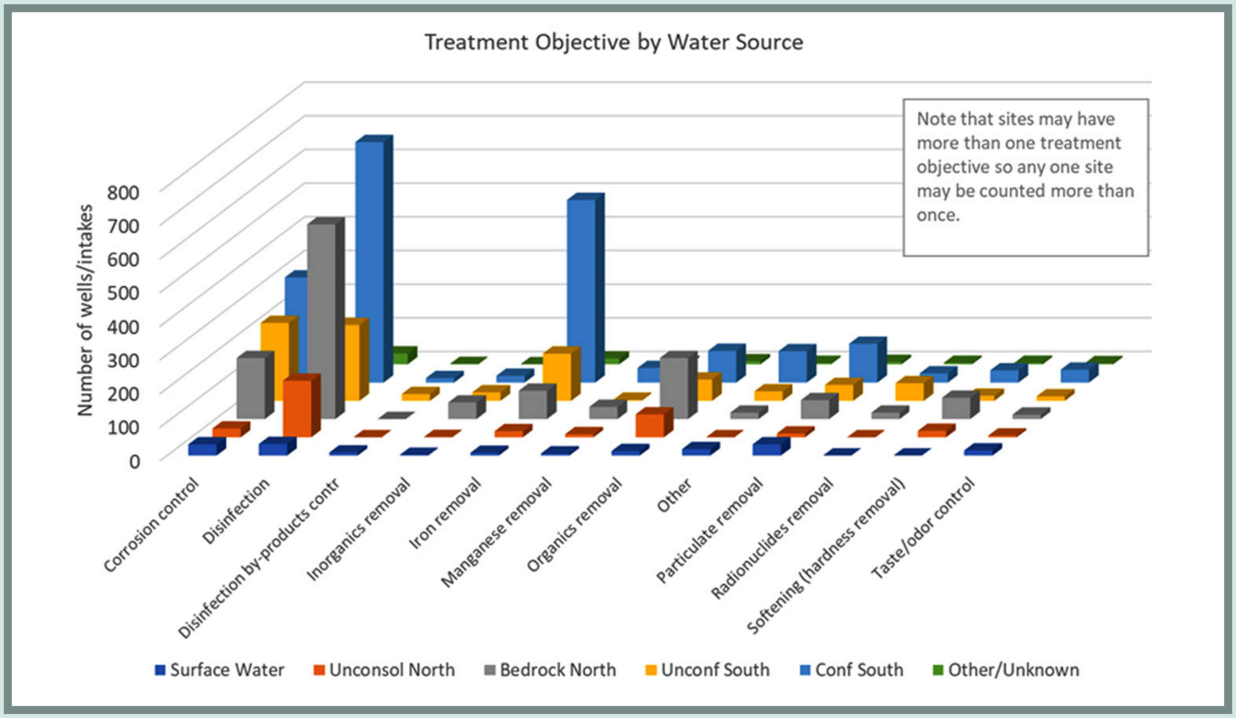


Figure 5.5 Shows the number of wells/intakes where the listed treatment objectives are applied. Data is grouped by water source.

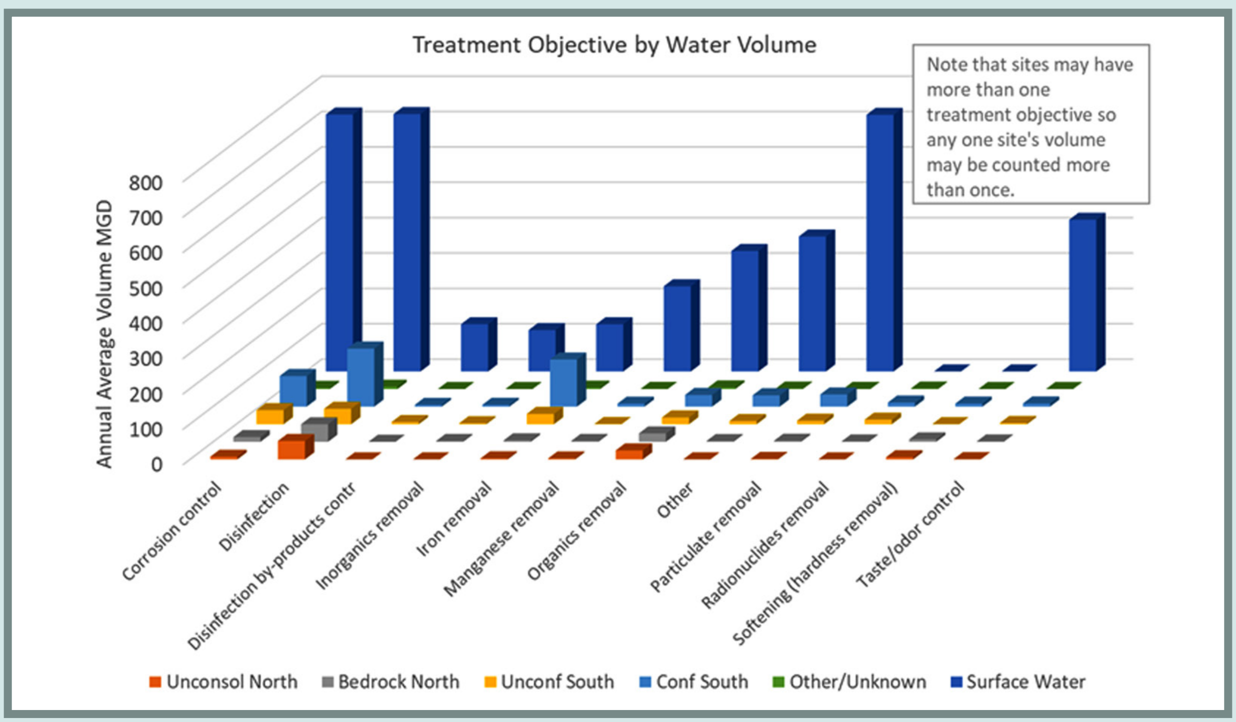


Figure 5.6 Shows the volume of water that undergoes the listed treatment objectives. Data is grouped by water source.

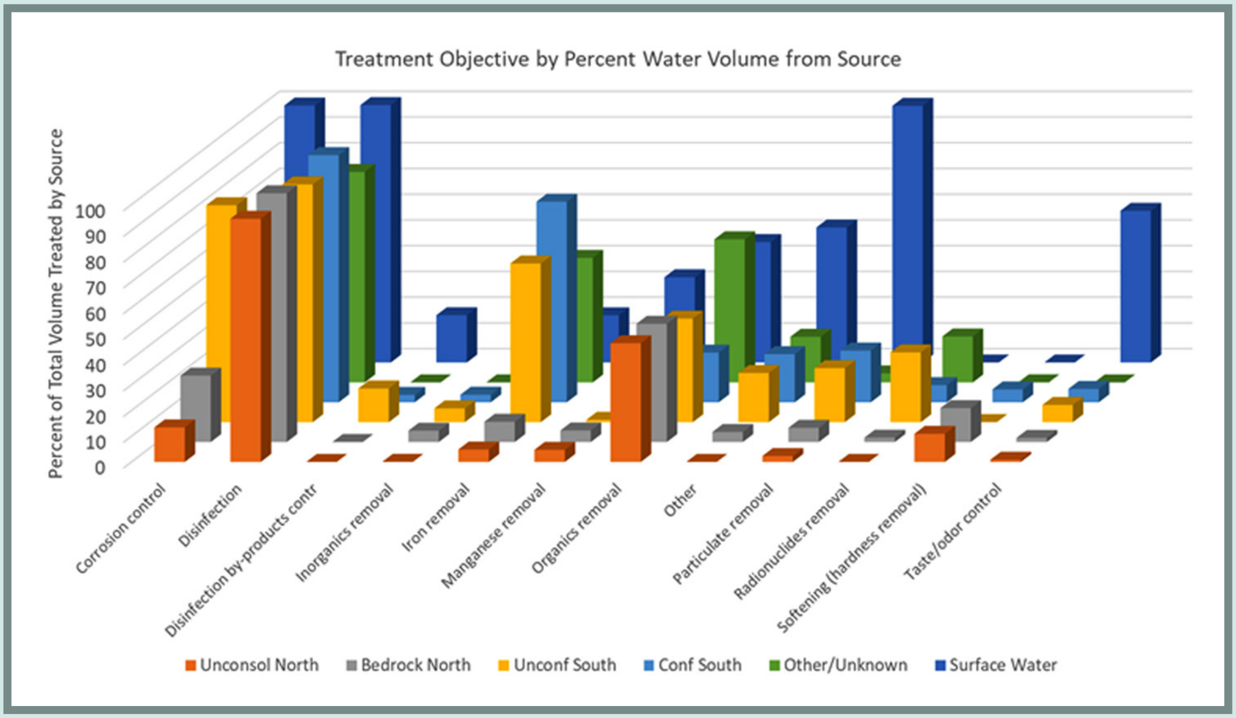


Figure 5.7 Shows the percent volume of water that undergoes the listed treatment objectives for all withdrawals within a given water source.

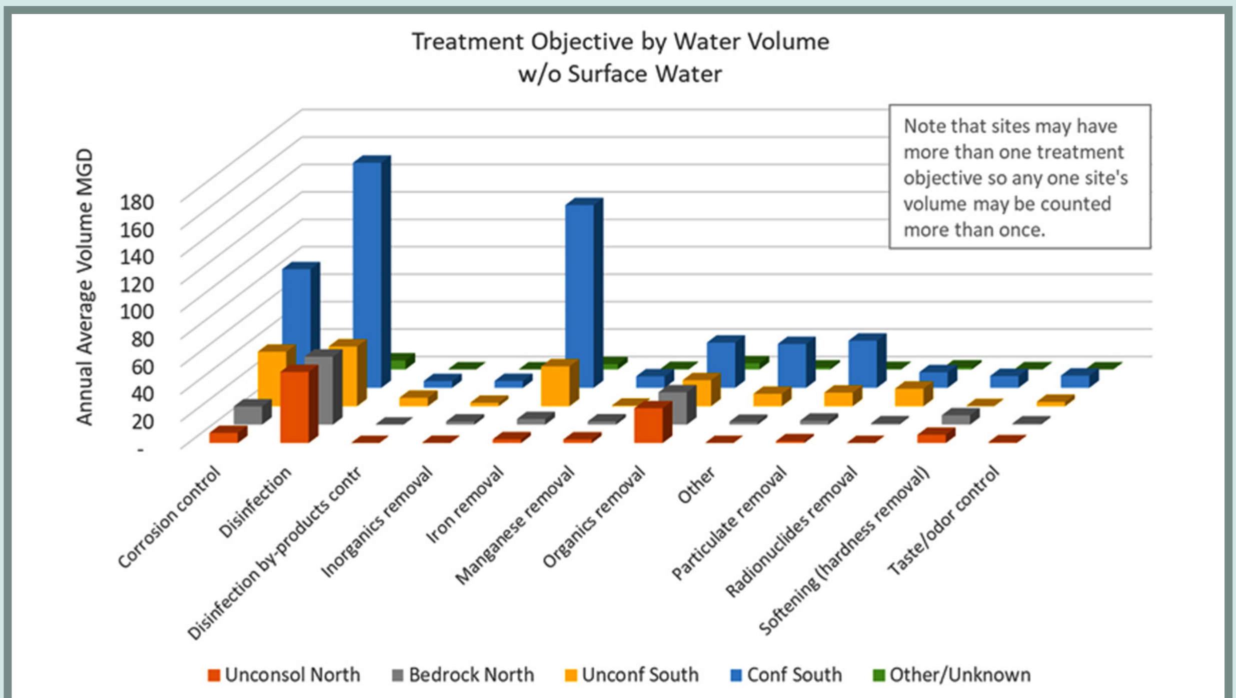


Figure 5.8 Shows the volume of water that undergoes the listed treatment objectives with all surface water removed. Data is grouped by water source.

The following maps show similar information on a subset of treatment objectives and analytes by water system location. These maps are not exhaustive but are included to show the geographic extent of water system service area and drinking water treatment. Note that purchaser systems may be using treated or not treated water.

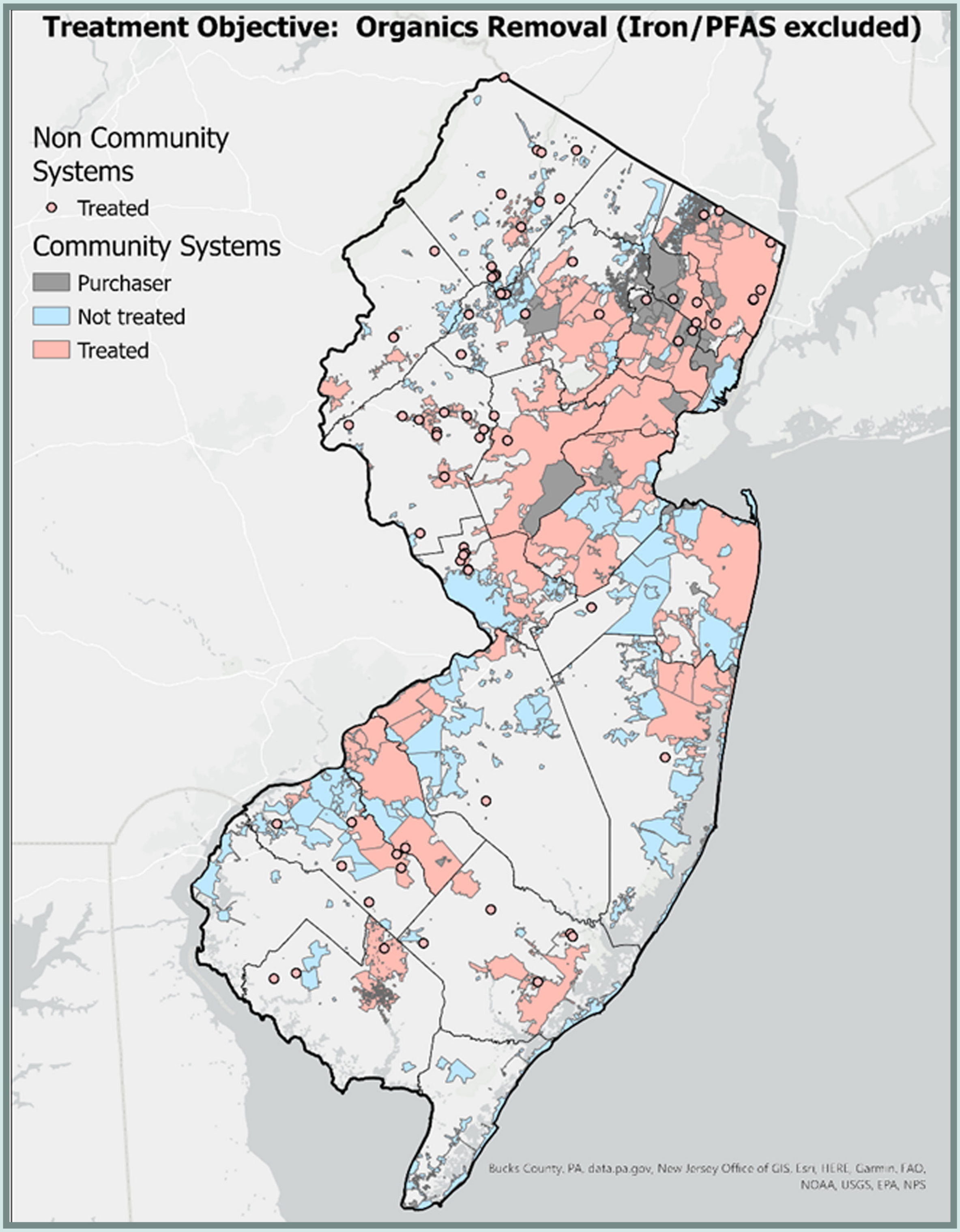


Figure 5.9 Statewide map showing water systems that apply organics removal treatment.

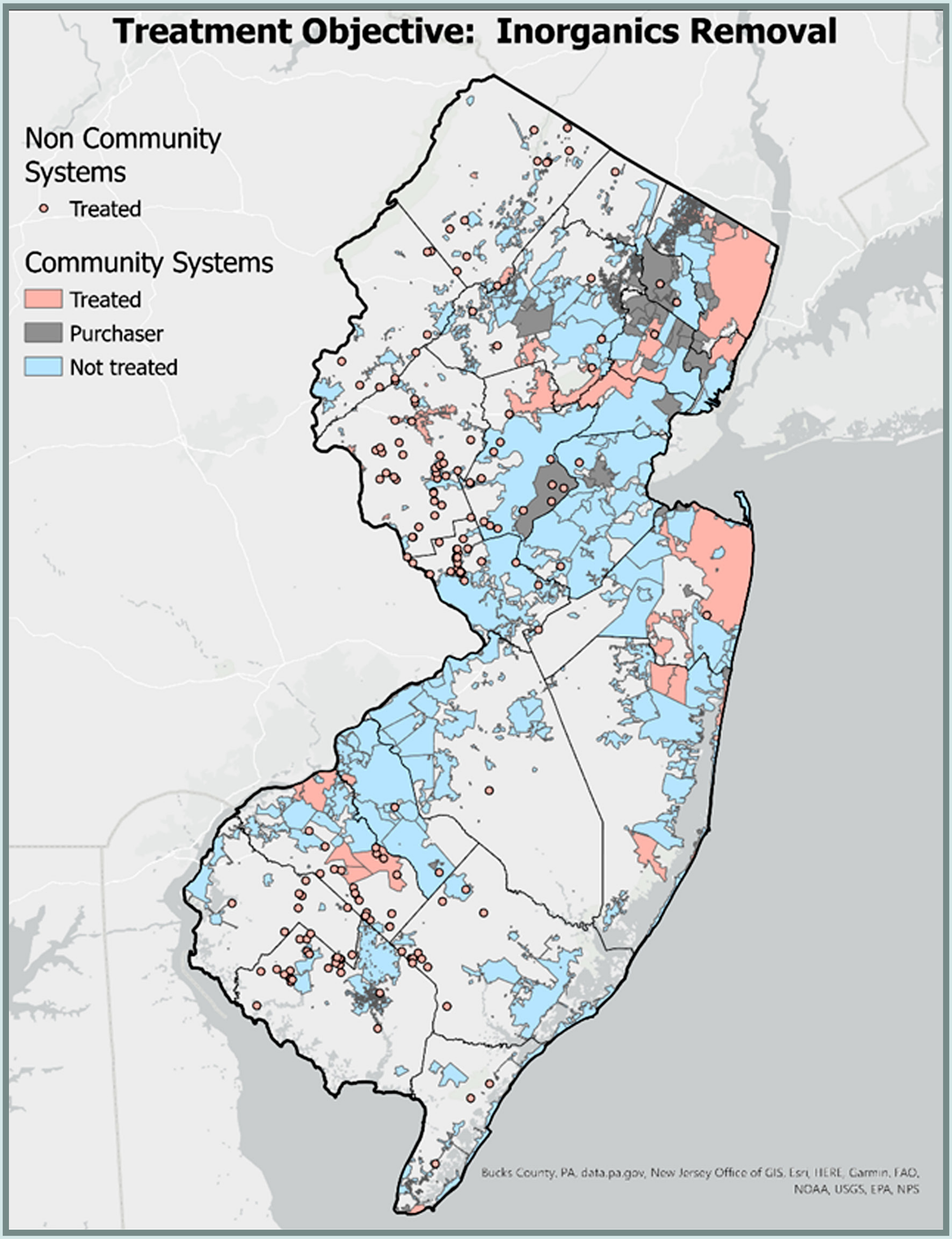


Figure 5.10 Statewide map showing water systems that apply inorganics removal treatment.

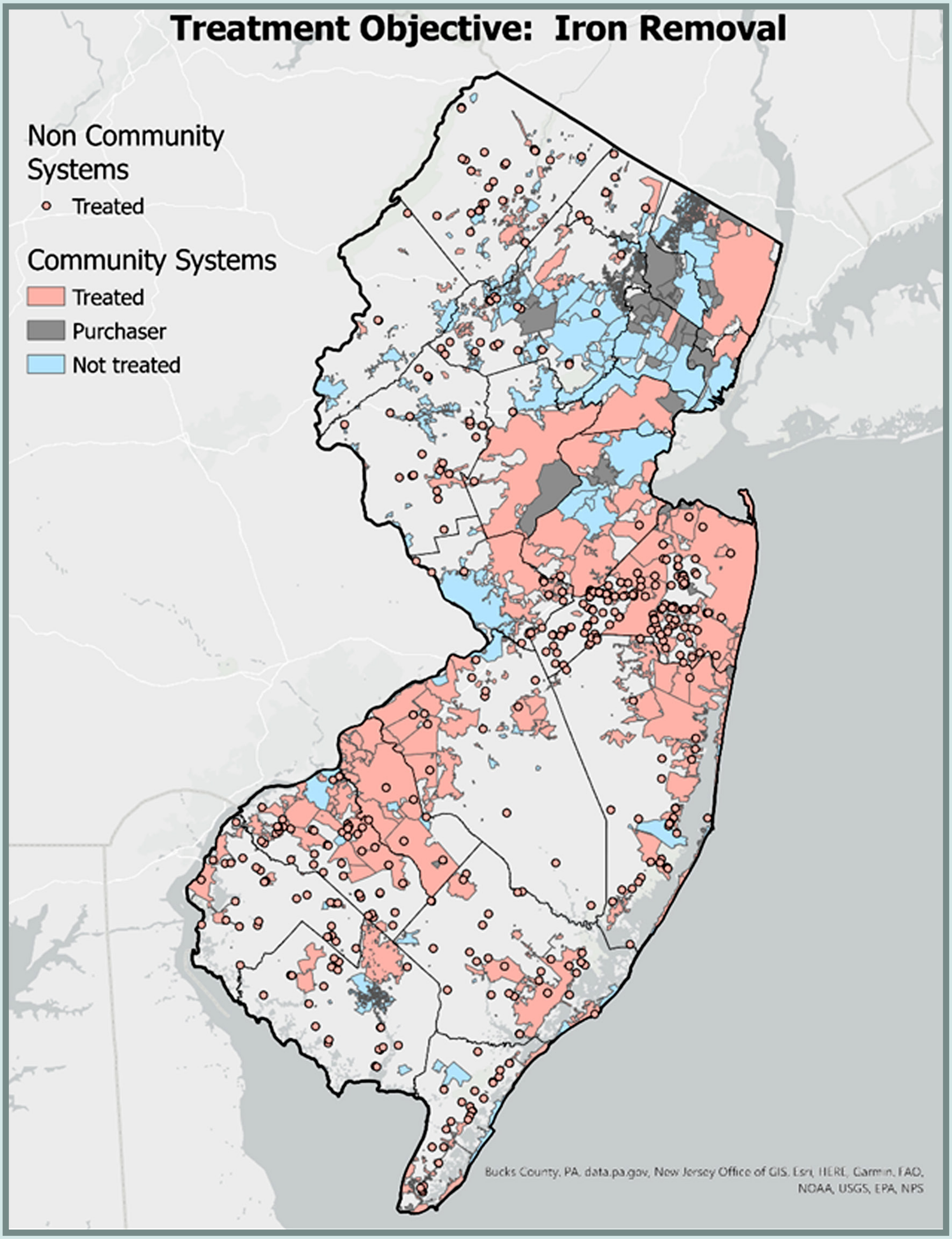


Figure 5.11 Statewide map showing water systems that apply iron removal treatment.

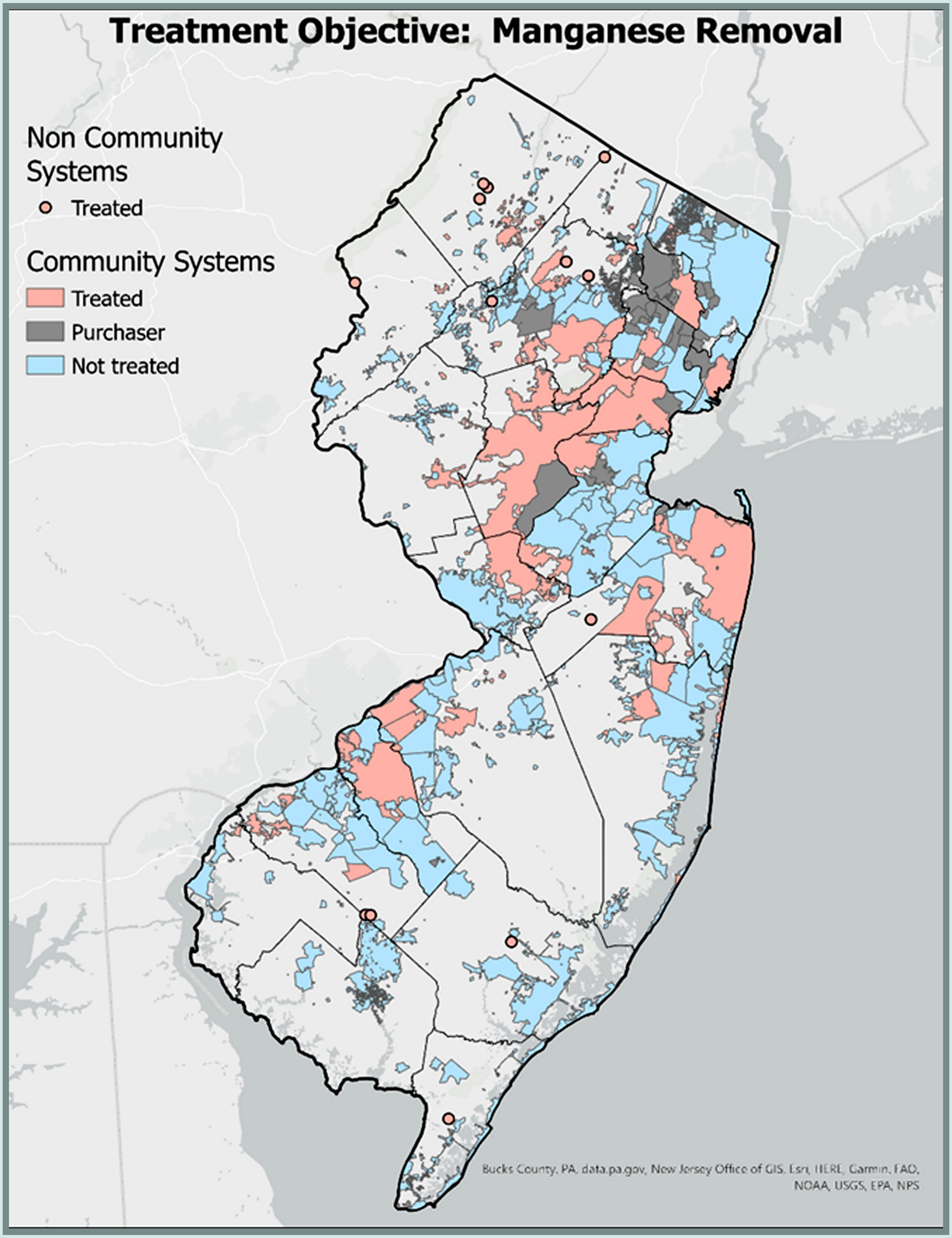


Figure 5.12 Statewide map showing water systems that apply manganese removal treatment.

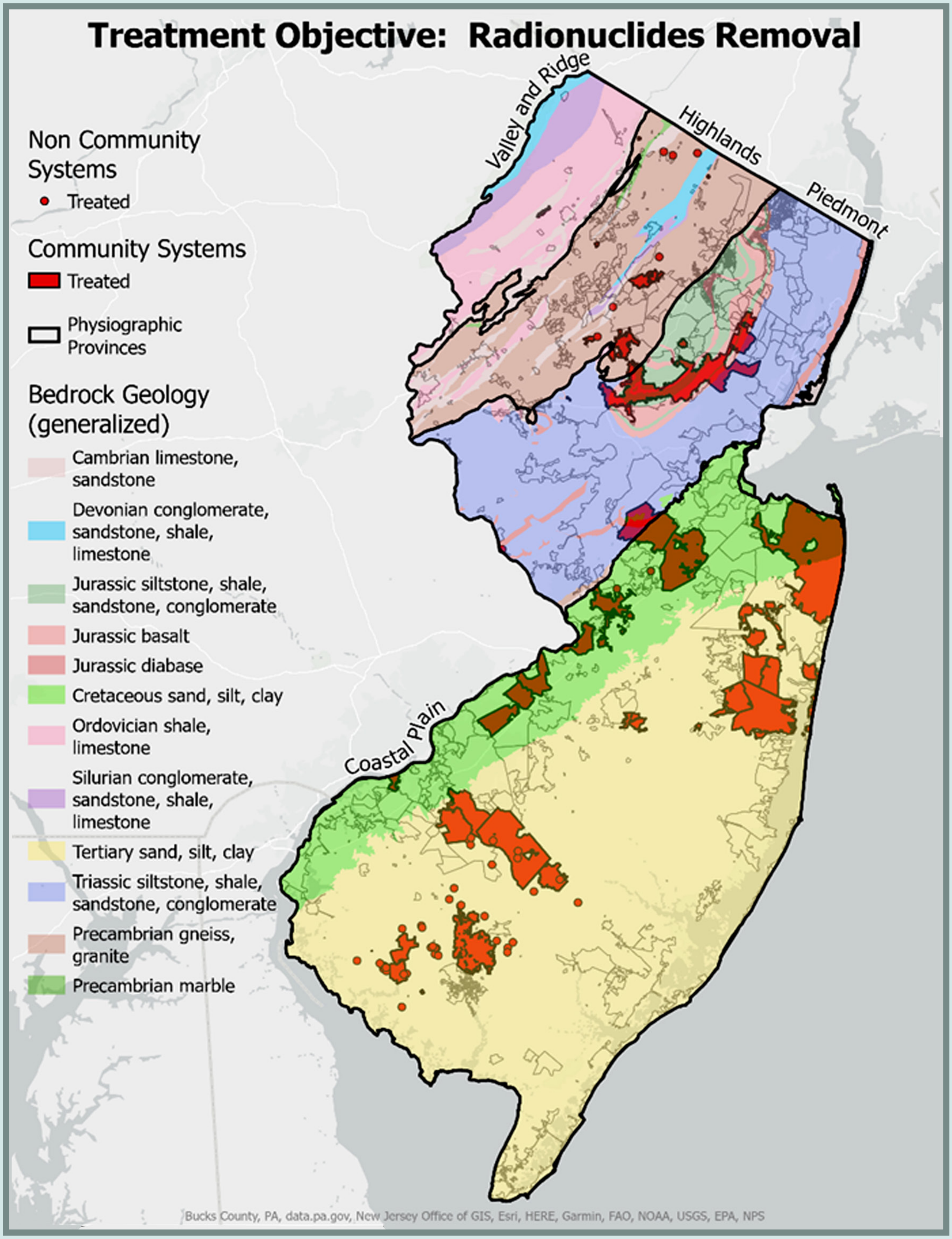


Figure 5.13 Statewide map showing water systems that apply radionuclide removal treatment.

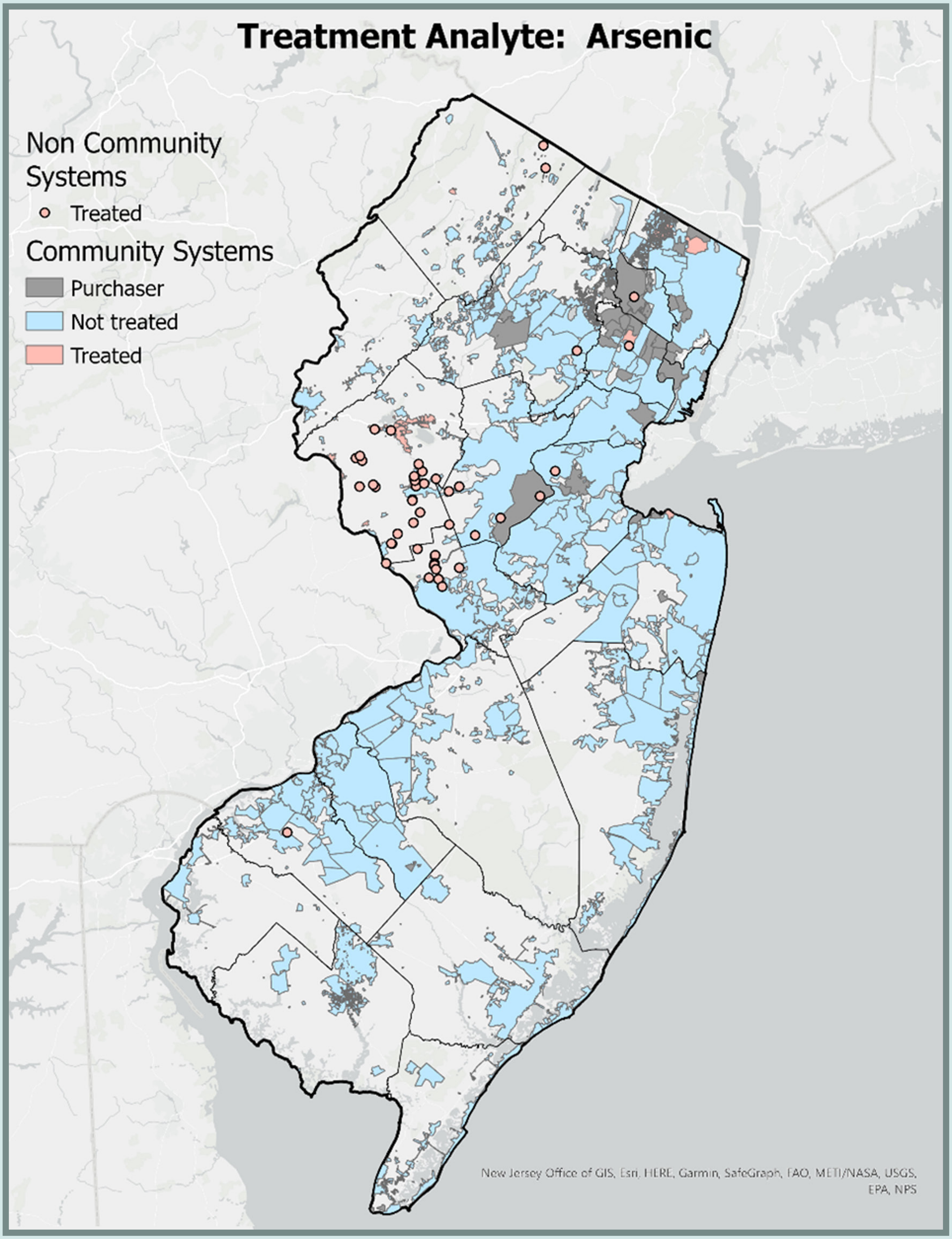


Figure 5.14 Statewide map showing water systems that apply Arsenic removal treatment.

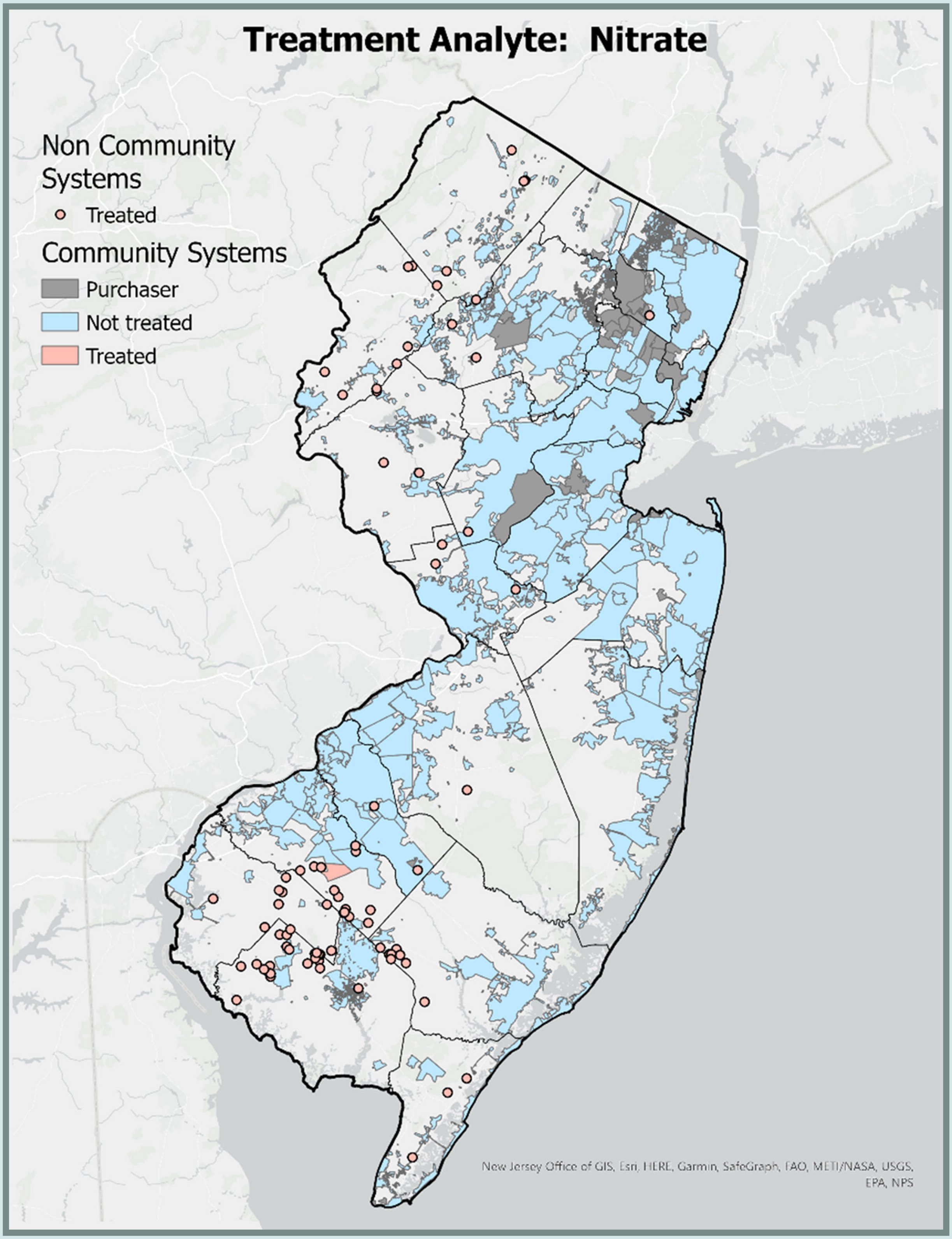


Figure 5.15 Statewide map showing water systems that apply nitrate removal treatment.

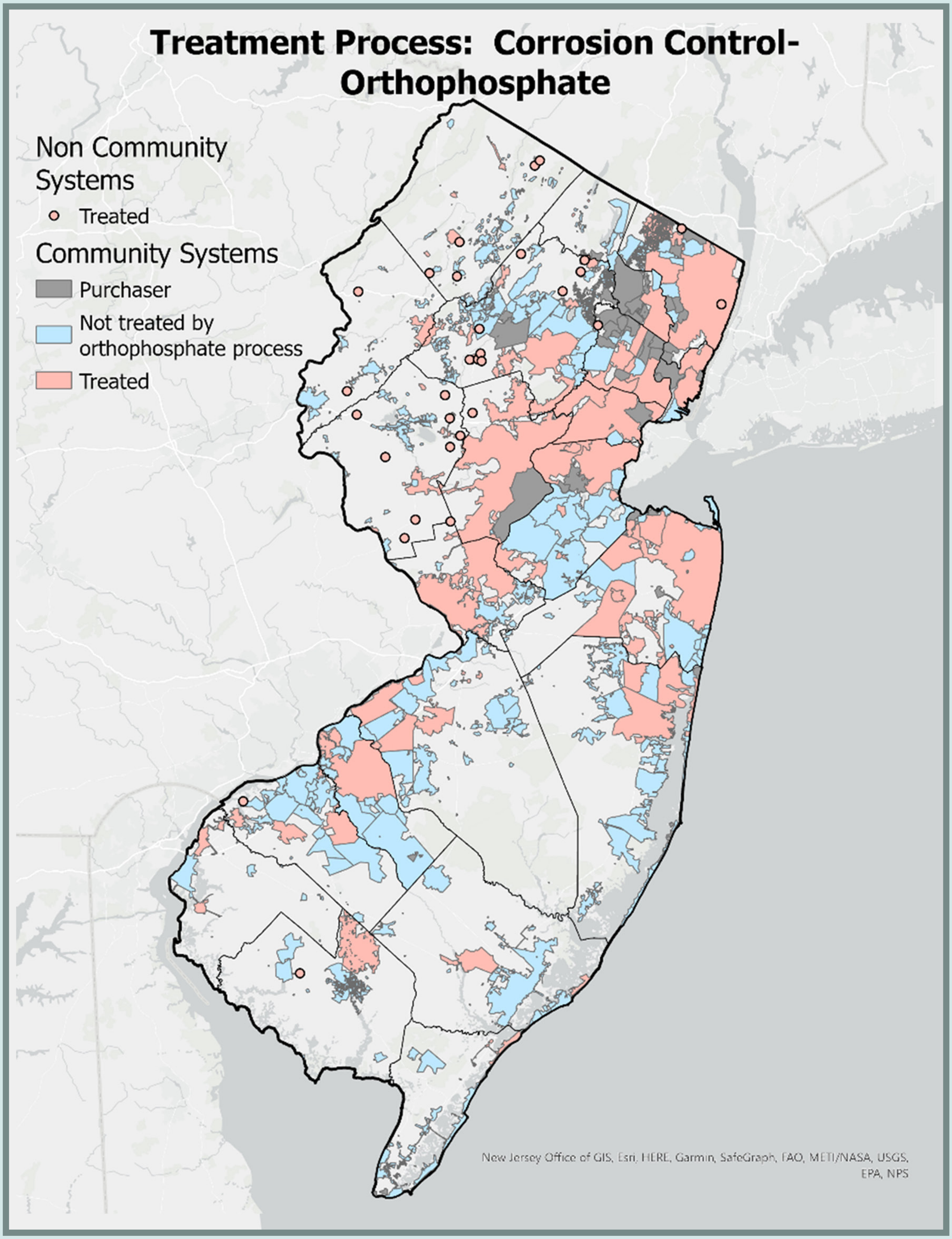


Figure 5.16 Statewide map showing water systems that apply the orthophosphate treatment process to control corrosion.

Through its safe drinking water program DEP works tirelessly to protect the drinking waters of New Jersey. There are many actions that are taken to do so, some of which have been highlighted in this section. DEP is dedicated to ensuring that residents of New Jersey have access to continuous supplies of safe drinking water.

MONITORING AND ASSESSMENT OF WATER RESOURCES

Water resource protection and planning should be based on observed data and sound science. DEP, the U.S. Geological Survey, and other parties such as water supply utilities, have been monitoring New Jersey ground and surface waters for decades, and have developed models to assess data to determine management strategies, such as establishing safe yields and aquifer withdrawal limitations. In water resource and drought monitoring and assessment systems, available measurements, monitoring, modeling, and trends analysis can be used to understand current and past status. To understand potential future changes, DEP must rely on available data, forecasts, projections, and modeling methods. Discussed below are two forms of DEP water resource and drought monitoring and assessment systems, ambient and drought monitoring and New Jersey Water Transfer Database, with greater detail provided in Appendix L.

- **Ambient and Drought Monitoring:** As discussed in Chapter 2, DEP maintains extensive ambient and drought monitoring networks. New Jersey's ambient water monitoring program includes four networks that are operated by USGS and are cooperatively supported by DEP. These networks include a stream gauging network, groundwater level network, coastal plain synoptic network, and drought monitoring network.
- **New Jersey Water Transfer Database (NJWaTr):** The NJWaTr database is primarily funded through the 1981 Water Supply Bond Fund and is used to determine water budgets and water availability estimates for HUC11 watersheds. The database includes approximately 38,000 sites, 24,000 conveyances, and 2.1 million monthly transfers. DEP continuously maintains and updates this database to provide the "living data document" framework envisioned for future water supply planning. Within this Plan, the NJWaTr database was used to create the water budgets and availability assessments in both regional and statewide analyses, including analyses on confined aquifer budgets and HUC11 watershed water budgets. This Plan also included more detailed assessments and modeling efforts conducted by the USGS (under DEP contract) for groundwater systems in the southern part of the State (i.e. Critical Areas 1 and 2, and the confined aquifers).

REGIONAL WATER RESOURCE AGENCIES AND INTERSTATE WATERS

In addition to the water supply planning conducted by DEP, New Jersey is home to several regional and interstate planning agencies that have their own water supply planning programs focused on defined regions within New Jersey. The Delaware River Basin Commission, the New Jersey Highlands Council and the New Jersey Pinelands Commission have water resource protection, permitting, and planning responsibilities which are discussed below. There are also interstate areas of importance from a water resources perspective that do not have planning agencies solely devoted to their management. These include the Passaic and Hackensack Rivers which receive flows from New York State and the Wallkill River which provides flows from New Jersey to New York State. Finally, there are other programs which have water planning elements focused on New Jersey waters such as the New Jersey Water Supply Authority, the National Estuary Program including the Barnegat Bay watershed. Barnegat Bay is New Jersey's largest enclosed estuary and a major recreational resource that depends on high quality water flows from tributary rivers and streams to maintain its ecological health. In this Plan only the three major water planning agencies and primary intestate waters are discussed, but all water planning across the state and its shared water resources should strive to be consistent and coordinated.

DELAWARE RIVER BASIN COMMISSION

The Delaware River Basin includes a drainage area covering 13,539 square miles in four states. The headwaters of the Delaware River are located in east central New York State and flow generally southward, dividing New Jersey from Pennsylvania and Delaware before traveling to the Delaware Bay and emptying into the Atlantic Ocean, approximately 330 miles downstream.

The Delaware River Basin Commission ("DRBC" or "Commission") was established by the **Delaware River Basin Compact**, a statute enacted in 1961 by the states of Delaware, New Jersey, and New York, the Commonwealth of Pennsylvania, and the federal government ("the Compact"). The DRBC is charged with formulating and implementing a comprehensive plan for the immediate and long-range development and uses of the basin's water resources. **The Commission's members** are, ex officio, the Governors of the four basin states, and on behalf of the federal government, the North Atlantic Division Commander, U.S. Army Corps of Engineers, also serving ex officio. For more information on the DRBC, see Chapter 3 of this document and visit the Commission's website at drbc.gov.

Under the Compact, the Commission must review activities that could have a substantial effect on the water resources of the Basin to ensure they do not substantially impair or conflict with the Comprehensive Plan (Compact, §3.8). In accordance with DRBC's "One permit program" regulations and an administrative agreement between DRBC and the DEP adopted on December 9, 2015, for surface water and groundwater diversions and discharges to surface water within the Delaware River Basin in New Jersey, DRBC requirements are included in the state water allocation or NJPDES permit, as appropriate. This process avoids duplication and improves efficiency, but depending on the type of project, applicants may be interacting with both the DRBC and DEP. In 2024, the administrative agreement between the two agencies was revised to clarify administrative processes and to include underground storage cavern permitting. Additional information about the one permit program and DRBC approvals under that program is available at: **DRBC Programs website**, **DRBC Interactive Map**, and **DRBC/DEP Administrative Agreement**.

A view of the Delaware River from Goat Hill Overlook (located in Lambertville, New Jersey).

Flow management in the Delaware River and out-of-basin diversions to New York City and New Jersey are governed by a complex set of operating rules which originated with decrees of the Supreme Court in 1931 and 1954 to resolve a case brought by New Jersey (joined by the states of Delaware and Pennsylvania) over New York City's construction of large dams in the Delaware's headwaters. **The 1954 decree** ("Decree"), among other provisions, authorized out-of-basin diversions by the City of New York (NYC) and the State of New Jersey of 800 and 100 million gallons per day (mgd), respectively. The Decree required NYC to make compensating releases from its Delaware River Basin reservoirs to maintain a flow objective in the main stem Delaware River at Montague, New Jersey, where the boundaries of the states of New York, New Jersey and Pennsylvania meet.

Flow and drought management in the Basin are regulated by the Commission's Delaware River Basin **Water Code**. During the drought of the 1960s, historically the most severe, and for planning purposes the "drought-of-record" for the Delaware Basin, the amount of water that NYC's Delaware Basin reservoirs could provide was less than previously determined and insufficient to support the operating provisions of the Decree. In response, the DRBC together with the parties to the Decree ("Decree Parties"), performed studies of the Basin's water resources and needs to determine modifications to the Decree terms to address future droughts. This work was done under the Commission's drought management and regulatory authorities, which include the authority to modify the Decree provided that the Decree Parties unanimously concur.

The Decree Parties submitted a set of consensus recommendations to the Commission, referred to as the "Good Faith Agreement" (GFA), for adoption as regulations in the DRBC Water Code or inclusion as conditions of one or more docket approvals ("dockets" in DRBC parlance, similar to permits). The resulting Water Code regulations and dockets include a flow and drought management plan that incorporates a regulatory flow objective for the Delaware River at Trenton, New Jersey for salinity repulsion, a coordinated reservoir operating plan for upper and lower basin reservoirs, reductions in out-of-basin diversions, reductions in reservoir releases, and an experimental augmented conservation release program to protect fisheries in the tailwaters of the New York City reservoirs. Over the years, the Commission's docket and regulations have been modified to address new issues or incorporate new scientific information. These revisions include improved cold-water fisheries flows, modest flood mitigation procedures, and incorporation of coordinated drought emergency operations for multiple basin reservoirs to support flow objectives. In 2007, the Decree Parties developed a consensus agreement known as the Flexible Flow Management Program (FFMP), which largely incorporated the flow and Drought management provisions of the Water Code, but increased the limit applicable to New Jersey's diversion in times of drought.

The FFMP operating plan has evolved over time. The 2017 FFMP comprised a ten-year, two phased program that included:

- provision for a number of studies to be undertaken to inform future agreements;
- New York City reservoir releases for upper-basin fisheries based on forecast-based available water;
- a modest degree of uncontrolled spill mitigation (i.e., flood mitigation); and
- an increase to New Jersey's Delaware and Raritan Canal (canal) diversion during drought operations (limit increased to 80 mgd from 65 mgd under drought emergency conditions).

Minor modifications to the study scopes and timelines were agreed to in May of 2023 at the start of Phase II; however, the bulk of the agreement remained unchanged.

New Jersey continues to negotiate with the Decree Parties to increase the limit on its out of-basin diversion during drought, a change that ultimately requires action by the DRBC with the Decree Parties' unanimous consent. This diversion increasingly plays a critical role in meeting New Jersey's current and future water supply needs, and enhances water system resilience in the Central, Coastal North and Northeast drought regions. The major HAB event on the Millstone River in the summer of 2022 is a recent example of the critical importance of D&R Canal water during normal and drought periods. New Jersey also continues to negotiate with the Parties to implement regulatory mechanisms to ensure that NYC balances use of its Delaware Basin and Hudson Basin reservoirs, to not overuse the Delaware sources and unnecessarily cause drought conditions and their associated cutbacks in the Delaware Basin, and to provide protection from saltwater impacts to potable intakes and groundwater recharge areas. The mechanisms ultimately implemented need to balance operational flexibility for NYC but must include 'guardrails' to ensure reasonable protection of all the water users of the Delaware River Basin.

PINELANDS COMMISSION

The Pinelands National Reserve was created by the enactment of Section 502 of the National Parks and Recreation Act of 1978, followed by a State-designated Pinelands Area created by the New Jersey Pinelands Protection Act of 1979.

This internationally significant ecological region covers 1.1 million acres and occupies 22 percent of New Jersey's land area across portions of seven counties (Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester and Ocean), and is underlain by aquifers containing an estimated 17 trillion gallons of water. It was designated the New Jersey Pinelands Biosphere Region by UNESCO in 1988.

The New Jersey Pinelands Protection Act (P.L. 1979, c. 111) established the **Pinelands Commission** and charged it with, among other things, developing a management plan to guide future development within the State's Pinelands region -- known today formally as the **Pinelands Comprehensive Management Plan (CMP)**. The CMP sets forth regulations and standards designed to promote orderly development and,

Batsto Village located in the Wharton State Forest in the Pinelands National Reserve. The tea-color water is a natural characteristic of the streams in the New Jersey Pine Barrens.

at the same time, preserve and protect the significant and unique natural, ecological, agricultural, archaeological, historical, scenic, cultural, and recreational resources of the Pinelands. Residential and other development is limited and directed toward "growth areas" in order to protect the remaining unique, natural, ecological, agricultural, and horticultural resources.

Certain CMP regulations (N.J.A.C. 7:50-6.86 (a-e)) outline water management within the Pinelands. These regulations address inter-basin transfers, the export of water outside the Pinelands, water allocation and conservation, and criteria for withdrawals from the Kirkwood-Cohansey aquifer. In late 2022, the Pinelands Commission proposed amendments to these provisions of the CMP, to provide "clearer, quantifiable standards for assessing the ecological impacts of non-agricultural diversions from the Kirkwood-Cohansey aquifer…and introducing new, quantifiable standards to protect the available water supply in the watershed in which a diversion will be located…". These standards were then adopted in December of 2023. DEP coordinates with the Pinelands Commission staff to ensure that the water supply permits it issues comport with the CMP goals and objectives.

HIGHLANDS WATER PROTECTION AND PLANNING COUNCIL

The New Jersey Highlands is a 1,343-square mile area in the northwestern part of the State noted for its scenic beauty, water resources and environmental significance. The region includes 88 municipalities in all or parts of seven counties (Hunterdon, Somerset, Sussex, Warren, Morris, Passaic, and Bergen). The Highlands Region is a vital source of drinking water for over 5 million residents both in and outside of the Highlands. The Highlands Water Protection and Planning Act (Highlands Act), N.J.S.A. 13:20-1 et seq., was signed into law on August 10, 2004.

Monksville Reservoir located in Long Pond Ironworks State Park in the New Jersey Highlands.

Specific to water supply management, the Highlands Act rules (N.J.A.C. 7:38) limit the issuance of water allocation permits to projects that are exempt from the Highlands Act, or to those projects for which a Highlands Preservation Area Approval with waiver has been issued, where deemed consistent with the Regional Master Plan by the Highlands Council. The rules also include standards for water supply diversion sources where a diversion source is located within the preservation area, and PCWS serving authorized development in the preservation area (N.J.A.C. 7:38-3.2 and 3.3 respectively). The Highlands Act also amended the Water Supply Management Act to prohibit the DEP from issuing Water Allocation and Registration permits that are inconsistent with the Act and Highlands Regional Master Plan. Within the Preservation Area, the regulatory threshold of 100,000 gallons per day (3.1 million gallons per month) for a water allocation permit was reduced to 50,000 gallons per day (1.55 million gallons per month). DEP has and will continue to coordinate and cooperate with the **Highlands Water Protection and Planning Council** on water supply related decision making.

INTERSTATE WATERSHEDS: PASSAIC, HACKENSACK, AND WALLKILL

New Jersey receives river flows from New York State primarily through watersheds of the Hackensack River (from Rockland County) and the Wanaque, Ramapo and Mahwah Rivers (from Rockland and Orange Counties), New York State receives river flows from New Jersey through the Wallkill River in Sussex County.

The Passaic and Hackensack watersheds are of critical importance to water supplies in northern New Jersey. Several of the six major surface water systems rely in part on interstate water flows: the North Jersey District Water Supply Commission's Wanaque System, Passaic Valley Water Commission's Passaic River System and Veolia New Jersey's Hackensack System. These and the other three major systems (Newark's Pequannock System, Jersey City's Rockaway System, and New Jersey American

Water Passaic System) are highly interconnected to allow the systems to transfer water under normal conditions, in the event of a water supply emergency, or in response to the uneven effects of droughts. Interstate flows along the Ramapo River also help support aquifer resources in the Oakland and Mahwah area.

Written agreements exist between the two states to ensure that specific minimum river flows are met for the Ramapo and Hackensack Rivers, but lack of agreement formalization into legal documents has resulted in differing and inconsistent interpretation of required actions. Additionally, continued development in the New York portions of the watersheds can result in lower annual flows, even when the required minimum flows are met. At times, Rockland County has considered water supply projects, new consumptive use or wastewater exports to the Hudson River, that could threaten flows into New Jersey. Significant growth is projected for parts of Orange and western Rockland Counties. Additionally, there are contamination issues in aquifers along the Ramapo River in the Suffern, NY, area as well as surface water quality changes, e.g., nutrients, that can result in drinking water treatment difficulties for downstream intakes. It is not clear if the past written agreements have been carried forward in New York State water permits or are actively utilized currently. For this reason, DEP monitors potential issues that might harm New Jersey water supplies.

The Wanaque Reservoir located along the Wanaque River in Wanaque and Ringwood, New Jersey. In addition to being located in the New Jersey Highlands, the Wanaque River is a tributary of the greater Passaic River watershed, which includes areas in both New York and New Jersey.

The Hackensack River faces similar interstate management issues. The main example is Veolia NY’s reservoir, DeForest Lake and the Town of Nyack diversion in Rockland County, both of which are upstream of and control flows to Veolia New Jersey reservoirs- Lake Tappan and the Oradell Reservoir.

With water supply reservoirs on both sides of the border, different operating water utilities and multiple state and local regulations, water management is complicated and past agreements to share water have not always been interpreted in similar manners. This issue is also monitored as needed by DEP. Preliminary RiverWare modeling analysis indicates that there may be alternative reservoir management scenarios in the Hackensack River basin that could increase the safe yield of the Deforest Reservoir and improve water supply reliability in New Jersey without creating new problems. DEP should consider working with New York government authorities and water utilities to see if agreement or management plans can be agreed to.

The Wallkill River watershed flows in the other direction, starting from Lake Mohawk in Sparta and going north into Orange County, New York. No New York reservoirs are fed by the Wallkill River, but several small towns are located on its length. To date, no interstate issues have been raised and no minimum flow agreements exist, but should additional New Jersey demands threaten flows into New York, issues could arise.

SUMMARY

DEP's comprehensive water resources management aims to provide a holistic approach to managing the state's water resources. This includes providing protection of water quality and supply, allocation to users, safe drinking water, and infrastructure regulation and financial assistance from a supply, standards, and monitoring perspective. DEP must operate not only under general and legislative authority, but must also coordinate its efforts with regional authorities, such as the Delaware River Basin, Highlands and Pinelands Commissions, which carry out their own planning processes based on their associated regulations and statutes.

DEP works to not only promote water use efficiency and conservation, but also encourage water system resilience and asset management. Current DEP actions encouraging statewide water conservation include: (a) the implementation of the New Jersey Water Savers program; (b) ongoing efforts to improve access to PCWS water loss data to reduce non-revenue water losses; and (c) its collaboration with Sustainable Jersey to create an Outdoor Water Conservation model ordinance for municipal consideration. DEP has also pursued efforts to increase statewide water system resilience. With the WQAA setting new requirements for purveyors of public water systems to improve their water infrastructure, DEP continues to promote water system resilience by continuing its collaboration with water purveyors to implement asset management requirements for the WQAA and monitoring emergency agreements between purveyors, along with continuing its implementation of recommendations from the 2007 Statewide Interconnection Study. DEP also continues to pursue efforts to increase the resilience of public water systems by considering new and potentially expanded sources of water supply.

The Delaware and Raritan Canal at Swan Creek located in Lambertville, New Jersey.

DEP implements the New Jersey Safe Drinking Water Act by using a multi-barrier approach starting with water source protection, since treatment systems will be more successful if incoming source waters are high quality. To implement the Safe Drinking Water program, DEP's Division of Water Supply and Geosciences is responsible for regulating and guiding the proper operation of New Jersey's public water suppliers, and DEP works with drinking water utilities during emerging water contamination issues, including line breaks and water pressure problems. As shown in the Statewide Safe Drinking Water Assessment sub-section, many actions and treatment processes are conducted by public water systems to ensure that residents of the state have safe drinking water.

DEP's holistic approach to managing the state's water resources also aims to address potential environmental justice concerns related to water supply. Many PCWSs with large numbers of overburdened communities are located in historic urban centers and may face challenges in the future, such as rate increases or stress from trying to meet water demands. Also, as numerous overburdened communities are located outside of PCWS service areas, residents may not have the financial resources to conduct adequate system maintenance and regular testing of private wells or for small isolated PCWSs. This may make them more vulnerable to experiencing negative health effects if contamination of their water supply were to occur. Climate change may also present additional financial challenges for PCWSs with large numbers of overburdened communities as they may have difficulties in raising rates to pay for good asset management in normal times and responding to disaster response costs during emergencies.

Preventing and mitigating inequities in affordability related to water supply may take on several different forms, including DEP's ongoing efforts to provide low-interest financing of water infrastructure projects through resources, such as the New Jersey Water Bank and the Drinking Water State Resolving Fund, to reduce costs to ratepayers. Currently, there is no permanent state or national program to assist customers so PCWSs can set rates at viable levels that consider customer income levels. Recommendations were proposed for improving state assistance to overburdened communities regarding their water supply include: (a) DEP potentially working with NJDOH, NJDCA, and local and county health officials to conduct further research on the financial needs of low-income private well owners, and (b) Legislature potentially considering the appropriation of a supplemental fund to support low-income residents for the replacement of failing wells due to age or the installation of treatment for naturally occurring contaminants.

DEP has been working with USGS, water supply utilities, and other organizations to monitor New Jersey's ground and surface waters for decades and has developed models to guide the development of water resource protection and management strategies. DEP maintains an extensive ambient and drought monitoring network, which includes data from four networks (stream gauging network, groundwater level network, coastal plain synoptic network, and drought monitoring network) that are operated by USGS and cooperatively supported by DEP. The New Jersey Water Transfer database is also used by DEP to create water budgets and availability assessments for both statewide and regional analyses. This includes USGS detailed assessments and modeling efforts for groundwater systems in the southern part of the state that are provided in this Plan.

Specific areas DEP intends to target related to its comprehensive water management approach include:

- continuing ongoing efforts to expand its existing safe yield models to address all surface water systems, including interconnection flow scenarios with the goal of improving operation and coordination between water systems during both normal and emergency conditions;
- reviewing and evaluating Water Allocation rules at N.J.A.C. 7:19 2.2(i) to enhance current Water Conservation and Drought Management Plans and considering amendments to update existing water supply emergency management procedure rules (N.J.A.C. 7:19);
- continuing to develop, encourage and implement where appropriate, water conservation and water use efficiency to preserve supplies, increase resilience, and minimize costs;
- continuing to support, expand, fund, and require (where appropriate) asset management and enhanced water resource and infrastructure resilience;
- continuing to expand the water supply OBC analyses to better define issues, needs and appropriate actions;
- continuing to support and expand the water resource monitoring networks and assessment research and models (could include expanded assessment of drinking water treatment applications used by water purveyors); and
- Source Water Assessment Program updates that improve coordination and integration with other water quality planning and protection programs in the DEP and which ultimately improves drinking water quality treatment efficacy.

Chapter 6:
Regional Planning for Deficit Mitigation and Avoidance

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OVERVIEW

A primary purpose of statewide water supply planning is to identify specific areas where existing or potential future withdrawals do or may exceed available natural and constructed water supplies, especially during dry periods. In accordance with the Water Supply Management Act as well as common understanding, running out of water is not acceptable, and damaging ecosystems by withdrawing too much water is also not acceptable. This chapter discusses a general framework for risk assessment and a process for regional planning and management that has previously been used region-by-region but not formalized. This chapter also addresses various regions of New Jersey where DEP assessments or the statewide evaluations discussed in prior chapters have identified one or more factors (e.g., demands, supply limitations, ecological concerns, supply contamination) that indicate a need for more detailed, regional analyses and responses or where specific water allocation restrictions are warranted. The framework is applied to each of the regions discussed, providing a sense of where the region is within the planning process- from early efforts to completed management actions.

Beach vegetation and a beachfront community located in Ocean City in Cape May County, New Jersey. Some locations in Cape May face challenges from saltwater intrusion into their water sources.

Water supply planning or management strategies are not a one-size fits all approach or contained within defined boundaries. Varying severities of resource stress and breadth of issues affect regions differently and require specific planning approaches. This section addresses the areas of concern as they were identified in previous planning efforts as well as new areas of concern with newly defined boundaries.

RISK ANALYSIS APPROACH IN REGIONAL PLANNING

Not all indicators of water supply stresses are the same, nor are the uses of these indicators. Planning programs may use indicators differently than regulatory programs. The Plan assesses stresses using a hierarchy of indicators, as applied through a matrix that assesses certainty of the indicators against the severity of indicated stresses. This section briefly discusses this approach and how it applies to identified water stress issues.

INDICATORS OF WATER SUPPLY STRESSES

Water availability indicators are useful in assessing current and potential future conditions. For both, indicators may reflect physical or ecological parameters. The following table shows a variety of indicators and the methods used to measure their current or future status.

Table 6.1 Shows analytical methods applied to listed indicators to measure current and future stresses.

Indicator	Analytical Methods (Current Stresses)	Analytical Methods (Future Stresses)
Reservoir levels	-In-situ measurement, past trends, reservoir curve comparisons	-Safe yield models-simple -Safe yield models-sophisticated with climate change
Unconfined aquifer levels	-Static water level measurements, past trends	-Low Flow Margin methodology -Regional aquifer models -Land Phase model with climate change
Stream flows	-In situ measurement, past trends	-Low Flow Margin methodology -Land phase model with climate change
Confined aquifer pressure (potentiometric surface levels[1])	-Static water level measurements, past trends	-Confined aquifer models
Aquatic ecosystem integrity	-Macroinvertebrate analysis, stream channel assessments (SVAP, etc.), Fish IBI analysis	-Low Flow Margin methodology

Some of these methods provide a stronger validation of indicator status than others. In general, lower certainty is associated with models that are based on statewide statistical analyses, which are used where direct data are not available and characterizations of hydrologic parameters for some water resources must be applied to all water resources. Higher certainty comes from resource-specific measurements and models calibrated and validated using data from that water resource. Models of future conditions are inherently uncertain, as assumptions must be made regarding how future conditions may be different from current conditions, such as populations, demand patterns and climate conditions influenced by climate change.

Data also have varying levels of certainty, based on the measurement frequency and record length (longevity) relative to the inherent variability of what is being measured. For example, agricultural withdrawals are usually estimated by multiplying pump capacity by hours of operation, rather than by in-line metering that would be more accurate but more expensive and not required by law. A second example is stream flow, which is inherently variable and therefore must be measured frequently and for extended periods to yield valid statistics. Periodic monitoring provides less certainty than continuous monitoring.

These uncertainties are a major reason why this Plan is periodically updated, so that additional data, better forecasting assumptions and improved models can be applied to water resource issues.

[1] The potentiometric surface is the level to which water will rise in tightly cased wells that withdraw from a confined aquifer. It reflects the pressure on water in the confined aquifer. The potentiometric surface is for a confined aquifer similar to the water table for an unconfined aquifer.

LEVELS OF CERTAINTY IN WATER SUPPLY STRESSES

Using the indicators and analytical methods outlined above, it is possible to identify a hierarchy of analyses that show potential or validated stresses (or lack thereof).

- **Potential Stress or Surplus:** A water availability deficit or surplus is indicated by generalized statistical modeling (e.g., LFM method; simple aquifer models; simple safe yield models), but direct measures of water resource stress trends have not been carried out, such as measurements of local stream flows, water table measurements from specific unconfined aquifers or potentiometric surfaces from specific confined aquifers. At this level of analysis, absence or presence of a small stress or surplus is not definitive, especially where monitoring data may be of questionable accuracy level. The higher the deficit or surplus, the more likely the finding is qualitatively correct regarding the direction and general magnitude of the result.
- **Validated Stress or Surplus**: A water availability deficit or surplus is shown by resource-specific models based on local, validated data (e.g., USGS or NJGWS aquifer models; reservoir systems safe yield models using RiverWare or similar software; LFM results based on updated NJWaTr data and water monitoring data such as stream flow trends and groundwater levels) that show a clear deficit or surplus; especially, a result that exceeds the understood uncertainty of the model. Another validation approach involves the use of longitudinal trends in stream flows, water table measurements or potentiometric surfaces that have demonstrated declines or increases correlated to consumptive and depletive water uses.
- **Validated, Highly Stressed:** In addition to the modeling approaches discussed for validated results, a high stress is indicated where longitudinal data from trends in stream flows, water table measurements or potentiometric surfaces have demonstrated long-term, rapid short-term or other major problematic declines related to consumptive and depletive water uses.

APPLICATION TO KNOWN WATER AVAILABILITY ISSUES

Based on the discussion above, Table 6.2 presents a variety of water availability issues, with certainty ranging from high to low and severity from minimal to high. In each case, **Blue** text indicates that the issue has been resolved (no water availability deficit or the deficit has been eliminated or is actively managed), and **Orange** text means that the issue is not resolved (a deficit is indicated or validated and still exists). Conceptually, this matrix maps water supply risks. Issues in the top left (High Certainty, Minimal Severity) need minimal planning attention. Issues at the lower right (Low Certainty, High Severity) are strong candidates for extensive research. Issues at the upper right (High Certainty, High Severity) should be the focus of immediate management attention if not already addressed.

Table 6.2 Matrix displaying certainty vs. severity with water availability issues to serve as examples

Certainty of Measurement	No Concern or Minimal Severity	Moderate Severity	High Severity
High (fully validated)	**-Raritan System Safe Yield**	**-Cape May Saltwater Intrusion**	**-WS Critical Area 1** **-WS Critical Area 2**
Moderate (modeled or trend results)	**-HUC11s with Positive or Minimal Negative LFM Water Availability** **-Current impacts to water availability from climate change**	**-NE-NJ Safe Yield (no deficits but drought sensitive)** **-HUC11s with Negative LFM Water Availability**	**-Loss of water availability from contamination**
Low (preliminary results)	**-Current system drafts exceeding permitted safe yields**	**-Short-term (to 2028) climate change impacts to water availability**	**-Medium to long-term (2050-2100) climate change impacts to water availability**

FRAMEWORK FOR REGIONAL WATER SUPPLY PLANNING AND MANAGEMENT

The statewide water supply planning process since 1981 has identified multiple regions with confirmed or potential water supply deficits that could constrain water demands (e.g., potable, agricultural, industrial) or put aquatic ecosystems at risk. Some of these regions have been addressed through initiatives to control or reduce water demands, increase or replace water supplies, or both. In other regions, additional research has helped better understand the certainty and severity of the potential deficits.

The following general approach is intended to address regions at least tentatively identified as having water supply stresses. The approach is a stepwise effort to improve certainty, evaluate severity, identify remedial options, and then track progress toward avoidance, mitigation, or elimination of deficits. Efforts in specific water supply regions may already have addressed one or more of these steps.

All regional planning efforts should include engagement with agencies, organizations, and representative public individuals who can help DEP understand the target region, data issues, analytical issues and remedial options. Engagement should start early in the planning process so that key interests understand the nature and potential uncertainty of the issue, and data and analytical approaches used, so that they may be effectively involved in development of viable responses.

Step 1: Data Verification

All regional analyses (e.g., Low Flow Margin approach, confined aquifer models, safe yield models) use the best data available at the time of development. However, each data source will have different uncertainties, as discussed in the previous section. For example, continuous stream flow gauging stations have higher certainty than periodic flow measurements; metered agricultural withdrawals will have higher certainty than withdrawal estimations. In addition, new data may be available for models that have not been recently updated. Finally, no database is perfect, and so verification of existing information may be appropriate. To address these issues, this step involves an analysis of the data used to assess whether more current or accurate data may be available or necessary to confirm water resource stresses.

Step 2: Model Reanalysis

All water supply models are approximations of reality based on available data, statistical analysis, mathematical representations of system interactions, and interpretation. Even highly sophisticated modeling software faces limitations such as incomplete datasets or imperfect hydrologic knowledge. For aquifer modeling, boundary conditions (i.e., the potential for water flows between aquifer units or between aquifers and surface waters) create modeling complications as well.

Therefore, all models have some uncertainty associated with their results. In general, models built to assess specific resources using local data, such as for reservoir safe yields or confined aquifers, will have more robust results than models that use large scale (e.g., statewide) approaches to assess local resources.

This step involves an analysis of the model(s) used for the initial assessment and the extent to which modeling is reliant on local data and purpose-built approaches, and whether improved modeling will be needed to better understand the potential for water supply stresses. Hydrologic modeling is complex so choosing the best model can be difficult, but not impossible. The DEP will utilize industry best practices and standards, experience, and outside state and/or federal agencies as benchmarks for decision making.

Step 3: Regional Evaluation

Water demands are in large part a function of land uses and human needs. Regional water supply planning occurs within this broader context. This step involves evaluation of existing and potential regional land uses, geography, demographics, and water demands, compared to the existing water availability. The purpose of this step is to assess the potential for increased or decreased future demands, water quality impacts of existing and future development, and hydrologic changes related to land use development and redevelopment.

Step 4: Enhanced Monitoring, Modeling, and Analysis

Where the first three steps support a concern that the water demands may exceed water availability, but the assessment has insufficient certainty to justify management or regulatory actions, development of a more detailed water availability analysis may be appropriate. This step could include one or more of the following:

- Additional data from existing or new monitoring points to support an existing or improved model. For example, additional years of stream flow or aquifer level data may provide improved statistics for use in a model.
- Enhanced modeling: For example, where a statewide modeling approach indicates a concern regarding an unconfined aquifer/surface water system, development of a local or regional model could provide more accurate results for the specific regional resource.
- Enhanced analysis: Model results can be combined with other information that allows a broader and more useful context for determining whether and to what extent a regional water supply problem exists or will occur. Climate change impacts will be one consideration for model improvement, as new information is available.

Step 5: Planning, Management, and Regulatory Responses

With a solid basis for determining that a regional water supply problem exists, the next step is a planning process to determine the appropriate management and regulatory responses to avoid, mitigate or eliminate the problem. A good example is the reduction of confined aquifer withdrawals in Water Supply Critical Areas 1 and 2, which occurred through implementation of amendments to the Water Supply Management Act during the late 1980s in response to signs of aquifer depletion. Reduced withdrawals were replaced by new surface water supplies where environmental concerns were reasonably mitigated. Methods could include:

- establishment of resource-specific water resource objectives, such as confined aquifer levels, consumptive and depletive use limitations, or stream flow patterns;
- demand management, such as water allocation or certification restrictions for specific water resources, utility water loss reductions, water conservation initiatives by water users, and land use controls such as zoning modifications and site development requirements;
- supply management, such as shifting demands between available supply points; or
- supply augmentation, such as reservoir construction or expansion or use of MAR.

Step 6: Progress Evaluation

Finally, periodic reexamination of the regional issue is important to determine whether the planning, management and regulatory responses achieved the intended results. Examples include the calculation of new safe yields subsequent to addition of a surface water reservoir, periodic reports on the confined aquifers in Water Supply Critical Areas 1 and 2, or maintenance of appropriate stream flows during critical low flow periods. The reexamination can then identify a need for new work in any of the prior steps, including modifications to the management approach, or it may determine that all objectives are being or have been achieved. If the water resource objectives have been permanently achieved, no further region-specific evaluation may be needed, but continued monitoring would be needed to ensure long-term compliance with the objectives. Where objectives are not yet met, or achieved objectives may not be permanent, then periodic reexaminations are appropriate.

WEB-BASED RESOURCES AND APPLICATIONS

The DEP continues to provide GIS and other online resources to assist water users, planners and managers in decision making. These resources are available from a host of web locations. Of specific interest to this Plan and this chapter are the following resources provided below.

Water Use Data: Available to the public is an online interactive ArcGIS product called “New Jersey Water Withdrawal Data Summary Viewer”. The interactive map allows users to select, plot and download water withdrawal data by either municipality or 14-digit hydrologic unit. It provides an alternative way of viewing withdrawal data that is also included in the **DGS13-1 Computer Workbook Summarizing New Jersey Withdrawals and Discharges on a HUC11 Basis** and utilizes the same data available from the **DEP NJGS DGS10-3 website**. Data can be viewed statewide or by selecting one or more of the geographic divisions. Downloads, in CSV format, are reflective of municipality or HUC14 selection. Data can also be sorted by source of water (e.g. groundwater, surface water, etc.) or by use of water (e.g. potable, agriculture, power generation, etc.). The dashboard can be viewed at **New Jersey Water Withdrawal Data Summary Viewer (arcgis.com)**. This new graphical and interactive format should increase user access and accessibility.

HUC11 Drainage Basins: The DEP's interactive mapping tool developed by the Bureau of GIS can be used to identify the location of a specific municipality in relation to one or more of the State's 151 onshore HUC11s. Access to this tool can be gained through the following link: **Bureau of GIS NJ-GeoWeb**. Many other data layers are available from this resource.

New Jersey Geology Information App: Most of the geographic regions and water resources identified in this chapter can be mapped and accessed from the **New Jersey Geology Information App** which contains information on geology, hydrogeology and ambient water quality data through its interface.

WAAS Tool: Of specific relevance to this Plan and chapter is the Water Allocation Availability Screening Tool (WAAS). This tool is hosted in the New Jersey Geology Information App. It can be launched by selecting the hammer icon located in the upper right-hand corner of the New Jersey Geology Information App webpage. The WAAS Tool launches a python script to compare a user defined state plane coordinate against many water allocation areas of concern identified **here in Chapter 6**.

Several regions of New Jersey are areas for intensive planning and management efforts regardless of whether the waters within them are identified as having potential or validated water availability constraints. Two of these regions, the Highlands Region of northern New Jersey and the Pinelands Region of southern New Jersey, have special state agencies tasked with planning for and protecting water and ecological resources while providing for compatible development, the Highlands Water Protection and Planning Council and the Pinelands Commission, respectively. The Delaware River Basin is of national importance, as the focus of an interstate compact agency, the Delaware River Basin Commission, and a U.S. Supreme Court order regarding the allocation and management of water supplies in the basin for New York City and the four basin states. An overview of their water supply planning responsibilities is discussed below, and more detailed information can be found in Chapter 5.

REGIONAL PLANNING AGENCIES

DELAWARE RIVER BASIN COMMISSION

Article 3 Section 3.2 of the Delaware River Basin Compact directs the Commission to formulate and adopt "[a] comprehensive plan, after consultation with water users and interested public bodies, for the immediate and long-range development and uses of the water resources of the basin...". DRBC has developed numerous plans since it was established in 1961 and the Water Resources Program Report released in June 2023 (**Water Resources Program FY 2024-2026 Report**) documents recent activities to meet the goals of their 2001 Comprehensive Plan (**DRBC 2001 Comprehensive Plan**).

HIGHLANDS WATER PROTECTION AND PLANNING COUNCIL

The Highlands Water Protection and Planning Council (Highlands Council) is a regional planning agency that works in partnership with municipalities and counties in the Highlands Region to encourage a comprehensive regional approach to implementing the 2004 Highlands Water Protection and Planning Act (the Highlands Act). The Highlands Act established the Highlands Council and charged it with the creation and adoption of a regional master plan to protect and enhance the natural resources within the New Jersey Highlands. The Highlands Regional Master Plan (RMP) was adopted by the Highlands Council on July 17, 2008 and became effective on September 8, 2008. The RMP (**New Jersey Highlands Council RMP website**) covers multiple topics and specifically addresses water supply.

PINELANDS COMMISSION

The New Jersey Pinelands Commission is an independent state agency whose mission is to "preserve, protect, and enhance the natural and cultural resources of the Pinelands National Reserve, and to encourage compatible economic and other human activities consistent with that purpose." To accomplish its mission, the Commission implements a comprehensive plan that guides land use, development and natural resource protection programs in the 938,000-acre Pinelands Area of southern New Jersey. Additional information about the plan and its water supply elements can be found on the **Comprehensive Management Plan page**.

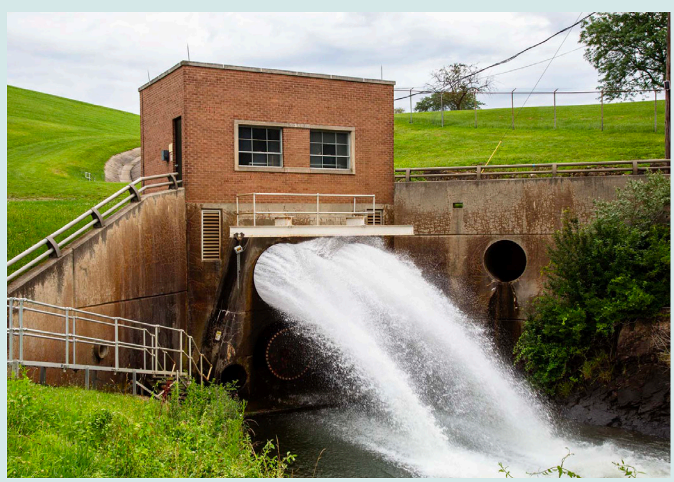
WATER RESOURCES OF CONCERN FOR DEFICIT MITIGATION AND AVOIDANCE

This section addresses regional resources where a potential or validated deficit has been identified. Some regional issues have already been addressed, some are being addressed by current studies, and others should be addressed through additional research and coordinated policy development. The resources of concern may involve surface water reservoir systems, unconfined groundwater and surface water supplies, confined aquifers, or a combination of these.

SURFACE WATER RESERVOIR SYSTEMS

The surface water supply reservoir systems' (see Chapter 2 and Appendix B) contractual obligations and water use are reviewed in accordance with N.J.A.C. 7:19 and N.J.A.C. 7:10, to ensure that they have not overcommitted or withdrawn more water than their safe yield will support. No reservoir systems in New Jersey face deficits, but some are expected to face additional demands due to population growth as population shifts throughout the coming years. The Raritan System of New Jersey Water Supply Authority has uncommitted safe yield for future needs (current average annual demand is 176 mgd of a total 241 mgd safe yield, as of early 2023), but it has the potential for interbasin transfers to support other systems. The Monmouth County reservoir systems (both publicly-owned and investor-owned) appear to have sufficient supplies for current demands (current average annual demand is 23.7 mgd of a total 30 mgd safe yield), but the reservoir systems in southern Monmouth County may face additional demands from northern Ocean County, especially for the Lakewood area that has been growing very quickly. It is important to note that demands on any one reservoir system can vary year-to-year. These demand changes can result when interconnected systems lose supply to contamination and choose to purchase water to meet their own system demands. These shifts can be permanent or temporary and necessitate close monitoring to ensure demands do not exceed safe yield. It is also important to periodically review reservoir operations to ensure that the current operations will supply adequate water to meet current demands.

The reservoir systems that need and have received greatest attention are those of the Passaic, Hackensack and Raritan watersheds, in part because they support a large percentage of the state's population, and in part because they are highly interconnected. Importantly, when a drought occurs, it does not necessarily affect all reservoir systems equally; precipitation is not necessarily equal across the watersheds, and some reservoirs drop faster than others. At times, droughts have forced the transfer of supplies between different systems, which has cost and supply risk implications. To help understand the water supply issues, drought risks and potential climate change impacts, DEP has developed a regional model using the RiverWare platform. DEP routinely interacts with the various major surface water systems in the region (North Jersey District Water Supply Commission, Newark, Jersey City, Passaic Valley Water Commission and New Jersey American Water in the Passaic, and Veolia in the Hackensack) to monitor storage trends and demands, especially during dry periods. The model is currently being expanded to ultimately include the coastal north (i.e., Monmouth County) reservoir systems. In recent droughts, the issue of changes to finished water or drinking quality when source water is shifted has risen as an important issue that requires further assessment. Nevertheless, finished water interconnections and coordinated operations are critical tools to address water supply emergencies, droughts, and future demands.



A water release at Spruce Run Reservoir in Clinton, New Jersey. This reservoir is considered one of the first water supply facilities to be constructed and operated by the state.

CONFINED AQUIFERS

Several confined aquifers experienced excessive withdrawals and drawdowns due to historic allocations exceeding sustainable limits. The 1981 Water Supply Management Act provided the DEP with an important process to address these areas. The areas of critical water supply concern are defined in 58:1A Subchapter 7 and 7:19 Subchapter 8. In two cases, DEP formally declared Areas of Critical Water Supply Concern (commonly referred to as Critical Areas), where confined aquifer withdrawals were sharply restricted and alternative surface water supplies were provided. Concerns about additional confined aquifers have resulted in aquifer models supporting planning, management and regulatory actions short of an Area of Critical Water Supply Concern designation. DEP and USGS cooperatively monitor and assess confined aquifer water levels through the Coastal Plain Synoptic Water Level program, ensuring that changes in aquifer levels are identified and management responses can be triggered by adverse trends. The most recent analysis used 2018-2019 data.

These areas are discussed in this section, with an overview of the major issues, actions taken prior to this Plan, and any necessary actions that are anticipated as a result of this Plan and ongoing activities. Additional confined aquifer analysis and data are available in a recently published USGS report (Gordon et. al, 2021). Additional information is also available in Appendix C- Water Management Options: Confined Aquifers of the New Jersey Coastal Plain.

WATER SUPPLY CRITICAL AREA #1

Issue Overview: Water Supply Critical Area #1 or CA1 is centered on Monmouth County but includes large portions of northern Ocean and eastern Middlesex counties (Whipple, 1987). The critical area was designated in 1985 to address saltwater intrusion potential in the Potomac-Raritan-Magothy (PRM) confined aquifers (specifically, the Englishtown/Middle PRM/Mt. Laurel/Upper PRM), caused by drawdown of potentiometric surface due to excessive withdrawals. Based on aquifer models and amendments to the Water Supply Management Act, withdrawals were fixed or reduced up to 50% of the respective systems' water use in 1983 depending on aquifer and location, with alternative water supplies identified and developed. This resource has been addressed through Step 6 of the Regional Planning and Management Framework.

Water Supply Critical Areas are governed by 7:19 Subchapter 8 and CA1 boundaries are defined in 7:19 8.4(a), which states that "[t]he boundary of the depleted zone of the critical area corresponds to the average potentiometric contour 30 feet below mean sea level for each affected aquifer, as published in "Water Levels in Major Artesian Aquifers of the New Jersey Coastal Plain, 1983 U.S.G.S., WRI 86-4028." The threatened zone, consisting of a three-mile-wide margin area, surrounds the depleted zone of each aquifer."

Level of Certainty: Validated, based on detailed aquifer monitoring and modeling.

Level of Severity: Highly Stressed prior to initiation of management activities, now substantially reduced and managed.

Completed Planning and Management Activities: The USGS collaborated with DEP to develop an understanding of confined aquifer levels in the Coastal Plain aquifer system, which were then used to develop confined aquifer models for the affected area, providing the basis for reducing annual withdrawals. DEP identified alternative water sources to replace the lost confined aquifer supplies. The Manasquan Reservoir in southern Monmouth County was constructed and is operated by the New Jersey Water Supply Authority (NJWSA). A pipeline from Middlesex County transfers water treated and delivered by Middlesex Water Company from the NJWSA Raritan System to the northern portion of Critical Area #1.

Ongoing Planning and Management Activities: The models are updated periodically (see Spitz et al., 2008) and used to determine whether the reduced withdrawals are achieving the intended purpose. At this time, the models indicate that the management objectives have been achieved. The DEP works with the USGS to collect and analyze water levels on a five-year cycle for all coastal plain aquifers (which include those of Critical Area #1). To prevent worsening of conditions, the DEP is prohibited from granting new or increased diversions from the affected aquifers in both the threatened and depleted zones.

Potential Planning and Management Activities: Continued implementation of critical area procedures. No additional activities are required other than periodic assessment, review and enforcement of current requirements.

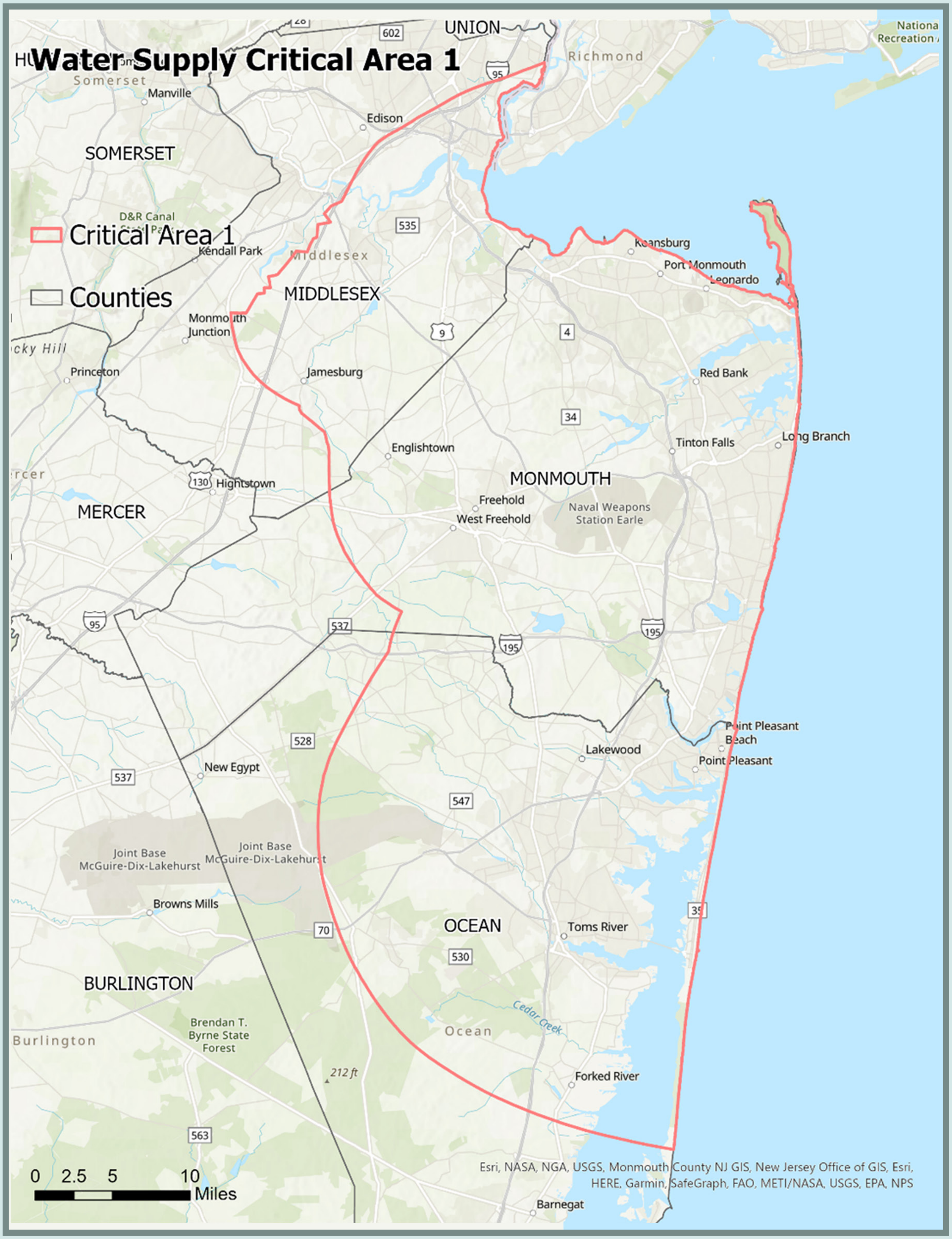


Figure 6.1 Composite boundary for Water Supply Critical Area #1 and surrounding counties.

WATER SUPPLY CRITICAL AREA #2

Issue Overview: Water Supply Critical Area #2 or CA2 is centered on Camden County but includes most of Burlington and Gloucester counties and much of western Atlantic County (Spitz et al., 2008). The critical area was designated in 1993 to respond to saltwater intrusion potential in the Potomac-Raritan-Magothy (PRM) confined aquifers, especially along the Delaware River, caused by drawdown of potentiometric surface due to excessive withdrawals, as defined by a static water level contour equal to or lower than 30 feet below mean sea level (-30 ft msl). Based on aquifer models and amendments to the Water Supply Management Act, withdrawals were reduced by up to 35%, of the volume diverted in 1983, or the volume diverted in 1991, which ever volume is smaller with alternative water supplies identified and provided. This resource has been addressed through Step 6 of the Regional Planning and Management Framework.

Water Supply Critical Areas are governed by 7:19 Subchapter 8 and CA2 boundaries are defined in 7:19 8.5(a), which states that "[t]he boundary of the depleted zone of the critical area corresponds to the average potentiometric contour 30 feet below mean sea level for each affected aquifer, as published in "Water Levels in Major Artesian Aquifers of the New Jersey Coastal Plain, 1983 U.S.G.S., WRI 86-4028." The threatened zone, consisting of a three-mile-wide margin area, surrounds the depleted zone of each aquifer."

Level of Certainty: Validated, based on detailed aquifer monitoring and modeling.

Level of Severity: Highly Stressed prior to initiation of management activities, now substantially reduced and managed.

Completed Planning and Management Activities: The USGS collaborated with DEP to develop an understanding of confined aquifer levels in the Coastal Plain, which were then used to develop confined aquifer models for the affected area, which provided the basis for reducing annual withdrawals. DEP identified alternative water sources to replace the lost confined aquifer supplies. The primary alternative supply was a new intake and treatment plant on the Delaware River at Delran, owned and operated by the New Jersey American Water Company.

Ongoing Planning and Management Activities: The models are updated periodically (see Spitz & DePaul, 2008) and used to determine whether the reduced withdrawals are achieving the intended purpose. At this time, the models indicate that the management objectives have been achieved. As with Critical Area #1, DEP is prohibited from granting new or increased diversions from the affected PRM Aquifer System. However, water allocation credits may be transferred from the water allocation credit exchange to become part of a permittee's base allocation. The credit exchange program is available to areas in the northern portion of the Rancocas Creek and is subject to DEP approval, but managed by the Burlington County Water Credit Exchange program (N.J.A.C. 7:19-8.5(d)).

Potential Planning and Management Activities: Continued implementation of critical area procedures. No additional activities are required other than periodic assessment, review and enforcement of current requirements.

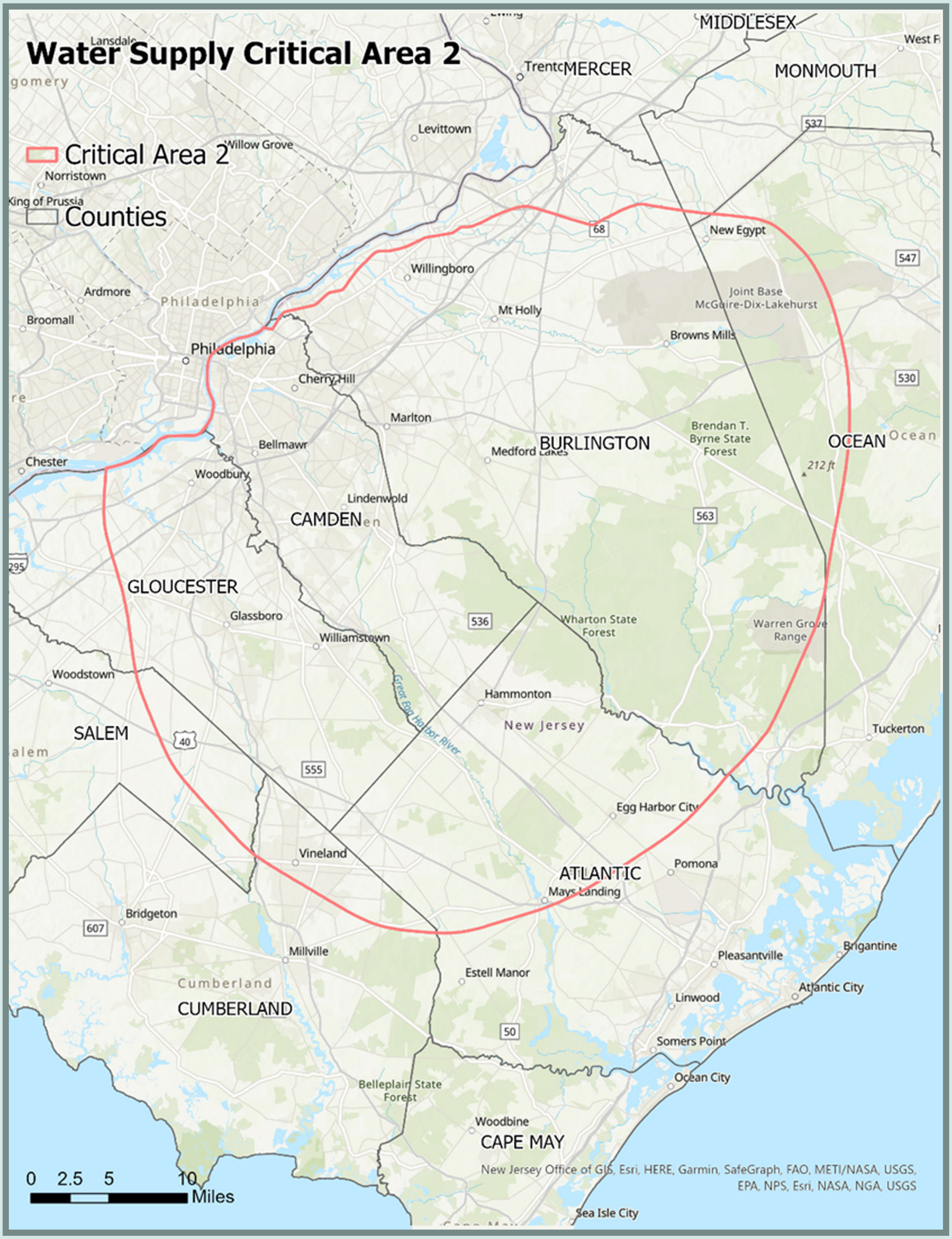


Figure 6.2 Water Supply Critical Area #2 and surrounding counties.

WENONAH-MOUNT LAUREL AQUIFER

Issue Overview: DEP has identified this confined aquifer as showing declining static water levels. There are concerns that the aquifer may be experiencing withdrawals that exceed long-term sustainability. This aquifer is in the same geographic area as Water Supply Critical Area #2 (but affecting a different confined aquifer), raising the possibility that Wenonah-Mt. Laurel aquifer would be relied upon as an alternative water supply for those withdrawals that were reduced in the same area.

Level of Certainty: Validated Stress, based on aquifer monitoring and modeling.

Level of Severity: Moderate. The concern is sufficient to justify restrictions on new or increased water allocation permits, but not to a level required for designation of a water supply critical area or addition to the aquifers currently in Water Supply Critical Area #2.

Completed Planning and Management Activities: USGS cooperated with DEP on development of two studies regarding these aquifers, Navoy (1994) and Watt and Voronin (2006). The first study (Navoy, 1994) was developed to assess the potential impacts of additional withdrawals from the Wenonah-Mt. Laurel aquifer, in part due to withdrawal reductions in PRM in Water Supply Critical Area #2. This study indicated the potential for major reductions in potentiometric surfaces in the Camden and Burlington County portions of the aquifer due to additional withdrawals. The second study (Watt & Voronin, 2006) investigated the possible effects of using wells (specifically, inactive wells in Deptford Township) near the outcrop area of the Wenonah-Mt. Laurel aquifer; the issue was whether the increased withdrawal effects would be felt in the confined portion of the aquifer or in the unconfined portion, potentially harming wetlands and stream flows. Half of the modeled withdrawals would come from decreased stream flow (the unconfined aquifers), and a third from increased movement of water from the overlying Vincentown aquifer.

Ongoing Planning and Management Activities: DEP discourages new or increased annual confined ground water diversions from the Wenonah-Mt. Laurel aquifer and evaluates each request, taking into consideration the availability of alternative supplies and localized conditions in the aquifer.

Potential Planning and Management Activities: The connection between the aquifer and the PRM in Water Supply Critical Area #2 provides a case for updating the 2005 model with new population and water demand projections to determine if additional steps are required.

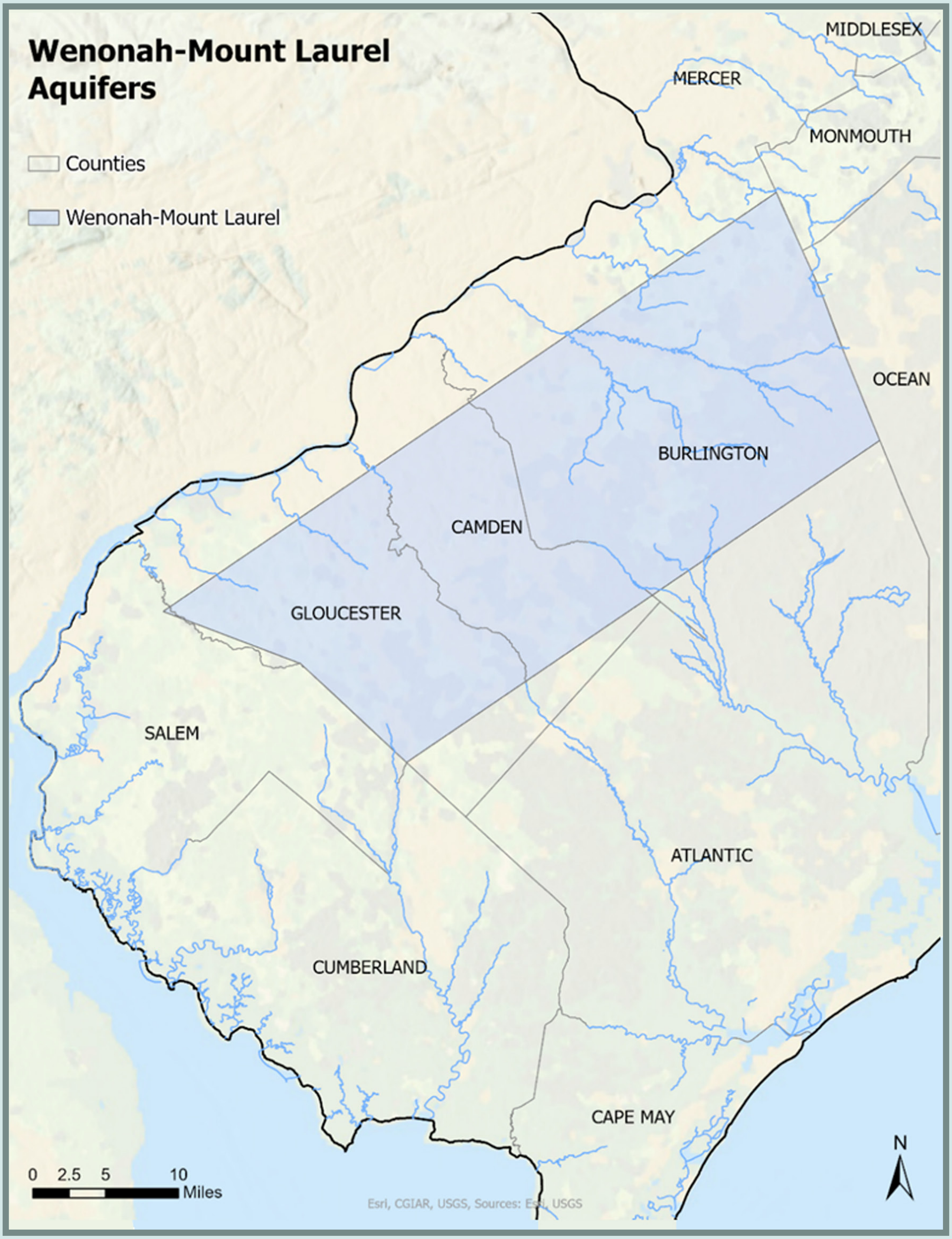


Figure 6.3 Wenonah-Mount Laurel aquifer and surrounding counties.

PINEY POINT AQUIFER

Issue Overview: DEP has observed declining water levels in the Piney Point aquifer in the Bridgeton area. Additionally in the Ocean County area, the aquifer is at or near full allocation. There are concerns that the aquifer may be experiencing withdrawals that exceed long-term sustainability.

Level of Certainty: Validated Stress, based on aquifer monitoring and modeling.

Level of Severity: Moderate. The concern is sufficient to justify restrictions on new or increased water allocation permits, but not to a level required for designation of a water supply critical area.

Completed Planning and Management Activities: Several aquifer tests were reviewed by DEP staff to determine hydrogeologic boundaries and limitations which may be exacerbating the observed drawdown.

Ongoing Planning and Management Activities: Proposed new and increased allocations are reviewed to determine if they will increase aquifer drawdown or interfere with other permitted diversions.

Potential Planning and Management Activities: Development of a regional groundwater model should be considered to better characterize and quantify the impacts and to evaluate alternatives.

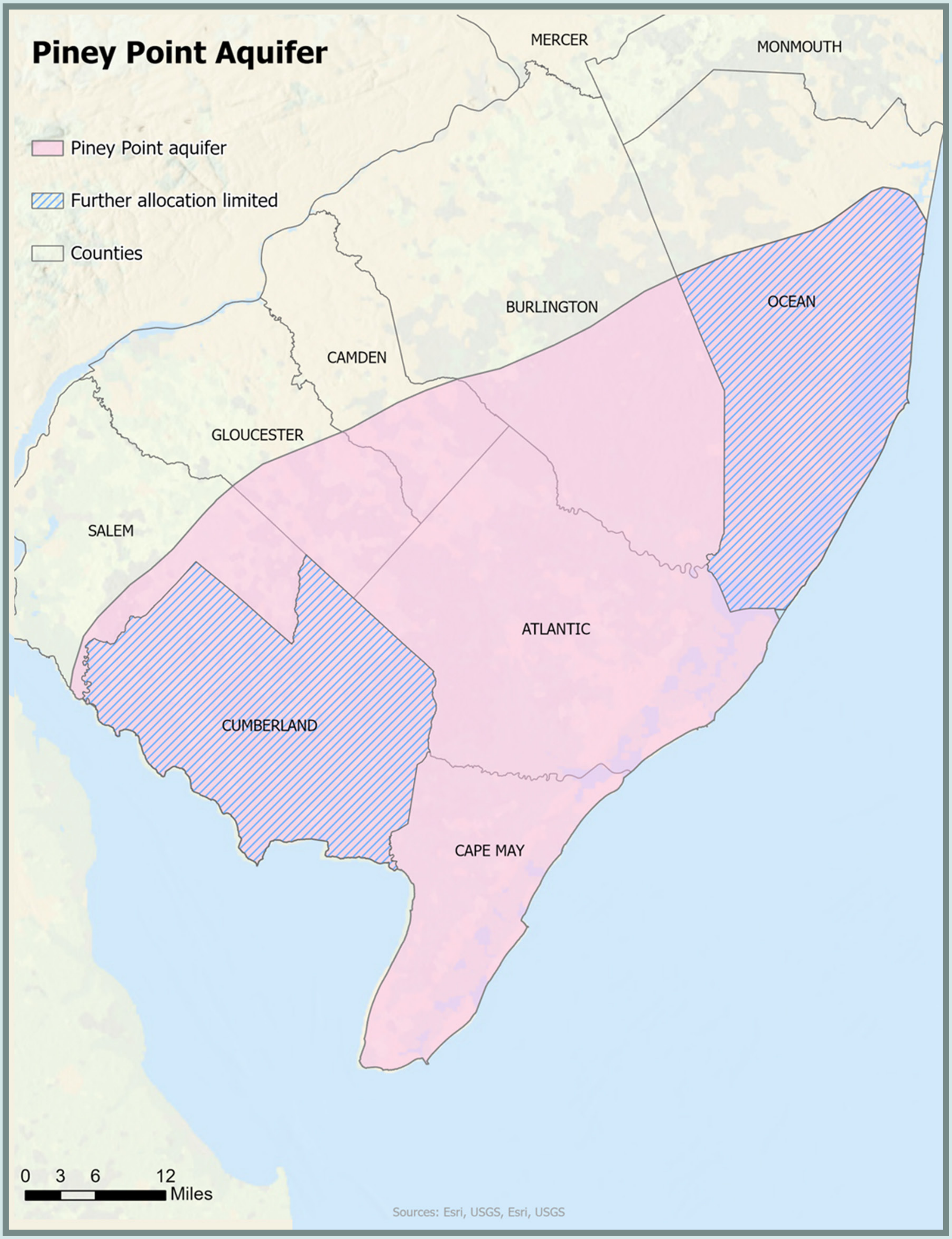


Figure 6.4 Piney Point aquifer and surrounding counties. The aquifer is at or near full allocation in hatched counties where the aquifer is present.

WMA 16: CAPE MAY STUDY AREA

Issue Overview: Saltwater intrusion occurred in multiple aquifers (e.g., Holly Beach water-bearing zone, estuarine sand aquifer, Cohansey aquifer, Rio Grande water-bearing zone, Atlantic City 800-foot sand) under the southern Cape May peninsula, resulting in loss of freshwater public water supply wells in several municipalities including Cape May City (Cohansey aquifer wells replaced with desalination using locally brackish groundwater from wells completed in the Atlantic City 800-foot sand) and a concern about further saltwater intrusion in the area. The New Jersey Legislature appropriated funds (P.L. 2001, Chapter 165) to DEP for a detailed study of the issue including ecological impacts from groundwater withdrawals in addition to saltwater intrusion. This resource has been addressed to Step 6 of the Regional Planning and Management Framework.

Level of Certainty: Validated, based on aquifer monitoring and modeling.

Level of Severity: Moderately Stressed, based on confirmed saltwater intrusion that forced a shift to desalination in Cape May City, mixing of well water in other municipalities, and potential loss of domestic wells in southwestern Lower Township MUA (LTMUA).

Completed Planning and Management Activities: USGS has collaborated with DEP to complete several studies of the affected aquifers in southern Cape May County, including aquifer modeling. Other recent studies (Carleton, 2021; Lacombe, 1996; Lacombe & Carlton, 2002; Lacombe et al., 2009; Spitz, 1996; Spitz, 1998) have provided significant insight into the hydrogeologic setting of Cape May and feasible alternatives. The DEP is currently conducting a comprehensive review of these options in conjunction with localized monitoring efforts. The goal is a unified water allocation permitting strategy for water supply to Cape May while addressing the saltwater intrusion threats to production wells. Most recent modeling simulations were done to see the effects of full allocation pumping effects compared to baseline scenario results (Carleton, 2021). These studies have allowed DEP to construct and implement a framework for water allocation permitting decisions and resulted in specific actions such as new interconnections and the movement of wells away from salty water towards the 'spine' of Cape May County.

Ongoing Planning and Management Activities: DEP will not approve new or increased annual allocations that would accelerate saltwater intrusion, reduce stream flow, or harm natural resources. Only sustainable water supply alternatives based on USGS recommendations are considered when necessary to meet the current and future water supply needs of Cape May County. Options to relocate water withdrawals away from areas of concern would require collaboration among multiple water supply entities, with resulting cost implications.

While Cape May County's year-round population is expected to remain close to the same through 2050, much of the water demand is driven by tourism during the summer season. Sea level rise is expected to increase the submerged areas of the county, placing some wells at risk of tidal inundation, as discussed in Chapter 3.

Upgrading emergency interconnection infrastructure to enhance two-way transmission points throughout the region is ongoing and further encouraged. This allows for more flexibility and resilience for the region.

Potential Planning and Management Activities: The aquifer model needs to be updated using recent aquifer monitoring, water withdrawals, sea level rise, population trends and tourism activity data to determine whether the scenarios of the USGS 2009 and Addendum 2020 study (Carleton, 2021) are still valid in the context of sea level rise. While most confined aquifers are deemed safe from sea level rise impacts for the foreseeable future (see Chapter 3), that cannot be said for confined aquifers already experiencing saltwater intrusion in stressed areas. Unconfined and leaky confined aquifers are also at risk from sea-level rise induced saltwater intrusion. Based on the updated analysis, DEP will collaborate with local interests to determine whether and how further actions should be taken to mitigate or avoid further saltwater intrusion.

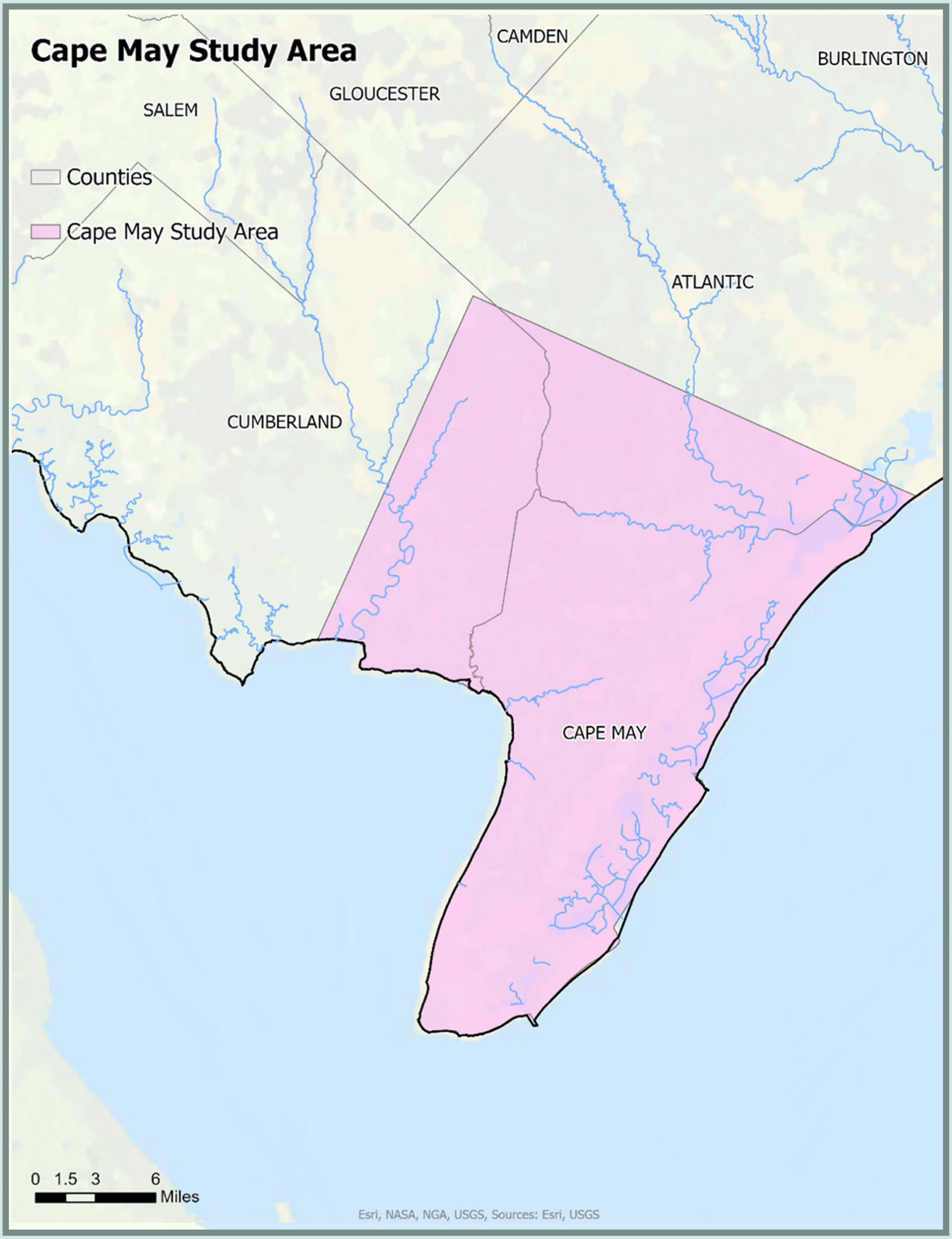


Figure 6.5 Cape May Study Area and surrounding counties.

WMA 17: GLOUCESTER/SALEM STUDY AREA CONFINED AQUIFERS

Issue Overview: DEP has identified that increased PRM confined aquifers withdrawals south of the existing Water Supply Critical Area #2 boundary could potentially force expansion of the Critical Area, as defined by a static water level contour equal to or lower than 30 feet below mean sea level (-30 ft msl). Expansion of the Critical Area, using existing authorities, could trigger withdrawal limitations and substitution with other water supplies.

Level of Certainty: Validated Stress, based on aquifer monitoring and modeling.

Level of Severity: Moderate, as some saltwater intrusion impacts have been experienced but not at a wide scale; the concerns are validated enough to require monitoring and management.

Completed Planning and Management Activities: USGS has cooperated with DEP in the development of a 2011 report to assess the effects of allocated and projected withdrawals on PRM aquifer levels in the project area (Charles et al., 2011). A regional evaluation of WMA 17, including Salem, Cumberland and part of Gloucester counties (Step 3 of the Framework for Regional Water Supply Planning and Management) was prepared as part of the 2024 Plan (see Appendix J), providing context for further planning. While the Salem County population is projected to decline by roughly 10% between 2020 and 2050, Gloucester County's population is expected to grow by more than 10%, with seven times the population gain as Salem's projected loss. Sea level rise is a significant issue in Salem County, including the City of Salem.

Ongoing Planning and Management Activities: In Salem and Gloucester counties south of Critical Area #2 there are concerns that new or increased diversions from the PRM Aquifer System could expand the -30 static water level contour that could expand the critical area. At this time, DEP has determined that proposed new or increased allocations must be evaluated taking into consideration availability of alternative supplies and localized conditions in the aquifer.

Potential Planning and Management Activities: The 2011 USGS study projected demands out to the year 2025. New population and water demand projections could be coupled with updated aquifer status data and sea level rise projections in the tidal Delaware River, to re-evaluate the results of the 2011 model and determine if additional steps are required.

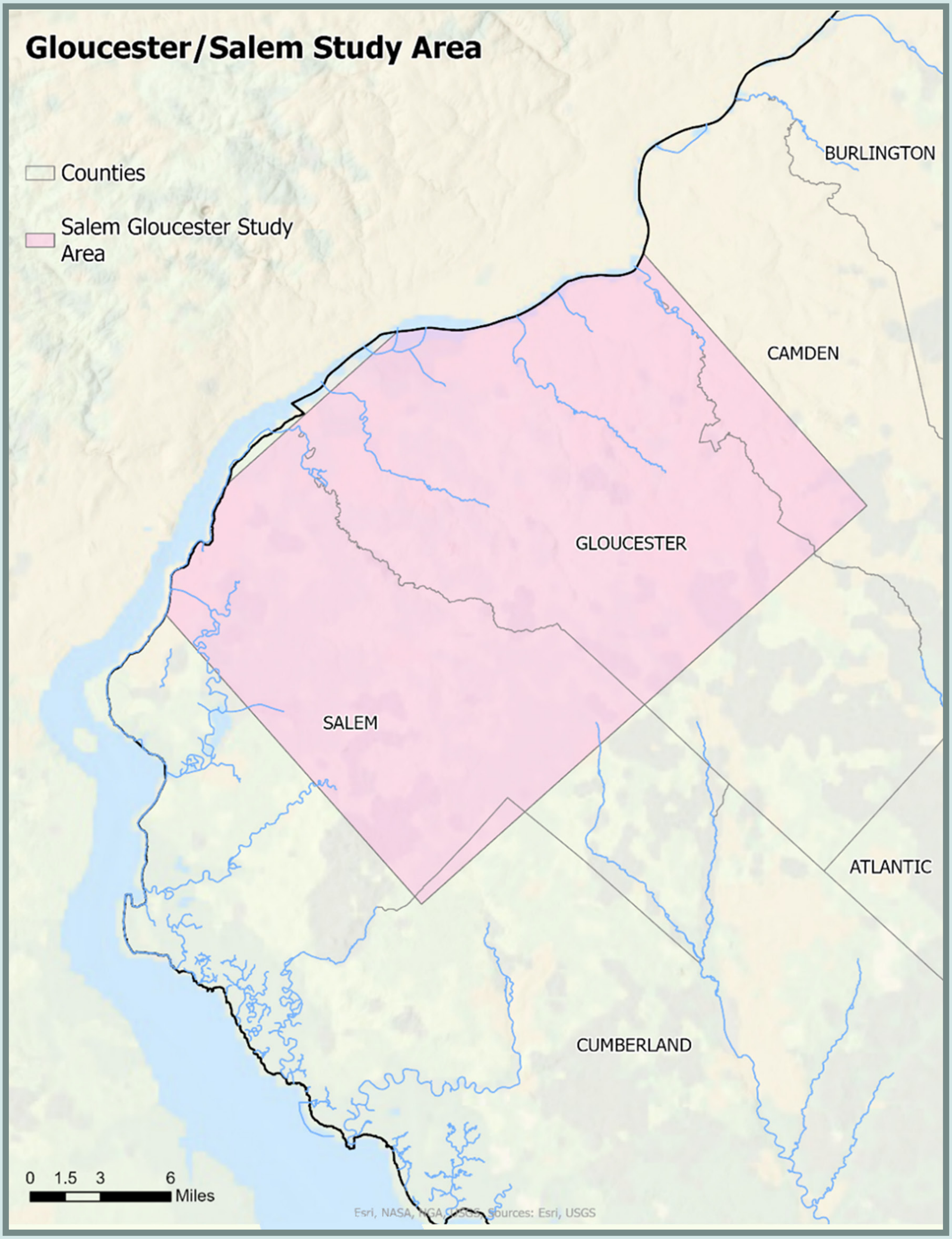


Figure 6.6 Gloucester/Salem Study Area and surrounding counties.

UNCONFINED AQUIFERS AND RELATED STREAMS

As with confined aquifers, there are unconfined aquifers where historic water allocations, prior to more modern understanding of aquifer sustainable yields, have resulted in either excessive withdrawals or full allocation of the aquifers. In other areas, initial information indicates a potential concern based on statewide models. More detailed information and, at times, resource-specific modeling will be needed to verify the concerns. These areas are discussed in this section, with an overview of the major issues, actions taken prior to this Plan, and any necessary actions that are anticipated as a result of this Plan and ongoing activities.

WMA06: BURIED VALLEY AQUIFER SYSTEM OF MORRIS AND ESSEX COUNTIES

Issue Overview: A large and somewhat interconnected system of buried valley aquifers exists in the Central Passaic River area of western Essex County and eastern Morris County. Buried valleys are pre-glacial valleys that were filled with sediments, sands and gravels during the period of glacial retreat. In several cases, the buried valleys have sand and gravel deposits that are highly productive for wells. They underly a number of rivers, such as the Passaic, Whippany and Rockaway, but also cross watershed lines.

These aquifers have been used since the late 1800s, and with the advent of major suburbanization in the region, water levels in the aquifers were dropping. Unlike confined aquifers, these buried valley aquifers are either unconfined or semi-confined. This allows water to move between the buried valley aquifers and either overlying surface waters or adjacent bedrock groundwater units. Their unconfined nature also allowed for the movement of pollutants into the aquifers, which frequently occurred due to industrial development, landfills, leaking gasoline station tanks and other sources (Van Abs, 1986).

Level of Certainty: Validated, based on aquifer monitoring and modeling.

Level of Severity: Moderate. The concern is sufficient to justify restrictions on new or increased water allocation permits, but not to a level required for designation of a water supply critical area.

Completed Planning and Management Activities: DEP developed an aquifer model in the 1980s to better understand the aquifer systems and test the effects of additional withdrawals (Hoffman, 1989). The study concluded that several buried valley aquifers were already over pumped as of 1985, others were overallocated but not yet over pumped, and some had remaining capacity beyond current pumping or allocations. As a result of this model and other analyses, DEP determined that no new or additional water allocations should be permitted. Partially as a result of these restrictions and additional water needs, three water systems (Parsippany-Troy Hills Township, Southeast Morris County Municipal Utility Authority (SMCMUA) and New Jersey American Water) augmented their aquifer withdrawals (and in the case of New Jersey American Water, pumped storage reservoirs) with additional surface water supplies drawn from the Jersey City system (Parsippany) and a pipeline from the Passaic Valley Water Commission facility in Totowa (SMCMUA and New Jersey American Water).

In addition, a regional evaluation (Step 3 of the Framework for Regional Water Supply Planning and Management) was prepared as part of this Plan (see Appendix H), providing context for further planning. Morris and Essex counties anticipate low to moderate population increases. Water withdrawals have declined since the 1990s and for most PCWS that trend is expected to continue, reducing aquifer stresses.

Ongoing Planning and Management Activities: In addition to the specific regulatory actions and infrastructure improvements, DEP has generally been protecting these and other aquifers from additional recharge losses through the NJAC 7:8 Stormwater Management Rules that are applicable statewide. These rules, most recently amended in 2023, seek to maintain existing groundwater recharge and minimize pollutants in stormwater runoff among other goals. Specifically, no new or increased allocations from the Buried Valley Aquifer System in northeast New Jersey (Ramapo/Passaic/Par-Troy areas) are permitted as these areas have been fully allocated since the 1990s.

Potential Planning and Management Activities: The 1989 groundwater model is among the oldest in New Jersey. Given the importance of these buried valley aquifers to the region, and despite the potential for declining withdrawal trends, an update to the model may be appropriate to address the history of aquifer pollution, major changes in development patterns since the 1980s, the potential for population growth, and the fact that much of the Morris County area is now within the Highlands Region.

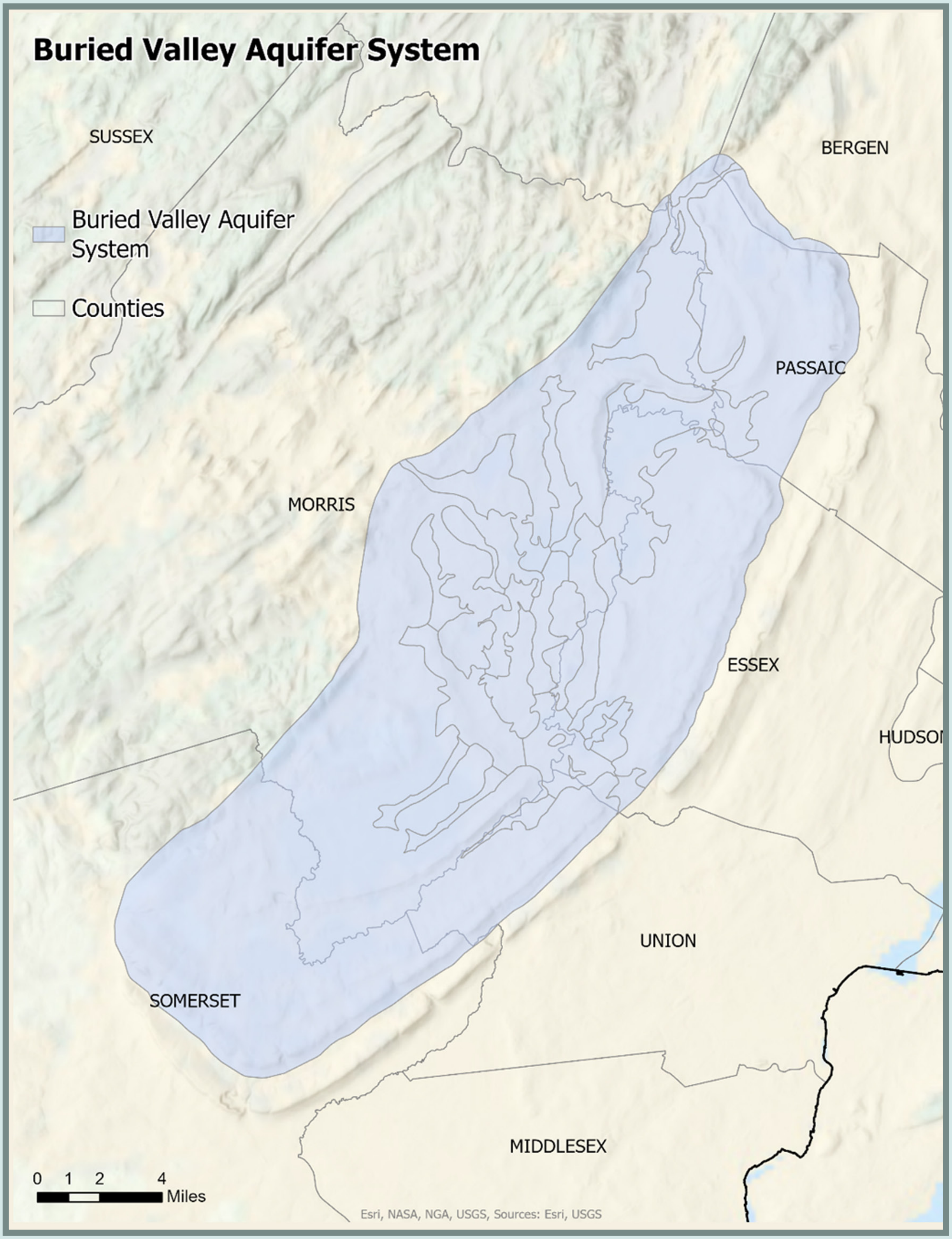


Figure 6.7 Buried Valley Aquifer System and surrounding counties.

WMA11: LOCKATONG CREEK SURFICIAL AQUIFERS

Issue Overview: Lockatong Creek is part of WMA 11-Central Delaware Tributaries, and it provides part of the flow to the Delaware & Raritan Canal, a major water supply to central New Jersey that is owned and operated by the New Jersey Water Supply Authority (NJWSA), a state agency. DEP has determined that the watershed is at or approaching full allocation, based on existing water allocation permits and agricultural use certifications. The watersheds largely have shallow soils over Newark basin aquifer's limited groundwater storage potential. Despite the mostly rural nature of the watersheds, the streams have very high flows during storms and limited base flow during dry periods. It is the limited potential for groundwater infiltration and storage that makes the watersheds sensitive to withdrawals, which have been increasing with development. The high storm flows also contribute to erosion that damages water quality in the Delaware & Raritan Canal.

Level of Certainty: Potential Stress

Level of Severity: Moderate. The concern is sufficient to justify restrictions on new or increased water allocation permits, but not to a level required for designation of a water supply critical area. Limited population growth is forecast through 2050 from a small existing population base in this rural area.

Completed Planning and Management Activities: The NJWSA developed a watershed management study for the Lockatong Creek and its neighboring watershed, the Wickecheoke Creek (New Jersey Water Supply Authority Watershed Protection Programs Unit, 2009). This project identified the initial concerns regarding water withdrawals. The Lockatong and Wickecheoke comprise HUC11 02040105200; the LFM analysis shows some remaining capacity based on recent peak annual withdrawals, but total water allocations significantly exceed the available water.

Ongoing Planning and Management Activities: DEP has determined that new or increased water allocations will be evaluated on a case-by-case basis.

Potential Planning and Management Activities: This area has been identified using the LFM analysis and NJWSA study. Therefore, the initial steps from the Framework for Regional Water Supply Planning and Management are appropriate for this area. They include data verification and model reanalysis (steps 1 and 2). If the same limitations are still identified, then regional evaluation and enhanced monitoring, modeling, and analysis would be warranted (steps 3 and 4) and planning, management, and regulatory responses might be warranted (Step 5).

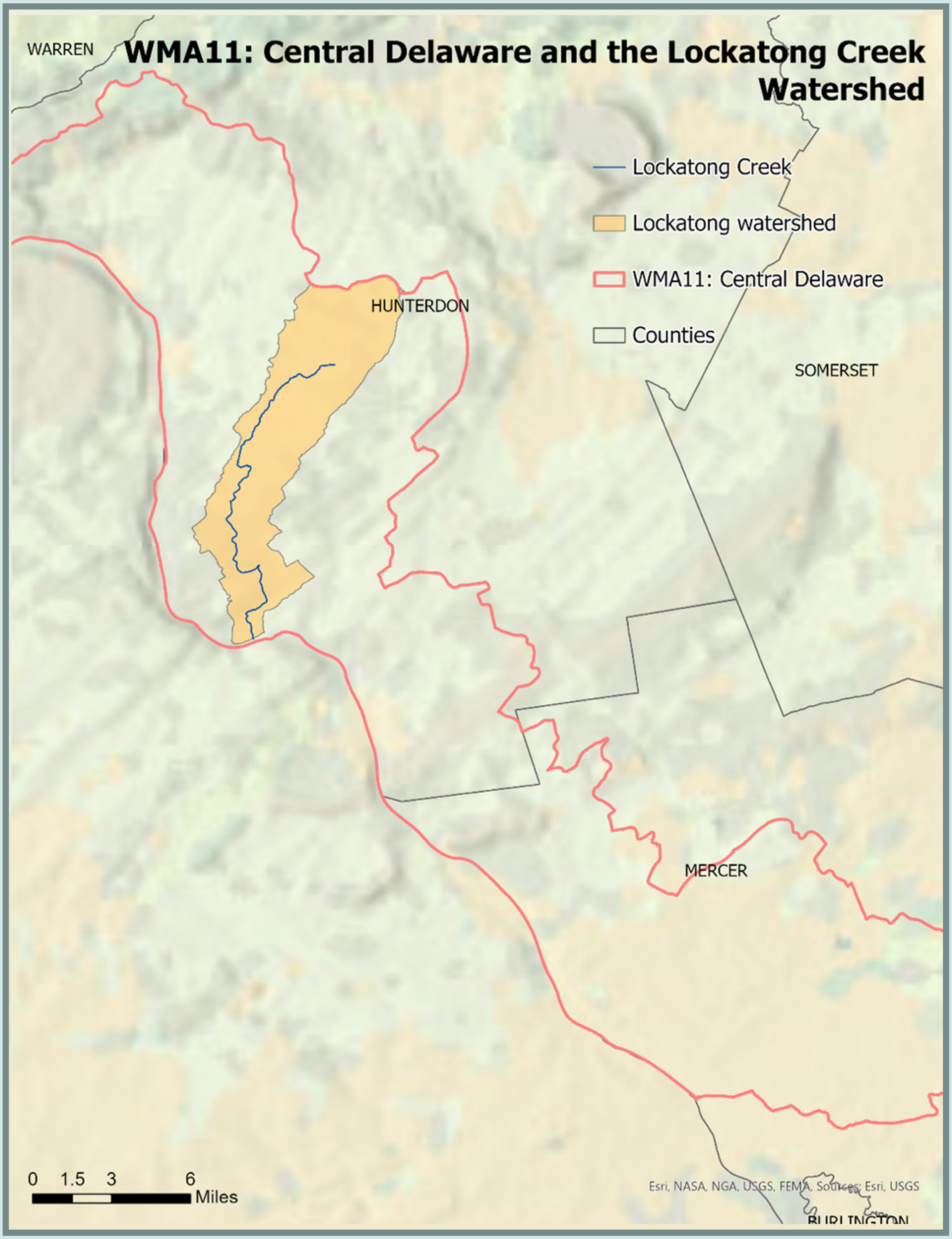


Figure 6.8 WMA 11 and the Lockatong Creek watershed.

WMA13: BARNEGAT BAY WATERSHEDS SURFICIAL AQUIFERS

Issue Overview: Barnegat Bay and the adjacent barrier islands are critical components of New Jersey's tourism industry; flows from tributaries to the Bay are critical to maintaining the ecological integrity of the estuarine Bay (Barnegat Bay Partnership, 2021). Through a combination of monitoring and models, DEP has identified static water level decline in the unconfined aquifers near pumping centers in this region, indicating potential excess use of the unconfined aquifer. In addition, the LFM analysis indicates that four HUC11 areas in WMA13 have calculated consumptive and depletive water demands that exceed water availability (Metedeconk River (02040301040), Kettle Creek / Barnegat Bay North (02040301050), Toms River (above Oak Ridge Parkway) (02040301060), and Toms River (below Oak Ridge Parkway) (02040301080)). All the more densely populated areas within the region are connected to sewage treatment facilities that discharge to the ocean, and most of these areas are dependent on aquifer withdrawals. Population growth through 2050 is forecast to significantly outpace statewide growth, adding to these stresses.

Level of Certainty: Validated Stress (USGS model) and potential deficit (LFM method)

Level of Severity: Minor with some subregions moderate.

Completed Planning and Management Activities: As a result of planning efforts leading to the 1996 Plan, USGS and DEP cooperated on a study (Nicholson & Watt, 1997) to evaluate potential effects of unconfined aquifer withdrawals on stream flows in the Toms River, Metedeconk River and Kettle Creek watersheds, in the northern portions of WMA13. The study determined that aquifer withdrawals through the 1980s had created static water level declines near the well fields, reducing stream flows by up to 11%, and withdrawals at full allocation levels would reduce stream flows even more, up to 15% in Kettle Creek. Seasonal reductions would be even higher due to the close connection between the groundwater and stream flows and the much higher summer withdrawals to address tourism and outdoor water uses.

In addition, a regional evaluation (Step 3 of the Framework for Regional Water Supply Planning and Management) was prepared as part of the 2024 Plan (see Appendix I). Ocean County is expected to grow, adding potential water demands that may be offset to some extent by ongoing water use efficiency trends. The region includes Lakewood Township, a very rapidly growing municipality.

Ongoing Planning and Management Activities: DEP has determined that new or increased water allocations in the Kettle Creek watershed (a subwatershed to WMA13) must address impacts to base flow. This could include long-term aquifer testing and surface water level and streamflow monitoring, or the development of ground or surface water models calibrated to the watershed.

Potential Planning and Management Activities: The USGS modeling was developed in the 1990s using aquifer withdrawals from the 1980s. An update of the model is appropriate to reflect more recent (and likely better documented) withdrawals, recent static water levels, and updated demand projections.

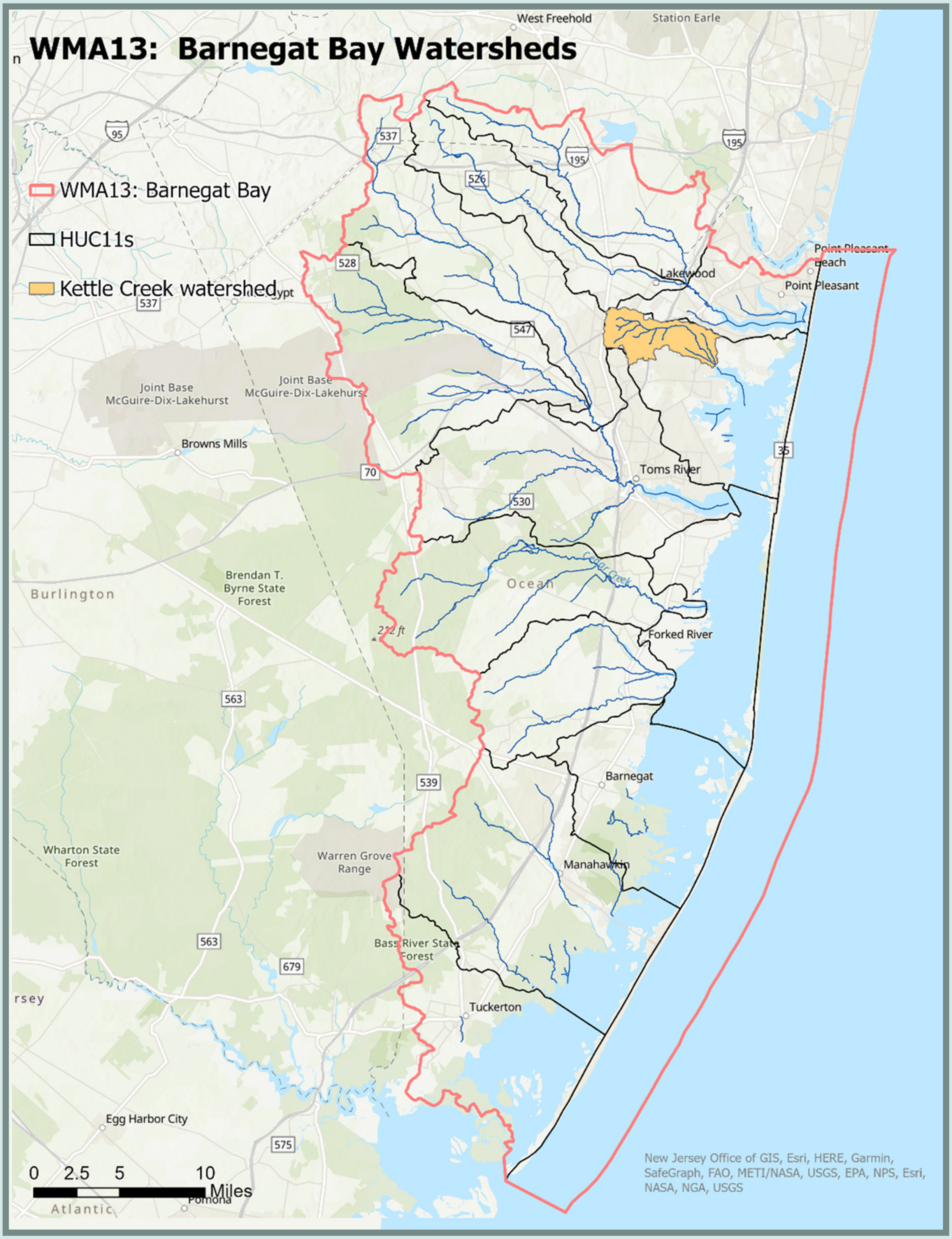


Figure 6.9 WMA 13, watersheds with allocation restrictions, and the HUC11s within.

WMA17: MAURICE/SALEM/COHANSEY WATERSHEDS SURFICIAL AQUIFERS

Issue Overview: WMA17 includes several rivers that drain the southern portion of the Pinelands and other lands along the Delaware Bay. The region has extensive agricultural areas but also forested lands and various small to medium urban centers that developed either as town centers for regional agricultural or manufacturing (e.g., glass making) endeavors. The Delaware Bay shore area is very flat and highly susceptible to sea level rise as seen in the Climate Change portion of this Plan. The Maurice River and several of its tributaries (Menantico and Muskee Creeks and the Manumuskin River) are part of the National Wild & Scenic River System. While Salem County's population is projected to decline, Cumberland County's population is forecast to increase, though slower than the statewide average.

Groundwater modeling has identified issues regarding the impacts of groundwater and surface water withdrawals within the WMA17 watersheds on river flows. Using the Low Flow Margin evaluations for the 2024 Plan, 13 HUC11s in WMA17 are identified as stressed. HUC11s 02040206080 (Cohansey River (above Sunset Lake)), 02040206150 (Muddy Run), and 02040206030 (Salem River (above 39d40m14s dam)/Salem Canal) have the third, seventh, and tenth highest results in the State, respectively, in terms of calculated demands exceeding total available water. The dominant largest consumptive/depletive peak loss in the stressed HUC11s is agricultural irrigation, which was reported in nine of 13 stressed HUC11s. The stress in WMA17 is a known deficit area, with previous research identifying stress in the following areas:

- Gloucester-Salem;
- Salem River Watershed;
- Upper Maurice Drainage Basin; and
- Water Supply Critical Area #2.

Level of Certainty: Validated Stress

Level of Severity: Moderate. The concern is sufficient to justify restrictions on new or increased water allocation permits, but not to a level required for designation of a water supply critical area.

Completed Planning and Management Activities: As a result of planning efforts leading to the 1996 Plan, USGS and DEP cooperated on studies in the Salem River (Johnson & Charles, 1997) and Upper Maurice River watersheds (Cauller & Carleton, 2006). The Salem River study area is roughly equivalent to Salem County (with part of southwestern Gloucester County) and includes the river, nearby watersheds, and both the unconfined and confined aquifers of the region. The study assessed base stream flow, which represented 64 to 75 percent of total annual flow, depending on the stream. The study developed a general water budget based on 1990 data, estimating that consumptive uses comprised 1% of annual precipitation; recharge was equivalent to 29% of precipitation. However, the study did not include development of a full aquifer model.

The Upper Maurice River study compared modeled pre-development groundwater conditions with mid-1990s conditions. Withdrawals were estimated to have caused major reductions in stream water base flows (i.e., dry weather flows) by 25 to roughly 60 percent, depending on the watershed involved. Using future withdrawal projections to 2040 indicated that at least one stream could have no base flow in summer conditions and others would suffer losses beyond 1990s conditions, though higher recharge changes would have a significant positive effect on these findings. At full allocation withdrawals, the base flow reductions would be worse than under projected demands, with several streams losing all or nearly all base flow during summer conditions. Wells in the unconfined aquifers have a roughly 1:1 effect on stream base flows.

In addition, a regional evaluation (Step 3 of the Framework for Regional Water Supply Planning and Management) was prepared as part of the 2024 Plan (see Appendix J), to provide context for further planning. While the Salem County population is projected to decline by roughly 10% between 2020 and 2050, Gloucester County's population is expected to grow by more than 10%, with seven times the population gain as Salem's projected loss. Sea level rise is a significant issue in Salem County, including the City of Salem.

Ongoing Planning and Management Activities: DEP has restricted new or increased surface water allocations from the Salem River and the related unconfined aquifer, as the basin is fully allocated upstream of the Salem Canal. Likewise, new or increased Kirkwood-Cohansey Aquifer System or surface water consumptive uses upstream of Union Lake in the Upper Maurice River watershed are restricted. See Figure 6.10 for a map of these subregions.

Potential Planning and Management Activities: The two USGS studies are from 1997 and 2005 for the Salem and Maurice River watersheds, respectively, reflecting water withdrawal data that is from 20 or more years ago. In the intervening years, withdrawal patterns may have changed significantly, and it has become clear that climate change (including sea level rise) is an increasingly important issue in the region because of the potential for warmer temperatures to increase agricultural withdrawals. Also, the low elevations along the Delaware Bay pose a threat to the nearby groundwater resources and to local farmlands. In addition, recent research has shown that reported agricultural withdrawals may be significantly higher than actual withdrawals due to the method used (i.e., pump capacity multiplied by hours of operation, rather than metered flows).

Therefore, improved withdrawals data for both areas, updated analyses of the Maurice River watershed model and development of a similar model for the Salem River study area are appropriate at this time. The analyses will benefit from use of the regional evaluation found in Appendix J.

Figure 6.10 WMA 17, watersheds with allocation restrictions, and the HUC11s within.

WMA20: BLACKS CREEK WATERSHED

Issue Overview: Surface water in Blacks Creek (HUC11 02040201080) above Chesterfield-Georgetown Road show signs of overallocation and difficulty meeting permitted surface water diversions under low flow conditions. The LFM method shows the HUC11 to be limited at full allocation.

Level of Certainty: Likely Stress based on potential deficit (LFM method)

Level of Severity: Moderately severe

Completed and Ongoing Planning and Management Activities: New surface water allocations in this area are reviewed on a case-by-case basis.

Potential Planning and Management Activities: Data validation and additional monitoring are needed to improve the hydrology and hydrogeology of the sub-watershed.

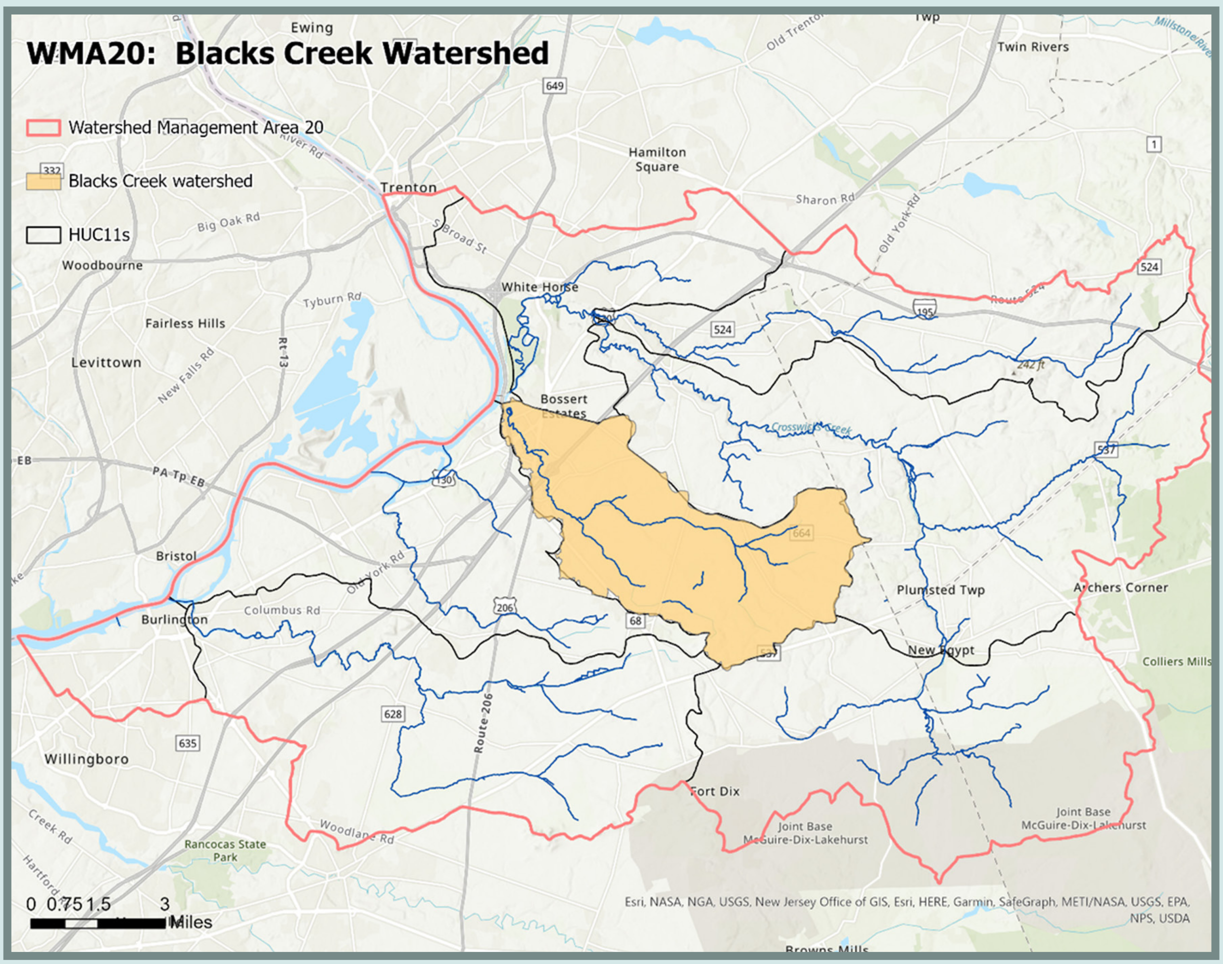


Figure 6.11 WMA 20 and the Blacks Creek watershed with allocation restrictions.

COMBINED CONFINED AND UNCONFINED AQUIFERS

One region has been identified as a potential future concern for excess use of interconnected confined and unconfined aquifers, based on potential future demands.

WMA 14 AND 15: MULLICA AND GREAT EGG HARBOR STUDY AREA AQUIFERS

Issue Overview: These two Watershed Management Areas are predominantly in the Pinelands Region, discharge to estuarine bays, and have major unconfined aquifers (primarily the Kirkwood-Cohansey) and underlying confined aquifers that require assessment as somewhat interconnected resources. Pinelands stream, wetlands, and bog ecosystems are highly dependent on the Kirkwood-Cohansey aquifer system. Some of the HUC11 drainage areas are showing indications of water stresses. In addition, significant agricultural production areas exist within the region, which are highly dependent on groundwater for irrigation purposes on a seasonal basis; reported withdrawals may not be accurate due to methodology issues with withdrawals for agricultural uses. Growth in the Pinelands Region is restricted in some areas and encouraged in other areas within these watersheds. Much of the region is within the Preservation Area, Forest Area or Agricultural Production Area. Atlantic County is forecast to experience population growth at less than half the statewide average.

Level of Certainty: Validated Stress

Level of Severity: Moderate

Completed Planning and Management Activities: USGS and DEP have cooperated on a modeling study in the two areas, for the unconfined and confined aquifers (Pope et al., 2012). Demands are largest from the Kirkwood-Cohansey aquifer system, but the confined aquifers are important water resources as well for potable supplies. In addition, the Kirkwood-Cohansey aquifer is the major source of recharge to the lower confined aquifers (primarily the Atlantic City 800-foot sand). The model was used to evaluate current, projected and full allocation scenarios. The 2050 demand scenario would have demands roughly 50% higher than the 1998-2006 average, primarily due to potable supply demand increases, while the full allocation scenario would be twice the 1998-2006 average, with the addition primarily due to agricultural water use certifications. The 1998-2006 Average scenario indicated that deficits (excessive base flow depletion) occurred in half the subbasins, nine for the 2050 Demand scenario and 11 for the Full Allocation scenario.

Ongoing Planning and Management Activities: DEP has determined that new or increased allocations from confined and unconfined aquifers must be evaluated taking into consideration alternate available water supplies for the intended use and potential impacts on the resource and other users of the resource. Seasonal conjunctive use (confined and unconfined aquifers) and reuse of treated wastewater could be evaluated to lessen groundwater demands. In late 2022, the Pinelands Commission proposed amendments to CMP regulations (N.J.A.C. 7:50-6.86 (a-e)) regarding water management within the Pinelands, which may limit Pinelands water withdrawals further.

Potential Recommended New Planning and Management Activities: Several steps are recommended for this region. The importance of agricultural withdrawals (both current and at full allocation) indicates that additional effort should be made to better quantify actual withdrawals and to project future needs. Potable water withdrawals are important currently and for the year 2050; an update to demand forecasts should be tested in the model to assess stresses for that year. In addition, if the Pinelands CMP rules are adopted, the implications of those rules for future water demands should be assessed.

Figure 6.12 Mullica and Great Egg Harbor Study Area.

OTHER REGIONS NEEDING ADDITIONAL REVIEW

In addition to the specific regions discussed above there are several more generic situations which also require additional review when the DEP makes water supply allocation or agricultural certification decisions. These areas and the additional review are listed below.

- **Classification Exception Area (CEA):** new or increased allocation to be evaluated on a case-by-case basis. The CEA (Polygon) coverage was developed to provide information regarding the spatial extent of groundwater contamination within designated Classification Exception Areas (CEAs) and Well Restriction Areas (WRAs). The potential for proposed withdrawals to interfere with CEAs must be evaluated and avoided.
- **Delaware and Raritan Canal:** any new or modified surface water diversion from the Delaware and Raritan Canal may proceed only with the approval of the NJWSA. Interstate water rights and negotiations determine water availability via the canal during phases of drought, as prescribed by Section 2.5.3 of the Delaware River Basin Water Code and **Table 1** of the FFMP 2017 Operation Plan, part of an operating agreement among the Delaware River Basin states and New York City. Evaluations of current yield and existing allocations are necessary to ensure future water availability for new and current users.
- **Emergent Wetland:** new or increased allocation to be evaluated on a case-by-case basis. The Emergent data set depicts critical area maps for emergent dependent species which are generated by selecting specific land-use classes from the DEP's LULC data set. This data set is a product of the Landscape Project, a pro-active, ecosystem-level approach to the long-term protection of imperiled and priority species and their important habitats in New Jersey.
- **Forested Wetland:** new or increased allocation to be evaluated on a case-by-case basis. The NJDEP Forest Critical Habitat data set depicts critical area maps for forest dependent species which are generated by selecting specific land-use classes from the DEP's LULC data set. This data set is a product of the Landscape Project, a pro-active, ecosystem-level approach to the long-term protection of imperiled and priority species and their important habitats in New Jersey.
- **Raritan Basin:** new or increased allocation upstream of the Bound Brook gage must contract with the New Jersey Water Supply Authority for the consumptive portion of their annual allocation or increased annual allocation respectively. The Raritan River Basin includes 1,100 square miles of land that ultimately drain to the Raritan Bay through the Raritan River. The Basin includes large areas of urban, agricultural and forested land, along with significant areas of wetlands. Historic and recent land uses have resulted in the loss or degradation of significant watershed resources, including wetlands, riparian areas (stream corridors), and ecosystems in urban and agricultural areas. Ground water recharge is decreasing due to increased impervious cover such as roads, parking lots and buildings, which in turn reduces the flow in small streams during dry periods. For more information regarding the Raritan Basin and operational data can be found at **New Jersey Water Supply Authority - The Raritan Basin System**.
- **Upstream of Reservoir or Potable Water Intake:** the DEP has concerns with new or increased consumptive or depletive water uses upstream of surface water supply reservoir systems. The safe yield of these systems is based upon observed flows during the system's drought of record. Any new water loss that would occur during a repeat of the drought of record streamflow could reduce the system's safe yield. Requests are reviewed on a case-by-case basis to estimate the impact to safe yield and appropriate response. In some cases, the response may be to require the new diversion to contract with the impacted system for the amount of the safe yield reduction.

STREAM LOW FLOW MARGIN REGIONAL FOCUS AREAS

Appendix A- Stream Low Flow Margin (LFM) Method Results summarizes results for all of New Jersey's HUC11 drainage areas and are organized by Watershed Management Area (WMA). Each characterization includes a summary of the region's water sources as well as a description of categorical water usage during the peak water use year recorded between 2011 and 2020. The data and methodologies used in the development of these summaries are provided in Chapters 2 and 4 and referenced resources/documentation. Six principal water use categories may be represented within a WMA:

- Agriculture;
- Commerce/Industry/Mining;
- Domestic (individual, private wells);
- Non-agricultural Irrigation;
- Potable Supply; and
- Power Generation.

The New Jersey Water Tracking Model (NJWaTr, see Chapter 2) is used to identify water imports and exports. The LFM methodology (see Chapter 4) to quantify water availability, in combination with the NJWaTr results, is used to ensure the sustainability of surface and unconfined groundwater sources. It is important to emphasize that the quantification of net water availability provides a tool to help frame planning and regulatory decisions within HUC11s, but it cannot be used in place of site-specific assessments for individual water allocation permit decisions.

Results of the LFM analysis indicate two distinct regions of New Jersey where clusters of HUC11s share the same primary water use and have consumptive and depletive demands that exceed total water availability (limited HUC11s). These clusters cover large portions of a handful of WMAs and are focus areas for future DEP action. Specific areas of interest are outlined in the figures below. In the northeastern portion of New Jersey, a clear cluster of limited HUC11s can be observed in the Lower Raritan-Passaic region where the primary water use is potable. In the southwestern region of New Jersey, large portions of Cumberland and Salem counties are seen to have primary water use related to agriculture. Some of these areas, especially WMA 17 in Salem and Cumberland counties, were discussed above (e.g., WMA 06 Buried Valley Aquifer System, WMA 17 Maurice/Salem/Cohansey Watersheds). They are grouped here as having common issues at a larger regional level.

NORTHEASTERN REGION: LOWER RARITAN-PASSAIC

Issue Overview: This region includes all of WMA 09, most of WMA 07 and the southern (non-Highlands) portion of WMA 06. It includes some of the most complex of New Jersey's water supply infrastructure and surface water management capabilities. The region also serves many New Jersey residents. It is served by several water purveyors that operate large surface water systems located outside of the identified region that are interrelated both with respect to meeting the water demands of their customer base as well as passing flow requirements that are ecologically protective. However, this region also has concentrated areas of groundwater withdrawals in suburban areas that historically relied on groundwater prior to creation of the reservoir systems, or because the reservoirs primarily served more urban areas.

Level of Certainty: Potential Stress (LFM)

Level of Severity: Moderate to High, depending on the HUC11 assessed.

Completed Planning and Management Activities: As discussed previously, modeling for the Buried Valley Aquifer System of the Central Passaic River Basin in WMA06 (Hoffman, 1989) provided the basis for restrictions on new or increased water allocations from those aquifers. Other portions of the region have not been the focus of detailed aquifer analysis or modeling.

Ongoing Planning and Management Activities: This area is newly identified as a whole, and therefore there are no completed activities. Subregions have been previously identified and are covered in other sections of this chapter.

Potential Planning and Management Activities: To refine the analysis of water availability, it would be appropriate for further research in this region to incorporate more robust future predictions of streamflow regimes into existing hydraulic modeling of the region, based on the best available climate change science. Reanalysis at the HUC12 level should be considered. Preliminary research by DEP indicates that in some instances there may be increases in average and dry-period streamflow due to increasing precipitation, potentially associated with climate change. Updating water system modeling to include these potential flow regimes will enable DEP to better understand whether this region is likely to remain limited in its availability as noted by the LFM. Additionally, the discharge data from the NJPDES program for treatment plants operating in the region should be further verified to ensure that key discharges are being adequately reflected in the LFM calculations (i.e., as discharges either to freshwater or saline waters), leading to greater confidence in the modeled LFM results. Finally, a deeper examination of the region's resiliency can be assessed through examination of supply contracts between suppliers.

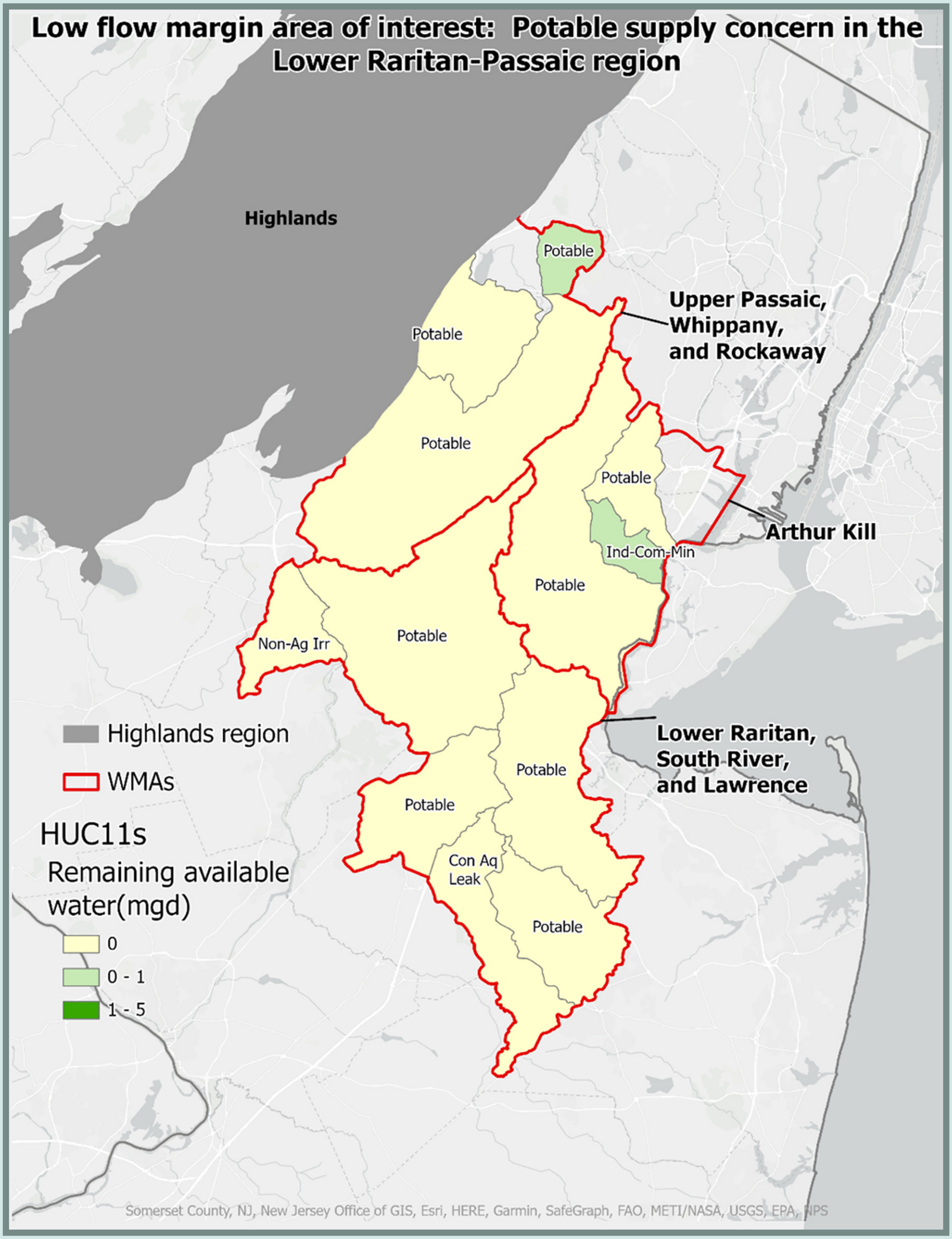


Figure 6.13 Shows limited HUC 11s (yellow) in the northeastern region of interest. HUC 11s are labeled with the use group that contributes most to depletive/consumptive loss.

SOUTHWESTERN REGION: WMA 17 - CUMBERLAND AND SALEM COUNTIES

Issue Overview: This region includes the bulk of WMA 17 which spans the counties of Cumberland and Salem, as discussed above. The predominant water use in the limited HUCs seen in this region is for agriculture. Specifically, regarding the agricultural demands, there has been uncertainty surrounding the data on agricultural withdrawals for some time in New Jersey, as noted in both the 1996 and 2017 Plans. Agricultural irrigation withdrawals are often estimated as opposed to being measured with totalizing flow meters, which are not required for agricultural withdrawals in New Jersey. Recent work has shown that when estimated, reported agricultural withdrawals often exceed that which was withdrawn, particularly by higher volume users. As agricultural consumptive water uses drive LFM results in this region, it is critical that improved withdrawal data be developed.

Figure 6.14 Shows limited HUC11s (yellow) in the southwestern region of interest. HUC11s are labeled with the use group that contributes most to depletive/consumptive loss.

Level of Certainty: Potential Stress (LFM)

Level of Severity: Moderate to High, depending on the HUC11 assessed.

Completed Planning and Management Activities: See WMA 17 section above.

Ongoing Planning and Management Activities: See WMA 17 section above.

Potential Planning and Management Activities: Greater work in data verification should be undertaken to improve confidence in the LFM results. This should include careful examination of all water uses in the region with a particular focus on improving confidence in the data related to agricultural water use. Agricultural certifications and registrations (permits) should be analyzed to better understand where totalizing flow meters are already being used so that DEP can focus on sub watersheds where the bulk of the water use reporting by agriculture relies on estimation. Reanalysis at the HUC12 level should be considered. Further QAQC can be performed on the data in this area and DEP should consider funding programs to place totalizing flow meters on withdrawals by larger volume agricultural users as a way of validating the LFM results and providing a more accurate accounting of agricultural water use in this region. As part of this process, the research could determine whether statistical relationships could be used to modify estimated withdrawals where metered data are not available.

ADDITIONAL HUC11S SHOWING A LFM DEFICIT

Issue Overview: In addition to the major regional areas outlined above, there are some HUC11s outside these regions where LFM results indicate potential limitations. These HUCs may or may not fall into areas where there are known water supply issues. In many cases they will be entirely their own case studies and potentially require different planning and management solutions. However, in general they will all require first data validation of the LFM results followed by model reanalysis.

Level of Certainty: Potential Stress

Level of Severity: Minor to moderate depending on local water use data.

Completed and Ongoing Planning and Management Activities: DEP should review each HUC on a case-by-case basis to determine next steps. The overall LFM methodology may need to be revised first prior to identification of specific management options.

Potential Planning and Management Activities: Data validation and then model reanalysis are required as first steps so that DEP can determine if these areas are truly in deficit. Once completed DEP can move on to more enhanced monitoring or planning and management responses where necessary.

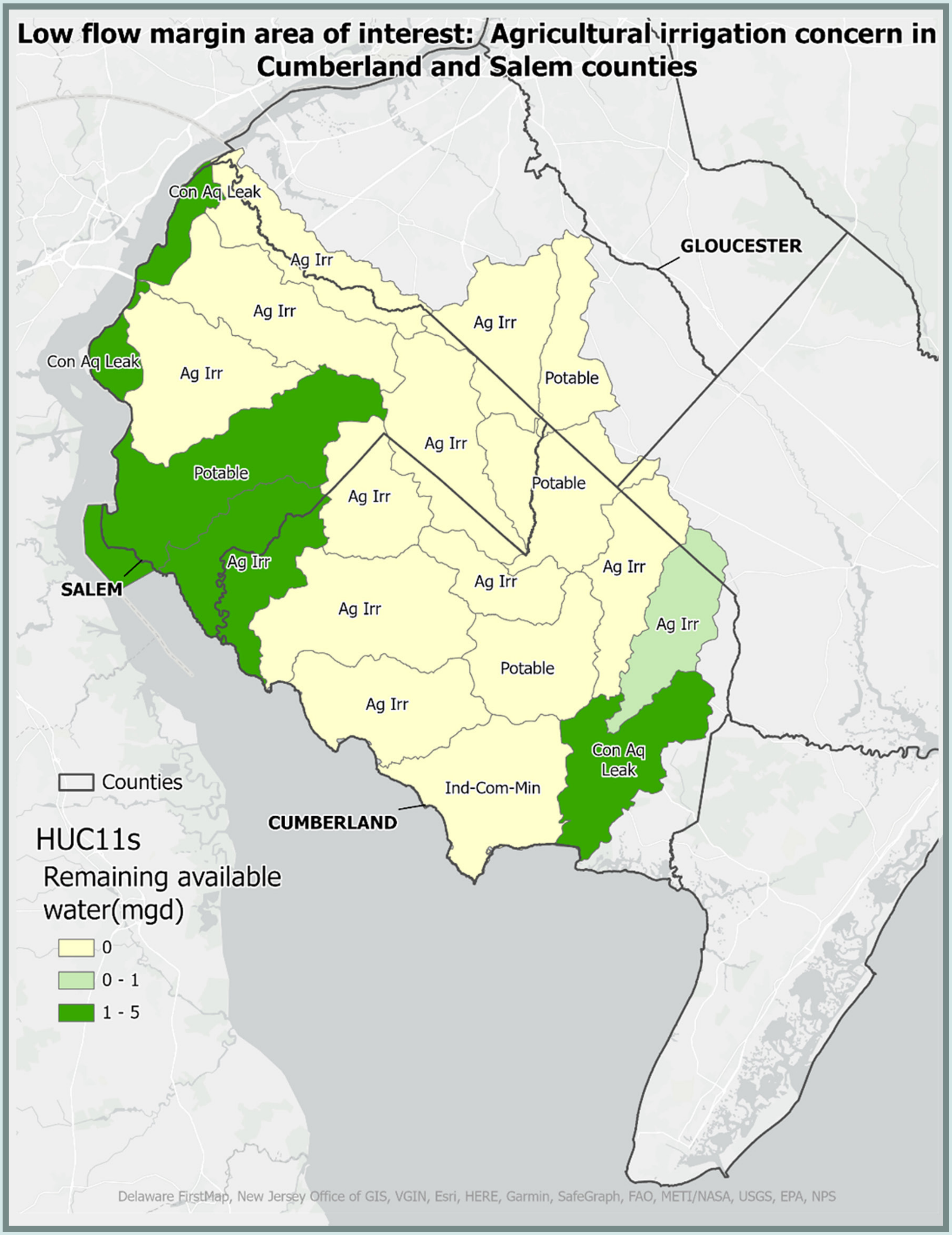


Figure 6.14 Shows limited HUC 11s (yellow) in the southwestern region of interest. HUC 11s are labeled with the use group that contributes most to depletive/consumptive loss.

OPTIONS FOR REGIONAL WATER DEFICIT MITIGATION

Once a water resource is confirmed as having deficits, defined as either current or realistically projected withdrawals that exceed available water, a variety of actions are available that can mitigate or eliminate deficits. The following options comprise a "toolkit" that may be useful in specific regions. It is not expected that all approaches will be relevant to all resources in deficit. Many of these approaches are drawn from the statewide approaches discussed in Appendix L, but in this case could be implemented more extensively within specific regions, focused on specific water resources.

- **Protection of Water Resources:** A major factor in mitigation of deficits is to ensure that the existing water resources are protected and maintained, so that loss of water availability does not exacerbate deficits caused by demands. One approach is to engage in more intensive efforts to protect water quality and quantity, and in some cases to improve recharge to groundwater through green stormwater infrastructure and aquifer recharge.

- **Water Loss Reduction:** Water losses from public community water systems represent a withdrawal from water resources that is not used for any purpose. In many cases, the leakage from the PCWS will not return to the source water. Therefore, where water losses are abnormally high in deficit areas, reduction of withdrawals can be achieved through reduction of real water losses. PCWS which fail to mitigate water losses as identified in their Water Loss Audit, would be subject to the remedial measures identified pursuant to the DEP's rule proposal codifying the WQAA. PCWS which lack capacity to address the water loss are recommended to solicit technical assistance from the DEP, or other technical assistance providers, or consider regionalization-style approaches to share resources with neighboring systems.

- **Demand Reduction:** Water uses that are inefficient represent an unnecessary demand against resources. Improvements in water use efficiency often represent a cost-effective method of reducing withdrawals. The greater the deficit, the higher the benefit of demand reductions. Demand reductions can come from both indoor and outdoor water uses and from all types of land uses. The priority water demand categories and land uses for attention will change from region to region, based on which uses are major factors in creating the confirmed deficits.

- **Alternative Water Supplies:** The provision of alternative water supplies may or may not be feasible in specific regions, but it should be considered where and to the extent reduction of water losses and demands will not be sufficient to eliminate water deficits. The alternatives should focus on using the lowest quality water acceptable for the intended use. Solutions could include the shifting of demands from high-quality potable water to untreated water for non-potable water needs, interconnections and bulk purchases of treated or raw water from neighboring systems, or beneficial reuse of treated wastewater (RWBR). Use of RWBR should only occur where it will not harm stream flows that support aquatic ecosystems and other water supplies. Other possibilities include stormwater capture and storage and aquifer recharge via treated captured/stored stormwater or treated wastewater, also known as Managed Aquifer Recovery (MAR), where applicable and where water quality remains appropriate.

- **New Water Supplies:** The option of developing a new water supply is the last major approach. In many parts of the state, the potential for new supplies will be limited by the same factors that resulted in the deficits, such as limited groundwater resources in a region that has no potential for surface water development. In other areas, surface water resources are fully developed as are the groundwater resources in the same area. However, there are some resources that could be developed after appropriate analysis.

SUMMARY

A critical goal of statewide water supply planning is to determine specific areas where existing or potential future withdrawals do or may exceed available natural and constructed water supplies, especially during dry periods. In this chapter, a water supply planning and management framework is provided to examine different regions with confirmed or potential water supply deficits. This six-stage framework ((1) Data Verification; (2) Model Reanalysis; (3) Regional Evaluation; (4) Enhance Monitoring, Modeling, and Analysis; (5) Planning, Management, and Regulatory Responses; and (6) Progress Evaluation) is designed to be used in conjunction with the provided matrix that classifies the risks associated with water availability issues by considering stress certainty and stress severity.

The six-stage framework provides several benefits for increasing understanding of the risk associated with regional water supply issues. First, it can provide the opportunity to classify and prioritize more serious water issues, such as those designated as low certainty, high severity, or high certainty, high severity. In addition, efforts already taken to address regional water supply issues can be tracked using the framework to determine if water supply deficits have been avoided, mitigated, or eliminated. Furthermore, this framework can be implemented in coordination with other special regional initiatives that are already in place, such as those in the Delaware River Basin and the Highlands Region, where intensive planning and management efforts occur regardless of the presence of water availability constraints.

This chapter also identifies several regional resources identified as having either a potential or validated water supply deficit. While some regional issues have already been addressed (Water Supply Critical Areas 1 and 2), some are being addressed in current studies (such as the regional evaluations conducted on WMA13's Barnegat Bay watersheds and WMA17's Maurice, Salem, and Cohansey watersheds – See Appendix I and J for more information). New areas of concern were also identified, such as the northeastern region's Lower Raritan – Passaic region, along with research needs to further evaluate several regional resources.

Belhaven Lake located in the New Jersey Pinelands.

Once it has been determined that a water resource has deficits, a "toolkit" of actions is available to mitigate or eliminate deficits. Policy development should be pursued and may include consideration of strategies that can reduce water demand and water loss, provide further water resource protection, and/or explore the use of alternative and new water supplies. Planning efforts should include early engagement with agencies, organizations, and representative individuals to ensure key interests understand the water supply issue(s) and can effectively assist in the development of response strategies.

Two specific areas DEP intends to target related to regional planning for deficit mitigation and avoidance include:

- further evaluation and assessment of potential and validated regions of water supply deficit concern (especially newly identified areas) through more localized study and analysis; and
- continued coordination and engagement within DEP and with regional initiatives, such as those in the Pinelands and Highlands, in the development of planning efforts and policy to address water supply deficit issues.

Chapter 7:

Managing Uncertainty: Drought, Resilience and Sustainability

TABLE OF CONTENTS

OVERVIEW

Precipitation varies across New Jersey -- from year to year, month to month, and even within a single rain event. On average, the State’s hilly northwestern region is wetter (roughly totaling up to 50 inches per year) than the coastal plain to the south and east (as low as 39 inches per year) (Figure 7.1). However, average annual precipitation masks wide variations in precipitation events that occur throughout a given year. This precipitation variability, coupled with concentrated population centers, can produce wide fluctuations in water availability and demands. Many of New Jersey’s reservoirs are relatively small and many users rely on unconfined aquifers, making them sensitive to annual or seasonal drought conditions, not just multi-year droughts. Over the past six decades, New Jersey has experienced several episodes of drought emergencies that resulted in water shortages of varying degrees, the most notable of which occurred in the mid-1960’s, the early-to-mid 1980’s, and again in 2001-02. Each drought emergency provided policy makers and water system operators lessons on how to better manage droughts or improve overall water supplies to increase overall water supply resilience. In some cases, drought emergencies paved the way for major legislation, as in the case of the Water Supply Management Act, and the construction of new reservoirs and pump stations, as was the case for the Wanaque South Project.

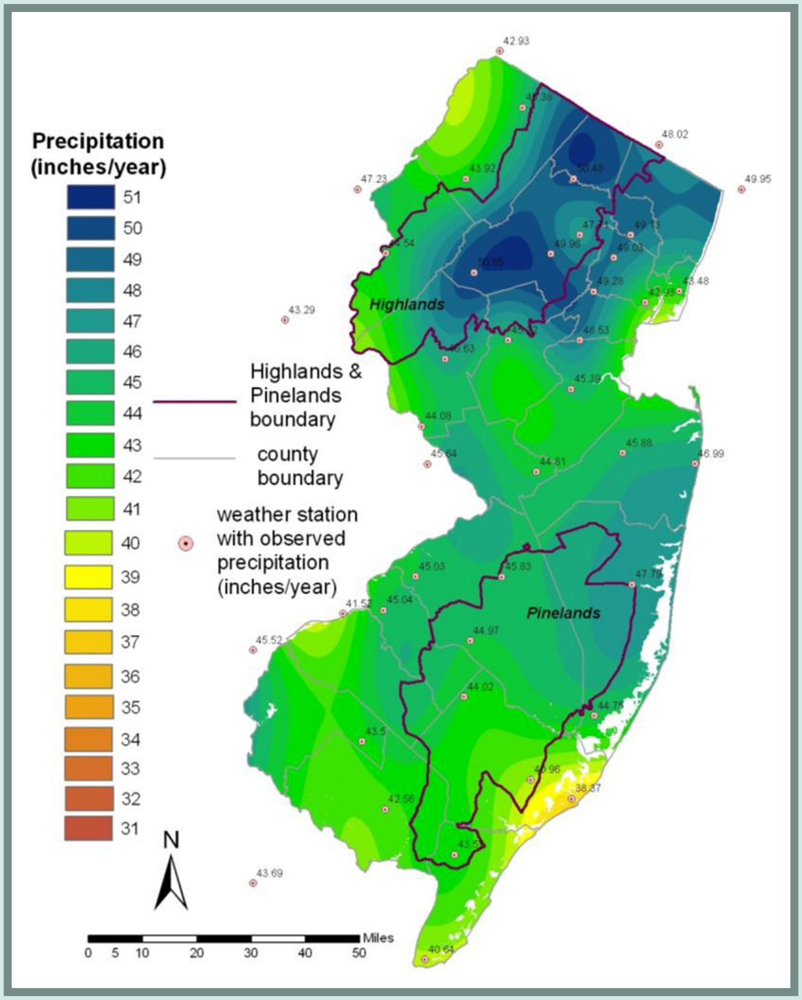


Figure 7.1 New Jersey annual average precipitation.

It is important to note that New Jersey also experiences potential water shortages during relatively short periods of dry weather that technically may not qualify as “official” water supply droughts according to state managers. Such periods, while exhibiting some of the characteristics of a drought in terms of the relative scarcity of rainfall and/or above-average temperatures, might best be characterized as demand-driven events marked by high temperatures, significantly increased water demands and rapidly depleted surface water and groundwater reserves. This is exacerbated when the high-demand season begins with system reservoir storage below peak capacity. These demand-driven events occurred in 1995, 2005, 2006, 2010, 2017 and 2022 necessitating enhanced scrutiny and action by the DEP to ensure adequate water supplies were maintained.

The recurrence of these episodes is even more notable since they occurred during New Jersey’s wettest period on record, based on annual precipitation.[1] In general, declines in total and per capita water use have been observed over the past two decades. However, steadily increasing water consumption for potable use, agricultural needs, and non-agricultural irrigation

[1] Since 1970, state-wide-average annual precipitation has increased about 3 inches. Average annual rainfall for the period 1895-1970 was 44.2. For the period 1971-2022 average precipitation is 47.5 (**Monthly Climate Tables, NJ State Climatologist**).

presents challenges to meeting essential water needs, especially in hot, dry summers. The developing statewide trend of more and more fresh water -- much of it highly treated drinking water-- being used to irrigate lawns and landscapes quickly strips water reserves during demand-driven water shortages. A shift in potable water demand was noted anecdotally during the COVID-19 summers of 2020 and 2021 when many residents invested in home landscaping and, where possible, worked from home, which resulted in many households using more water compared to the historical trends. Data from this time period is still being evaluated and while it does appear that some systems saw an increase in total demand, the results are mixed. This situation was further complicated by DEP's adoption of rules concerning per-and polyfluoroalkyl substances (PFAS) in June of 2020 which caused some purveyors to turn off or switch sources or purchase water from a larger neighboring utility with excess capacity due to detections of PFAS in certain water supplies.

As discussed in detail in Chapter 3, climate change impacts to water availability are a major concern, among other issues. At this time and based on the initial analyses conducted for this Plan, it appears that average groundwater availability has been increasing in many but not all areas, and projections indicate that in most future climate scenarios this trend will continue. The same is true for reservoir supplies. The forecasting of precipitation at time steps more granular than rough annual averages is not possible with current climate change models, but many researchers have suggested that variability between dry and wet periods may become more extreme. While droughts of short duration are expected to increase in frequency, the implications for drought management are not entirely clear. This has led to more frequent use of the term 'flash drought'. The National Oceanic and Atmospheric Administration (NOAA) defines flash drought as rapid onset or intensification of drought set in motion by lower-than-normal rates of precipitation, accompanied by abnormally high temperatures, winds, and radiation (NOAA, n.d.-b). While it is debatable as to whether New Jersey has experienced flash droughts in recent years, there has frequently been a juxtaposition between intense hot and dry periods that begin to concern water supply managers which are then punctuated by large precipitation events. Therefore, DEP is committed to ongoing research, model development, planning, monitoring, and event management to help better understand the likelihood of drought, both short-term, demand driven and multi-year, in the larger context of climate change. This will help the DEP identify approaches to preserve the water supply of the State and help ensure an adequate supply into the future.

Besides drought, other forms of uncertainty (bulleted below) also exist and must be addressed by DEP, water utilities and others. All these issues raise concerns, but also opportunities, with respect to environmental justice issues.

- The financial sustainability of water supply systems, as affected by the rising costs of energy, labor, materials, and capital projects contrast with declining per capita and total water sales.
- Resilience of water supply systems or the ability of each system to maintain operations and recover from external shocks such as weather events or cybersecurity failures.
- Redundance of water supply systems or the ability of each system to maintain operations and recover from internal shocks such as major infrastructure failures.
- The implications of sea level rise for the viability of water supply service areas in coastal locations.
- Potential changes in land use patterns which have the capacity to shift water supply needs in ways not easily forecast.

MANAGING WITHIN UNCERTAINTY

All water supply planning involves models, and all models are simplifications of reality. There can be no perfect knowledge of current and past conditions and there can be no perfect knowledge of the future. Therefore, uncertainty is inherent in water supply planning, and plans must acknowledge these uncertainties and develop ways of assessing future actions that incorporate uncertainty, usually through the use of scenarios that test a range of possible futures. It is important to note that uncertainty is fundamentally different from error. The term "margin of error" is misleading and should properly be seen as a "margin of uncertainty". Errors can be corrected, but uncertainty can only be mitigated or incorporated in planning and management.

The states of California, Florida, Georgia, Massachusetts, North Carolina, Texas, Virginia, and Washington are all large states with robust water planning programs. These states address uncertainty within their water supply plans in several ways. Many used modeling approaches that responded to uncertainties through the use of incremental modeling (e.g., demand planning for a horizon year that is routinely updated, projections in five-year increments), use of conservative assumptions (e.g., safe yield models based on severe precipitation shortages), use of regional models to augment statewide modeling, and incorporation of climate change sub-models. Several states used multiple projections based on differing model assumptions (e.g., varying population projections, drought versus average demands, future demand patterns by sector, and land development projection models).

States differed in their presentation of uncertainties within their statewide plans, ranging from limited statements to highly detailed appendices or modeling reports. Some noted the limitations of trend-based population projections and the potential effects of price elasticity. Several noted the complexity of water modeling, including water system interactions, land use change implications, data limitations, modeled versus observed flows, and the use of a margin of safety. The difficulty of downscaling global climate models for state and sub-state precipitation projections was a frequent issue; some employed multiple scenarios or simulations to overcome these limitations in the modeling approach.

The states responded to these uncertainties by incorporating various research agendas and long-term planning approaches. No state incorporated all these approaches, but these ideas were common across many states. Key approaches include:

- development of regional studies, enhanced monitoring, updated statistics and modeling approaches, and collaborative research to better understand specific issues so that statewide results are improved;
- research on the use of multiple metrics within modeling, such as incorporating both water availability and water quality concerns within the modeling process;
- incorporation of multiple approaches to climate change, such as the use of central tendency models plus observed conditions;
- peer review to ensure appropriate "state of practice" in the planning process;
- establishing priorities among policy options, such as focusing on obvious beneficial steps first, or the use of multiple distinct approaches; and
- adaptive planning, using routine updates to models and plans that result in improvements based on improved data, related models (e.g., climate change), and concepts.

New Jersey's statewide water supply planning process already includes many of these approaches, specifically the use of regional studies, adaptive and iterative planning, identification of implementation priorities, and peer review of technical studies. General review of the Plan is also accomplished through the Water Supply Advisory Council. DEP's recent work regarding climate change science and adaptation will provide a more robust basis for water supply planning in future iterations of this Plan, as will improved interaction between water supply and water quality models and planning.

REDUCING UNCERTAINTY

Managing water supplies and water utilities requires dealing with uncertainty that is inherent in any effort to anticipate the future. No approach is perfect, and no innovation is possible to achieve perfection or total certainty. The primary approach that the state's water managers can take to address this uncertainty is to continuously monitor, assess, reevaluate, and revise and update the Plan. In fact, the periodic update is identified in the 1982 Water Supply Management Act- N.J.S.A. 58:1A-1 et seq. Examples of updates include:

- When underlying data or projections are updated the corresponding water demand or availability model should also be updated. For example, the metropolitan planning organizations such as the North Jersey Transportation Planning Authority will be revising their population projections using the 2020 census values, which will change the 2050 PCWS Demands model (discussed in Chapter 4) and will result in a more robust range of future water demand estimates.
- Global Climate Models and specifically downscaling techniques will continue to improve, and these revised future climate forecasts can be incorporated into water availability models for streams, reservoirs, and groundwater in the state.

- Continued implementation of the Water Quality Accountability Act, especially regarding water loss reductions through infrastructure improvements, will obligate utilities to replace aging/failing distribution mains in alignment with the 150 year replacement cycle. This is anticipated to provide a reduction in water withdrawals needed to meet consumer demands.
- The DEP has and will continue to improve other regulatory, financial and planning regulations which will in turn enhance a water systems' resilience and redundancy. These improvements will need to be addressed via updated planning efforts.

The DEP remains committed to a robust, evidence-based approach to ensuring an adaptive and resilient water supply for the state. This will enable DEP to meet challenges stemming from uncertainty head on via sound planning followed by direct implementation of targeted actions.

WATER MANAGEMENT DURING DROUGHTS

DEP has developed a robust approach to managing water supplies and demands in response to drought conditions. This section discusses the types of droughts, how droughts are monitored, and the management system for addressing drought impacts. More information is available at the **New Jersey Drought Information** website.

TYPES OF DROUGHTS

According to the National Drought Mitigation Center, drought is a normal, temporary, and recurrent feature of climate, which occurs practically everywhere in the world. Drought can be described as a period of unusual or persistent dry weather of a duration and magnitude that results in a shortage of water and adversely affects some activity, group, or environmental sector. For more information see the **National Drought Mitigation Center**. Drought is based on an assessment of existing conditions compared to some long-term average. There are different types of drought and all can occur in the New Jersey including:

- A meteorological (precipitation) drought occurs when recorded rainfall/snowfall is significantly below normal for a protracted period.
- An agricultural drought occurs when the soil-moisture deficit hinders crop growth.
- A hydrological drought occurs when low water supply becomes evident in the water system such as low stream flows, lake levels or unconfined aquifer groundwater depths.
- An ecological/environmental drought occurs when an ecological community is harmed by a lack of water (e.g., low stream flows that reduce water quality and, in turn, stress fish and other aquatic organisms).
- A water-supply drought occurs when there is the potential for water demands to exceed available water supplies. This definition combines: (a) amount of water in storage; (b) anticipated water demands; (c) the severity of the precipitation deficit; and (d) specific water sources available to an affected area.

Drought evolves over time and while all types of droughts can impact New Jersey, this Plan concentrates on water-supply droughts, which are the type that the DEP regulates. See Figure 7.2 for infographic of drought types and their relative relationships.

DROUGHT MONITORING

Today, DEP regularly monitors various water supply conditions in six water supply regions, including regular communication with key water purveyors. The water supply conditions are monitored weekly, aiding the decision making of DEP and the Governor of New Jersey in declaring and changing drought status.

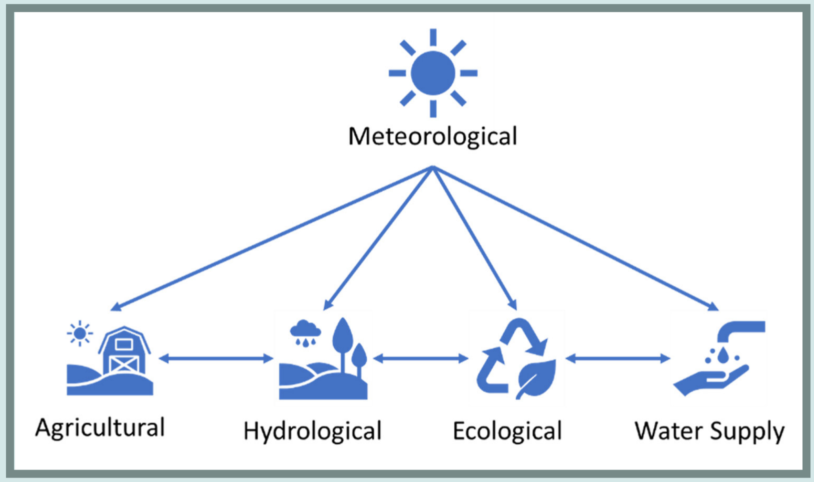


Figure 7.2 Drought type infographic.

New Jersey's drought monitoring program grew out of an analysis of historic water-supply data and the State's experience and response to drought events during the early 1980s, mid- and late-1990s. Prior to the year 2000 decisions about the severity of drought conditions were based largely on precipitation deficits and storage in drinking water reservoirs as well as a broad assessment of data related to stream flows and groundwater levels. The DEP's actions during this period were dictated by the drought requirements of the Water Supply Management Act (N.J.S.A. 58:1A-1 et seq.) and the Water Supply Management Act Rules (N.J.A.C. 7:19).

In the fall of 1998, DEP recognized a developing precipitation deficit that extended through January of 1999, a relatively wetter period through spring, and a return of drought conditions by summer 1999 (Hoffman and Domber, 2004). The post-drought analysis revealed that the entire period (summer 1998 through fall 1999) was an extended drought interspersed with a few relatively wetter months that temporarily alleviated conditions. In fact, following a continuation of severely dry conditions that culminated in the 2002 water emergency, some observers considered the event to have been a multi-year drought interrupted by torrential rains associated with Hurricane Floyd in August of 1999.

This post-drought evaluation also showed the need for a more consistent method of comparing precipitation, stream flow and groundwater levels to historical values. Additionally, the State's effectiveness to manage the situation had been compromised by the lack of a means to easily compare the severity of drought conditions in different parts of the State and then communicate this information to the public. As a result, in 2000, DEP revised its methods, as described below, for monitoring and objectively assessing water-supply conditions, and communicating with decision makers and the public.

DROUGHT MANAGEMENT REGIONS

DEP divides New Jersey into six drought regions: Central, Coastal North, Coastal South, Northeast, Northwest and Southwest (Figure 7.3). The regional approach recognizes that precipitation patterns, water-supply sources, water demands, and existing infrastructure often vary considerably across New Jersey. The approach also acknowledges the distinction between sources of water, such as ground and surface water, and, more specifically, differences between surface water withdrawn from reservoirs and rivers, and between confined and unconfined groundwater diversions.

For the purpose of administering and enforcing water use restrictions and other emergency orders when they become necessary, drought region borders align with municipal boundaries. This regional emphasis allows the State to tailor drought restrictions according to conditions within each designated region, thus avoiding the imposition of restrictions in areas with sufficient supply. Drought region boundaries may be modified as needed to increase their usefulness. Specific drought event declarations do not need to be based solely on the defined six drought regions if specific event conditions warrant a different area. Drought region municipalities can be found at: **DEP Municipality/Assigned Drought Region**.

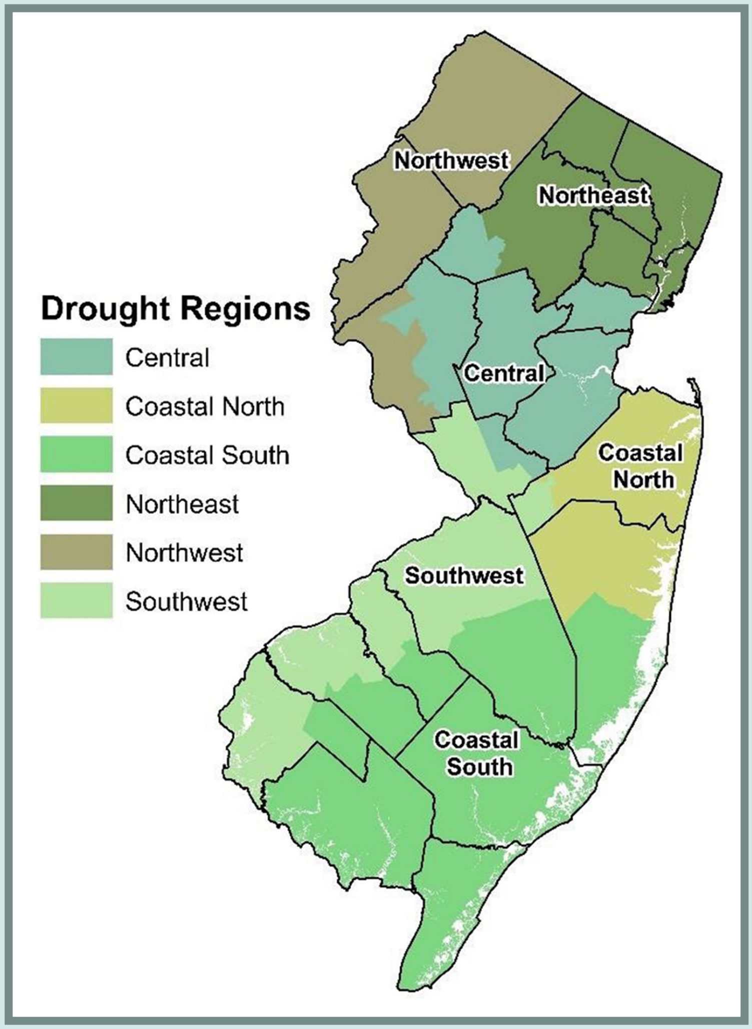


Figure 7.3 New Jersey Drought Regions.

DROUGHT INDICATORS

The tools DEP uses to assess waters supplies and monitor drought conditions have grown progressively more sophisticated in the last twenty years. Information about precipitation, stream flow, reservoir storage, and groundwater levels that are gathered from reference monitoring sites informs the State's drought indicators. The goal of each drought indicator is to summarize the status of a single factor affecting water supply in a given region. The indicators are designed to:

- integrate large amounts of available data about water-supply sources;
- be based on real-time data;
- be distributed quickly over the Internet; and
- relate accurate information about drinking water supplies to the public and decision makers.

The drought indicators do not automatically trigger a change in drought status; rather, DEP staff evaluates the indicators using best professional judgment, input from water suppliers, other drought-related resources, and other professionals in the formulation of an appropriate drought status (normal, watch, warning or emergency) for each region. The basis and background for the indicators and their application is summarized in New Jersey Geological and Water Survey (NJGS) Information Circular "New Jersey Water-Supply Drought Indicators", which is available at **New Jersey Drought Indicators**. The indicators themselves are updated weekly and they, and a wealth of other drought-related information, are available at **New Jersey Drought Information**.

ADMINISTRATIVE DROUGHT ACTIONS

When demand threatens to outstrip available water supplies, as with extended periods of below-average precipitation and/or above-average temperatures, DEP -- after evaluation of drought indicators in the State's six drought regions -- may designate a drought watch or drought warning condition to avert a more serious water shortage. New Jersey's governor may declare a state of water emergency when drought conditions persist (or in the event of a serious water system compromise or failure). Both DEP and a Governor's declarations are based on authorities within the Water Supply Management Act of 1981. In New Jersey, the relative status of water-supply conditions is classified as follows and shown in the infographic below:

- A normal condition indicates that an average or above-average amount of precipitation has fallen, or that the conditions relevant to water supply are not far enough below average to be of concern.
- A drought watch condition implies degraded, but not significantly compromised, water supply indicators. This status level was added to the indicators, though not formally adopted by rule, in 2000 following drought conditions experienced in 1998-1999. The purpose of the designation of a drought watch by DEP is to alert water-supply professionals to monitor the situation closely and prepare for the initial stages of drought response, as well as to boost awareness to the public so they are encouraged to conserve water. No regulatory restrictions are involved at this stage. Drought watches were declared for short periods of time in 2005, 2006, 2010, 2015 and most recently in 2022 with the declaration made in August 2022 and lifted in December 2022.
- A drought warning condition (**N.J.A.C. 7:19-13.1(d)**), designated by the DEP Commissioner, reflects a continued worsening of water supply conditions. Under a drought warning, water-supply professionals actively monitor conditions and implement appropriate requirements, in accordance with N.J.A.C. 7:19. The drought warning requirements consist primarily of supply-side management measures designed to forestall a significant water shortage and avert a water emergency. Continued voluntary water conservation by the public is urged, though not required, at this time as well as cooperation by affected water suppliers. DEP also may exercise its non-emergency powers to order: tests of water system interconnections, water transfers between water systems, reductions of permitted passing flows and reservoir releases conducted in coordination with pertinent programs to conserve water in reservoirs, and other measures to ensure an adequate water supply. The most recent drought warning was declared for 14 counties in October 2016 and lifted for all but two counties in April 2017. The drought warning was lifted in full in August 2017.

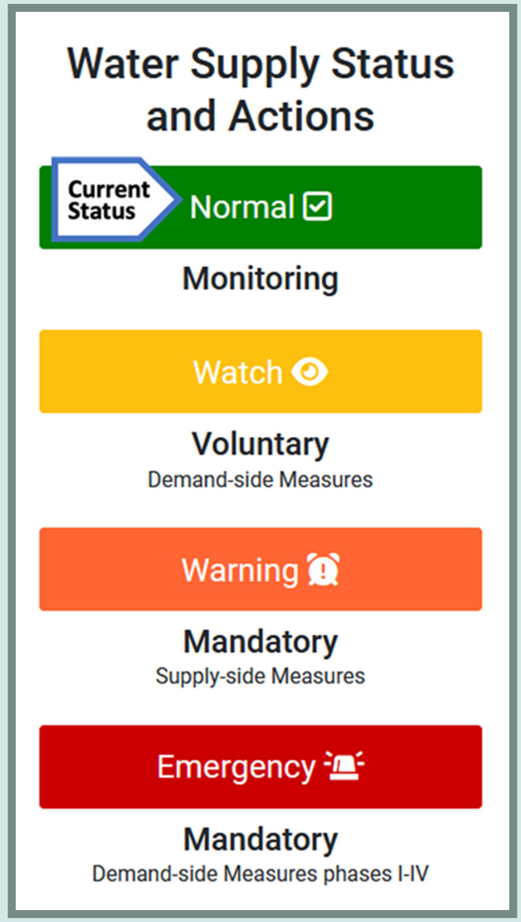


Figure 7.4 New Jersey water supply status and associated actions summarized.

- A state of water emergency (**N.J.A.C. 58:1A-4**) may be declared by the Governor when a potential or actual water shortage endangers the public health, safety and welfare. Under an emergency, DEP may impose mandatory water use restrictions by any party and may require specific actions to be taken by water suppliers. Such actions may include the interconnection of water systems; reduction, reapportionment or cessation of a particular supply; bans on adjustable water uses; and additional water transfers between affected water systems and/or drought regions. A water emergency provides for a priority-based, phased system of mandatory water restrictions, which seek to reduce water consumption and preserve available supplies, while causing as little disruption as possible to commercial activity and employment. The phases are:
  - **Phase I** limits water use for "non-essential" purposes (e.g., lawn/ landscape watering, non-commercial car and power washing, and swimming pool maintenance).
  - **Phase II** involves selective indoor water rationing when the severity of the water emergency poses a substantial threat to the public health and welfare.
  - **Phase III** requires further rationing to all sectors, including the selective curtailment of industrial water uses.
  - **Phase IV**, the disaster stage, is reserved for when public health and safety cannot be guaranteed, and water quality is of utmost concern; maintenance of health facilities is at emergency levels; and industrial use is further curtailed, and selective closures may become necessary.

Note that the DEP has the authority to designate one or more drought status(es) on any region within the state, not just for a drought region. This authority allows the DEP to tailor its actions only on the impacted area and to take the most effective steps to address the issues specific to each geographic area and drought event.

DROUGHT DECISION SUPPORT TOOLS

A 2005 Interconnection Study found that if water transfers had been initiated sooner during past droughts (i.e., prior to 2005), all but two of the past five water emergencies since the 1960s could have been avoided. Working cooperatively with water suppliers to balance water supplies between areas of surplus and deficit in order to avert or lessen the impact of an impending water emergency is a critical water supply management tool. Therefore, as part of the 2016 Drought Warning, water transfers were ordered between several systems in order to preserve storage for those systems at highest risk. As a result, an estimated 1.8 billion gallons of water was preserved in critical reservoirs as a result of water transfers ordered between 2016 and 2017. An additional 2.8 bg was preserved from reducing reservoir passing flows.

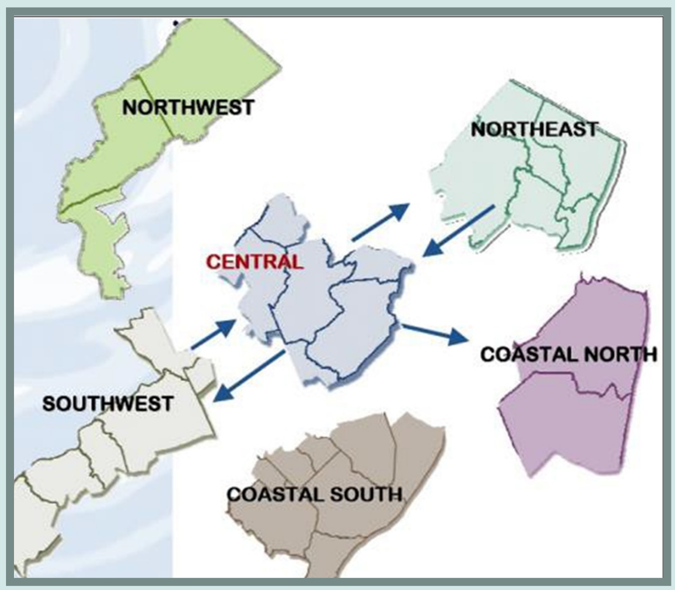


Figure 7.5 Water supply interconnections between drought regions.

The goals of the drought-related water transfers include:

- optimizing water diversions and transfers between systems to avert and mitigate drought-related water supply emergencies;
- identifying procedures to lessen the impacts on the State's water supply systems due to catastrophic losses; and
- recommending how to optimize existing system interconnections during "normal operations" and pre-drought to help increase overall water transmission efficiencies across the State.

However, one finding from the 2016-2017 drought was reluctance from many water suppliers to make the complete transfers as ordered due to concerns around water chemistry. Following the 2015 re-emphasis within DWSG on the implementation of the Lead and Copper Rule, many water suppliers became more aware of the potential for chemical interactions between different treated waters and how that could impact corrosion of lead in domestic plumbing or lead service lines. Since then, water suppliers, particularly in the Northeast region have improved their understanding of the chemical interactions of their waters. However, the concern of water quality impacts as a consequence of transferring water in ways beyond typical flows remains. Reversing flows at interconnections or distribution and transmission mains can disturb biofilms and mineral deposits within distribution infrastructure and can create poor water quality conditions for customers. While in acute emergency conditions transient water quality issues like this may be overlooked by some customers, it may still have overall damaging effects on public trust in the quality of their tap water. Regular maintenance and proactive efforts to enhance distribution water quality remain essential to minimize these disturbances when they do occur. Additional ongoing work by the DEP which is referenced in the Plan, also identifies the need to expand the existing interconnection network to ensure that drinking water remains available even during major emergencies.

After the 2005 study, DEP began development of a regional surface water supply reservoir system model using RiverWare software. The software was developed by the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado Boulder starting in 1986 and is funded primarily by the U.S. Bureau of Reclamation, the Tennessee Valley Authority, and the U.S. Army Corps of Engineers. It is utilized by numerous water utilities and management agencies across the county.

In New Jersey, the software has been used to create what is referred to as the New Jersey Model. This model simulates the major surface water supply systems in the Passaic, Hackensack, and Raritan River basins. It is used for both permit modification evaluations as well as to evaluate the effectiveness of drought or emergency response actions. The model can be used to optimize existing system interconnections during "normal operations" to help increase overall water transmission efficiencies and delay the onset of a drought declaration. The same model provides the ability to better manage water supplies during drought and water supply emergency periods, by testing different operational procedures. It was recently used to evaluate alternative operations for New Jersey Water Supply Authorities Raritan System during the Round Valley Project and to inform reservoir operations during the state's first ever significant Harmful Algal Bloom on a major river- the Millstone in the summer of 2022 during a period of low precipitation. Additional capacity can be built into the regional RiverWare model to investigate finished drinking water interconnections. The model is currently being expanded to include the major surface water reservoir supply systems in the Coastal North region (which is interconnected to the Raritan River basin) and could be used to evaluate the feasibility of forecast-based reservoir rule curves for drought management. Further research into modeling that can incorporate weather forecasting (e.g., National Weather Service 30-day projections) into drought management scenarios will also be useful. The model was also used to assess potential impacts of climate change on each system and its safe yield. The findings of this effort are discussed in Chapter 3.

While a few other reservoir simulation software programs exist, e.g., USACE HEC-ResSim, they are fundamentally different in their design and programming language and not interchangeable. The DEP has committed significant staff and financial resources to the RiverWare program over the last two decades and gained significant benefit from these efforts. Continued use of this modeling software is a key element to effectively manage the state's reservoir systems. Transition to one of the other software providers would likely require several years of startup efforts and significant cost, possibly putting these critical water supplies at risk.

PCWS SYSTEM RESILIENCE AND SUSTAINABILITY

The terms "resilience" and "sustainability" have many definitions and are sometimes conflated or confused for one another, but they address different aspects of system and societal management. Marchese et al. (2018) suggest that resilience addresses "the ability of a system to prepare for threats, absorb impacts, recover and adapt following persistent stress or a disruptive event." They suggest that sustainability is more of a long-term societal concept, involving continuing wellbeing as identified through social, environmental, and economic domains. Furthermore, New Jersey defines climate resilience specifically as "the ability of social and ecological systems to absorb and adapt to shocks and stresses resulting from a changing climate, while becoming better positioned to respond in the future" (NJDEP, 2021). Using these concepts, we can recognize that a system that is not resilient isn't sustainable, but a system that is resilient is not necessarily sustainable. In other words, the system may be able to respond effectively to disruptive events but not achieve long-term sustainability internally or in its interactions with society. This section addresses resilience and sustainability of public community water systems (PCWS) from several perspectives: long-term infrastructure degradation; sudden infrastructure failure; and disruption from hazardous conditions/extreme events and droughts. The first two categories are internal threats to service continuity, which are primarily under each system's control. The last category involves external threats that a system cannot control, but for which they can be prepared.

Guard Lock on Delaware and Raritan Canal in Bulls Island State Park near Stockton.

INFRASTRUCTURE INTEGRITY

Both nationally and in New Jersey, major issues have been identified regarding the integrity of drinking water infrastructure, including aging water distribution systems, components that have not been tested recently for functionality (e.g., valves, hydrants, interconnections), and treatment systems that may not be able to address new drinking water standards. In response, for more than 15 years, DEP has worked closely with the United States Environmental Protection Agency (USEPA), the New Jersey Clean Water Council and Water Supply Advisory Council (WSAC), the Jersey Water Works collaborative, the New Jersey Board of Public Utilities, the Department of Community Affairs and the Governor's office in multiple administrations and the Legislature to evaluate infrastructure needs and identify approaches to addressing these needs, including guidance, regulations and funding.

A major step forward occurred on July 21, 2017, when the 'Water Quality Accountability Act' (WQAA) became law in New Jersey and was subsequently amended November 8, 2021. This law, **N.J.S.A. 58:31**, sets standards for asset management, and other actions by certain water purveyors (i.e., PCWS with more than 500 service connections). Specifically, the WQAA requires:

- testing valves and fire hydrants to ensure proper function, including the ability to shut off sections of the system in the event of a major leak;
- development of cybersecurity programs to protect critical hardware/software used by PCWS to operate water systems, and manage customer billing information;
- mitigation plans for addressing notices of violation, including maximum contaminant level exceedances;
- annual notification of state authorities of compliance with all federal and state drinking water regulations; and
- development of an asset management plan consistent with best practice standards set by the American Water Works Association. This shall include dedicated funds to enable addressing the highest priority capital projects and annual progress reports that include the previous year's capital expenditures to address high priority projects and anticipated capital expenditures over the next 10 years.
    - o Asset management plans shall be designed to inspect, maintain, repair, and renew infrastructure and shall include analysis of the condition and estimated service lines of water mains as well as an appropriate replacement cycle.

The WQAA is a major advance in water system infrastructure management; it is a national trend-setting approach. DEP works with water supply purveyors to ensure they have proper financial and technical assistance in meeting the requirements of the WQAA (see **DEP-DWSG-WQAA**). Meeting these requirements will help ensure water system resilience and the water supply of New Jersey, while reducing life cycle costs for system operation, maintenance, rehabilitation and replacement. Each step will enhance system resilience, especially for the major components (e.g., large water mains, major valves, treatment systems) that, should they fail, would compromise services for large portions of a PCWS customer base. The reduction of life cycle costs will enhance sustainability of a PCWS, by reducing long-term pressures on customer rate schedules. Water audits, developed by the American Water Works Association (AWWA) are another tool that can greatly aid in the enhancement of water system resilience. Though not explicitly required by the WQAA, DEP intends to require the use of this methodology by all regulated under the WQAA.

It is recognized that meeting all requirements noted above will also increase short-term costs, with affordability implications for lower-income residential customers. For this reason, **New Jersey Water Bank**, a partnership between DEP and the New Jersey Infrastructure Bank, is continuing to issue low-interest loans for qualifying systems which include forgiveness of loan principal repayment. With this low-cost financing option, many more systems are able to undertake critical capital projects while maintaining affordability for their customers. With the advent of several federal programs to assist with infrastructure rebuilding, in response to the Covid-19 pandemic and national infrastructure needs, the Governor and Legislature have committed major funding to both the drinking water and wastewater infrastructure funding programs, to help reduce the customer costs of WQAA implementation and other mandates such as removal of lead service lines and compliance with new MCLs for PFAS compounds (PFOA, PFOS, and PFNA) and anticipated MCLs such as 1,4-dioxane.

To consolidate the numerous water infrastructure financing opportunities in recent years, DEP launched the **Water Infrastructure Investment Plan** (WIIP). This initiative is intended to highlight the low-cost financing that water systems, particularly those which are financially stressed, can leverage to minimize added costs of system modernization to meet evolving regulatory requirements. These costs would otherwise be borne in rates likely to negatively impact customers.

Both resilience and sustainability concepts are important in drinking water treatment. Resilience comes into play for systems that rely on water sources that could be contaminated by a major pollution incident that cannot be predicted, such as a chemical spill or HAB. River intakes and reservoirs with upstream developed areas are at risk; even if a system is fortunate for decades, a surprise event can force shutdown of the source, as has happened in other states. While wells are at lower risk of sudden contamination, PCWS that rely on wells can lose significant capacity if a major pollution problem is identified, as groundwater moves slowly and is far harder to clean up than a pollutant spill into surface water.

These regulatory and funding initiatives are in their early years at this time, but they will greatly accelerate water infrastructure rehabilitation and replacement in the 2020s. Preliminary findings from data submitted by water systems subject to the WQAA project approximately $12 billion in capital needs between 2023 and 2033. A report card summarizing the capital needs, and status of many water purveyors is available **here**.

DRINKING WATER SYSTEM STORAGE

Adequate finished water storage is key to a water system's resiliency. In addition to storage being a critical component in daily operations, it provides a backup source of supply should a water system experience an emergency such as loss of power, water main break, or well or treatment plant failure.

Water storage requirements for public community water supplies are specified under the Safe Drinking Water rules, N.J.A.C. 7:10-11 and the Water Supply Management Act Rules, N.J.A.C. 7:19-6. Per these regulations, the volume of storage required to be provided is based on factors such as whether a water system has multiple water supply sources/treatment facilities, auxiliary power, and interconnections with other public water systems in relation to the water system's average daily demand.

The regulations do allow some flexibility for a water system to meet these requirements. In cases where an approval has been granted to modify a water system's storage requirements, DEP has historically issued a Storage Waiver. These Waivers have been issued under a variety of circumstances including to very small water systems whereby regulatory storage requirements may impose an unnecessary hardship, to large water systems that are relying on another water system to provide its storage.

However, considering events that have occurred where resilience has been compromised, DEP will be re-evaluating the approval criteria that has been used in past issuance of Storage Waivers. It is anticipated that in order to help ensure water systems have adequate storage capacity to provide service during a water supply emergency, some Storage Waivers may be rescinded. In some cases, additional storage and/or alternate interconnections with other systems may need to be constructed or undertaken. Project costs could be economically significant for some water systems. DEP will be moving forward with a stakeholder initiative to solicit input on this proposal.

In addition, DEP is advancing a rule proposal to change some of the existing storage requirements. One of the proposed amendments will modify the term used for the basis of storage from "total storage" to "finished water storage capacity". As not all stored water can be utilized based on hydraulic constraints, "finished water storage capacity" will relate to that supply available for system delivery while maintaining required minimum system pressure. This change to the regulatory definition will be a benefit to public health and safety.

Another regulatory change contained within the rule proposal relates to water systems that are reliant on interconnections with other water systems to provide some or all of their storage. The proposed rule would require these systems to have a written agreement detailing the terms of their storage. Many water systems in the state have "handshake agreements" or other informal agreements where one system will provide sufficient storage for one or many systems which are interconnected. This practice results in several challenges, particularly with cost-sharing and liability around those storage facilities wherein resilience for each system may be lost if that storage is not properly maintained.

SEVERE WEATHER EVENTS

Water systems need to be able to prepare for, respond to, and recover from hazards and extreme weather events that threaten their operations. Coastal damages from Superstorm Sandy (2012) and river flooding from Hurricane Ida (2021) are good examples. The storm surge from Sandy damaged critical water supply infrastructure along the coast, and high winds compromised electrical and other energy distribution across much of the State, which in turn harmed the ability to supply water. The DEP instituted emergency response plans developed in accordance with **N.J.A.C. 7:19-11.2**. The impacts of and experiences associated with Sandy and reinforced by Ida and other storms resulted in lessons learned and informed the steps taken since then to recover and become more resilient to future hazards, which include the need:

- for sufficient fuel to supply auxiliary power equipment during a multi-day interruption in power;
- to protect and/or harden all infrastructure within flood hazard areas (e.g., moving, elevating, or flood-proofing key infrastructure assets (such as with seals or membranes or within floodwalls) in ways that account for current and future climate change exacerbated flood and storm events);
- to update delineated flood hazard areas using the best available information and accounting for future increased precipitation events and sea-level rise;
- for secure communication among decision makers to quickly share critical information; and
- to proactively plan appropriate response measures and responsibilities prior to an event or hazard.

Many of these items have been instituted via Emergency Response Plans but additional revisions are likely needed and some may require regulatory updates.

In the wake of recent adverse weather events, DEP developed new guidance aimed at ensuring that repairs, reconstruction, new facilities, and operation/maintenance were focused on enhancing the resilience of our critical infrastructure. The guidance documents address Auxiliary Power, Flood Protection, Emergency Response/Planning, and Asset Management, available at **DEP Water Supply** and **Asset Management**. These documents present relevant material to address some of the core capabilities applicable to water systems regarding all hazards. These capabilities include establishing goals, threat assessment, response and resiliency planning, prevention, detection, investigation, and response and recovery protocols. In general, the guidance is applicable to both drinking water and wastewater systems. The long-term viability and effective operation of water systems can also be improved through asset management, as discussed in the previous section.

DROUGHT HAZARDS

Droughts generally do not harm the physical infrastructure of a water system, though they can render water sources unusable if water levels drop too much (e.g., a well that runs dry) or if the low flows create an adverse water quality event (such as the summer 2022 Millstone HAB event or the 2017-2018 elevated nitrate levels in the lower Passaic River). The primary concern is the ability to provide water which meets drinking water standards and simultaneously meets customer demands. Preparation for droughts can also require expenditures by the PCWS, such as enhanced interconnections, improved storage of raw or treated drinking water, or development of new wells to enhance firm capacity. Drought preparedness therefore imposes a financial cost on PCWS that will be passed on to customers through the rate schedules.

ENERGY PROVISIONS AND COSTS

Drinking water treatment can require significant amounts of energy. Nationally, USEPA estimates that drinking water and wastewater treatment account for 2 percent of national energy consumption, and that energy costs are often 25 to 30 percent of all drinking water operating costs and can be as much as 40 percent. However, energy demands vary considerably based on the nature of the water supply (reservoirs, river intakes, shallow wells, deep wells), treatment needs due to source water contaminants, and topography of the service area (e.g., hills that require more energy to pump water to customers). Drinking water treatment costs are heavily influenced by raw water quality, and for similar raw water quality, smaller treatment plants have higher costs per volume (Grzegorzek et al., 2023).

Resilience is also an issue regarding potential energy disruptions, as seen with Superstorm Sandy. When electricity is suddenly unavailable from the energy utilities, a water system must continue operations by self-supplying energy. Water systems are thus faced with the requirement to build, service and provide fuel for generators that are only periodically needed, increasing both capital and operating costs. Some utilities are moving toward routine energy generation with renewable energy sources, such as solar and wind, but these sources have intermittency issues that must be addressed, such as with batteries, that will raise costs.

Delaware River looking downstream from the Calhoun Street Bridge in Trenton. This historic bridge crosses the Delaware River, connecting Trenton, New Jersey with Morrisville, Pennsylvania.

Sustainability issues arise where long-term energy costs substantially increase operating costs and therefore increase fiscal stress for the PCWS and for its customers. Energy costs could rise due to market conditions, PCWS decision making regarding which source waters to use (e.g., desalination of brackish water or saltwater), or drinking water quality requirements that force selection of energy-intensive advanced treatments.

UNCERTAINTY IN DEVELOPMENT TRENDS

In New Jersey, the potable water sector comprises over half of all water use and this pattern is likely to remain the same. Population forecasts are a fundamental component of water demand projections. These population forecasts come from the three metropolitan planning organizations (MPOs) that are responsible for transportation and other planning efforts in New Jersey: North Jersey Transportation Planning Authority, South Jersey Transportation Planning Organization and Delaware Valley Regional Planning Commission. Each MPO has its own methodology for population forecasting, but all include an assessment of likely births and deaths (age-cohort survival) and the movement of people to and from municipalities (migration), including development expectations that would facilitate population growth. These forecasts through 2050 are discussed in Chapter 4.

Forecasts are not predictions. Rather, they are statements of possible futures based on trends and assumptions. Some of the trends, such as birth and death rates, are fairly stable through years of time, though the Covid-19 pandemic and deaths from opioids and fentanyl have shifted the death rate (annual drug-related deaths have roughly tripled in the last ten years). Migration between municipalities and states is not as stable, nor are development patterns. Prior to the Great Recession of 2007-2008, most housing starts were in suburban and exurban areas, while housing starts immediately after that period were heavily oriented to municipalities with greater than 90 percent developed lands (Evans, 2010). Housing affordability for prospective new homeowners and renters is a major factor in location preference, including whether people even stay in New Jersey. Evans (2017) noted that: “Millennials’ desire for more modestly sized housing options in walkable neighborhoods is not likely to disappear completely, even as they grow older and begin to raise families. Meanwhile, New Jersey is endowed with an over-supply of single-family homes on large lots, particularly in places that are dependent on driving." The question is whether there will be a sufficient supply of housing to meet new expectations, such as walkable communities, or whether housing costs increase to the point where buyers move to other states.

Affordable housing projects (including "builders remedy" projects that include affordable units within otherwise market-rate developments) will increase opportunities for moderate income households in some areas. The creation of this housing is the direct result of the Mount Laurel decisions, several New Jersey Supreme Court rulings that have defined the responsibility municipalities have in providing a certain amount of affordable housing to people with low or moderate incomes. The location of these developments will be a result of the evolving market for new housing, proactive planning and zoning by municipalities, and in some cases court settlements. The Covid-19 pandemic also has affected locational preferences, at least temporarily, through acceleration of trends toward working at home (at least part time) or establishing sole-proprietor businesses that do not require offices. The possibility of major shifts to working at home raise questions about both residential and commercial office water demands, with the possibility of a significant shift from office use to residential use.

Finally, federal immigration policies have a major impact on New Jersey's population, given that our state is nearly one-fourth foreign-born, much higher than the national average of 13.6 percent as of 2021 (**Statista**). New Jersey's population grew by 5.7 percent from 2010 to 2020 (Census Bureau), but continued growth is not assured.

All of these factors result in significant uncertainty regarding population growth in New Jersey, generally, and for each of its municipalities and thus water demand. There is no method to create certainty out of this uncertainty. However, the uncertainty can be bounded through the use of scenarios that create higher and lower population projections for each set of assumptions regarding ongoing or changing trends. Van Abs et al. (2018) assessed the potential effects of changing demographic trends on county populations to the year 2040; foreign immigration and net domestic migration are both major factors. No municipal-level population forecast scenarios have been developed for alternative conditions. Therefore, the approach used in this Plan is to periodically reassess population forecasts as they are generated by MPOs, while acknowledging that the planning horizon forecast (2050 for this Plan) has the greatest uncertainty.

SUMMARY

As previously mentioned, uncertainty is inherent in water supply planning, and plans must develop ways of assessing future actions that incorporate uncertainty. This chapter has noted numerous areas that DEP has and will continue to target in its efforts to reduce uncertainty and plan for adequate future water supply. Key areas include but are not limited to drought management, aiding in the efficient operation of New Jersey's reservoir systems and the transfer of raw and finished water between systems, and improving PCWS resilience and sustainability through administration of the WQAA. Currently New Jersey faces great challenges as the unknowns associated with climate change loom before us. Therefore, DEP is committed to ongoing research, model development, planning, monitoring, and event management that will make use of best available datasets related to water supply. This work will be the foundation that enables DEP to continuously work to reduce uncertainty around the core issues of climate change, drought, and water system resilience and sustainability.

Three specific items DEP intends to target as a result of this Plan include the following:

- ongoing research to inform a better understanding of drought (short-term, demand driven and multi-year) in the larger context of climate change and identification of approaches to preserve the water supply of the State and help ensure an adequate supply into the future;
- stakeholder initiative to solicit input on re-evaluation of the approval criteria that has been used for the issuance of Storage Waivers in the past; and
- sustained efforts to minimize issues associated with the mixing of treated water via interconnections between water systems in order to maximize resilience of regional water supplies, and to ensure that critical infrastructure is properly maintained and functioning.
    - o During water supply emergencies it is vital that capability exists to move water quickly to regions in need.

Crowley's Landing on the Mullica River near Egg Harbor City.

Chapter 8:
Recommendations and Action Items

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OVERVIEW

In recent years, New Jersey has repeatedly faced a confluence of water resource challenges that have tested our infrastructure, as well as the responsive capacity of our institutions. In the summer of 2022 extremely low precipitation and streamflow led DEP to declare a Drought Watch- the first in over six years. During the same period, aging infrastructure failed resulting in massive water main breaks, water systems were required to address sources contaminated with per- and polyfluoroalkyl substances (PFAS), and rampant harmful algal blooms worsened by the extreme temperatures occurred. Individually these events would have been challenging, but combined, they severely tested the resilience of New Jersey's management of water resources. Such conditions are expected to persist or worsen in the years ahead, requiring DEP and its partner institutions to delicately balance the management of our water resources by carefully administering their planning, regulatory, investment, and incident response initiatives.

While 2023 proved to be a wetter year, it was also the third warmest on record. The spring season started out extremely dry and warm which resulted in numerous forest fires, agricultural stresses, and earlier than normal peak water demands. Fortunately, precipitation returned to more normal ranges over the summer and fall and supplies remained adequate. While the state avoided any formal drought action, sources continued to be challenged by new and emerging contaminants, repeated emergence of harmful algal blooms on water supplies, and water infrastructure emergencies.

A car submerged from flood waters due to a water main break that occurred in Belleville in August 2022.

Through multiple legislative enactments, DEP is obligated and empowered to improve and protect water resources and water system infrastructure to ensure safe drinking water and system sustainability. The Water Supply Management Act (N.J.S.A. 58:1A-13) requires DEP to prepare a Statewide Water Supply Plan that assesses the state of our water supplies and identifies the policies necessary to ensure that the State and its water providers are adequately prepared for current and future water supply challenges. As discussed throughout this report, these challenges have been exacerbated by anthropogenic climate change that will present as a progressive risk multiplier in the years ahead and which must be more fully considered in the development and implementation of water supply policy. In this Plan, DEP has identified the following actions and recommendations, which are interrelated and therefore also discussed in other chapters and appendices. The interrelationship of these actions and recommendations reflects the nature of the continuum of holistic water supply management.

As issues evolve and more information becomes available, the focus of Department action will change. Future Plan updates will address those changes if and when they occur.

HYDROLOGIC DATA, MONITORING, MODELS, AND ASSESSMENTS

The availability of long-term and real-time hydrologic datasets are critical pieces of information that DEP uses to quantify trends, characterize current conditions, build and calibrate models, and ultimately utilize to make focused and informed decisions and to update future water supply plans. The following items require continued, and in some cases expanded, financial, administrative, and technical support. To accomplish this, DEP will:

- Maintain, and expand where necessary, New Jersey's surface water, ground water and drought monitoring networks and assessment tools, both for water quantity and quality. Monitoring network data is used by multiple programs in DEP who contribute to their annual funding. The networks include:
    - Streamgaging Network including water quality monitoring;
    - Groundwater Network including ambient water quality monitoring;
    - Coastal Plain Synoptic Network; and
    - Drought Monitoring Network (for more information, see Chapter 5: Monitoring and Assessment of Water Resources section).
- Maintain, and expand where necessary, New Jersey's Ambient Groundwater Quality Monitoring Network (AGWQMN) and the associated data analyses. As feasible, emerging contaminants (EC) will continue to be added to the network's parameter list utilizing EPA's Contaminant Candidate List, and Unregulated Contaminated Monitoring Rule promulgated lists as guidance or if an EC has been identified by the DEP as a priority. DEP will consider expanding the network to provide more complete and dense state-wide spatial coverage, target specific aquifers or watersheds, target deeper aquifers (typically associated with potable water diversions), and address changing land use types. This decision-making process for the AGWQMN would also be applied to the expansion of the salt-water intrusion monitoring network. If expanding the network will not address a specific groundwater quality need, DEP will consider designing and implementing new groundwater quality monitoring networks. DEP will periodically review hydrologic datasets to identify and assess trends and revise the monitoring network, summary metrics and indictors as needed (for more information, see Chapter 5: Monitoring and Assessment of Water Resources section and Chapter 2: Potential Water Losses to Contamination section).
- Continue and expand cooperative modeling, monitoring and data sharing between purveyors, dischargers, other pertinent agencies or groups and DEP to advance sound water supply management, particularly during instances of water quality track down and emergency events.
- Maintain, expand, and enhance the surface water supply reservoir system models to ensure that water availability/safe yield is accurately quantified. This process may include the development of forecasting and drought management tools used to improve reliability and accuracy of forecasts. Models may be expanded, or new models developed to assess finished water distribution storage, infrastructure, and pipe hydraulics (for more information, see Chapter 5: DEP Water System Resilience Actions section).
- Maintain, expand, and enhance groundwater models for both the unconfined and confined aquifers of New Jersey (for more information, see Chapter 2: Natural Water Resource Availability section and Chapter 3: Climate Change Initiatives for Water Supply section).
- Maintain, expand, and enhance the New Jersey Water Tracking Database so that accurate and comprehensive data sets can be used in Department models. It will also continue to update water demand forecasts for all sectors (for more information, see Chapter 5: Monitoring and Assessment of Water Resources section and Chapter 4: Estimating Future Water Needs section).

- Update and refine the stream low flow margin water availability assessments by:
    - o updating the methodology to utilize HUC12 basins;
    - o incorporating current and projected climate change water availability impacts; and
    - o assessing two regional areas identified as potentially limited.
        - Northeastern Region: Lower Raritan-Passaic
        - Southwestern Region: WMA 17 – Cumberland and Salem Counties (for more information, see Chapter 2: Surface-Water and Unconfined Aquifers section and Chapter 6: Stream Low Flow Margin Regional Focus Areas section)
- Build upon its analysis of the agricultural water-use metering pilot study results. While this study was limited, it indicated the potential for larger errors with estimated volumes (especially with estimated diversions greater than 2 million gallons per month). DEP will assess alternative approaches to improve agricultural water use data reported to DEP. Initial actions can be coordinated with the WMA17 LFM reassessment (for more information, see Chapter 4: Data Uncertainties section). These actions should continue through coordination between DEP, the NJ Department of Agriculture, Rutgers Cooperative Extension, National Resource Conservation Services, and the agricultural community.
- Work cooperatively with the Drinking Water Quality Institute and others to develop a comprehensive HAB water supply strategy and management plan, to complete a cyanotoxin rulemaking, and identify additional funding specific to HAB management for drinking water systems. In addition, the Division of Water Monitoring, Standards, and Pesticide Control will update the Integrated Water Quality Assessment Report (IR) Methods Document to identify methodology to assess new HABs narrative nutrient criteria interpretation. The IR assesses current water quality conditions, causes, and sources of water quality impairment needed to inform and guide water quality monitoring, restoration and protection efforts at drinking water sources affected by HABs (for more information, see Chapter 5: DEP Water System Resilience Actions section and Protecting New Jersey's Water Resources section).

CLIMATE CHANGE - WATER AVAILABILITY RESEARCH AND MODELING

This Plan and its recommendations benefit from the availability of sound and reliable climate change science. This science continues to evolve and DEP will remain committed to monitoring new developments, with a particularized focus on the regional and local impacts of climate change upon New Jersey and its natural resources. As new and additional climate change data becomes available, it will be utilized to improve DEP water supply models and monitoring methods to mitigate and manage climate change impacts to water resources more effectively. As such, DEP will:

- Support state and federal actions to expand and share climate science developments, including the projected impacts of climate change upon New Jersey's water resources; i.e. precipitation projections, temperature and sea-level rise for short, medium and long-term forecast periods and emission scenarios (for more information, see Chapter 3: Overview of Climate Science section).

Paterson Great Falls National Historic Park in Paterson, New Jersey.

- Advance the spatial and temporal granularity of climate change water supply models. The assessments conducted as part of this Plan generally focused on annual changes over time and were conducted at larger watershed or statewide scales. Properly developed and calibrated models with decreased temporal and spatial scales can improve estimates of risk and identify specific alternatives or actions to mitigate those risks (for more information, see Chapter 3: Climate Change Impacts Relevant to New Jersey Water Supply section).
- Improve estimates of short-term changes in temperature and precipitation due to climate variability, which can lead to changes in drought severity and frequency, and develop monitoring approaches and management strategies to reduce risk (for more information, see Chapter 3: Temperature and Precipitation Nexus section and Chapter 7: Water Management During Droughts section).
- Continue quantifying risks to freshwater aquifers and recharge areas at risk from saltwater intrusion as a result of rising sea-levels and/or groundwater diversions and develop action plans to mitigate risks and maintain available supplies (for more information, see Chapter 3: Sea-Level Rise and Resulting Impacts section).
- Continue developing and refining DEP's Land Phase Model to improve estimates of and climate change induced impacts to groundwater recharge. DEP will also expand the model to estimate changes to evapotranspiration, runoff, baseflow and total streamflow resulting from climate changes to temperature and precipitation on both annual and shorter-term periods (for more information, see Chapter 3: Impacts to Unconfined Aquifer Recharge section).
- Periodically evaluate trends in hydrologic datasets to quantify impacts from climate change and utilize the results to adjust and improve monitoring networks, indicators, and models. Typical evaluation periods will be coordinated with Plan updates (e.g. once every five years), unless more frequent actions are appropriate (e.g. every one to two years for water use trends) (for more information, see Chapter 3: Climate Change Impacts Relevant to New Jersey Water Supply section).
- Incorporate climate change findings into surface water supply reservoir system models to better identify how 'normal' operations or existing infrastructure may need to be modified/expanded/relocated/hardened to mitigate and reduce risk and increase system and regional resilience (for more information, see Chapter 3: Potential Impacts to Surface Water Reservoir System Safe Yields section).
- Advance research to better quantify how climate change will impact water demands, (e.g. longer growing seasons resulting from warmer temperatures) and incorporate findings into water supply models and plans. This would include potable, power generation, and agricultural and other non-potable irrigation uses (for more information, see Chapter 3: Overview of Climate Science section).
- Support research that informs climate change driven impacts to water quality that can impact water availability, e.g., harmful algal bloom frequency and occurrence and resulting drinking water treatment or raw water flow management requirements (for more information, see Chapter 3: Water Quality Impacts section). This research will include continuing model development to forecast storm events and potential impacts to water system operation and communities served.

CLIMATE CHANGE - INFRASTRUCTURE RESILIENCE RECOMMENDATIONS

DEP will develop recommendations and establish criteria to improve the resilience of water infrastructure and mitigate the adverse impacts of climate change upon the State's water supply, including through actions to:

- Reform relevant DEP policies, protocols or regulations pertaining to water infrastructure assessments and modifications, including, but not limited to:
  - ensuring owners of community supply wells located within a climate adjusted flood elevation (CAFE) area modify well construction and associated infrastructure to prevent the flow of saltwater into the well or to allow saltwater to flow outside the well casing into potable aquifer(s);
  - ensuring owners of surface water intakes, dams, and/or reservoirs within the CAFE area develop a sea-level rise-water availability vulnerability assessment and develop an action plan to mitigate the risk(s) identified;
  - ensuring owners of critical water supply assets (pipelines, pump stations, power sources, etc.) at elevations within the CAFE area develop a sea-level rise-water availability vulnerability assessment and develop an action plan to mitigate the risk(s) identified;
  - aligning risk assessments and mitigation plans identified in this Plan with the 2021 New Jersey Climate Change Resilience Strategy (or current DEP guidance documents);
  - ensuring regulated entities submit GPS location information for major infrastructure such as but not limited to treatment plants, pump stations, storage tanks, and large interconnections and valves consistent with DEP GIS standards; and
  - ensuring applicable water purveyors consider climate change impacts when developing/revising their asset management plans (for more information, see Chapter 3: Sea Level Rise and Resulting Impacts section).
- Update and revise applicable water related regulations and statutes to continue to address the emerging issues resulting from climate change and develop climate resilient water supplies (for more information, see Chapter 3: Summary section).
- Implement the New Jersey Water Bank's "**Building Water Infrastructure Resilience**," guidance that requires applicants for State Revolving Fund financing to evaluate the potential effects of climate change such as sea level rise, storm surges, and changes in precipitation patterns and intensity during the planning and design of water infrastructure projects and to incorporate appropriate resilience measures into project designs. This resilience guidance will be updated as needed to remain consistent with water-related regulations and statutes (for more information, see Chapter 5: Adequate Asset Management section).

REGIONAL AND STATEWIDE WATER SUPPLY PLANNING AND PROTECTION

Water supply planning is a critical element to ensure that the state continues to have adequate supplies of acceptable quality to meet all its current and future needs and to balance human uses with ecological needs. As discussed in this NJSWSP, regional and statewide planning is adaptive and evolves as new information becomes available or issues emerge. As such, DEP will:

- Support the ongoing development and update of robust water supply plans (for more information, see Chapter 1).
- Further refine its overburdened community water supply analysis, which could include detailed regional/community assessments, and identify additional opportunities to incorporate Environmental Justice Rules into water supply and drinking water permitting actions. DEP will consider working with state, county, and local agencies to sponsor additional research to define the scope of financial need for low-income private well owners. DEP will also consider appropriating a supplemental fund to support low-income residents for the replacement of failing drinking water wells due to age, or installation of treatment for naturally occurring contaminants (for more information, see Chapter 5: Overburdened Communities and Private Wells section and Environmental Justice Recommendations section).

- Include a representative from the environmental justice community on the Water Supply Advisory Council. Council makeup is defined by the Water Supply Management Act (for more information, see Chapter 5: Environmental Justice and Water Supply section).
- Expand on the existing Northeast Resilience Study finding to focus on key feasible recommendations that could be made statewide to enhance resilience especially considering issues such as, resolving uncovered finished water reservoirs, aging infrastructure, and harmful algal blooms (for more information, see Chapter 5: Interconnections, Conjunctive Use, Managed Aquifer Recharge, and Source Substitution section and Potential New and Expanded Sources of Supply section). Initial efforts will focus on the Northeast region.
- Expand upon the drinking water quality assessments that were included in the 2024 NJSWSP (for more information, see Chapter 5: Statewide Safe Drinking Water Assessments section).
- Identify opportunities to expand its planning activities to include a holistic and watershed-based approach to source water protection. This could include one or more of the following items.
    - Review of, and update where necessary, its Source Water Assessment Program Plans. These actions may also consider expansion or enhancement to the SWAP planning process. This would include both surface water and groundwater sources.
    - Prioritization of funding sources to preserve open space upstream of drinking water intakes or in wellhead protection areas, including Green/Blue Acres funds.
    - Prioritization of funding for water quality restoration projects and initiatives through the 319 Grants program to identify and address nonpoint source pollutants upstream of drinking water sources. Funding sources include USEPA pass-through grants issued under Section 319(h) of the federal Clean Water Act and other federal and state funds that may be available for nonpoint source pollution related water quality restoration activities.
    - Consideration of water supply availability and drinking water quality criteria during review of Water Quality Management Plan applications and plans, as was past practice. Special consideration should be given to areas upstream of potable intakes or in Wellhead Protection Areas. This will require a rule change. Promotion of the balanced implementation of stormwater retention and groundwater recharge that preserves or improves water quality and availability, especially in areas of concern or where supplies may be limited (for more information, see Chapter 5: Protecting New Jersey's Water Resources section).
- Further coordinate with the Parties to the 1954 Supreme Court Decree, the Office of the Delaware River Master, and the Delaware River Basin Commission to ensure that the water supply and instream flow needs of the basin are managed to balance in-basin and water supply needs. Priorities include establishment of a permanent Delaware and Raritan Canal diversion minimum of no less than 85 mgd, addition of regulatory provisions to ensure balanced use, and to continue to provide saltwater protections to potable intakes and groundwater recharge areas (for more information, see Chapter 5: Delaware River Basin Commission section).
- Expand coordination with neighboring States on water supply issues. The Passaic and Hackensack watersheds have their headwaters located in New York State and they provide critical water supplies to northeastern New Jersey. DEP should assess water quality and quantity trends in the watersheds and work with New York State agencies and local governments to mitigate negative trends and to ensure that adequate quantities and quality of waters continue to flow downstream to New Jersey and its long-established and critical water supplies (for more information, see Chapter 5: Interstate Watersheds: Passaic, Hackensack, and Wallkill section).
- Recommend municipalities implement the **Winter Best Practices to Reduce Road Salt Impacts** to limit the levels of road salt that contribute to chloride contamination of ground and surface waters.

WATER POLICY MODERNIZATION

As discussed in Chapter 5 and throughout this Plan, DEP is obligated and empowered to improve and protect water supply resources and water system infrastructure to ensure water availability and the delivery of safe drinking water to homes and businesses. In some cases, the federal and state laws and attendant regulations that give rise to these obligations are fit for modernization to better position the State and its water providers to confront new and evolving water supply challenges. DEP identifies the following areas for revision.

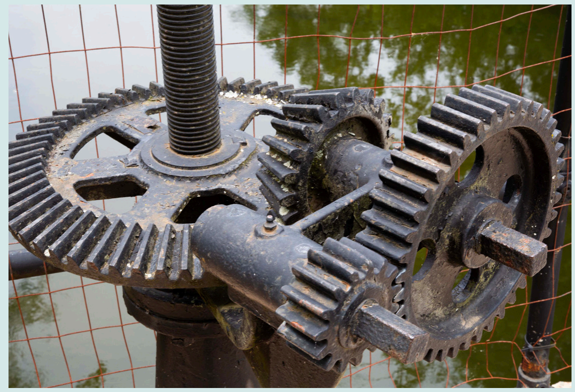
- The Water Supply Management Act, N.J.S.A. 58:1A-1, was amended in 2002 to address temporary water allocation permits in Salem and Gloucester Counties; in 2004 to address provisions of the Highlands Water Protection and Planning Act (Highlands Act), N.J.S.A. 13:20; in 2006 to exempt the payment of water use registration annual fees for volunteer fire companies pursuant to N.J.S.A. 40A:14-70; and in 2008 to address provisions of the Environmental Enforcement Enhancement Act, N.J.S.A. 58:1A-16d. However, the Water Supply Allocation Permits rules (N.J.A.C. 7:19) have been readopted without substantiative change since 1995 and must be amended in response to enactments since. This includes proposed amendments to address issues recognized after the 2002 drought emergency. Several problems with the existing rule have been identified, which inhibit DEP and permittees from efficiently and effectively responding during drought emergencies. The formal addition of drought watch designation also warrants inclusion. Other amendments would modernize and simplify business process, increase flexibility, incorporate stakeholder input and create consistency across Department programs and the Pinelands Commission (for more information, see Chapter 4: Data Sources section and Administratively Approved Withdrawals section).
- Explore opportunities for formalizing a cross-programmatic review process for potential impacts to wetlands from proposed water diversions greater than 100,000 gallons per day.
- Modify N.J.A.C. 7:10 to address raw water sampling and submission of results for all community water systems' wells and intakes at a minimum of once per year as this data is critical to effectively manage drinking water quality and to ensure that water systems have the financial and technical resources needed to meet drinking water standards (for more information, see Chapter 5: Safe Drinking Water Program section and Safe Drinking Water Program Next Steps section).
- Modernize the New Jersey Safe Drinking Water Act, N.J.S.A. 58:10-1 et seq. and attendant rules to promote the development and administration of operating permits for New Jersey public water systems and better define requirements for backup water storage. Currently, whole system permits do not exist for entire water systems. Integral parts to these operations are permitted (e.g. withdrawals, discharges, or new treatment); however, there is no system-wide permit that is comprehensively reviewed on a regular basis. For example, this holistic review would assist with the earlier detections of problems with systems that may be generally in compliance but have underlying operational and maintenance issues that pose a public health risk (for more information, see Chapter 5: Safe Drinking Water Program section and Safe Drinking Water Program Next Steps section).

- Further modernization of the Water Quality Accountability Act (WQAA) at N.J.S.A. 58:31-1 et seq., including through:
  - the adoption of rules to accomplish several key WQAA policy objectives, such as establishing requirements for submitting AWWA Water Loss Audits, codifying Asset Management planning requirements, and providing clear enforcement powers to DEP, and
  - exploring WQAA amendments to:
    - include water purveyors who indirectly serve systems with more than 500 service connections aka regional wholesalers or bulk providers;
    - require some reduced level of asset management oversight for smaller systems, with less than 500 service connections;
    - include certain wastewater systems, as recommended by the Joint Legislative Task Force's Report on Drinking Water, as failure of wastewater infrastructure directly impacts water quality; and
    - allocate new/additional resources (funds/FTE) to the WQAA program, which has not received resources since its initial passage and has drained existing resources from drinking water program/DOIT to implement the statutory requirements (for more information, see Chapter 5: Statewide Water Conservation Strategies section and Water System Resilience and Asset Management section).
- Support legislative efforts to explore the establishment of a revolving funding source that provides low- or no-interest loans or grants to eligible homeowners to ensure that replacement wells are accessible to residents in need. Due to the cost of replacement of aging wells, many low-income private well owners, particularly those in overburdened communities, may not have the finances to hire a properly licensed well driller to ensure their home has a safely constructed, reliable well for water supply (for more information, see Chapter 5: Environmental Justice and Water Supply section).
- Support legislative efforts to explore the establishment of a permanent Low-Income Household Water Assistance Program (LIHWAP). LIHWAP temporarily offset water utility costs for New Jersey residents using federal funding. The program was part of the federal response to the Covid-19 pandemic and was intended to be temporary. Ensuring a permanent funding source will support low-income customers, help avoid water shutoffs, and assist PCWS in setting rates necessary to fund infrastructure projects (for more information, see Chapter 5: Environmental Justice Recommendations section).
- Continue implementation and regulatory oversight over laws and regulations overseeing lead in drinking water. As the EPA promulgates the Lead and Copper Rule Revisions and the Lead and Copper Rule Improvements, DEP finalizes its own proposal for New Jersey-specific Lead and Copper rules and oversees implementation of the Lead Service Line Replacement Law. DEP will fulfill its obligations outlined by each of these pieces of rules and laws.
- Develop regulations outlined by DEP's Science Advisory Board to regulate the installation of Horizontal Directional Drilling (HDD) under the rules in N.J.A.C. 7:9D which govern wells as these activities pose risks to potable aquifers and surface waters and threaten current or future use. The State Well Drillers and Pump Installers Examining and Advisory Board, which oversees licensing of well drillers in New Jersey as well as advises DEP, has also recommended this rulemaking (for more information, see Chapter 5: Water Quality Regulatory Program section).
- Support legislative efforts to explore the establishment of certification or licensing requirements related to the installation of point-of-entry or point-of-use water quality treatment systems in homes (for more information, see Chapter 5: Safe Drinking Water Program Next Steps section).

ASSET MANAGEMENT AND RESILIENCE

Maintenance and improvement of infrastructure is a key element of effective and successful water supply management and critical to ensure the state has access to clean and plentiful drinking water. Proper asset management can reduce water incidents and emergencies, limit disruptions to customers, and reduce long-term costs. As such, DEP will:

- Continue to implement the requirements of the WQAA. This includes the technical support and maintenance of electronic portals and data management of Annual Certifications and Capital Improvement Reports. Processes for evaluating and reporting the content of these submittals will continue to be developed. The Water Purveyor Report Card dashboard will continue to be updated on an annual basis (for more information, see Chapter 5: Water System Resilience and Asset Management section).
- Ensure annual reporting of American Water Works Association (AWWA) water loss audits by all community water systems regulated by the WQAA (for more information, see Chapter 5: Statewide Water Conservation section).



Delaware and Raritan Canal lock control gears in Bulls Island State Park.

- Further analyze community water system interconnections and infrastructure needs. DEP will develop a strategy that will include actions including, but not limited to, the following:
    - o continuing and expanding cooperation between purveyors and DEP;
    - o further evaluation of the water system vulnerability analysis previously covered in Chapter 2 to improve the accuracy of results with respect to systems reliant on unconfined groundwater;
    - o improving the methodology of the water system vulnerability analysis and expanding it to include loss of surface or confined aquifer water sources;
    - o enhancing and expanding funding and online data submission options for DEP's geodatabase of critical water supply infrastructure to improve planning and emergency response capabilities (for more information, see Chapter 5: DEP Water System Resilience Actions section and Chapter 2: PCWS Vulnerability Assessment section); and
    - o ensuring water systems submit interconnection agreements to the DEP for review in accordance with N.J.A.C. 7:19-6.9(g). Each interconnection operation agreement should include the interconnection location, size, conditions for use and hydraulic capacity for both directions under the conditions expected for interconnection use.
- Support water system and legislative endeavors to expand financial support for drinking water infrastructure needs, including through regionalization, shared service arrangements, and rate realignment. The ongoing need for updating aging infrastructure to protect reliable drinking water supply and quality indicates that adequate resources are not currently available to water systems, which could result in rate shock scenarios without additional support.
- Review its storage waiver approval criteria to address emergent issues which may result in the revocation of previous approvals and new requirements for the addition of new storage and/or interconnections. These actions may also include definition changes and contract requirements to the rule. All these actions will result in increased resiliency for water systems (for more information, see Chapter 5: Water System Resilience and Asset Management section).

- Continue to reduce risks posed from uncovered finished water reservoirs to ensure that all drinking water quality standards are met while maintaining adequate levels of finished water storage that meet regional needs (for more information, see Chapter 5: Potential New and Expanded Sources section).
- Continue to ensure that proposed but-not-built projects remain viable options if needed in the future. These include but are not limited to Dunker Pond, Six-Mile Run Reservoir, the Raritan Confluence project, Dundee dam, and Trap Rock Quarry. Additionally, DEP will ensure that water supply sources such as Greenwood Lake, Lake Wawayanda and Lake Hopatcong which were used in past drought emergencies remain viable options if needed for future emergencies (for more information, see Chapter 5: Potential New and Expanded Sources of Supply section).
- Work with partner agencies to expand efforts in support of regionalization/shared services for water systems, where appropriate. DCA continues to offer **grant opportunities** for systems to explore this option, but broader efforts are needed to ensure that water systems are able to keep up in a rapidly evolving regulatory environment. Sales of water systems to investor-owned utilities may be appropriate in certain scenarios. Regional/shared service approaches which retain public ownership of critical assets should also be considered, where appropriate.
- Provide technical support to interagency endeavors to ensure emergency costs attendant to drinking water system operations are accounted in the course of water system and/or municipal fiscal planning.
- Continue to support new and expanded critical water supply projects discussed throughout this NJSWSP, such as but not limited to new and expanded interconnections, finished water storage, addressing uncovered finished water reservoirs, treatment plant upgrades, and contracts for emergency and routine transfers (for more information, see Chapter 5: Water System Resilience and Asset Management section).
- Continue to maximize use of state and federal funding sources to meet water supply program priorities including:
    - continuing to leverage the New Jersey Water Bank to maximize funding from the State Revolving Fund to provide low-cost funding to water systems;
    - continuing to provide assistance to water systems serving small and disadvantaged communities via NJTAP to ensure that they have the ability to access funding from the water bank;
    - supporting continued legislative investment in water infrastructure; and
    - exploring establishment of a funding source to support capacity development and long-term viability of small water systems that do not have operational alternatives (for more information, see Chapter 5: Adequate Asset Management section and Environmental Justice Recommendations section).
- Continue to support and utilize water system interconnection assessments and modeling.
    - DEP will enhance the understanding of the connections between water systems by requiring the submission of information of all pertinent water system assets including geospatial locations (i.e. treatment plants, storage tanks, transmission main and interconnection size and capacity). Though DEP currently has some of this data, it is not all required to be submitted and nor are submittals always in a format conducive to essential understanding of those connections.
    - Data Management and Security – DEP will seek to require specific data format submission specifications to allow facilitation of statewide or regional assessments. These submissions would be stored in a secure file format and location as much of the water system information is considered sensitive (for more information, see Chapter 5: Interconnections, Conjunctive Use, Managed Aquifer Recharge, and Source Substitution section).

POLICIES AND PRIORITIES FOR THE EFFICIENT USE OF WATER

The practices and policies identified below are discussed in this NJSWSP and lead to the responsible and efficient use of the state's water resources. As such, DEP will:

- Continue to facilitate the use and development of Managed Aquifer Recharge (MAR) to meet water supply needs and address shortages, where appropriate. DEP programs will be coordinated to ensure that the use of MAR is a viable alternative, especially in the coastal regions where confined aquifers are present, water demands can increase significantly during the summer months, and where surface water or groundwater resources are threatened by sea-level rise and salt-water intrusion (for more information, see Chapter 5: Interconnections, Conjunctive Use, Managed Aquifer Recharge, and Source Substitution section).
- Discourage new or increased allocation for highly consumptive non-potable uses especially in areas with known or potential water availability and/or water quality concerns (for more information, see Chapter 4: Water Withdrawals and Use section).
- Continue to require the use of the lowest quality of water available for intended use, pursuant to N.J.A.C. 7.19.

PUBLIC OUTREACH

DEP is committed to continuing public education and engaging with people and communities we serve on key water supply issues and initiatives. Though many residents do not consider drinking water issues in their daily lives, its importance cannot be overstated. As such, DEP will:

- Develop this Plan into an online interactive document such as a story map to illustrate the findings of this iteration of the Plan and as a way of communicating updates following its publication.
- Continue to provide and improve educational tools to inform the public about water supply issues, drought management, and water conservation and efficiency strategies - **DEP Water Conservation**. Examples of water conservation programs DEP has implemented include the **New Jersey Water Savers** program and the **Water Champions** program. DEP also continues to promote statewide water conservation and efficiency through involvement in the Sustainable Jersey program and the Environmental Protection Agency's (USEPA) WaterSense program. Tailored programs may also need to be developed to address community or region specific issues; e.g. OBCs or vacation/shore communities. For more information, see Chapters 5 and 7.
- Continue to implement the AmeriCorps New Jersey Watershed Ambassadors Program to help the DEP conduct education and stewardship projects that relate to sources of drinking water (See **Watershed Ambassador AmeriCorps program**).
- Collaborate with partner agencies like Rutgers University and Sustainable New Jersey in their conservation efforts including key public outreach programs such as model ordinance development for municipalities and rain barrel initiatives.
- Continue to provide education resources for private well owners and continue to update and improve existing tools (See **New Jersey Private Well Information**).

View of the Wading River from Evans Bridge located in the Wharton State Forest in the New Jersey Pine Barrens.

CONCLUSION

New Jersey's 9.3 million residents, $800 billion economy, and diverse ecosystems are dependent upon a clean, secure, and resilient water supply in order to meet daily needs, expand economic opportunities, enhance standards of living, improve public health, and restore ecosystems.

While New Jersey must contend with new and increasing water supply challenges now and in the years ahead, the state's public and private water supply managers will draw from a strong foundation. Through the analyses presented in this Plan, DEP has found that New Jersey has sufficient quantities of water to meet current and reasonably anticipated future needs in most regions of the state. However, the continued availability of water resources and their readiness for use is dependent upon intentional and consistent actions to conserve, bolster, and actively manage public and private water supplies. Through active water supply management that includes continuous investments in aging water infrastructure, renewed focus on sound asset management, proactive adaptation measures to respond to the worsening impacts of climate change, and implementation of the policy supports identified in this Plan, New Jersey can better protect and improve its water resources, avoid water scarcity, assure water security, and continue to expand economic opportunities and improve standards of living for all residents.

New Jersey residents, communities, businesses, and institutions are as connected and interdependent as the water resources we share, and each of us must be careful stewards of this precious, finite resource. As public and private water supply managers work to implement the measures identified in this Plan in the years ahead, DEP stands as a partner to every community, water system, business, institution, and member of the public we serve. As DEP does its part to discharge the recommendations made here, the Department will closely monitor new developments and update this Plan periodically to ensure that the most up-to-date data and best available science are utilized to address our water supply needs and challenges. Together, we will ensure that current and future generations of New Jerseyans have access to a clean, secure, and resilient supply of water.

Glossary

ACCRETIVE means the addition of water to a watershed, generally through the imports of either fresh water or sewage or reclaimed wastewater.

ADMINISTRATIVELY APPROVED ABILITY is the amount of water a water supplier is approved to deliver under current regulatory permits.

ADVECTIVE TRANSPORT is the transport of a substance or quantity by bulk motion of a fluid. In the context of this Plan it is a method used to simulate areas where groundwater may be prone to salt-water migration.

AGRICULTURAL CERTIFICATION means the document obtained from the County agricultural agent if a person diverts ground and/or surface water in excess of 100,000 gallons per day for agricultural, aquacultural or horticultural purposes.

AGRICULTURAL REGISTRATION means the document obtained from the County agricultural agent if a person has the capability to divert ground and/or surface water in excess of 100,000 gallons per day for agricultural, aquacultural or horticultural purposes, but who diverts less than this quantity.

AQUACULTURE includes the propagation, rearing, and subsequent harvesting of aquatic animals (generally fish or shellfish, either freshwater or marine) in controlled or selected environments, as well the processing, packaging, and marketing of the harvested animals. Common freshwater aquaculture species include trout, tilapia and catfish. Common marine aquaculture species include oysters, mussels, crabs and shrimp.

AQUIFER means any water-saturated zone in sedimentary or rock stratum which is significantly permeable so that it may yield sufficient quantities of water from wells or spring in order to serve as a practical source of water supply.

AQUIFER RECOVERY (AR) is a form of MANAGED AQUIFER RECHARGE where water is injected into a well without recovery.

AQUIFER STORAGE AND RECOVERY (ASR) is a form of MANAGED AQUIFER RECHARGE where water is injected into a well for storage in the aquifer and recovery form the same well.

AQUIFER STORAGE TRANSFER AND RECOVERY (ASTR) is a form of MANAGED AQUIFER RECHARGE where water is injected into a well for storage in the aquifer and recovery from a different well or wells.

CONFINED AQUIFER is an aquifer which contains groundwater confined under pressure between relatively impermeable or significantly less permeable material so that the water level in a well that is open to the confined aquifer only rises above the top of the aquifer.

CONSUMPTIVE WATER USE means the use of water in such a way that a portion of the water used is lost to evaporation, transpiration, incorporation in product, etc., and not discharged to any location.

CRITICAL WATER SUPPLY AREA or CRITICAL AREA means a water supply area of concern in which it is officially designated by the Commissioner of the DEP, after public notice and a public meeting, that adverse conditions exist, related to the ground or surface water, which require special measures in order to achieve the objectives of the Water Supply Management Act. The DEP will not issue new or increased diversions from affected aquifers within an area of critical water supply or from wells located outside, but that affect the area of critical water supply concern, except for certain cases as defined at N.J.A.C. 7:19-8.3(i) through (k). The DEP may require that diversions be reduced if an alternative supply is made available.

DEPENDABLE YIELD means the yield of water by a water system which is available continuously throughout a repetition of the most severe drought of record, without causing undesirable effects.

DEPLETIVE WATER USE means the withdrawal of water from a water supply resource (ground or surface water) where the water, once used, is not discharged to the same water supply resource in such a manner as to be useable within the same watershed.

DROUGHT means a condition of dryness due to lower than normal precipitation, resulting in reduced stream flows, reduced soil moisture and / or lowering of the potentiometric surface in wells.

EVAPOTRANSPIRATION means the water lost to the atmosphere from the GROUND surface, EVAPORATION from the capillary fringe of the groundwater table, and the TRANSPIRATION of groundwater by plants whose roots tap the capillary fringe of the groundwater table.

FIRM CAPACITY means the peak daily demand of water a public water supply can meet through pumping equipment and/or treatment capacity (excluding coagulation, flocculation, and sedimentation) when the largest pumping station (including a well) or treatment unit is out of service.

FRESH WATER means all non-tidal and tidal waters generally having a salinity due to natural sources of less than or equal to 3.5 parts per thousand at near high tide.

HYDROGEOLOGY means the field of geology that deals with the distribution of movement and groundwater in the soil and rocks of the Earth.

HYBRID AQUIFER STORAGE TRANSFER AND RECOVERY (HASTR) is a form of MANAGED AQUIFER RECHARGE where water is injected into a well for storage in the aquifer and recovery from both the injection wells and neighboring wells.

HUC11 refers to an 11-digit Hydrologic Unit Code drainage area. This is a multi-level, hierarchical drainage system defined by the U.S. Geological Survey. There are 150 HUC11s onshore in NJ with an average size of 51.9 square miles.

HUC14 refers to a 14-digit Hydrologic Unit Code drainage area. This is a multi-level, hierarchical drainage system defined by the U.S. Geological Survey. There are 921 HUC14s onshore in NJ with an average size of 8.5 square miles.

INTERBASIN TRANSFER means the movement of water (as raw, treated or used water) from one watershed to another.

INTERCONNECTION means a water supply connection with another water supply system or systems. An interconnection may be for routine or non-routine (e.g., emergency) supply purposes.

LOW FLOW MARGIN means the difference between normal dry-season flow (September Median Flow) and the 7Q10 low flow.

MANAGED AQUIFER RECHARGE means the injection of water into a well for a recharge purposes. The water may not be recovered as in Aquifer Recharge (AR). The injected water may be recovered from the same well site as in Aquifer Storage and Recovery (ASR), it may be recovered from a different well or wells as in Aquifer Storage Transfer and Recovery (ASTR), or it may be recovered from both the injection well and neighboring wells as in Hybrid Aquifer Storage Transfer and Recovery (HASTR).

MULTIPLE SOURCES means one or more production wells, surface water intakes, or interconnections or a combination of wells, surface water intakes or interconnections utilized to meet the demands of a public community water system.

NATURAL RESOURCE AVAILABILITY means the naturally occurring baseline ability of a water resource to maintain a pattern of water flow and storage.

NJWaTr refers to the New Jersey Water Transfers Database developed by the U.S. Geological Survey and maintained by the DEP to track water withdrawals, use, interbasin transfers, treatment, and discharge in New Jersey.

NON-CONSUMPTIVE WATER USE means that portion of water use which is not lost to evaporation, transpiration, incorporation in product, etc. This volume is available for use by a downstream user.

NON-REVENUE WATER means the difference between the annual volume input into the water supply system and billed authorized consumption (includes billed metered and billed unmetered consumption).

POTABLE WATER means water that does not contain objectional pollution, contamination, minerals, or infective agents and is considered satisfactory for domestic consumption using conventional water treatment processes (e.g., chemical coagulation / flocculation, clarification, filtration, disinfection).

PURVEYOR means any municipality, authority, commission, company or person who owns or operates a public community water supply system.

PUBLIC COMMUNITY WATER SYSTEM or PCWS means a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents. Examples include mobile home communities and municipalities.

PUBLIC NONCOMMUNITY WATER SYSTEM or PNCWS means a public water system used by individuals other than year around residents for at least sixty days of the year. A noncommunity water system can be either transient or nontransient. A nontransient noncommunity water system serves at least twenty-five of the same people over a period of six months during the year, such as schools, factories, and office buildings. A transient noncommunity water system is a system that serves year around for at least sixty days of the year but does not serve the same individuals during that time period. Transient noncommunity water systems include rest stop areas, restaurants, and motels.

RWBR (Reclaimed water for beneficial reuse) means water that has been treated to meet restricted access or public access reuse requirements as specified in a NJPDES permit where the NJPDES permit authorizes that water to be directly reused for non-potable applications in place of potable water, diverted surface water, or diverted groundwater.

RESERVOIR means a large natural or artificial lake used as a source of water supply, either directly or through release and stream flow to a downstream point of withdrawal.

SAFE YIELD means the yield maintainable by a surface water system (especially where supported by a reservoir) continuously throughout a repetition of the most severe drought of record, after compliance with requirements of maintaining minimum passing flows, assuming no significant changes in upstream or up-basin depletive withdrawals or drought conservation actions.

SEPTEMBER MEDIAN FLOW means half of the September flows will be higher and half will be lower during a critical time when streamflow tends to be the lowest in New Jersey.

SOURCE WATER means the surface water (streams, rivers, lakes and reservoirs) or groundwater (aquifers) that supply water to a public water system for drinking or other domestic purposes.

SOURCE WATER ASSESSMENT AREA (GROUNDWATER) means the area from which water flows to a well within a certain time period. Each ground water source water assessment area in New Jersey contains three tiers, labeled as Tier 1, Tier 2, and Tier 3. Tier 1 is a two-year time of travel, which means the ground water within this tier flows to the well within a two-year time period. Tier 2 is a five-year time of travel; the ground water within this tier will flow and reach the well within five years. The final tier, Tier 3, is a twelve-year time of travel, in which the ground water within this tier will flow and reach the well within twelve years.

SOURCE WATER ASSESSMENT AREA (SURFACE WATER) means the area upstream of a surface water intake including the tributaries and headwaters.

STREAM LOW FLOW MARGIN METHOD is the approach developed by DEP to define unconfined aquifer and non-reservoir surface water availability and is described in NJGWS Publication TM 13-3, Using the Stream Low Flow Margin Method to Assess Water Availability in New Jersey's Water-Table-Aquifer Systems. Also referred to as LFM or low flow margin method.

SURFICIAL AQUIFER (see UNCONFINED OR SEMI–CONFINED AQUIFER)

TRANSPIRATION is the process by which moisture is carried through plants from roots to small pores on the underside of leaves, where it changes to vapor and is released to the atmosphere.

TREATED WASTEWATER means the treated spent water of a community. From the standpoint of source, it may be a combination of the liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, and storm water that may be present. Consistent with available information, municipal wastewaters will be categorized into primary level treatment, secondary level treatment, and advanced treatment.

UNACCOUNTED-FOR-WATER means water withdrawn by a purveyor from a source and not accounted for as being delivered to customers in measured amounts.

UNCONFINED OR SEMI–CONFINED AQUIFER means an aquifer close to the land surface with continuous layers of material with permeability in the high to low range, extending from the land surface to the base of the aquifer, where the water table (the upper surface of the saturated zone) is at or near atmospheric pressure.

USER means any person or other entity which utilizes water, whether authorized or not.

WATER ALLOCATION PERMIT means the document required for the diversion of ground and/or surface water in excess of 100,000* gallons per day for a period of more than 30 days in a 365 consecutive day period, for purposes other than agriculture, aquaculture or horticulture. This includes water diversions for public water supply, industrial processing and cooling, irrigation, sand and gravel operations, remediation, power generation, and other uses.

WATER LOSS means difference between the amount of water placed into a distribution system and the total authorized water use (i.e., water that does not reach a valid user or use, whether billed or not billed).

WATERSHED means a geographic area in which all water, sediments and dissolved material drain to a particular receiving body.

WATERSHED MANAGEMENT AREAS means the 150 HUC11 drainage basin boundaries in New Jersey grouped into 20 regions with similar characteristics and/or discharge locations and used to target and focus statewide and regional watershed management activities.

WATER SUPPLY DEFICIT means the amount or amounts by which the available resources fall short of a given demand.

WATER SUPPLY SYSTEM means a physical infrastructure operated and maintained to deliver water on either a retail or wholesale basis to customers.

WATER SYSTEM IMPROVEMENT means any action which increases the capacity, capability, or efficiency of a water system.

WATER TABLE means the water surface in the upper most part of the water saturated zone which is at atmospheric pressure.

WATER TABLE AQUIFER means an aquifer which carries water at atmospheric pressure at the top of the saturated zone, the water table. See also UNCONFINED AQUIFER.

WATER USE REGISTRATION means the document required for any person with the capability to divert in excess of 100,000 gallons of water per day, but who diverts less than this quantity for purposes other than agriculture, aquaculture or horticulture.

WELL HEAD PROTECTION AREA or WHPA is the area from which a well draws its water within a specified timeframe.

XERISCAPING means the practice of the landscaping design so that little or no irrigation is needed.

7Q10 FLOWS means the seven-day, consecutive low flow with a ten-year (10 percent probability) return frequency; the lowest stream flow for seven consecutive days that would be expected to occur an average of once in ten years.

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