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EXECUTIVE SUMMARY

BACKGROUND

A Hazard Mitigation Plan (HMP) is a living document that communities use to reduce their vulnerability to hazards. It forms the foundation for a community's long-term strategy to reduce disaster losses and creates a framework for decision making to reduce damages to lives, property, and the economy from future disasters. Examples of mitigation projects include home acquisitions or elevations to remove structures from high risk areas, upgrades to critical public facilities, and infrastructure improvements. Ultimately, these actions reduce vulnerability, and communities are able to recover more quickly from disasters. Gloucester County has demonstrated its commitment to reducing disaster losses by initially developing its multi-jurisdictional HMP in 2009 and updating information upon which to base a successful mitigation strategy to reduce the impacts of natural disasters and to increase the resiliency of its communities.

Hazard Mitigation is any sustained action taken to reduce or eliminate the long-term risk and effects that can result from specific hazards.

FEMA defines a **Hazard Mitigation Plan** as the documentation of a state or local government evaluation of natural hazards and the strategies to mitigate such hazards.

In response to the requirements of the Disaster Mitigation Act of 2000 (DMA 2000), which requires local governmental agencies to develop and update their HMP every five years, this plan serves as the 2022 update to the 2016 Gloucester County HMP. During the course of the planning process, the entire plan was updated with a focus on examining changes in vulnerability due to hazard events, reviewing local and county capabilities and how they implement hazard mitigation, and reviewing the mitigation strategy and identifying new initiatives to increase overall resiliency in the County.

Benefits of Mitigation Planning

Mitigation planning forms the foundation for Gloucester County's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage. Mitigation planning also allows Gloucester County, as a whole and with participating jurisdictions, to remain eligible for mitigation grant funding for mitigation projects that will reduce the impact of future disaster events. The long-term benefits of mitigation planning include the following:

- An increased understanding of hazards faced by Gloucester County and their inclusive jurisdictions.
- Building more sustainable and disaster-resistant communities.
- Increasing education and awareness of hazards and their threats, as well as their risks.
- Developing implementable and achievable actions for risk reduction in the County and its jurisdictions.

- Building relationships by involving residents, organizations, and businesses.
- Identify implementation approaches that focus resources on the greatest risks and vulnerabilities.
- Financial savings through partnerships that support planning and mitigation efforts.
- Focused use of limited resources on hazards that have the biggest impact on the community.
- Reduced long-term impacts and damages to human health and structures.
- Reduced repair costs.

Organizations Involved in the Mitigation Planning Effort

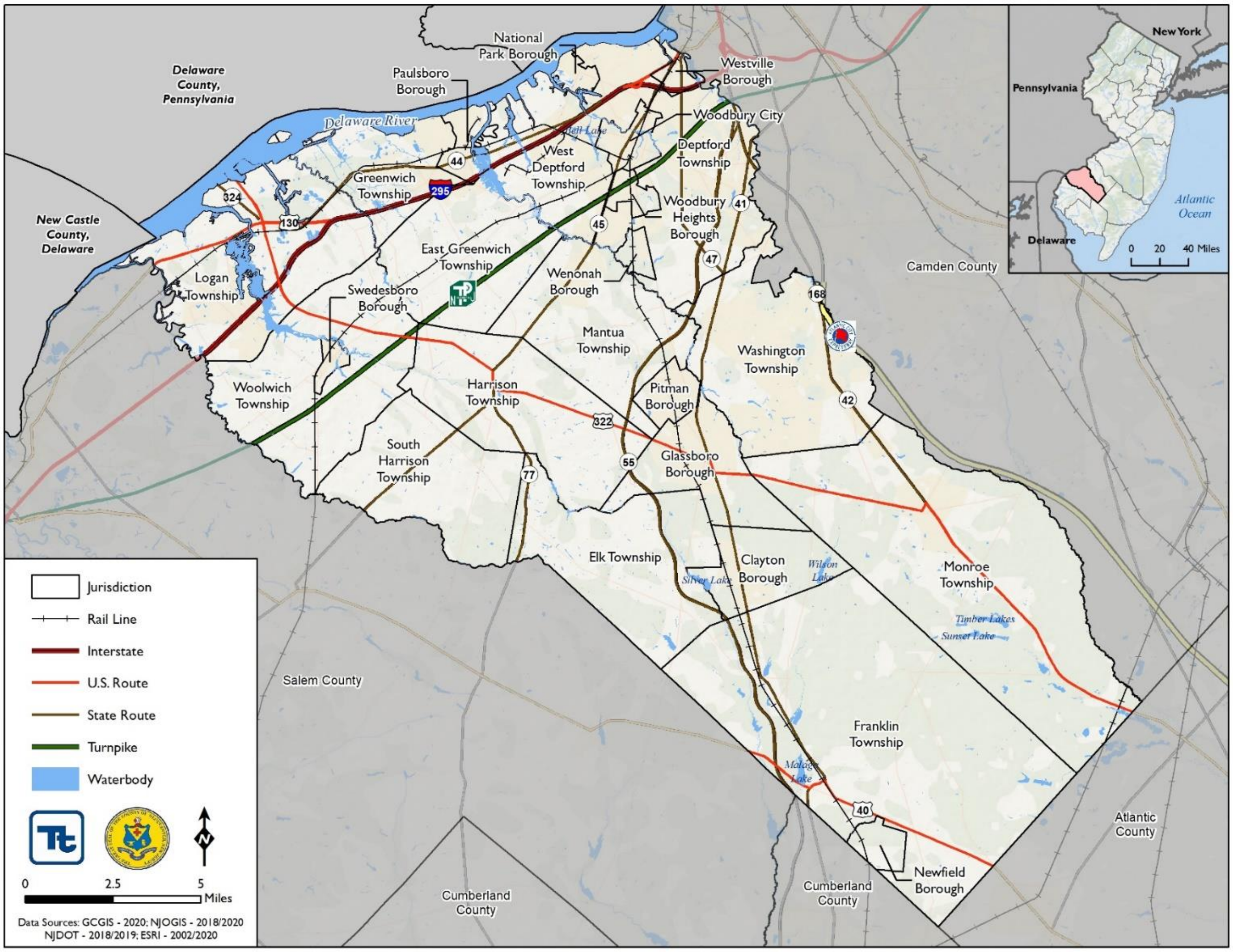
Gloucester and the participating jurisdictions intend to implement this HMP with full coordination and participation of County and local departments, organizations and groups, and relevant state and federal entities. Coordination helps to ensure that stakeholders have established communication channels and relationships necessary to support mitigation planning and mitigation actions included in Section 6 (Mitigation Strategy) and in the jurisdictional annexes in Section 9 (Jurisdictional Annexes).

In addition to Gloucester County, all 24 municipal governments in the County, and Rowan University participated in the 2022 planning process as indicated in Table ES-1 below. A map of the Gloucester County HMP planning area is provided in Figure ES-1.

Table ES-1. Participating Gloucester County Jurisdictions

Jurisdictions		
Gloucester County		
Clayton (B)	Mantua (Twp)	Wenonah (B)
Deptford (Twp)	Monroe (Twp)	West Deptford (Twp)
East Greenwich (Twp)	National Park (B)	Westville (B)
Elk (Twp)	Newfield (B)	Woodbury (C)
Franklin (Twp)	Paulsboro (B)	Woodbury Heights (B)
Glassboro (B)	Pitman (B)	Woolwich (Twp)
Greenwich (Twp)	South Harrison (Twp)	Rowan University
Harrison (Twp)	Swedesboro (B)	
Logan (Twp)	Washington (Twp)	

Figure ES-1. Gloucester County, New Jersey



Multiple Agency Support for Hazard Mitigation

Input and support for this planning effort was obtained from a range of agencies, stakeholders, and through public involvement (as discussed in Section 3). Gloucester County Office of Emergency Management, with support from the Steering Committee, provided project management and oversight of the planning process. While participating jurisdictions were asked to identify a primary and alternate local Point of Contact (POC), broad participation by jurisdictional representatives was encouraged and supported throughout the planning process. A list of Steering Committee and municipal POCs is provided in Section 3 (Planning Process), while Appendix B (Participation Matrix) provides further documentation of the broader level of municipal involvement.

This HMP was prepared in accordance with the following regulations and guidance:

- FEMA *Local Mitigation Planning Handbook*, March 2013.
- FEMA *Integrating Hazard Mitigation into Local Planning*, March 1, 2013.
- FEMA *Plan Integration: Linking Local Planning Efforts*, July 2015.
- FEMA *Local Mitigation Plan Review Guide*, October 1, 2011.
- DMA 2000 (Public Law 106-390, October 30, 2000).
- 44 Code of Federal Regulations (CFR) Parts 201 and 206 (including: Feb. 26, 2002, Oct. 1, 2002, Oct. 28, 2003, and Sept. 13, 2004 Interim Final Rules).
- FEMA *How-To Guide for Using HAZUS-MH for Risk Assessment FEMA Document No. 433*, February 2004.
- FEMA *Mitigation Planning How-to Series (FEMA 386-1 through 4, 2002)*, available at: http://www.fema.gov/fima/planhowto.shtm.
- FEMA *Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards*, January 2013.

Table ES-2 summarizes the requirements outlined in the DMA 2000 Interim Final Rule and provides the section where each is addressed in the HMP.

Table ES-2. FEMA Local Mitigation Plan Review Guide

Plan Criteria	Primary Location in Plan
Prerequisites	
Adoption by the Local Governing Body: §201.6(c)(5)	Section 2; Appendix A
Planning Process	
Documentation of the Planning Process: §201.6(b) and §201.6(c)(1)	Section 3
Risk Assessment	
Identifying Hazards: §201.6(c)(2)(i)	Section 5.2
Profiling Hazards: §201.6(c)(2)(i)	Section 5.4
Assessing Vulnerability: Overview: §201.6(c)(2)(ii)	Section 5.4
Assessing Vulnerability: Identifying Structures: §201.6(c)(2)(ii)(A)	Section 4; Section 5.4
Assessing Vulnerability: Estimating Potential Losses: §201.6(c)(2)(ii)(B)	Section 5.4
Assessing Vulnerability: Analyzing Development Trends: §201.6(c)(2)(ii)(C)	Section 4; Section 9 Annexes
Mitigation Strategy	
Local Hazard Mitigation Goals: §201.6(c)(3)(i)	Section 6; Section 9 Annexes
Identification and Analysis of Mitigation Actions: §201.6(c)(3)(ii)	Section 6; Section 9 Annexes
Implementation of Mitigation Actions: §201.6(c)(3)(iii)	Section 6; Section 9 Annexes
Multi-Jurisdictional Mitigation Actions: §201.6(c)(3)(iv)	Section 6; Section 9 Annexes
Plan Maintenance Process	
Monitoring, Evaluating, and Updating the Plan: §201.6(c)(4)(i)	Section 7
Incorporation into Existing Planning Mechanisms: §201.6(c)(4)(ii)	Section 7; Section 9 Annexes
Continued Public Involvement: §201.6(c)(4)(iii)	Section 7

PLANNING PROCESS OVERVIEW

Gloucester County and the participating jurisdictions intend to implement this HMP with full coordination and participation of County and local departments, organizations and groups, and relevant state and federal entities. Coordination helps to ensure that stakeholders have established communication channels and relationships necessary to support mitigation planning and mitigation actions included in Section 6 (Mitigation Strategy) and Section 9 (Jurisdictional Annexes).

During the Gloucester County HMP planning process, the nation, the State of New Jersey and Gloucester County were facing the COVID-19 pandemic. The COVID-19 pandemic was declared a major disaster on March 25, 2020 (DR-4488). The Governor and local governments issued various orders requiring masks and social distancing based upon different infection levels in the State, County, and local governments. Gloucester County has been greatly impacted by the COVID-19 pandemic.

The Gloucester County Office of Emergency Management, Steering Committee members and the planning partners (County departments, municipalities and municipal utility authorities) were facing the COVID-19 pandemic concurrent with completing the update to the HMP. Gloucester County and all planning partners made their best effort to work through this unprecedented time to complete the HMP update and meet FEMA and State requirements. The public and stakeholder engagement strategy was modified to eliminate in-person engagement and meetings. All meetings were held virtually, including the Steering Committee draft review meeting and the draft plan presentation to the public.

The Gloucester County Office of Emergency Management website was updated, and social media and email was utilized to advertise the draft plan posting to residents and stakeholders. Additionally, the website created for the HMP update (https://www.gloucestercountynjhmp2021.com/) was maintained throughout the planning process and included the draft plan and a link to provide comments and input. All planning partners were notified that the draft plan was posted for public and stakeholder review, were provided social media posts/images, and were asked to distribute these notifications in their jurisdictions. Lastly, stakeholders that were distributed the stakeholder surveys were notified via email that the draft plan was posted for public review and comment. Public and stakeholder comments received on the draft plan were shared with the planning partners via email. To complete the update to the draft plan prior to submission to NJOEM, teleconference meetings were held in a best effort to complete jurisdictional annexes given staffing constraints during the active pandemic.

MULTIPLE AGENCY SUPPORT FOR HAZARD MITIGATION

Primary responsibility for the development and implementation of mitigation strategies and policies lies with local governments. However, local governments are not alone; various partners and resources at the regional, state, and federal levels are available to assist communities in the development and implementation of mitigation strategies. Within New Jersey, NJOEM is the lead agency providing hazard mitigation planning assistance to local jurisdictions. NJOEM provides guidance to support mitigation planning. In addition, FEMA provides grants, tools, guidance, and training to support mitigation planning.

Steering Committee (SC) is comprised of County and municipal representatives that guide and lead the HMP update process on behalf of the Planning Partnership.

Planning Committee (PC) is comprised of representatives from each participating jurisdiction (County and municipalities).

Planning Partnership = SC + PC

The Gloucester County Office of Emergency Management and the Steering Committee provided project management and oversight of the planning process. Participating jurisdictions were asked to identify a primary and alternate local point of contact (POC) to be members of the Planning Committee and lead the planning process update on behalf of the jurisdiction. At the start of the planning process, each municipality identified their Floodplain Administrator and requested their involvement. Further, each jurisdiction was encouraged to form a 'mitigation team' comprised of representatives across departments to ensure broad participation, share the work of the update process and ensure accurate information was captured in their chapter, or annex. The mitigation team worked directly with the primary and alternate POCs and contributed to the jurisdictional annexes presented in Section 9 (Jurisdictional Annex). Together, the Steering Committee and Planning Committee are referred to as the Planning Partnership for the Gloucester County HMP update. A list of Steering Committee and jurisdiction POCs is provided in Section 2 (Planning Process), while Appendices B (Meeting Documentation) and Appendix C (Participation Documentation) provide further documentation of the broader level of municipal involvement. Additional input and support for this planning effort was obtained from a range of agencies and through public and stakeholder involvement (as discussed in Section 2 and presented in Appendix D – Public and Stakeholder Outreach).

GOALS AND OBJECTIVES

The planning process included a review and update of the prior mitigation goals and objectives as a basis for the planning process and selection of appropriate mitigation actions addressing all hazards of concern. Further, the goal development process considered the mitigation goals expressed in the 2019 State of New Jersey HMP, as well as other relevant county and local planning documents, as discussed in Section 6 (Mitigation Strategy).

HAZARDS OF CONCERN

Gloucester County and participating jurisdictions reviewed the hazards that caused measurable impacts based on events, losses, and information available since the development of the 2016 Gloucester County HMP and the 2019 State of New Jersey HMP. A list of potential hazards of concern was reviewed by the Planning Partnership, and each was evaluated to identify the hazards of concern for the 2022 update planning process. The list was presented to each of the participating jurisdictions where they evaluated their risk and vulnerability from each hazard of concern. While the overall hazard rankings were calculated for the County and each participating jurisdiction, the specific hazard rankings displayed in each annex reflect jurisdictional input. The hazard risk rankings were used to focus and prioritize individual jurisdictional mitigation strategies.

PLAN INTEGRATION INTO OTHER PLANNING MECHANISMS

Plan integration is the process by which jurisdictions look at their existing planning framework and align efforts with the goal of building a safer, smarter, and more resilient community. It is specific to each community and depends on the vulnerability of the built environment. Community-wide plan integration supports risk reduction through various planning and development measures, both before and after a disaster. Plan integration involves a community's plans, policies, codes, and programs that guide development and the roles of people and government in implementing these capabilities. Successful integration occurs through collaboration among a diverse set of stakeholders in the community (FEMA 2015).

Effective mitigation is achieved when hazard awareness and risk management approaches and strategies are integrated into local planning mechanisms and become an integral part of public activities and decision making. Within Gloucester County, there are numerous existing plans and programs that support hazard risk management and reduction, and thus, it is critical that the 2022 HMP update integrates, coordinates with, and complements those mechanisms.

Section 5 (Capability Assessment) provides a summary and description of the existing plans, programs and regulatory mechanisms at all levels of government (federal, state, county, local) that support hazard mitigation within the County. Within each jurisdictional annex in Section 9 (Jurisdictional Annexes), the County and each participating jurisdiction identified how they have integrated hazard risk management into their existing planning, regulatory and operational/administrative framework ("existing integration"), and how they intend to promote this integration ("opportunities for future integration").

A further summary of these continued efforts to develop and promote a comprehensive and holistic approach to hazard risk management and mitigation is presented in Section 9 (Jurisdictional Annexes).

IMPLEMENTATION OF PRIOR AND EXISTING LOCAL HAZARD MITIGATION PLANS

Section 6 (Mitigation Strategy) and Section 9 (Jurisdictional Annexes) of the plan present the status of the mitigation projects identified in the 2016 Gloucester County HMP. Numerous projects and programs have been implemented that have reduced hazard vulnerability to assets in the planning area. The County and jurisdictional annexes, as well as plan maintenance procedures in Section 7 (Plan Maintenance), were developed to encourage specific activities. Future actions including integrating hazard mitigation goals into Master Plan updates; reviewing the HMP during updates of codes, ordinances, zoning, and development; and ensuring a more thorough integration of hazard mitigation, with its related benefits into municipal operations, will be completed within the upcoming five-year planning period.

IMPLEMENTATION OF THE PLANNING PROCESS

The planning process and findings are required to be documented in local HMPs. To support the planning process in developing this HMP, Gloucester County and the participating jurisdictions have accomplished the following:

- Developed a Steering Committee and countywide planning partnership with jurisdictions and stakeholders.
- Reviewed the 2016 Gloucester County Hazard Mitigation Plan.
- Identified and reviewed those hazards that are of greatest concern to Gloucester County and its jurisdictions (hazards of concern) to be included in the plan.
- Profiled the relevant hazards.
- Estimated the inventory at risk and potential losses associated with the relevant hazards.
- Reviewed and updated the hazard mitigation goals and objectives.
- Reviewed mitigation strategies identified in the 2016 Gloucester County HMP.
- Developed new mitigation actions to address reduction of vulnerability of hazards of concern.
- Involved a wide range of stakeholders and the public in the plan process.
- Developed mitigation plan maintenance procedures to be executed after obtaining approval of the plan from NJOEM and FEMA.

As required by the DMA 2000, Gloucester County and its participating jurisdictions have informed the public and provided opportunities for public comment and input. Numerous agencies and stakeholders were invited to participate in the planning process by providing input and expertise. Refer to Appendix D (Public and Stakeholder Outreach Documentation) for copies of public service announcements, social media posts and other forms of public and stakeholder outreach conducted.

ADOPTION

Upon FEMA Approval Pending Adoption (APA) status of the 2022 HMP update, Gloucester County and each participating jurisdiction will adopt the plan by resolution of local governing body. An example resolution authorizing adoption of the 2022 Gloucester County Hazard Mitigation Plan may be found in Appendix A (Plan Adoption). The Gloucester County and jurisdiction adoption resolutions will be included in Appendix A upon receipt of the FEMA APA status. Please refer to Section 8 (Planning Partnership) for additional information on plan adoption procedures.

JURISDICTIONAL ANNEXES

Similar to the 2016 HMP, jurisdictional annexes were maintained and updated for the 2022 HMP. The jurisdictional annexes continue to provide a unique, stand-alone guide to mitigation planning for each jurisdiction. The Gloucester County HMP Update is organized so that there is an annex for Gloucester County and for every jurisdiction within the county's borders. Section 9 (Jurisdictional Annexes) includes an annex for every jurisdiction in the County.

SECTION 1. INTRODUCTION

1.1 PURPOSE

Gloucester County and its jurisdictions have prepared this multi-hazard mitigation plan to better protect the residents and property throughout the County from the effects of hazard events. This plan demonstrates the County's and each jurisdiction's commitment to reducing risk from hazards, increasing resilience overall, and provide a tool to help decision makers integrate mitigation in their day-to-day processes. This plan was also developed to position Gloucester County and its participating jurisdictions for eligibility of pre- and post-disaster Federal Emergency Management Agency (FEMA) grants, including: Hazard Mitigation Assistance grant programs (HMA), which include Hazard Mitigation Grant Program (HMGP), Building Resilient Infrastructure and Communities (BRIC), and Flood Mitigation Assistance (FMA). This plan also aligns with the planning elements of the National Flood Insurance Program's Community Rating System (CRS) which provides for lower flood insurance premiums in CRS communities.

1.2 BACKGROUND

A Hazard Mitigation Plan (HMP) is a living document that communities use to reduce their vulnerability to hazards. It forms the foundation for a community's long-term strategy to reduce disaster losses and creates a framework for decision making to reduce damages to lives, property, and the economy from future disasters. Examples of mitigation projects include home acquisitions or elevations to remove structures from high risk areas, upgrades to critical public facilities, and infrastructure improvements. Ultimately, these actions reduce vulnerability, and communities are able to recover more quickly from disasters. Gloucester County has demonstrated its commitment to reducing disaster losses by initially developing its multi-jurisdictional HMP in 2009 and updating information upon which to base a successful mitigation strategy to reduce the impacts of natural disasters and to increase the resiliency of its communities.

> **Hazard Mitigation** is any sustained action taken to reduce or eliminate the long-term risk and effects that can result from specific hazards.
>
> FEMA defines a **Hazard Mitigation Plan** as the documentation of a state or local government evaluation of natural hazards and the strategies to mitigate such hazards.

In response to the requirements of the Disaster Mitigation Act of 2000 (DMA 2000), which requires local governmental agencies to develop and update their HMP every five years, this plan serves as the 2022 update to the 2016 Gloucester County HMP. During the course of the planning process, the entire plan was updated with a focus on examining changes in vulnerability due to hazard events, reviewing local and county capabilities and how they implement hazard mitigation, and reviewing the mitigation strategy and identifying new initiatives to increase overall resiliency in the County.

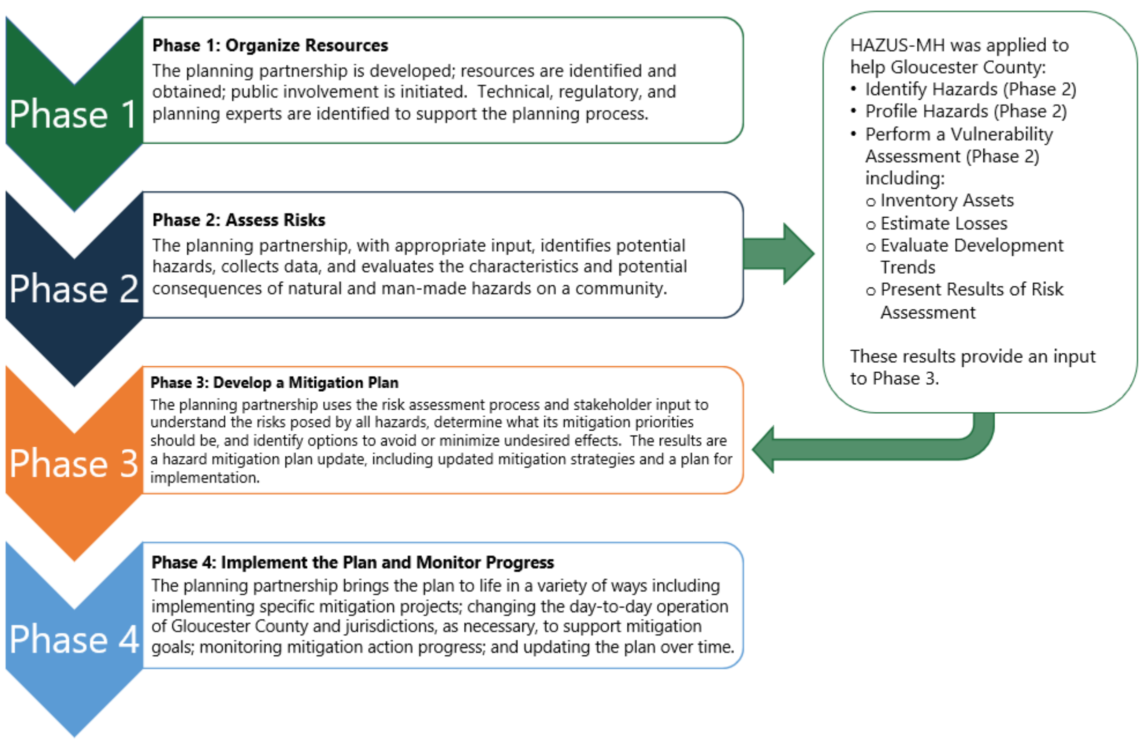
1.3 PLAN ORGANIZATION

The Gloucester County Hazard Mitigation Plan 2022 Update is organized as a two-volume plan and is in alignment with the DMA planning requirements, the 2013 FEMA *Local Mitigation Planning Handbook,* and the FEMA *Local Mitigation Plan Review Tool*.

Volume I provides information on the overall planning process and hazard profiling and vulnerability assessments, which serves as a basis for understanding risk and identifying mitigation actions. As such, Volume I is intended for use as a resource for on-going mitigation analysis.

Volume II provides an annex dedicated to each participating jurisdiction. Each annex summarizes the jurisdiction's legal, regulatory, and fiscal capabilities; identifies vulnerabilities to hazards; documents mitigation plan integration with other planning efforts; records status of past mitigation actions; and presents an individualized mitigation strategy. The annexes are intended to provide a useful resource for each jurisdiction for implementation of mitigation projects and future grant opportunities, as well as a place for each jurisdiction to record and maintain their local aspect of the countywide plan.

Figure 1-1. Gloucester County Hazard Mitigation Planning Process



Volume I of this HMP includes the following sections:

Section 1: Introduction: Overview of the planning process and layout of the plan.

Section 2: Planning Process: Description of the HMP methodology and development process; Steering Committee, Planning Committee, Planning Partnership, and stakeholder involvement efforts; and a description of how this HMP will be incorporated into existing programs.

Section 3: County Profile: Overview of Gloucester County, including: (1) physical setting, (2) land use, (3) land use trends, (4) population and demographics, (5) general building stock and (6) critical facilities and lifelines.

Section 4: Risk Assessment: Documentation of the hazard identification and hazard risk ranking process, hazard profiles, and findings of the vulnerability assessment (estimates of the impact of hazard events on life, safety, health, general building stock, critical facilities, the economy); description of the status of local data; and planned steps to improve local data to support mitigation planning.

Section 5: Capability Assessment: A summary and description of the existing plans, programs and regulatory mechanisms at all levels of government (federal, state, county, local) that support hazard mitigation within the County.

Section 6: Mitigation Strategy: This section provides information regarding the mitigation goals and objectives in response to priority hazards of concern and the process by which Gloucester County and local mitigation strategies have been developed or updated.

Section 7: Plan Maintenance Procedures: System established to continue to monitor, evaluate, maintain, and update the HMP.

Volume II of this plan includes the following sections:

Section 8: Planning Partnership: Description of the planning partnership, their responsibilities, and description of jurisdictional annexes.

Section 9: Jurisdictional Annexes: Jurisdiction-specific annex for Gloucester County and each participating jurisdiction containing their hazards of concern, hazard ranking, capability assessment, mitigation actions, action prioritization specific only to Gloucester County or that jurisdiction, progress on prior mitigation activities (as applicable), and a discussion of prior local hazard mitigation plan integration into local planning processes.

Appendices include the following:

Appendix A: Plan Adoption: Resolutions from the County and each jurisdiction included as each formally adopts the HMP update.

Appendix B: Participation Documentation: Matrix to give a broad overview of who attended meetings and when input was provided to the HMP update, as well as Letters of Intent to Participate described in Section 2 (Planning Process), annex sign-off sheets discussed in Section 6 (Mitigation Strategy) and additional worksheets submitted during workshops conducted throughout the planning process.

Appendix C: Meeting Documentation: Agendas, attendance sheets, minutes, and other documentation (as available and applicable) of planning meetings convened during the development of the plan.

Appendix D: Public and Stakeholder Outreach Documentation: Documentation of the public and stakeholder outreach effort including webpages, informational materials, public and stakeholder meetings and presentations, surveys, and other methods used to receive and incorporate public and stakeholder comment and input to the plan process.

Appendix E: Risk Assessment Supplementary Data: Expanded explanation of community lifelines; critical facility storm surge exposure results by municipality; and the previous hazard events from the 2016 HMP.

Appendix F: Mitigation Strategy Supplementary Data: Documentation of the broad range of actions identified during the mitigation process; types of mitigation actions; the mitigation catalog developed using jurisdiction input and potential mitigation funding sources.

Appendix G: Plan Maintenance Tools: Examples of plan review tools and templates available to support annual plan review.

Appendix H: Linkage Procedures: Procedures for non-participating local governments to "link" to the plan within the period of performance to gain eligibility for programs under the DMA 2000.

Appendix I: Critical Facilities: Includes a full list of critical facilities identified for the update of the HMP. Due to the sensitive nature of the information, critical facility details have been redacted.

1.4 THE UPDATED PLAN – WHAT IS DIFFERENT?

Both the planning process and the 2016 HMP have been enhanced for this update. An increased effort to actively engage stakeholders and the public was a focus of the update, as well as the continued education of the Planning Partnership of mitigation and available grant funding opportunities. The mitigation strategy was updated to only contain detailed actions that are considered priority to each jurisdiction (i.e., quality not quantity). Further, the sections in the 2022 HMP have been realigned to increase the readability of the plan. The following summarizes process and plan changes that differ from the 2016 process and HMP:

- Section 4 (Risk Assessment) has been streamlined and updated.
    - Several new hazards of concern, Disease Outbreak, Invasive Species, Nor'Easter, and Utility Failure, were added to the plan.
    - The updated plan is based on new inventory data and hazard data.
    - The topic of FEMA lifelines is included. All jurisdictions identified critical facilities considered lifelines in accordance with FEMA's community lifeline definition.
    - The flood hazard was expanded to include urban flooding or flooding outside of the floodplain. The Planning Partnership identified locations of urban flooding which was developed into a spatial layer to inform the mitigation strategy.
    - The 2016 effective DFIRMs for Gloucester County were used in the HMP update.
    - The hazard ranking methodology was expanded to include adaptive capacity and climate change.
- Section 9 (Jurisdictional Annexes) has an expanded capability assessment to include additional planning mechanisms in New Jersey as well as information regarding plan integration in the Planning, Legal and Regulatory table.
- The jurisdictional annexes in Section 9 have been enhanced to include the following:
    - Identification of the NFIP Floodplain Administrator as part of the hazard mitigation planning team.
    - Expanded capability assessment including the identification of additional administrative and technical capabilities and catalog of adaptive capacity for each hazard of concern for each jurisdiction.
    - Inclusion of a table of jurisdiction-specific risk assessment results per hazard.
    - Expansion of the critical facility and lifeline flood hazard exposure table to include a mitigation action, if appropriate.
    - A user-friendly presentation of the hazard ranking results.
    - A revised 2016 previous mitigation strategy status table to more clearly identify if the action is to be included in the 2022 HMP update.
    - An increased focus on actionable projects has been applied; removing actions that are ongoing capabilities and focusing on high-ranked hazards.
    - A more detailed proposed mitigation action table that now specifies the problem statement and the proposed solution (mitigation action). The more detailed mitigation strategy is also reflected in the mitigation action worksheets that also include additional details.
    - A table that summarizes the actions across the ranked hazards and their mitigation action types.
    - Individuals that contributed to the annex are specifically listed at the beginning of each annex.

  - Mitigation action worksheets have only been developed for FEMA-eligible projects, per NJOEM guidance.
- To increase public engagement, the following efforts were made:
  - All Planning Partnership meetings were made open to the public.
  - Social media (Facebook) was used to inform the public of meetings and to take the public survey.
  - A website was developed for the HMP update to provide project update, resources, links to the draft plan, and information on upcoming and previous meetings.
  - A Story Map was developed to provide information regarding the HMP planning process and provide an opportunity for virtual public participation.
- A user-friendly tone was used to cater to the strong desire for this plan to be understandable to the general public and not overly technical. This includes limiting the hazard profile section to brief summaries and providing an increased number of graphical summaries throughout the risk assessment.
- An enhanced mitigation strategy process was utilized to develop a robust and actional action plan.
  - A mitigation toolbox was built to assist with mitigation action identification.
  - Utilizing the risk assessment and capability assessment results, problem statements were drafted by each municipality and used to inform the mitigation action development.
  - Actions are identified, rather than strategies. Strategies provide direction, but actions are fundable under grant programs. The identified actions are designed to meet multiple measurable objectives, so that each planning partner can measure the effectiveness of their mitigation actions.
- The plan maintenance strategy is more clearly defined to provide a roadmap for the annual monitoring of the plan.

It should be noted that due to the limitations on participation posed by the pandemic and the strains on time and resources for many local governments and other community organizations from 2020 to present, participation of stakeholders at the municipal level was limited. In accordance with FEMA guiding principles for inclusive participation at various levels, the planning team will place a high priority on an expanded effort on stakeholder participation with local planning committees in future plan updates.

Table 1-1 indicates the major changes between the two plans as they relate to 44 CFR planning requirements.

Table 1-1. HMP Changes Crosswalk

44 CFR Requirement	2016 HMP	2022 HMP Update
Requirement §201.6(b): In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include: An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;	The 2016 plan followed an outreach strategy that included a project website, informational flyers, public education and outreach activities, working group work sessions, public meetings, and public adoption proceedings.	Building upon the 2016 plan, the 2022 planning effort deployed an enhanced public engagement methodology: • Use of social media (Facebook and Twitter). • Web-deployed surveys to residents and targeted stakeholders • All meetings open to the public

44 CFR Requirement	2016 HMP	2022 HMP Update
An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and Review and incorporation, if appropriate, of existing plans, studies, reports and technical information.		• Development of an interactive StoryMap to provide risk communication to residents and direct access to the citizen and stakeholder surveys. As with the 2016 plan, the 2022 planning process identified key stakeholders and coordinated with them throughout the process. A comprehensive review of relevant plans and programs was performed by the planning team.
§201.6(c)(2): The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.	The 2016 plan included a comprehensive risk assessment of hazards of concern. Risk was defined by using the Calculated Prioritized Risk Index (CPRI): ▪ Probability of occurrence (P), weighted at 0.45 or 45% ▪ Severity of impacts (I), weighted at 0.30 or 30% ▪ Warning time before hazard onset (W), weighted at 0.15 or 15% ▪ Duration of the hazard exposure (D), weighted at 0.10 or 10% *CPRI* = (*0.45 x P*) + (*0.30 x I*) + (*0.15 x W*) + (*0.10 x D*)	The 2022 plan update includes a comprehensive update to the risk assessment. The flood hazard was expanded to include urban flooding (or flooding outside of the floodplain). New and updated hazards of concern were included. The hazard ranking methodology was adjusted and includes adaptive capacity and climate change. Jurisdiction-specific risk assessment results are summarized in Section 4 (Risk Assessment) and in each jurisdictional annex (Section 9).
§201.6(c)(2)(i): [The risk assessment] shall include a] description of the ... location and extent of all-natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.	The 2016 plan presented a risk assessment of each hazard of concern. Each section included the following: ▪ Description of the hazard ▪ Location and extent of the hazard ▪ Severity of the hazard ▪ Impact on life and property ▪ Past occurrences (and probability) of the hazard Associated risk assessment information	New and updated data was used for the 2022 plan update. Each section of the risk assessment includes the following: • Hazard profile, including maps of extent and location, previous occurrences, and probability of future events. • Climate change impacts on future probability using the best available data for New Jersey. • Vulnerability assessment includes impact on life, safety, and health, general building stock, critical facilities/lifelines, and the economy, as well as future changes that could impact vulnerability (population, development and climate). • The vulnerability assessment also includes changes in vulnerability since the 2016 plan.
§201.6(c)(2)(ii): [The risk assessment] shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i). This description shall include an overall summary of each hazard and its impact on the community.	Vulnerability was assessed for all hazards of concern. The HAZUS-MH-MH computer model was used for the wind, earthquake, and flood hazards. Site-specific data on County-identified critical facilities were entered into the HAZUS-MH model. HAZUS-MH outputs were generated for other hazards by applying an estimated	A robust vulnerability assessment was conducted for the 2022 plan update, using new and updated asset and hazard data. Volume 1, Section 4.3 summarizes countywide and municipal-specific vulnerability for each hazard of concern. The jurisdictional annexes (Section 9)

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44 CFR Requirement	2016 HMP	2022 HMP Update
	damage function to an asset inventory extracted from HAZUS-MH-MH.	include a summary table of impacts on each community.
§201.6(c)(2)(ii): [The risk assessment] must also address National Flood Insurance Program insured structures that have been repetitively damaged floods.	A summary of NFIP insured properties including an analysis of repetitive loss property locations was included in the plan.	Updated NFIP statistics, as well as Write-Your-Own statistics were presented in the 2022 plan update using best available data.
Requirement §201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure and critical facilities located in the identified hazard area.	A complete inventory of the numbers and types of buildings exposed was generated for each hazard of concern. The Steering Committee defined "critical facilities" for the planning area, and these were inventoried by exposure. Each hazard chapter provides a discussion on future development trends.	Quantitative and qualitative analyses were conducted using the updated hazard and inventory data as presented in Section 4 (Risk Assessment). In addition, critical facilities considered lifelines in accordance with FEMA's definition were identified.
Requirement §201.6(c)(2)(ii)(B): [The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) and a description of the methodology used to prepare the estimate.	Loss estimates were generated for all hazards of concern. These were generated by HAZUS-MH-MH for the wind, earthquake, and flood hazards. For the other hazards, loss estimates were generated by applying a regionally relevant damage function to the exposed inventory. In all cases, a damage function was applied to an asset inventory. The asset inventory was the same for all hazards and was generated in HAZUS-MH.	Quantitative and qualitative analyses were conducted using the updated hazard and inventory data as presented in Section 4 (Risk Assessment). Estimated potential losses are reported in both Volume 1, Section 4.3 and Volume II Section 9 for each jurisdiction.
Requirement §201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.	There is a summary of anticipated development in the County profile, as well as in each individual annex.	A spatial analysis using identified growth areas, and potential new development identified by municipalities was conducted to determine if located in hazard areas. These results were reported to all participants and summarized in their annexes to discuss mitigation measures. In Volume I, Section 4.3, projected changes in population and development are discussed in each hazard section and how these projected changes may lead to increased vulnerability, or plans/regulations/ordinances in place to implement mitigation to protect the development. Further, a land use analysis was conducted for the flood hazard to examine residential and non-residential classified land in the floodplain.
§201.6(c)(3):[The plan shall include a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and	The 2016 plan contained goals, objectives and actions. Each planning partner identified actions that could be implemented within their capabilities. The actions were jurisdiction-specific and strove to meet multiple objectives. All objectives	The Steering Committee reviewed and updated the goals and objectives and they were approved by the Planning Committee. A mitigation strategy workshop with associated tools and guidance on problem statement

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44 CFR Requirement	2016 HMP	2022 HMP Update
resources, and its ability to expand on and improve these existing tools.]	met multiple goals and stand alone as components of the plan. Each planning partner completed an assessment of its regulatory, technical, and financial capabilities.	development was deployed to inform the identification of mitigation actions. Actions that were completed or no longer considered to be feasible were removed; and actions considered general or capabilities were moved to the capability and integration sections. The balance of the actions was carried over to the 2022 plan, and in some cases, new actions were added to the action plan.
Requirement §201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.	The Steering Committee identified goals, and objectives targeted specifically for this hazard mitigation plan. These planning components supported the actions identified in the plan.	The Steering Committee reviewed and updated the goals and objectives and they were approved by the Planning Committee. Several new objectives were identified to align with updated County and municipal priorities.
Requirement §201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.	The 2016 plan did not include mitigation action worksheets that evaluated alternative actions considered for the final mitigation strategy.	For the 2022 update, a mitigation catalog was developed to provide a comprehensive range of specific mitigation actions to be considered. A table with the analysis of mitigation actions by type and hazard was used in jurisdictional annexes to the plan. Mitigation action worksheets with an alternative project evaluation were prepared for FEMA-eligible projects.
Requirement: §201.6(c)(3)(ii): [The mitigation strategy] must also address the jurisdiction's participation in the National Flood Insurance Program, and continued compliance with the program's requirements, as appropriate.	All municipal planning partners that participate in the National Flood Insurance Program indicated their commitment to maintain compliance and good standing under the program.	An analysis of repetitive and severe repetitive loss properties was conducted and is summarized in Section 4.3.7 (Flood) and in Section 9 (Jurisdictional Annexes). Municipalities with repetitive and severe repetitive loss properties included an action to mitigate those properties.
Requirement: §201.6(c)(3)(iii): [The mitigation strategy shall describe] how the actions identified in section (c)(3)(ii) will be prioritized, implemented and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.	Each recommended action was prioritized using a revised methodology based on the STAPLEE criteria was used to prioritize projects.	A revised methodology based on the STAPLEE criteria and using new and updated data was used for the 2022 plan update. The 14 criteria were used to evaluate each potential mitigation action. The evaluation included a qualitative benefits and cost review. The results of the evaluation were used to identify the actions to include in the plan and assist with the prioritization. An emphasis was placed on benefits and costs (quantified where possible and listed in the mitigation action worksheets), as well as timeline for implementation (also documented in the mitigation action worksheets for FEMA-eligible projects).

44 CFR Requirement	2016 HMP	2022 HMP Update
Requirement §201.6(c)(4)(i): [The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.	The 2016 plan outlined a detailed maintenance strategy.	The 2022 plan details a plan maintenance strategy similar to that of the initial plan. It has been enhanced to provide a roadmap for the annual monitoring of the plan and a program to assist with project progress reporting. This includes the inclusion of a summary plan maintenance matrix that provides an overview of the planning partner responsibilities for monitoring, evaluation, and update of the plan.
Requirement §201.6(c)(4)(ii): [The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.	The 2016 plan details recommendations for incorporating the plan into other planning mechanisms.	The 2022 plan details recommendations for incorporating the plan into other planning mechanisms such as the following: ▪ Master Plan ▪ Emergency Response Plan ▪ Capital Improvement Programs ▪ Municipal Code
Requirement §201.6(c)(4)(iii): [The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.	The 2016 plan details a strategy for continuing public involvement.	The 2016 plan maintenance strategy was enhanced for the 2022 plan. In addition, the County will use a proprietary online tool to support the annual progress reporting of mitigation actions. Section 7 (Plan Maintenance) also details the continued public participation in the plan maintenance process.
Requirement §201.6(c)(5): [The local hazard mitigation plan shall include] documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County Commissioner, Tribal Council).	Gloucester County and 25 jurisdictions participated in the 2016 HMP.	The 2022 plan achieves DMA compliance for Gloucester County and all participating jurisdictions. Resolutions for each partner adopting the plan can be found in Appendix A of this volume.

SECTION 2. PLANNING PROCESS

2022 HMP Changes

- All aspects of the planning process were updated for the 2022 HMP.
- Public outreach was enhanced to reach a broader audience by using additional media outlets (Facebook, Twitter) and attending already-scheduled planning process meetings.
- Due to the COVID-19 pandemic, in-person meetings and workshops were not held. Virtual workshops and webinars were held for the Planning Partnership, along with one-on-one calls with the County and municipalities to update their annexes.

2.1 INTRODUCTION

This section includes a description of the planning process used to update the 2016 Gloucester County Multi-Jurisdictional Hazard Mitigation Plan (HMP), including how it was prepared, who was involved in the process, and how the public was involved. To ensure that the plan meets requirements of the DMA 2000 and that the planning process would have the broad and effective support of the participating jurisdictions, regional and local stakeholders, and the public, an approach to the planning process and plan documentation was developed to achieve the following goals:

- The HMP is multi-jurisdictional and considers natural and human-caused hazards facing Gloucester County, thereby satisfying the natural hazards mitigation planning requirements specified in the DMA 2000.
- Gloucester County invited all municipalities in the County to join with them in the preparation of the Gloucester County HMP. The County and all municipalities are participating in the HMP as indicated in Table 2-1 below.
- The HMP was developed following the process outlined by the DMA 2000, FEMA regulations, and prevailing FEMA and NJOEM guidance. Following this process ensures all the requirements are met and support HMP review.

Table 2-1. Participating Gloucester County Jurisdictions

Jurisdictions		
Gloucester County		
Clayton (B)	Logan (Twp)	Swedesboro (B)
Deptford (Twp)	Mantua (Twp)	Washington (Twp)
East Greenwich (Twp)	Monroe (Twp)	Wenonah (B)
Elk (Twp)	National Park (B)	West Deptford (Twp)
Franklin (Twp)	Newfield (B)	Westville (B)
Glassboro (B)	Paulsboro (B)	Woodbury (C)

Jurisdictions		
Greenwich (Twp)	Pitman (B)	Woodbury Heights (B)
Harrison (Twp)	South Harrison (Twp)	Woolwich (Twp)
	Rowan University	

The Gloucester County HMP update was written using the best available information obtained from a wide variety of sources. Throughout the HMP update process, a concerted effort was made to gather information from local and regional agencies and staff, as well as stakeholders, federal and state agencies, and the residents of the County. The HMP Steering and Planning Committees, together called the Planning Partnership, solicited information from local agencies and individuals with specific knowledge of certain hazards and past historical events, as well as considering planning and zoning codes, ordinances, and other recent planning decisions. The hazard mitigation strategies identified in this HMP have been developed through an extensive planning process involving local, county and regional agencies, County residents and stakeholders.

This section describes the mitigation planning process, including (1) Organization of the Planning Process; (2) Stakeholder Outreach and Involvement; (3) Public Participation; (4) Incorporation of Existing Data, Plans, and Technical Information; (5) Integration with Existing Planning Mechanisms and Programs; and (6) Continued Public Involvement.

2.2 ORGANIZATION OF THE PLANNING PROCESS

Many parties supported the preparation of this HMP update: County officials, municipal officials, the Steering Committee, Planning Partnership, stakeholders and planning consultant. This planning process does not represent the start of hazard risk management in the County; rather it is part of an ongoing process that various State, County and local agencies and individuals have continued to embrace. A summary of the past and ongoing mitigation efforts is provided in Section 6 (Mitigation Strategy), as well as in Volume II Section 9 (Jurisdictional Annexes), to give an historical perspective of the County and local activities implemented to reduce vulnerability to hazards in the planning area.

This section of the HMP identifies how the planning process was organized with the many "planning partners" involved and outlines the major activities that were conducted in the development of this HMP update.

2.2.1 Organization of Planning Partnership

Recognizing the need to manage risk within the County, and to meet the requirements of the DMA 2000, the Gloucester County Office of Emergency Management led the update to the 2016 Gloucester County HMP. On March 18, 2020, Gloucester County Office of Emergency Management signed the Grantee-Subgrantee Agreement (PDMC-PL-02-NJ-2018-008) between the State of New Jersey and Gloucester County for funds to update the Gloucester County HMP. The period of performance for this grant is from October 1, 2018 and ending April 1, 2022.

Project management and grant administration has been the responsibility of the Gloucester County Office of Emergency Management. The County has been proactive in supporting natural hazard mitigation. This update supported implementation of projects, provided the basis of the initial mitigation strategy update, and formed problem statements to focus efforts on identifying high priority mitigation projects to reduce vulnerability to hazards of concern for the planning area.

The County selected a contract planning consultant (Tetra Tech Inc. – Parsippany, NJ) to guide the County and participating jurisdictions through the HMP update process. A contract between Tetra Tech Inc. (Tetra Tech) and the County was executed in March 2021. Specifically, Tetra Tech, the "contract consultant", was tasked with:

- Assisting with the organization of a Steering Committee and Planning Partnership.
- Assisting with the development and implementation of a public and stakeholder outreach program.
- Data collection.
- Facilitation and attendance at meetings (Steering Committee, Planning Partnership, stakeholder, public and other).
- Review and update of the hazards of concern, and hazard profiling and risk assessment.
- Assistance with the review and update of mitigation planning goals and objectives.
- Assistance with the review of progress of past mitigation strategies.
- Assistance with the screening of mitigation actions and the identification of appropriate actions.
- Assistance with the prioritization of mitigation actions.
- Authoring of the draft and final HMP documents.

On April 21, 2021, Gloucester County Office of Emergency Management notified all municipalities within the County of the pending planning process and invited them to formally participate. Municipalities were provided with a copy of the Planning Partner Expectations and asked to formally notify the County of their intent to participate [via a Letter of Intent to Participate (LOIP)] and to identify a primary and secondary planning point of contact to serve on a Planning Committee and represent the interests of their respective community. In addition, each municipal Floodplain Administrator (FPA) was identified in the LOIP and requested to actively participate in the planning process. Section 9 (Jurisdictional Annexes) and Appendix B (Participation Documentation) detail contributions provided by the FPA. All jurisdictions returned their LOIP; refer to Appendix B for copies of their LOIPs.

To facilitate HMP development, with support from their contract planning consultant, Gloucester County developed a Steering Committee to provide guidance and direction to the planning effort, and to ensure the resulting document will be embraced both politically and by the constituency within the planning area. The Steering Committee consisted of county and local officials (refer to Table 2-2 for a list of Steering Committee members). All municipalities participating in the plan update authorized the Steering Committee to perform certain activities on their behalf, via the LOIP. Specifically, the Steering Committee was charged with:

- Providing guidance and overseeing the planning process on behalf of the general planning partnership.

- Attending and participating in Steering Committee meetings.
- Establish a timeline for completion of the plan;
- Assisting with the development and completion of certain planning elements, including:
- Reviewing and updating the hazards of concern,
- Developing a public and stakeholder outreach program,
- Assuring that the data and information used in the plan update process is the best available
- Reviewing and updating the hazard mitigation goals and objectives,
- Identification and screening of appropriate mitigation strategies and activities; and
- Reviewing and commenting on plan documents prior to submission to NJOEM and FEMA.
- Ensure that the plan meets the requirements of DMA 2000, FEMA, and NJOEM guidance.
- The organizational structure was successfully implemented for the 2022 HMP updated consistent with the development of the initial 2016 planning process. The Steering Committee representation of non-municipal organizations was greatly expanded for the 2022 HMP. The Steering Committee provided guidance and leadership, oversight of the planning process, and acted as the point of contact for all participating jurisdictions and the various interest groups in the planning area.

The Steering Committee provided guidance and leadership, oversight of the planning process, and acted as the point of contact for all participating jurisdictions and the various interest groups in the planning area. The members of the Steering Committee worked to maintain continuity of the process throughout the process, to overcome the issues created by the COVID-19 pandemic.

Table 2-2. Gloucester County Hazard Mitigation Steering Committee

Organization	Name	Title
Gloucester County Office of Emergency Management	Dennis McNulty	OEM Director
	Charles Murtaugh	OEM Deputy Coordinator
	Jack DeAngelo	OEM Coordinator
	Joe Ward	GIS
Gloucester County Department of Buildings and Grounds	Peter Scirrotto, Sr.	Director
Gloucester County Department of Economic Development	Tom Bianco	Director
Gloucester County Department of Public Works	Vincent M. Voltaggio	Director
Gloucester County Department of Public Works – Planning Division	Theresa Ziegler	Principal Planner
	Nick Cressman	GIS
	Jackie Huston	Planner
Gloucester County Improvement Authority	Kelly Baker	Director
	Joe Baker	Project Manager
Gloucester County Utilities Authority	John Vinci	Director
	Vern Marino	Assistant Executive Director
Gloucester County Cooperative Extension Services	Michelle Infante- Casella	Director

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As part of the initial outreach to each municipality, the County outlined the planning partner expectations that outlined the responsibilities of the participants and asked each municipality to complete a LOIP if they chose to participate. By submitting the LOIP to Gloucester County, each municipality authorized the Steering Committee to represent the municipality in the completion of certain portions of the planning elements. All municipalities in the County agreed to participate. Table 2-3 lists the current members of the Planning Partnership (Steering Committee and Planning Committee), at the time of this HMP's publication. Please note that Steering Committee members are also part of the overall project Planning Partnership, fulfilling these responsibilities on behalf of Gloucester County. This planning partnership (Steering and Planning Committees) were charged with the following:

- Represent their jurisdiction throughout the planning process and assure participation expectations are met by their community.
- Assure participation of all department and functions within their jurisdiction that have a stake in mitigation (e.g., planning, engineering, code enforcement, police and emergency services, public works).
- Assist in gathering information for inclusion in the HMP update, including the use of previously developed reports and data.
- Support and promote the public involvement process.
- Report on progress of mitigation actions identified in prior or existing HMPs, as applicable.
- Identify, develop, and prioritize appropriate mitigation initiatives.
- Report on progress of integration of prior or existing HMPs into other planning processes and municipal operations.
- Develop and author a jurisdictional annex for their jurisdiction.
- Review, amend, and approve all sections of the plan update when requested.
- Adopt, implement, and maintain the plan update.

Table 2-3. Gloucester County Hazard Mitigation Planning Partnership (Steering Committee and Planning Committee)

Jurisdiction	Name	Title	Primary POC	Secondary POC	NFIP FPA	Steering Committee
Gloucester County Office of Emergency Management	Dennis McNulty	OEM Director	X			X
	Charles Murtaugh	OEM Deputy Coordinator		X		X
	Jack DeAngelo	OEM Coordinator				X
	Joe Ward	GIS				X
Gloucester County Department of Buildings and Grounds	Peter Scirrotto, Sr.	Director				X
Gloucester County Department of Economic Development	Tom Bianco	Director				X
Gloucester County Department of Public Works – Planning Division	Vince Voltaggio	County Engineer & Director of Public Works				X
	Theresa Ziegler	Principal Planner				X
	Nick Cressman	GIS				X

Jurisdiction	Name	Title	Primary POC	Secondary POC	NFIP FPA	Steering Committee
	Jackie Huston	Planner				X
Gloucester County Improvement Authority	Kelly Baker	Director				X
	Joe Baker	Project Manager				X
Gloucester County Utilities Authority	John Vinci	Director				X
	Vern Marino	Assistant Executive Director				X
Gloucester County Cooperative Extension Services	Michelle Infante-Casella	Director				X
Clayton (B)	Sam Teague, Jr.	OEM Coordinator	X			
	Sue Miller	Administrator		X		
Deptford (Twp)	Thomas Newman, Jr.	Township Manager/ Deputy OEM Coordinator	X			
	Michael DiVito	Deputy OEM Coordinator		X		
	Christian Romano	Construction Official			X	
East Greenwich (Twp)	Kyle Messick	OEM Coordinator	X			
	Anthony Rossett	Public Works Manager		X		
	James Sabetta	Construction Official			X	
Elk (Twp)	Ed Selb	OEM Coordinator	X			
	Kevin Keen	1st Deputy OEM Coordinator		X		
	Tony Dariano	Construction Official			X	
Franklin (Twp)	Matthew DeCesari	OEM Coordinator	X			
Glassboro (B)	Cpl. Jack Manning	OEM Director	X			
	Craig Rawles	Deputy OEM Coordinator		X		
Greenwich (Twp)	Robert S. Schoch Jr.	OEM Coordinator	X			
	Kirk Fairley	Deputy Coordinator		X		
	Joseph Giordano	Floodplain Administrator			X	
Harrison (Twp)	Brian Bartholomew	OEM Coordinator	X			
	Frank Rodgers	Deputy OEM Coordinator		X		
	Dennis McNulty, PE	Township Engineer			X	
Logan (Twp)	Capt. Joseph V. Flatley	OEM Coordinator	X			
	Robert Taylor	Deputy OEM Coordinator		X		
	Ron Snyder	Construction Official			X	
Mantua (Twp)	Capt. Brian Grady	OEM Coordinator	X			
Monroe (Twp)	Sgt. Ryan Borkoswki	OEM Coordinator	X			
	Det. Don Darcangelo	Deputy OEM Coordinator		X		
	Tara Nelms	Zoning			X	
National Park (B)	Joseph Conboy	OEM Coordinator	X			
	Joy Gunn	Clerk		X		
Newfield (B)	Michael Carlino	OEM Coordinator	X			
Paulsboro (B)	Gary Stevenson	Mayor/OEM Coordinator	X			
Pitman (B)	Jim Foley	OEM Coordinator	X			
	Michael Mollet	OEM Deputy		X		
	Jonathon Bryson, PE	Borough Engineer			X	
South Harrison (Twp)	Celeste Brennen	Clerk	X			
	Tom Luchay	OEM		X		
Swedesboro (B)	Eric Voight	OEM Coordinator	X			
	Lois Elder	Clerk		X		
Washington (Twp)	Chief Patrick Gursick	OEM Coordinator	X			
Wenonah (B)	Richard Black	OEM Coordinator	X			
	John Dominy	Mayor		X		
	Susan Mayer	Councilwoman		X		

Jurisdiction	Name	Title	Primary POC	Secondary POC	NFIP FPA	Steering Committee
	Dave Kreck	Borough Engineer			X	
West Deptford (Twp)	LeeAnn DeHart	Township Administrator	X			
	William Gigliotti	Public Works Manager / OEM Coordinator		X		
Westville (B)	Kathleen Carroll	Deputy Clerk		X		
	Ryan Giles	Borough Administrator	X			
	Anthony Darriano	Construction Official			X	
Woodbury (C)	Joe Buono	Deputy Coordinator/ Fire Marshall	X			
	John Leech	Zoning		X		
Woodbury Heights (B)	John Witasick	OEM Coordinator	X			
	Jolyn Gregoria	Clerk		X		
Woolwich (Twp)	Det. Sgt. Chris Beckett	OEM Coordinator	X		X	
	Joe Morgan	Dep. Chief		X		
Rowan University	Steve Rolando	Asst EMC	X			
	Mike Kantner	EMC		X		

The jurisdictional LOIP identifies the above "Planning Partner Expectations" as serving to identify those activities comprising overall participation by jurisdictions throughout the planning process. The jurisdictions in Gloucester County have differing levels of capabilities and resources available to apply to the plan update process, and further have differing exposure and vulnerability to the hazard risks being considered in this plan. Gloucester County's intent was to encourage participation by all-inclusive jurisdictions, and to accommodate their specific needs and limitations while still meeting the intents and purpose of plan participation. Such accommodations have included the establishment of a Steering Committee and engaging a contract consultant to assume certain elements of the planning process on behalf of the jurisdictions, and to provide additional and alternative mechanisms to meet the purposes and intent of mitigation planning.

Ultimately, jurisdictional participation is evidenced by a completed annex (chapter) of the HMP (Section 9) wherein the jurisdictions have identified their planning points of contact, evaluated their risk to the hazards of concern, identified their capabilities to effect mitigation in their community, and identified and prioritized an appropriate suite of mitigation initiatives, actions, and projects to mitigate their natural hazard risk; and eventually by the adoption of the updated plan via resolution.

Appendix B (Participation Documentation) identifies those individuals who represented their jurisdictions during this planning effort and indicates how they contributed to the planning process. This matrix is intended to give a broad overview of who attended meetings and when input was provided. All participants were encouraged to attend the Kick-off Meeting, Risk Assessment Meeting, and Mitigation Action Workshop. During the planning process the planning consultant contacted each participant to offer support, explain the process, meet individually to collect updated information and to facilitate the submittal and review of critical documents.

All municipalities actively participate in the National Flood Insurance Program (NFIP) and have designated NFIP Floodplain Administrators (FPA). All known FPAs were informed of the planning process, were provided the opportunity to review the plan including the jurisdictional annex and provide direct input to the plan update. Local FPAs are identified in the Points of Contact and Administrative and Technical portions of the jurisdictional annexes in Section 9 (Jurisdictional Annexes).

2.2.2 Planning Activities

Members of the Planning Partnership (individually and as a whole), as well as key stakeholders, convened and/or communicated regularly to share information and participate in workshops to identify hazards; assess risks; review existing inventories of and identify new critical facilities; assist in updating and developing new mitigation goals and strategies; and provide continuity through the process to ensure that natural hazards vulnerability information and appropriate mitigation strategies were incorporated. All members of the Steering Committee and Planning Partnership had the opportunity to review the draft plan and supported interaction with other stakeholders and assisted with public involvement efforts.

A summary of committee meetings (Steering Committee and Planning Partnership) held and key milestones met during the development of the HMP update is included in Table 2-4 that also identifies which DMA 2000 requirements the activities satisfy. Documentation of meetings (e.g., agendas, sign-in sheets, meeting notes) are in Appendix C (Meeting Documentation). Table 2-4 identifies only the formal meetings held during plan development and does not reflect all planning activities conducted by individuals and groups throughout the planning process. In addition to these meetings, there was a great deal of communication between the County, committee members, and the contract consultant through individual local meetings, electronic mail (email), and by phone.

After completion of the HMP update, implementation and ongoing maintenance will become a function of the Planning Partnership as described in Section 7 (Plan Maintenance). The Planning Partnership is responsible for reviewing the HMP and soliciting and considering public comment as part of the five-year mitigation plan update.

This table summarizes a list of mitigation planning activities and meetings and their respective participants. A more detailed list of participants for each meeting is provided in Appendix C (Meeting Documentation). Refer to DMA 2000 (Public Law 106-390) for details on each of the planning requirements (https://www.fema.gov/media-library-data/20130726-1524-20490-1790/dma2000.pdf).

Table 2-4. Summary of Mitigation Planning Activities & Efforts

Date	DMA 2000 Requirement	CRS Activity 510 Step	Description of Activity	Participants
October 1, 2018	2	-	County receives sub-grant agreement from FEMA to update the HMP	Gloucester County OEM

Date	DMA 2000 Requirement	CRS Activity 510 Step	Description of Activity	Participants
March 3, 2021	N/A	-	Pre-Kick Off Meeting with County: Plan timing and administration; Data needs and sharing; Hazards of concern; Dates and next steps	Gloucester County Department of Emergency Response, Tetra Tech
April 21, 2021	2	1	All municipalities invited to participate in the planning process.	Gloucester County OEM, all municipal governments
April 21, 2021	1b, 1c, 2, 3a, 4a	1, 2, 3	Steering Committee #1: Review of mitigation; Review of Steering Committee guidelines; Project schedule and data request; Hazards of concern review and updated; Stakeholders identified; Outreach was discussed (social media, website, brochures); Review of goals and objectives.	Gloucester County Emergency Response, Gloucester County Utilities Authority, GCIA, Gloucester County GIS, Gloucester County Planning Division, NJOEM
May 5, 2021	1b, 2, 3a-c, 3e, 4a, 4b	1, 2	Planning Partnership Kickoff Meeting – *open to the public:* Importance of mitigation and HMP; Participation Requirements; Review of Steering Committee decisions on June 24; Hazards of concern identification and previous events discussion.	Gloucester County Emergency Response, Gloucester County Planning Division, Gloucester County Utilities Authority, Borough of Clayton, Township of Deptford, Township of East Greenwich, Township of Elk, Township of Franklin, Borough of Glassboro, Township of Greenwich, Township of Harrison, Township of Logan, Township of Mantua, Township of Monroe, Borough of National Park, Borough of Pitman, Township of South Harrison, Township of Washington, Borough of Wenonah, Township of West Deptford, Borough of Westville, City of Woodbury, Borough of Woodbury Heights, Township of Woolwich, NJOEM
May 18, 2021	2, 4a, 4b, 4c	-	Annex Guidance Webinar – Municipal representatives were trained on how to provide data and information to fill out the capability assessment portion of their municipal annexes, identify problem areas, and update progress on previous actions.	Gloucester County Emergency Response, Gloucester County Planning Division, Gloucester County Deputy County Clerk, Borough of Clayton, Township of Deptford, Township of Elk, Borough of Glassboro, Township of Greenwich, Township of Harrison, Township of Logan, Township of Mantua, Township of Monroe, Borough of National Park, Borough of Pitman, Borough of Swedesboro, Borough of Wenonah, Township of West Deptford, Borough of Westville
May 20, 2021	2, 4a, 4b, 4c	-	Annex Guidance Webinar – Municipal representatives were trained on how to provide data and information to fill out the capability assessment portion of their municipal annexes, identify problem areas, and update progress on previous actions.	Township of East Greenwich, Borough of Wenonah, City of Woodbury, Borough of Woodbury Heights
June 23, 2021	1b, 2, 3a, 4a	6	Steering Committee #2: Project status update; risk assessment and hazard ranking; confirmation of goals.	Gloucester County Office of Emergency Response, Gloucester County Planning, NJOEM
June 30, 2021	1b, 2, 3a, 3b, 3c, 3d, 3e	4	Planning Partnership Risk Assessment Meeting – Presentation of preliminary hazard ranking, introduction of SWOO	Gloucester County, Borough of Clayton, Township of Deptford, Township of East Greenwich, Township of Elk, Borough of Glassboro, Township of Loga, Township

Date	DMA 2000 Requirement	CRS Activity 510 Step	Description of Activity	Participants
				of Mantua, Township of South Harrison, Borough of Swedesboro. Township of Washington, Borough of Wenonah, Township of West Deptford, Borough of Westville, Borough of Woodbury Heights, NJOEM
August 26, 2021	1b, 2, 4a, 4b, 4c	5, 7	Planning Partnership Mitigation Strategy Workshop – Review of project schedule, Review of survey responses; Review of FEMA and State mitigation strategy requirements; Mitigation strategy update process; Review of Mitigation action types; Review of Mitigation Action Worksheets	Gloucester County Planning, Gloucester County Office of Emergency Management, NJOEM, Borough of Clayton, Borough of Wenonah, Township of Mantua, Township of Deptford, Township of Greenwich, Township of East Greenwich, Rowan University, Township of Logan, City of Woodbury, Township of West Deptford, Township of Elk, Township of Franklin, FEMA
November 18, 2021	1b, 2	2, 3, 7, 8	Planning Partnership Draft Plan Review Meeting	TBD
December 1, 2021	1b, 2	8	Draft HMP posted to public project website All plan participants were notified and asked to assist with the public outreach including social media. Neighboring counties and stakeholders were notified of the posting as well.	Public and Stakeholders
January 17, 2022	2	-	HMP submitted to NJOEM and FEMA Region II	NJOEM, FEMA Region II
Upon plan approval by FEMA	1a	-	Plan adoption by resolution by the governing bodies of all participating municipalities	All plan participants

Notes:

Each number in column 2 identifies specific DMA 2000 requirements, as follows:
1a – Prerequisite – Adoption by the Local Governing Body
1b – Public Participation
2 – Planning Process – Documentation of the Planning Process
3a – Risk Assessment – Identifying Hazards
3b – Risk Assessment – Profiling Hazard Events
3c – Risk Assessment – Assessing Vulnerability: Identifying Assets
3d – Risk Assessment – Assessing Vulnerability: Estimating Potential Losses
3e – Risk Assessment – Assessing Vulnerability: Analyzing Development Trends
4a – Mitigation Strategy – Local Hazard Mitigation Goals
4b – Mitigation Strategy – Identification and Analysis of Mitigation Measures
4c – Mitigation Strategy – Implementation of Mitigation Measures
5a – Plan Maintenance Procedures – Monitoring, Evaluating, and Updating the Plan
5b – Plan Maintenance Procedures – Implementation through Existing Programs
5c – Plan Maintenance Procedures – Continued Public Involvement

Each number in column 3 identifies specific CRS 510 Plan requirements, as follows:
1 – organize to prepare the plan
2 – involve the public
3 – coordinate with other agencies
4 – assess the hazard
5 – assess the problem
6 – set goals
7 – review possible activities
8 – draft an action plan

2.3 STAKEHOLDER OUTREACH AND INVOLVEMENT

Stakeholders are the individuals, agencies, and jurisdictions that have a vested interest in the recommendations of the HMP, including all planning partners. Diligent efforts were made to assure broad regional, county and local representation in this planning process. To that end, a comprehensive list of stakeholders was developed with the support of the Planning Partnership. Stakeholder outreach was performed early on, and continually throughout the planning process. However, due to the limitations on participation posed by the pandemic and the strains on time and resources for many local governments and other community organizations starting in 2020 through present, participation of stakeholders at the municipal level was limited. In accordance with FEMA guiding principles for inclusive participation at various levels, the planning team will place a high priority on an expanded effort on stakeholder participation with local planning committees in future plan updates.

This subsection discusses the various stakeholders that were invited to participate in the development of this HMP update, and how these stakeholders participated and contributed. This summary listing cannot possibly represent the total of stakeholders that were aware of and/or contributed to this HMP update, as outreach efforts were being made, both formally and informally, throughout the process by the many planning partners involved in the effort, and documentation of all such efforts is impossible. Instead, this summary is intended to demonstrate the scope and breadth of the stakeholder outreach efforts made during the plan update process:

- All Planning Partnership meetings were open to the public and advertised via the Gloucester County HMP website (https://www.gloucestercountynjhmp2021.com/).
- Municipalities were provided outreach materials to post on their websites, social media platforms, and distribute printed materials.
- Distributed a stakeholder survey and neighboring county survey to provide input regarding vulnerabilities, capabilities and mitigation projects.
- Held one-on-one teleconference meetings with stakeholders to gain a better understanding of the work and projects they do in Gloucester County.
- Posted draft plan on the Gloucester County HMP website and advertised using social media platforms.
- Email correspondence to regional stakeholders and neighboring counties to review the draft HMP and provide input.

2.3.1 Federal, State, and County Agencies

The following describes the various departments and agencies that were involved during the planning process.

Federal Agencies

Please see Appendix B (Participation Documentation) for further details regarding federal agency participation. All responses to the stakeholder surveys may be found in Appendix D (Public and Stakeholder Outreach).

FEMA Region II: Provided updated planning guidance; provided summary and detailed NFIP data for planning area; attended meetings and presented at the August 2021 Mitigation Strategy Workshop; and conducted plan review.

Information regarding hazard identification and the risk assessment for this plan update were requested and received or incorporated by reference from the following agencies and organizations:

- National Climatic Data Center (NCDC)
- National Hurricane Center (NHC)
- National Oceanic and Atmospheric Administration (NOAA)
- National Weather Service (NWS)
- Storm Prediction Center (SPC)
- U.S. Army Corps of Engineers (USACE)
- U.S. Census Bureau
- U.S. Department of Agriculture (USDA)
- U.S. Department of Health and Human Services
- U.S. Environmental Protection Agency (USEPA)
- U.S. Geological Survey (USGS)

State Agencies

Please see Appendix B (Participation Documentation) for further details regarding state agency participation. All responses to the surveys may be found in Appendix D (Public and Stakeholder Outreach).

New Jersey Office of Emergency Management (NJOEM): Administered the planning grant; provided updated planning guidance; attended the April 2021 Steering Committee Meeting, the May 2021 Planning Partnership Kickoff Meeting, June 2021 Risk Assessment Meeting, August 2021 Mitigation Strategy Workshop, and November 2021 Draft Plan Presentation; and provided review of the draft HMP update.

New Jersey Department of Environmental Protection: Provided the Community Assistance Visit dates and associated NFIP information for all jurisdictions.

New Jersey Pinelands Commission: The New Jersey Pinelands Commission (the 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."

On June 9, 2021, the Commission was contacted to participate as a stakeholder in the planning process. The Commission responded on June 17, 2021 to provide details on services they provided to Gloucester County municipalities. The role of the Pinelands Commission is, in part, to assure that any ordinances adopted by municipalities within the Pinelands (Monroe Township and Franklin Township in Gloucester County) conform to the standards of the Pinelands Comprehensive Management Plan (CMP). Any amendments to municipal master plans or ordinances in those municipalities must be approved by the Pinelands Commission before they take effect. Any hazard mitigation steps directed by the updated County hazard mitigation plan (HMP) for Monroe Township and Franklin Township should, therefore, also conform to the standards of the CMP. Since the primary natural hazards in the Pinelands Area are wildfire and/or riverine flooding, the CMP addresses these to a large extent by limiting development in wetlands (or stream) buffers and near areas of high or extreme wildfire susceptibility.

Delaware Valley Regional Planning Commission (DVRPC): On June 10, 2021, a representative for the Delaware Valley Regional Planning Commission (DVRPC) met with Tetra Tech staff to discuss the Commission's capabilities, prior planning efforts partnered with local municipalities, and potential projects to include in the County's mitigation strategy. The Commission has provided various assistance to municipalities in the past including Natural Resource Inventories, sidewalk inventories, trail mapping, and Community Forestry Management Plans. The Commission has developed guidance for the Municipal Management of Extreme Heat, completed an assessment of planning tools for climate change resiliency in the Delaware Valley.

The Commission has developed the Transportation Improvement Program (TIP), which is a regionally agreed-upon list of priority transportation projects. The TIP lists all projects that intend to use federal funds, along with all non-federally funded projects that are regionally significant and State funded capital projects relating to transportation improvements of rail, highway, public transportation, and pedestrian pathways.

County Departments

Several county departments were represented on the Steering Committee and involved in the HMP update planning process. Appendix B (Participation Matrix) provides further details regarding regional and local stakeholder agencies. All responses to the stakeholder surveys are in Appendix D (Public and Stakeholder Outreach). Refer to Section 5 (Capability Assessment) for details on each department and their roles during the HMP update and their overall responsibilities in Gloucester County.

- Gloucester County Office of Emergency Management
- Gloucester County Department of Public Works
- Gloucester County Department of Public Works – Planning Division
- Gloucester County Utilities Authority
- Gloucester County Department of Buildings and Grounds
- Gloucester County Department of Economic Development
- Gloucester County Improvement Authority

- Gloucester County Cooperative Extension Services

2.3.2 Regional and Local Stakeholders

All Planning Partnership meetings were announced on the Gloucester County HMP project website and posted on social media to invite residents and stakeholders. In addition, the County and municipal representatives emailed regional and local stakeholders requesting their participation in stakeholder sector-specific surveys to provide input on vulnerable assets, capabilities, and current/potential future mitigation projects; and invited to provide input on the draft HMP. Refer to Appendix C (Participation Documentation) for further details regarding regional and local stakeholder agency attendance at meetings and Appendix D for additional details on the public and stakeholder outreach, including responses received to the surveys.

Emergency Services

Numerous Municipal OEM Coordinators participated as points of contact for municipalities and contributed to the plan. Emergency services stakeholders were contacted directly by Gloucester County and participating municipalities to take a stakeholder survey which included capabilities, vulnerabilities and mitigation projects/actions. The following completed the survey:

- United States Army Corps of Engineers - Philadelphia

Hospitals and Healthcare Facilities

Hospitals and healthcare facilities that serve the County were asked to complete the stakeholder survey. No responses were received.

Transportation and Public Works

Many municipal public works departments participated as points of contact for municipalities and contributed to the plan. In addition, municipal, county and state transportation and public works departments were asked to complete the stakeholder survey. No responses were received.

Utilities

Utility providers for the County were asked to complete the stakeholder survey. The following completed the survey:

- Mantua Township Municipal Utilities

Business and Commerce

Businesses and commercial industries were asked to complete the stakeholder survey. No responses were received.

Academia

Schools, universities and other academia institutions were asked to complete the stakeholder survey. The following completed the survey:

- Rowan University

Adjacent Counties

Gloucester County has made an effort to keep surrounding counties and municipalities appraised of the project and allowed the opportunity to provide input to this planning process. Specifically, the following adjoining and nearby county representatives were contacted in June 2021 to inform them about the availability of the project website, draft plan documents, and surveys, and to invite them to provide input to the planning process. None of the adjacent counties took the survey.

- Delaware County, PA
- Philadelphia County, PA
- Salem County, NJ

Other Identified Stakeholders

The following additional stakeholders completed the survey:

- New Jersey Pinelands Commission

2.3.3 Stakeholder Survey Summary

The following provides a summary of the results and feedback received by stakeholders who completed the survey. Feedback was reviewed by the Steering Committee and integrated where appropriate in the plan.

Stakeholder Survey

The stakeholder survey was designed to help identify general needs for hazard mitigation and resiliency within Gloucester County from its perspective, as well as to identify specific projects that may be included in the mitigation plan. It was distributed to identified stakeholders, including the various county and municipal departments and agencies in the county. As of November 5, 2021, 4 stakeholders completed the survey, 50% of which in the academic/research category, and 50% in utility services.

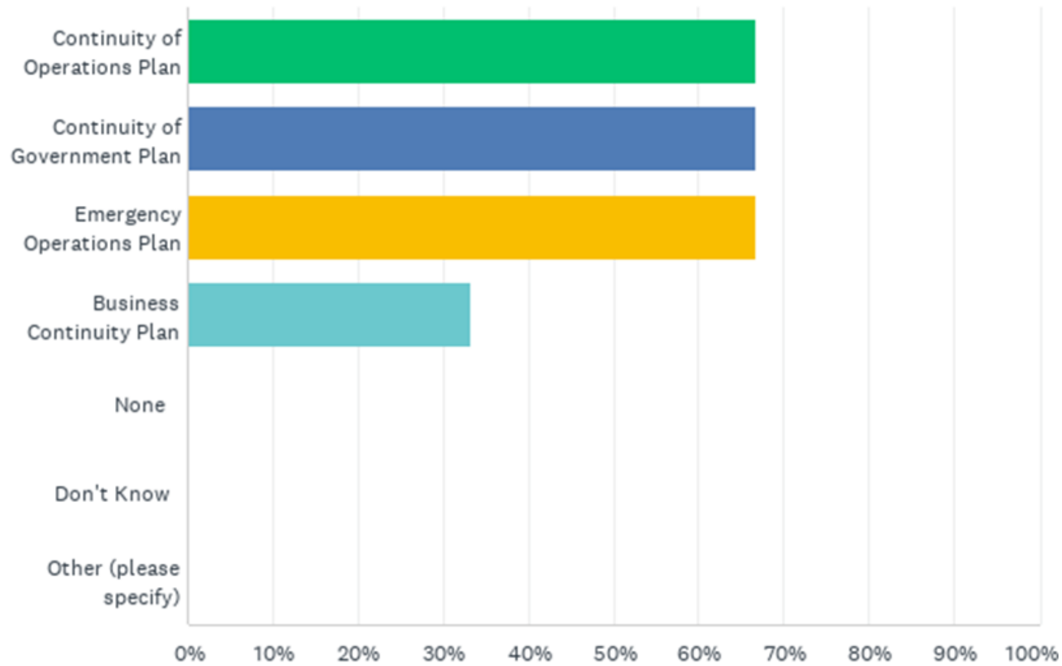
Hazard and Damage Identification

Two-thirds of respondents said the buildings/facilities/structures they have worked in and/or are responsible for have been impacted by a hazard. Both respondents identified storms as being the event that caused damage, as they caused flooding of parking lots and a residence hall, and an extended power outage. Similarly, they believe low-lying areas of buildings and parking lots are most vulnerable to hazards. Two-thirds of respondents also believe the facilities and infrastructure for their organization are equipped to handle a disaster and/or are resilient to damages.

Community Preparedness

All of the respondents stated that their organization has some kind of hazard plan. Most (66.7%) of the respondents are covered by a Continuity of Operations Plan, a Continuity of Government Plan, and an Emergency Operations Plan. Only 33.3% are covered by a Business Continuity Plan (Figure 2-5).

Figure 2-5-. Plans of Stakeholders



Project Identification

Respondents identified the following projects or programs that could reduce their organization's vulnerability to damages, including operation of service:

- Storm water mitigation
- Loss prevention programs

The following were identified as recently implemented projects that reduced vulnerabilities to hazard events:

- Storm water mitigation
- NJ Utility Authorities Joint Insurance Fund's loss prevention programs

Respondents were also asked to detail how their organization has been involved in response to the ongoing COVID-19 pandemic. Respondents detailed the following:

- Rowan University Pandemic Operations Plan is under the direction of University Wellness Center which includes response, testing, and care
- We've maintained our services which are operational 24/7 adhering to CDC and State of NJ guidelines

The following services and infrastructure needs were identified by respondents as needing to be built or improved upon within their communities in order to mitigate damages experienced by the pandemic:

- Continued engagement of Pandemic Operations Plan as daily situations change with the pandemic

Neighboring County Survey

The neighbor survey was sent to the surrounding counties of Gloucester County due to their proximity to and because effects of hazard events that impact Gloucester County would be similar to that of their neighbors. As of November 5, 2021, no counties completed the survey.

2.4 PUBLIC PARTICIPATION – CITIZEN INVOLVEMENT

In order to facilitate better coordination and communication between the Planning Partnership and citizens and to involve the public in the planning process, it was determined that meeting dates/locations will be made available to the public via the Gloucester County OEM website dedicated to the HMP update and social media; and the draft HMP available on the Gloucester County website. The participating partners also feel that community input on the HMP will increase the likelihood of hazard mitigation becoming one of the standard considerations in the evolution and growth of the County.

The Planning Partnership has made the following efforts toward public participation in the development and review of the HMP:

- The Gloucester County OEM created a dedicated website for this project (https://www.gloucestercountynjhmp2021.com/). The website went live in April 2021 and was continuously updated throughout the planning process. The public website contains a project overview, meeting announcements, draft documents for review and comment, and a link to the public and stakeholder surveys.
- All hazard mitigation Planning Partnership meetings that were open to the public were advertised on the Gloucester County website and various social media accounts (Facebook and Twitter). Additional examples of municipal outreach are presented in Appendix D.
- An on-line natural hazards preparedness public survey was developed to gauge household preparedness that may impact the County and to assess the level of knowledge of tools and techniques to assist in reducing risk and loss of those hazards. The questionnaire asked quantifiable questions about citizen

perception of risk, knowledge of mitigation, and support of community programs. The questionnaire also asked several demographic questions to help analyze trends. The questionnaire was available on the public website from April 2021 to August 2021, and further advertised on additional County and municipal websites and on printed materials. Reponses were collected and provided back to plan participants for consideration in the mitigation action development (195 responses in total). Appendix D summarizes public input received through the website, the online survey, and other sources.

- A hazard mitigation planning brochure was developed to inform the public of the planning process, provide local contact information, and encourage the public to review the plan and provide input. This brochure was provided to all plan participants in electronic and hard copy format to distribute in their offices and communities; refer to Appendix D.
- All plan participants were encouraged to distribute the project brochure and post the links to the project webpage and citizen survey. In addition, all participating municipalities were requested to advertise the availability of the project website, citizen survey and stakeholder surveys via local homepage links, and other available public announcement methods (e.g., Facebook, Twitter, email blasts). Refer to Appendix D which highlights these local efforts.
- Gloucester County residents were provided opportunity to comment on the draft HMP before submittal to FEMA. The HMP was posted on the HMP public website on November 19, 2021 for review. All jurisdictions were requested to assist with advertising the plan was posted via their websites and social media. Public comments received through December 20, 2021 were distributed to Planning Partnership for their consideration.
- Additional examples of public outreach efforts, and results of surveys distributed, are presented in Appendix D (Public and Stakeholder Outreach Documentation).

2.5 INCORPORATION OF EXISTING PLANS, STUDIES, REPORTS, AND TECHNICAL INFORMATION

The Gloucester County HMP strives to use the best available technical information, plans, studies and reports throughout the plan process to support hazard profiling; risk and vulnerability assessment; review and evaluation of mitigation capabilities; and the identification, development and prioritization of county and local mitigation strategies.

The asset and inventory data used for the risk and vulnerability assessments is presented in the County Profile (Section 3). Details of the source of this data, along with technical information on how the data was used to develop the risk and vulnerability assessment, is presented in the Risk Assessment, specifically in Section 4.2 Methodology and Tools, as well as throughout the hazard profiles in Section 4.3 (Hazard Profiles). Further, the source of technical data and information used may be found within the References section.

Plans, reports, and other technical information were identified and provided directly by the County, participating jurisdictions, and numerous stakeholders involved in the planning effort, as well as through independent research by the planning consultant. The County and participating jurisdictions were tasked with updating the inventory of their Planning and Regulatory capabilities in Section 9 (Jurisdictional Annexes) and providing relevant planning and regulatory documents, as applicable. Relevant documents, including plans, reports, and ordinances were reviewed to identify the following:

- Existing County and municipal capabilities.
- Needs and opportunities to develop or enhance capabilities, which may be identified within the County or local mitigation strategies.
- Mitigation-related goals or objectives considered in the review and update of the overall Goals and Objectives in Section 6 (Mitigation Strategy).
- Proposed, in-progress, or potential mitigation projects, actions, and initiatives to be incorporated into the updated County and local mitigation strategies.

The following local regulations, codes, ordinances, and plans were reviewed during this process to develop mitigation planning goals, objectives, and strategies that are consistent across local and regional planning and regulatory mechanisms to accomplish complementary and mutually supportive strategies:

- Master Plans
- Building Codes
- Zoning and Subdivision Ordinances
- NFIP Flood Damage Prevention Ordinances
- Site Plan Requirements
- Stormwater Management Plans
- Emergency Management and Response Plans
- Land Use and Open Space Plans
- Capital Plans
- New Jersey State Hazard Mitigation Plan (2019)

2.6 INTEGRATION WITH EXISTING PLANNING MECHANISMS AND PROGRAMS

Effective mitigation is achieved when hazard awareness and risk management approaches and strategies become an integral part of public activities and decision-making. Within the County there are many existing plans and programs that support hazard risk management, and thus it is critical that this hazard mitigation plan integrate and coordinate with, and complement, those mechanisms.

The Capability Assessment section of Section 5 (Capability Assessment) provides a summary and description of the existing plans, programs, and regulatory mechanisms at all levels of government (federal, state, county, and local) that support hazard mitigation within the County. Within each jurisdictional annex in Section 9, the

County and each participating jurisdiction identified how they integrated hazard risk management into their existing planning, regulatory, and operational/administrative framework (integration capabilities) and how they intend to promote this integration (integration actions). In addition, as noted above, a summary of the plan reviews indicating relevant goals and mitigation actions is provided in Appendix J. This information provided input to identify integration of mitigation concepts into the operations of the County and municipalities.

A further summary of these continued efforts to develop and promote a comprehensive and holistic approach to hazard risk management and mitigation is presented in Section 7 (Plan Maintenance).

2.7 CONTINUED PUBLIC INVOLVEMENT

Gloucester County and participating jurisdictions are committed to the continued involvement of the public in the hazard mitigation process. This HMP update will be made available for review on the HMP public website. Each jurisdiction's elected official shall be responsible for receiving, tracking, and filing public comments regarding this HMP update.

A notice regarding annual updates of the plan and the location of plan copies will be publicized annually after the annual plan evaluation meeting (refer to Section 7 – Plan Maintenance) and posted on the public website at https://www.gloucestercountynjhmp2021.com/.

The public will have an opportunity to comment on the HMP update as a part of the annual mitigation planning evaluation process and the next five-year mitigation plan update. The HMP Coordinator (currently Dennis McNulty, Office of Emergency Management) is responsible for coordinating the plan evaluation portion of the meeting, soliciting feedback, collecting and reviewing the comments, and ensuring their incorporation in the 5-year plan update as appropriate; however, members of the Planning Partnership will assist the HMP Coordinator. Additional meetings may also be held as deemed necessary. The purpose of these meetings would be to provide the public an opportunity to express concerns, opinions, and ideas about the HMP.

Further details regarding continued public involvement are provided in Section 7 (Plan Maintenance).

After completion of this HMP update, implementation and ongoing maintenance will continue to be a function of the Planning Partnership. The Planning Partnership will review the plan and accept public comment as part of an annual review and as part of five-year mitigation plan updates.

A notice regarding annual updates of the plan will be publicized annually after the HMP Committee's annual evaluation and posted on the public web site.

Dennis McNulty has been identified as the ongoing County HMP Coordinator (see Section 7), and is responsible for receiving, tracking, and filing public comments regarding this HMP update. Contact information is:

Mailing Address:	Gloucester County Office of Emergency Management 1200 N Delsea Drive, Clayton, NJ 08312
Contact Name:	Dennis McNulty
Email Address:	dmcnulty@co.gloucester.nj.us

SECTION 3. COUNTY PROFILE

This section provides general information for Gloucester County, including its physical setting, general building stock, and land use, population and demographics and population trends. The profile also includes the County's critical facilities county. Analyzing this information leads to an understanding of the study area, including economic, structural, and population assets at risk, and concerns that could be related to hazards analyzed later in this plan (e.g., low lying areas prone to flooding, high percentage of vulnerable persons in an area).

3.1 General Information

Gloucester County was founded in 1686 and once included the present Atlantic and Camden Counties. Greenwich Township became the first township. Incorporated on March 1, 1694. The original townships formed at that time were Gloucester, Deptford, Greenwich, Waterford, Newton and Egg Harbor. It included present-day Atlantic County and Camden County. Woodbury is the county seat of Gloucester County (County, County History 2021). Today, the County is situated on the eastern bank of the Delaware River and located directly across the river from the Greater Philadelphia Airport. The I-95 Industrial Corridor runs through the County as well. There is a total of 2,032 miles of roads, 410 miles of county highways, 24 municipalities, and 329 square miles of land (County, Fast Facts 2021).

About 55,100 acres, or nearly 26 percent of Gloucester County, has been developed for residential, industrial, commercial, or recreational uses. The remainder of the acreage is used for agriculture or is woodland, wetland, or open water. Wooded areas account for about 30 percent of the acreage in the county. About 25 percent of the county is used for crops, hay and pasture, or orchards (New Jersey Planning Division 2002). Important agricultural commodities include corn, wheat, soybeans, vegetables, greenhouse crops, nursery stock, flowers, and orchard products. Livestock products are also important to the county. They include beef cattle, dairy products, hogs, sheep, and poultry (USDA, NASS 1997).

According to the 2010 United States Census, Gloucester County is composed of 288,288 people, 104,271 households, and 75,805 families. The population is largely white with a small proportion of black, native American, Asian and Pacific Islanders, and Hispanic. Additionally, the economic makeup is considered working to upper middle class, which median income for the county being $54,273. Based on data from the Bureau of Economic Analysis, Gloucester County had a gross domestic product (GDP) of $14.4 billion in 2018, which was ranked 14th in the state and represented an increase of 1.3% from the previous year.

Gloucester County is presently one of the fastest growing counties in southern New Jersey. It is in close proximity to the major cities of Philadelphia, Pennsylvania, and Camden, New Jersey, and provides residential living with easily accessible employment opportunities. The county is well connected by an extensive road and highway system.

3.2 Major Past Hazard Events

Presidential disaster declarations are typically issued for hazard events that cause more damage than state and local governments can handle without assistance from the federal government, although no specific dollar loss threshold has been established for these declarations. A presidential disaster declaration puts federal recovery programs into motion to help disaster victims, businesses and public entities. Some of the programs are matched by state programs. Review of presidential disaster declarations helps establish the probability of reoccurrence for each hazard and identify targets for risk reduction. Table 3-1 shows FEMA disaster declarations that included Gloucester County through 2021 since 1954, when records began.

Table 3-1. History of Hazard Events in Gloucester County, New Jersey

Disaster Number	Event Date	Declaration Date	Incident Type	Title
DR-41-NJ	August 20,1955	August 20, 1955	Hurricane	Hurricane & Floods
DR-124-NJ	March 9, 1962	March 9, 1962	Flood	Severe Storm, High Tides & Flooding
DR-205-NJ	August 18, 1965	August 18, 1965	Drought	Water Shortage
DR-310-NJ	September 4, 1971	September 4, 1971	Flood	Heavy Rains & Flooding
DR-477-NJ	July 23, 1975	July 23, 1975	Flood	Heavy Rains, High Winds, Hail & Tornadoes
DR-528-NJ	February 8, 1977	February 8, 1977	Severe Ice Storm	Ice Conditions
EM-3083-NJ	October 19, 1980	October 19, 1980	Drought	Water Shortage
EM-3160-NJ	March 13, 1993	March 17, 1993	Snow	Severe Blizzard
DR-1088-NJ	January 7, 1996 - January 12, 1996	January 13, 1996	Snow	Blizzard of '96 (Severe Snow Storm)
EM-3148-NJ	September 16, 1999 - September 18, 1999	September 17, 1999	Hurricane	Hurricane Floyd Emergency Declarations
EM-3156-NJ	May 30, 2000 - November 1, 2000	November 1, 2000	Other	West Nile Virus
EM-3169-NJ	September 11, 2001	September 19, 2001	Fire	Fires and Explosions - 911 Terrorist Attack
EM-3181-NJ	February 16, 2003 - February 17, 2003	March 20, 2003	Snow	Snow
DR-1588-NJ	April 1, 2005 - April 3, 2005	April 19, 2005	Severe Storms	Severe Storms and Flooding
EM-3257-NJ	August 29, 2005 - October 1, 2005	September 19, 2005	Hurricane	Hurricane Katrina Evacuation
DR-1694-NJ	April 14, 2007 - April 20, 2007	April 26, 2007	Severe Storms	Severe Storms and Inland and Coastal Flooding
DR-1873-NJ	December 19 – December 20 2009	February 5, 2010	Snow	Snowstorm
DR-1889-NJ	February 5, 2010 - February 6, 2010	March 23, 2010	Snow	Severe Winter Storm and Snowstorm

TETRA TECH

Disaster Number	Event Date	Declaration Date	Incident Type	Title
DR-1897-NJ	March 12, 2010 - April 15, 2010	April 2, 2010	Severe Storms	Severe Storms and Flooding
EM-3332-NJ	August 26, 2011 - September 5, 2011	August 27, 2011	Hurricane	Hurricane Irene
DR-4021-NJ	August 26, 2011 - September 5, 2011	August 31, 2011	Hurricane	Hurricane Irene
DR-4033-NJ	August 13, 2011 - August 15, 2011	September 15, 2011	Severe Storms	Severe Storms and Flooding
EM-3354-NJ	October 26, 2012 - November 8, 2012	October 28, 2012	Hurricane	Hurricane Sandy
DR-4086-NJ	October 26, 2012 - November 8, 2012	October 30, 2012	Hurricane	Hurricane Sandy
DR-4231-NJ	June 23, 2015	July 22, 2015	Severe Storm	Severe Storm
EM-3451-NJ	January 20, 2020 and continuing	March 13, 2020	Biological	Covid-19
DR-4488-NJ	January 20, 2020 and continuing.	March 25, 2020	Biological	Covid-19 Pandemic
DR-4574-NJ	August 4, 2020	December 11, 2020	Hurricane	Tropical Storm Isaias
EM-3573-NJ	September 1, 2021 – September 3, 2021	September 2, 2021	Hurricane	Remnants of Hurricane Ida
DR-4614-NJ	September 1, 2021 – September 3, 2021	September 5, 2021	Hurricane	Remnants of Hurricane Ida

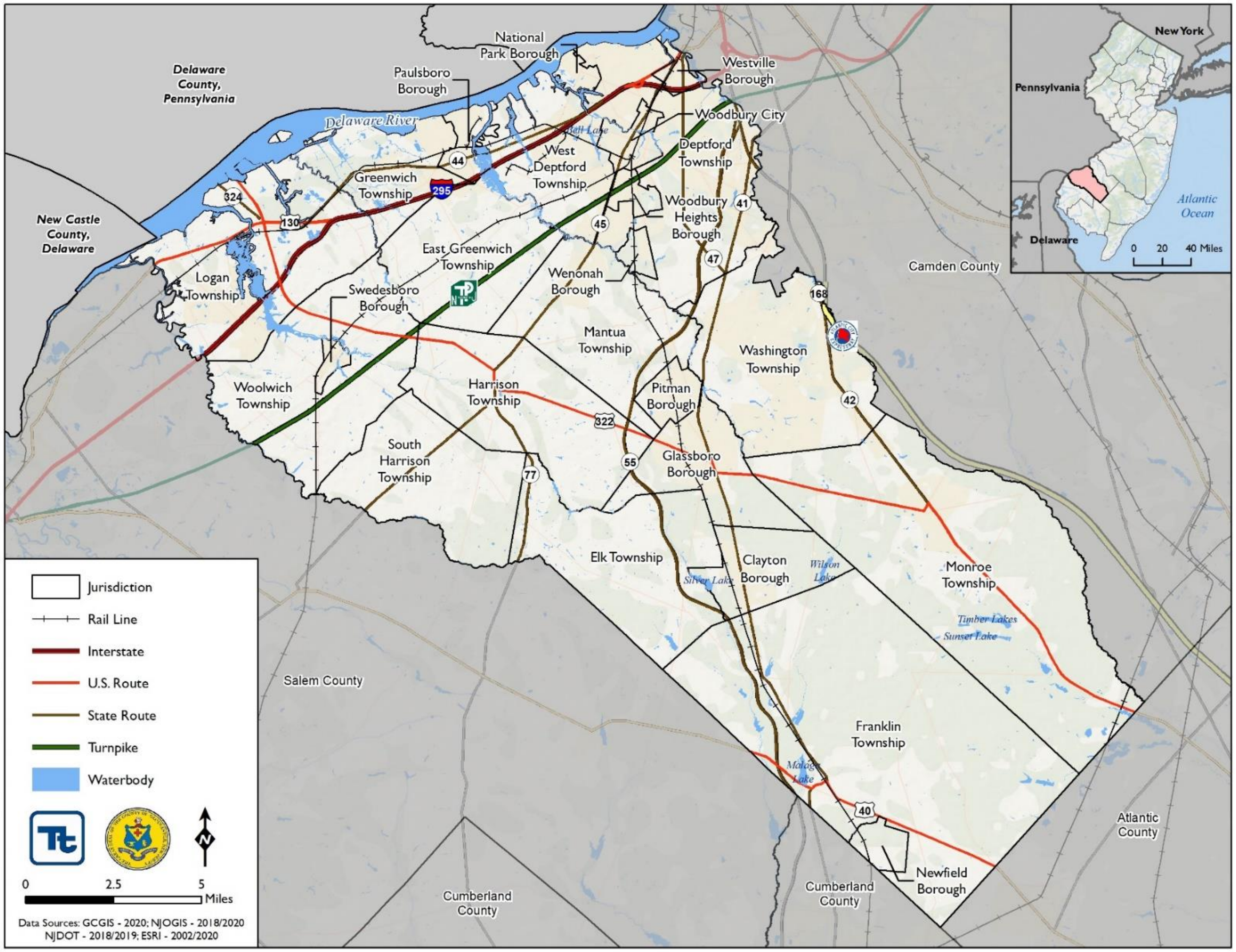
3.3 Physical Setting

This section presents the physical setting of the county, including location, hydrography and hydrology, topography and geology, climate, and land use/land cover.

3.3.1 Location

Gloucester County is in southern New Jersey. It is along the southeast side of the Delaware River, south of the City of Camden. The County comprises about 329 square miles. It is in the Outer Coastal Plain and Inner Coastal Plain Physiographic Regions. All of Gloucester County, except the tidal flats, was originally forested. The soil resources of the county greatly influenced the nature of these previously undisturbed forests and provided a great variety and abundance of tree species for use by the early colonial settlers. Early forest products included lumber, pitch, tar, charcoal, and resin. Later, trees were cut for fuel needed by rapidly growing industries. The county is largely composed of low-lying rivers and coastal plains. The highest elevation in the county is a slight rise along County Route 654 southeast of Cross Keys that reaches approximately 180 feet above sea level; the lowest point is at sea level on the Delaware River. Figure provides the location of the county and its municipalities.

Figure 3-1. Location of Gloucester County, New Jersey



3.3.2 Topography and Geology

Gloucester County is part of the Southern Delaware Valley Region which is composed of Camden, Gloucester, Salem, and Cumberland Counties. The region encompasses a highly diverse mix of land uses ranging from densely populated urban and suburban communities to the north within Camden and Gloucester Counties to smaller scattered cities and more sparsely settled agricultural and bayshore communities in Salem and Cumberland Counties in the south and west.

3.3.3 Hydrography and Hydrology

Gloucester County is situated along the Delaware River and has multiple tributaries that run through the county that flow into the river. These include Big Timber Creek, Great Egg Harbor River, Hospitality Branch, Mantua Creek, Oldmans Creek, Racoon Creek, and Scotland Run. To the Southwestern corner of the County, Racoon Creek Conserve is located towards the mouth of Racoon Creek which is home to various aquatic animals. New Jersey's rivers and streams flow either to the Atlantic Ocean or the Delaware River and Bay. There are in the Atlantic drainage or the Delaware River watershed. In Gloucester County, all except one of the streams and rivers flow to the Delaware River.

3.3.3.1 Watersheds

There are eight watersheds that are wholly or partially within Gloucester County. Two of these consist of the headwater streams of two large river systems. These watersheds occupy 39.2 percent or 131.6 square miles of Gloucester territory. These include:

- The Great Egg Harbor River watershed
- The Maurice River watershed
- The Great Egg Harbor River flows southeast and empties into the Atlantic Ocean. The Maurice River flows south to the Delaware Bay. The U.S. National Park Service has designated both of these rivers as national Scenic and Recreational Rivers, because of their importance to the nation's cultural and natural heritage. Such rivers are generally free flowing and relatively undeveloped and have features that are "outstandingly remarkable" for their scenic or recreational value.
- The other six watersheds in Gloucester County have streams that flow northwestward to the Delaware River. These six smaller watersheds make up 60.8 percent or 204.3 square miles of Gloucester County. They are, from north to south:
- The Big Timber Creek watershed, two-thirds of which is located in Camden County
- The Woodbury Creek watershed
- The Mantua Creek watershed
- The Repaupo Creek watershed
- The Raccoon Creek watershed
- The Oldmans Creek watershed, half of which is within Salem County.

3.3.3.2 Water Supply

The water supply for Gloucester County residents varies depending on the municipality. Some residents rely on public water which draws water from deep public wells while other rely on private wells which tend to be shallower.

The geology of Gloucester County is that of a tilted "layer cake" or strata of gravels, sands, silts, and clays. The saturated gravel and sand layers, with their large pore spaces, are the aquifers, from which water is drawn through wells. The silt and clay layers, which impede the movement of water, are called confining beds.

Three major aquifers exist beneath Gloucester County. These are the Potomac –Raritan – Magothy (called the PRM), the Wenonah – Mount Laurel, and the Kirkwood – Cohansey aquifer. The first two are confined aquifers, meaning that there are layers of less permeable material (silt and clay), which generally isolate the water-bearing layers from each other. These confining layers also protect the aquifer from contamination that might seep down into the groundwater from the land surface. The Kirkwood – Cohansey is close to the surface in eastern Gloucester County. Because it is unconfined, rainwater can get into it easily and resupply (recharge) the aquifer. This also makes it more vulnerable to surface contamination.

The PRM yields the most water of the three aquifers and is the primary water supply in the western half of Gloucester County, as well as in Burlington and Camden Counties and across the river in the heavily developed northern part of the state of Delaware. Because it supplies drinking water to so many people, there has been a significant decline in its water levels. As this issue progressed, the New Jersey Department of Environmental Protection established Water Supply Critical Area #2 in 1986. All water supply companies (companies and municipal utilities) within Critical Area #2 were given annual limits on water withdrawals in the PRM. Usage from the PRM was cut back by over 20 percent and no increases in pumping were allowed. The western half of the County is currently served by various public water utilities and companies that maintain large pumping stations. These facilities usually pump water from several wells and often store it in a large water tank, from which it is sent by pipes to homes and businesses in the area.

Many people living in the southeastern part of Gloucester County, including farmers who irrigate their fields, rely on private wells that draw water directly from the Kirkwood – Cohansey aquifer. A well is basically a hole drilled into an aquifer. A pipe and a pump on the property are used to pull water out of the ground and must be individually maintained by the resident. Protecting the groundwater under their property is an important responsibility for individual homeowners in these communities (Delaware Valley Regional Planning Commission Unknown).

3.3.4 Climate

The State of New Jersey is located approximately halfway between the equator and the North Pole, resulting in a climate that is influenced by wet, dry, hot and cold airstreams, making a highly variable environment. The southern portion of New Jersey tends to be more temperate than the north. The dominant feature of the atmospheric circulation over North America, including New Jersey, is the broad, undulating flow from west to east across the middle latitudes of the continent. This pattern exerts a major influence on the weather throughout the State.

As most counties in the Northeast region, Gloucester County experiences all four seasons. In winter, the average temperature is 33.2 degrees F and the average daily minimum temperature is 24.8 degrees. The lowest temperature on record, which occurred on January 22, 1984, is -8 degrees. In summer, the average temperature is 73.7 degrees and the average daily maximum temperature is 83.8 degrees. The highest recorded temperature, which occurred on July 4, 1966, is 104 degrees. The total average annual precipitation is 44.33 inches. Of this, 27.3 inches, or nearly 62 percent, usually falls in April through September. The growing season for most crops falls within this period. The heaviest 1-day rainfall during the period of record was 6.67 inches at Glassboro on August 27, 1971. Thunderstorms occur on about 30 days each year, and most occur in May or August.

The average relative humidity in midafternoon is about 55 percent. Humidity is higher at night, and the average at dawn is about 78 percent. The sun shines 63 percent of the time in summer and 52 percent in winter. The prevailing wind is from the southwest in most months. Average wind speed is highest, around 11 miles per hour, from February to April.

The average seasonal snowfall is about 5.7 inches. The greatest snow depth at any one time during the period of record was 19 inches recorded on January 8, 1996. On the average, 11 days of the year have at least 1 inch of snow on the ground. The heaviest 1-day snowfall on record was 12.5 inches recorded on February 12, 1983.

3.3.5 Land Use and Land Cover

Land use refers to the way land is developed or left in an undeveloped state. Land use in Gloucester County is diverse and varies between the mainland and resort communities. Table 3-2 identifies the classification of the municipalities.

As previously stated, from a historical context, Gloucester County used to have large areas of wooded lands that were eventually cut down for agricultural purposes. The county today is generally suburban and has pockets that are relatively urban, and others that are more rural. As depicted in Figure, a large portion of the county, approximately 50% is agricultural. This is primarily in the southern portions of the county. However, there are areas further to the north, approaching the city of Philadelphia, along the Delaware River and the boundary between Gloucester and Camden County that are classified as urban. Much of these areas are low density urban and, unlike more populated counties, have less issues around urban heatwaves. Further towards the southeast, the county has larger patches of forest intermixed with wetlands. This is primarily within the Winslow Fish and Wildlife management area that is partly within Gloucester County, Camden County, and Atlantic County. As a result, this region of the county is relatively cooler and provides vital wildlife habitat for native species. There are patches of barren land throughout the county. These are likely related to agricultural or industrial abandoned land that was previously used but might currently have disturbed soils.

Understanding a community's land use and land cover is critical to analyzing vulnerabilities. According to the New Jersey Hazard Mitigation Plan, land cover often determines how exposed a community is when it comes to flooding, erosion, landslides, ground failure, and other types of events that can cause structural damage to surrounding communities. Oftentimes, permeable surfaces like forests and grassland can significantly reduce runoff that would otherwise flood neighboring communities. On the other hand, impermeable surfaces that are often associated with urban areas, such as blacktop, can prevent seepage of runoff, causing higher water contamination as well as flooding. However, there are also other factors besides landcover that can influence these behaviors like geological composition and soil type (USGS).

Refer to Table 3-2 and Figure 3-2 below which provide information on land use land cover in Gloucester County.

Table 3-2. Land Use Summary for Gloucester County, 2019

	2007 Data		2012 Data		2015 Data	
Land Use Category	Acreage	Percent of County	Acreage	Percent of County	Acreage	Percent of County
Agriculture	43,255	21.2%	41,235	20.2%	41,294	20.2%
Barren	3,798	1.9%	3,057	1.5%	3,284	1.6%
Forest	48,722	23.8%	48,958	23.9%	48,270	23.6%
Urban	73,472	35.9%	76,105	37.2%	76,587	37.4%
Wetland	35,233	17.2%	35,103	17.2%	35,150	17.2%
Gloucester County (Total)	**204,481**	**100.0%**	**204,458**	**100.0%**	**204,585**	**100.0%**

Source: NJDEP 2015/2019

Note: 2015 LULC data was published in 2019
2012 LULC data includes 2007 and 2012 LULC published in 2019

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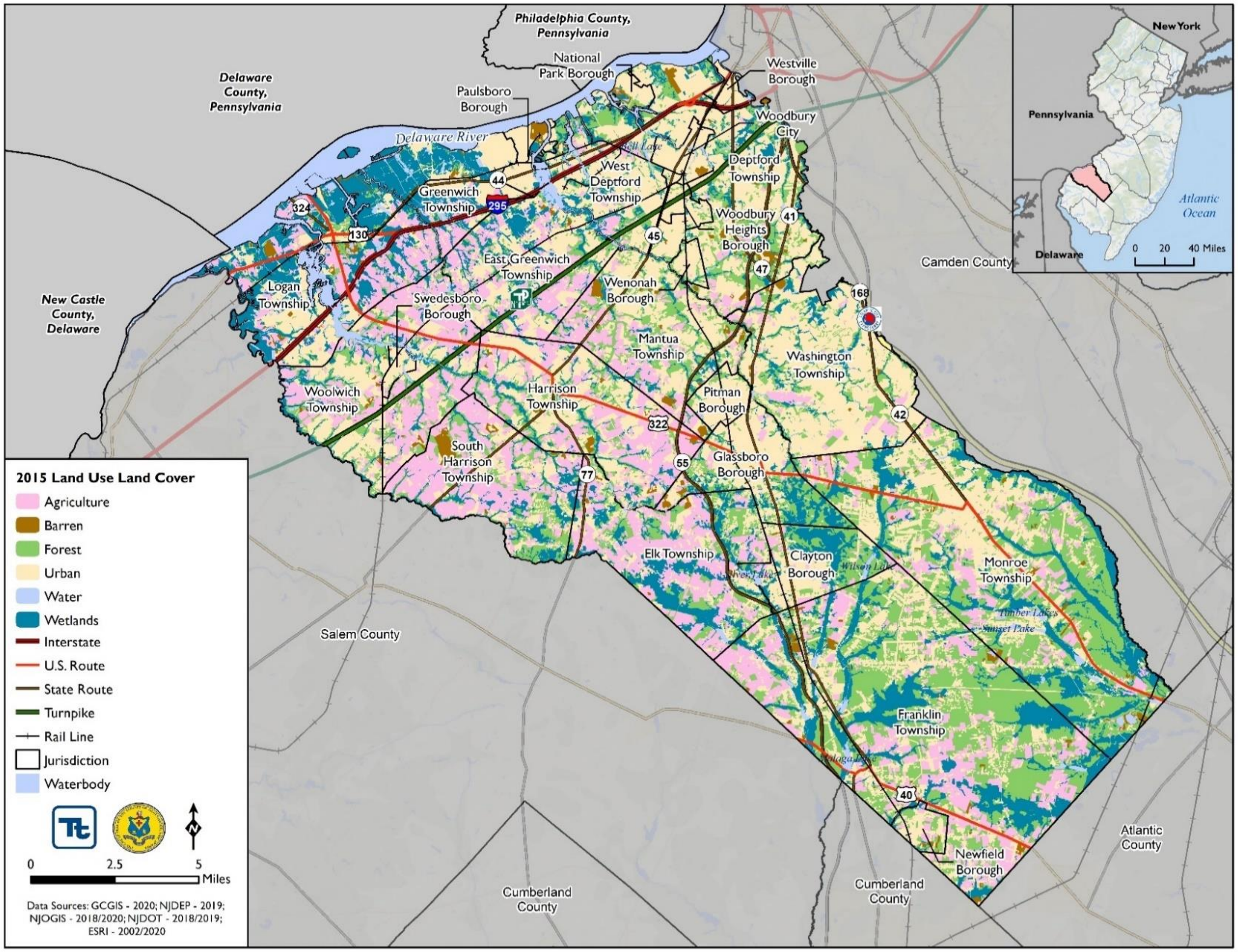
Figure 3-2. 2015 New Jersey Department of Environmental Protection (NJDEP) Land Use Land Cover for Gloucester County



3.4 Population And Demographics

> Various Census Bureau products were used as sources for the population trends section. The Decennial Census is the official population count taken every 10 years. American Community Survey 5-Year Estimates are used to show annual population changes, but it is not an official population county. 5-Year Estimates are used because they are the most accurate form of American Community Survey with the largest sample size which allows for greater accuracy at smaller geographic areas. The American Community Survey 5-Year Estimate products were used to establish annual changes in population. The numbers provided are not official census counts, but are official estimates provided to communities so that they may have a greater understanding in population changes within their jurisdictions.

An understanding of the planning area population characteristics provides a foundation for deciphering the impacts of natural hazards in the county. As noted in Section 4.2 (Methodology) of this plan, modeling of the impacts of natural hazards on the population was performed using FEMA's Hazards U.S. Multi-Hazard (HAZUS-MH) in which the available population information includes the 2010 U.S. Decennial Census data, which indicates a county population of 288,288. However, more current data, according to U.S. Census Bureau, 2019 American Community Survey 5-Year Estimate, estimates a county population of approximately 291,165, which is an increase in population since 2010. A detailed population table for the 2010 Census is shown below in Table 3-3. A detailed table for the 2019 American Community Survey is included in Table 3-3. Table 3-3 shows the distribution of the 2019 5-Year American Community Survey Population Estimates general population density (persons per square mile) by census block. Both sets of population statistics are provided for context. For the purposes of this plan, the default population data available in Hazus-MH v4.2 are used for Hazus estimated results (representing 2010 data) to support the analysis for displaced households and number of persons seeking shelter. Population exposure results are based upon the 2019 5-year American Community Survey Population Estimates.

Table 3-3. Population Statistics From 2010 Census Population Estimates for Gloucester County, New Jersey

Jurisdiction	Population (2010) Total	Percent of County Total	Over 65	Percent of Jurisdiction Total	Under 5	Percent of Jurisdiction Total
Clayton (B)	8,179	2.8%	838	10.2%	578	7.1%
Deptford (Twp)	30,561	10.6%	4,597	15.0%	1,876	6.1%
East Greenwich (Twp)	9,555	3.3%	1,007	10.5%	810	8.5%
Elk (Twp)	4,216	1.5%	507	12.0%	272	6.5%
Franklin (Twp)	16,820	5.8%	1,768	10.5%	916	5.4%
Glassboro (B)	18,579	6.4%	1,981	10.7%	1,066	5.7%
Greenwich (Twp)	4,899	1.7%	883	18.0%	260	5.3%
Harrison (Twp)	12,417	4.3%	1,041	8.4%	817	6.6%
Logan (Twp)	6,042	2.1%	408	6.8%	379	6.3%
Mantua (Twp)	15,217	5.3%	1,945	12.8%	779	5.1%
Monroe (Twp)	36,129	12.5%	4,904	13.6%	2,316	6.4%
National Park (B)	3,036	1.1%	349	11.5%	176	5.8%
Newfield (B)	1,553	0.5%	219	14.1%	76	4.9%
Paulsboro (B)	6,097	2.1%	698	11.4%	492	8.1%
Pitman (B)	9,011	3.1%	1,525	16.9%	462	5.1%
South Harrison (Twp)	3,162	1.1%	330	10.4%	185	5.9%
Swedesboro (B)	2,584	0.9%	259	10.0%	198	7.7%
Washington (Twp)	48,559	16.8%	6,048	12.5%	2,410	5.0%
Wenonah (B)	2,278	0.8%	289	12.7%	120	5.3%
West Deptford (Twp)	21,677	7.5%	3,116	14.4%	1,159	5.3%
Westville (B)	4,288	1.5%	499	11.6%	241	5.6%
Woodbury (C)	10,174	3.5%	1,423	14.0%	710	7.0%
Woodbury Heights (B)	3,055	1.1%	415	13.6%	164	5.4%
Woolwich (Twp)	10,200	3.5%	650	6.4%	930	9.1%
Gloucester County (Total)	**288,288**	**100.0%**	**35,699**	**12.4%**	**17,392**	**6.0%**

Source: U.S. Census Bureau 2010

Table 3-4. Population Statistics From 2019 5-Year American Community Survey for Gloucester County, New Jersey

	Population (2015-2019 American Community Survey Estimates)											
Jurisdiction	Total	Percent of County Total	Over 65	Percent of Jurisdiction Total	Under 5	Percent of Jurisdiction Total	Non-English Speaking	Percent of Jurisdiction Total	Disability	Percent of Jurisdiction Total	Poverty Level	Percent of Jurisdiction Total
Clayton (B)	8,626	3.0%	1,484	17.2%	448	5.2%	225	2.6%	1,365	15.8%	869	10.1%
Deptford (Twp)	30,448	10.5%	5,337	17.5%	1,602	5.3%	1,142	3.8%	4,403	14.5%	2,021	6.6%
East Greenwich (Twp)	10,488	3.6%	1,547	14.8%	789	7.5%	282	2.7%	913	8.7%	300	2.9%
Elk (Twp)	4,135	1.4%	668	16.2%	124	3.0%	163	3.9%	591	14.3%	315	7.6%
Franklin (Twp)	16,440	5.6%	2,220	13.5%	865	5.3%	253	1.5%	2,613	15.9%	1,187	7.2%
Glassboro (B)	19,826	6.8%	2,395	12.1%	943	4.8%	776	3.9%	3,036	15.3%	4,287	21.6%
Greenwich (Twp)	4,831	1.7%	983	20.3%	183	3.8%	105	2.2%	602	12.5%	534	11.1%
Harrison (Twp)	12,995	4.5%	1,340	10.3%	753	5.8%	103	0.8%	975	7.5%	244	1.9%
Logan (Twp)	5,924	2.0%	645	10.9%	227	3.8%	203	3.4%	706	11.9%	229	3.9%
Mantua (Twp)	14,941	5.1%	2,313	15.5%	713	4.8%	107	0.7%	1,919	12.8%	724	4.8%
Monroe (Twp)	36,789	12.6%	5,892	16.0%	1,729	4.7%	1,040	2.8%	4,597	12.5%	1,983	5.4%
National Park (B)	2,959	1.0%	404	13.7%	175	5.9%	37	1.3%	570	19.3%	278	9.4%
Newfield (B)	1,521	0.5%	272	17.9%	38	2.5%	25	1.6%	225	14.8%	80	5.3%
Paulsboro (B)	5,904	2.0%	799	13.5%	351	5.9%	195	3.3%	1,062	18.0%	1,059	17.9%
Pitman (B)	8,805	3.0%	1,665	18.9%	398	4.5%	52	0.6%	1,225	13.9%	1,053	12.0%
South Harrison (Twp)	3,148	1.1%	406	12.9%	200	6.4%	77	2.4%	272	8.6%	234	7.4%
Swedesboro (B)	2,579	0.9%	191	7.4%	174	6.7%	389	15.1%	317	12.3%	236	9.2%
Washington (Twp)	47,833	16.4%	8,203	17.1%	2,517	5.3%	1,252	2.6%	5,194	10.9%	1,816	3.8%
Wenonah (B)	2,259	0.8%	328	14.5%	104	4.6%	37	1.6%	211	9.3%	41	1.8%
West Deptford (Twp)	21,149	7.3%	3,820	18.1%	1,147	5.4%	648	3.1%	3,230	15.3%	943	4.5%
Westville (B)	4,169	1.4%	536	12.9%	228	5.5%	66	1.6%	769	18.4%	492	11.8%
Woodbury (C)	9,861	3.4%	1,604	16.3%	640	6.5%	492	5.0%	1,740	17.6%	1,888	19.1%
Woodbury Heights (B)	2,986	1.0%	417	14.0%	236	7.9%	39	1.3%	366	12.3%	130	4.4%
Woolwich (Twp)	12,549	4.3%	1,325	10.6%	789	6.3%	543	4.3%	832	6.6%	397	3.2%
Gloucester County (Total)	**291,165**	**100.0%**	**44,794**	**15.4%**	**15,373**	**5.3%**	**8,251**	**2.8%**	**37,733**	**13.0%**	**21,340**	**7.3%**

Source: *American Community Survey - 2019 (5-year estimates 2015-2019)*
Note: *Pop. = population*
** Individuals below poverty level (Census poverty threshold in 2019 for a 3-person family unit is approximately $20,335)*

3.4.1 Vulnerable Populations

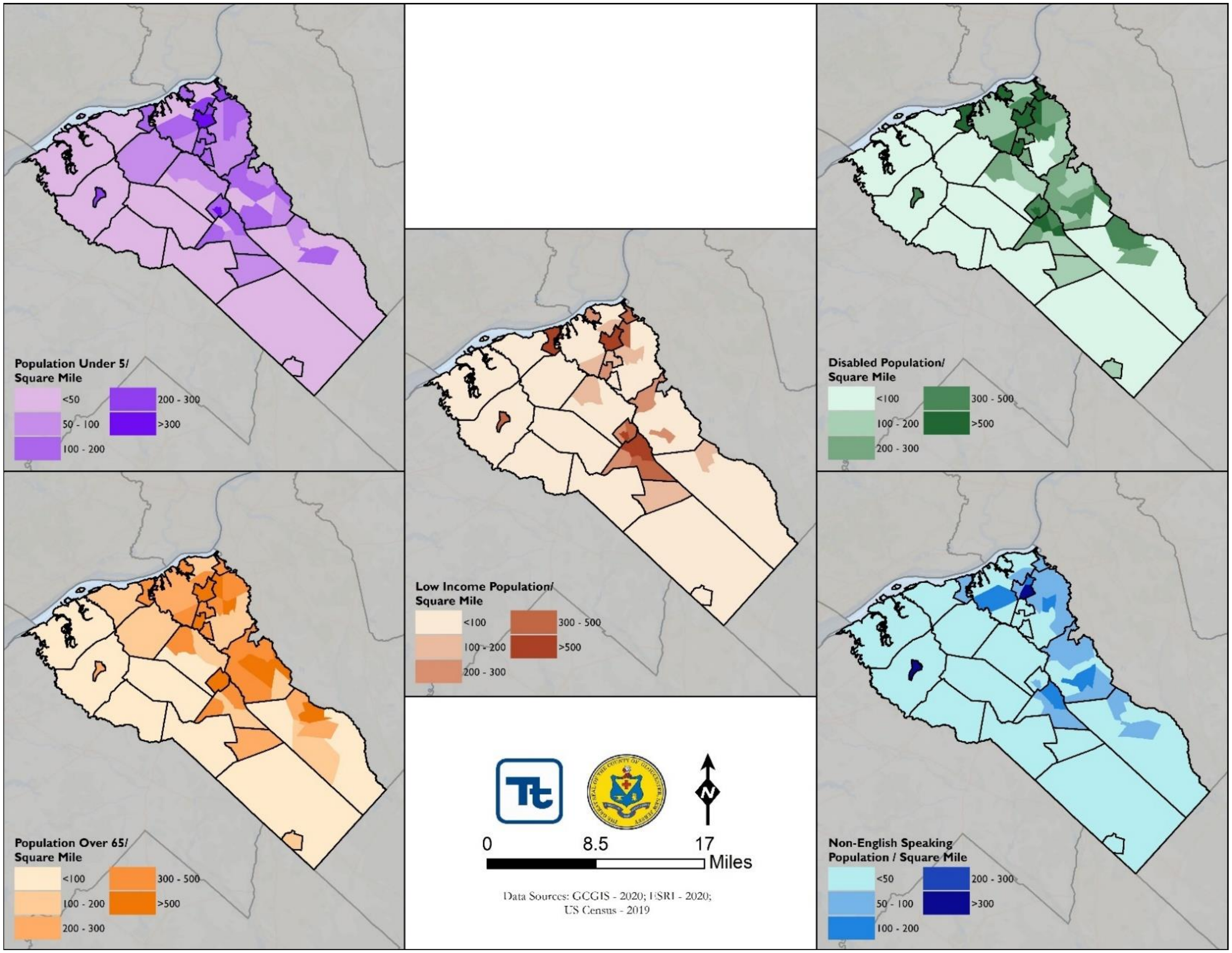
DMA 2000 requires that HMPs consider socially vulnerable populations. These populations can be more susceptible to hazard events based on several factors, including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. The vulnerable populations in the 2016 Hazard Mitigation Plan include (1) the elderly (persons aged 65 and over) and (2) those living in low-income households. In the current plan, additional vulnerable populations are identified including: the physically or mentally disabled, and non-English speakers. Identifying concentrations of vulnerable populations can assist communities in targeting preparedness, response and mitigation actions.

Populations with a higher level of vulnerability can be more seriously affected during an emergency or disaster. Vulnerable populations have unique needs that need to be considered by public officials to help ensure the safety of demographics with a higher level of risk. Refer to Table 3-4, which summarizes Gloucester County's 2019 5-Year Population Estimates Vulnerable Population Statistics by jurisdiction.

3.4.1.1 Age

Children are considered vulnerable to hazard events because they are dependent on others to safely access resources during emergencies and may experience increased health risks from hazard exposure. The elderly is more likely to lack the physical and economic resources necessary for response to hazard events and are more likely to suffer health-related consequences. Those living on their own may have more difficulty evacuating their homes. The elderly also is more likely to live in senior care and living facilities where emergency preparedness occurs at the discretion of facility operators. According to the 2019 American Community Survey 5-Year Estimates, the median age in Gloucester County was 40.7 years. The 2019 American Community Survey reports 5.3-percent of the population of Gloucester County is under the age 5. Of the 2019 population, 15.4-percent of the county's population is age 65 and older. Figure 3-3 shows the distribution of persons over age 65, persons under age 5, low income population, disabled population, and non-English speaking persons.

Figure 3-3. Distribution and Density of Vulnerable Populations in Gloucester County, New Jersey



3.4.1.2 Income

The 2019 American Community Survey 5-Year Estimates provides that the median household income in Gloucester County was $89,447. The U.S. Census Bureau identifies households with two adults and two children with an annual household income below $25,926 per year as *low income* (Census 2021). The 2019 American Community Survey 5-Year Estimates indicates that 7.3-percent persons live below the poverty level within the County.

3.4.1.3 Physically or Mentally Disabled

According to the Centers for Disease Control, "Persons with a disability include those who have physical, sensory, or cognitive impairment that might limit a major life activity (Centers for Disease Control 2015)." Cognitive impairments can increase the level of difficulty that individuals might face during an emergency and reduce an individual's capacity to receive, process, and respond to emergency information or warnings. Individuals with a physical or sensory disability can face issues of mobility, sight, hearing, or reliance on specialized medical equipment. According to the 2014-2019 American Community Survey, 37,733 residents in Gloucester County are living with a disability. Figure 3-3 shows the geographic distribution of disabled individuals throughout Gloucester County, including individuals living with hearing, vision, cognitive, ambulatory, self-care, and independent living difficulties.

3.4.1.4 Non-English Speakers

Individuals who are not fluent or working proficiency in English are vulnerable because they can have difficulty with understanding information being conveyed to them. Cultural differences also can add complexity to how information is being conveyed to populations with limited proficiency of English (Centers for Disease Control 2015). According to the 2015-2019 American Community Survey, 24,819 individuals over the age of 5 primarily speaks a language other than English at home; within that group approximately 8,251 individuals are reported as speaking English "less than very well." Of the county's population, 10,270 speak Spanish, 4,827 speak Asian and Pacific Island languages and 7,590 percent speak other Indo-European languages. Figure 3-3 shows the geographic distribution of individuals who speak English less than "very well."

3.4.2 General Building Stock

The 2015-2019 American Community Survey data identifies 113,485 household units in Gloucester County. The U.S. Census Bureau defines household as all the persons who occupy a housing unit and a housing unit as a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or if vacant, is intended for occupancy) as separate living quarters. The median price of a single-family home in Cape May County was estimated at $236,900 in 2019 (American Community Survey 5-Year Estimates).

For this update, a customized general building stock was created using building footprints and parcel data from the County, which was supplemented with county provided data and 2021 RS Means replacement cost value for building and content replacement costs. Contents for residential structures are valued at 50-percent of the building's value. For non-residential facilities, the value of the contents are valued at 100-percent of the building's structural value.

The updated building inventory contains 113,093 buildings with a total building replacement value (structure and content) of approximately $59.3 billion. This inventory was incorporated into Hazus at the structure and aggregate level. Approximately 90-percent of the buildings (101,804 buildings) and 61.5-percent of the building stock replacement value (approximately $61.2 billion) are associated with residential housing. Commercial buildings make up the second building classification at approximately 24.1-percent of the total building replacement value. Washington Township has the greatest number of structures at with 17,413 and the Newfield Borough has the smallest number of structures with 891.

Figure 3-4 through Figure 3-6 show the distribution and exposure density of residential and, commercial, and industrial buildings in Gloucester County. Exposure density is the dollar value of structures per unit area, including building content value. Generally, contents for residential structures are valued at about 50 percent of the building's value. For commercial facilities, the value of the contents is generally about equal to the building's structural value. The densities are shown in units of $1,000 ($K) per square mile. Viewing exposure distribution maps, such as Figure 3-4 throughs Figure 3-6 can assist communities in visualizing areas of high exposure and in evaluating aspects of the study area in relation to the specific hazard risks.

Figure 3-4: Distribution of Residential Building Stock and Value Density in Gloucester County, New Jersey

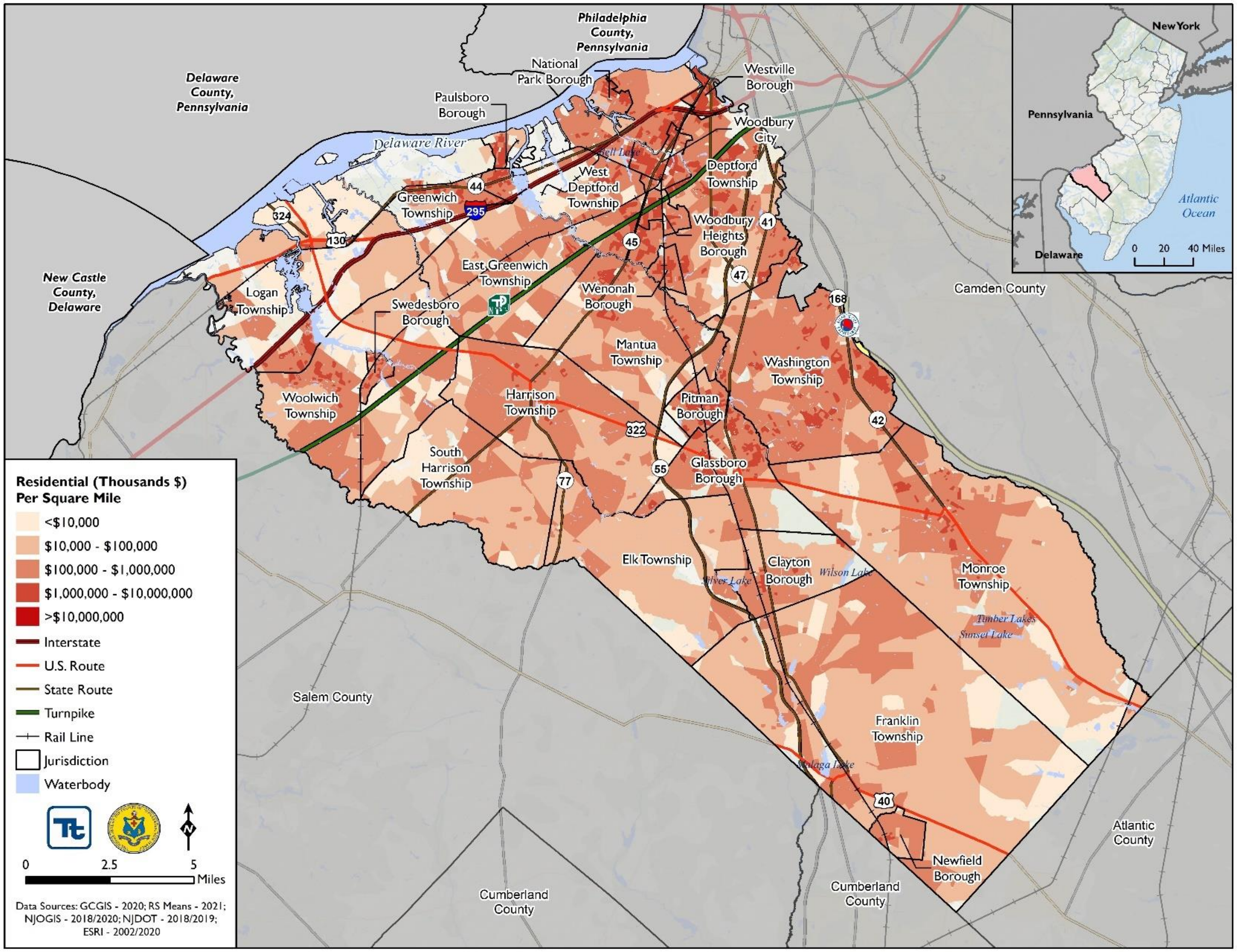


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Figure 3-5: Distribution of Commercial Building Stock and Exposure Density in Gloucester County, New Jersey

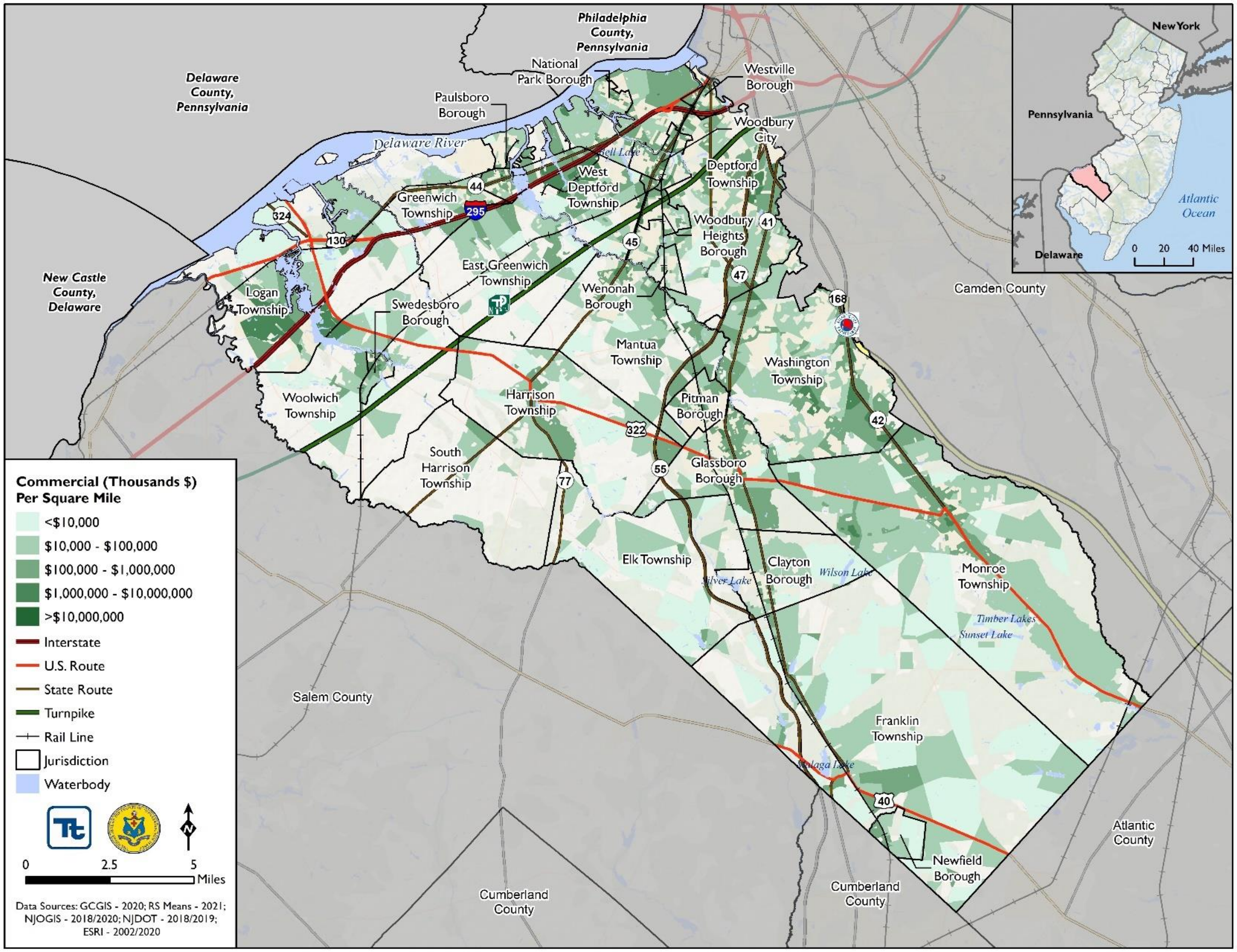
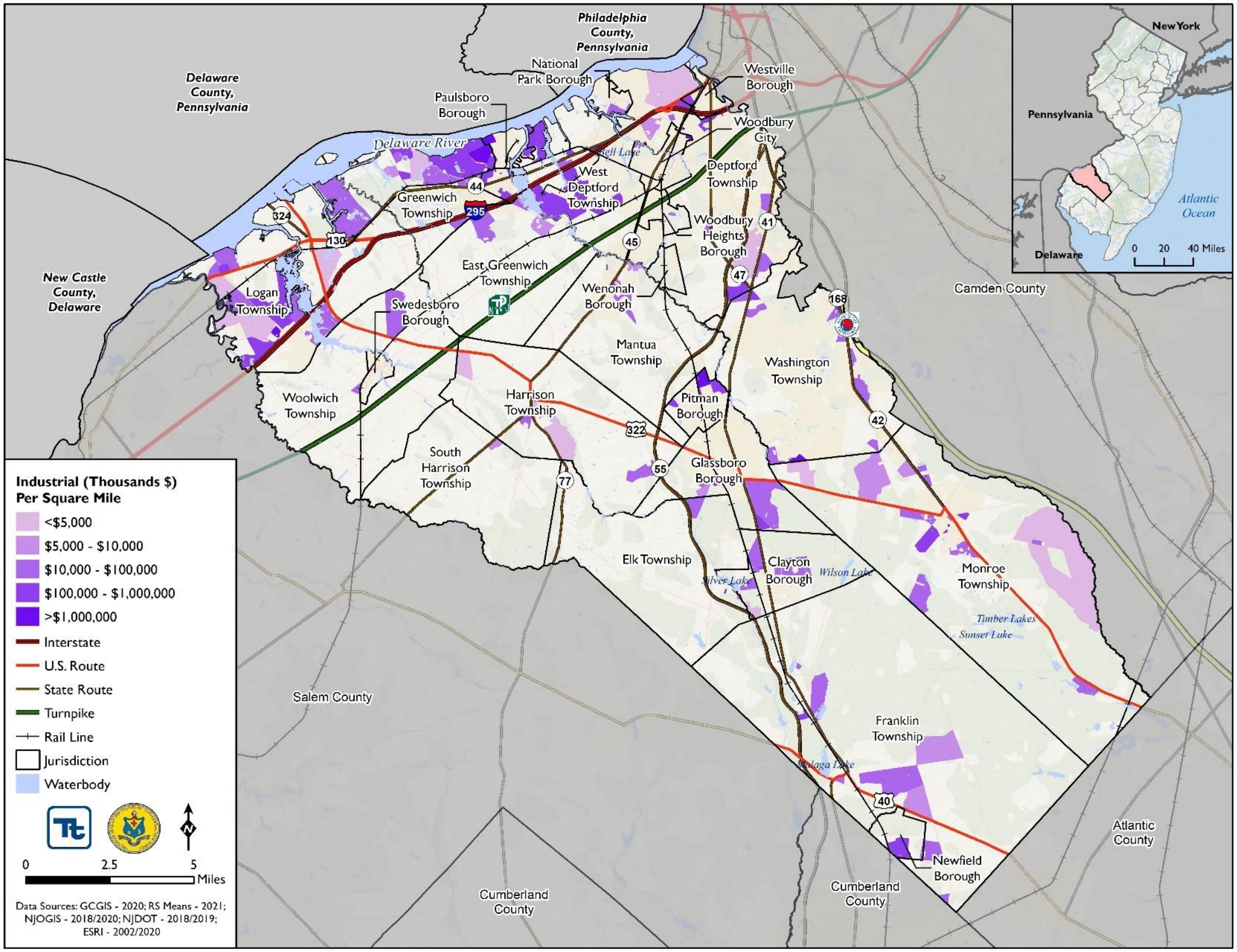


Figure 3-6: Distribution of Industrial Building Stock and Value Density in Gloucester County, New Jersey



3.5 Land Use And Population Trends

Local zoning and planning authority is provided for under the New Jersey Municipal Land Use Law, which gives municipalities zoning and planning authority. DMA 2000 requires that communities consider land use trends, which can impact the need for, and priority of, mitigation options over time. Land use trends significantly impact exposure and vulnerability to various hazards. For example, significant development in a hazard area increases the building stock and population exposed to that hazard.

This plan provides a general overview of population and land use and types of development occurring within the study area. An understanding of these development trends can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place to protect human health and community infrastructure.

3.5.1 Land Use Trends

Gloucester County is relatively sprawling suburban development with generally increased urban density towards the north, increased forest towards the southeast, and agricultural lands to the southern boundary. This slow urbanization with increasing population has and will likely influence the increase of impermeable surfaces and reduced green space. A recent trend in land use in some areas has been the loss of some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and less productive and cannot be easily cultivated. These various factors could lead to increased erosion, degraded soil quality, degraded water quality, and loss of habitat for wildlife (USDA 2007)

3.5.1.1 Economy

The U.S. Census Bureau's County Business Pattern provides an annual series of sub-national economic data by industry covering the majority of the country's economic activity. According to the 2016 Gloucester County Business Pattern, the county had a total of 5,958 business establishments. These businesses provided more than $3.8 billion in payroll. Three industries dominate private employment in the County: education and healthcare services, retail trade manufacturing, and arts and entertainment. Table 3-5. provides 2017 industry and employment information in Cape May County exclusive of public administration.

Table 3-5. 2017 Economic Census for Gloucester County, New Jersey

Industry	Number of Establishments	Annual Payroll ($1,000)	Number of Employees
Total for all sectors	5,958	$1,106,046	93,340
Agriculture, forestry, fishing and hunting, and mining	5	2,743,687	11
Construction	705	10,207,602	20
Manufacturing	230	15,651,460	8,037

Industry	Number of Establishments	Annual Payroll ($1,000)	Number of Employees
Wholesale trade	335	4,016,566	8,402
Retail trade	905	17,267,009	17,466
Transportation and warehousing, and utilities	208	8,305,602	4,308
Information	96	3,114,222	1,294
Finance and insurance, and real estate and rental and leasing	252	10,151,206	1,799
Professional, scientific, and management, and administrative and waste management services	519	17,924,655	3,718
Educational services, and health care and social assistance	74	35,840,954	16,141
Arts, entertainment, and recreation, and accommodation and food services	95	14,962,299	1,447
Other services, except public administration	676	7,522,777	4,493
Public administration	394	7,134,146	7,867

Source: U.S. Census, County Business Pattern 2016

3.5.1.2 Zoning

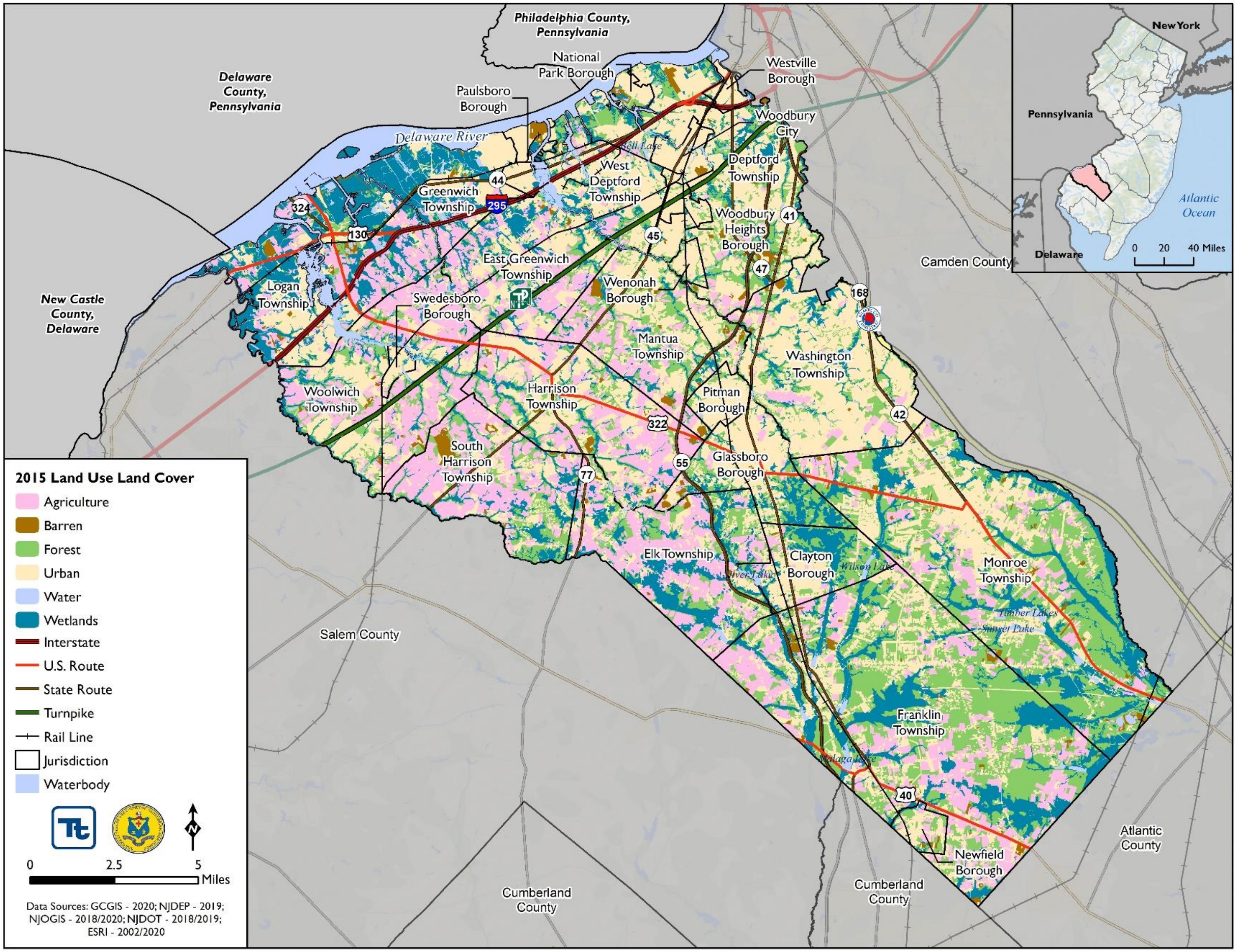
Historical land use patterns show how the community has developed over time. Zoning and related ordinances are used to guide development within the county and largely reflect the existing and desired development patterns. Traditional zoning divides a community into various districts and permits or disallows land uses by zoning district. Much of the County's land area (approximately 37.4-percent) is set aside for urban (or residential) uses, followed by forested land at 23.6-percent. Agricultural zoning makes up 20.2-percent of the County's total land area (NJDEP 2019). The County pays attention to zoning policies and enforcement to make sure development occurs in a way that is consistent with the County's master plan for maintaining a desirable quality of life (County, Quality of Life 2021). Table 3-6. and Figure 3-7. display the local zoning information for Gloucester County.

Table 3-6. Local Zoning in Gloucester County, New Jersey (2015)

Zoning Category	Acres	Percent
Agriculture	41,294	20.2%
Barren	3,284	1.6%
Forest	48,270	23.6%
Urban	76,587	37.4%
Wetland	35,150	17.2%
Gloucester County (Total)	**204,585**	**100.0%**

Source: NJDEP 2019

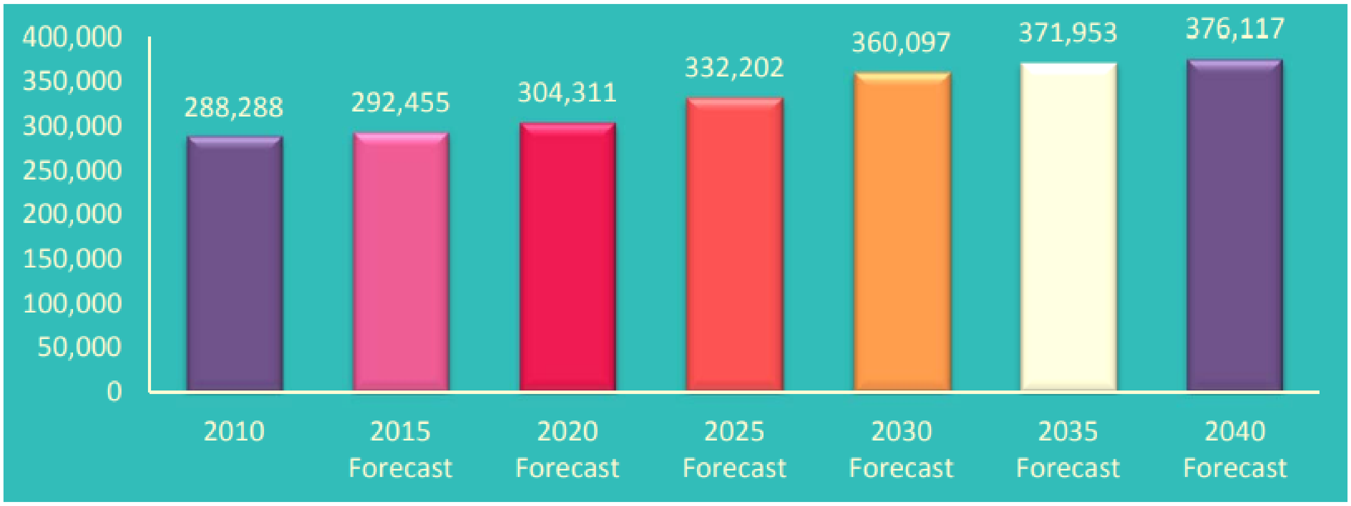
Figure 3-7. Countywide Zoning in Gloucester County, New Jersey



3.5.2 Population Trends

Gloucester County is one of the fastest-growing counties in its area, experiencing a 13-percent (33,615) growth in population between 2000 and 2010. Between 2010 and 2020, Gloucester County experienced a 1.7-percent increase in population, from 288,288 (2010) to 304,311 (2020). This trend is expected to continue through 2040 as its projected population growth is estimated at over 25-percent (87,829), reaching 376,117 residents by 2040 (DVRPC 2015).

Figure 3-8. Gloucester County Population Forecasts through 2040



Source: DVRPC 2015

3.5.3 Future Growth and Development

The National Economic Recession of 2008 has had a significant impact on all New Jersey counties, for Gloucester County and 2009 and 2010 were particularly challenging, job growth stagnated and unemployment rates skyrocketed. There were three major corporate layoffs announced between 2009 and 2012. Since 2012, the local economy has moderated and our business environment has begun to improve. In 2013 New business coming into Gloucester County that has worked with the department represents 1.6 million sq. ft. of new or renovated space, 604 new jobs, 448 retained jobs and $41.5 million dollars in new investment in the County.

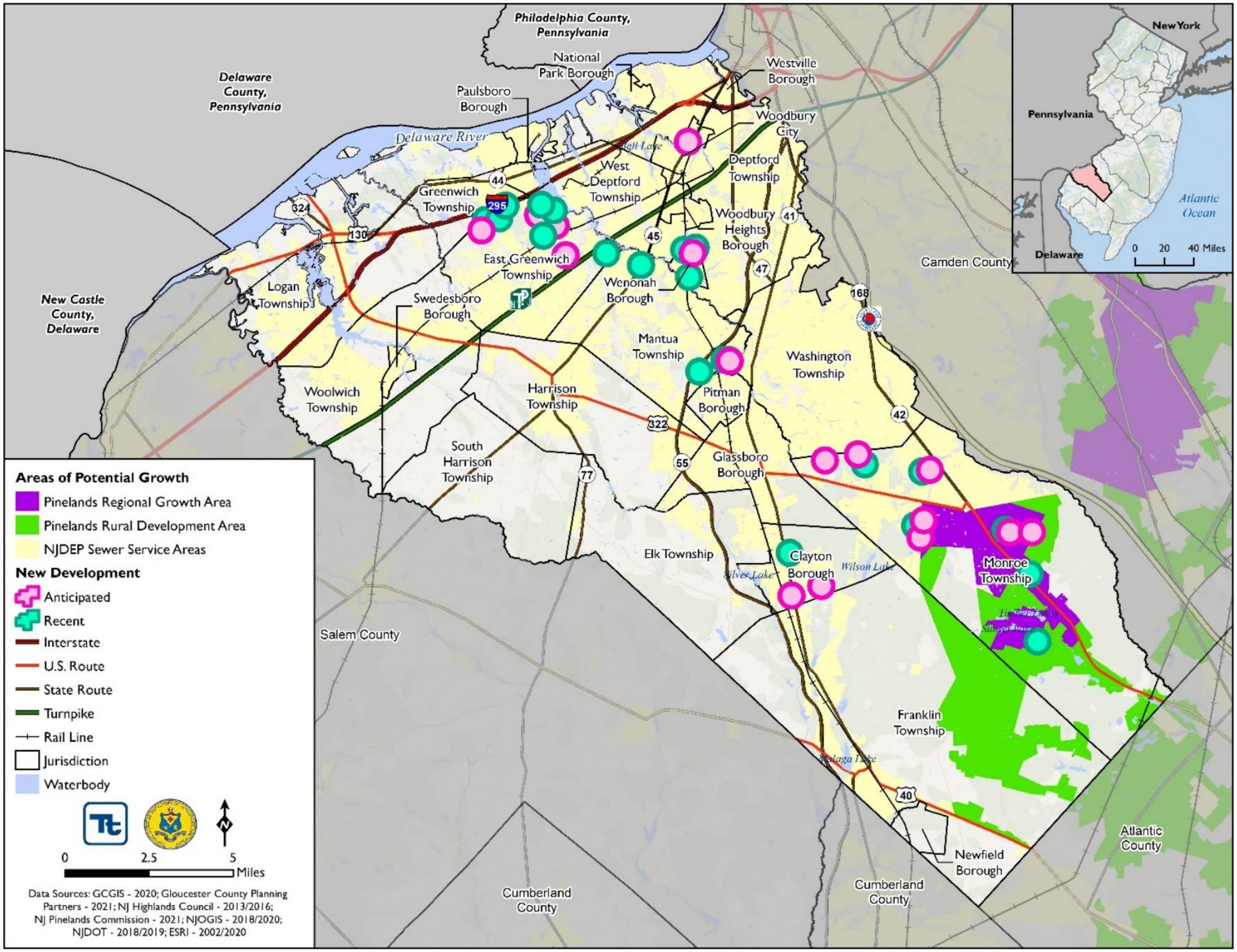
Gloucester County has attractive and varied landscapes and an abundance of developable land. This, along with the County's close proximity to historically major metro areas like Camden, Philadelphia, Atlantic City and Wilmington, assisted the County to witness considerable growth between 1970 to 2000. The trend of population growth has continued and according to the Delaware Valley Regional Planning Commission, Gloucester County is expected to see a 30.5% population change from 2010-2040. DVRPC has recognized that Gloucester County will see the largest percent change in population growth in the nine-county DVRPC region.

TETRA TECH

According to the County Economic Development Plan, the medical and healthcare services and agribusiness are expected to drive the economic development in the County. For communities located along the waterfront of the Delaware River, communities are expected to see an increase in port and waterfront development.

A summary of development planned within Gloucester County is provided in the Figure 3-9 below. This figure shows areas of potential growth in the Pinelands Regional and Pinelands Rural Areas, along with NJDEP Sewer Service Areas, and areas identified for new development by each municipality. Locations of development are indicated on the Hazard Area Extent and Location Maps included in Section 9 (Jurisdictional Annexes).

Figure 3-9. Planned Development in Gloucester County, New Jersey



3.6 Lifelines and Critical Facilities

Critical infrastructure and facilities are those that are essential to the health and welfare of the population. These facilities are especially important after any hazard event. Critical facilities are those that maintain essential and emergency functions and are typically defined to include police and fire stations, schools, and emergency operations centers. Critical infrastructure can include the roads and bridges that provide ingress and egress and allow emergency vehicles access to those in need and the utilities that provide water, electricity, and communication services to the community. Also included are Tier II facilities (hazardous materials) and rail yards; rail lines hold or carry significant amounts of hazardous materials with a potential to impact public health and welfare in a hazard event.

Critical Facilities are those facilities considered critical to the health and welfare of the population and that are especially important following a hazard. As defined for this HMP, critical facilities include transportation systems, lifeline utility systems, high-potential loss facilities, and hazardous material facilities, and essential facilities

Essential facilities are a subset of critical facilities that include those facilities that are important to ensure a full recovery following the occurrence of a hazard event. For the county risk assessment, this category was defined to include police, fire, EMS, schools/colleges, shelters, senior facilities, and medical facilities.

Lifelines enable the continuous operation of critical business and government functions and are essential to human health and safety or economic security.

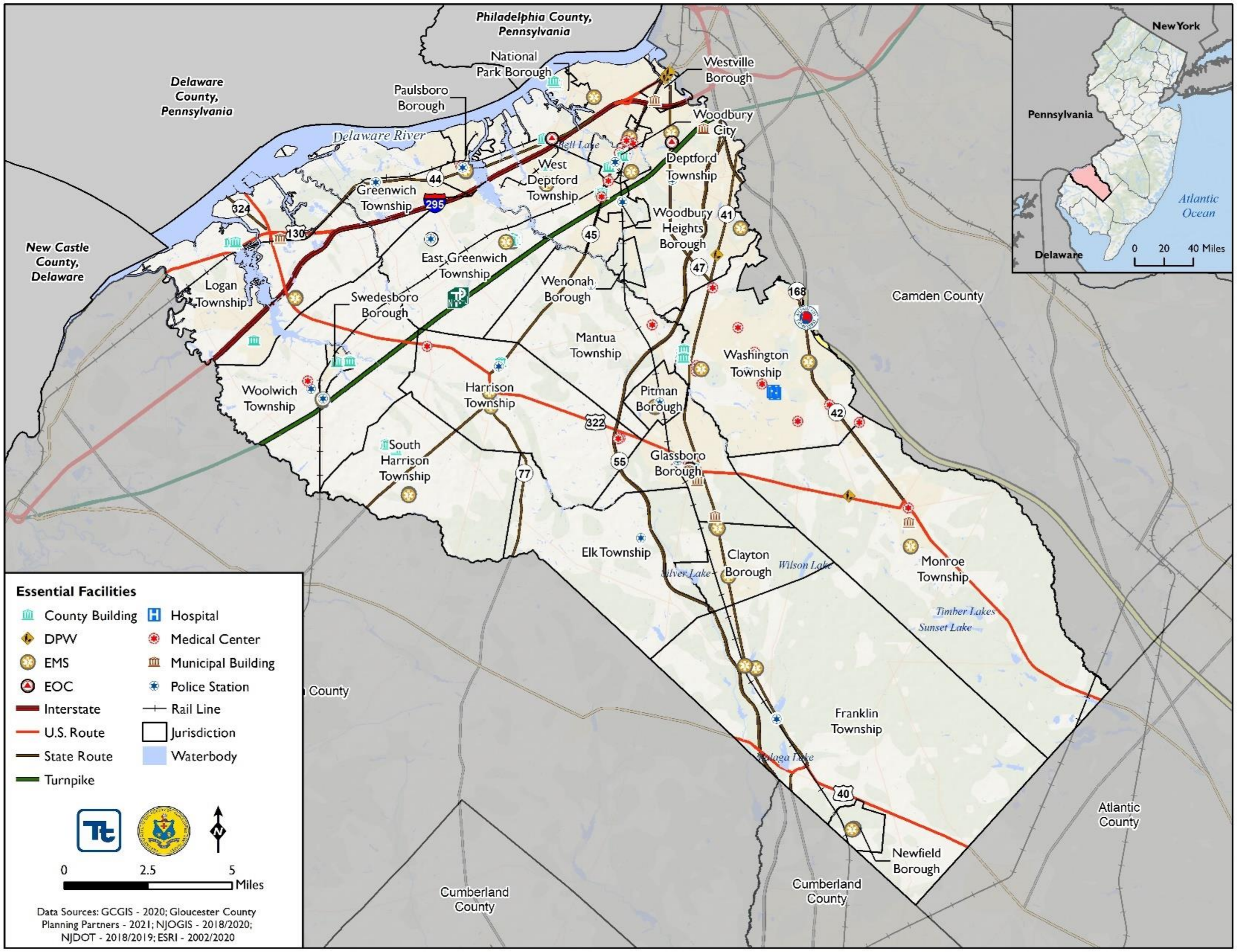
Beginning in 2017, FEMA developed a new construct to increase effectiveness for disaster operations and position response to catastrophic incidents. This construct, known as "community lifelines", represents the most fundamental services in the community that, when stabilized, enable all other aspects of society. Following a disaster event, intervention is required to stabilize community lifelines. Lifelines are divided into seven categories which include:

- Safety and Security
- Food, Water, Shelter
- Health and Medical
- Energy (Power and Fuel)
- Communications
- Transportation
- Hazardous Materials

To facilitate consistency with the National Response Framework, FEMA Strategic Plan, and guidance for the Building Resilient Infrastructure and Communities grant program, critical facilities in Gloucester County are discussed in terms of lifelines.

A comprehensive inventory of critical facilities and lifelines in Gloucester County was developed from various sources including input from the Planning Committees. The inventory of critical facilities presented in this section represents the current state of this effort at the time of publication of the HMP and was used for the risk assessment in Section (Risk Assessment). Figure 3-10 shows the location of Gloucester County lifelines.

Figure 3-10. Planning Area Critical Facilities in Gloucester County, New Jersey



TETRA TECH

3.6.1 Safety and Security

This section provides information on Safety and Security lifelines. Components of this lifeline category include law enforcement/security, fire services, search and rescue services, government services, and community safety (e.g. dams). There are 481 safety and security lifelines in Gloucester County.

3.6.1.1 Emergency Facilities

For the purposes of this HMP, emergency facilities include police, fire, EMS and emergency operations centers. Emergency facilities are shown in Figure 3-10. There are 47 emergency facilities in Gloucester County.

3.6.1.2 Schools

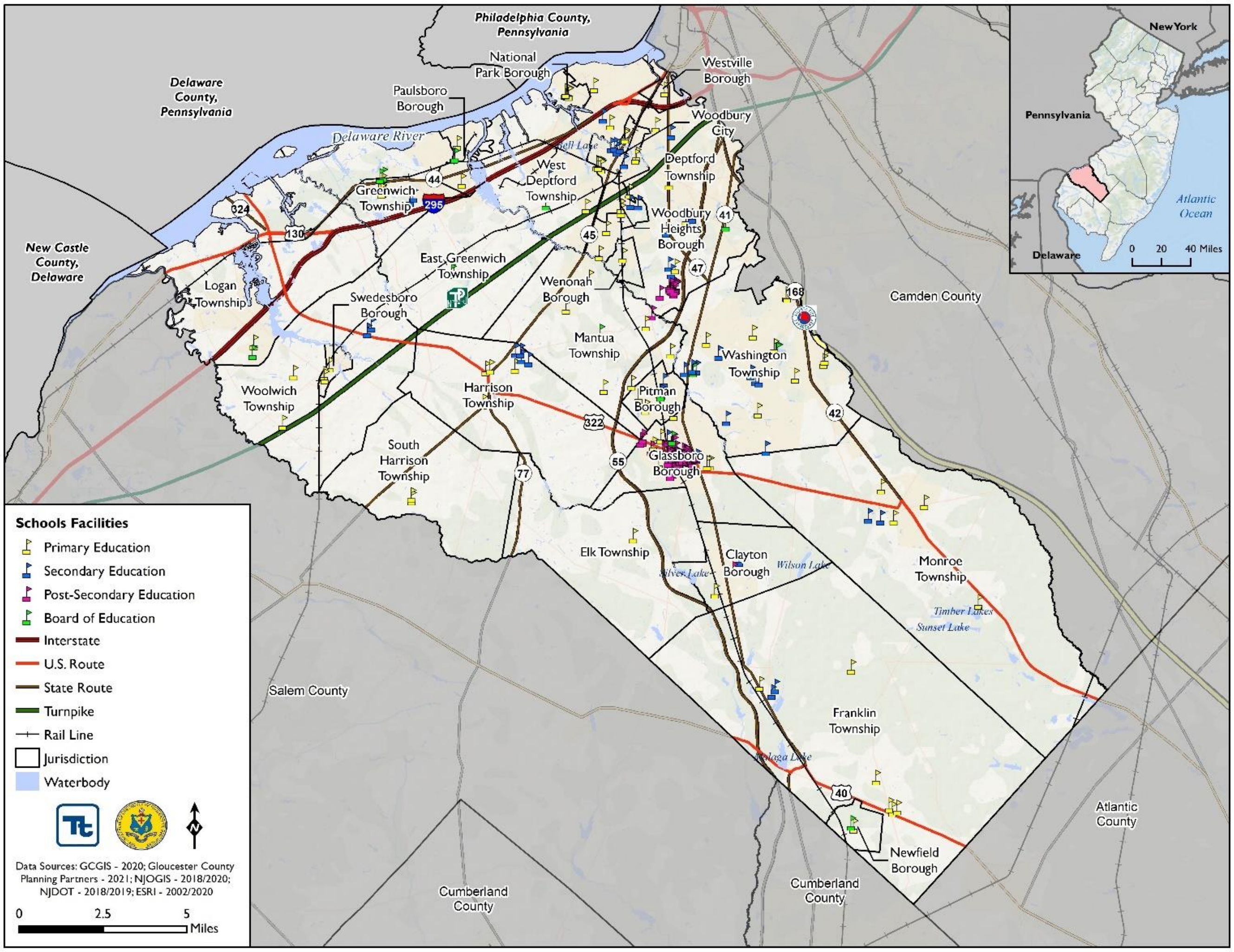
There are 104 schools, ranging from elementary to post-secondary education, service the County. During an emergency event, some of these facilities function as shelters. Schools are shown in Figure 3-11. Rowan University is the major post-secondary education facility in Gloucester County. The County is home to 28 public school districts as of 2020. The table below shows the school districts and their enrollment.

Table 3-7. Gloucester County School District Enrollment

District	Enrollment (2019-2020)	Enrollment (2010-2011)	Change (#)	Change (%)
Clayton Borough	1470	1,338	-132	-8.98%
Clearview Regional	2254	2,524	270	11.98%
Deptford Twp	4061.5	4,374	313	7.69%
East Greenwich Twp	1318	1,009	-309	-23.44%
Elk Twp	323	388	65	20.12%
Franklin Twp	1421	1395	-26	-1.83%
Gateway Regional	900	858	-42	-4.67%
Glassboro	1925	2239	314	16.31%
Gloucester Co Spec Serv	563	603	40	7.10%
Gloucester Co Vocational	1522.5	1138	-385	-25.25%
Greenwich Twp	442	476	34	7.69%
Harrison Twp	1420	1496	76	5.35%
Kingsway Regional	2796	2223	-573	-20.49%
Logan Twp	836	868	32	3.83%
Mantua Twp	1263	1419	156	12.35%
Monroe Twp	5665	6017	352	6.21%
National Park Borough	289	288	-1	-0.35%
Paulsboro Borough	1165	1207	42	3.61%
Pitman Borough	1234	1499	265	21.47%
South Harrison Twp	330	368	38	11.52%
Delsea Regional H.S Dist.	1616	NA	NA	NA
Swedesboro-Woolwich	1581	1722	141	8.92%
Washington Twp	7205	8427	1,222	16.96%
Wenonah Borough	166	255	89	53.61%
West Deptford Twp	2955.5	3096	141	4.75%
Westville Borough	359	336	-23	-6.41%

District	Enrollment (2019-2020)	Enrollment (2010-2011)	Change (#)	Change (%)
Woodbury City	1609	1547	-62	-3.85%
Woodbury Heights Borough	248	218	-30	-12.10%
Total	**46937.5**	**47,328**	**391**	**0.83%**

Figure 3-11. Schools in Gloucester County



3.6.1.3 Government Buildings

Government buildings – specifically those operated by County and municipal governments – are invaluable lifelines during hazard events. These include both municipal office buildings as well as facilities owned and operated by the County government and municipal governments that support various functions, including public works, administration, public safety, and recreation. There are 61 government buildings located in the County.

3.6.1.4 Dams and Levees

Dams

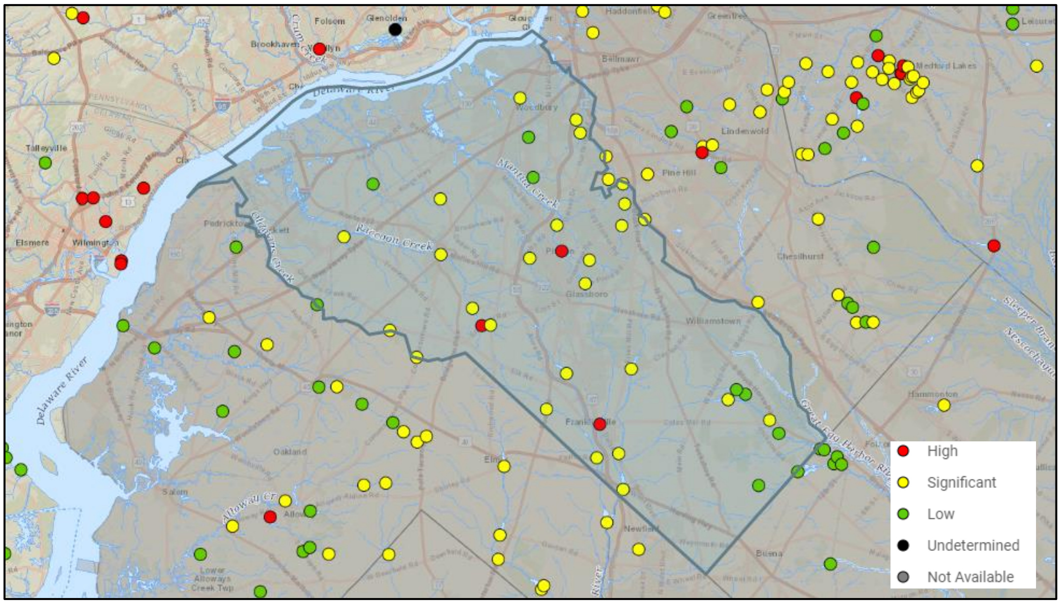
For the purpose of this HMP Update, dams are not considered critical facilities, as the Steering and Planning Committees recognizes that these facilities are covered by other regulatory instruments. However, a summary of the dams in the County is presented in this section to provide an awareness of the number and types of these structures within the County.

According to the NJDEP, there are four hazard classifications of dams in New Jersey. The classifications relate to the potential for property damage and/or loss of life should the dam fail:

- Class I (High-Hazard Potential) - Failure of the dam may result in probable loss of life and/or extensive property damage
- Class II (Significant-Hazard Potential) - Failure of the dam may result in significant property damage; however, loss of life is not envisioned
- Class III (Low-Hazard Potential) - Failure of the dam is not expected to result in loss of life and/or significant property damage
- Class IV (Small-Dam Low-Hazard Potential) - Failure of the dam is not expected to result in loss of life or significant property damage

According to the U.S. Army Corps of Engineers National Inventory of dams, there are 39 dams located in Gloucester County, 3 of which are classified with a high-hazard potential, 27 of which are classified as a significant hazard potential, and 9 classified as low hazard potential (USACE; National Performance of Dams 2021). Figure 3-12 shows the dams and their classifications located in the County.

Figure 3-12. Dams of Gloucester County, New Jersey



Source: USACE 2022

Levees

Gloucester County is home to 10 levee systems that provide some degree of protection to vulnerable areas along the Delaware River. Basic information on the systems in the County was gathered from the National Levee Database (NLD) to integrate components of the levee accreditation process with this HMP and identify ways the hazard mitigation process can help to establish a path forward for the levee accreditation process. Table 3-8 present data about levee systems collected from the NLD.

Table 3-8. Levee System Feature Information from the NLD in Gloucester County, New Jersey

System	Total Length	Leveed Area	# Segments	Primary Purpose
Gibbstown	3.96 miles	8.67 sq. mi.	4	Flood Risk Reduction
Left Bank Old Canal	5.24 miles	-	1	Flood Risk Reduction
Left Bank Raccoon Creek	5.37 miles	-	1	Flood Risk Reduction
Oldmans	1.45 miles	-	1	Flood Risk Reduction
Red Bank	0.13 miles	0.0055 sq. mi.	1	Flood Risk Reduction
Repaupo Creek	4.21 miles	4.04 sq. mi.	1	Flood Risk Reduction
Right Bank Old Canal	0.6 miles	-	1	Flood Risk Reduction
Right Bank Raccoon Creek	2.6 miles	-	1	Flood Risk Reduction
Washington Point Neck	1.73 miles	-	1	Flood Risk Reduction
West Deptford	0.96 miles	0.05 sq. mi.	1	Flood Risk Reduction

Source: U.S. Army Corps of Engineers 2021

3.6.2 Food, Water, Shelter Lifelines

Food, Water, and Shelter lifelines include facilities pertaining to food supply (distribution facilities, programs, and supply chain), water supply (including both potable and wastewater systems), shelter (housing and hotels), and agricultural facilities.

3.6.2.1 Food Supply

Food supply facilities in the County include commercial food distribution (e.g., grocery stores), commercial food supply chain, and food distribution programs such as food banks. According to the Gloucester County Division of Social Services, there are 54 emergency food pantries in Gloucester County, many associated with local churches. There are numerous grocery stories and food distributors in the County as well.

3.6.2.2 Water Supply

Potable Water

Potable water in Gloucester County is mainly derived from aquifers (Potomac-Raritan-Magothy [Raritan], Wenonah-Mt. Laurel, Delaware River, and Cohansey) and delivered from a system of wells. The County also receives potable water from surface water (Delaware River). It is supplied by different providers including: NJ American Water, Washington Township MUA, Logan Township MUA, and Gloucester County Utilities Authority (GCUA). Figure 3-13 shows the distribution of potable water facilities in the County. There are 55 potable water facilities located in the County. The breakdown by type is as follows:

- 27 Potable Water Facilities

- 3 Potable Water Pump Stations
- 6 Potable Water Tanks
- 3 Potable Water Towers
- 1 Potable Water Treatment Plant
- 15 Potable Water Wells

Wastewater Facilities

Gloucester County Utilities Authority (GCUA) is a regional wastewater collection and treatment system serving 16 out of 24 municipalities in the County and several industrial customers in Gloucester County. In addition to providing treatment of domestic wastewater, the GCUA owns and operates a septage pretreatment facility processing and disposing of thousands of gallons a day of trucked-in, non-hazardous waste streams, such as liquid, thickened and dewatered sewage sludges; non-hazardous industrial wastewater; domestic landfill leachate; non-petroleum oils and greases; grease and scum from domestic wastewater treatment facilities; domestic and commercial septage; and backwash slurries from potable water treatment facilities (GCUA 2021).

Figure 3-13 illustrates the locations of wastewater facilities. There are 138 wastewater facilities located in Gloucester County. The breakdown by type is as follows:

- 52 Wastewater Metering Stations
- 70 Wastewater Pump Stations
- 16 Wastewater Treatment Facilities

3.6.2.3 Shelters

Shelter facilities in Gloucester County include housing (e.g., homes and shelters), and commercial facilities like hotels. They also include senior living facilities. The Housing Authority of Gloucester County provides affordable housing options to residents no served adequately by private/unsubsidized organizations in Gloucester County. There are five properties of the Housing Authority. There are also 10 senior living facilities in the County. Lastly, there are three identified shelters in Gloucester County; however, there are numerous buildings and facilities that can serve as shelters, heating, or cooling centers throughout the County.

3.6.3 Health and Medical Lifelines

Health and medical lifelines include: medical care (e.g., hospitals, pharmacies, long-term care facilities), patient movement (e.g., EMS), fatality management, public health, and medical supply chain. In Gloucester County, there are 102 facilities identified as health and medical lifelines.

3.6.3.1 Medical Care

Medical care facilities include: hospitals, dialysis, pharmacies, long-term care facilities, VA health system, veterinary services, senior centers, and home care. In Gloucester County, there are 67 facilities:

3.6.3.2 Patient Movement

Patient movement includes Emergency Medical Services (EMS). There are 34 EMS providers in Gloucester County.

3.6.4 Energy (Power and Fuel) Lifelines

Gloucester County has 5 energy lifelines: one electric substation, three fuel facilities that are municipal owned, and one electric facility.

Figure 3-13. Utilities in Gloucester County

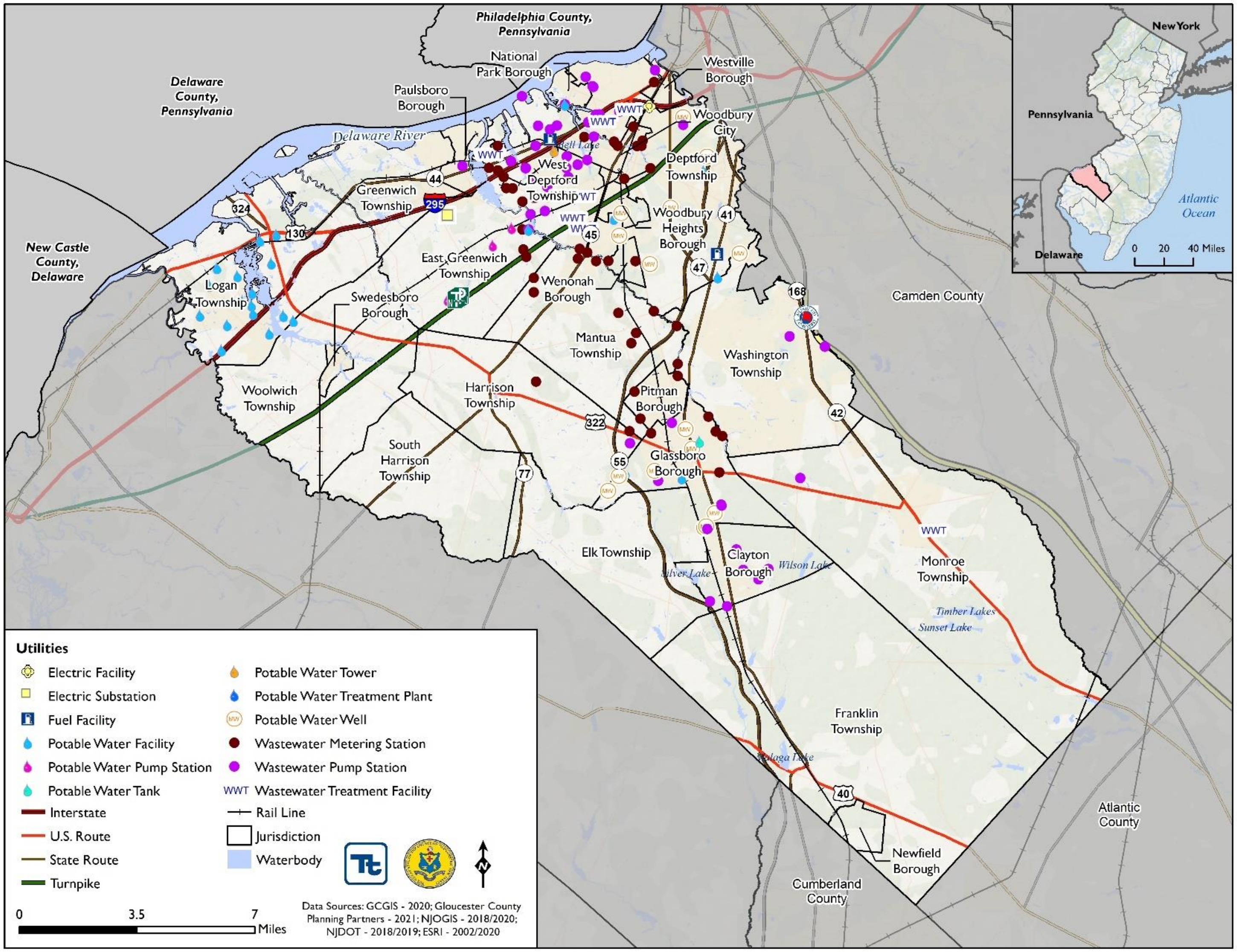
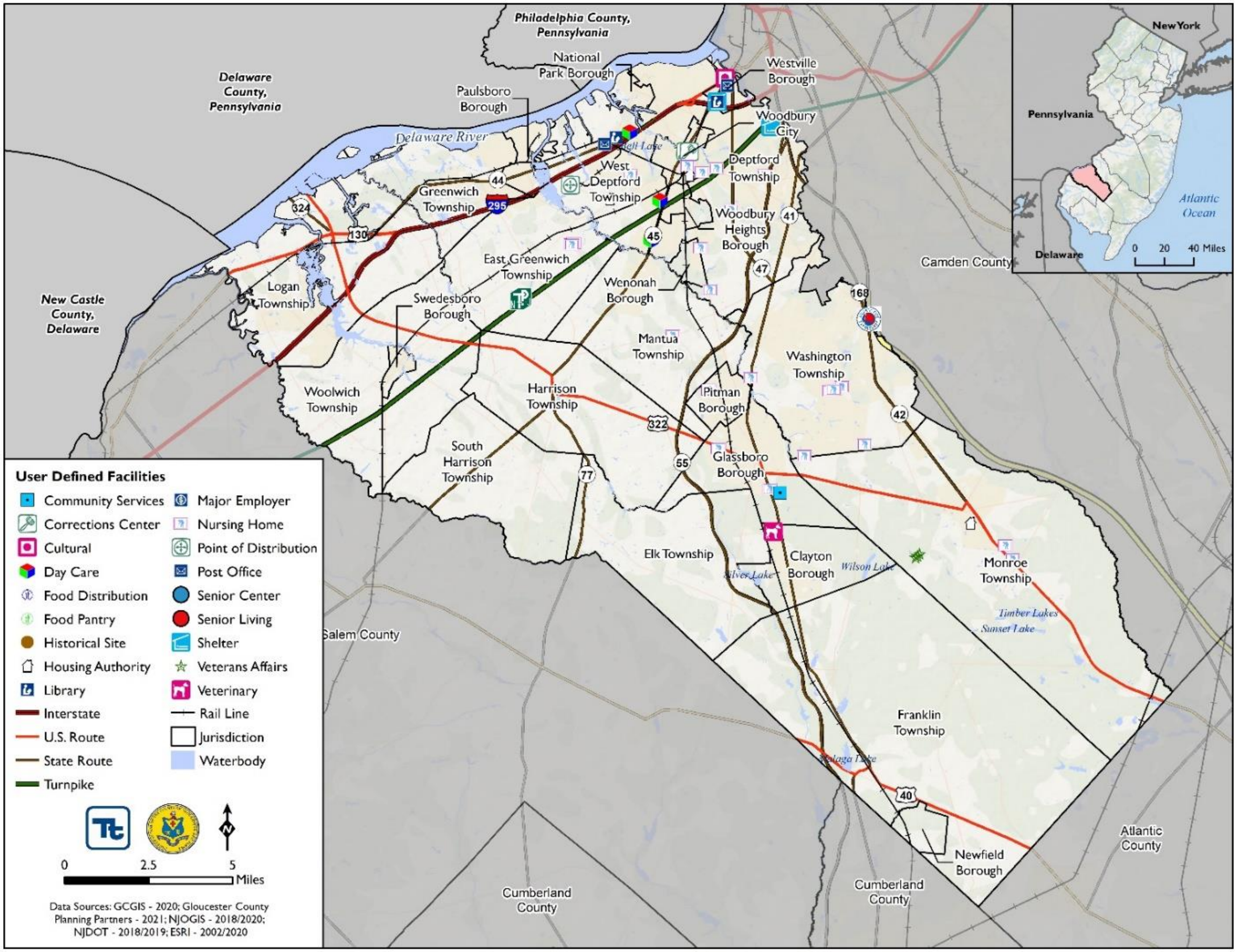


Figure 3-14. User Defined Facilities in Gloucester County



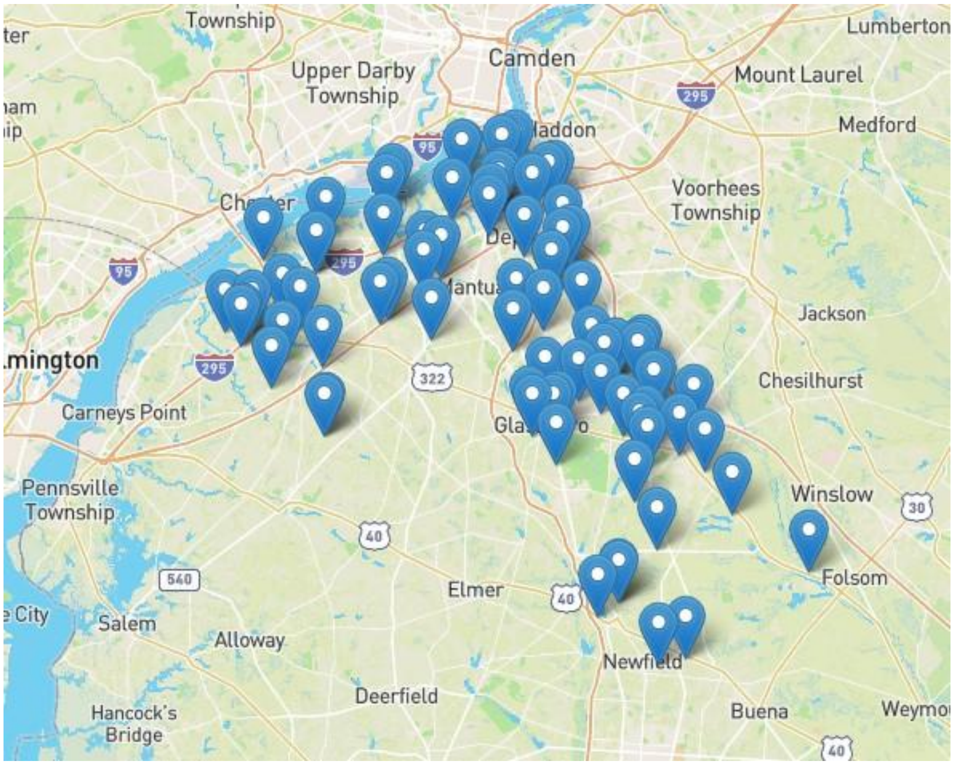
3.6.5 Communication Lifelines

3.6.5.1 Communications

The county's facility dispatches all fire and EMS. AT&T, Verizon, and T-Mobile each provide nearly complete 4G LTE coverage throughout the County. Significant portions of the County receive 5G service through T-Mobile and AT&T, and Verizon provides coverage to parts of West Deptford, Deptford, Greenwich, East Greenwich, Mantua, and Woolwich. Gaps in 5G coverage from any provider remain in Newfield, Monroe, and Franklin (AT&T, T-Mobile, Verizon 2021).

The Federal Communications Commission reports that there are 51 structures in its Antenna Structure Registration as of 2021, with 3 more having been granted approval. A map of these structures is shown on the following map. Many of these structures are located along Route 42, Route 295, and the New Jersey Turnpike and are owned by a variety of entities, including utility companies, transportation departments, and communication firms (Federal Communications Commission, 2021).

Figure 3-15. Structures in the FCC's Antenna Structure Registration in Gloucester County



3.6.6 Transportation Lifelines

Major highways in the County converge in Deptford. These include Route 130, Route 45, the New Jersey Turnpike, and Route 55. Most of these roads originate along the County's southern border with Salem and

Cumberland Counties. Route 322 connects the southeastern part of the County in Monroe Township with the northwestern part in Logan Township, and then continues across the Delaware river to Delaware County, Pennsylvania.

Route 322 is the only road in the County that crosses the Delaware River. Other roads that provide access out of the county include Route 130, Route 295 (from Wilmington to Cherry Hill), the New Jersey Turnpike, Route 45, Route 55, Route 40, and Route 322. Access into and out of the county on its northeastern border is limited by the Atlantic City Expressway which parallels the boarder of Gloucester County in Camden County. Multiple routes provide access into Camden in the County's northernmost corner, including the New Jersey Turnpike, Route 55, Route 295, and Route 130.

3.6.6.1 Ports

There are 11 ports in Gloucester County.

3.6.6.2 Public Transportation

Bus transportation in Gloucester County is provided by New Jersey Transit, which provides service from Philadelphia to Salem, Pennsville, Bridgeton, and Sewell. There are 11 routes that serve the County. Access Link, a shuttle for people with disabilities, services the same routes. Gloucester County is also part of the Pureland East-West Shuttle, which has stops between the Pureland Industrial Park in Logan Township, and Avandale Park & Ride in Sicklerville. The Division of Transportation Services in Gloucester County provides free curb-to-curb shuttle service to senior citizens, people with disabilities, Veterans, and low-income residents. 14 municipalities provide intermunicipal shuttle services to nearby shopping facilities, senior lunch programs, and area malls.

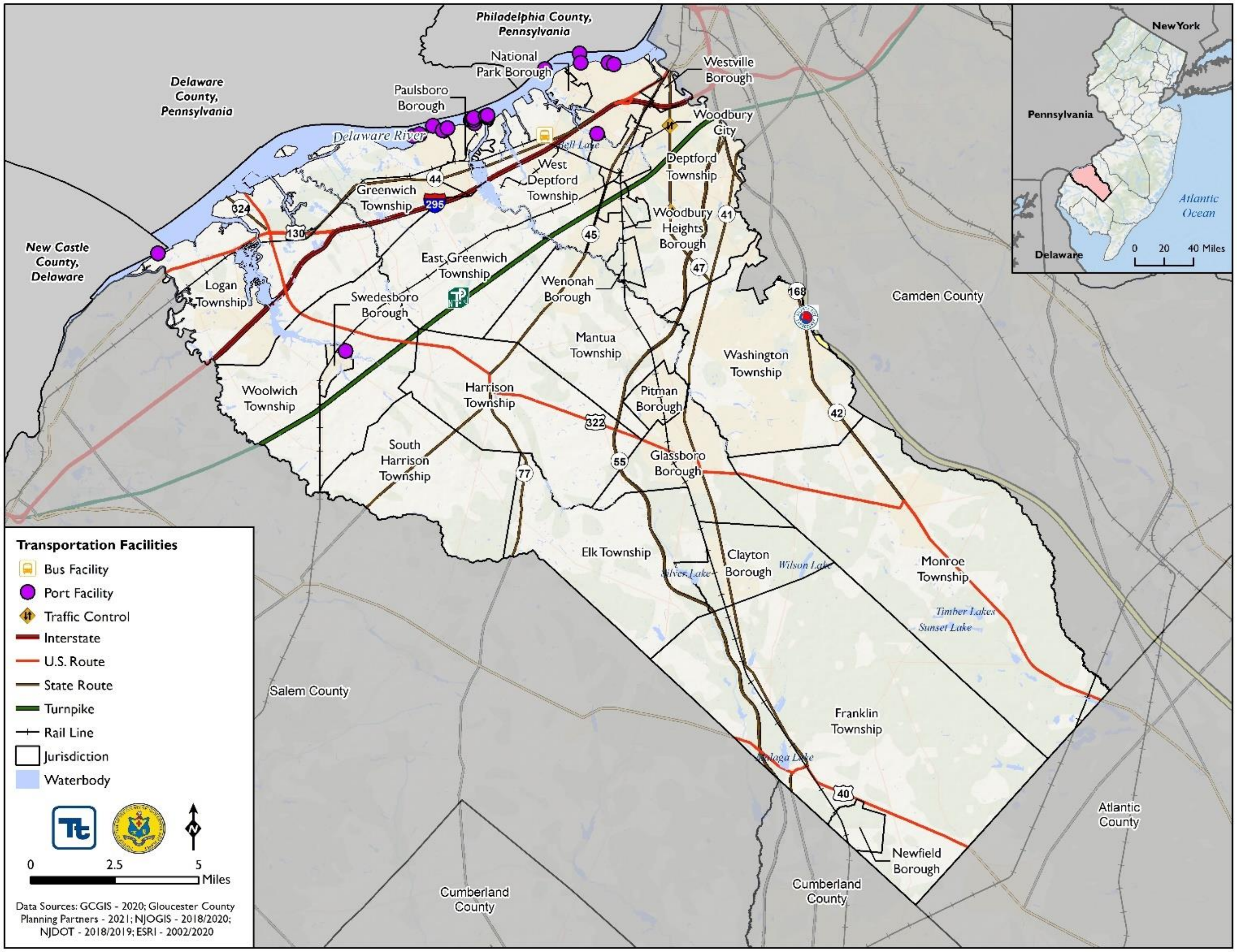
3.6.6.3 Air

Air travel within the County is facilitated by six airports: Bridge Cahill Airport in Swedesboro, Cross Keys Airport in Monroe, Downstown Airport in Vineland, Ledden Farm Airport in Glassboro, Peaslees Airport in Clarksboro, and Southern Cross Airport in Monroe. The Philadelphia International Airport, located 22 miles from the center of the County, services larger commercial aircraft for business as well as private travel (County Office 2021).

3.6.6.4 Rail

There are no active passenger rail lines within Gloucester County. A rail line connecting Glassboro to Philadelphia was planned to open in 2019, however a lack of funding has delayed that date. The freight line is operated by SMS Rail Lines delivers all freight car delivery to businesses located in the Pureland Industrial Park in Bridgeport.

Figure 3-16. Transportation Features in Gloucester County



3.6.7 Hazardous Materials Lifelines

Due to heightened security concerns, local utility lifeline data needed to complete the analysis were only partially obtained. Figure 3-17 shows the locations of the facilities for these various lifeline utility systems in Gloucester County.

3.6.7.1 HAZMAT Facilities

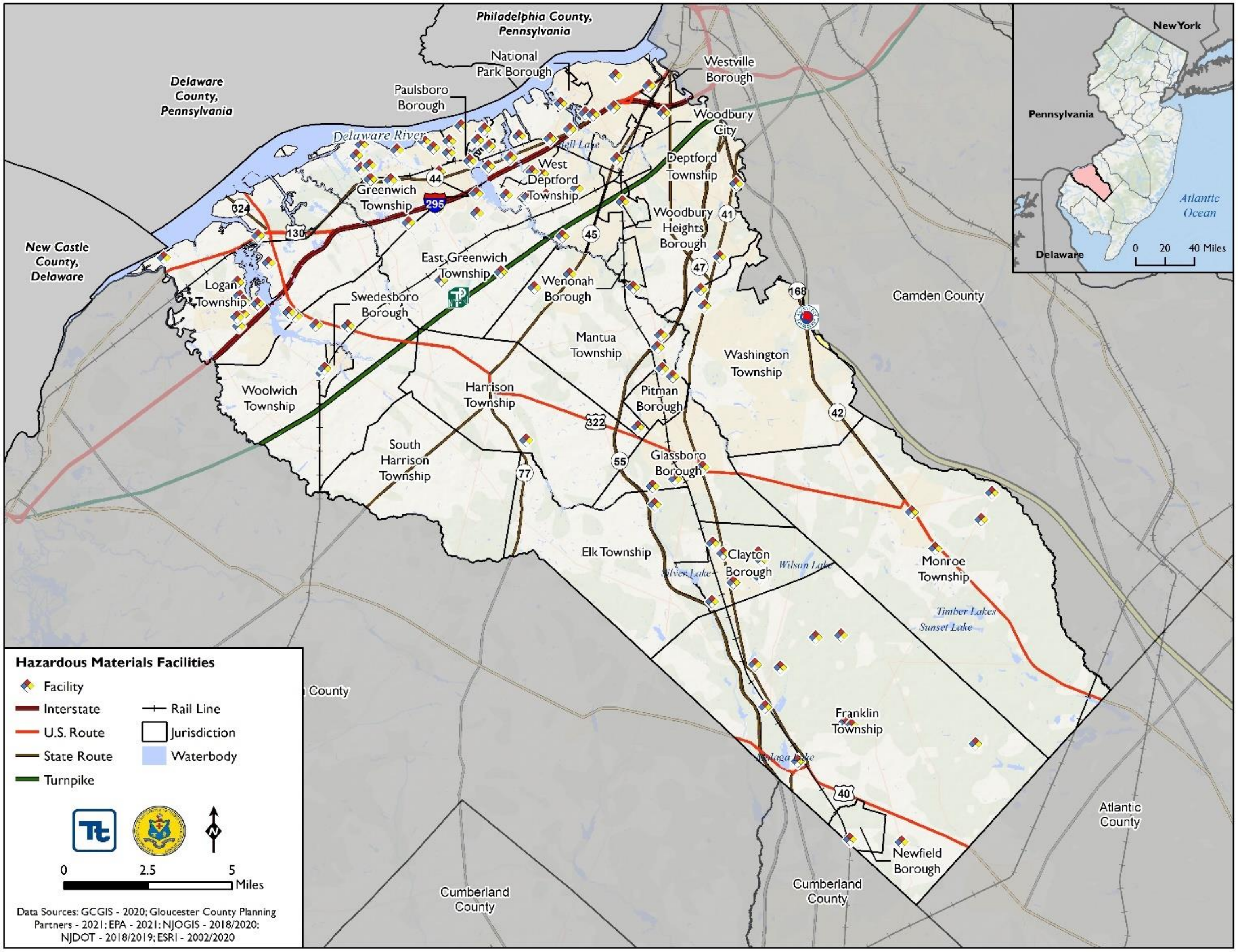
A Superfund site consists of land in the United States that has been contaminated by hazardous waste and identified by the U.S. Environmental Protection Agency (EPA) as a candidate for cleanup because it poses a risk to human health or the environment. These sites are placed on the National Priorities List (NPL), the list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The NPL is intended primarily to guide EPA in determining which sites warrant further investigation.

Abandoned hazardous waste sites placed on the federal NPL include those that EPA has determined present *a significant risk to human health or the environment*, with the sites being eligible for remediation under the Superfund Trust Fund Program. As of 2021, Gloucester County hosts ten hazardous sites in the federal Superfund Program that are listed as on the NPL (CERCLIS 2021). These are: Franklin Burn in Franklin, Pioneer Metal Finishing Inc., in Franklinville, Shieldalloy Corp., in Newfield, Lipari Landfill in Pitman, Helen Kramer Landfill in Mantua, Matteo & Sons, Inc. in Thorofare, Hercules, Inc., in Gibbstown, Matlack, Inc., in Wollwich, and Bridgeport Rental & Oil Services and Chemical Leaman Tank Lines, Inc., in Bridgeport/

The EPA Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) (Superfund) Public Access Database (CPAD) reports that there is currently one archived Superfund sites located in Cape May County (CERCLIS 2021). A deleted Superfund site is one that has no further interest under the Federal Superfund Program based on available information and is no longer part of the CERCLIS inventory. Archived and active Superfund sites are accessible through the same database but are differentiated by status.

Figure 3-17 shows the location of hazardous material facilities throughout Gloucester County.

Figure 3-17. Hazardous Material Facilities in Gloucester County



4.1 IDENTIFICATION OF HAZARDS OF CONCERN

2022 HMP Update Changes

- The 2017 NJ4HMP 'Hazard Identification and Risk Assessment' was presented in section 3. For the 2022 HMP update, it is presented in subsection 4.1 (Identification of Hazards of Concern).
- The 2022 HMP hazard profiles have been updated to include the following: the Flood hazard includes more discussion of urban flooding and storm surge; the Dam and Levee Failure hazard has been combined into one section (Section 4.3.2); three new hazards of concern have been added – Disease Outbreak and Pandemic, Invasive Species and Harmful Algal Blooms, and Utility Failure.

> Hazards of Concern are defined as those hazards that are considered most likely to impact a community. These are identified using available data and local knowledge.

To provide a strong foundation for mitigation strategies considered in Section 6 (Mitigation Strategy), Gloucester County considered a full range of natural hazards that could impact the area, and then identified and ranked those hazards that presented the greatest concern. The natural hazard of concern identification process incorporated input from the County and participating jurisdictions; review of the State of New Jersey Hazard Mitigation Plan (NJ HMP) and previous hazard identification efforts; research and local, state, and federal information on the frequency, magnitude, and costs associated with the various hazards that have previously, or could feasibly, impact the region; and qualitative or anecdotal information regarding natural hazards and the perceived vulnerability of the study area's assets to them. Table 4.1-1 documents the process of identifying the natural hazards of concern for further profiling and evaluation.

For the purposes of this planning effort, the Planning Partnership chose to group some natural hazards together, based on the similarity of hazard events, their typical concurrence or their impacts, consideration of how hazards have been grouped in FEMA guidance documents (FEMA 386-1, "Understanding Your Risks, Identifying Hazards and Estimating Losses; FEMA's "Multi-Hazard Identification and Risk Assessment – The Cornerstone of the National Mitigation Strategy"), and consideration of hazard grouping in the NJ HMP.

Table 4.1-1. Identification of Hazards of Concern for Gloucester County

Hazard	Is this a hazard that may occur in Gloucester County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
Avalanche	No	No	• The NJ HMP does not identify avalanche as a hazard of concern for New Jersey. • The topography and climate of Gloucester County does not support the occurrence of an avalanche event. • New Jersey in general has a very low occurrence of avalanche events based on statistics provided by the American Avalanche Association (AAA) between 1950 and 2014.	• NJ HMP • Review of NAC-AAA database • Steering and Planning Committee Input
Coastal Erosion and Sea Level Rise	Yes	Yes	• Numerous studies and reports are available documenting the occurrence and risks associated with climate change and sea level rise, on global, regional, state and even local scales. • The NJ HMP identifies coastal erosion as a hazard of concern for New Jersey. Counties bounded by coastal waters are most affected by coastal erosion, including Gloucester County. • While climate change and sea level rise act as exacerbating conditions for the primary hazards of concern (flood, severe weather, wildfire, etc.), the Steering Committee has elected to develop a separate hazard profile for climate change and sea level rise for this update.	• NJ HMP • FEMA FIRMs • Various studies and reports from Federal and State agencies and other interested • Steering Committee Input
Coastal Storm	Yes	Yes	• The NJ HMP identifies hurricanes/tropical storms and nor'easters as hazards of concern for New Jersey. • Due to its proximity to the Atlantic Ocean and Delaware River, Gloucester County is susceptible to hurricanes, tropical storms, and Nor'Easters. • For the purpose of this HMP Update, hurricanes and tropical storms will be included in 'Hurricanes/Tropical Storms' and Nor'Easters will be included separately in 'Nor'Easters'. Please see those sections for information regarding hurricanes, tropical storms, and Nor'Easters in Gloucester County.	• NJ HMP • FEMA • NOAA • NOAA-NCEI Storm Database • Steering and Planning Committee Input
Dam and Levee Failure	Yes	Yes	• The NJ HMP identifies dam failure as a hazard of concern for New Jersey. • According to USACE, there are 39 dams located in Gloucester County; with 3 identified as high hazard, 27 as significant hazard, and 9 as low hazard. There are also 4 levee systems in the County, made up of 28 structures. • The Planning Partnership identified dam and levee failure as a hazard of concern for Gloucester County.	• NJ HMP • USACE • Steering and Planning Committee Input
Disease Outbreak	Yes	Yes	• The NJ HMP identifies pandemic as a hazard of concern for New Jersey. • According to the NJ HMP, New Jersey's geographic and demographic characteristics make it particularly vulnerable to importation and spread of infectious diseases. All 21 counties in New Jersey have experienced the effects of a pandemic or disease outbreak.	• NJ HMP • FEMA • Steering and Planning Committee Input

Hazard	Is this a hazard that may occur in Gloucester County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
			• Gloucester County has been impacted by mosquito and tick-borne diseases, food-borne illness and most recently the COVID-19 pandemic. • Gloucester County was part of a statewide emergency declaration for West Nile Virus in 2000 (EM-3156) and the DR-4488/EM-3451 for COVID-19.	
Drought	Yes	Yes	• The NJ HMP identifies drought as a hazard of concern for New Jersey. • Drought is considered a hazard of concern due to the impact on drinking water resources, and agriculture. • Drought is a hazard of concern for Gloucester County because potable water in the County is supplied by both surface water and groundwater. Surface water supplies are affected more quickly during drought conditions. • The Planning Partnership identified drought has a hazard of concern for Gloucester County.	• NJ HMP • FEMA • USGS • NRCC • NOAA • NOAA-NCEI Storm Database • Steering and Planning Committee Input
Earthquake	Yes	Yes	• The NJ HMP identifies earthquake as a hazard of concern for New Jersey. Although they are known to occur on a regular basis, records indicate that no major earthquakes have struck the state since the establishment of historical record-keeping (1500's). Between 1783 and 2017, there have been 204 earthquakes recorded for New Jersey. One of these events have been epicentered in Gloucester County. • Soil types in Gloucester County include NEHRP Class C and D which exacerbate ground shaking. Approximately 36.8% of the entire population is located in Class D soil areas. • The Planning Partnership identified earthquake as a hazard of concern for Gloucester County.	• NJ HMP • NJDEP • NJGWS • USGS • Steering and Planning Committee Input
Expansive Soils	No	No	• The NJ HMP does identify expansive soils as a hazard of concern for New Jersey; however, the Planning Committee did not identify this as a hazard of concern for Gloucester County. • Soils that expand (swell) as they become wet and contract (shrink) as they dry are called expansive soils. This change can cause the ground to move up and down several inches during a cycle of wetting and drying. Expansive soils that are predominately clay minerals have the ability to absorb water. • Based on the soil type and no history of expansive soil incidence occurring, expansive soils was not identified as a hazard of concern for Gloucester County.	• NJ HMP • USGS 1989 Swelling Clays Map of the Conterminous U.S. • Steering and Planning Committee Input
Extreme Temperature	Yes	Yes	• The NJ HMP identifies extreme temperature as a hazard of concern for New Jersey. • Gloucester County has experienced excessive heat and extreme cold temperature events throughout the years.	• NJ HMP • FEMA
Flood (Riverine, Coastal, Flash	Yes	Yes	• The NJ HMP identifies flooding as a hazard of concern in New Jersey. • The County has 924 NFIP policies There has been a total of over $4 million paid claims in Gloucester County.	• NJ HMP • FEMA • FEMA FIS

Hazard	Is this a hazard that may occur in Gloucester County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
Flooding, Urban Flooding)			• There are 64 repetitive loss properties and 1 severe repetitive loss property in the County. • The 2016 FEMA DFIRMs indicate that approximately 1.5-percent of the total population is located in the 1-percent annual chance flood hazard area.	• NFIP • NOAA-NCEI Storm Database • Steering and Planning Committee Input
Geological Hazards	Yes	Yes	• The NJ HMP identifies geological hazards as a hazard of concern for New Jersey. • According to NJGWS, Gloucester County does not have a history of landslide occurrences. • Approximately 11.3-percent of the total population is located within areas of carbonate rock and approximately 2.3-percent of the total population is located in steep slope areas. • The portion of the County along the Delaware River has a moderate landslide susceptibility with the remainder of the County in a low susceptibility area. • The Steering and Planning Committees did identify geological hazards as a hazard of concern for Gloucester County.	• NJ HMP • NJGWS • NJDEP • Steering and Planning Committee Input
Hailstorm	Yes	Yes	Please see Severe Weather	
Hazardous Materials	Yes	Yes	• The NJ HMP identifies geological hazards as a hazard of concern for New Jersey. • Several major transportation routes are located in Gloucester County and pose a threat to spills, accidents, and incidents. • 88.1-percent of the total population is located within one mile of hazmat roadway routes. • The Steering and Planning Committees did identify hazardous materials as a hazard of concern for Gloucester County.	• NJ HMP • EPA • Steering and Planning Committee Input

Hurricane (and other Tropical Cyclones)	Yes	Yes	• The NJ HMP identifies hurricanes and tropical storms as hazards of concern for New Jersey.
			• According to FEMA, between 2015 and 2021, Gloucester County was included in two declarations associated with hurricanes and tropical storms.
			  ○ DR-4574 – Tropical Storm Isaias – August 4, 2020
			  ○ DR-4614 – Remnants of Hurricane Ida – September 1-3, 2021
			• The Steering and Planning Committees identified hurricanes and tropical storms as a hazard of concern for Gloucester County.
				• NJ HMP
				• NOAA – NCEI
				• NHC
				• FEMA
				• Steering and Planning Committee Input

Ice Storm	Yes	Yes	Please see Severe Winter Weather	
Infestation and Invasive Species	Yes	Yes	• Gloucester County has a diverse landscape with development woven through natural areas. • Pests in Gloucester County that compete for natural resources or transmit diseases to humans, livestock and the environment include insects and invasive plants. • Due to the large, forested areas located throughout the County, Emerald Ash Borer (EAB) and other pests that damage trees have become an increased focus.	• NJDEP • Steering and Planning Committee Input

Hazard	Is this a hazard that may occur in Gloucester County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
			• Gloucester County has experienced harmful algal blooms in the past causing impacts to natural systems and the local economy. • Infestation and invasive species has been added as a new hazard of concern to the 2022 HMP update.	
Land Subsidence	No	No	Please see Geological Hazards	
Landslide	Yes	Yes	Please see Geological Hazards	
Nor'Easters	Yes	Yes	• The NJ HMP identifies Nor'Easters as hazards of concern for New Jersey. • The County has been impacted by several Nor'Easter events since 2015. This includes: ○ January 22, 2016 – Winter Storm ○ March 21, 2018 – Winter Storm • The Steering and Planning Committees identified Nor'Easter events as a hazard of concern for Gloucester County.	• NJ HMP • NOAA – NCEI • FEMA • Steering and Planning Committee Input
Severe Weather (Windstorms, Thunderstorms, Hail, Lightning, and Tornadoes)	Yes	Yes	• The NJ HMP identifies thunderstorms, lightning, tornadoes, and winds as hazards of concern for New Jersey. • According to FEMA, between 2015 and 2021, Gloucester County was included in one declarations associated with severe weather events. ○ DR-4231 – Severe Storm – June 23, 2016 • NOAA's NCEI storm events database indicates that Gloucester County was impacted by approximately 141 severe weather events between 2015 and 2021 causing a total of over $17.4 million in property damages. • The Steering and Planning Committees identified severe weather (windstorms, thunderstorms, hail, lightning, and tornadoes) as a hazard of concern for Gloucester County.	• NJ HMP • NOAA – NCEI • FEMA • NJ OEM • Steering and Planning Committee Input
Severe Winter Weather (Heavy Snow, Blizzards, Freezing Rain/Sleet, Ice Storms)	Yes	Yes	• The NJ HMP identifies severe winter weather as a hazard of concern for New Jersey and includes snow, blizzards, and ice storms. For the purpose of this HMP update, Gloucester County is including blizzards, heavy snow, and ice storms under the severe winter weather hazard. • According to FEMA, between 2015 and 2021, Gloucester County was not included in any FEMA declarations. • NOAA-NCEI has indicated that Gloucester County has experienced the impacts of 45 winter storm events between 2015 and 2021. • Based on the history of occurrences and losses, and based on input from the Planning and Steering Committees, Gloucester County identified severe winter weather as a hazard of concern.	• NJ HMP • FEMA • NOAA – NCEI Storm Database • ONJSC • Steering and Planning Committee Input
Tornado	Yes	Yes	Please see Severe Weather	
Tsunami	No	No	• The NJ HMP does not identified tsunami as a hazard of concern for New Jersey.	• NJ HMP

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Hazard	Is this a hazard that may occur in Gloucester County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
			• None of Gloucester County is bounded by coastal waters; therefore, tsunami is not identified as a hazard of concern for the County.	• Steering and Planning Committee Input
Volcano	No	No	• The NJ HMP does not identify volcano as a hazard of concern for New Jersey.	• NJ HMP • Steering and Planning Committee Input
Wildfire	Yes	Yes	• The NJ HMP identifies wildfire as a hazard of concern for New Jersey. • Gloucester County experiences brush fires and wildfires throughout the year. • Based on input from the Planning Committee, wildfire is considered a hazard of concern for Gloucester County.	• NJ HMP • NOAA – NCEI Storm Events Query • USGS • NJFFS • Steering and Planning Committee Input
Windstorm	Yes	Yes	Please see Severe Weather	

DR *Presidential Disaster Declaration Number*
EM *Presidential Disaster Emergency Number*
FEMA *Federal Emergency Management Agency*
HMP *Hazard Mitigation Plan*
K *Thousands ($)*
M *Millions ($)*
NJ *New Jersey*
NJDEP *New Jersey Department of Environmental Protection*
NJDOH *New Jersey Department of Health*
NJFFS *New Jersey Forest Fire Service*
NJGS *New Jersey Geological Survey (as part of the NJDEP)*
NOAA *National Oceanic and Atmospheric Administration*
NRCC *Northeast Regional Climate Center*
NWS *National Weather Service*
OEM *Office of Emergency Management*
ONJSC *Office of New Jersey State Climatologist*
PHSMA *Pipeline and Hazardous Materials Safety Administration*
SPC *Storm Prediction Center*
USEPA *United States Environmental Protection Agency*
USGS *U.S. Geologic Survey*

According to input from the County, and review of all available resources, a total of 15 hazards concern were identified as significant hazards affecting the entire planning area, to be addressed at the county level in this plan:

- Coastal Erosion and Sea Level Rise
- Dam and Levee Failure
- Disease Outbreak
- Drought
- Earthquake
- Extreme Temperature
- Flood
- Geologic Hazards
- Hazardous Materials
- Hurricane/Tropical Storm
- Nor'Easter
- Severe Weather
- Severe Winter Weather
- Wildfire
- Utility Failure

Other natural and human-caused hazards of concern have occurred within Gloucester County, have a low potential to occur and/or result in significant impacts within the County, or are covered in other plans that specifically address technological and intentional hazards. Therefore, these hazards will not be further addressed within this version of the plan. However, if deemed necessary by the County, these hazards may be considered in future versions of the HMP.

4.2 METHODOLOGY AND TOOLS

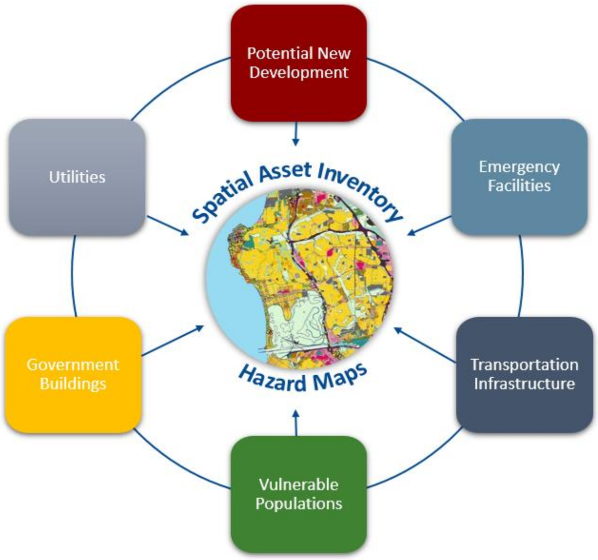
2022 HMP Changes

- The risk assessment was updated using best available information.
- Hazard events and associated impacts were researched and summarized from 2015 to 2021
- 2015-2019 ACS 5-year estimates were utilized
- 2021 building footprints from the County, 2021 parcel data from the County, and 2020 MOD-IV tax assessor data were referenced to develop a structure-level building inventory. This inventory was updated with 2021 RS Means values to estimate the replacement cost value of each building.
- The 2016 critical facility was reviewed and updated by the Planning Partnership.
- Lifelines were identified in the critical facility inventory, and additional lifelines added, to align with FEMA's lifeline definition.
- An updated version of Hazus (v4.2) was used to estimate potential impacts to the flood, wind and seismic hazards.
- Best available hazard data was used as described in this section.

The following summarizes the asset inventories, methodology and tools used to support the risk assessment process.

4.2.1 Asset Inventories

Gloucester County assets were identified to assess potential exposure and loss associated with the hazards of concern. For the HMP update, Gloucester County assessed exposure vulnerability of the following types of assets: population, buildings and critical facilities/infrastructure and the environment. Some assets may be more vulnerable because of their physical characteristics or socioeconomic uses. To protect individual privacy and the security of critical facilities, information on properties assessed is presented in aggregate, without details about specific individual personal or public properties.



The risk assessment included the collection and use of an expanded and enhanced asset inventory to estimate hazard exposure and vulnerability

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4.2.1.1 Population

Total population statistics from the 2015-2019 ACS Survey 5-year estimate were used to estimate the exposure and potential impacts to the County's population in place of the 2010 U.S. Census block estimates. Population counts at the Census tract level were averaged among the residential structures in the County to estimate the population at the structure level. This estimate is a more precise distribution of population across the County compared to only using the Census block or Census tract boundaries. Limitations of these analyses are recognized, and thus the results are used only to provide a general estimate for planning purposes.

As discussed in Section 3 (County Profile), research has shown that some populations are at greater risk from hazard events because of decreased resources or physical abilities. Vulnerable populations in Gloucester County included in the risk assessment are children, elderly, and population below the poverty level.

4.2.1.2 Buildings

The building stock inventory was updated countywide. To develop the building inventory, 2021 data received from Gloucester County, i.e., County Parcels and County Building Footprints, and 2020 MODIV parcel data was used. The 2020 MODIV parcel data was referenced to assign attributes to the County parcels using the PAMS_PIN fields. Once the parcels were assigned attributes based on the assessor's data, building footprints provided by the County were converted to point data, and the parcel data was spatially joined to the building footprint point data. If a parcel had multiple building points, these buildings were assigned the same occupancy class as the parcel.

Default information was used to fill in the gaps for building attributes. The centroid of each building footprint was used to estimate the building location. Structural and content replacement cost values (RCV) were calculated for each building utilizing available assessor data and RSMeans 2021 values; a regional location factor for Gloucester County was applied (1.13 for residential structures; 1.10 for non-residential structures). Replacement cost value is the current cost of returning an asset to its pre-damaged condition, using present-day cost of labor and materials. Total replacement cost value consists of both the structural cost to replace a building and the estimate value of contents of a building. The occupancy classes available in Hazus v4.2 were condensed into the following categories (residential, commercial, industrial, agricultural, religious, governmental, and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single-family dwellings.

> A **lifeline** provides indispensable service that enables the continuous operation of critical business and government functions, and is critical to human health and safety, or economic security (FEMA).

4.2.1.3 Critical Facilities and Lifelines

The 2016 HMP critical facility inventory, which includes essential facilities, utilities, transportation features and user-defined facilities was updated by the Planning Partnership. The update involved a review for accuracy, additions or deletions of new/moved critical assets, identification of backup power for each asset (if known) and whether the critical facility is considered a lifeline in accordance with

FEMA's definition; refer to Appendix E (Risk Assessment Supplement). To protect individual privacy and the security of assets, information is presented in aggregate, without details about specific individual properties or facilities.

4.2.1.4 Environment

The NJDEP Land Use Land Cover dataset was published in 2019 for the 2015 aerial coverage. This dataset models land cover change between 2012 and 2015. The classes used from this dataset summarized land use exposure aggregated by agricultural, barren, forested, urban, and wetland land use land cover types.

4.2.1.5New Development

In addition to assessing the vulnerability of the built environment, Gloucester County examined recent and anticipated new development. Each jurisdiction was asked to provide input via Survey 123 for all major development that has taken place over the last 5 years and anticipated major development over the next 5 years. Additionally, the NJ Sewer Service Areas and the NJ Pinelands Council's regional growth area and rural development area were included because they are areas of future potential growth.

An exposure analysis was conducted in GIS to determine hazard exposure to major development planned for the next 5 years as provided by the County and municipalities. Identifying these changes and integrating into the risk assessment provides communities information to consider when developing the mitigation strategy to reduce these vulnerabilities in the future (one tool in the Mitigation Toolbox discussed in Section 6 – Mitigation Strategy). The identified new development is listed in Section 3 (County Profile) and hazard exposure analysis results are presented in Section 9 (Jurisdictional Annexes) as a table in each annex.

4.2.2 Methodology

To address the requirements of the DMA 2000 and better understand potential vulnerability and losses associated with hazards of concern, Gloucester County used standardized tools, combined with local, state, and federal data and expertise to conduct the risk assessment. Three different levels of analysis were used depending upon the data available for each hazard as described below. Table 4.2-1 summarizes the type of analysis conducted by hazard of concern.

- Historic Occurrences and Qualitative Analysis – This analysis includes an examination of historic impacts to understand potential impacts of future events of similar size. In addition, potential impacts and losses are discussed qualitatively using best available data and professional judgement.
- Exposure Assessment – This analysis involves overlaying available spatial hazard layers, or hazards with defined extent and locations, with assets in GIS to determine which assets are located in the impact area of the hazard. The analysis highlights which assets are located in the hazard area and may incur future impacts.

- Loss estimation — The FEMA Hazus modeling software was used to estimate potential losses for the following hazards: flood, earthquake, hurricane. In addition, an examination of historic impacts and an exposure assessment was conducted for these spatially-delineated hazards.

Table 4.2-1. Summary of Risk Assessment Analyses

Hazard	Population	General Building Stock	Critical Facilities and Lifelines	New Development
Coastal Erosion	E	E	E	E
Dam and Levee Failure	Q	Q	Q	Q
Disease Outbreak	Q	Q	Q	Q
Drought	Q	Q	Q	Q
Earthquake	E, H	E, H	E, H	E
Extreme Temperatures	Q	Q	Q	Q
Flood	E, H	E, H	E, H	E
Geological Hazards (Landslide and Subsidence)	E	E	E	E
Hazardous Materials	E	E	E	E
Hurricane	E, H	E, H	E, H	E
Infestation and Invasive Species	Q	Q	Q	Q
Nor'Easter	Q	Q	Q	Q
Sea Level Rise	E	E	E	E
Severe Weather	Q	Q	Q	Q
Severe Winter Weather	Q	Q	Q	Q
Wildfire	E	E	E	E
Utility Failure	Q	Q	Q	Q

E – Exposure analysis; H – Hazus analysis; Q – Qualitative analysis

4.2.2.1Hazards U.S. – Multi-Hazard (Hazus)

In 1997, FEMA developed a standardized model for estimating losses caused by earthquakes, known as Hazards U.S. or Hazus. Hazus was developed in response to the need for more effective national-, state-, and community-level planning and the need to identify areas that face the highest risk and potential for loss. Hazus was expanded into a multi-hazard methodology, Hazus-MH, with new models for estimating potential losses from wind (hurricanes) and flood (riverine and coastal) hazards. Hazus is a Geographic Information System (GIS)-based software tool that applies engineering and scientific risk calculations, which have been developed by hazard and information technology experts, to provide defensible damage and loss estimates. These methodologies are accepted by FEMA and provide a consistent framework for assessing risk across a variety of hazards. The GIS framework also supports the evaluation of hazards and assessment of inventory and loss estimates for these hazards.

Hazus uses GIS technology to produce detailed maps and analytical reports that estimate a community's direct physical damage to building stock, critical facilities, transportation systems and utility systems. To generate this information, Hazus uses default Hazus provided data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. Damage reports can include induced damage (inundation, fire, threats posed by hazardous materials and debris) and direct economic and social losses (casualties, shelter requirements, and economic impact) depending on the hazard and available local data. Hazus' open data architecture can be used to manage community GIS data in a central location. The use of this software also promotes consistency of data output now and in the future and standardization of data collection and storage. More information on Hazus is available at http://www.fema.gov/hazus.

In general, modeled losses were estimated in the program using user-defined flood depth grids for the flood analysis and probabilistic analyses were performed to develop expected/estimated distribution of losses (mean return period losses) for hurricane wind and seismic hazards. The probabilistic model generates estimated damages and losses for specified return periods (e.g., 100- and 500-year). Table 4.2-2 displays the various levels of analyses that can be conducted using the Hazus software.

Table 4.2-2. Summary of Hazus Analysis Levels

Hazus Analysis Levels	
Level 1	Hazus provided hazard and inventory data with minimal outside data collection or mapping.
Level 2	Analysis involves augmenting the Hazus provided hazard and inventory data with more recent or detailed data for the study region, referred to as "local data"
Level 3	Analysis involves adjusting the built-in loss estimation models used for the hazard loss analyses. This Level is typical done in conjunction with the use of local data.

4.2.2.2 Coastal Erosion

Best available data was used to assess Gloucester County's vulnerability to coastal erosion. To help understand the geographic distribution of coastal risk, the Limit of Moderate Wave Action (LiMWA) boundary was referenced from FEMA's 2016 Effective DFIRM flood data. The LiMWA boundary was selected to assess coastal erosion because it represents land area that is susceptible to wave action. Wave action can be a driver for coastal erosion in Gloucester County. Asset data (population, building stock, critical facilities, and new development) were used to support an evaluation of assets exposed and potential impacts and losses. To determine what assets are exposed to coastal erosion, the County's assets were overlaid with the hazard area. Assets with their centroid located in the hazard area were totaled to estimate the number and values exposed to coastal erosion.

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4.2.2.3 Dam and Levee Failure

Assets that fall with dam inundation hazard areas within Gloucester County are at greatest risk of impacts from dam failure events. A qualitative assessment was conducted for the dam failure hazard. Because of the sensitive nature of the dam failure inundation zones, potential losses have not been quantified and presented in the vulnerability assessment.

4.2.2.4 Disease Outbreak

All of Gloucester County is exposed to disease outbreak events. A qualitative assessment was conducted for the disease outbreak hazard. Research from the Centers for Disease Control and Prevention was utilized to qualitatively assess the most recent COVID-19 outbreak.

4.2.2.5 Drought

To assess the vulnerability of Gloucester County to drought and its associated impacts, a qualitative assessment was conducted. The United States Department of Agriculture (USDA) Census of Agriculture 2017 was used to estimate economic impacts. Information regarding the number of farms and farmland area was extracted from the report and summarized in the vulnerability assessment.

4.2.2.6 Earthquake

A probabilistic assessment was conducted for Gloucester County for the 100 and 500-year mean return period (MRPs) through a Level 2 analysis in Hazus to analyze the earthquake hazard and provide a range of loss estimates. The probabilistic method uses information from historic earthquakes and inferred faults, locations and magnitudes, and computes the probable ground shaking levels that may be experienced during a recurrence period by Census tract.

As noted in the Hazus Earthquake User Manual, "*Although the software offers users the opportunity to prepare comprehensive loss estimates, it should be recognized that uncertainties are inherent in any estimation methodology, even with state-of-the-art techniques. Any region or city studied will have an enormous variety of buildings and facilities of different sizes, shapes, and structural systems that have been constructed over a range of years under diverse seismic design codes. There are a variety of components that contribute to transportation and utility system damage estimations. These components can have differing seismic resistance.*" However, Hazus' potential loss estimates are acceptable for the purposes of this HMP.

Groundwater was set at a depth of five (5) feet (default setting). The default assumption is a magnitude 7.0 earthquake for all return periods. In 2012, the New Jersey Department of Transportation published a map of zip-codes in New Jersey and their associated soil classification. It shows that Gloucester County contains Class C and D soils. An associated soil layer was imported into Hazus in order to estimate loss from ground-shaking. Although damages are estimated at the census tract level, results were presented at the municipal level. Since there are multiple census tracts that contain more than one jurisdiction, a density analysis was used to extract

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the percent of building structures that fall within each tract and jurisdiction. The percentage was multiplied against the results calculated for each tract and summed for each municipality.

Damage estimates are calculated for losses to buildings (structural and non-structural) and contents; structural losses include load carrying components of the structure, and non-structural losses include those to architectural, mechanical, and electrical components of the structure, such as nonbearing walls, veneer and finishes, HVAC systems, boils, etc.

Additionally, an exposure analysis of the County's assets (general building stock, population, critical facilities and lifelines, and new development) was conducted referencing the Class D soils. Soft soils (NJDOT Soil Class D) can amplify ground shaking to damaging levels even during a moderate earthquake. Therefore, buildings located on NJDOT Class D soils are at increased risk of damage from an earthquake.

4.2.2.7 Extreme Temperatures

All of Gloucester County is exposed to extreme temperature events. A qualitative assessment was conducted for the extreme temperatures hazard. Information from FEMA, the Centers for Disease Control and Prevention, and New Jersey Office of Emergency Management were used to assess the potential impacts to the County's assets.

4.2.2.8 Flood

The 1- and 0.2-percent chance flood events were examined to evaluate Gloucester County risk and vulnerability to the riverine and coastal flood hazard areas. These flood events are generally those considered by planners and evaluated under federal programs such as the NFIP.

The effective Gloucester County FEMA Digital Flood Insurance Rate Map (DFIRM) dated August 17, 2016 was used to evaluate exposure and determine potential future losses. A coastal and riverine depth grid for the 1-percent annual chance flood event were used in the damage analysis. The riverine depth grid was provided by the State of New Jersey and was created in 2014. The coastal depth grid was created by FEMA in 2017. The final depth grids were integrated into the Hazus v4.2 riverine and coastal flood models, respectively, used to estimate potential losses for the 1-percent annual chance flood event.

To estimate exposure to the 1-percent- and 0.2-percent annual chance flood events, the DFIRM flood boundaries were overlaid on centroids of updated assets (population, building stock, critical facilities, and new development). Centroids that intersected the flood boundaries were totaled to estimate the building replacement cost value and population vulnerable to the flood inundation areas. A Level 2 Hazus v4.2 riverine flood analysis was performed. Both the critical facility and building inventories were formatted to be compatible with Hazus v4.2 and its Comprehensive Data Management System (CDMS). Once updated with the inventories, the Hazus riverine flood model was run to estimate potential losses in Gloucester County for the 1-percent annual chance flood event. A user-defined analysis was also performed for the building stock.

Buildings located within the floodplain were imported as user-defined facilities to estimate potential losses to the building stock at the structural level. Hazus calculated the estimated potential losses to the population (default 2010 U.S. Census data), potential damages to the general building stock, and potential damages to critical facility inventories based on the depth grids generated and the default Hazus v4.2 damage functions in the flood model.

Locations identified as repetitive and severe repetitive properties were provided by the County and summarized to obtain an understanding of repetitive flood loss areas. County Planning Partners were also asked to identify problem areas of flooding via survey 123, which can be found on jurisdiction maps in Volume II, Section 9.

4.2.2.9 Geological Hazards

This updated Hazard Mitigation Plan referenced landslide and subsidence hazard areas to assess the County's risk to the geologic hazard. To assess the vulnerability of the County to landslide events and its associated impacts, a quantitative assessment was conducted using ESRI ArcGIS v10.5.1 and a landslide layer that was created using the 2015 Digital Elevation Model (DEM) from the United States Geological Survey (USGS). The ArcGIS slope tool was used to calculate the degrees of the slopes in the DEM. Areas where slopes are greater than or equal to 15-percent grade may be susceptible to landslide events. Therefore, areas where the slope angles were equal to or greater than 15-percent grade were converted to degrees (e.g., 15-percent is equal to 8.5 degrees). Degrees that are equal to or greater than 8.5 were converted to vectors, which created the final landslide hazard layer. To estimate potential exposure to the landslide hazard area, assets (population, building stock, critical facilities and lifelines, new development) with their centroid in the hazard area were totaled to estimate the numbers and values exposed to the landslide hazard boundary.

To assess the vulnerability of the County to subsidence events and its associated impacts, a quantitative assessment was conducted using a carbonate rock spatial layer from USGS which consists of karst topography. Karst describes a distinctive topography that indicates dissolution of underlying carbonate rocks (limestone and dolomite) by surface water or groundwater over time. The dissolution process causes surface depressions and the development of sinkholes, sinking stream, enlarged bedrock fractures, caves, and underground streams. To estimate potential exposure to the subsidence hazard area, assets (population, building stock, critical facilities and lifelines, new development) with their centroid in the hazard area were totaled to estimate the numbers and values exposed to the subsidence hazard boundary.

4.2.2.10 Hazardous Materials

All of Gloucester County is exposed to hazardous materials events; both in-transit and at fixed sites. Impacts depend upon the location of release and chemical and physical properties of the hazardous material(s) involved. A quantitative assessment was conducted for the hazardous materials hazard.

To assess the County's vulnerability to hazardous materials, a 1-mile buffer was placed around the following 2017 NJOIT roadway types: County 500, I-295, US 130, NJ Turnpike, County Roads: 603, 607, 609, 620, 643, 651, 653, 655, 656, 667, 678, 684, 689, 694; a 2-mile buffer was placed around 2012 NJDOT railroad routes; and a 1 mile buffer was placed around 2021 EPA superfund and TRI sites. To estimate potential exposure to the subsidence hazard area, assets (population, building stock, critical facilities and lifelines, new development) with their centroid in the hazard area were totaled to estimate the numbers and values exposed to the hazardous materials hazard boundary.

4.2.2.11 Hurricane

A Hazus probabilistic analysis was performed to analyze the wind hazard losses for Gloucester County for the 100- and 500-year mean return period events. The probabilistic Hazus hurricane model activates a database of thousands of potential storms that have tracks and intensities reflecting the full spectrum of Atlantic hurricanes observed since 1886 and identifies those with tracks associated with the County. Hazus contains data on historic hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. Default demographic and updated building and critical facility inventories in Hazus were used for the analysis. Although damages are estimated at the census tract level, results were presented at the municipal level. Since there are multiple census tracts that contain more than one jurisdiction, a density analysis was used to extract the percent of building structures that fall within each tract and jurisdiction. The percentage was multiplied against the results calculated for each tract and summed for each municipality.

In addition to estimating potential losses due to wind, an exposure analysis was conducted using the "Sea – Lake Overland Surge from Hurricanes – SLOSH Model, which represents potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide were used to estimate exposure. Please note these inundation zones do not include riverine flooding caused by hurricane surge or inland freshwater flooding. The 2014 model, developed by the NOAA National Hurricane Center to forecast surges that occur from wind and pressure forces of hurricanes, considers only storm surge height and does not consider the effects of waves. The SLOSH spatial data includes boundaries for Category 1 through Category 4 hurricane events.

Asset data (population, building stock, critical facilities, and new development) were used to support an evaluation of assets exposed and potential impacts and losses associated with this hazard. To determine what assets are exposed to storm surge, the County's assets were overlaid with the SLOSH hazard area. Assets with their centroid located in the hazard area were totaled to estimate the replacement cost value (structure and content) and population exposed to the hazard.

4.2.2.12 Infestation and Invasive Species

All of Gloucester County is exposed to infestation and invasive species. This is a new hazard of concern for the County, and a qualitative assessment was conducted. Resources from NJDEP, Rutgers University, the Centers for Disease Control and Prevention, and the United States Department of Agriculture were used to assess the County's risk to infestation and invasive species.

4.2.2.13 Nor'Easter

All of Gloucester County is exposed to Nor'Easters. A qualitative assessment was conducted for the Nor'Easter hazard. Resources from the State of New Jersey HMP, the Office of the New Jersey State Climatologist, United States Department of Agriculture, and National Oceanic and Atmospheric Administration were referenced to assess the County's risk to the Nor'Easter hazard.

4.2.2.14 Sea Level Rise

Projected sea-level rise data (in one-foot increments) available from the NOAA Office of Coastal Management (https://coast.noaa.gov/slrdata/) was considered and used for this analysis to understand the assets within communities projected to be impacted by sea level rise (refer to Section 4.3.1 – Coastal Erosion and Sea Level Rise). Please note these levels do not include additional storm surge due to a hurricane or Nor'easter. The current Flood Insurance Rate Maps (FIRMs) also do not include the effects of sea-level rise. Rutgers University Science and Technical Advisory Panel (STAP) Report, entitled, Assessing New Jersey's Exposure to Sea-Level Rise and Coastal Storms: Report of the New Jersey Climate Adaptation Alliance Science and Technical Advisory Panel details several projected sea level rise scenarios for New Jersey between 2030 and 2100. Using these estimates, the sea level rise +1 ft and sea level rise +3 ft inundation areas were chosen and used in the 2019 New Jersey State Hazard Mitigation Plan. To be consistent with the State HMP, these spatial datasets were used for the 2021 Gloucester County HMP update in addition to the +2 ft and +4 ft inundation areas.

Asset data (population, building stock, critical facilities and lifelines, and new development) were used to support an evaluation of assets exposed and potential impacts and losses. To determine what assets are exposed to sea-level rise, the County's assets were overlaid with the hazard area. Assets with their centroid located in the hazard area were totaled to estimate the number and values exposed to sea-level rise.

4.2.2.15 Severe Weather

All of Gloucester County is exposed to severe weather events. A qualitative assessment was conducted for the severe weather hazard. Information from the National Weather Service, National Oceanic and Atmospheric Administration, Environmental Protection Agency, U.S. Department of Health and Human Services, the New Jersey State 2019 Hazard Mitigation Plan, and the Centers for Disease Control and Prevention were used to assess the potential impacts to the County's assets.

4.2.2.16 Severe Winter Weather

All of Gloucester County (population, buildings and environment) is exposed and vulnerable to the winter storm hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. A percentage of the custom-building stock structural replacement cost value was utilized to estimate damages that could result from winter storm conditions (i.e., 1-percent, 5-percent, and 10-percent of total replacement cost value). Given professional knowledge and currently available information, the potential losses for this hazard are considered to be overestimated; hence, providing a conservative estimate for losses associated with winter storm events.

4.2.2.17 Wildfire

The NJFFS uses Wildfire Fuel Hazard data to assign wildfire fuel hazard rankings across the State. This data, developed in 2009, is based upon NJDEP's 2002 Land Use/Land Cover datasets and NJDEP's 2002 10-meter Digital Elevation Grid datasets. For the wildfire hazard, the NJFFS Wildfire Fuel Hazard "extreme', 'very high' and 'high' areas are identified as the wildfire hazard area. The defined hazard area was overlaid upon the asset data (population, building stock, critical facilities and potential new development) to estimate the exposure to each hazard.

To determine what assets are exposed to wildfire, the County's assets (population, building stock, critical facilities, and new development) were overlaid with the hazard area. Assets with their centroid located in the hazard area were totaled to estimate building replacement cost value and population exposed to a wildfire event.

4.2.2.18 Utility Failure

All of Gloucester County is vulnerability to utility failure events. To assess the County's vulnerability to the utility failure hazard and its associated impacts, a qualitative assessment was conducted. Information from the EPA, FEMA, and other federal and state resources were referenced to assess the potential impacts to the County's assets from utility failure.

4.2.2.19 Considerations for Mitigation and Next Steps

The following items are to be discussed for considerations for the next plan update to enhance the vulnerability assessment:

- All Hazards
    - Utilize updated and current demographic data. If 2020 U.S. Census demographic data is available at the U.S. Census block level during the next plan update, use the census block estimates and residential structures for a more precise distribution of population, or the current American Community Survey 5-Year Estimate populations counts at the Census tract level.
- Flood

    - The general building stock inventory can be updated to include attributes regarding first floor elevation and foundation type (basement, slab on grade, etc.) to enhance loss estimates.
    - Conduct a Hazus loss analysis for more frequent flood events (e.g., 10 and 50-year flood events).
    - Further refine the repetitive loss area analysis.
    - Continue to expand and update urban flood areas to further inform mitigation.
    - Conduct Hazus loss analysis in the latest version of Hazus
- Earthquake
    - Identify unreinforced masonry in critical facilities and privately-owned buildings (i.e., residences) by accessing local knowledge, tax assessor information, and/or pictometry/orthophotos. These buildings may not withstand earthquakes of certain magnitudes and plans to provide emergency response/recovery efforts at these properties can be developed.
    - Conduct Hazus loss analysis in the latest version of Hazus
- Extreme Temperatures
    - Track extreme temperature data for injuries, deaths, shelter needs, pipe freezing, agricultural losses, and other impacts to determine distributions of most at risk areas.
- Geological Hazards
    - If available during the next plan update, update the risk assessment using a comprehensive landslide susceptibility and subsidence incidence hazard data.
    - Collect data on historic costs incurred to reconstruct buildings, cultural resources and/or infrastructure due to geologic hazards.
- Hurricanes
    - The general building stock inventory can be updated to include attributes regarding protection against strong winds, such as hurricane straps, to enhance loss estimates.
    - Estimate storm surge related losses using the Hazus flood model if the data is available.
    - If available during the next plan update, update the risk assessment using a comprehensive coastal erosion hazard area map and updated sea level rise inundation areas.
    - Collect data on historic costs incurred to reconstruct buildings, cultural resources and/or infrastructure due to coastal erosion impacts.
    - Integrate evacuation route data that is currently being developed.
    - Conduct Hazus loss analysis in the latest version of Hazus
- Wildfire
    - General building stock inventory can be updated to include attributes such as roofing material or fire detection equipment or integrate distance to fuels as another measure of vulnerability.
- Disease Outbreak, Hazardous Substances
    - Additional information regarding localized concerns and past impacts may be collected and analyzed.
    - Assess the impacts and outcome from COVID-19.

4.2.3 Data Source Summary

Table 4.2-3 summarizes the data sources used for the risk assessment for this plan.

Table 4.2-3. Risk Assessment Data Documentation

Data	Source	Date	Format
Population data	U.S. Census Bureau; American Community Survey 5-Year Estimates	2010; 2019	Digital (GIS) Format
Building Footprints	Gloucester County	2021	Digital (GIS) Format
Parcel Boundaries	Gloucester County	2021	
MODIV Tax Assessor data	NJ Office of Information Technology	2020	Digital (GIS/Tabular) Format
Critical facilities	Gloucester County Steering Committee and Planning Committee	2016/2021	Digital (GIS) Format
Digitized Effective FIRM maps	FEMA	2016	Digital (GIS) Format
NEHRP Soil	NJDOT	2012	Digital (GIS) Format
Landslide Susceptibility (Steep Slopes >15% Grade)	USGS/Tetra Tech	2015/2021	Digital (GIS) Format
Carbonate Rock Soil Data	USGS	n.d.	Digital (GIS) Format
Wildfire Fuel Hazard	NJFFS	2009	Digital (GIS) Format
Census of Agriculture	USDA	2017	Digital (PDF Report) Format
Sea Level Rise	NOAA	2017	Digital (GIS) Format
Sea-Lake Overland Surge from Hurricanes (SLOSH) Model	NOAA	2014	Digital (GIS) Format
Coastal Erosion	Tetra Tech/FEMA	2021/2016	Digital (GIS) Format
1-Meter Resolution Digital Elevation Model	United State Geological Survey (USGS)	2015	Digital (GIS) Format
1-Percent Annual Chance Event – Riverine Depth Grid	State of New Jersey	2014	Digital (GIS) Format
1-Percent Annual Chance Event – Coastal Depth Grid	FEMA	2017	Digital (GIS) Format
Hazardous Materials Facilities	EPA	2021	Digital (GIS) Format

Data	Source	Date	Format
Hazardous Materials Roadways	NJOIT	2017	Digital (GIS) Format
Hazardous Materials Railways	NJDOT	2012	Digital (GIS) Format
Dams	Gloucester County OEM/NJDEP	2021/2020	Digital (GIS/Tabular) Format

4.2.3.1Limitations

Loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

1) Approximations and simplifications necessary to conduct such a study
2) Incomplete or dated inventory, demographic, or economic parameter data
3) The unique nature, geographic extent, and severity of each hazard
4) Mitigation measures already employed by the participating municipalities
5) The amount of advance notice residents have to prepare for a specific hazard event
6) Uncertainty of climate change projections

These factors can result in a range of uncertainty in loss estimates, possibly by a factor of two or more. Therefore, potential exposure and loss estimates are approximate. These results do not predict precise results and should be used to understand relative risk. Over the long term, Gloucester County will collect additional data to collect additional data, update and refine existing inventories, to assist in estimating potential losses.

Potential economic loss is based on the present value of the general building stock utilizing best available data. The County acknowledges significant impacts may occur to critical facilities and infrastructure as a result of these hazard events causing great economic loss. However, monetized damage estimates to critical facilities and infrastructure, and economic impacts were not quantified and require more detailed loss analyses. In addition, economic impacts to industry such as tourism and the real-estate market were not analyzed.

4.3.1 Coastal Erosion and Sea Level Rise

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the coastal erosion and sea level rise hazard in Gloucester County.

2022 Plan Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences (updated with events that occurred between 2016 and 2021), probability of future occurrence, and potential climate change impacts using best available data.
- A vulnerability assessment section was completed for the coastal erosion hazard that provides a more accurate estimated exposure and potential losses to Gloucester County.

4.3.1.1 Profile

Hazard Description

Coastal Erosion

Along with flooding, coastal erosion is one of the primary coastal hazards leading to loss of lives or damage to property and infrastructure in damaged coastal areas. Coastal erosion is a complex physical process shaped by both natural processes and human activity. Natural factors include the sediment supply; changes in sea level; geologic characteristics of the shore; the effects of waves, currents, tides and wind; and the bathymetry of the offshore sea bottom. Human activity may have direct or indirect effects on the coastal areas (USGS 2015).

Many natural factors affect erosion of the shoreline, including shore and nearshore morphology, shoreline orientation, and the response of these factors to storm frequency and sea level rise. Coastal shorelines change constantly in response to wind, waves, tides, sea-level fluctuation, seasonal and climatic variations, human alteration, and other factors that influence the movement of sand and material within a shoreline system.

Unsafe tidal conditions, as a result of high winds, heavy surf, erosion, and fog are ordinary coastal hazard phenomena. Some or all of these processes can occur during a coastal storm, resulting in an often detrimental impact on the surrounding coastline. Factors including: (1) storms such as hurricanes and Nor'Easters, (2) decreased sediment supplies, and (3) sea-level rise contribute to these coastal hazards. For more information regarding hurricanes, refer to Section 4.3.10. For more information regarding Nor'Easters, refer to Section 4.3.12.

Historically, some of the methods used by the USACE, the state, municipalities, and property owners to stop or slow down coastal erosion or shoreline change have actually exacerbated the problem. Attempting to halt the natural process of erosion with shore parallel or perpendicular structures such as seawalls (groins and jetties) and other hard structures typically worsens the erosion in front of the structure (i.e. walls), prevents or starves any sediment behind the structure (groins) from supplying down-drift properties with sediment, and subjects down-drift beaches to increased erosion. Since most sediment transport associated with erosion and longshore drift has been reduced, some of the State's greatest assets and attractions – beaches, dunes, barrier beaches, salt marshes, and estuaries – are threatened and will slowly disappear as the sediment sources that feed and sustain them are eliminated. This increased erosion impacts natural habitats, spawning grounds, recreational activity areas, and public access (Frizzera 2011).

Coastal erosion is typically a sporadic event and most typically associated with another hazard event, such as a hurricane. Additionally, erosion rates are influenced by local geographic features and man-made structures. Although most typically associated with flooding, coastal erosion can also be caused by windstorm events, which can blow sediment overland into adjacent low-lying marshes, upland habitats, inland bays, and communities. If related to a flood event, erosion is typically seen when extreme rainfall scours and erodes dunes and when inland floodwaters return through the beach face into the ocean (FEMA 1996).

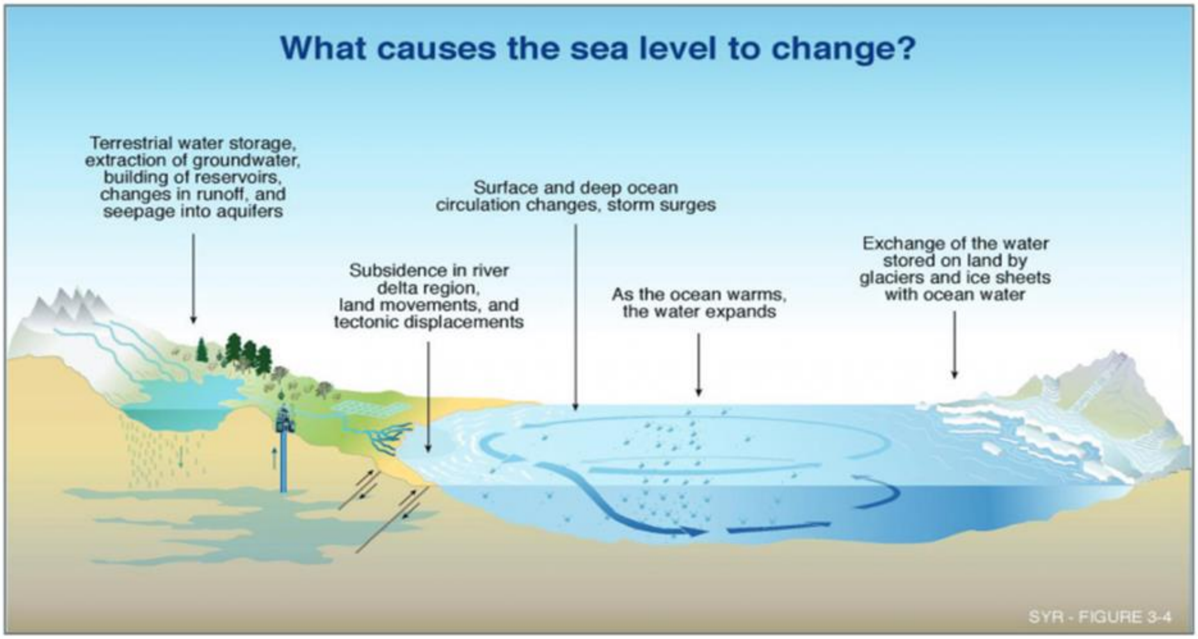
Coastal erosion can result in significant economic loss through the destruction of buildings, roads, infrastructure, natural resources, and wildlife habitats. Damage often results from an episodic event with the combination of severe storm waves and dune or bluff erosion.

Sea Level Rise

Sea level rise associated with climate change will have significant effects on coastal areas, including tidal portions of the Delaware River in Gloucester County. Long-term sea level records show changes in global temperatures, hydrologic cycles, coverage of glaciers and ice sheets, and storm frequency and intensity. Sea levels provide a key to understanding the impact of climate change.

There are two types of sea level: global and relative. Global sea level rise refers to the increase currently observed in the average global sea level trend (primarily attributed to changes in ocean volume due to ice melt and thermal expansion). The melting of glaciers and continental ice masses can contribute significant amounts of freshwater input to the earth's oceans. In addition, a steady increase in global atmospheric temperature creates an expansion of saltwater molecules, increasing ocean volume. Figure 4.3.1-1 illustrates the causes of sea level change.

Figure 4.3.1-1. Causes of Sea Level Change



Source: U.S. Climate Resilience Toolkit 2019

Local sea level refers to the height of the water as measured along the coast relative to a specific point on land. Water level measurements at tide stations are referenced to stable vertical points on the land and a known relationship is established. Measurements at any given tide station include both global sea level rise and vertical land motion (subsidence, glacial rebound, or large-scale tectonic motion). The heights of both the land and water are changing; therefore, the land-water interface can vary spatially and temporally and must be defined over time. Relative sea level trends reflect changes in local sea level over time and are typically the most critical sea level trend for many coastal applications (coastal mapping, marine boundary delineation, coastal zone management, coastal engineering, and sustainable habitat restoration) (U.S. Climate Resilience Toolkit 2019).

Short-term variations in sea level typically occur on a daily basis and include waves, tides, or specific flood events. Long-term variations in sea level occur over various time scales, from monthly to several years and may be repeatable cycles, gradual trends, or intermittent differences. Seasonal weather patterns (changes in the earth's declination), changes in coastal and ocean circulation, anthropogenic influences, vertical land motion, etc. may influence changes in sea level over time. When estimating sea level trends, a minimum of 30 years of data are used in order to account for long-term sea level variations and reduce errors in computing sea level trends based on monthly mean sea level (U.S. Climate Resilience Toolkit 2019).

In New Jersey, sea levels are rising faster than they are globally due to changes in the Gulf Stream, localized land subsidence, and continued geologic influences as land slowly adjusts to the loss of the North American ice sheet at the end of the last ice age. This rate will continue to increase (Kopp et al. 2019). The amount of greenhouse gases that are emitted is tied to rates of sea level rise. By 2050, New Jersey will likely experience at least a 0.9 to 2.1-foot increase (above the levels in 2000; all emissions scenarios), 1.4 to 3.1-foot increase by 2070 (moderate emissions scenario), and potentially a 2.0 to 5.1-foot increase by 2100 (moderate emissions scenario) (Kopp et al. 2019). Understanding how precipitation and sea level rise will change in the future is vital to New Jersey's coastal zone because low-lying coastal areas are already experiencing tidal flooding, even on sunny days in the absence of precipitation events.

According to NOAA, sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. All of these factors change during extreme weather and climate events (NOAA 2012). Other secondary hazards that could occur along the mid-Atlantic coast in response to sea level rise:

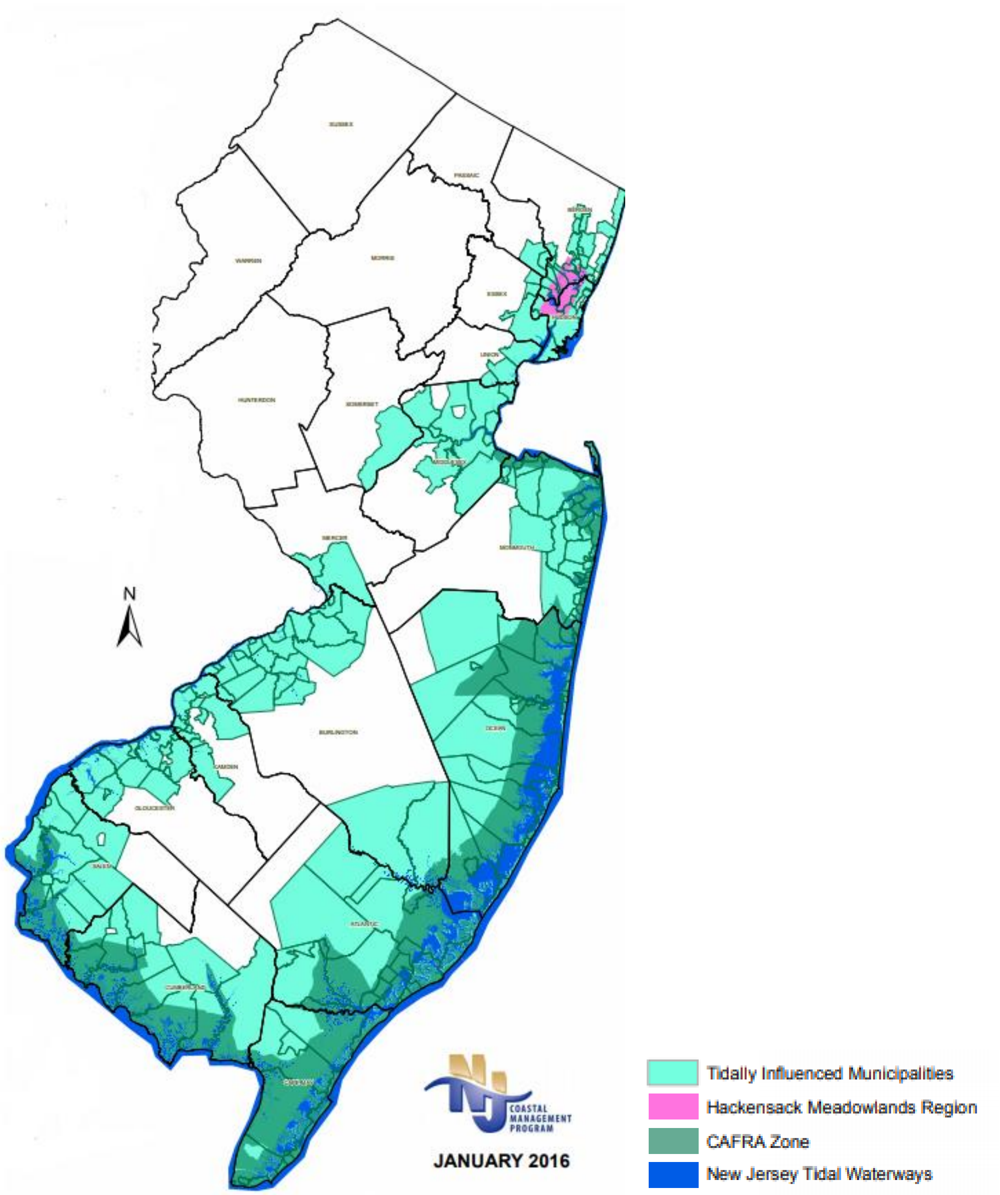
- Bluff and upland erosion – shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As sea level rises, the uplands are eroded and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments (Gutierrez et al. 2007).
- Threshold behavior – changes in sea level can lead to conditions where a barrier system becomes less stable and crosses a geomorphic threshold; making the potential for rapid barrier-island migration or segmentation/disintegration high. Unstable barriers may be defined by rapid landward recession of the ocean shoreline, decrease in barrier width and height, increased overwashing during storms, increased barrier breaching and inlet formation, or chronic loss of beach and dune sand volume. With the rates of sea level rise and climate change, it is very likely that these conditions will worsen (Gutierrez et al. 2007).
- Loss of critical habitat – natural ecosystems may be impacted by warmer temperatures and associated changes in the water cycle. The changes could lead to loss of critical habitat and further stresses on some threatened and endangered species (Kopp et al. 2019).

An increase in sea level will cause further issues as stormwater recharge is challenged as sea-levels submerge discharge points, resulting in increases in flooding (Kopp et al. 2019).

Location

Gloucester County experiences the impacts of coastal erosion and sea level rise in coastal areas. NJDEP defines 'coastal' as any land adjacent to a tidally influenced waterway. New Jersey has three primary coastal regions: the Atlantic Coast which includes communities along the Atlantic Ocean and communities that lie inland of the Atlantic coast barrier islands; the Delaware Bayshore; and the urban coast which includes communities such as Jersey City and Hoboken that lie along the tidal portion of the Hudson River (Rutgers 2014). The coastal area includes coastal waters to the limit of tidal influence including: the Atlantic Ocean (to the limit of New Jersey's seaward jurisdiction); Upper New York Bay, Newark Bay, Raritan Bay and the Arthur Kill; the Hudson, Raritan, Passaic, and Hackensack Rivers, and the tidal portions of the tributaries to these bays and rivers. The Delaware River and Bay and other tidal streams of the Coastal Plain are also in the coastal area, as is a narrow band of adjacent uplands in the Waterfront Development area beyond the CAFRA area (NJDEP 2016). As previously stated, a coastal area is any land adjacent to a tidally influenced waterway; therefore, Gloucester County is considered a coastal county because it borders the tidal portion of the Delaware River. Figure 4.3.1-2 illustrates the coastal municipalities of New Jersey and Gloucester County.

Figure 4.3.1-2. New Jersey Coastal Municipalities



Source: NJDEP 2016

The following municipalities in Gloucester County are tidally influenced and considered to be coastal:

- Township of Deptford
- Township of East Greenwich
- Township of Greenwich
- Township of Logan
- Township of Mantua
- Borough of National Park
- Borough of Paulsboro
- Borough of Swedesboro
- Borough of Wenonah
- Borough of West Deptford
- City of Woodbury
- Borough of Westville

Extent

Coastal Erosion

All coastal areas are affected by storms and other natural events that cause erosion; however, the extent and severity of erosion differs across the United States. It may be intensified by activities such as boat wakes, shoreline hardening, or dredging. Natural recovery after erosive episodes can take months or years. If a beach or wetland does not recover quickly enough via natural processes, coastal and upland property may be exposed to further damage in subsequent events. Coastal erosion can cause the destruction of buildings and infrastructure (FEMA 1996).

Coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a period of time. Geologists measure the severity of erosion in two ways -- as a rate of linear retreat (feet of shoreline recession per year) and volumetric loss (cubic yards of eroded sediment per linear foot of shoreline frontage per year) (NYC Emergency Management 2019).

Coastal erosion can be classified as short-term or long-term. The long-term changes of shoreline may not be evident on a day-to-day or even year-to-year basis. They occur over a period of decades, over which short-term changes tend to average out to the underlying erosion or accretion trend. However, short-term changes due to storm events are immediately noticed. Short-term changes occur over periods ranging from a few days to a few years. They can be highly variable in direction and magnitude.

A number of factors determine whether a community exhibits greater long-term erosion or accretion:

- Exposure to high-energy storm waves,
- Sediment size and composition of eroding coastal landforms feeding adjacent beaches,
- Near-shore bathymetric variations which direct wave approach,
- Alongshore variations in wave energy and sediment transport rates,
- Relative sea level rise,

- Frequency and severity of storm events, and
- Human interference with sediment supply (e.g. revetments, seawalls, jetties) (Woods Hole Sea Grant 2003).

Sea Level Rise

For New Jersey, Rutgers University, in partnership with other academic, local, federal and state agencies and programs, has developed online tools that help provide an understanding of how climate change is affecting and will continue to affect the State. With the interactive, user-centered NJFloodmapper web tool, New Jersey decision-makers can visualize flood risk due to sea level rise and extreme storms to aid resilience and hazard mitigation planning efforts. NJFloodmapper streamlines the latest spatial data and decision-support tools into a single resource that provides current, accessible, science-based and state-specific data and visualizations.

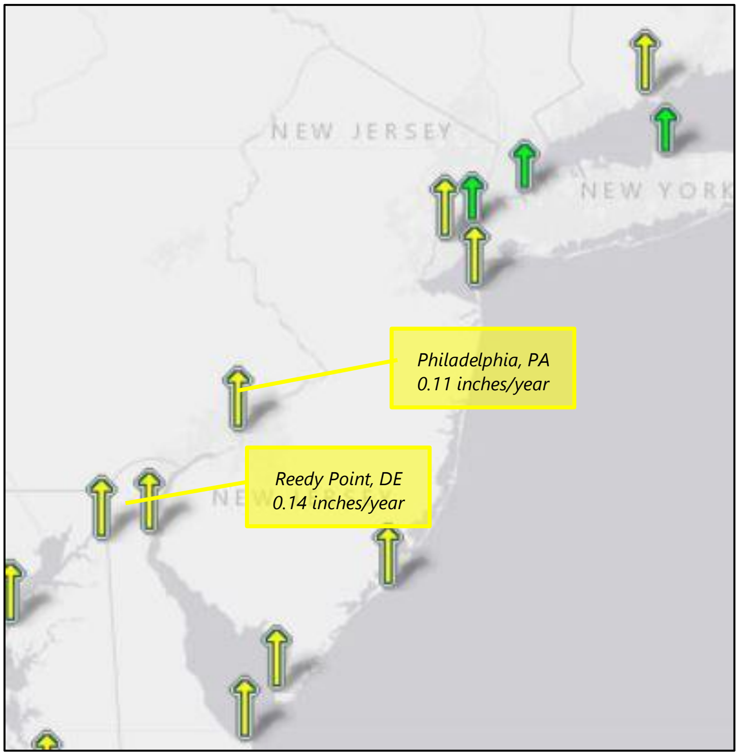
NJFloodmapper offers a unique Total Water Level approach to flood risk visualization that reflects user-defined combinations of sea level rise and flood conditions, providing flexibility to evaluate a range of flood conditions and time horizons for planning. NJFloodmapper also includes enhanced data layers that show physical infrastructure, evacuation routes, land uses, and socio-demographics to give a fuller picture of community vulnerability. Users can choose hazard overlays including Total Water Level, SLOSH for Categories 1-4, Sea Level Rise for 1-10 feet, FEMA Flood Zones, and Sandy Surge Extent. After creating a map, users can share a link or create a pdf for further use. NJFloodmapper also includes Municipal Snapshots that provide easy access to information about the people, places, and assets that are at risk from coastal flood hazards in each of New Jersey's municipalities. The mapping portal is found here: https://www.njfloodmapper.org/.

The global sea level trend has been recorded by satellite altimeters since 1992 and the latest calculation can be obtained from NOAA's Laboratory for Satellite Altimetry. The University of Colorado's Sea Level Research Group compares global sea level rates calculated by different research organizations and provides detailed explanations about the issues involved (NOAA 2020). A map of regional MSL in the United States can be found here: http://tidesandcurrents.noaa.gov/sltrends/slrmap.htm. The map provides an overview of variations in the rates of relative local MSL at long-term tide stations. The variations in sea level trends primarily reflect differences in rates and sources of vertical land motion. Areas that experienced little-to-no change in MSL are shown in green, including stations consistent with average global sea level rise rate of 0.06 to 0.07 in/year. These stations do not experience significant vertical land motion. Stations that experienced positive sea level trends (yellow to red) experience both global sea level rise and lowering or sinking of the local land, causing an apparent exaggerated rate of relative sea level rise. Stations that are blue to brown have experienced global sea level rise and a greater vertical rise in local land, causing an apparent decrease in relative sea level. The rates of relative sea level rise reflect actual observations and must be accounted for in any coastal planning or engineering applications (NOAA 2021).

There are two NOAA tide gauge stations located near Gloucester County. Though each are located outside of New Jersey, they are located along the Delaware River and provide the best representation of sea level rise in

Gloucester County. Figure 4.3.1-3 shows these changes for Philadelphia, Pennsylvania and Reedy Point, Delaware.

Figure 4.3.1-3. Mean Sea Level Trends in New Jersey



Source: NOAA 2021

Additionally, in an article titled "A geological perspective on sea level rise and its impacts along the U.S. mid-Atlantic coast" written by Kenneth Miller, Robert Kopp, Benjamin Horton, James Browning, and Andrew Kemp, an analysis of geological and historical sea level records was done. This showed a significant rate of increase in sea level rise since the 19th century. It was stated that in New Jersey, it is extremely likely that sea level rise in the 20th century was faster than during any century in the last 4,300 years. Based on the findings of this article and the 2019 update of the initial study, it is anticipated that the arrival of one foot of sea level rise will be experienced before 2050. As sea level rise is expected to accelerate in this century, three feet of sea level rise is very likely before 2100. The table below (Table 4.3.1-1) shows the "low", "moderate, and "high" estimates for sea level rise projects in New Jersey for the years 2030, 2050, 2070, 2100 and 2150.

Table 4.3.1-1. Sea Level Rise Projections for New Jersey (ft. above year 2000 average sea level) for New Jersey From 2030 to 2150 Under Low, Moderate and High Emissions Scenarios.

	Chance SLR Exceeds	2030	2050	2070 Emissions Low	2070 Emissions Mod.	2070 Emissions High	2100 Emissions Low	2100 Emissions Mod.	2100 Emissions High	2150 Emissions Low	2150 Emissions Mod.	2150 Emissions High
Low End	>95% chance	0.3	0.7	0.9	1.0	1.1	1.0	1.3	1.5	1.3	2.1	2.9

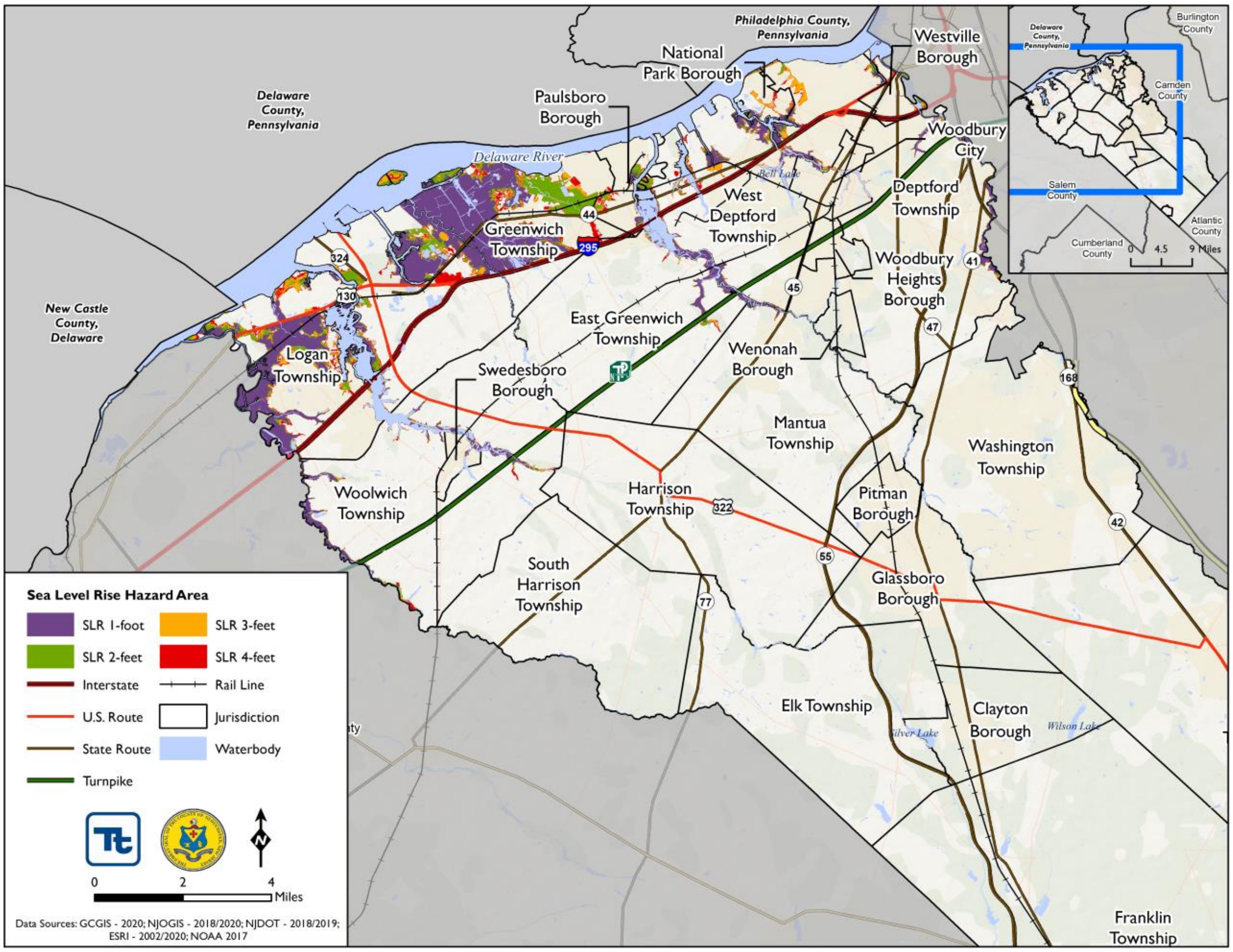
	Chance SLR Exceeds	2030	2050	2070 Emissions			2100 Emissions			2150 Emissions		
				Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Likely Range	>83% chance	0.5	0.9	1.3	1.4	1.5	1.7	2.0	2.3	2.4	3.1	3.8
	~50% chance	0.8	1.4	1.9	2.2	2.4	2.8	3.3	3.9	4.2	5.2	6.2
	<17% chance	1.1	2.1	2.7	3.1	3.5	3.9	5.1	6.3	6.3	8.3	10.3
High End	<5% chance	1.3	2.6	3.2	3.8	4.4	5.0	6.9	8.8	8.0	13.8	19.6

Source: *Kopp et al. 2019*

Note: *The likely range represents the range of levels between which there is 66% chance that SLR will occur*

Looking at Figure 4.3.1-4, just one foot of sea level rise will inundate several areas of Gloucester County, including significant areas of the Township of Logan and the Township of Greenwich. Higher levels of sea level will result in expansion of inundated areas.

Figure 4.3.1-4. Sea Level Rise in Gloucester County



Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with coastal erosion throughout the State of New Jersey and Gloucester County; therefore, the loss and impact information for many events varies depending on the source. The accuracy of monetary figures discussed is based only on the available information in cited sources.

Although many factors contribute to the natural coastal erosion of Gloucester County shorelines; historical hurricanes, tropical storms and Nor'Easter events have significantly increased coastal erosion processes throughout Gloucester County. Details regarding hurricane and Nor'Easter events that have impacted Gloucester County are presented in Section 4.3.10 and Section 4.3.12, respectively.

Federal Disaster Declarations

Between 1954 and 2021, Gloucester County and the State of New Jersey has not had a coastal erosion specific event but have been included in numerous FEMA major disaster and emergency declarations for events that could have included coastal erosion impacts including events for flood, hurricane, Nor'Easter, severe storm, and severe winter storm. For a list of the associated declarations for these events, refer to Sections 4.3.7 (Flood), 4.3.10 (Hurricane), 4.3.12 (Nor'Easter), 4.3.13 (Severe Weather), and 4.3.14 (Severe Winter Weather). No sea level rise specific declarations have been declared.

USDA Disaster Declarations

The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Gloucester County was not included in declarations related to coastal erosion or sea level rise from 2015 to 2021 (USDA 2021).

Previous Events

For this 2021 Plan Update, known coastal erosion events that have impacted Gloucester County between 2016 and 2021 were researched. No events were identified. Sea level rise is a long term and continuous hazard , instead of a specific event. However, the impacts of sea level rise, such as gradual shoreline retreat and higher frequency of coastal flooding events, continue to be documented in Gloucester County.

Probability of Future Occurrences

Long-term coastal erosion is a continuous and dynamic process, impacting coastal counties. It is anticipated that coastal erosion will continue due to the predicted increase in sea level rise and storm frequency and intensity. In New Jersey, coastal erosion will continue to be an ongoing problem along many areas of coastline. It is difficult to assign a probability to the near constant small ongoing erosion that may occur over a continuous period of time. However, a probability can be assigned to larger storm events such as Nor'easters and hurricanes, which can result in significant, rapid coastal erosion. The period of time suggest the probability of coastal erosion will be about the same in the future, with year-to-year variations. For information on the probability of coastal storm events which can contribute to coastal erosion, refer to the Hurricane and Tropical Storm (Section 4.3.10) and Nor'Easter (Section 4.3.12) hazard profiles.

For Gloucester County, coastal erosion impacts will vary from place to place along the surge-impacted areas of the County. As temperatures increase (see climate change impacts), the probability for future events will likely increase as well. Climate change and sea level rise have been documented since the 19th century. In Philadelphia, Pennsylvania and Reedy Beach, Delaware (the nearest tide gages to Gloucester County on the Delaware River), sea-level has risen at a rate of approximately 0.11 to 0.15 inches per year since the beginning of the 20th century (NOAA 2021), and this rate will continue to increase (Kopp et al. 2019).

In Section 4.4, the identified hazards of concern for the County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Partnership, the probability of occurrence for coastal erosion in the County is considered 'occasional' (10 to 100 percent chance of occurring in any given year, occurring multiple times a year).

Climate Change Impacts

Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015).

Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017).

According to NOAA, sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. Other secondary hazards that could occur along the Mid-Atlantic coast in response to sea level rise include:

- *Bluff and upland erosion* – Shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As sea level rises, the uplands are eroded and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments.
- *Overwash* – As sea level rise occurs, storm overwash will become more likely.

- *Shoreline retreat* - The combination of rising sea level and stronger storms can create the potential to accelerate shoreline retreat in many locations. (Gutierrez et al. 2007).

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017). As temperatures increase so will the energy in a storm system, increasing the potential for more intense tropical storms (Huang et al. 2017), especially those of Category 4 and 5 (Melillo et al. 2014).

In Philadelphia, Pennsylvania and Reedy Beach, Delaware (the nearest tidal gages to Gloucester County on the Delaware River), sea-level has risen at a rate of approximately 0.11 to 0.15 inches per year since the beginning of the 20th century (NOAA 2021), and this rate will continue to increase (Kopp et al. 2019). The amount of greenhouse gases that are emitted is tied to rates of sea-level rise. By 2050, New Jersey will likely experience at least a 0.9 to 2.1-foot increase (above the levels in 2000; all emissions scenarios), 1.4 to 3.1-foot increase by 2070 (moderate emissions scenario), and potentially a 2.0 to 5.1-foot increase by 2100 (moderate emissions scenario).

Impacts of climate change can lead to shoreline erosion, coastal flooding, and water pollution; affecting man-made coastal infrastructures and coastal ecosystems. Coastal areas may be impacted by climate change in different ways. These areas are sensitive to sea level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures (USEPA 2017). As noted above, temperatures are predicted to increase in Gloucester County, which lead to an increase in intensity and frequency of severe storm. This increase may lead to more weather patterns that cause coastal erosion events. Rising sea levels will also exacerbate erosional issues.

4.3.1.2 Vulnerability Assessment

To assess Gloucester County's risk to the coastal erosion and sea level rise hazards, a spatial analysis was conducted using the best available data. To determine the geographic distribution of coastal risk, the Limit of Moderate Wave Action (LiMWA) boundary was referenced from FEMA's 2016 Effective DFIRM flood data. The LiMWA boundary was selected to assess coastal erosion because it represents land area that is susceptible to wave action. Wave action can be a driver for coastal erosion in Gloucester County. Additionally, NOAA's 2017 sea level rise data in 1-foot increments were used to assess the County's risk to the sea level rise hazard area. Refer to Section 4.2 (Methodology and Tools) for additional details on the methodology used to assess coastal erosion and sea level rise risk.

Impact on Life, Health and Safety

Coastal erosion is not generally considered an imminent threat to public safety when the changes are gradual over many years. However, drastic changes to the shoreline may occur as a result of a single storm event which can threaten homes and public safety. The population exposed, or located in the estimated hazard area, is also considered vulnerable to this hazard. The analysis indicates that 21 people are located in the estimated coastal erosion hazard area (Table 4.3.1-2).

Table 4.3.1-2. Estimated Population Located in the Coastal Erosion Hazard Area

Jurisdiction	Total Population (American Community Survey 2015-2019)	Estimated Population Located in the Coastal Erosion Hazard Area	
		Number of People	Percent of Total
Clayton (B)	8,626	0	0.0%
Deptford (Twp)	30,448	0	0.0%
East Greenwich (Twp)	10,488	0	0.0%
Elk (Twp)	4,135	0	0.0%
Franklin (Twp)	16,440	0	0.0%
Glassboro (B)	19,826	0	0.0%
Greenwich (Twp)	4,831	4	0.1%
Harrison (Twp)	12,995	0	0.0%
Logan (Twp)	5,924	0	0.0%
Mantua (Twp)	14,941	0	0.0%
Monroe (Twp)	36,789	0	0.0%
National Park (B)	2,959	0	0.0%
Newfield (B)	1,521	0	0.0%
Paulsboro (B)	5,904	13	0.2%
Pitman (B)	8,805	0	0.0%
South Harrison (Twp)	3,148	0	0.0%
Swedesboro (B)	2,579	0	0.0%
Washington (Twp)	47,833	0	0.0%
Wenonah (B)	2,259	0	0.0%
West Deptford (Twp)	21,149	3	<0.1%
Westville (B)	4,169	0	0.0%
Woodbury (C)	9,861	0	0.0%
Woodbury Heights (B)	2,986	0	0.0%
Woolwich (Twp)	12,549	0	0.0%
Gloucester County (Total)	**291,165**	**21**	**0.0%**

Source: ACS 5-year Estimate 2015-2019; FEMA 2016
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Additionally, people living and working in the sea level rise hazard area may be displaced as homes and businesses become flooded and permanently lost. To estimate population exposed and vulnerable to the sea level rise hazards, a spatial analysis was conducted using the NOAA sea level rise inundation areas; refer to Table 4.3.1-3. This table summarizes the impacts of sea level rise for the 1-foot through 4-foot scenarios by Gloucester County's municipalities. Please note the limitations of this analysis are recognized and the results should only be used as an estimate.

The analysis estimates that there are 491 persons living in the sea level rise 1-foot hazard area and up to 2,291 persons living in the sea level rise 4-feet hazard area. Overall, the Township of Greenwich has the greatest proportion of its population and the greatest number of persons in the sea level rise hazard areas that may become displaced (Table 4.3.1-3).

Table 4.3.1-3. Estimated Population Located in the Sea Level Rise Hazard Area

Jurisdiction	Total Population (American Community Survey 2015-2019)	Number of Persons Located in the Sea Level Rise 1-Foot Flood Hazard Area	Percent of Total	Number of Persons Located in the Sea Level Rise 2-Feet Flood Hazard Area	Percent of Total	Number of Persons Located in the Sea Level Rise 3-Feet Flood Hazard Area	Percent of Total	Number of Persons Located in the Sea Level Rise 4-Feet Flood Hazard Area	Percent of Total
Clayton (B)	8,626	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Deptford (Twp)	30,448	3	<0.1%	3	<0.1%	3	<0.1%	3	<0.1%
East Greenwich (Twp)	10,488	5	0.1%	10	0.1%	16	0.2%	16	0.2%
Elk (Twp)	4,135	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Franklin (Twp)	16,440	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Glassboro (B)	19,826	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Greenwich (Twp)	4,831	402	8.3%	637	13.2%	839	17.4%	1,067	22.1%
Harrison (Twp)	12,995	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Logan (Twp)	5,924	35	0.6%	81	1.4%	119	2.0%	185	3.1%
Mantua (Twp)	14,941	0	0.0%	2	<0.1%	2	<0.1%	5	<0.1%
Monroe (Twp)	36,789	0	0.0%	0	0.0%	0	0.0%	0	0.0%
National Park (B)	2,959	13	0.4%	36	1.2%	136	4.6%	244	8.3%
Newfield (B)	1,521	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Paulsboro (B)	5,904	0	0.0%	0	0.0%	8	0.1%	140	2.4%
Pitman (B)	8,805	0	0.0%	0	0.0%	0	0.0%	0	0.0%
South Harrison (Twp)	3,148	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Swedesboro (B)	2,579	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Washington (Twp)	47,833	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Wenonah (B)	2,259	0	0.0%	0	0.0%	0	0.0%	0	0.0%
West Deptford (Twp)	21,149	26	0.1%	77	0.4%	366	1.7%	482	2.3%

Jurisdiction	Total Population (American Community Survey 2015-2019)	Number of Persons Located in the Sea Level Rise 1-Foot Flood Hazard Area	Percent of Total	Number of Persons Located in the Sea Level Rise 2-Feet Flood Hazard Area	Percent of Total	Number of Persons Located in the Sea Level Rise 3-Feet Flood Hazard Area	Percent of Total	Number of Persons Located in the Sea Level Rise 4-Feet Flood Hazard Area	Percent of Total
Westville (B)	4,169	0	0.0%	22	0.5%	40	1.0%	129	3.1%
Woodbury (C)	9,861	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Woodbury Heights (B)	2,986	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Woolwich (Twp)	12,549	7	0.1%	7	0.1%	7	0.1%	20	0.2%
Gloucester County (Total)	**291,165**	**491**	**0.2%**	**875**	**0.3%**	**1,536**	**0.5%**	**2,291**	**0.8%**

Source: ACS 5-year Estimate 2015-2019; NOAA 2017
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Impact on General Building Stock

After considering the population exposed and potentially vulnerable to the coastal erosion and sea level rise hazard areas, the built environment was evaluated. Exposure includes those buildings located in the coastal erosion and sea level rise hazard areas. Table 4.3.1-4 through Table 4.3.1-6 summarize these results county-wide.

In summary, 13 buildings accounting for approximately $6.4 million of replacement cost value are located in the estimated coastal erosion hazard area (Table 4.3.1-4). In total, this represents less than 0.1-percent of the County's total general building stock inventory. Furthermore, 254 structures (approximately $176.4 million) are located in the 1-foot sea level rise hazard area and up to 1,164 structures (approximately $1.3 billion) are located in the 4-feet sea level rise hazard area (Table 4.3.1-5 and Table 4.3.1-6, respectively). As mentioned above, please note the limitations of this analysis are recognized and the results should only be used as an estimate.

Table 4.3.1-4. Estimated Buildings Located in the Coastal Erosion Hazard Area

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located in the Coastal Erosion Hazard Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Clayton (B)	3,295	$1,933,299,905	0	0.0%	$0	0.0%
Deptford (Twp)	11,284	$10,081,159,584	0	0.0%	$0	0.0%
East Greenwich (Twp)	4,346	$2,927,045,409	0	0.0%	$0	0.0%
Elk (Twp)	2,339	$1,784,179,937	0	0.0%	$0	0.0%
Franklin (Twp)	8,432	$5,637,186,975	0	0.0%	$0	0.0%
Glassboro (B)	5,959	$5,816,332,907	0	0.0%	$0	0.0%
Greenwich (Twp)	2,807	$2,734,741,222	6	0.2%	$3,621,543	0.1%
Harrison (Twp)	4,817	$4,828,239,008	0	0.0%	$0	0.0%

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located in the Coastal Erosion Hazard Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Logan (Twp)	2,805	$6,591,573,691	0	0.0%	$0	0.0%
Mantua (Twp)	6,569	$4,738,271,524	0	0.0%	$0	0.0%
Monroe (Twp)	12,553	$8,458,118,166	0	0.0%	$0	0.0%
National Park (B)	1,483	$781,021,288	0	0.0%	$0	0.0%
Newfield (B)	891	$622,948,021	0	0.0%	$0	0.0%
Paulsboro (B)	2,615	$2,076,864,026	6	0.2%	$2,181,729	0.1%
Pitman (B)	3,521	$2,916,470,733	0	0.0%	$0	0.0%
South Harrison (Twp)	1,726	$1,494,748,661	0	0.0%	$0	0.0%
Swedesboro (B)	1,040	$936,236,069	0	0.0%	$0	0.0%
Washington (Twp)	17,413	$13,732,374,547	0	0.0%	$0	0.0%
Wenonah (B)	930	$778,702,966	0	0.0%	$0	0.0%
West Deptford (Twp)	7,561	$9,201,121,261	1	<0.1%	$638,574	<0.1%
Westville (B)	1,733	$1,529,846,612	0	0.0%	$0	0.0%
Woodbury (C)	3,605	$4,139,381,075	0	0.0%	$0	0.0%
Woodbury Heights (B)	1,295	$1,265,332,236	0	0.0%	$0	0.0%
Woolwich (Twp)	4,074	$4,551,585,778	0	0.0%	$0	0.0%
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**13**	**<0.1%**	**$6,441,846**	**<0.1%**

Source: Gloucester County GIS 2021; MODIV 2020; RSMeans 2021; FEMA 2016
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Table 4.3.1-5. Estimated Buildings Located in the 1-foot and 2-feet Sea Level Rise Hazard Area

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Number of Buildings Located in the Sea Level Rise 1-Foot Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the Sea Level Rise 1-Foot Flood Hazard Area	Percent of Total	Number of Buildings Located in the Sea Level Rise 2-Feet Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the Sea Level Rise 2-Feet Flood Hazard Area	Percent of Total
Clayton (B)	3,295	$1,933,299,905	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Deptford (Twp)	11,284	$10,081,159,584	1	<0.1%	$652,868	<0.1%	1	<0.1%	$652,868	<0.1%
East Greenwich (Twp)	4,346	$2,927,045,409	2	<0.1%	$502,255	<0.1%	4	0.1%	$1,696,541	0.1%
Elk (Twp)	2,339	$1,784,179,937	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Franklin (Twp)	8,432	$5,637,186,975	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Glassboro (B)	5,959	$5,816,332,907	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Greenwich (Twp)	2,807	$2,734,741,222	209	7.4%	$145,239,315	5.3%	350	12.5%	$309,112,448	11.3%
Harrison (Twp)	4,817	$4,828,239,008	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Logan (Twp)	2,805	$6,591,573,691	19	0.7%	$14,846,448	0.2%	47	1.7%	$40,387,092	0.6%
Mantua (Twp)	6,569	$4,738,271,524	0	0.0%	$0	0.0%	1	<0.1%	$727,754	<0.1%
Monroe (Twp)	12,553	$8,458,118,166	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
National Park (B)	1,483	$781,021,288	10	0.7%	$8,660,862	1.1%	26	1.8%	$20,965,778	2.7%
Newfield (B)	891	$622,948,021	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Paulsboro (B)	2,615	$2,076,864,026	1	<0.1%	$58,794	<0.1%	3	0.1%	$4,876,693	0.2%
Pitman (B)	3,521	$2,916,470,733	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
South Harrison (Twp)	1,726	$1,494,748,661	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Swedesboro (B)	1,040	$936,236,069	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Washington (Twp)	17,413	$13,732,374,547	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Wenonah (B)	930	$778,702,966	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
West Deptford (Twp)	7,561	$9,201,121,261	8	0.1%	$2,853,936	<0.1%	26	0.3%	$12,566,222	0.1%
Westville (B)	1,733	$1,529,846,612	1	0.1%	$317,863	<0.1%	10	0.6%	$6,469,613	0.4%
Woodbury (C)	3,605	$4,139,381,075	1	<0.1%	$2,205,856	0.1%	1	<0.1%	$2,205,856	0.1%
Woodbury Heights (B)	1,295	$1,265,332,236	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Woolwich (Twp)	4,074	$4,551,585,778	2	<0.1%	$1,068,321	<0.1%	2	<0.1%	$1,068,321	<0.1%

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Number of Buildings Located in the Sea Level Rise 1-Foot Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the Sea Level Rise 1-Foot Flood Hazard Area	Percent of Total	Number of Buildings Located in the Sea Level Rise 2-Feet Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the Sea Level Rise 2-Feet Flood Hazard Area	Percent of Total
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**254**	**0.2%**	**$176,406,519**	**0.2%**	**471**	**0.4%**	**$400,729,187**	**0.4%**

Source: Gloucester County GIS 2021; MODIV 2020; RSMeans 2021; NOAA 2017
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Table 4.3.1-6. Estimated Buildings Located in the 3-feet and 4-feet Sea Level Rise Hazard Area

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Number of Buildings Located in the Sea Level Rise 3-Feet Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the Sea Level Rise 3-Feet Flood Hazard Area	Percent of Total	Number of Buildings Located in the Sea Level Rise 4-Feet Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the Sea Level Rise 4-Feet Flood Hazard Area	Percent of Total
Clayton (B)	3,295	$1,933,299,905	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Deptford (Twp)	11,284	$10,081,159,584	1	<0.1%	$652,868	<0.1%	1	<0.1%	$652,868	<0.1%
East Greenwich (Twp)	4,346	$2,927,045,409	6	0.1%	$2,410,564	0.1%	6	0.1%	$2,410,564	0.1%
Elk (Twp)	2,339	$1,784,179,937	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Franklin (Twp)	8,432	$5,637,186,975	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Glassboro (B)	5,959	$5,816,332,907	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Greenwich (Twp)	2,807	$2,734,741,222	462	16.5%	$431,920,676	15.8%	589	21.0%	$584,179,379	21.4%
Harrison (Twp)	4,817	$4,828,239,008	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Logan (Twp)	2,805	$6,591,573,691	77	2.7%	$74,056,182	1.1%	114	4.1%	$306,990,467	4.7%
Mantua (Twp)	6,569	$4,738,271,524	1	<0.1%	$727,754	<0.1%	2	<0.1%	$1,018,997	<0.1%
Monroe (Twp)	12,553	$8,458,118,166	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
National Park (B)	1,483	$781,021,288	77	5.2%	$43,972,801	5.6%	135	9.1%	$76,886,856	9.8%
Newfield (B)	891	$622,948,021	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Paulsboro (B)	2,615	$2,076,864,026	9	0.3%	$44,911,409	2.2%	84	3.2%	$189,608,445	9.1%

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Number of Buildings Located in the Sea Level Rise 3-Feet Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the Sea Level Rise 3-Feet Flood Hazard Area	Percent of Total	Number of Buildings Located in the Sea Level Rise 4-Feet Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the Sea Level Rise 4-Feet Flood Hazard Area	Percent of Total
Pitman (B)	3,521	$2,916,470,733	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
South Harrison (Twp)	1,726	$1,494,748,661	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Swedesboro (B)	1,040	$936,236,069	0	0.0%	$0	0.0%	1	0.1%	$1,830,928	0.2%
Washington (Twp)	17,413	$13,732,374,547	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Wenonah (B)	930	$778,702,966	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
West Deptford (Twp)	7,561	$9,201,121,261	125	1.7%	$59,057,240	0.6%	170	2.2%	$88,983,964	1.0%
Westville (B)	1,733	$1,529,846,612	18	1.0%	$12,867,683	0.8%	54	3.1%	$37,300,903	2.4%
Woodbury (C)	3,605	$4,139,381,075	2	0.1%	$3,733,325	0.1%	2	0.1%	$3,733,325	0.1%
Woodbury Heights (B)	1,295	$1,265,332,236	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Woolwich (Twp)	4,074	$4,551,585,778	2	<0.1%	$1,068,321	<0.1%	6	0.1%	$2,847,257	0.1%
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**780**	**0.7%**	**$675,378,823**	**0.7%**	**1,164**	**1.0%**	**$1,296,443,952**	**1.3%**

Source: Gloucester County GIS 2021; MODIV 2020; RSMeans 2021; NOAA 2017
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Impact on Critical Facilities and Lifelines

Coastal erosion and sea level rise may potentially impact critical facilities and lifelines identified within the County. Critical services may not be available if critical facilities or lifelines are directly damaged or transportation routes to access these critical facilities are breached due to coastal erosion or permanently inundated by sea level rise. Residual impacts from sea level rise include increased frequency of coastal flooding events and exacerbated impacts from coastal erosion. Flooding could disrupt utilities that are not protected with berms or other flood-proof measures. Coastal erosion may destabilize the roadways leading to facilities or destroy the foundation that supports the critical facilities along the shoreline.

Overall, port facilities may be impacted the most by coastal erosion or sea level rise. There are seven ports located in the coastal erosion hazard area and up to 18 ports located in the 4-feet sea level rise hazard area. The Township of Greenwich has the greatest number of critical facilities and lifelines located in the sea level rise hazard area and the Borough of Paulsboro has the greatest number of critical facilities and lifelines located in the coastal erosion hazard area. Refer to Table 4.3.1-7 through Table 4.3.1-11 for a summary of impacted critical facilities and lifelines distributed by jurisdiction and FEMA lifeline category type. Refer to Appendix E for a summary of critical facilities located in the coastal erosion and sea level rise hazard areas by critical facility type.

Table 4.3.1-7. Critical Facilities and Lifelines Located in the Coastal Erosion Hazard Area

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Located in the Coastal Erosion			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	0	0.0%	0	0.0%
Deptford (Twp)	79	77	0	0.0%	0	0.0%
East Greenwich (Twp)	46	46	0	0.0%	0	0.0%
Elk (Twp)	6	6	0	0.0%	0	0.0%
Franklin (Twp)	35	35	0	0.0%	0	0.0%
Glassboro (B)	137	137	0	0.0%	0	0.0%
Greenwich (Twp)	31	31	2	6.5%	2	6.5%
Harrison (Twp)	26	26	0	0.0%	0	0.0%
Logan (Twp)	50	50	1	2.0%	1	2.0%
Mantua (Twp)	30	30	0	0.0%	0	0.0%
Monroe (Twp)	29	26	0	0.0%	0	0.0%
National Park (B)	41	41	0	0.0%	0	0.0%
Newfield (B)	9	9	0	0.0%	0	0.0%
Paulsboro (B)	29	29	4	13.8%	4	13.8%
Pitman (B)	19	19	0	0.0%	0	0.0%
South Harrison (Twp)	12	12	0	0.0%	0	0.0%
Swedesboro (B)	9	9	0	0.0%	0	0.0%
Washington (Twp)	75	75	0	0.0%	0	0.0%
Wenonah (B)	4	4	0	0.0%	0	0.0%
West Deptford (Twp)	157	149	3	1.9%	3	2.0%

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Located in the Coastal Erosion			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Westville (B)	23	21	0	0.0%	0	0.0%
Woodbury (C)	59	59	0	0.0%	0	0.0%
Woodbury Heights (B)	9	9	0	0.0%	0	0.0%
Woolwich (Twp)	16	16	0	0.0%	0	0.0%
Gloucester County (Total)	**956**	**941**	**10**	**1.0%**	**10**	**1.1%**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2016/2020
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Table 4.3.1-8. Critical Facilities and Lifelines Located in the 1-foot Sea Level Rise Hazard Area

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located in the Sea Level Rise 1-Foot Flood Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	0	0.0%	0	0.0%
Deptford (Twp)	79	77	0	0.0%	0	0.0%
East Greenwich (Twp)	46	46	0	0.0%	0	0.0%
Elk (Twp)	6	6	0	0.0%	0	0.0%
Franklin (Twp)	35	35	0	0.0%	0	0.0%
Glassboro (B)	137	137	0	0.0%	0	0.0%
Greenwich (Twp)	31	31	6	19.4%	6	19.4%
Harrison (Twp)	26	26	0	0.0%	0	0.0%
Logan (Twp)	50	50	0	0.0%	0	0.0%
Mantua (Twp)	30	30	0	0.0%	0	0.0%
Monroe (Twp)	29	26	0	0.0%	0	0.0%
National Park (B)	41	41	3	7.3%	3	7.3%
Newfield (B)	9	9	0	0.0%	0	0.0%
Paulsboro (B)	29	29	7	24.1%	7	24.1%
Pitman (B)	19	19	0	0.0%	0	0.0%
South Harrison (Twp)	12	12	0	0.0%	0	0.0%
Swedesboro (B)	9	9	0	0.0%	0	0.0%
Washington (Twp)	75	75	0	0.0%	0	0.0%
Wenonah (B)	4	4	0	0.0%	0	0.0%
West Deptford (Twp)	157	149	2	1.3%	2	1.3%
Westville (B)	23	21	0	0.0%	0	0.0%
Woodbury (C)	59	59	3	5.1%	3	5.1%
Woodbury Heights (B)	9	9	0	0.0%	0	0.0%
Woolwich (Twp)	16	16	1	6.3%	1	6.3%
Gloucester County (Total)	**956**	**941**	**22**	**2.3%**	**22**	**2.3%**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; NOAA 2017
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Table 4.3.1-9. Critical Facilities and Lifelines Located in the 2-feet Sea Level Rise Hazard Area

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located in the Sea Level Rise 2-Feet Flood Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	0	0.0%	0	0.0%
Deptford (Twp)	79	77	0	0.0%	0	0.0%
East Greenwich (Twp)	46	46	0	0.0%	0	0.0%
Elk (Twp)	6	6	0	0.0%	0	0.0%
Franklin (Twp)	35	35	0	0.0%	0	0.0%
Glassboro (B)	137	137	0	0.0%	0	0.0%
Greenwich (Twp)	31	31	15	48.4%	15	48.4%
Harrison (Twp)	26	26	0	0.0%	0	0.0%
Logan (Twp)	50	50	0	0.0%	0	0.0%
Mantua (Twp)	30	30	0	0.0%	0	0.0%
Monroe (Twp)	29	26	0	0.0%	0	0.0%
National Park (B)	41	41	3	7.3%	3	7.3%
Newfield (B)	9	9	0	0.0%	0	0.0%
Paulsboro (B)	29	29	8	27.6%	8	27.6%
Pitman (B)	19	19	0	0.0%	0	0.0%
South Harrison (Twp)	12	12	0	0.0%	0	0.0%
Swedesboro (B)	9	9	0	0.0%	0	0.0%
Washington (Twp)	75	75	0	0.0%	0	0.0%
Wenonah (B)	4	4	0	0.0%	0	0.0%
West Deptford (Twp)	157	149	3	1.9%	3	2.0%
Westville (B)	23	21	0	0.0%	0	0.0%
Woodbury (C)	59	59	4	6.8%	4	6.8%
Woodbury Heights (B)	9	9	0	0.0%	0	0.0%
Woolwich (Twp)	16	16	1	6.3%	1	6.3%
Gloucester County (Total)	**956**	**941**	**34**	**3.6%**	**34**	**3.6%**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; NOAA 2017
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Table 4.3.1-10. Critical Facilities and Lifelines Located in the 3-feet Sea Level Rise Hazard Area

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located in the Sea Level Rise 3-Feet Flood Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	0	0.0%	0	0.0%
Deptford (Twp)	79	77	0	0.0%	0	0.0%
East Greenwich (Twp)	46	46	0	0.0%	0	0.0%
Elk (Twp)	6	6	0	0.0%	0	0.0%
Franklin (Twp)	35	35	0	0.0%	0	0.0%
Glassboro (B)	137	137	0	0.0%	0	0.0%
Greenwich (Twp)	31	31	15	48.4%	15	48.4%
Harrison (Twp)	26	26	0	0.0%	0	0.0%
Logan (Twp)	50	50	1	2.0%	1	2.0%
Mantua (Twp)	30	30	0	0.0%	0	0.0%
Monroe (Twp)	29	26	0	0.0%	0	0.0%

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located in the Sea Level Rise 3-Feet Flood Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
National Park (B)	41	41	4	9.8%	4	9.8%
Newfield (B)	9	9	0	0.0%	0	0.0%
Paulsboro (B)	29	29	9	31.0%	9	31.0%
Pitman (B)	19	19	0	0.0%	0	0.0%
South Harrison (Twp)	12	12	0	0.0%	0	0.0%
Swedesboro (B)	9	9	0	0.0%	0	0.0%
Washington (Twp)	75	75	0	0.0%	0	0.0%
Wenonah (B)	4	4	0	0.0%	0	0.0%
West Deptford (Twp)	157	149	8	5.1%	8	5.4%
Westville (B)	23	21	0	0.0%	0	0.0%
Woodbury (C)	59	59	4	6.8%	4	6.8%
Woodbury Heights (B)	9	9	0	0.0%	0	0.0%
Woolwich (Twp)	16	16	1	6.3%	1	6.3%
Gloucester County (Total)	**956**	**941**	**42**	**4.4%**	**42**	**4.5%**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; NOAA 2017
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Table 4.3.1-11. Critical Facilities and Lifelines Located in the 4-feet Sea Level Rise Hazard Area

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located in the Sea Level Rise 4-Feet Flood Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	0	0.0%	0	0.0%
Deptford (Twp)	79	77	0	0.0%	0	0.0%
East Greenwich (Twp)	46	46	0	0.0%	0	0.0%
Elk (Twp)	6	6	0	0.0%	0	0.0%
Franklin (Twp)	35	35	0	0.0%	0	0.0%
Glassboro (B)	137	137	0	0.0%	0	0.0%
Greenwich (Twp)	31	31	16	51.6%	16	51.6%
Harrison (Twp)	26	26	0	0.0%	0	0.0%
Logan (Twp)	50	50	4	8.0%	4	8.0%
Mantua (Twp)	30	30	0	0.0%	0	0.0%
Monroe (Twp)	29	26	0	0.0%	0	0.0%
National Park (B)	41	41	4	9.8%	4	9.8%
Newfield (B)	9	9	0	0.0%	0	0.0%
Paulsboro (B)	29	29	9	31.0%	9	31.0%
Pitman (B)	19	19	0	0.0%	0	0.0%
South Harrison (Twp)	12	12	0	0.0%	0	0.0%
Swedesboro (B)	9	9	0	0.0%	0	0.0%
Washington (Twp)	75	75	0	0.0%	0	0.0%
Wenonah (B)	4	4	0	0.0%	0	0.0%
West Deptford (Twp)	157	149	14	8.9%	14	9.4%
Westville (B)	23	21	1	4.3%	1	4.8%
Woodbury (C)	59	59	4	6.8%	4	6.8%
Woodbury Heights (B)	9	9	0	0.0%	0	0.0%
Woolwich (Twp)	16	16	1	6.3%	1	6.3%

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located in the Sea Level Rise 4-Feet Flood Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Gloucester County (Total)	**956**	**941**	**53**	**5.5%**	**53**	**5.6%**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; NOAA 2017
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Table 4.3.1-12. Number of Lifelines by FEMA Lifeline Category Located in the Coastal Erosion Hazard Area

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the Coastal Erosion Hazard Area
Energy	5	0
Food, Water, Shelter	214	2
Hazardous Material	116	1
Health and Medical	102	0
Safety and Security	481	0
Transportation	23	7
Gloucester County (Total)	**956**	**10**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2016/2020

Table 4.3.1-13. Number of Lifelines by FEMA Lifeline Category Located in the 1-foot through 4-feet Sea Level Rise Hazard Areas

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the Sea Level Rise 1-Foot Flood Hazard Area	Number of Lifelines Located in the Sea Level Rise 2-Feet Flood Hazard Area	Number of Lifelines Located in the Sea Level Rise 3-Feet Flood Hazard Area	Number of Lifelines Located in the Sea Level Rise 4-Feet Flood Hazard Area
Energy	5	0	0	0	0
Food, Water, Shelter	214	3	4	6	13
Hazardous Materials	116	3	7	9	11
Health and Medical	102	0	0	0	0
Safety and Security	481	2	7	9	11
Transportation	23	14	16	18	18
Gloucester County (Total)	**956**	**22**	**34**	**42**	**53**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; NOAA 2017; FEMA 2020

Additionally, sea level rise and coastal erosion can have a major impact on transportation routes in the County, particularly roadways that serve as evacuation routes for the community. Evacuation routes in the County are at risk of becoming breached with rising tide or erosion along the shoreline caused by sea level rise. If these routes become inoperable from flooding or the infrastructure becomes unstable from erosion and/or permanent inundation, these communities can become isolated during an evacuation event. Refer to Section 4.3.7 (Flood) for more information about the transportation routes in the County at risk to flooding.

Impact on Economy

Coastal erosion and sea level rise can significantly impact the local and regional economy. This includes but is not limited to general building stock damages and associated tax loss, impacts to utilities and infrastructure, business interruption, impacts on tourism, and impacts on the tax base to Gloucester County. In areas that are directly flooded by sea level rise, renovations of commercial and industrial buildings may be necessary, disrupting associated services. The total replacement cost value of structures located in the coastal erosion and 1-foot through 4-feet sea level rise inundation areas are $6.4 million, $176.4 million, $400.7 million, $675.4 million, and $1.3 billion, respectively. Other economic components such as loss of facility use, functional downtime and socio-economic factors are less measurable with a high degree of certainty.

Coastal erosion and sea level rise can cause extensive damage to public utilities and disruptions to delivery of services. Loss of power and communications may occur and drinking water and wastewater treatment facilities may be temporarily out of operation. Additionally, disruption to business operations can occur in cases where infrastructure is breached by erosion caused by sea level rise. Loss of income may occur as a secondary impact if businesses are closed under repairs due to this breaching. To prevent these potential business losses, public expenditures may need to be spent to implement shoreline stabilizers and to protect key infrastructure like highways and interstates that follow along the coastline.

Impact on the Environment

Erosion is a natural or man-made process that can greatly impact the environment. Sediment transferred through streams, lakes, rivers can erode soil and impact ecosystems. High sediment concentrations can benefit the environment by retaining dead plant production and capturing suspended sediment (Delaware Estuary Regional Sediment Management Plan Workbook 2013). Alternatively, upland erosion can degrade water quality and quantity, ultimately impacting aquatic life. Negative overall impacts to the environment occur when erosion eliminates or contaminates critical habitats. For instance, filter-feeding bivalves consume small particles, which, if contaminated from erosion runoff, could kill them (Kreeger et al. 2010).

According to the State of New Jersey 2019 Hazard Mitigation Plan, sea level rise exacerbates coastal erosion and shoreline destabilization. Erosion would inhibit these natural landscapes to perform important ecosystem services such as buffering against future land loss, filtering pollutants, and maintaining a livable habitat that enhances the aesthetics of these coastal environments. Consequentially, natural habitats that would mitigate and protect the coastline become unstable and require replenishment actions (State of New Jersey 2019).

Additionally, disruption to business operations can occur in cases where infrastructure is breached by erosion caused by sea level rise. Loss of income may occur as a secondary impact if businesses are closed under repairs due to this breaching. To prevent these potential business losses, public expenditures may need to be spent to implement shoreline stabilizers and to protect key infrastructure like highways and interstates that follow along the coastline.

Future Changes That May Impact Vulnerability

Understanding future changes that affect vulnerability can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. The New Jersey Highlands Council has identified areas of potential growth (Sewer Service Areas) that may provide insight as to where potential new development may occur in Gloucester County. Further, the New Jersey Pinelands Commission has identified Pinelands Management Area Boundaries, including regional growth areas and rural development areas that may also provide insight to where development and growth may occur in the County. In addition, each community was requested to provide recent and anticipated new development and infrastructure projects; summarized in Section 9 (Jurisdictional Annexes).

Any areas of growth located in the defined coastal erosion hazard areas could be potentially impacted by coastal erosion similar to those that currently exist within the County. According to the Gloucester County Planning Partnership, there are 38 recent or anticipated new development sites in Gloucester County. An exposure analysis found that none of the new development sites are located in the coastal erosion hazard area or the sea level rise hazard areas. Refer to Figure 4.3.1-5 and Figure 4.3.1-6 which illustrate the distribution of these new development sites and their proximity to the coastal erosion and sea level rise hazard areas.

Projected Changes in Population

Gloucester County has experienced an increase in its population since 2010. According to the U.S. Census Bureau, the County's population increased by approximately 1-percent between 2010 and 2019 (U.S. Census Bureau 2020). However, the Township of Greenwich has experienced a slight decrease in its population. Any change in the density of persons in municipalities within the coastal erosion and sea level rise hazard areas, such as the Township of Greenwich, will ultimately impact the number of persons at risk to these hazards. Additional factors impacting the County’s population, such as the number of persons visiting the County for its coastal amenities along the Delaware River are not accounted for in the change in population but should be considered for hazard mitigation planning purposes.

Climate Change

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of events that exacerbate coastal erosion. While predicting changes of coastal erosion under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society, and the environment (U.S. Environmental Protection Agency [EPA], 2006).

Impacts of climate change can lead to shoreline erosion, coastal flooding, and water pollution, affecting man-made infrastructure and aquatic and land ecosystems. Coastal areas may be impacted by climate change in different ways. As sea levels rise, larger tidal volumes will bring salt water further up the Delaware estuary. Such increase in salinity and water levels will increase the likelihood of erosion. Additionally, oceans are absorbing more carbon dioxide from the rising atmospheric concentrations of the gas, resulting in oceans becoming more acidic. This could have significant impacts on coastal and marine ecosystems (Kreeger et al. 2010). As previously stated, warmer temperatures may lead to an increase in frequency of storms, thus leading to more weather events with potentially increased severity, that cause erosion.

Change of Vulnerability Since 2016 HMP

Since the 2016 analysis, population statistics have been updated using the 2015-2019 American Community Survey population data. The updated building stock inventory was created using building footprints and parcels from the 2021 Gloucester County GIS dataset and updated 2020 tax assessor data from MODIV. RS Means 2021-dollar values were used to develop a structure-level building inventory and estimate replacement cost value for each building. The 2016 critical facility and lifeline inventory was also reviewed and updated by the Planning Partnership. Furthermore, a coastal erosion hazard area was generated using the FEMA 2016 Effective DFIRM LiMWA boundary and NOAA 2017 sea level rise 1-foot through 4-feet data was used to assess the County's risk to the sea level rise hazard area.

These changes provide an up-to-date look at the entire building stock for Gloucester County and gives more accurate results for the exposure and loss estimation analysis.

Figure 4.3.1-5. Recent and Anticipated New Development Located in the Coastal Erosion Hazard Area

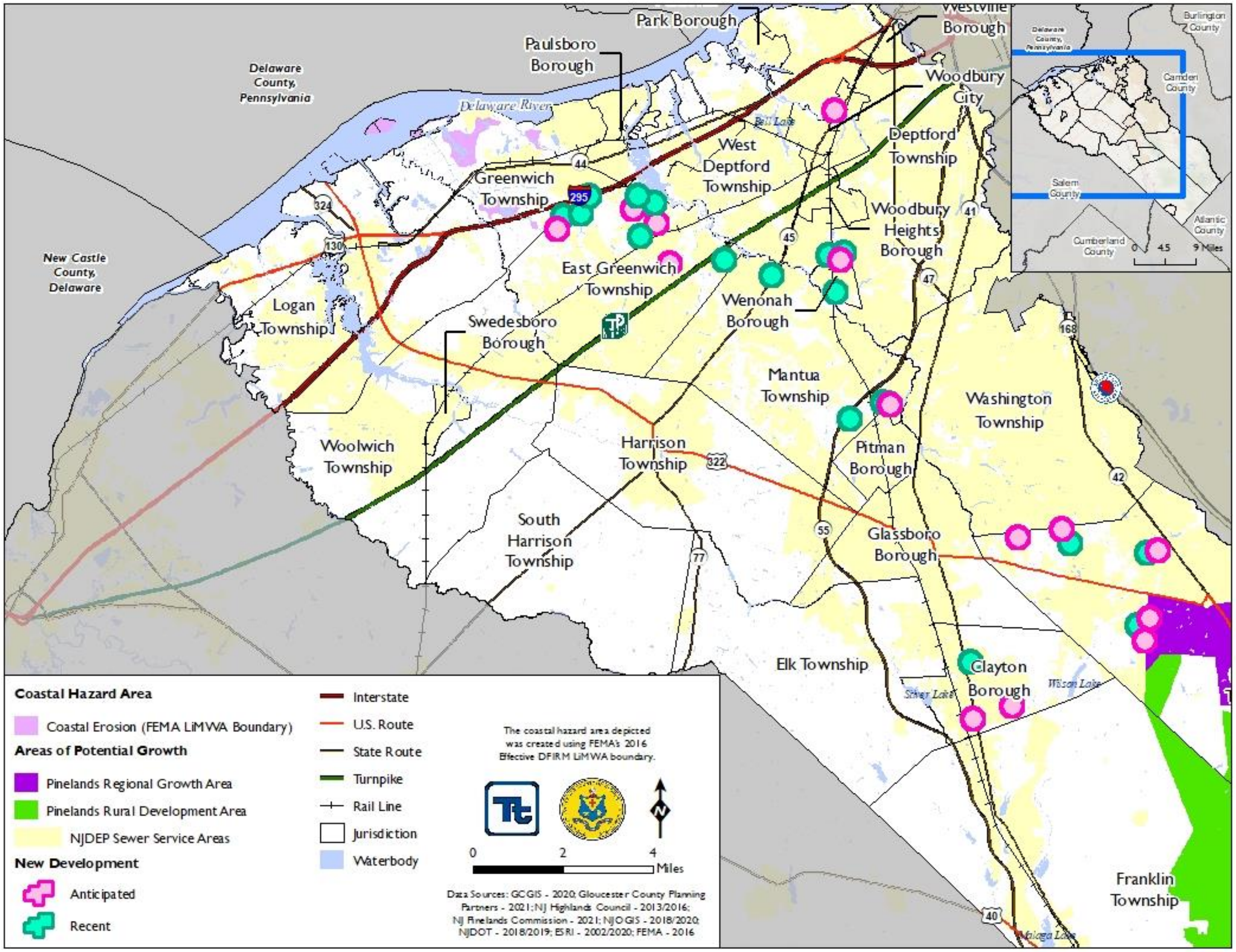
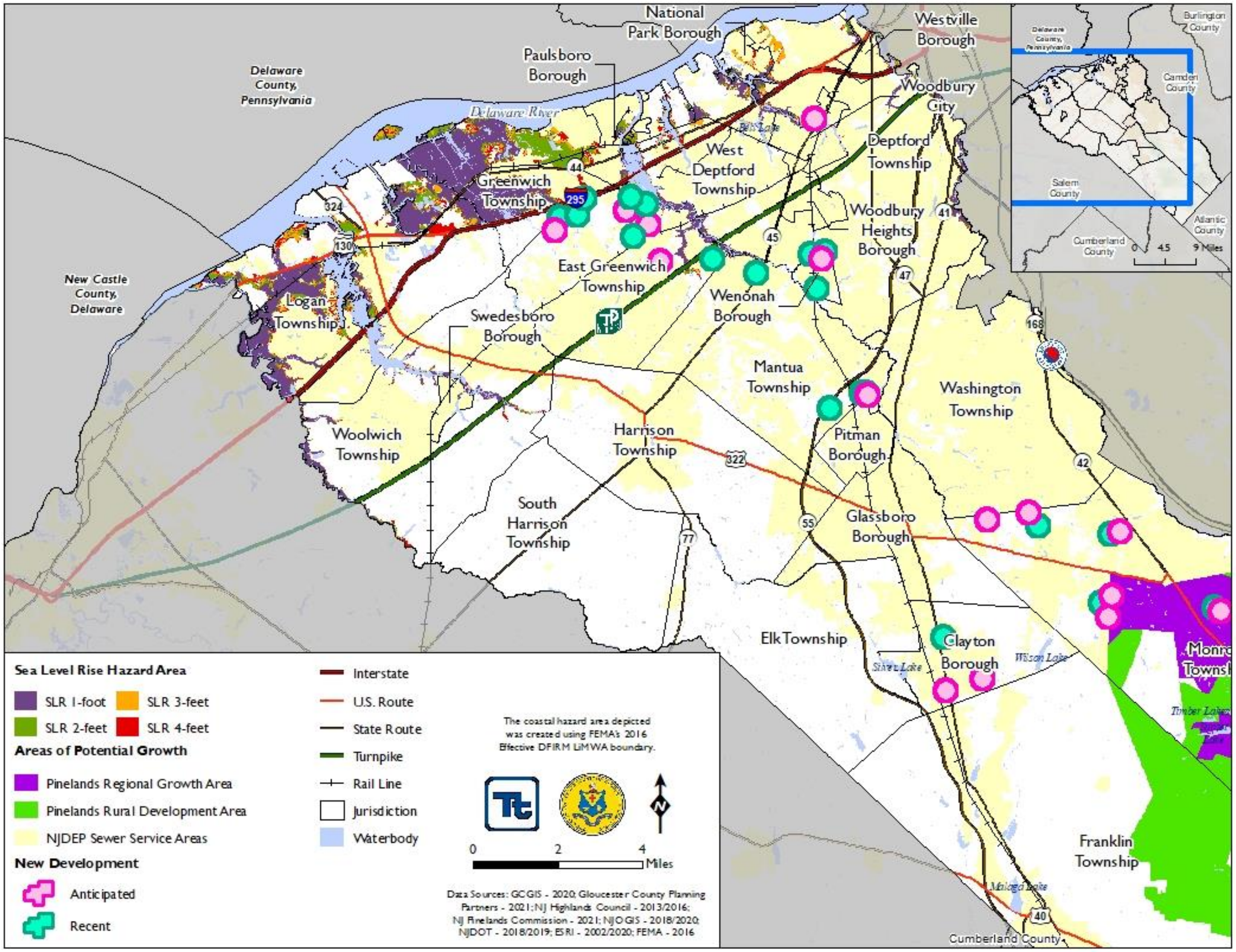


Figure 4.3.1-6. Recent and Anticipated New Development Located in the 1-foot through 4-feet Sea Level Rise Hazard Areas



4.3.2 Dam and levee Failure

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the dam and levee failure hazard in Gloucester County.

2022 HMP Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, probability of future occurrence, and potential change in climate and its impacts on the dam and levee failure hazard is discussed. The dam and levee failure hazard is now located in Section 4 of the plan update.
- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2016 and 2021.
- A vulnerability assessment was conducted for the dam failure hazard and it now directly follows the hazard profile.

4.3.2.1 Profile

Hazard Description

Dam Failure

A dam is an artificial barrier that has the ability to store water, wastewater, or liquid-borne materials for many reasons (flood control, human water supply, irrigation, livestock water supply, energy generation, containment of mine tailings, recreation, or pollution control. Many dams fulfill a combination of the stated functions (Association of State Dam Safety Officials 2020).

Dam failures typically occur when spillway capacity is inadequate and excess flow overtops the dam, or when internal erosion (piping) through the dam or foundation occurs. Complete failure occurs if internal erosion or overtopping results in a complete structural breach, releasing a high-velocity wall of debris-filled waters that rush downstream damaging and/or destroying anything in its path (FEMA 1997).

Dam failures can result from one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam
- Deliberate acts of sabotage
- Structural failure of materials used in dam construction
- Movement and/or failure of the foundation supporting the dam
- Settlement and cracking of concrete or embankment dams
- Piping and internal erosion of soil in embankment dams
- Inadequate maintenance and upkeep (New Jersey HMP 2019).

Levee Failure

A levee is a physical barrier constructed to protect areas from rising floodwaters. Levees typically remove valuable floodplain storage and block the ability of the channel to move water. There are also concerns with rainfall that falls on the levee itself. Most important is the possibility for catastrophic and sudden failure under extreme flood events, potentially resulting in loss of life and total destruction of property.

A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass. A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. Earthen levees can be damaged in several ways. Strong river currents and waves can erode the surface. Trees growing on a levee can blow over, leaving a hole where the root wad and soil used to be. Burrowing animals can create holes that enable water to pass through a levee. If severe enough, any of these situations can lead to a zone of weakness that could cause a levee breach. In seismically active areas, earthquakes and ground shaking can cause a loss of soil strength, weakening a levee and possibly resulting in failure. Seismic activity can also cause levees to slide or slump, both of which can lead to failure.

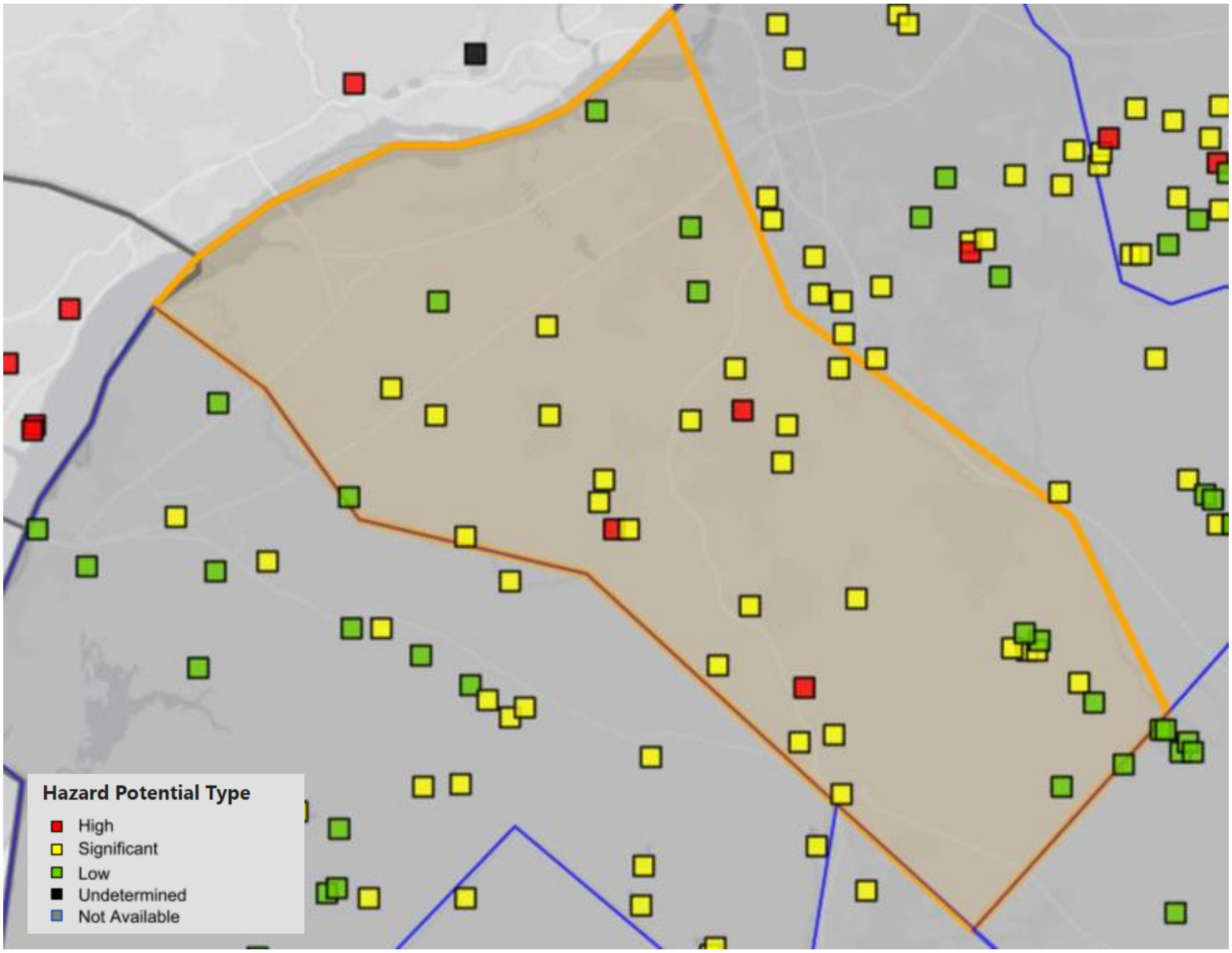
Location

According to NJDEP, Gloucester County has 39 dams. Of these dams, 3 are considered high hazard, 27 are considered significant hazard, and 9 are considered low hazard. Dams in poor condition have a dam safety deficiency recognized for any required loading condition (static, hydrologic, seismic) in accordance with the applicable dam safety regulatory criteria. Remedial action is necessary. Poor also applies when further critical studies or investigations are needed to identify any potential dam safety deficiencies. Unsatisfactory dams are considered unsafe due to a dam safety deficiency that requires immediate or emergency remedial action for problem resolution. Reservoir restrictions may be necessary. Figure 4.3.2-1 shows the dams by class throughout the County.

In addition to dams located within the County, there are multiple dams that are located in neighboring counties that could impact Gloucester County if failure occurs. The County might require emergency action plans for these respective dams for the various communities that might be affected.

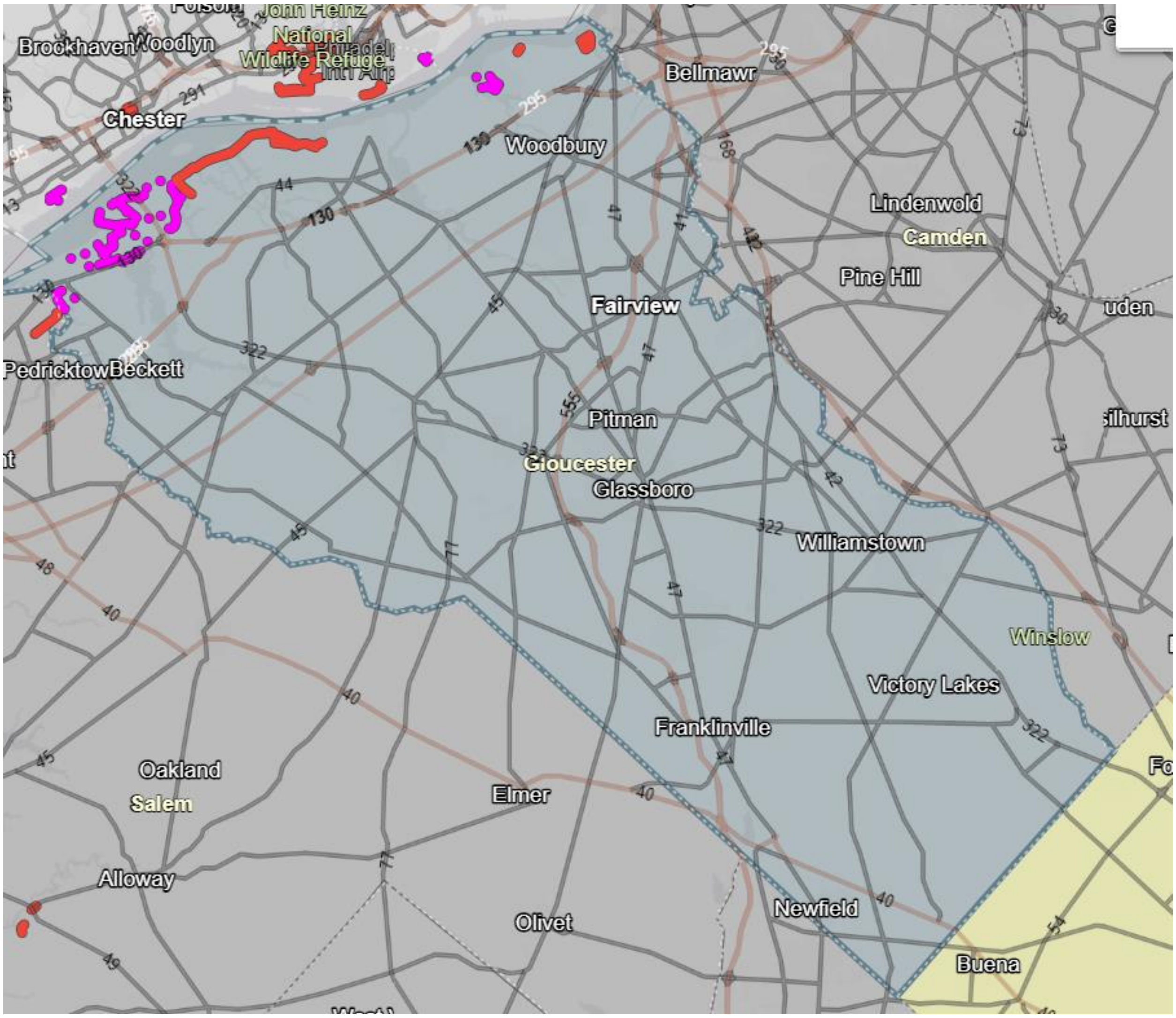
According to USACE, there are 10 levee systems in New Jersey, four of which are in Gloucester County, comprising of 28 structures (USACE 2021).

Figure 4.3.2-1. Dams in Gloucester County



Source: USACE 2021

Figure 4.3.2-2 Levees in Gloucester County



Source: USACE 2021

Extent

Dam Failure

The extent or magnitude of a dam failure event can be measured in terms of the classification of the dam. Additionally, there are two factors that influence the potential severity of a full or partial dam failure are: (1) the amount of water impounded; and (2) the density, type, and value of development and infrastructure located downstream (Association of State Dam Safety Officials 2020).

FEMA, USACE and NJDEP all have classification systems for dams. Please refer to *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams* (2004) and *Safety of Dams – Police and Procedures* (2014) for an explanation of the FEMA and USACE classifications.

The New Jersey Department of Environmental Protection (NJDEP) assigns one of four hazard classifications to state-regulated dams in New Jersey. The classifications relate to the potential property damage and/or loss of life in the event of a dam failure.

- Class I (High-Hazard Potential) - Failure of the dam may result in probable loss of life and/or extensive property damage
- Class II (Significant-Hazard Potential) - Failure of the dam may result in significant property damage; however, loss of life is not envisioned.
- Class III (Low-Hazard Potential) - Failure of the dam is not expected to result in loss of life and/or significant property damage.
- Class IV (Small-Dam Low-Hazard Potential) - Failure of the dam is not expected to result in loss of life or significant property damage. Dam must also meet the requirements of a Class IV dam above (NJDEP 2014).

It is required by the State of New Jersey that all High Hazard and Significant Hazard dams must have NJDEP-approved Emergency Action Plans (EAP) in place. It is the responsibility of the dam owner to review and update the EAP on an annual basis. The State also requires regular dam inspections. Dam Safety Inspections are intended to identify conditions that may adversely affect the safety and functionality of a dam and its appurtenant structures; to note the extent of deterioration as a basis for long term planning, periodic maintenance or immediate repair; to evaluate conformity with current design and construction practices; and to determine the appropriateness of the existing hazard classification. Inspection guidelines are summarized in Table 4.3.2-1. Complete inspection and operating requirements for dams can be found in the New Jersey Dam Safety Standards (N.J.A.C. 7:20-1.11).

Table 4.3.2-1. New Jersey Dam Inspection Requirements

Dam Size/Type	Regular Inspection	Formal Inspection
Class I (High Hazard) Large Dam	Annually	Once every 3 years
Class I (High Hazard) Dam	Once every 2 years	Once every 6 years
Class II (Significant Hazard) Dam	Once every 2 years	Once every 10 years
Class III (Low Hazard) Dam	Once every 4 years	Only as required
Class IV (Zero Hazard) Dam	Once every 4 years	Only as required

Source: N.J.A.C. 7:20-1.11

In New Jersey, every dam in the State as defined in the Safe Dam Act, N.J.S.A. 58:4 is required to meet State dam safety standards. Dam Safety Laws provide the NJDEP with enforcement capabilities to achieve statewide compliance with dam safety standards. This includes issuing orders for compliance to dam owners, and pursuing legal action if the owner does not comply (with the goal of compliance and possible fines levied on a per-day basis for violations) (NJDEP 2017).

Levee Failure

In the event of a levee failure, floodwaters may ultimately inundate the protected area landward of the levee. The extent of inundation is dependent on the flooding intensity. Failure of a levee during a 1 percent annual chance flood will inundate the approximate 100-year flood plain previously protected by the levee. Residential and commercial buildings located nearest the levee overtopping or breach location will suffer the most damage from the initial embankment failure flood wave. Landward buildings will be damaged by inundation (FEMA 2004).

Levees require maintenance to continue to provide the level of protection they were designed and built to offer. Maintenance responsibility belongs to a variety of entities including local, state, and federal government and private landowners. Well-maintained levees may obtain certification through independent inspections. Levees may not be certified for maintaining flood protection when the levee owner does not maintain the levee or pay for an independent inspection. The impacts of an uncertified levee include higher risk of levee failure. In addition, insurance rates may increase because FEMA identifies on Flood Insurance Rate Maps that the structures are not certified to protect from a 1-percent annual chance flood event (FEMA 2004).

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with dam and levee failure throughout the State of New Jersey and Gloucester County; therefore, the loss and impact information for many events varies depending on the source. The accuracy of monetary figures discussed are based only on the available information in cited sources.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2021, no disasters (DR) or emergencies (EM) were declared for dam or levee failure in the State of New Jersey (FEMA 2021).

U.S. Department of Agriculture Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2015 and 2020, Gloucester County was not included in any USDA declaration involving dam or levee failure (USDA 2021).

Dam and Levee Failure Events

As stated in the 2019 New Jersey State HMP Update, dam and levee failures can occur suddenly, without warning, and may occur during normal operating conditions. This is referred to as a “sunny-day” failure. Dam and levee failures may also occur during a large storm event. Significant rainfall can quickly inundate an area and cause floodwaters to overwhelm a reservoir. If the spillway of the dam cannot safely pass the resulting flows, water will begin flowing in areas not designed for such flows, and a failure may occur. New Jersey has seen significant property damage including damage or loss of dams, bridges, roads, and buildings as a result of storm events and dam failures (NJOEM 2019).

For the 2021 HMP update, known dam and levee failure events that have impacted Gloucester County between 2015 and 2020 were researched. No events were found to have occurred (NOAA-NCEI 2021). For events prior to 2015, refer to Appendix E (Risk Assessment Supplement).

Probability of Future Occurrences

Dam and levee failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides, and excessive rainfall and snowmelt. As noted in the *Previous Occurrences and Losses* section, dam failures typically occur in New Jersey as a result of heavy rains or other precipitation. There is a "residual risk" associated with dams. Residual risk is the risk that remains after safeguards have been implemented. For dams, the residual risk is associated with events beyond those that the facility was designed to withstand. However, the probability of any type of dam and levee failure is low in today's dam safety regulatory and oversight environment (NJOEM 2019).

According to the 2009 Gloucester County HMP, there have been no historically significant dam or levee failures in the County. However, according to the 2016 Gloucester HMP and NJ HMP (NJOEM 2019) significant damage was reported for the Singley Dam during Hurricane Floyd in 1999, though the event was not classified as a total failure. During 2011, Gloucester County was affected by the Seeley's Pond Dam along the Cohansey River (DRBC 2016). As for levee failure, a levee breach was noted in the NJ HMP, caused by Tropical Storm Cindy in 2005 (NJOEM 2019). The breach occurred in Logan Township and affected neighboring properties. Since then, emergency repairs were made to the structure to keep the Delaware River at bay. This totals three events that occurred between 1950 and 2021. Using previous event history from the 2009 and 2016 HMP, and the 2019 State HMP, information collected from Stanford University's National Performance of Dams Program (NPDP) database and from NOAA-NCEI storm events database, the probability of future occurrences of dam and levee failure was calculated for Gloucester County. In order to determine the probability of future occurrence of dam and levee failure events in Gloucester County, events that occurred between 1950 and 2021 were used. Please note that only readily available data was used for the calculations and not all events may have been included in the calculation.

Based on the number of occurrences, there is an estimated 4.23 percent chance of occurrence of a dam or levee failure occurring, in a given year, in Gloucester County. The table below shows these statistics, as well as the annual average number of events and the percent chance of a dam failure occurring in Gloucester County in future years (NOAA-NCEI 2021).

Table 4.3.2-2. Probability of Future Occurrences of Dam and Levee Failure

Hazard Type	Number of Occurrences Between 1950 and 2021	Percent chance of occurrence in any given year
Dam and Levee Failure	3	4.23%

Source: NOAA-NCEI 2021; NPDP 2021, NJOEM 2019

TETRA TECH

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for dam failure in the County is considered 'rare' (between 1 and 10 percent annual probability of a hazard event occurring, as presented in Table 4.4-1). The ranking of the dam failure hazard for individual municipalities is presented in the jurisdictional annexes.

Climate Change Impacts

Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (ONJSC 2021), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo 2014) and the world (1.5° F [0.8° C]) (Meyer 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date. The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh 2014) and with more intensity (Huang 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan 2014). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Le Treut 2011). New Jersey could also experience an increase in the number of flood events (Broccoli 2020).

A warmer atmosphere means storms have the potential to be more intense (Guilbert 2015) and occur more often (Coumou 2012). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017). As temperatures increase, so will the energy in a storm system, increasing the potential for more intense tropical storms (Huang 2017) especially those of Category 4 and 5 (Melillo 2014).

Dams and levees are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can significantly affect the hydrograph used for the design of a dam. If the hygrograph changes, the dam conceivably could lose some or all of its designed margin of safety, also known as freeboard. Loss of designed margin of safety increases the possibility that floodwaters would overtop the dam or levee or create unintended loads, which could lead to a dam or levee failure.

4.3.2.2 Vulnerability Assessment

The dam failure hazard is of significance to Gloucester County because 39 dams are present across the County, three of which are identified as high hazard (Figure 4.3.2-1). Dam failure events are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard.

Dam failure inundation maps and downstream hazard areas are considered sensitive information and are not made available in the Gloucester County Hazard Mitigation Plan. To assess the County's risk to dam failure, a qualitative review was implemented.

Impact on Life, Health and Safety

The impact of dam and levee failure on life, health, and safety is dependent on several factors such as the class of dam/levee, the area that the dam/levee is protecting, the location of the dam/levee, and the proximity of structures, infrastructure, and critical facilities to the dam or levee structure. According to the State HMP, the level of impact that a failure would have can be predicted based upon the hazard potential classification as rated by the United States Army Corps of Engineers (State of NJ 2019). Table 4.3.2-3 outlines the recommended hazard classifications.

Table 4.3.2-3. United States Army Corps of Engineers Hazard Potential Classification

Hazard Category (a)	Direct Loss of Life (b)	Lifeline Losses (c)	Property Losses (d)	Environmental Losses (e)
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

Source: NJOEM 2019
Note:
a. Categories are assigned to overall projects, not individual structures at a project.
b. Loss-of-life potential is based on inundation mapping of area downstream of the project. Analyses of loss-of-life potential should take into account the population at risk, time of flood wave travel, and warning time.

c. Lifeline losses include indirect threats to life caused by the interruption of lifeline services from project failure or operational disruption; for example, loss of critical medical facilities or access to them.
d. Property losses include damage to project facilities and downstream property and indirect impact from loss of project services, such as impact from loss of a dam and navigation pool, or impact from loss of water or power supply.
e. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.

The entire population residing within a dam failure inundation zone is considered exposed and vulnerable to an event. The potential for loss of life is affected by the capacity and number of evacuation routes available to populations living within these areas. Those most at risk include the economically disadvantaged and the population over the age of 65. The 2019 American Community Survey population estimates indicate there were 44,794 persons over 65 years old and 21,340 living below the poverty level in Gloucester County. These populations are more at risk during a dam failure event because economically disadvantaged populations are likely to evaluate their risk and make the decision to evacuate based upon the net economic impact to their family, while elderly populations are likely to seek or need medical attention. The availability of medical attention may be limited due to isolation during a flood event and other difficulties in evacuating. There is often limited warning time for a dam failure event. Populations without adequate warning of the event are highly vulnerable.

Dam failure can cause persons to become displaced if flooding of structures occurs. Dam failure may mimic flood events, depending on the size of the dam reservoir and breach. Understanding potential outcomes of flooding for each dam in Gloucester County would require intensive hydraulic modeling.

Impact on General Building Stock

Buildings located downstream of a dam are at risk to damages should there be a failure. Downstream inundation areas were not available to quantify any potential losses to structures. Properties located closest to the dam inundation area have the greatest potential to experience the largest, most destructive surge of water. The overall impact of flooding damages caused by dam failure will vary depending on the depth of flooding and velocity of the surge.

Impact on Critical Facilities and Lifelines

Dam failures may also impact critical facilities and lifelines located in the downstream inundation zone. Consequentially, dam failure can cut evacuation routes, limit emergency access, and/or create isolation issues. Dam failure can cause severe downstream flooding and may transport large volumes of sediment and debris, depending on the magnitude of the event. Widespread damage to buildings and infrastructure affected by an event would result in large costs to repair these locations. In addition to physical damage costs, businesses can be closed while flood waters retreat and utilities are returned to a functioning state. Further, utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

Impact on the Economy

Severe flooding that follows an event like a dam failure can cause extensive structural damage and withhold essential services. The cost to recover from flood damages after a surge will vary depending on the hazard risk of each dam. The State HMP discusses damages from dam failures ranging from $7 million to $25 million as a result of previous events in the State. This cost likely varies because of the density of structures and businesses that surround the protected area.

Severe flooding that follows an event like a dam failure can cause extensive damage to public utilities and disruptions to delivery of services. Loss of power and communications may occur and drinking water and wastewater treatment facilities can become temporarily out of operation. Debris from surrounding buildings can accumulate should the dam mimic major flood events, such as the 1-percent annual chance flood event that is discussed in Section 4.3.5 (Flood).

Based on existing data, given the County's higher density along the Delaware River, potential damage might cascade from upstream of hazardous dams, namely Gilman Lake Dam, Franklinville Lake Dam, and Wadsworth Dam which are both ranked as high hazard dams (USACE 2021).

Impact on the Environment

The environmental impacts of a dam failure can include significant water-quality and debris-disposal issues or severe erosion that can impact local ecosystems. Flood waters can back up sanitary sewer systems and inundate wastewater treatment plants, causing raw sewage to contaminate residential and commercial buildings and the flooded waterway. The contents of unsecured containers of oil, fertilizers, pesticides, and other chemicals may get added to flood waters. Hazardous materials may be released and distributed widely across the floodplain. Water supply and wastewater treatment facilities could be offline for weeks. After the flood waters subside, contaminated and flood-damaged building materials and contents must be properly disposed of. Contaminated sediment must be removed from buildings, yards, and properties.

Future Changes That May Impact Vulnerability

Understanding future changes that affect vulnerability can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. Several factors are examined in this section to assess hazard vulnerability.

Projected Development

As discussed, and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. Any areas of growth could be potentially impacted by a dam or levee failure event if the structures are located within the flood protection area and mitigation measures are not considered. Therefore, it is the intention of the County and all participating municipalities to discourage development in vulnerable areas or to encourage higher regulatory standards at the local level. Due to the sensitive nature of dam locations and downstream inundation zones, an assessment to determine the proximity of these new development sites to potential dam inundation cannot be performed at this time.

Projected Changes in Population

Gloucester County has experienced an increase in population of approximately 0.98-percent between 2010 and 2019. According to the American Community Survey 5-year population estimates, in 2019 Gloucester County had a population of 291,165. As the population increases any changes in the density of population can impact the number of persons exposed to the probable maximum flood inundation hazard areas. Higher density can, not only create issues for local residents during evacuation of a dam or levee failure event but can also have an effect on commuters that travel into and out of the County for work, particularly during a flood event that may impact transportation corridors, which are also major commuter roads. Refer to Section 3 (County Profile) for more information about population trends in the County.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual precipitation. Annual precipitation amounts in the region are projected to increase, primarily in the form of heavy rainfalls, which have the potential to increase the risk to dam and levee failures. Increases in precipitation may stress the structures. Further, existing flood control structures may not be able to retain and manage increases in water flow from more frequent, heavy rainfall events. Heavy rainfalls may result in more frequent overtopping of these levees and dams and flooding of the County's assets in adjacent inundation areas. However, the probable maximum flood used to design each dam may be able to accommodate changes in climate.

Change of Vulnerability Since 2016 HMP

Overall, the County's vulnerability has not changed and the County will continue to be exposed and vulnerable to dam failure events, especially those located within or near downstream inundation zones. Because of the sensitive nature of the dam failure inundation zones, potential losses have not been quantified and presented in this plan. To estimate potential losses to population, buildings, critical facilities and infrastructure, dam inundation areas and depths of flooding may be used to generate depth grids. Hazus may be used to estimate potential losses for the County and participating municipalities.

4.3.3 Disease Outbreak

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the disease outbreak hazard in Gloucester County.

2022 HMP Changes

- Disease outbreak is a new hazard of concern for this 2022 HMP update.

4.3.3.1 Profile

Hazard Description

An outbreak or an epidemic occurs when new cases of a certain disease, in a given population, substantially exceed what is expected. An epidemic may be restricted to one locale, or it may be global, at which point it is called a pandemic. Pandemic is defined as a disease occurring over a wide geographic area and affecting a high proportion of the population. A pandemic can cause sudden, pervasive illness in all age groups on a local or global scale. A pandemic is a novel virus to which humans have no natural immunity that spreads from person-to-person. A pandemic will cause both widespread and sustained effects and is likely to stress the resources of both the State and federal government (NJOEM 2019).

Of particular concern in Gloucester County are arthropod-borne viruses (arboviruses), which are viruses that are maintained in nature through biological transmission between susceptible hosts (mammals) and blood-feeding arthropods (mosquitos and ticks). More than 100 arboviruses can cause disease in humans; over 30 have been identified as human pathogens in the western hemisphere (New Jersey Department of Health and Senior Services 2008). New Jersey has been impacted by various past and present infestations including: high population of mosquitoes (mosquito-borne diseases) and deer ticks (tick-borne diseases).

Mosquito-borne diseases are diseases that are spread through the bite of an infected female mosquito. The three most common mosquito-borne diseases in New Jersey are: West Nile Virus (WNV), Eastern equine encephalitis (EEE) virus, and St. Louis encephalitis (SLE) virus. These diseases rely on mosquitos to spread. They become infected by feeding on birds carrying the virus; and then spread to humans and other animals when the mosquito bites them (New Jersey Department of Health 2013a).

Tick-borne diseases are bacterial illnesses that spread to humans through infected ticks. The most common tick-borne diseases in New Jersey are: Lyme disease, Ehrlichiosis, Anaplasmosis, Rocky Mountain Spotted Fever, and Babesiosis. These types of diseases rely on ticks for transmission. Ticks become infected by micro-organisms when feeding on small, infected mammals (mice and voles). Different tick-borne diseases are caused by different micro-organisms, and it is possible to be infected with more than one tick-borne disease at a time. Anyone who is bitten by an infected tick may get a tick-borne disease. People who spend a lot of time outdoors have a greater risk of becoming infected. The three types of ticks in New Jersey that may carry disease-causing micro-organisms are the deer tick, lone star tick, and the American dog tick (New Jersey Department of Health 2013b).

For the purpose of this HMP update, the following arboviruses will be discussed in further detail: West Nile Virus, Eastern Equine Encephalitis virus, St. Louis Encephalitis virus, Lyme disease, and Ebola virus. Influenza will also be discussed due to several outbreaks in the past five years. In addition, due to the COVID-19 pandemic, coronavirus is also described in this section.

West Nile Virus

West Nile Virus (WNV) encephalitis is a mosquito-borne viral disease, which can cause an inflammation of the brain. WNV is commonly found in Africa, West Asia, the Middle East and Europe. WNV was first confirmed in North America in the New York metropolitan area during the summer and fall of 1999. WNV successfully over-wintered in the northeastern U.S. and has been present in humans, horses, birds, and mosquitoes since that time. WNV is spread to humans by the bite of an infected mosquito. A mosquito becomes infected by biting a bird that carries the virus (New Jersey Department of Health 2013a).

Eastern Equine Encephalitis

Eastern Equine Encephalitis (EEE) is a virus disease of wild birds that is transmitted to horses and humans by mosquitoes. It is a rare but serious viral infection. EEE is most common in the eastern half of the U.S. and is spread by the bite of an infected mosquito. EEE can affect humans, horses, and some birds. The risk of getting this virus is highest from late July through early October (New Jersey Department of Health 2012a). New Jersey represents a major focus for the infection with some form of documented viral activity nearly every year. Horse cases are most common in the southern half of New Jersey because the acidic water swamps that produce the major mosquito vectors are especially prevalent on the southern coastal plain (Crans 2013).

St. Louis Encephalitis

St. Louis Encephalitis (SLE) is a rare but serious viral infection. It is transmitted to humans by the bite of an infected mosquito. Most cases of SLE disease have occurred in eastern and central states. Most persons infected with SLE have no apparent illness. Initial symptoms of those who become ill include fever, headache, nausea, vomiting, and tiredness. Severe neuroinvasive disease (often involving encephalitis, an inflammation of the brain) occurs more commonly in older adults (CDC 2021a).

Lyme Disease

Lyme disease is an illness caused by infection with the bacterium *Borrelia burgdorferi*, which is carried by ticks. The infection can cause a variety of symptoms and, if left untreated, can be severe. Lyme disease is spread to people by the bite of an infected tick. In New Jersey, the commonly infected tick is the deer tick. Immature ticks become infected by feeding on infected white-footed mice and other small mammals. Deer ticks can also spread other tick-borne diseases. Anyone who is bitten by a tick carrying the bacteria can become infected (New Jersey Department of Health 2012b).

Influenza

The risk of a global influenza pandemic has increased over the last several years. This disease is capable of claiming thousands of lives and adversely affecting critical infrastructure and key resources. An influenza pandemic has the ability to reduce the health, safety, and welfare of the essential services workforce; immobilize core infrastructure; and induce fiscal instability. Densely populated areas will spread diseases quicker than less densely populated areas (NJOEM 2019).

Pandemic influenza is different from seasonal influenza (or "the flu") because outbreaks of seasonal flu are caused by viruses that are already among people. Pandemic influenza is caused by an influenza virus that is new to people and is likely to affect many more people than seasonal influenza. In addition, seasonal flu occurs every year, usually during the winter season, while the timing of an influenza pandemic is difficult to predict. Pandemic influenza is likely to affect more people than the seasonal flu, including young adults. A severe pandemic could change daily life for a time, including limitations on travel and public gatherings (Barry-Eaton District Health Department 2013).

At the national level, the CDC's Influenza Division has a long history of supporting the World Health Organization (WHO) and its global network of National Influenza Centers (NIC). With limited resources, most international assistance provided in the early years was through hands-on laboratory training of in-country staff, the annual provision of WHO reagent kits (produced and distributed by CDC), and technical consultations for vaccine strain selections. The Influenza Division also conducts epidemiologic research including vaccine studies and serologic assays and provided international outbreak investigation assistance (CDC 2011).

Ebola Virus

Ebola, previously known as Ebola hemorrhagic fever, is a rare and deadly disease caused by infection with one of the Ebola virus strains. According to the CDC, the 2014 Ebola epidemic is the largest in history affecting multiple countries in West Africa. Two imported cases, including one death, and two locally-acquired cases in healthcare workers have been reported in the United States. The CDC and partners are taking precautions to prevent the further spread of Ebola in the United States (CDC 2014).

Coronavirus

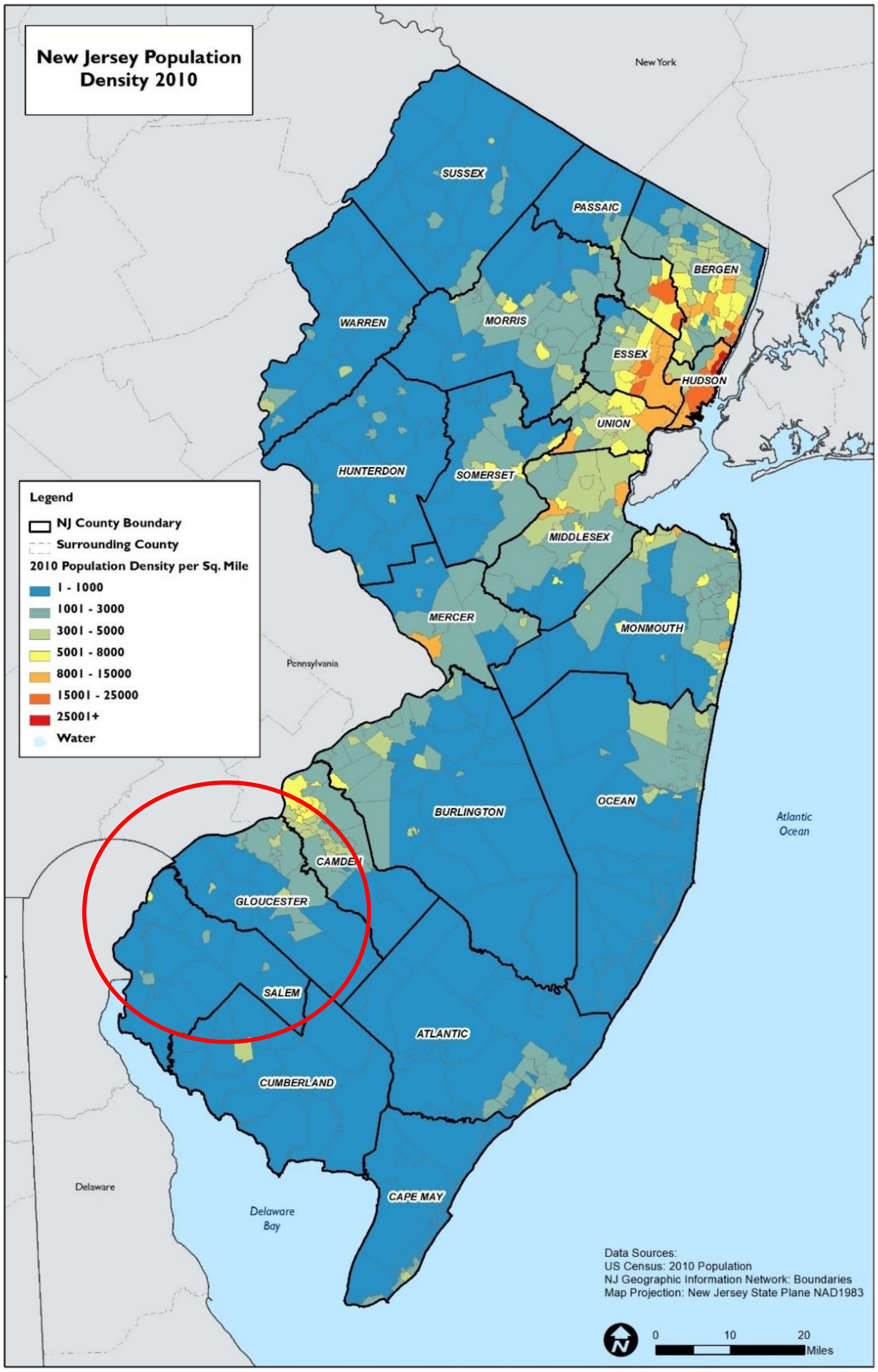
Coronavirus disease (COVID-19) is an infectious disease first identified in 2019. The virus rapidly spread into a global pandemic by spring of 2020. The elderly and those with underlying medical conductions such as cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illness (WHO 2021a). With the virus being relatively new, information regarding transmission and symptoms of the virus is emerging from the research. The COVID-19 virus spreads primarily through droplets of saliva or discharge from the nose when an infected person coughs or sneezes. Reported illnesses have ranged from mild symptoms to severe illness and death. Reported symptoms include trouble breathing, persistent pain or pressure in the chest, new confusion or inability to arouse, and bluish lips or face. Symptoms may appear 2-14 days after exposure to the virus (based on the incubation period of MERS-CoV viruses) (CDC 2020).

In an effort to slow the spread of the virus, the federal government and States have urged the public to avoid touching of the face, properly wash hands often, and use various social distancing measures. At the time of this plan update, several vaccines have been developed and efforts are underway to inoculate the population (WHO 2021a).

Location

New Jersey's geographic and demographic characteristics make it particularly vulnerable to importation and spread of infectious diseases. All 21 counties in New Jersey have experienced the effects of a pandemic or disease outbreak. In terms of pandemic influenza, all counties may experience pandemic influenza outbreak caused by factors such as population density and the nature of public meeting areas. Densely populated areas will spread diseases quicker than less densely populated areas. Figure 4.3.3-1 shows population density throughout the State. Additionally, much of the State can experience other diseases such as WNV due to the abundance of water bodies throughout the State, which provide a breeding ground for infected mosquitos.

Figure 4.3.3-1. New Jersey Population Density (United States Census 2010)



Source: United States Census 2010; New Jersey Geographic Information Network (NJGIN)
Note: Gloucester County is circled in red.

Extent

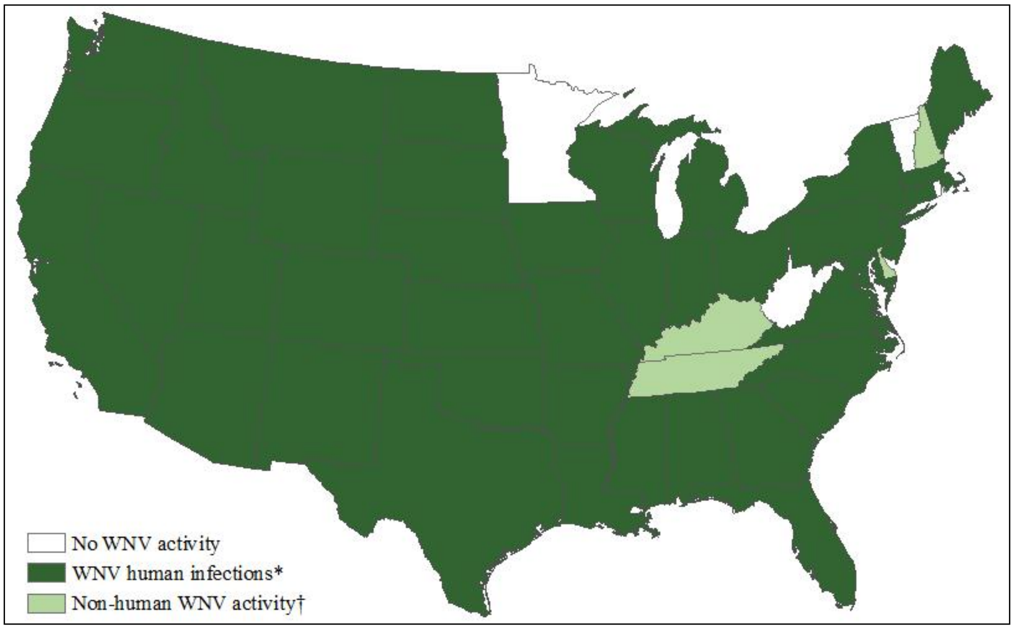
The exact size and extent of an infected population depends on how easily the illness is spread, the mode of transmission, and the amount of contact between infected and uninfected individuals. The transmission rates of pandemic illnesses are often higher in more densely populated areas. The transmission rate of infectious diseases will depend on the mode of transmission of a given illness.

The extent and location of disease outbreaks depends on the preferred habitat of the species, as well as the species' ease of movement and establishment. The magnitude of disease outbreaks species ranges from nuisance to widespread. The threat is typically intensified when the ecosystem or host species is already stressed, such as periods of drought. The already weakened state of the ecosystem causes it to more easily be impacted to an infestation. The presence of disease-carrying mosquitoes and ticks has been reported throughout most of New Jersey and Gloucester County.

West Nile Virus

Since it was discovered in the western hemisphere, WNV has spread rapidly across North America, affecting thousands of birds, horses and humans. As of January 2021, every state in the continental United States aside from Maine and West Virginia has WNV activity with Delaware, Rhode Island, Vermont, and New Hampshire only being impacted by non-human WNV activity. Figure 4.3.3-2 shows the activity of WNV by state in 2020.

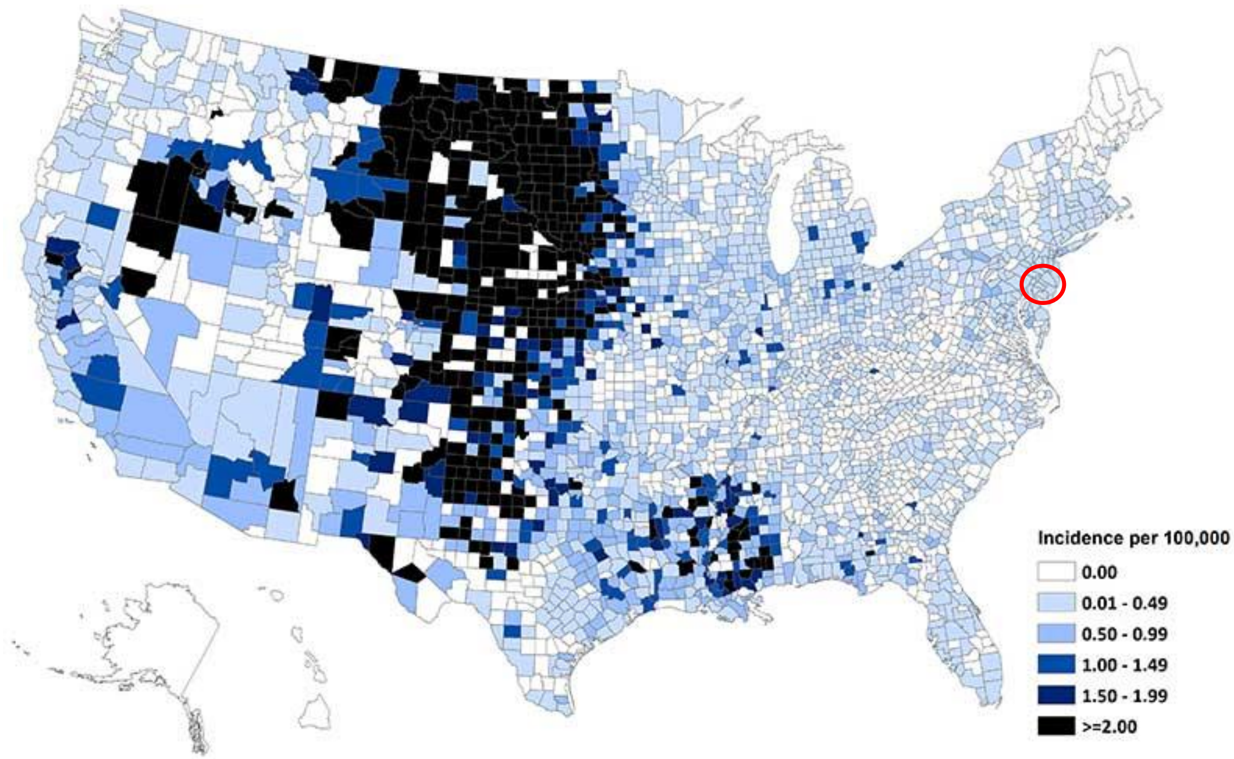
Figure 4.3.3-2. WNV Activity by State 2020



Source: CDC 2021b

The CDC has a surveillance program for WNV. Data is collected on a weekly basis and reported for five categories: wild birds, sentinel chicken flocks, human cases, veterinary cases and mosquito surveillance (CDC 2019). Figure 4.3.3-3 illustrates WNV activity in the U.S. from 1999-2018.

Figure 4.3.3-3. Average Annual Incidence of West Nile Virus Neuroinvasive Disease Reported to CDC by County, 1999-2018



Source: CDC 2019
Note: The circle indicates the approximate location of Gloucester County.

Eastern Equine Encephalitis

In the State of New Jersey, there have been five cases of EEE from 2010-2019 (CDC 2019.)

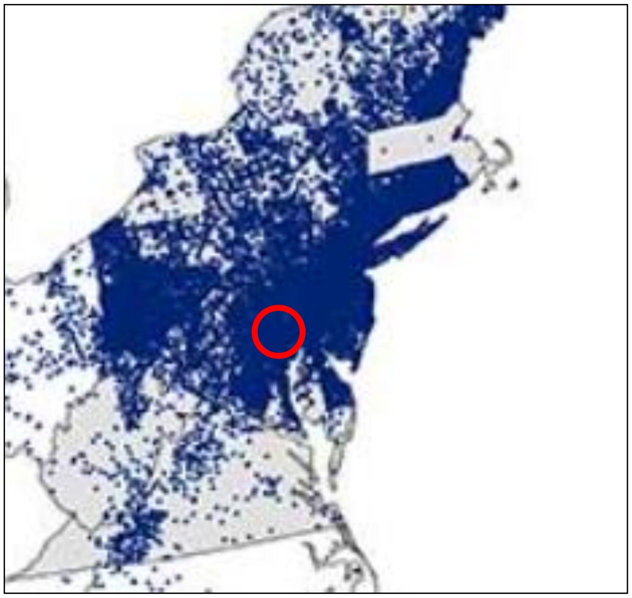
St. Louis Encephalitis

In the State of New Jersey, there have been no cases of St. Louis virus neuroinvasive disease from 2010-2019. However, nearby states have reported cases (CDC 2019).

Lyme Disease

Lyme disease is the most commonly reported vector borne illness in the U.S. Between 2015 and 2019, there were 619 confirmed cases of Lyme disease in Gloucester County (NJ DOH 2021). Figure 4.3.3-4 shows the reported cases of Lyme disease in the northeast U.S. for 2018.

Figure 4.3.3-4. 2018 Reported Cases of Lyme Disease in the Northeast U.S.

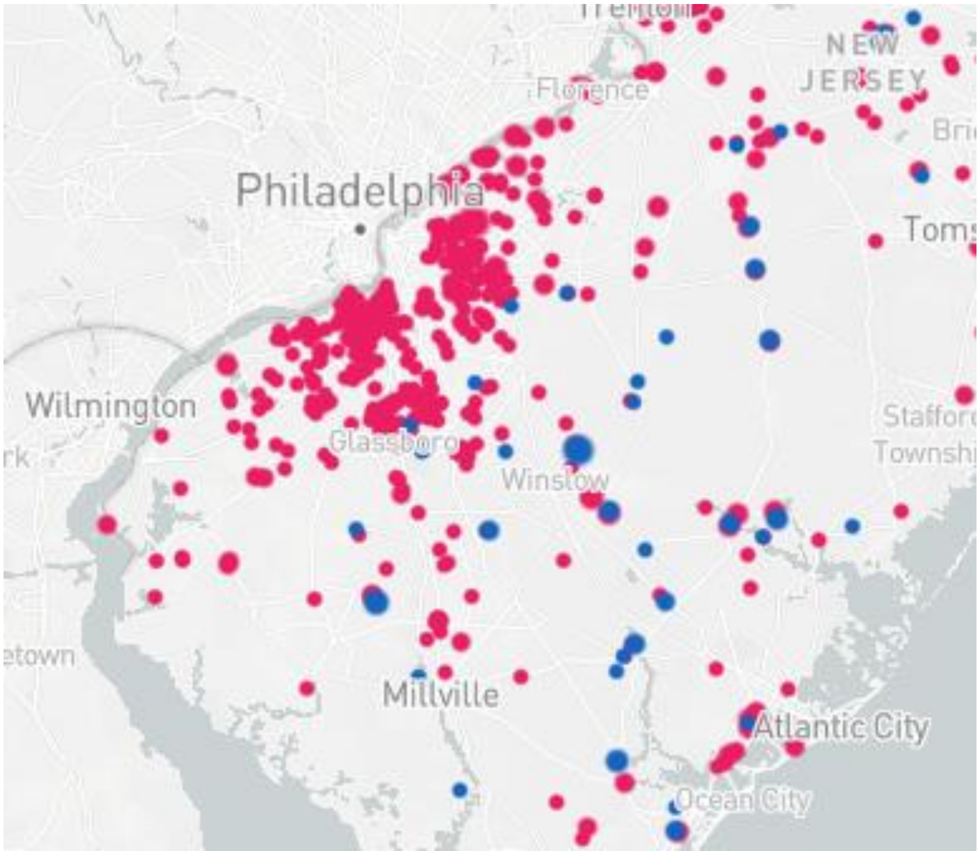


Source: CDC 2021c
Note: The red circle indicates the approximate location of Gloucester County.

The CDC Division of Vector Borne Diseases (DVBD) indicated in 2018 that New Jersey was the state with the second-highest number of confirmed Lyme disease cases, totaling approximately 4,000 cases. For total number of cases between 2007 and 2017, New Jersey ranked third highest for the number of confirmed Lyme disease cases, totaling approximately 32,731 (12.4 percent of the total reported cases in the U.S.). New Jersey is also considered a High Incidence State for Lyme Disease, with the average incidence of at least 10 confirmed cases per 100,000 persons for three reporting years (CDC 2018).

The map below shows reports of arbovirus in Gloucester County between January 2003 and April 2021. The red dots are for locations of mosquitos with West Nile Virus, whereas blue dots show the location of mosquitos carrying Eastern Equine Encephalitis.

Figure 4.3.3-5: Arbovirus Reports in Gloucester County



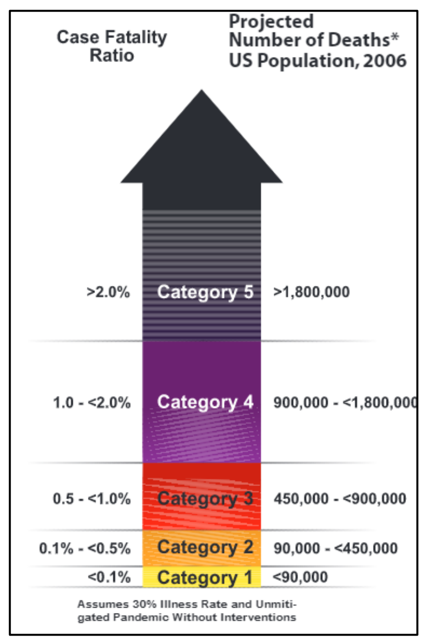
Source: VectorSurv Maps 2021

Influenza, Ebola and Coronavirus

The severity of a pandemic or infectious disease threat in New Jersey will range significantly depending on the aggressiveness of the virus in question and the ease of transmission. Pandemics around the nation have the potential to affect New Jersey's populated areas.

The CDC and Prevention Community Strategy for Pandemic Influenza Mitigation guidance introduced a Pandemic Severity Index (PSI), which uses the case fatality ratio as the critical driver for categorizing the severity of a pandemic. The index is designed to estimate the severity of a pandemic on a population to allow better forecasting of the impact of a pandemic, and to enable recommendations on the use of mitigation interventions that are matched to the severity of influenza pandemic. Pandemics are assigned to one of five discrete categories of increasing severity (Category 1 to Category 5) (NJDOH 2017). Figure 4.3.3-6 illustrates the five categories of the Pandemic Severity Index (PSI).

Figure 4.3.3-6. Pandemic PSI



Source: NJDOH 2017

In 1999, the WHO Secretariat published guidance for pandemic influenza and defined the six phases of a pandemic. Updated guidance was published in 2005 to redefine these phases. This schema is designed to provide guidance to the international community and to national governments on preparedness and response for pandemic threats and pandemic disease. Compared with the 1999 phases, the new definitions place more emphasis on pre-pandemic phases when pandemic threats may exist in animals or when new influenza virus subtypes infect people but do not spread efficiently. Because recognizing that distinctions between the two interpandemic phases and the three pandemic alert phases may be unclear, the WHO Secretariat proposes that classifications be determined by assessing risk based on a range of scientific and epidemiological data (WHO 2009). The WHO pandemic phases are outlined in Table 4.3.3-1.

Table 4.3.3-1. WHO Global Pandemic Phases

Phase	Description
Preparedness	
Phase 1	No viruses circulating among animals have been reported to cause infections in humans.
Phase 2	An animal influenza virus circulating among domesticated or wild animals is known to have caused infection in humans, and is therefore considered a potential pandemic threat.
Phase 3	An animal or human-animal influenza reassortant virus has caused sporadic cases or small clusters of disease in people, but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks. Limited human-to-human transmission may occur under some circumstances, for example, when there is close contact between an infected person and an unprotected caregiver. However, limited transmission under such restricted circumstances does not indicate that the virus has gained the level of transmissibility among humans necessary to cause a pandemic.
Response and Mitigation Efforts	
Phase 4	Human infection(s) are reported with a new subtype, but no human-to-human spread or at most rare instances of spread to a close contact.
Phase 5	Characterized by human-to-human spread of the virus into at least two countries in one WHO region. While most countries will not be affected at this stage, the declaration of Phase 5 is a strong signal that a pandemic is imminent and that the time to finalize the organization, communication, and implementation of the planned mitigation measures is short.
Phase 6	The pandemic phase is characterized by community level outbreaks in at least one other country in a different WHO region in addition to the criteria defined in Phase 5. Designation of this phase will indicate that a global pandemic is under way.

Source: WHO 2009

In New Jersey, health and supporting agency responses to a pandemic are defined by the WHO phases and federal pandemic influenza stages, and further defined by New Jersey pandemic situations. The State's situations are similar, but not identical to the United States Department of Homeland Security federal government response stages. Transition from one situation to another indicates a change in activities of one or more New Jersey agencies. Table 4.3.3-2 compares the federal and New Jersey pandemic influenza phases and situations.

Table 4.3.3-2. Federal and New Jersey Pandemic Phases and Situations

Federal Pandemic Influenza Stage		New Jersey Situations	
0	New domestic outbreak in at-risk country (WHO Phase 1, 2, or 3)	1	Novel (new) influenza virus in birds or other animals outside the U.S.
		2	Novel (new) influenza virus in birds or other animals in the U.S./NJ
1	Suspected human outbreak overseas (WHO Phase 3)	3	Human case of novel (new) influenza virus outside of the U.S.
2	Confirmed human outbreak overseas (WHO Phase 4 or 5)	4	Human-to-human spread of novel (new) influenza outside the U.S. (no widespread human transmission)
3	Widespread human outbreak in multiple locations overseas (WHO Phase 6)	5	Clusters of human cases outside the U.S.
4	First human case in North America (WHO Phase 6)	6	Human case of novel (new) influenza virus (no human spread) in the U.S./NJ
5	Spread in the U.S. (WHO Phase 6)	7	First case of human-to-human spread of novel (new) influenza in the U.S./NJ
		8	Clusters of cases of human spread in the U.S./NJ
		9	Widespread cases of human-to-human spread of novel (new) influenza outside the U.S./NJ
6	Recovery and preparation for subsequent waves (WHO Phase 5 or 6)	10	Reduced spread of influenza or end of pandemic

Source: NJOEM 2019
NJ New Jersey
U.S. United States
WHO World Health Organization

At the time of this draft's writing, the COVID-19 pandemic was currently impacting Gloucester County.

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with disease outbreak throughout Gloucester County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events may vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2021, Gloucester County was included in two emergency declarations and one disaster declaration related to disease outbreak.

Table 4.3.3-3. Disease-Related Disaster (DR) and Emergency (EM) Declarations 1954-2021

Declaration	Event Date	Declaration Date	Event Description
EM-3156	May 30-November 1,2000	November 1, 2000	West Nile Virus

Declaration	Event Date	Declaration Date	Event Description
DR-4488 / EM-3451	January 20,2000 to present	March 25, 2020 and March 13, 2020	New Jersey COVID-19 Pandemic

Source: FEMA 2021

Disease Outbreak Events

Disease outbreak events that have impacted Gloucester County between 2015 and 2021 are identified in Table 4.3.3-4. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

Table 4.3.3-4. Previous Occurrences of Disease Outbreak Events, 2015-2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Description
2015	Influenza	N/A	N/A	In 2015, 59 cases of influenza were reported in Gloucester County.
2015	Lyme Disease	N/A	N/A	In 2015, 128 cases of Lyme disease were reported in Gloucester County.
2015	West Nile Virus	N/A	N/A	In 2015, two cases of West Nile Virus were reported in Gloucester County.
2016	Influenza	N/A	N/A	In 2016, 133 cases of influenza were reported in Gloucester County.
2016	Lyme Disease	N/A	N/A	In 2016, 119 cases of Lyme disease were reported in Gloucester County.
2016	West Nile Virus	N/A	N/A	In 2016, one case of West Nile Virus was reported in Gloucester County.
2016	Zika Virus	N/A	N/A	In 2016, two cases of Zika virus were reported in Gloucester County.
2017	Influenza	N/A	N/A	In 2017, 320 cases of influenza were reported in Gloucester County.
2017	Lyme Disease	N/A	N/A	In 2017, 124 cases of Lyme disease were reported in Gloucester County.
2017	West Nile Virus	N/A	N/A	In 2017, one case of West Nile Virus was reported in Gloucester County.
2018	Influenza	N/A	N/A	In 2018, 436 cases of influenza were reported in Gloucester County.
2018	Lyme Disease	N/A	N/A	In 2018, 109 cases of Lyme disease were reported in Gloucester County.
2018	West Nile Virus	N/A	N/A	In 2018, one case of West Nile Virus was reported in Gloucester County.
2019	Influenza	N/A	N/A	In 2019, 379 cases of influenza were reported in Gloucester County.
2019	Lyme Disease	N/A	N/A	In 2019, 139 cases of Lyme disease were reported in Gloucester County.
2019	West Nile Virus	N/A	N/A	In 2019, one case of West Nile Virus was reported in Gloucester County.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Description
2020-2021	Coronavirus	DR-4488 / EM-3451	Yes	In early spring of 2020, the coronavirus (COVID-19) pandemic began. High numbers of hospitalizations and deaths prompted masking and social distancing requirements and the closure of schools and non-essential businesses. At the time of this plan update, the pandemic continues as do many social distancing and masking requirements. By April 23, 2021, Gloucester County had recorded 25,483 cases and 569 deaths.

Source: FEMA 2021; NJDOH 2021; NJ.com 2021
Note: Not all events that have occurred in Gloucester County are included due to the extent of documentation and the fact that not all sources have been identified or researched.
Reportable disease statistics in NJ were only available up to 2019 at the writing of this plan update.

Probability of Future Occurrences

It is difficult to predict when the next disease outbreak will occur and how severe it will be because viruses are always changing. The Department of Health and Human Services and others are developing supplies of vaccines and medicines. In addition, the United States has been working with the WHO and other countries to strengthen detection of disease and response to outbreaks. Preparedness efforts are ongoing at the national, State, and local level (NJOEM 2019). The Gloucester County Division of Health is leading the effort in coordination with other departments on the COVID-19 response.

In Gloucester County, the probability for a future disease outbreak event is dependent on several factors. One factor that influences the spread of disease is population density. Populations that live close to one another are more likely to spread diseases. All of the critical components necessary to sustain the threat of mosquito-borne disease in Gloucester County have been clearly documented. Instances of the WNV have been generally decreasing because of aggressive planning and eradication efforts, but some scientists suggest that as global temperatures rise and extreme weather conditions emerge from climate change, the range of the virus in the United States will grow (Epstein 2001). While instances of Zika have decreased since the outbreak in 2016, there is still the possibility of an outbreak occurring in the future. Therefore, based on all available information and available data regarding mosquito populations, it is anticipated that mosquito-borne diseases will continue to be a threat to Gloucester County.

Disease-carrying ticks will continue to inhabit the northeast, including Gloucester County, creating an increase in Lyme disease and other types of infections amongst the county population if not controlled or prevented. Ecological conditions favorable to Lyme disease, the steady increase in the number of cases, and the challenge of prevention predict that Lyme disease will be a continuing public health concern. Personal protection measures, including protective clothing, repellents or acaricides, tick checks, and landscape modifications in or near residential areas, may be helpful. However, these measures are difficult to perform regularly throughout the summer. Attempts to control the infection on a larger scale by the eradication of deer or widespread use of acaricides, which may be effective, have had limited public acceptance. New methods of tick control, including host-targeted acaricides against rodents and deer, are being developed and may provide help in the future (Steere, Coburn, and Glickstein 2004).

Currently and in the future, control of Lyme disease will depend primarily on public and physician education about personal protection measures, signs and symptoms of the disease, and appropriate antibiotic therapy. Based on available information and the ongoing trends of disease-carrying tick populations, it is anticipated that Lyme disease infections will continue to be a threat to Gloucester County.

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for disease outbreak in the county is considered 'frequent' (100 percent annual probability; a hazard event may occur multiple times per year, as presented in Table 4.4-1). The ranking of the disease outbreak hazard for individual municipalities is presented in the jurisdictional annexes.

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli et al. 2020).

The relationship between climate change and increase in infectious diseases is difficult to predict with certainty, there are scientific linkages between the two. Increased rainfall and heavy rainfalls increase the chances of standing water where mosquitos breed. As warm habitats that host insects such as mosquitoes increase, more of the population becomes exposed to potential virus threats (The Washington Post 2017). The notion that rising temperatures will increase the number of mosquitoes that can transmit diseases such as WNV and Zika among humans (rather than just shift their range) has been the subject of debate over the past decade.

Some believe that climate change may affect the spread of disease, while others are not convinced. However, many researchers point out that climate is not the only force at work in increasing the spread of infectious diseases into the future (NJOEM 2019). Increased rainstorms contribute to flooding and poor drainage in Gloucester County. As flooding events increase in the County owing to climate change, water-borne and vector-borne diseases (particularly those associated with mosquitos) may similarly increase owing to the prevalence of standing water over long periods (World Health Organization 2021b).

4.3.3.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard. The following discusses Gloucester County's vulnerability, in a qualitative nature, to the disease outbreak hazard.

Impact on Life, Health and Safety

The entire population of Gloucester County is vulnerable to the disease outbreak hazard. Due to a lack of quantifiable loss information, a qualitative assessment was conducted to evaluate the assets exposed to this hazard and the potential impacts associated with this hazard.

Maintaining certain key functions is important to preserve life and decrease societal disruption during pandemics. Heat, clean water, waste disposal, and corpse management all contribute to public health. Ensuring functional transportation systems also protects health by making it possible for people to access medical care and by transporting food and other essential goods. Critical infrastructure groups have a responsibility to maintain public health, provide public safety, transport medical supplies and food, implement a pandemic response, and maintaining societal functions. If these workers were absent due to pandemic outbreak, these systems will fail (CISA 2020).

Healthcare providers and first responders have an increased risk of exposure due to their frequent contact with infected populations. Areas with a higher population density also have an increased risk of exposure or transmission of disease due to their proximity to potentially infected people. Further, the elderly and immunocompromised individuals may have increased vulnerability to becoming infected or experience exacerbated impacts depending upon the disease. Refer to Section 3 (County Profile) for summary of the vulnerable populations in Gloucester County.

Most recently with COVID-19, the Centers for Disease Control and Prevention have indicated that persons over 65 years and older, persons living in a nursing home or long-term care facility, and persons with underlying medical conditions such as diabetes, severe obesity, serious heart conditions, etc. are at a higher risk of getting severely ill (CDC 2020). Population data from the 2018 5-year American Community Survey indicates that 44,794 persons over 65 years old in Gloucester County would be considered at risk for getting severely ill from the COVID-19 virus. While the statistics of this virus are subject to change during the publication of this HMP, the New Jersey Covid-19 dashboard shows that Gloucester County is within the lower quarter of the impacted

Counties. Overall, persons over 65 make up approximately 16.3-percent of positive COVID-19 cases in the entire State (NJ DOH 2020).

Impact on General Building Stock

No structures are anticipated to be directly affected by disease outbreaks.

Impact on Critical Facilities

While the actual structures of County and municipal buildings, critical facilities, and infrastructure will not be impacted by a pandemic or disease outbreak, the effect of absenteeism on workers will impact local government services. The most significant impact on critical facilities would be the increase in hospitalization and emergency room visits that would take place as a result of the outbreak. This would create a greater demand on these critical facilities, their staff, and resources.

Mortuary services could be substantially impacted due to the anticipated increased numbers of deaths. The timely, safe, and respectful disposition of the deceased is an essential component of an effective response. Pandemic influenza may quickly rise to the level of a catastrophic incident that results in mass fatalities, which will place extraordinary demands (including religious, cultural, and emotional burdens) on local jurisdictions and the families of the victims (Homeland Security Council 2006).

The healthcare system will be severely taxed, if not overwhelmed, from the large number of illnesses and complications from influenza requiring hospitalization and critical care. Ventilators will be the most critical shortage if a pandemic were to occur (Homeland Security Council 2006).

Impact on Economy

The impact disease outbreaks have on the economy and estimated dollar losses are difficult to measure and quantify. Costs associated with the activities and programs implemented to conduct surveillance and address disease outbreaks have not been quantified in available documentation. Instead, activities and programs have been implemented by the County and State to address this hazard.

Impact on Environment

Disease outbreaks may have an impact on the environment if the outbreaks are caused by invasive species. Invasive species tend to be competitive with native species and their habitat. One study has shown that invasive mosquitos such as the Asian tiger mosquito, a common invasive mosquito found in New Jersey, have "desiccation-resistant eggs," which means that they have enhanced survival in inhospitable environments (Juliano and Lounibos 2005). This species is considered a competitive predator and will prey on other species of mosquitos and a range of insects disrupting the natural food chain. Invasive species of mosquitos can be the major transmitters of disease like Zika, dengue, and yellow fever (Placer Mosquito and Vector Control District 2019).

Secondary impacts from mitigating disease outbreaks could also have an impact on the environment. Pesticides used to control disease carrying insects like mosquitos have been reviewed by the EPA and department of health. If these sprays are applied in large concentrations, they could potentially leach into waterways and harm nearby terrestrial species. However, there is a law in New Jersey's Pesticide Regulations that states, "no person shall distribute, sell, offer for sale, purchase, or use any pesticide which has been suspended or canceled by the EPA, except as provided for in the suspension of cancellation order" (New Jersey nd).

Further Changes that May Impact Vulnerability

Understanding future changes that may impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

Any areas of growth could be potentially impacted by the disease outbreak hazard because the entire planning area is exposed. As population counts change in the County, there may be at increased risk to certain diseases. Higher concentrations of persons traveling via public transportation may become more vulnerable to the exchange of disease through airborne transmission.

Projected Changes in Population

Changes in population density may influence the number of persons exposed to disease outbreaks. Higher density jurisdictions are not only at risk of greater exposure to disease outbreak, but density may also reduce available basic services provided by critical facilities such as hospitals and emergency facilities for persons that are not affected by a disease. Further, as the population ages there may be increased risk to this demographic. Older adults and people who have severe underlying medical conditions like heart or lung disease or diabetes seem to be at higher risk for developing more serious complications from certain diseases, such as COVID-19.

Climate Change

As discussed earlier in this section, the relationship between climate change and increase in infectious diseases is difficult to predict with certainty, however there may be linkages between the two. Changes in the environment may create a more livable habitat for vectors carrying disease as suggested by the Centers for Disease Control and Prevention (CDC n.d.). Localized changes in climate and human interaction may also be a factor in the spread of disease.

The relationship between climate change and infectious diseases is somewhat controversial. The notion that rising temperatures will increase the number of mosquitoes that can transmit malaria among humans (rather than just shift their range) has been the subject of debate over the past decade. Some believe that climate change may affect the spread of disease, while others are not convinced. However, many researchers point out that climate is not the only force at work in increasing the spread of infectious diseases into the future. Other factors, such as expanded rapid travel and evolution of resistance to medical treatments, are already changing the ways pathogens infect people, plants, and animals. As climate change accelerates it is likely to work synergistically with many of these factors, especially in populations increasingly subject to massive migration and malnutrition (Harmon 2010).

Vulnerability Change Since the 2016 HMP

Overall, the County continues to remain vulnerable to the disease outbreak hazard. Any changes or perceived increase in vulnerability may be attributed to changes in population numbers and density or the emergence of new diseases.

4.3.4 Drought

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for drought hazard in Gloucester County.

2022 HMP Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, probability of future occurrence, and climate change impacts.
- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2015 and 2021.
- The County's 2019 5-year American Community Survey population was considered when determining its exposure and vulnerability to the drought hazard.

4.3.4.1 Profile

Hazard Description

Drought is a period characterized by long durations of below normal precipitation. Drought conditions occur in virtually all climatic zones, yet characteristics of drought vary significantly from one region to another, relative to normal precipitation within respective regions. Drought can affect agriculture, water supply, aquatic ecology, wildlife, and plant life. Drought is a temporary irregularity in typical weather patterns and differs from aridity, which reflects low rainfall within a specific region and is a permanent feature of the climate of that area.

Location

Climate divisions are regions within a state that are climatically homogenous. The National Oceanic and Atmospheric Administration (NOAA) has divided the U.S. into 359 climate divisions. The boundaries of these divisions typically coincide with the county boundaries, except in the western U.S., where they are based largely on drainage basins (U.S. Energy Information Administration, Date Unknown). According to NOAA, New Jersey is made up of three climate divisions: Northern, Southern, and Coastal (NOAA 2012). Gloucester County is located in the Southern Climate Division.

Drought regions allow New Jersey to respond to changing conditions without imposing restrictions on areas not experiencing water supply shortages. New Jersey is divided into six drought regions that are based on regional similarities in water supply sources and rainfall patterns (Hoffman and Domber 2003). These regions were developed based upon hydro-geologic conditions, watershed boundaries, municipal boundaries, and water supply characteristics. Drought region boundaries are contiguous with municipal boundaries because during a water emergency, the primary enforcement mechanism for restrictions is municipal police forces. Figure 4.3.4-1shows the drought regions of New Jersey. Gloucester County is located in both the Southwest,

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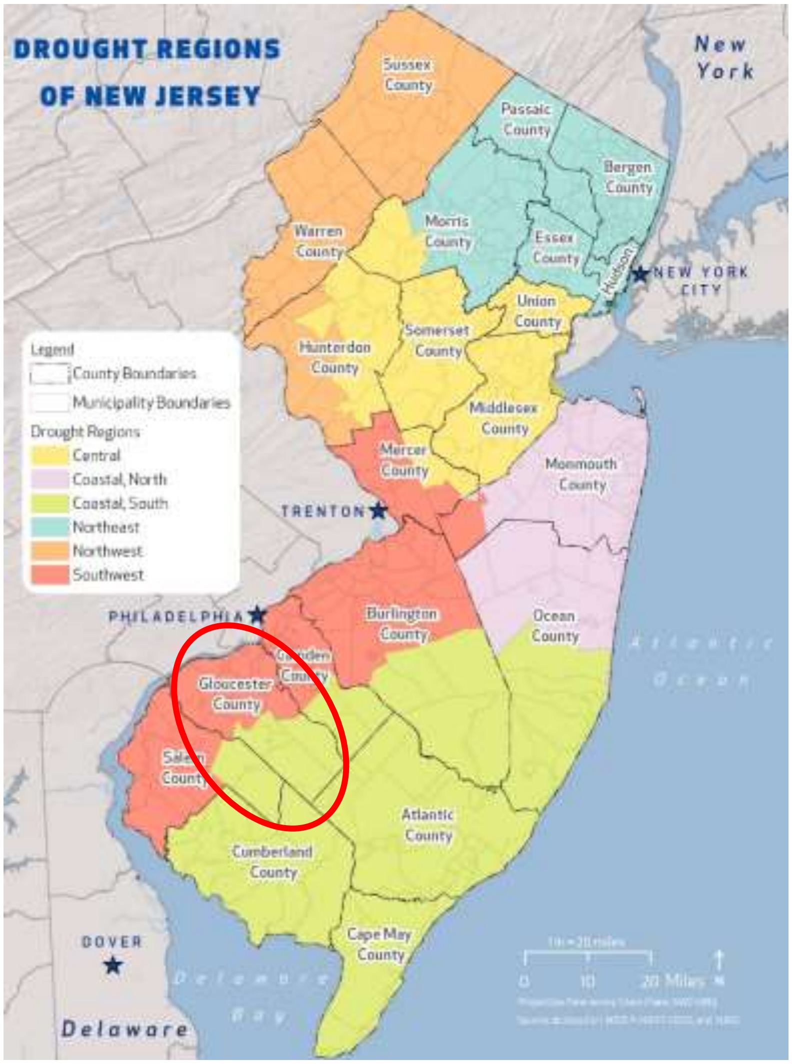
and the Coastal, South Drought Regions. Figure 4.3.4-1 shows the drought regions of New Jersey with Gloucester County circled in red.

Figure 4.3.4-1. Drought Regions of New Jersey

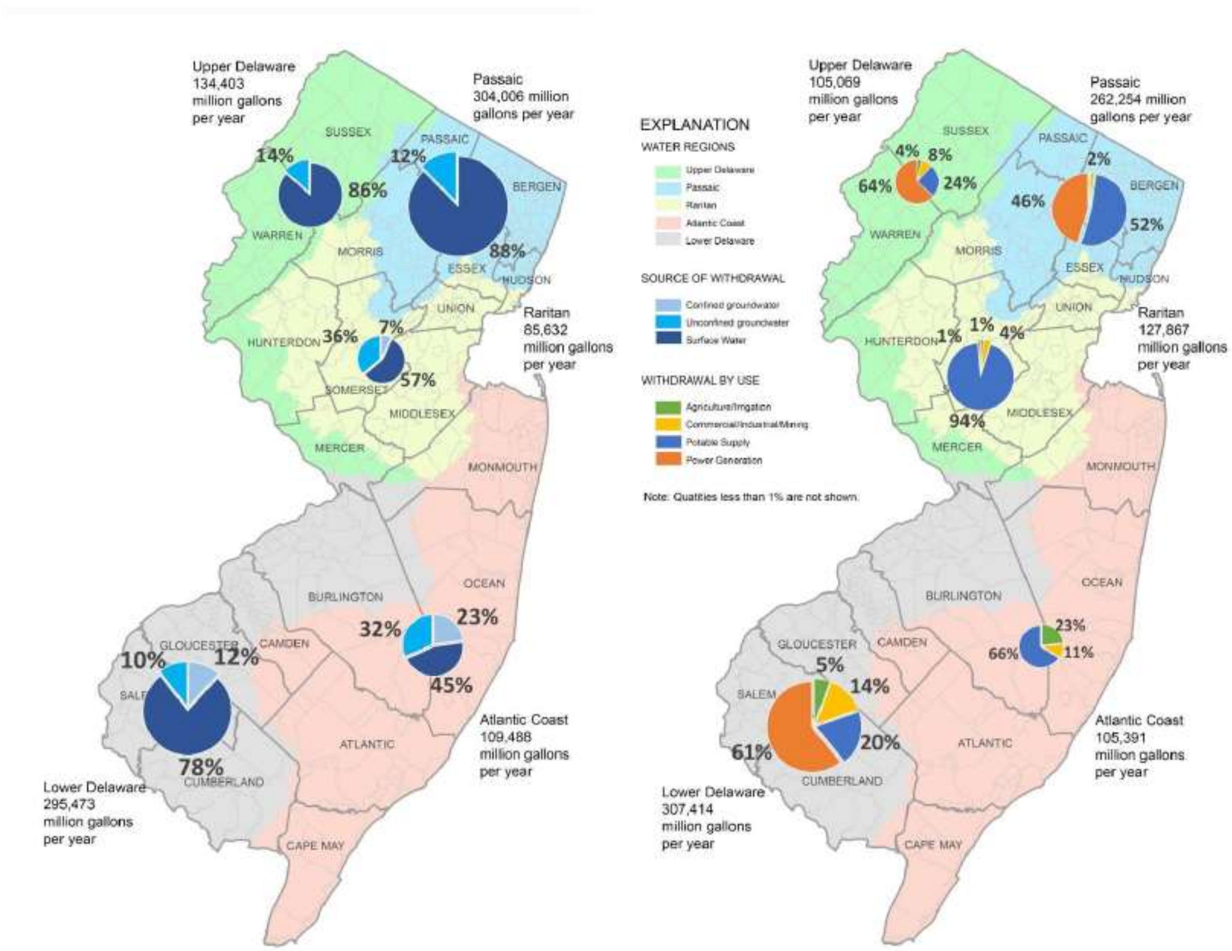


Source: NJOEM 2019
Note: The red circle indicates the location of Gloucester County

Surface waters in New Jersey provide much of the water used for drinking supplies, as well as for recreation, fishing, tourism, and commercial uses (NJDEP No Date).The state is divided into five water regions based upon watershed management area, and HUC11 (Hydrologic Unit Code). Gloucester County is located within both the Lower Delaware and Atlantic Coast water regions; refer to Figure 4.3.4-2. In terms of annual water withdrawal by sector in the Lower Delaware Region, the majority is for power generation, with a small percent of surface water used for potable water supply. By comparison, in the Atlantic Coast region, the majority of water withdrawals is for potable water supply, followed by agricultural and commercial uses. Water use trends, like withdrawal trends, vary from month to month with water use typically peaking during summer months when outdoor and irrigation demands are high (NJDEP 2017). According to the NJDEP, major water supply sources available to the Southwest Drought Region and northern portion of Gloucester County include the Delaware River Basin and unconfined ground water, and rivers as a minor source. For the Coastal South Drought Region and southern portion of Gloucester County, major water sources include unconfined ground water, and minor sources include rivers and the New Jersey Reservoir.

Due to the proximity to the Delaware Bay, this region adds a maritime influence on the climate, having some of the highest average daily temperatures as well as higher nighttime temperatures. In general, the region is drier than other parts of the state, and given its more inland characteristics, is not prone to major coastal storms.

Figure 4.3.4-2. Water Regions, Sources and Withdrawal by Sector in New Jersey



Source: NJDEP 2016

Over 1.2 billion gallons of potable water are used in New Jersey each day, with 88 percent of the state's population receiving its drinking water from public community water systems (NJDEP 2016). A public water system is defined as a water system that pipes water for human consumption that has at least 15 service connections or regularly serves at least 25 individuals 60 days or more a year. About half the state's population receives its drinking water from surface water, the rest from ground water.

Gloucester County is also home to a large agricultural industry which is heavily reliant on existing water resources. According to the USDA Agricultural Census, as of 2017 the county has 580 farms which total 49,381 acres of land within Gloucester County. The average size of each farm is approximately 85 acres which is a 12 percent increase since the 2012 Agricultural Census (USDA 2017). The total market value of products sold by farms located in Gloucester County is roughly 102 million dollars while the average market value of products sold by each farm is 176,644 dollars on an annual basis. The majority of farms, that is 42 percent of all farms have a sales value of less than $2,500 while 96 have an annual value of $100,000 or more. Most sales of farms located in the county are from grain and vegetable production while a small fraction of sales stem from livestock and poultry products. Because this industry is heavily reliant on water, it is critical to examine the County vulnerability to drought to reduce any loss of income from farming.

According to the Washington Township Water Conservation Guide, the Potomac-Raritan-Magothy Aquifer is the most productive aquifer; it is relied on heavily for most South Jersey communities, which is causing stress because water is being removed faster than it can regenerate, especially with the inability for rain to penetrate the dry soils. This is a delicate situation because, while the Raritan is at risk for pollution or saltwater intrusion, taking too much water from the Cohansey can negatively impact streams and lakes. All of these various phenomena can have significant impact on Gloucester County over time (Mazziotti 2018).

Extent

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts (NOAA 2021). The State of New Jersey uses a multi-index system that takes advantage of some of these indices to determine the severity of a drought or extended period of dry conditions.

Palmer Drought Severity Index

The Palmer Drought Severity Index is commonly used by drought monitoring agencies for drought reporting. The PDSI is primarily based on soil conditions. Soil with decreased moisture content is the first indicator of an overall moisture deficit. Table 4.3.4-1 lists the PDSI classifications. At the one end of the spectrum, 0 is used as normal and drought is indicated by negative numbers. For example, -2 is moderate drought, -3 is severe drought, and -4 is extreme drought. The PDSI also reflects excess precipitation using positive numbers; however, this is not shown in Table 4.3.4-1 (University of Nebraka, Lincoln. 2013).

Table 4.3.4-1. Palmer Drought Category Descriptions

Category	Description	Possible Impacts	Palmer Drought Index
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting and growth of crops or pastures; fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.	-1.0 to -1.99
D1	Moderate drought	Some damage to crops and pastures; fire risk high; streams, reservoirs, or wells low; some water shortages developing or imminent; voluntary water-use restrictions requested.	-2.0 to -2.99
D2	Severe drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed.	-3.0 to -3.99
D3	Extreme drought	Major crop or pasture losses; extreme fire danger; widespread water shortages or restrictions.	-4.0 to -4.99
D4	Exceptional drought	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies.	-5.0 or less

Source: NDMC 2013

Watches, Warnings and Emergencies

The Division of Water Supply and Geoscience within the NJDEP, regularly monitors various water supply conditions within the state based on the different Water Supply Regions. The water supply conditions aid the Department in declaring the regions as being within one of the four stages of water supply drought, Normal, Drought Watch, Drought Warning, and Drought Emergency.

- A ***Drought Watch*** is an administrative designation made by the Department when drought or other factors begin to adversely affect water supply conditions. A Watch indicates that conditions are dry but not yet significantly so. During a drought Watch, the Department closely monitors drought indicators (including precipitation, stream flows and reservoir and ground water levels, and water demands) and consults with affected water suppliers.
- A ***Drought Warning*** represents a non-emergency phase of managing available water supplies during the developing stages of drought and falls between the Watch and Emergency levels of drought response. The aim of a Drought Watch is to avert a more serious water shortage that would necessitate declaration of a water emergency and the imposition of mandatory water use restrictions, bans on water use, or other potentially drastic measures.
- A ***Drought Emergency*** can only be declared by the governor. While drought warning actions focus on increasing or shifting the supply of water, efforts initiated under a water emergency focus on reducing water demands. During a water emergency, a phased approach to restricting water consumption is

typically initiated. Phase I water use restrictions typically target non-essential, outdoor water use (NJDEP 2021).

Previous Occurrences and Losses

Precipitation variability, coupled with concentrated population centers, can produce wide fluctuations in water availability and demands. The State and County have experienced several episodes of drought that have resulted in water shortages of varying degrees (e.g., mid-1960's, early to mid-1980's and 2001-2002) (FEMA 2021).

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2021, the State of New Jersey experienced two FEMA declared drought-related disasters (DR) or emergencies (EM) classified as a water shortage. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Of those two declarations, Gloucester County has been included in both declarations (FEMA 2021).

Table 4.3.4-2. FEMA DR and EM Declarations for Drought Events in Gloucester County, 1954 to 2020

FEMA Declaration Number	Date(s) of Event	Declaration Date	Event Type
EM-3083	October 19, 1980	October 19, 1980	Water Shortage
DR-205	August 18, 1965	August 18, 1965	Water Shortage

Source: FEMA 2021

U.S. Department of Agriculture Disaster Declarations

Agriculture-related drought disasters are quite common. One-half to two-thirds of the counties in the U.S. have been designated as disaster areas in each of the past several years. The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2021, Gloucester County has been included in six USDA declarations related to drought as summarized in Table 4.3.4-3 (USDA 2021). Although USDA disasters were declared, there are no USDA records for historical losses from 2012-2020 (USDA 2021).

Table 4.3.4-3. USDA Disaster Declarations for Gloucester County 2012-2021

Declaration	Event Date	Declaration Date	Event Description
S3487	June 28, 2012	February 14, 2013	The combined effects of drought, high winds (Derecho), hail, excessive heat, excessive rain, flash flooding, Hurricane Sandy, snowstorm, and Nor'easter
S3932	July 16, 2015	September 29, 2015	Excessive Heat and Drought
S3930	April 1, 2015	November 4, 2015	Excessive Heat and Drought
S4071	April 1, 2016	September 19, 2016	Combined effects of freeze, excessive heat, and drought
S4425	June 24, 2018	October 31, 2018	Excessive heat and drought conditions
S4602	August 15, 2019	January 10, 2020	Drought

Source: USDA 2021

Drought Events

For the 2022 HMP update, four events have impacted Gloucester County since the last hazard mitigation plan, that is between 2015 and 2021. These events have been identified and are listed in Table 4.3.4-4.

Table 4.3.4-4. Drought Incidents in Gloucester County, 2015 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Description
July 7- July 13, 2020	Drought	NA	NA	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Gloucester County from July 7 – July 13, 2020.
September 17 – December 9, 2019	Drought	NA	NA	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Gloucester County from September 17 – September 23, 2019, D1 or “moderate drought” from September 24 – October 28, 2019, and then back to D0 or “abnormally dry” between October 29 – December 9, 2019.
July 17 – 30, 2018	Drought	NA	NA	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Gloucester County from July 17 – July 30, 2018.
December 12, 2017 – February 12, 2018	Drought	NA	NA	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Gloucester County from December 12, 2017 - February 12, 2018.
August 30, 2016 – April 3, 2017	Drought	NA	NA	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Gloucester County from August 30 – September 12, 2016, D1 or “moderate drought” from September 13 – October 3, 2016, and then back to D0 or “abnormally dry” between October 4 – November 14, 2016, , D1 or “moderate drought” from November 15, 2016 – March 13, 2017, and D0 or “abnormally dry” between March 14 – April 3, 2017.
June 28 – August 1, 2016	Drought	NA	NA	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Gloucester County from June 28 – August 1, 2016.
May 3 – May 9, 2016	Drought	NA	NA	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Gloucester County from May 3 – May 9, 2016.
September 1 – October 5, 2015	Drought	NA	NA	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Gloucester County from September 1 – October 5, 2015
May 26, 2015 – June 1, 2015	Drought	NA	NA	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Gloucester County from May 26 -June 1, 2015

Source: NOAA NCEI 2021. USDA 2021, NDMC 2021, nj.com. FEMA 2021, NJOEM 2019

Probability of Future Occurrences

Based upon risk factors for and past occurrences, it is likely that droughts will occur across New Jersey and Gloucester County in the future. In addition, as temperatures increase (see climate change impacts), the probability for future droughts will likely increase as well. Therefore, it is likely that droughts will occur in New Jersey of varied severity in the future.

It is estimated that Gloucester County will continue to experience direct and indirect impacts of drought and its impacts on occasion, with the secondary effects causing potential disruption or damage to agricultural activities and creating shortages in water supply within communities.

According to the US Drought Monitor, the long term projections show that precipitation will increase in the region, which is contradictory to the statement that drought events will increase. However, it is important to note that while precipitation will increase, that is likely due to extreme preceptory events in shorter periods of time. At the same time, the number of drought events will also increase due to the longer periods of no rain. This gives a better understanding of how precipitation can increase at the same time, frequency of droughts also increases.

In Section 4.4 (Hazard Ranking), the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Steering Committee and Planning Committee, the probability of occurrence for drought in the County is considered 'occasional' (between 10 and 100 percent annual chance of occurring).

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (ONJSC 2021),which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo 2014) and the world (1.5° F [0.8° C]) (R. K. Pachauri and L. A. Meyer 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date. The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Runkle 2017). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often and with more intensity (Huang 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan 2014). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011).

Droughts along with extreme precipitation have been an increasingly recurring phenomenon over the past decades. Precipitation has increased over time, which is counterintuitive given drought events are also projected to increase. However, this follows the trend of increased extreme weather. With isolated precipitation, in between long stretches of dry weather, wildfires, riverine flooding, and degraded water supply can all happen at the same time and therefore can put communities, especially those that live along a river, susceptible to structural flood damage along with potential degraded water supply due to the receding water table that cannot get replenished from such extreme precipitation. The county is thus vulnerable to droughts, especially along the Delaware River, where the temperatures increase dramatically and severe runoff from dry soils can cause degraded water supply (Cornell University 2021).

4.3.4.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. The following discusses Gloucester County's vulnerability, in a qualitative nature, to the drought hazard.

Impact on Life, Health and Safety

The entire population of Gloucester County is exposed to drought events (population of 291,165 people, according to the 2015-2019 American Community Survey population estimates). Drought conditions can cause a shortage of potable water for human consumption, both in quantity and quality. A decrease in available water may also impact power generation and availability to residents.

Public health impacts may include an increase in heat-related illnesses, waterborne illnesses, recreational risks, limited food availability, and reduced living conditions. Vulnerable populations could be particularly susceptible to the drought hazard and cascading impacts due to age, health conditions, and limited ability to mobilize to shelter, cooling and medical resources. Other possible impacts to health due to drought include increased recreational risks; effects on air quality; diminished living conditions related to energy, air quality, and sanitation and hygiene; compromised food and nutrition; and increased incidence of illness and disease. Health implications of drought are numerous. Some drought-related health effects are short-term while others can be long-term (CDC 2021)

Surface water supplies are affected more quickly during droughts than groundwater sources; however, groundwater supplies generally take longer to recover. In addition to 158 suppliers of groundwater throughout Gloucester County, the following list provides the surface water suppliers for Gloucester County (NJDEP 2021):

- DEPTFORD TWP MUA
- EAST GREENWICH TWP WATER DEPT
- GLASSBORO WATER DEPARTMENT

- NJ AMERICAN WATER – HARRISON
- NJ AMERICAN WATER – BRIDGEPORT
- NJ AMERICAN WATER – LOGAN
- MANTUA TOWNSHIP MUA
- MONROE TWP MUA
- NATIONAL PARK WATER DEPARTMENT
- PITMAN WATER DEPARTMENT
- WEST DEPTFORD TWP WATER DEPT
- WOODBURY CITY W DEPT
- WOODBURY HEIGHTS W UTILITY
- AQUA NJ - WOOLWICH

As previously stated, drought conditions can cause shortages in water for human consumption. Droughts can also lead to reduced local firefighting capabilities. The drought hazard is a concern for Gloucester County because the County's water is supplied by both surface water and groundwater. In the short-term, surface water supplies are affected more quickly during droughts than groundwater sources.

The Centers for Disease Control and Prevention's (CDC) 2018 Social Vulnerability Index (SVI) ranks U.S. Census tracts on socioeconomic status, household composition and disability, minority status and language, and housing and transportation. Gloucester County's overall score is 0.1675, indicating that its communities have low social vulnerability, though impacts from a drought event could severely impact parts of the community (CDC 2021).

Impact on General Building Stock

No structures are anticipated to be directly affected by a drought event. However, droughts contribute to conditions conducive to wildfires and reduce fire-fighting capabilities. Risk to life and property is greatest in those areas where forested areas adjoin urbanized areas (high density residential, commercial and industrial) also known as the wildfire urban interface (WUI). Therefore, all assets in and adjacent to, the WUI zone, including population, structures, critical facilities, lifelines, and businesses are considered vulnerable to wildfire. Refer Section 4.3.15 for the Wildfire risk assessment.

Impact on Critical Facilities

As mentioned, drought events generally do not impact buildings; however, droughts have the potential to impact agriculture-related facilities and critical facilities that are associated with water supplies such as potable water used with fire-fighting services. Critical facilities in and adjacent to the wildfire hazard areas are considered vulnerable to wildfire.

Water systems and thus distribution to the population may also be impacted by other hazards such as extreme weather events. A good example is Superstorm Sandy where storm surge damaged critical water supply infrastructure along the coast and high winds impacted energy distribution across the State which in turn impacted the ability to supply water. As a result, NJDEP has developed new guidance aimed to ensure that repairs, reconstruction, new facilities and operations/maintenance are focused on enhancing the resilience of critical infrastructure (NJDEP 2021).

Impact on the Economy

Drought can produce a range of impacts that span many economic sectors and can reach beyond an area experiencing physical drought. As previously discussed, water withdrawals are not only used for potable water but for use in the commercial/industrial/mining sectors and power generation. When a state of water emergency is declared by the Governor (when a potential or actual water shortage endangers the public health, safety and welfare), the NJDEP may impose mandatory water restrictions and require specific actions to be taken by water suppliers. According to the New Jersey Water Supply Plan, a water emergency seeks to cause as little disruption as possible to commercial activity and employment (NJ Department of Environmental Protection 2017).

A prolonged drought can have a serious economic impact on a community. One impact of drought is its impact on water supply. When drought conditions persist with little to no relief, water restrictions may be put into place by local or state governments. These restrictions may include placing limitations on when or how frequent lawns can be watered, car washing services, or any other recreational/commercial outdoor use of water supplies. In exceptional drought conditions, watering of lawns and crops may not be an option. If crops are not able to receive water, farmland will dry out and crops will die. This can lead to crop shortages, which, in turn, increases the price of food (NC State University 2013).

Increased demand for water and electricity can also result in shortages and higher costs for these resources. Industries that rely on water for business could be impacted the most (e.g., landscaping businesses). Although most businesses will still be operational, they may be impacted aesthetically. These aesthetic impacts are most significant within the recreation and tourism industry. Moreover, droughts within another area could impact the food supply and price of food for residents within the county.

Direct impacts of drought include reduced crop yield, increased fire hazard, reduced water levels, and damage to wildlife and fish habitat. The many impacts of drought can be listed as economic, environmental, or social. Direct and indirect losses include the following:

- Damage to crop quality and crop losses.
- Insect infestation leading to crop and tree losses.
- Plant diseases leading to loss of agricultural crops and trees.
- Reduction in outdoor activities.
- Increased risk of brush fires and wildfires due to dried crops, grasses, and dying trees.

When a drought occurs, the agricultural industry is most at risk in terms of economic impact and damage. For example, crops may not mature leading to a lessened crop yield, wildlife and livestock may become undernourished, land values could decrease, and ultimately there could be a financial loss for the farmer (IPCC 2016). Based on the 2017 Census of Agriculture, there were 518 farms in Gloucester County, a 1 percent decline from the 2012 reports. The average farm size was 85 acres. Gloucester County farms had a total market value of products sold of $94.9 million in crop sales and $7.6 million in livestock sales. Table 4.3.4-5 summarizes the acreage of agricultural land exposed to the drought hazard.

Table 4.3.4-5. Agricultural Land in Gloucester County in 2017

Number of Farms	Land in Farms (acres)	Total Cropland (percent)	Pastureland (percent)	Irrigated Land (acres)
580	49,381	72	5	8,732

Source: USDA 2017
(D) Withheld to avoid disclosing data for individual farms

Impact on the Environment

Droughts can impact the environment because these events can trigger wildfires, increase insect infestations, and exacerbate the spread of disease (IPCC 2016). Droughts will also impact water resources that are relied upon by aquatic and terrestrial species. Ecologically sensitive areas, such as wetlands, can be particularly vulnerable to drought periods because they are dependent on steady water levels and soil moisture availability to sustain growth. As a result, these types of habitats can be negatively impacted after long periods of dryness (NJDEP 2017).

Droughts also have the potential to lead to water pollution due to the lack of rainwater to dilute any chemicals in water sources. Contaminated water supplies may be harmful to plans and animals. If water is not getting into the soils, the ground will dry up and become unstable. Unstable soils increase the risk of erosion and loss of topsoil (NC State University 2013).

Future Changes That May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

As discussed in Section 3 (County Profile), areas targeted for future growth and development have been identified across Gloucester County. The New Jersey Water Supply Plan indicates seasonal outdoor water use is rising and is attributable to continued suburbanization and increases in residential and commercial lawn and landscape maintenance. Changes in water demands by commercial/industrial users will depend on future development of this water type use and how effectively efficiency techniques are implemented (NJDEP 2017).

Projected Changes in Population

Potable water use is the second largest water use sector and largest consumptive use in New Jersey. As such, population projections, per capital water use and percent non-residential water use by water system are important factors to consider when assessing future water needs. Gloucester County has experienced population growth since 2010, based on 2015-2019 Community Survey information. The Boroughs of Woolrich, East Greenwich Township, and Borough of Glassboro have experienced the greatest percentage of growth since 2010; greater than 5 percent each. Increases in population may create greater strain on water resources in those communities, throughout Gloucester County and the region as a whole.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures. Additionally, the State is projected to experience more frequency droughts which may affect the availability of water supplies, primarily placing an increased stress on the population and their available potable water. Agricultural needs may increase if the climate grows warmer but may decrease if more efficient irrigation techniques are adopted broadly or if precipitation increases. A decrease in water supply, or increase in water supply demand, may increase the County's vulnerability to structural fire and wildfire events. Critical water-related service sectors may need to adjust management practices and actively manage resources to accommodate for future changes.

Vulnerability Change Since the 2016 HMP

When examining the change in the County's vulnerability to drought events from the 2016 HMP to this update, it is important to look at each entity that is exposed and vulnerable. The total population across the County has experienced a slight increase, which can place a greater stress on the water supply during a drought event. In terms of the agricultural industry for Gloucester County, there has been a 1 percent decline in the number of farms since the 2012 USDA report.

4.3.5 Earthquake

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the earthquake hazard in Gloucester County.

2022 HMP Update Changes

- All subsections have been updated using best available data.
- Previous occurrences were updated with events that occurred between 2015 and 2021.
- A vulnerability assessment was conducted for the earthquake hazard using FEMA's Hazus-MH v4.2 earthquake model for the 100-year and 500-year Mean Return Period (MRP) events. An updated building stock and critical facility data set was imported in Hazus to assess damages for each jurisdiction at the aggregate Census Tract level.

4.3.5.1Profile

Hazard Description

An earthquake is the sudden movement of the Earth's surface caused by the release of stress accumulated within or along the edge of the Earth's tectonic plates, a volcanic eruption, or by a manmade explosion (FEMA 2001). Most earthquakes occur at the boundaries where the Earth's tectonic plates meet (faults); less than 10 percent of earthquakes occur within plate interiors. New Jersey is in an area where the rarer plate interior-related earthquakes occur. As plates continue to move and plate boundaries change geologically over time, weakened boundary regions become part of the interiors of the plates. These zones of weakness within the continents can cause earthquakes in response to stresses that originate at the edges of the plate or in the deeper crust (Shedlock 1997).

The location of an earthquake is commonly described by its focal depth and the geographic position of its epicenter. The focal depth of an earthquake is the depth from the Earth's surface to the region where an earthquake's energy originates, also called the focus or hypocenter. The epicenter of an earthquake is the point on the Earth's surface directly above the hypocenter (Shedlock 1997). Earthquakes usually occur without warning and their effects can impact areas of great distance from the epicenter (FEMA 2001).

According to the U.S. Geological Survey (USGS) Earthquake Hazards Program (USGS 2021), an earthquake hazard is any disruption associated with an earthquake that may affect residents' normal activities. This includes surface faulting, ground shaking, landslides, liquefaction, tectonic deformation, tsunamis, and seiches; each of these terms is defined below; however, not all occur within the Gloucester County planning area:

- *Surface faulting*: Displacement that reaches the earth's surface during a slip along a fault. Commonly occurs with shallow earthquakes—those with an epicenter less than 20 kilometers.

- *Ground motion (shaking):* The movement of the earth's surface from earthquakes or explosions. Ground motion or shaking is produced by waves that are generated by a sudden slip on a fault or sudden pressure at the explosive source and travel through the Earth and along its surface.
- *Landslide*: A movement of surface material down a slope.
- *Liquefaction*: A process by which water-saturated sediment temporarily loses strength and acts as a fluid, like the wet sand near the water at the beach. Earthquake shaking can cause this effect.
- *Tectonic Deformation*: A change in the original shape of a material caused by stress and strain.
- *Tsunami*: A sea wave of local or distant origin that results from large-scale seafloor displacements associated with large earthquakes, major sub-marine slides, or exploding volcanic islands.
- *Seiche*: The sloshing of a closed body of water, such as a lake or bay, from earthquake shaking (USGS 2012a).

Earthquakes can cause large and sometimes disastrous landslides and mudslides. Any steep slope is vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people. Earthen dams and levees are highly susceptible to seismic events and the impacts of their eventual failures can be considered secondary risks for earthquakes. Landslides are further discussed in Section 4.3.8 (Geologic Hazards) of this HMP update.

Earthquakes can also cause dam failures. The most common mode of earthquake-induced dam failure is slumping or settlement of earth-fill dams where the fill has not been property compacted. If the slumping occurs when the dam is full, then overtopping of the dam, with rapid erosion leading to dam failure is possible. Dam failure is also possible if strong ground motions heavily damage concrete dams. Earthquake-induced landslides into reservoirs have also caused dam failures. Dam failures are further discussed in Section 4.3.2 (Dam and Levee Failures) of this HMP update.

Another secondary effect of earthquakes that is often observed in low-lying areas near water bodies is ground liquefaction. Liquefaction is the conversion of water-saturated soil into a fluid-like mass. This can occur when loosely packed, waterlogged sediments lose their strength in response to strong shaking. Liquefaction effects may occur along the shorelines of the ocean, rivers, and lakes and they can also happen in low-lying areas away from water bodies in locations where the ground water is near the earth’s surface.

Tsunamis are formed as a result of earthquakes, volcanic eruptions, or landslides that occur under the ocean. When these events occur, huge amounts of energy are released as a result of quick, upward bottom movement. A wave is formed when huge volumes of ocean water are pushed upward. A large earthquake can lift large portions of the seafloor, which will cause the formation of huge waves (US SAR Task Force n.d).

4.3.5.2 Location

Earthquakes are most likely to occur in the northern parts of New Jersey, where significant faults are concentrated; however, low-magnitude events can and do occur in many other areas of the State. The National

Earthquake Hazard Reduction Program (NEHRP) developed five soil classifications defined by their shear-wave velocity that impact the severity of an earthquake. The soil classification system ranges from A to E, as noted in Table 4.3.5-1, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses.

Table 4.3.5-1. NEHRP Soil Classifications

Soil Classification	Description
A	Hard Rock
B	Rock
C	Very dense soil and soft rock
D	Stiff soils
E	Soft soils

Source: (FEMA 2021)

New Jersey Department of Transportation (NJDOT) compiled a report on seismic design consideration for bridges in New Jersey, dated March 2012 (Anil Agrawal 2012). In the report, NJDOT classifies the seismic nature of soils according to the American Association of State Highway and Transportation Officials (AASHTO) Guide Specifications for Bridge Seismic Design (SGS). For the purpose of seismic analysis and design, sites can be classified into Soil Classes A, B, C, D, E and F, ranging from hard rock to soft soil and special soils (similar to the NEHRP soil classifications with an additional class F); refer to Table 4.3.5-2.

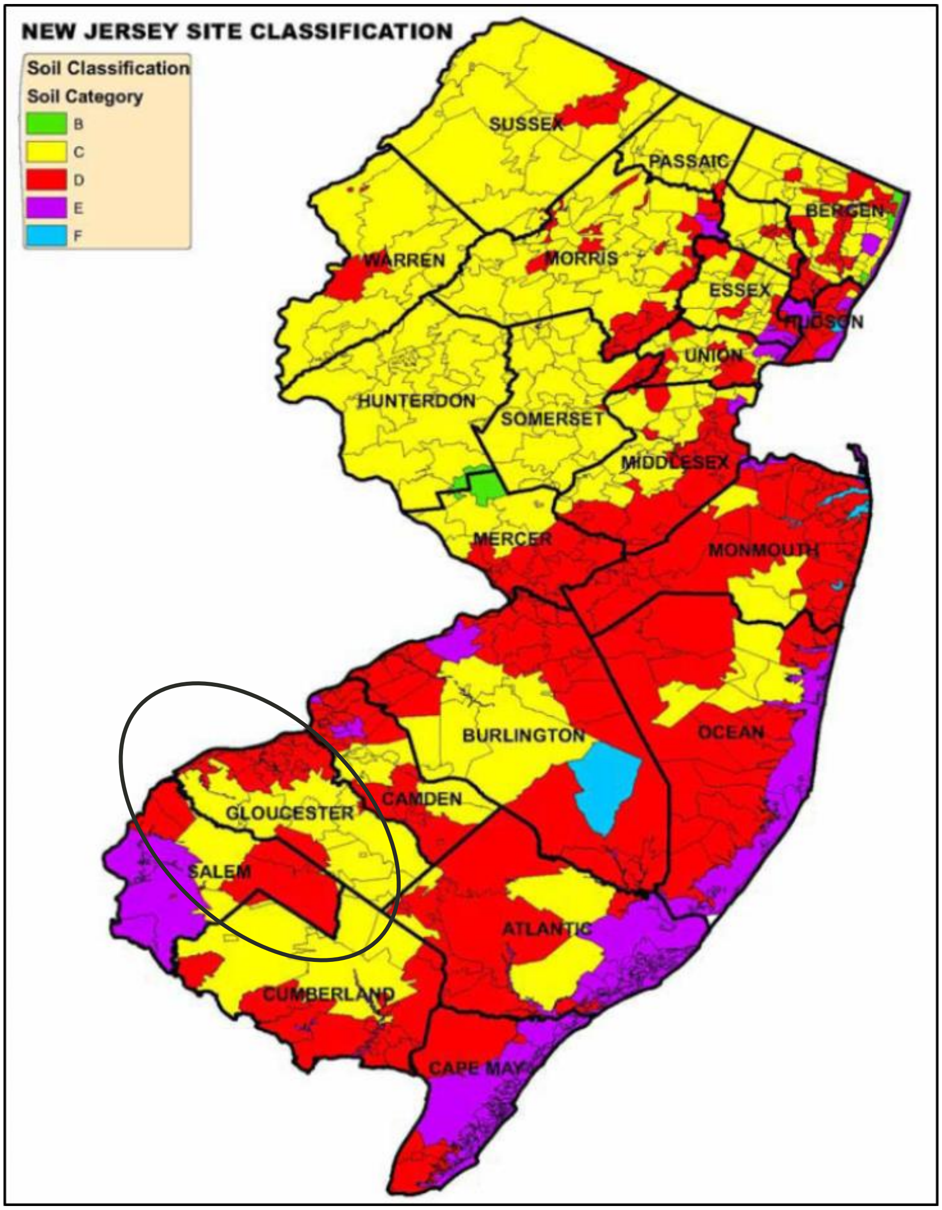
Table 4.3.5-2 NJDOT Soil Classifications

Soil Classification	Description
A-B	Rock sites
C	Very dense soil
D	Dense soil
E	Soft soil
F	Special soil requiring site-specific analysis

Source: NJDOT 2012

NJDOT also developed a Geotechnical Database Management System, which contains soil boring data across New Jersey. The soil boring logs were then used to classify soil sites. Through this analysis, NJDOT developed a map of soil site classes according to ZIP codes in New Jersey where each ZIP code was assigned a class based on its predominant soil condition. In Gloucester County, most ZIP codes were rated as either Category C or D. Figure 4.3.5-1 provides a displays this information.

Figure 4.3.5-1. ZIP Code-Based Soil Site Class Map



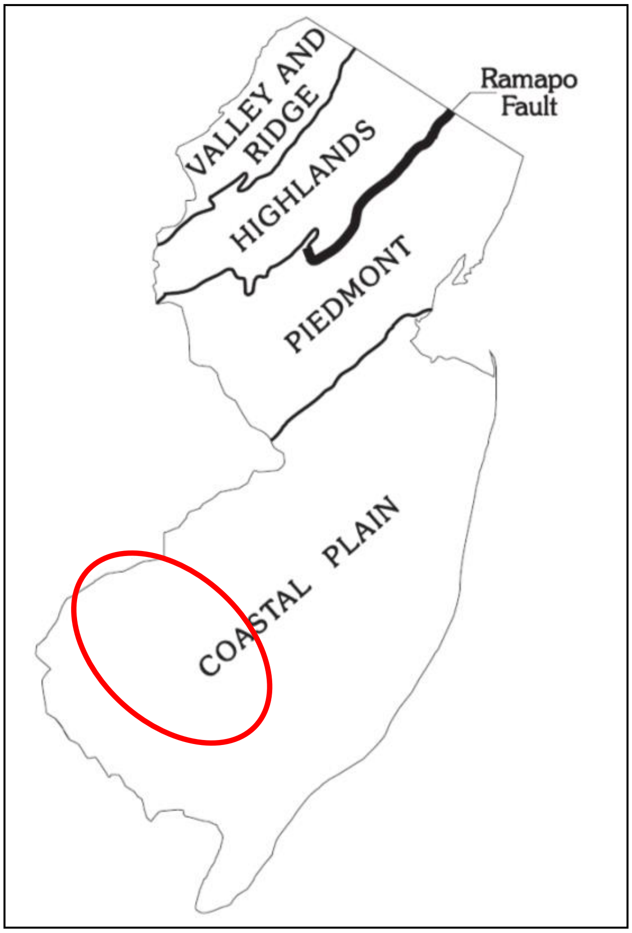
Source: NJDOT 2012
Note: Gloucester County is indicated by the black oval.

Liquefaction has been responsible for tremendous amounts of damage in historical earthquakes around the world. Shaking behavior and liquefaction susceptibility of soils are determined by their grain size, thickness, compaction, and degree of saturation. These properties, in turn, are determined by the geologic origin of the soils and their topographic position. In terms of liquefaction susceptibility, the majority of Gloucester County has low to no susceptibility (NJDEP 2021).

Liquefaction occurs in saturated soils and when it occurs, the strength of the soil decreases and the ability of a soil deposit to support foundations for buildings and bridges is reduced. Shaking from earthquakes often triggers an increase in water pressure which can trigger landslides and the collapse of dams. For information regarding dam failures, refer to Section 4.3.2 (Dam and Levee Failure). Earthquakes also contribute to landslide hazards. Earthquakes create stresses that make weak slopes fail. Earthquakes of magnitude 4.0 or greater have been known to trigger landslides. For information regarding landslides, refer to Section 5.48 (Geological Hazards).

Fractures or fracture zones along with rocks on adjacent sides have broken and moved upward, downward, or horizontally are known as faults (Volkert 2015). Movement can take place at faults and cause an earthquake. Earthquake epicenters in eastern North America and the New Jersey area, however, do not typically occur on known faults. The faults in these areas are the result of tectonic activity from over 200 million years ago. One of the most well-known faults in the state is the Ramapo Fault, which separates the Piedmont and Highlands Physiographic Provinces. As indicated in Figure 4.3.5-2, Gloucester County might feel the effects of an earthquake along the Ramapo Fault; however, the fault itself is not located within County borders (Volkert 2015).

Figure 4.3.5-2. Physiographic Provinces of New Jersey and the Ramapo Fault Line



Source: NJDEP, 2021
Note: Gloucester County is indicated by the red oval

Extent

An earthquake's magnitude and intensity are used to describe the size and severity of the event (NJOEM 2019). Magnitude describes the size at the focal point of an earthquake, and intensity describes the overall severity of shaking felt during the event. The earthquake's magnitude is a measure of the energy released at the source of the earthquake. Magnitude was formerly expressed by ratings on the Richter scale but is now most commonly expressed using the moment magnitude (Mw) scale. This scale is based on the total moment release of the earthquake (the product of the distance a fault moved and the force required to move it). The scale is as follows:

- Great Mw > 8
- Major Mw = 7.0 – 7.9
- Strong Mw = 6.0 – 6.9
- Moderate Mw = 5.0 – 5.9
- Light Mw = 4.0 – 4.9
- Minor Mw = 3.0 – 3.9
- Micro Mw = 3.0 – 3.9

The most commonly used intensity scale is the modified Mercalli intensity scale. Ratings of the scale, as well as the perceived shaking and damage potential for structures, are shown in Table 4.3.5-3. The modified Mercalli intensity scale is generally represented visually using shake maps, which show the expected ground shaking at any given location produced by an earthquake with a specified magnitude and epicenter An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region, depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth's crust. A USGS shake map shows the variation of ground shaking in a region immediately following significant earthquakes. Table 4.3.5-4 displays the MMI scale and its relationship to the areas peak ground acceleration (PGA).

Table 4.3.5-3. Modified Mercalli Intensity Scale

Mercalli Intensity	Description
I	Felt by very few people; barely noticeable.
II	Felt by few people, especially on upper floors.
III	Noticeable indoors, especially on upper floors, but may not be recognized as an earthquake.
IV	Felt by many indoors, few outdoors. May feel like passing truck.
V	Felt by almost everyone, some people awakened. Small objects move; trees and poles may shake.
VI	Felt by everyone; people have trouble standing. Heavy furniture can move; plaster can fall off walls. Chimneys may be slightly damaged.
VII	People have difficulty standing. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.

Mercalli Intensity	Description
VIII	Well-built buildings suffer slight damage. Poorly built structures suffer severe damage. Some walls collapse.
IX	Considerable damage to specially built structures; buildings shift off their foundations. The ground cracks. Landslides may occur.
X	Most buildings and their foundations are destroyed. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, and lakes. The ground cracks in large areas.
XI	Most buildings collapse. Some bridges are destroyed. Large cracks appear in the ground. Underground pipelines are destroyed.
XII	Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.

Source: (USGS 2021)

Table 4.3.5-4. Modified Mercalli Intensity and PGA Equivalents

Modified Mercalli Intensity	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	< .17	Not Felt	None
II	.17 – 1.4	Weak	None
III	.17 – 1.4	Weak	None
IV	1.4 – 3.9	Light	None
V	3.9 – 9.2	Moderate	Very Light
VI	9.2 – 18	Strong	Light
VII	18 – 34	Very Strong	Moderate
VIII	34 – 65	Severe	Moderate to Heavy

Source: USGS 2021
Note: PGA Peak Ground Acceleration

The ground experiences acceleration as it shakes during an earthquake. The peak ground acceleration (PGA) is the largest acceleration recorded by a monitoring station during an earthquake. PGA is a measure of how hard the earth shakes in a given geographic area. It is expressed as a percentage of the acceleration due to gravity (%g). Horizontal and vertical PGA varies with soil or rock type. Earthquake hazard assessment involves estimating the annual probability that certain ground accelerations will be exceeded, and then summing the annual probabilities over a time period of interest. Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures, as noted in Table 4.3.5-5.

Table 4.3.5-5. Damage Levels Experienced in Earthquakes

Ground Motion Percentage	Explanation of Damages
1-2%g	Motions are widely felt by people; hanging plants and lamps swing strongly, but damage levels, if any, are usually very low.
Below 10%g	Usually causes only slight damage, except in unusually vulnerable facilities.
10 - 20%g	May cause minor-to-moderate damage in well-designed buildings, with higher levels of damage in poorly designed buildings. At this level of ground shaking, only unusually poor buildings would be subject to potential collapse.

Ground Motion Percentage	Explanation of Damages
20 - 50%g	May cause significant damage in some modern buildings and very high levels of damage (including collapse) in poorly designed buildings.
≥50%g	May causes higher levels of damage in many buildings, even those designed to resist seismic forces.

Source: (NJOEM 2019)
Note: %g Peak Ground Acceleration

National maps of earthquake shaking hazards provide information for creating and updating seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities, and land use planning. After thorough review of the studies, professional organizations of engineers update the seismic-risk maps and seismic design requirements contained in building codes. The USGS updated the National Seismic Hazard Maps in 2014 (Figure 4.3.5-3 and Figure 4.3.5-4). New seismic, geologic, and geodetic information on earthquake rates and associated ground shaking were incorporated into these revised maps.

Figure 4.3.5-3 Peak Ground Acceleration (PGA) 100-Year Mean Return Period for Gloucester County

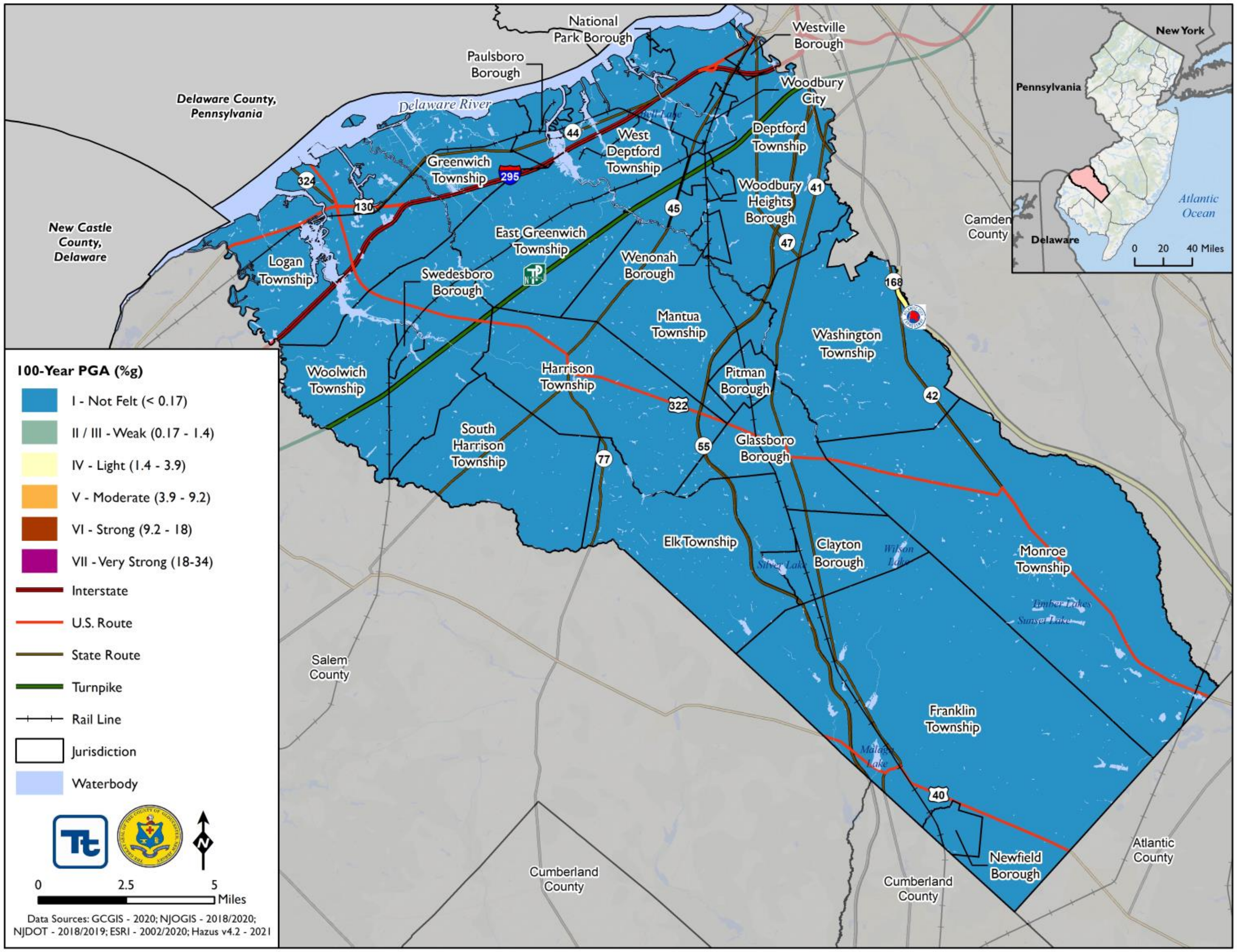
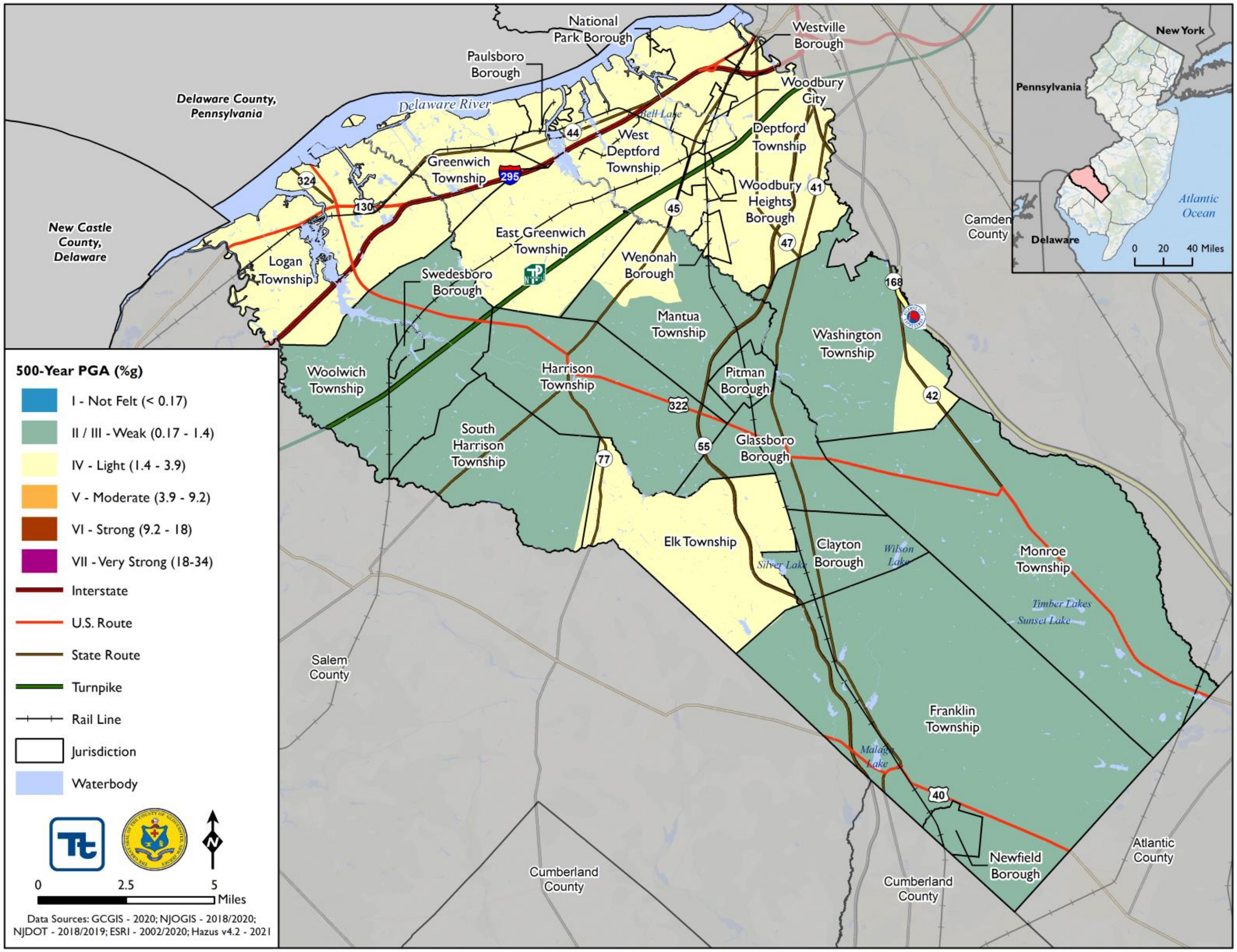


Figure 4.3.5-4 Peak Ground Acceleration (PGA) 500-Year Mean Return Period for Gloucester County



Previous Occurrences

New Jersey has a fairly extensive history of earthquakes. Small earthquakes occur several times a year and generally do not cause significant damage. The largest earthquake to impact New Jersey occurred in 1783. That earthquake, a magnitude 5.3 quake, occurred west of New York City and was felt from New Hampshire to Pennsylvania (Stover 1993). Figure 4.3.5-5 illustrates earthquake events with epicenters located in New Jersey. Of the 204 events in the State, 2 earthquake epicenters were located in Gloucester County. The majority of earthquakes have occurred along faults in the central and eastern Highlands, with the Ramapo Fault being the most seismically active fault in the region (Volkert 2015).

FEMA Major Disasters and Emergency Declarations

Between 2015 and 2021, no FEMA disaster declarations were made regarding earthquakes (FEMA 2021).

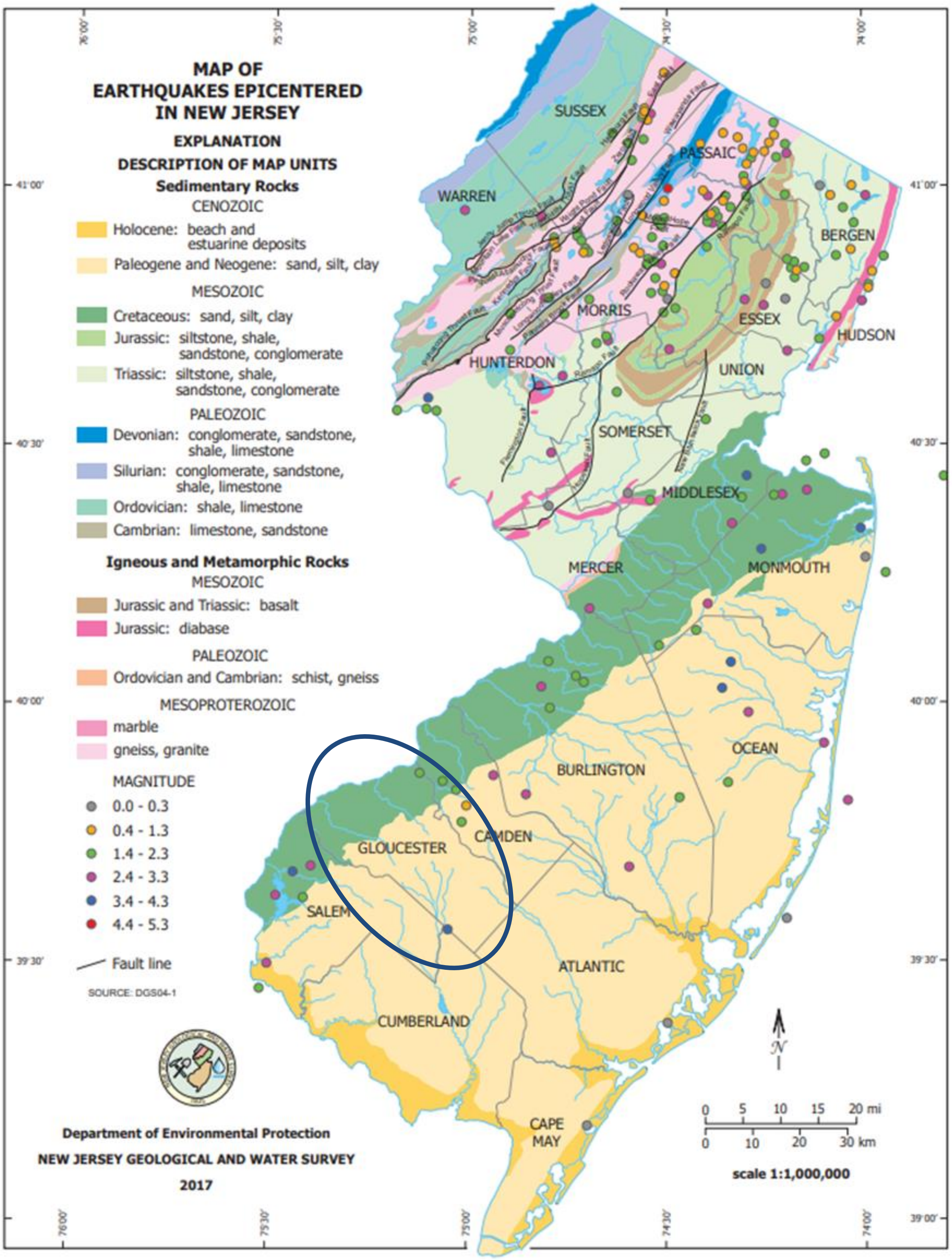
U.S. Department of Agriculture Disaster Declarations

Between 2015 and 2021, no USDA disaster declarations were made regarding earthquakes (USDA 2021).

Previous Events

For the 2022 HMP update, earthquake events that have impacted Gloucester County between 2015 and 2021 have been identified. These events have been identified and are listed in Table 4.3.5-6.

Figure 4.3.5-5 Earthquakes with Epicenters in New Jersey, 1783 to 2017



Source: NJGWS 2017

Note: The blue circle indicates the location of Gloucester County. The figure shows that several earthquakes have been epicentered in Gloucester County.

Table 4.3.5-6. Earthquake Events impacting Gloucester County

Date(s) of Event	Magnitude	FEMA Declaration Number	County Designated?	Location	Description
November 30, 2017	4.1	NA	NA	Dover, DE	An earthquake centered 9 km ENE of Dover, Delaware was faintly felt in Gloucester County.
September 9, 2020	3.1	NA	NA	Marlboro, NJ	An earthquake centered 3 km WSW of Marlboro, New Jersey was faintly felt in Gloucester County.

Source: USGS 2021, Gloucester County, 2021

Probability of Future Occurrences

Earthquakes cannot be predicted and may occur any time of the day or year. Major earthquakes are infrequent in the State and may occur only once every few hundred years or longer, but the consequences of major earthquakes would be very high. Based on the historic record, the future probability of damaging earthquakes impacting Gloucester County is low.

In Section 4.4 (Hazard Ranking), the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Steering Committee and Planning Committee, the probability of occurrence for impactful earthquake events in the County is considered 'unlikely' (less than 1 percent annual chance of occurring).

Climate Change

Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (ONJSC 2021) which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo, Climate change impacts in the United States 2014) and the world (1.5° F [0.8° C]) (IPCC 2016). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (R. D. Horton 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle, New Jersey State Climate Summary 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date. The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (ONJSC 2021). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (R. D. Horton 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh 2014) and with more intensity (Huang 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan 2014). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011).

The potential impacts of global climate change on earthquake probability are unknown. Some scientists feel that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the Earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. The National Aeronautics and Space Administration (NASA) and USGS scientists found that retreating glaciers in southern Alaska might be opening the way for future earthquakes (NJOEM 2019).

Secondary impacts of earthquakes could be magnified by future climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity because of the increased saturation. Dams storing increased volumes of water from changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts (NJOEM 2019).

4.3.5.3 Vulnerability Assessment

A probabilistic assessment was conducted for the 100-year and 500-year MRP events through a Level 2 analysis in Hazus v4.2 to analyze the earthquake hazard and provide a range of loss estimates. Refer to Section 4.2 (Methodology and Tools) for additional details on the methodology used to assess earthquake risk.

Impact on Life, Health, and Safety

The entire County may experience an earthquake. However, the degree of impact is dependent on many factors including the age and type of construction people live in, the soil types their homes are located on, and the intensity of the earthquake. Whether directly or indirectly impacted, residents could be faced with business closures, road closures that could isolate populations, and loss of function of critical facilities and utilities.

According to the 2015-2019 ACS 5-year population estimate, Gloucester County had a population of 291,165 people. Overall, risk to public safety and loss of life from an earthquake in the County is minimal for low magnitude events. However, there is a higher risk to public safety for those inside buildings due to structural damage or people walking below building ornamentations and chimneys that may be shaken loose and fall because of an earthquake.

As noted earlier, NEHRP soil classes D and E can amplify ground shaking to damaging levels even during a moderate earthquake, and thus increase risk to the population. Populations within municipalities located on class D and E soils were estimated and are listed in Table 4.3.5-7 below. Overall, approximately 107,065 residents (36.8-percent of the County’s population) reside on class D. Out of the 24 municipalities in the County, 7 are estimated to have 100-percent of their population living on Class D soils.

Table 4.3.5-7. Approximate Population Located Within Soil Class D Hazard Areas

Jurisdiction	Total Population (American Community Survey 2015-2019)	Estimated Population Located in the Class D NEHRP Soil Hazard Area	
		Number of People	Percent of Total
Clayton (B)	8,626	0	0.0%
Deptford (Twp)	30,448	28,467	93.5%
East Greenwich (Twp)	10,488	10,488	100.0%
Elk (Twp)	4,135	2,394	57.9%
Franklin (Twp)	16,440	898	5.5%
Glassboro (B)	19,826	0	0.0%
Greenwich (Twp)	4,831	4,818	99.7%
Harrison (Twp)	12,995	54	0.4%
Logan (Twp)	5,924	632	10.7%
Mantua (Twp)	14,941	8,079	54.1%
Monroe (Twp)	36,789	0	0.0%
National Park (B)	2,959	2,959	100.0%
Newfield (B)	1,521	0	0.0%
Paulsboro (B)	5,904	5,904	100.0%
Pitman (B)	8,805	0	0.0%
South Harrison (Twp)	3,148	0	0.0%
Swedesboro (B)	2,579	0	0.0%
Washington (Twp)	47,833	1,954	4.1%
Wenonah (B)	2,259	2,259	100.0%
West Deptford (Twp)	21,149	21,149	100.0%
Westville (B)	4,169	4,164	99.9%
Woodbury (C)	9,861	9,861	100.0%
Woodbury Heights (B)	2,986	2,986	100.0%
Woolwich (Twp)	12,549	0	0.0%
Gloucester County (Total)	**291,165**	**107,065**	**36.8%**

Source: ACS 5-year Estimates 2015-2019; NJDOT 2012
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Populations considered most vulnerable are those located in/near the built environment, particularly those near unreinforced masonry construction. Of these most vulnerable populations, socially vulnerable populations, including the elderly (persons over age 65) and individuals living below the poverty threshold, are most susceptible. Factors leadings to this higher susceptibility include decreased mobility and financial ability to react or respond during a hazard, and the location and construction quality of their housing. According to the 2015 – 2019 5-year ACS estimates, there are 21,340 total persons living below the poverty level and 44,794 persons over the age of 65 years in Gloucester County.

As a result of a significant earthquake event, residents may be displaced or require temporary to long-term sheltering. The number of people requiring shelter is generally less than the number displaced as some displaced persons use hotels or stay with family or friends following a disaster event. Hazus estimates that there will be zero displaced households and zero persons seeking short-term sheltering caused by the 100-year MRP event. Further, Hazus estimates that there will be 11 households displaced and seven persons seeking short-term sheltering caused by the 500-year MRP event (Table 4.3.5-8).

Table 4.3.5-8. Estimated Displaced Households and Persons Seeking Shelter Caused by the 500-Year Mean Return Period (MRP) Earthquake Event

Jurisdiction	500-Year MRP	
	Displaced Households	People Requiring Short-Term Shelter
Clayton (B)	0	0
Deptford (Twp)	5	3
East Greenwich (Twp)	0	0
Elk (Twp)	0	0
Franklin (Twp)	0	0
Glassboro (B)	0	0
Greenwich (Twp)	0	0
Harrison (Twp)	0	0
Logan (Twp)	0	0
Mantua (Twp)	0	0
Monroe (Twp)	0	0
National Park (B)	0	0
Newfield (B)	0	0
Paulsboro (B)	0	0
Pitman (B)	0	0
South Harrison (Twp)	0	0
Swedesboro (B)	0	0
Washington (Twp)	0	0
Wenonah (B)	0	0
West Deptford (Twp)	0	0
Westville (B)	1	1
Woodbury (C)	3	2
Woodbury Heights (B)	0	0
Woolwich (Twp)	0	0
Gloucester County (Total)	**11**	**7**

Source: Hazus v4.2
Notes: B = Borough, C = City, Twp = Township, MRP = Mean Return Period

According to the 1999-2003 NYCEM Summary Report (*Earthquake Risks and Mitigation in the New York / New Jersey / Connecticut Region*), a strong correlation exists between structural building damage and number of injuries and casualties from an earthquake event. Further, the time of day also exposes different sectors of the community to the hazard. For example, Hazus considers the residential occupancy at its maximum at 2:00 a.m., where the educational, commercial, and industrial sectors are at their maximum at 2:00 p.m., with peak commute time at 5:00 p.m. Whether directly impacted or indirectly impact, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could prevent people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself. Overall, Hazus estimates that there are no injuries or casualties caused by the 100-year MRP event; 16 injuries caused by the 500-year MRP event (4 during the 2:00 am commute, 8 during the 2:00 pm commute, and 4 during the 5:00 pm commute); and one hospitalization caused by the 500-year MRP event.

Impact on General Building Stock

The entire County's general building stock is considered at risk and exposed to this hazard. Soft soils (classes D and E) can amplify ground shaking to damaging levels even during a moderate earthquake. Therefore, buildings located on classes D and E soils are at increased risk of damage from an earthquake. Table 4.3.5-9 summarizes the number and replacement cost value of buildings in Gloucester County located on soil Class D hazard areas. Overall, 39-percent of the County's total general building stock replacement cost value is located on the Class D soil types.

Table 4.3.5-9. Estimated Number of Buildings Located in the NEHRP Class D Soil Hazard Area

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located in the Class D NEHRP Soil Hazard Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Clayton (B)	3,295	$1,933,299,905	0	0.0%	$0	0.0%
Deptford (Twp)	11,284	$10,081,159,584	10,486	92.9%	$8,794,741,181	87.2%
East Greenwich (Twp)	4,346	$2,927,045,409	4,346	100.0%	$2,927,045,409	100.0%
Elk (Twp)	2,339	$1,784,179,937	1,474	63.0%	$1,352,855,414	75.8%
Franklin (Twp)	8,432	$5,637,186,975	446	5.3%	$241,591,669	4.3%
Glassboro (B)	5,959	$5,816,332,907	0	0.0%	$0	0.0%
Greenwich (Twp)	2,807	$2,734,741,222	2,801	99.8%	$2,732,819,188	99.9%
Harrison (Twp)	4,817	$4,828,239,008	18	0.4%	$6,774,534	0.1%
Logan (Twp)	2,805	$6,591,573,691	290	10.3%	$204,957,068	3.1%
Mantua (Twp)	6,569	$4,738,271,524	3,439	52.4%	$2,083,188,719	44.0%
Monroe (Twp)	12,553	$8,458,118,166	0	0.0%	$0	0.0%
National Park (B)	1,483	$781,021,288	1,483	100.0%	$781,021,288	100.0%
Newfield (B)	891	$622,948,021	0	0.0%	$0	0.0%
Paulsboro (B)	2,615	$2,076,864,026	2,615	100.0%	$2,076,864,026	100.0%
Pitman (B)	3,521	$2,916,470,733	0	0.0%	$0	0.0%
South Harrison (Twp)	1,726	$1,494,748,661	0	0.0%	$0	0.0%
Swedesboro (B)	1,040	$936,236,069	0	0.0%	$0	0.0%
Washington (Twp)	17,413	$13,732,374,547	735	4.2%	$678,328,272	4.9%
Wenonah (B)	930	$778,702,966	930	100.0%	$778,702,966	100.0%
West Deptford (Twp)	7,561	$9,201,121,261	7,561	100.0%	$9,201,121,261	100.0%
Westville (B)	1,733	$1,529,846,612	1,731	99.9%	$1,528,849,303	99.9%
Woodbury (C)	3,605	$4,139,381,075	3,605	100.0%	$4,139,381,075	100.0%
Woodbury Heights (B)	1,295	$1,265,332,236	1,295	100.0%	$1,265,332,236	100.0%
Woolwich (Twp)	4,074	$4,551,585,778	0	0.0%	$0	0.0%
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**43,255**	**38.2%**	**$38,793,573,609**	**39.0%**

Source: NJDOT 2012
Notes: B = Borough, C = City, Twp = Township, RCV = Replacement Cost Value

There is a strong correlation between PGA and damage a building might undergo (New Jersey 2019). The Hazus model is based on best available earthquake science and aligns with these statements. The

Hazus probabilistic earthquake model was applied to analyze effects from the earthquake hazard on general building stock in Gloucester County. Refer to Figure 4.3.5-3 and **Error! Reference source not found.** earlier in this profile which illustrates the geographic distribution of PGA (%g) across the County for 100-year and 500-year MRP events at the Census-tract level.

A building's construction determines how well it can withstand the force of an earthquake. The New Jersey 2019 HMP indicates that unreinforced masonry buildings are most at risk during an earthquake because the walls are prone to collapse outward, whereas steel and wood buildings absorb more of the earthquake's energy. Additional attributes that affect a building's capability to withstand an earthquake's force include its age, number of stories, and quality of construction. Hazus considers building construction and age of building as part of the analysis. Because a custom general building stock was used for this Hazus analysis, the building ages and building types from the inventory were incorporated into the Hazus model.

Potential building damage was evaluated by Hazus across the following damage categories: none, slight, moderate, extensive, and complete. Table 4.3.5-10 provides definitions of these five categories of damage for a light wood-framed building. Definitions for other building types are included in the Hazus technical manual documentation. The results of potential damage states for buildings in Gloucester County categorized by general occupancy classes (i.e., residential, commercial, industrial, etc.) from Hazus are summarized in Table 4.3.5-11 for the 500-year MRP event. Hazus estimates that there are zero damages to structures caused by the 100-year MRP event.

Table 4.3.5-10. Example of Structural Damage State Definitions for a Light Wood-Framed Building

Damage Category	Description
Slight	Small plaster or gypsum-board cracks at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.
Moderate	Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.
Extensive	Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of room-over-garage or other soft-story configurations.
Complete	Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple-wall failure or the failure of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks.

Source: Hazus Technical Manual

Table 4.3.5-11. Estimated Buildings Damaged by General Occupancy for the 500-Year Mean Return Period (MRP) Earthquake Event

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	Earthquake 500-Year	
			Building Count	Percent Buildings in Occupancy Class
	101,804	None	100,845	99.1%

TETRA TECH

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	Earthquake 500-Year Building Count	Earthquake 500-Year Percent Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)		Minor	788	0.8%
		Moderate	156	0.2%
		Extensive	13	0.0%
		Complete Destruction	1	0.0%
Commercial Buildings	6,750	None	6,645	98.4%
		Minor	86	1.3%
		Moderate	18	0.3%
		Extensive	1	0.0%
		Complete Destruction	0	0.0%
Industrial Buildings	951	None	893	93.9%
		Minor	40	4.2%
		Moderate	16	1.6%
		Extensive	2	0.2%
		Complete Destruction	0	0.0%
Government, Religion, Agricultural, and Education Buildings	3,588	None	3,537	98.6%
		Minor	43	1.2%
		Moderate	8	0.2%
		Extensive	1	0.0%
		Complete Destruction	0	0.0%

Source: Gloucester County GIS 2021; MODIV 2020; Hazus v4.2
Notes: % = Percent, < = Less Than

Building damage as a result of the 100-year and 500-year MRP earthquakes were estimated for each municipality using Hazus. Hazus estimates that zero damages will occur to buildings or contents during the 100-year MRP event. Table 4.3.5-12 summarizes estimated total building and content losses caused by the 500-year MRP event by jurisdiction. This table also summarizes losses for structures categorized as residential, commercial, and all other occupancy classes. Less than 0.1-percent of the County's structures are impacted by the 500-year MRP event (i.e., approximately $30 million in replacement cost value). Majority of the losses are estimated to occur in the Township of West Deptford.

Table 4.3.5-12. Estimated Building Damages (Structure and Contents) from the 500-year Mean Return Period (MRP) Earthquake Event

Jurisdiction	Replacement Cost Value (RCV)	500-Year MRP				
		Estimated Total Damage	Percent of Total Building and Contents Replacement Cost Value	Estimated Residential Damage	Estimated Commercial Damage	Estimated Damages for All Other Occupancies
Clayton (B)	$1,933,299,905	$442,581	<0.1%	$321,380	$44,975	$76,226
Deptford (Twp)	$10,081,159,584	$4,174,429	<0.1%	$2,342,556	$1,057,832	$774,041
East Greenwich (Twp)	$2,927,045,409	$1,165,690	<0.1%	$826,961	$204,642	$134,087
Elk (Twp)	$1,784,179,937	$463,922	<0.1%	$309,057	$33,322	$121,542
Franklin (Twp)	$5,637,186,975	$1,068,783	<0.1%	$618,050	$132,804	$317,930
Glassboro (B)	$5,816,332,907	$1,348,529	<0.1%	$587,935	$244,637	$515,957
Greenwich (Twp)	$2,734,741,222	$2,104,059	0.1%	$1,022,477	$152,334	$929,248
Harrison (Twp)	$4,828,239,008	$762,837	<0.1%	$545,205	$96,562	$121,070
Logan (Twp)	$6,591,573,691	$1,667,998	<0.1%	$294,413	$896,572	$477,013
Mantua (Twp)	$4,738,271,524	$1,168,626	<0.1%	$780,202	$267,516	$120,907
Monroe (Twp)	$8,458,118,166	$1,580,200	<0.1%	$926,645	$337,300	$316,255
National Park (B)	$781,021,288	$297,554	<0.1%	$198,646	$55,184	$43,723
Newfield (B)	$622,948,021	$108,337	<0.1%	$53,615	$19,196	$35,525
Paulsboro (B)	$2,076,864,026	$1,131,807	0.1%	$505,214	$200,256	$426,337
Pitman (B)	$2,916,470,733	$854,254	<0.1%	$580,362	$120,744	$153,148
South Harrison (Twp)	$1,494,748,661	$214,116	<0.1%	$156,104	$15,495	$42,516
Swedesboro (B)	$936,236,069	$199,724	<0.1%	$86,318	$69,003	$44,403
Washington (Twp)	$13,732,374,547	$2,410,451	<0.1%	$1,344,470	$583,086	$482,896
Wenonah (B)	$778,702,966	$362,653	<0.1%	$313,393	$17,319	$31,942
West Deptford (Twp)	$9,201,121,261	$4,273,695	<0.1%	$1,533,533	$1,946,123	$794,039
Westville (B)	$1,529,846,612	$809,257	0.1%	$485,236	$255,500	$68,522
Woodbury (C)	$4,139,381,075	$2,099,600	0.1%	$1,115,275	$699,034	$285,291
Woodbury Heights (B)	$1,265,332,236	$537,840	<0.1%	$278,481	$157,809	$101,550
Woolwich (Twp)	$4,551,585,778	$744,645	<0.1%	$516,963	$113,292	$114,390
Gloucester County (Total)	**$99,556,781,602**	**$29,991,586**	**<0.1%**	**$15,742,492**	**$7,720,537**	**$6,528,557**

Source: Hazus 4.2; Gloucester County GIS 2021; MODIV 2020; RS Means 2021
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Historically, Building Officials Code Administration (BOCA) regulations in the northeast states were developed to address local concerns, including heavy snow loads and wind. Seismic requirements for design criteria are not as stringent as those of the west coast of the United States, which rely on the more seismically focused Uniform Building Code. As such, a smaller earthquake in the northeast can cause more structural damage than if it would occur in the west.

Impact on Critical Facilities and Lifelines

All critical facilities in Gloucester County are considered exposed to the earthquake hazard. Refer to subsection "Critical Facilities and Lifelines" in Section 3 (County Profile) of this HMP for a complete inventory of critical facilities in Gloucester County.

The Hazus earthquake model was used to assign the range or average probability of each damage state category to the critical facilities and lifelines in Gloucester County for the 100-year and 500-year MRP events. In addition, Hazus estimates the time to restore critical facilities to fully functional use. Results are presented as a probability of being functional at specified time increments (days after the event). For example, Hazus might estimate that a facility has 5 percent chance of being fully functional at Day 3, and a 95 percent chance of being fully functional at Day 90. For percent probability of sustaining damage, the minimum and maximum damage estimated value for that facility type is presented.

As a result of a 100-year MRP event, Hazus estimates that critical facilities will be nearly 100-percent functional with negligible damages. Therefore, the impact to critical facilities is not significant for the 100-year event. Whereas, for the 500-year MRP events, functionality can approximately decrease as low as 4.3-percent. Table 4.3.5-13 summarizes the damage state probabilities for critical facilities during the 500-year MRP event.

Table 4.3.5-13. Estimated Damage and Loss of Functionality for Critical Facilities and Utilities in Gloucester County for the 500-Year Mean Return Period (MRP) Earthquake Event

Name	Percent Probability of Sustaining Damage					Percent Functionality			
	None	Slight	Moderate	Extensive	Complete	Day 1	Day 7	Day 30	Day 90
Essential Facilities									
EOC	99.2% - 99.6%	0.4% - 0.7%	<0.1%	0.0%	0.0%	99.1% - 99.6%	99.9%	99.9%	99.9%
Medical Facilities	99.1% - 99.6%	0.4% - 0.8%	<0.1%	0.0%	0.0%	99.1% - 99.5%	99.9%	99.9%	99.9%
Police Stations	97.6% - 98.8%	0.7% - 1.4%	0.4% - 0.8%	<0.1% - 0.1%	0.0%	97.5% - 98.7%	98.9% - 99.5%	99.8% - 99.9%	99.9%
Fire Stations/EMS	97.6% - 98.8%	0.7% - 1.4%	0.4% - 0.8%	<0.1% - 0.1%	0.0%	97.5% - 98.8%	98.9% - 99.5%	99.8% - 99.9%	99.9%
Schools	98.4% - 99.2%	0.6% - 1.1%	0.2% - 0.4%	<0.1%	0.0%	98.3% - 99.2%	99.4% - 99.7%	99.9%	99.9%
Utilities									
Potable Water	95.7% - 99.6%	0.4% - 2.9%	<0.1% - 1.3%	0.0% - 0.1%	0.0%	96.9% - 99.8%	99.7% - 99.9%	99.8% - 99.9%	99.9%
Wastewater	97.6% - 98.7%	0.8% - 1.4%	0.4% - 0.8%	<0.1% - 0.1%	0.0%	98.1% - 99.0%	99.7% - 99.8%	99.8% - 99.9%	99.9%
Electric Power	97.6%	1.4%	0.8%	0.1%	0.0%	98.4%	99.9%	99.9%	99.9%
Transportation									
Bus Facilities	99.1%	0.8%	<0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%
Port Facilities	99.1% - 99.6%	0.4% - 0.9%	<0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; Hazus v4.
Notes: EOC = Emergency Operations Center, EMS = Emergency Medical Services, < = Less Than, % = Percent

Impact on Economy

Earthquakes also have impacts on the economy, including loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Hazus estimates building-related economic losses, including income losses (wage, rental, relocation, and capital-related losses) and capital stock losses (structural, non-structural, content, and inventory losses). Economic losses estimated by Hazus are summarized in Table 4.3.5-14. Hazus estimates that there are zero economic losses caused by the 100-year earthquake event.

Table 4.3.5-14. Economic Losses for the 500-Year Mean Return Period (MRP) Earthquake Event

Level of Severity	Mean Return Period 500-year
Income Losses	
Wage	$1,184,800
Capital Related	$628,000
Rental	$1,405,400
Relocation Loss	$3,836,900
Subtotal	**$7,055,100**
Capital Stock Losses	
Building and Content Losses	$29,990,900
Inventory	$124,800
Subtotal	**$30,115,700**

Source: Hazus v4.2

Although the Hazus analysis did not compute damage estimates for individual roadway segments and railroad tracks, assumedly these features would undergo damage due to ground failure, resulting in interruptions of regional transportation and of distribution of materials. Losses to the community that would result from damage to lifelines could exceed costs of repair (FEMA 2019).

Earthquake events can also significantly affect road bridges, many of which provide the only access to certain neighborhoods. Because softer soils generally follow floodplain boundaries, bridges that cross watercourses should be considered vulnerable. Another key factor in degree of vulnerability is age of facilities and infrastructure, which correlates with standards in place at times of construction.

Hazus also estimates the volume of debris that may be generated as a result of an earthquake event to enable the study region to prepare and rapidly and efficiently manage debris removal and disposal. Debris estimates are divided into two categories: (1) reinforced concrete and steel that require special equipment to break it up before it can be transported, and (2) brick, wood, and other debris that can be loaded directly onto trucks with bulldozers (Hazus Earthquake User's Manual 2019).

For the 100-year MRP event, Hazus estimates that zero tons of debris will be generated. For the 500-year MRP event, Hazus estimates a total of 13,706 tons of debris will be generated county-wide. Table 4.3.5-15 summarizes the estimated debris generated as a result of these events by municipality.

Table 4.3.5-15. Estimated Debris Generated by the 500-Year Mean Return Period (MRP) Earthquake Event

Jurisdiction	500-Year	
	Brick/Wood (tons)	Concrete/Steel (tons)
Clayton (B)	241	46
Deptford (Twp)	1,162	438
East Greenwich (Twp)	377	82
Elk (Twp)	108	28
Franklin (Twp)	417	91
Glassboro (B)	596	136
Greenwich (Twp)	1,804	375
Harrison (Twp)	147	32
Logan (Twp)	651	167
Mantua (Twp)	313	94
Monroe (Twp)	488	129
National Park (B)	34	21
Newfield (B)	63	14
Paulsboro (B)	588	177
Pitman (B)	503	115
South Harrison (Twp)	32	6
Swedesboro (B)	50	30
Washington (Twp)	532	101
Wenonah (B)	162	37
West Deptford (Twp)	1,038	424
Westville (B)	334	110
Woodbury (C)	713	300
Woodbury Heights (B)	137	71
Woolwich (Twp)	159	31
Gloucester County (Total)	**10,649**	**3,057**

Source: Hazus 4.2
Notes: Twp = Township, B = Borough, T = Town, C = City

Impact on the Environment

According to USGS, earthquakes can cause damage to the surface of the Earth in various forms depending on the magnitude and distribution of the event (USGS 2020). Surface faulting is one of the major seismic components to earthquakes that can create wide ruptures in the ground. Ruptures can have a direct impact on the landscape and natural environment because it can disconnect habitats for miles isolating animal species or tear apart plant roots.

Furthermore, ground failure as a result of soil liquefaction can have an impact on soil pores and retention of water resources (USGS 2020). The greater the seismic activity and liquefaction properties of the soil, the more likely drainage of groundwater can occur which depletes groundwater resources. In areas where there is higher pressure of groundwater retention, the pores can build up more pressure and make soil behave more like a fluid rather than a solid increasing risk of localized flooding and deposition or accumulation of silt.

Future Growth and Development

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. The New Jersey Highlands Council has identified areas of potential growth (Sewer Service Areas) that may provide insight as to where potential new development may occur in Gloucester County. Further, the New Jersey Pinelands Commission has identified Pinelands Management Area Boundaries, including regional growth areas and rural development areas that may also provide insight to where development and growth may occur in the County. In addition, each community was requested to provide recent and anticipated new development and infrastructure projects; summarized in Section 9 (Jurisdictional Annexes). According to the Gloucester County Planning Partnership, there are 38 recent or anticipated new development sites in Gloucester County.

Development built in areas with softer NEHRP soil classes, liquefaction, and landslide-susceptible areas may experience shifting or cracking in the foundation during earthquakes because of the loose soil characteristics of these soil classes. However, current building codes require seismic provisions that should render new construction less vulnerable to seismic impacts than older, existing construction that may have been built to lower construction standards. Refer to Section 4.3.8 for more information about the new development sites located in the geologic hazard areas.

Projected Changes in Population

Gloucester County has experienced an increase in its population since 2010. According to the U.S. Census Bureau, the County's population increased by approximately 1-percent between 2010 and 2019 (U.S. Census Bureau 2020). Persons that move into older buildings may increase their overall vulnerability to earthquakes. As noted earlier, if moving into new construction, current building codes require seismic provisions that should render new construction less vulnerable to seismic impacts.

Climate Change

Because the impacts of climate change on earthquakes are not well understood, a change in the County's vulnerability as the climate continues to change is difficult to determine. However, climate change has the potential to magnify secondary impacts of earthquakes. As a result of the climate change projections discussed above, the County's assets located on areas of saturated soils and on or at the base of steep slopes, are at a higher risk of landslides/mudslides because of seismic activity. Refer to Section 4.3.8 for additional discussion of the geological hazard.

Vulnerability Change Since the 2016 HMP

Overall, the entire County continues to be vulnerable to earthquakes. For the 2021 HMP, the building inventory was updated using RS Means 2021 values, which is more current and reflects replacement cost versus the building stock improvement values reported in the 2016 HMP. Additional building stock updates include updates to the critical facility inventory provided by Gloucester County. Updated hazard areas were used as well; since the 2016 HMP, an updated version of Hazus-MH was released (v4.2). This updated model includes longer historical records to pull from to generate probabilistic events.

4.3.6 Extreme Temperatures

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the extreme temperature hazard in Gloucester County.

2022 Plan Update Changes

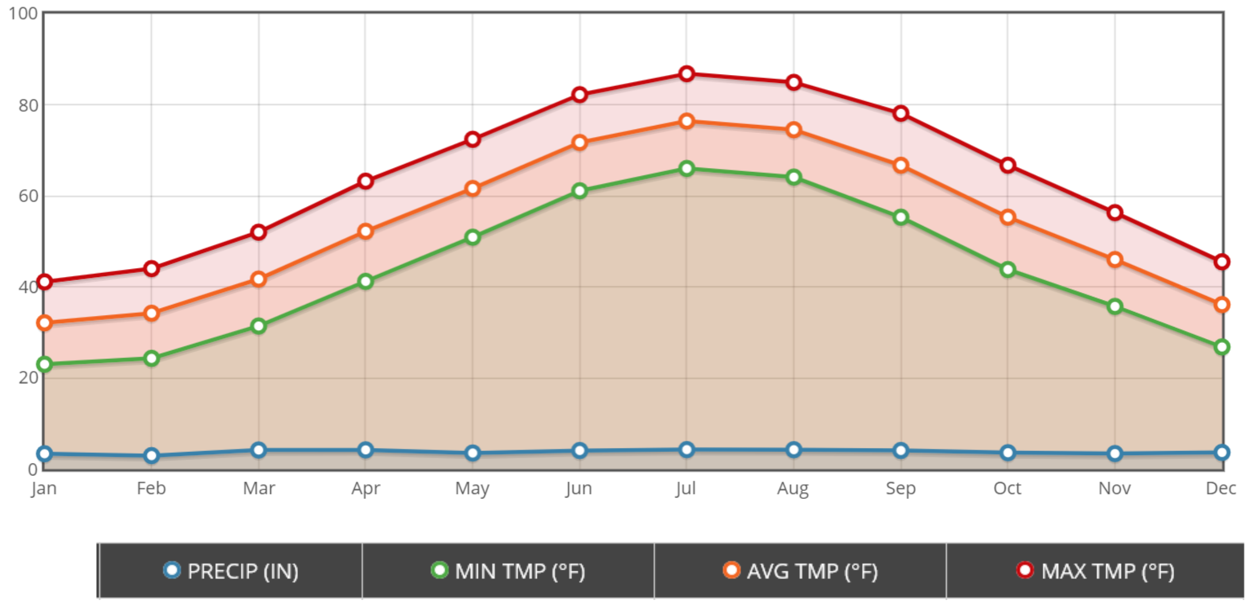
- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, probability of future occurrence, and climate change impacts.
- New and updated figures from other federal and state agencies are incorporated.
- Previous occurrences are updated with events that occurred between 2015 and 2021.
- A vulnerability assessment section is completed for the extreme temperature hazard. Available information and a preliminary assessment are used to complete this section. The vulnerability assessment directly follows the hazard profile.

4.3.6.1Profile

Hazard Description

Extreme temperature includes both heat and cold events that can have significant direct impacts to human health and commercial/agricultural businesses and primary and secondary effects on infrastructure (e.g., burst pipes and power failure). Distinguishing characteristics of "extreme cold" or "extreme heat" vary by location, based on the conditions to which the population is accustomed. Figure 4.3.6-1 shows the average low and high temperatures each month at the Hammonton Station in Atlantic County (no stations are located within Gloucester County).

Figure 4.3.6-1. Average Temperatures at Hammonton Station



Source: NWS 2021

Extreme Cold

Extreme cold events are when temperatures drop well below normal in an area. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered "extreme cold." Extreme cold temperatures are generally characterized in temperate zones by the ambient air temperature dropping to approximately 0ºF or below (CDC 2007). Extremely cold temperatures often accompany a winter storm, which can cause power failures and icy roads. Although staying indoors as much as possible can help reduce the risk of car crashes and falls on the ice, individuals may also face indoor hazards. Many homes will be too cold—either due to a power failure or because the heating system is not adequate for the weather. The use of space heaters and fireplaces to keep warm increases the risk of household fires and carbon monoxide poisoning (CDC 2007).

Extreme Heat

Extreme heat is defined as temperatures which hover 10 degrees or more above the average high temperature for a region and that last for several weeks (CDC 2016). A heat wave is defined as a period of abnormally and uncomfortably hot and unusually humid weather. Typically, a heat wave lasts two or more days (NWS 2009). There is no universal definition of a heat wave because the term is relative to the usual weather in a particular area. The term heat wave is applied both to routine weather variations and to extraordinary spells of heat which may occur only once a century (Meehl 2004).

Urbanized areas and urbanization create an exacerbated type of risk during an extreme heat event, compared to rural and suburban areas. As defined by the U.S. Census, urban areas are classified as all territory, population, and housing units located within urbanized areas and urban clusters. The term urbanized area denotes an urban area of 50,000 or more people. Urban areas under 50,000 people are called urban clusters. The U.S. Census delineates urbanized area and urban cluster boundaries to encompass densely settled territory, which generally consists of:

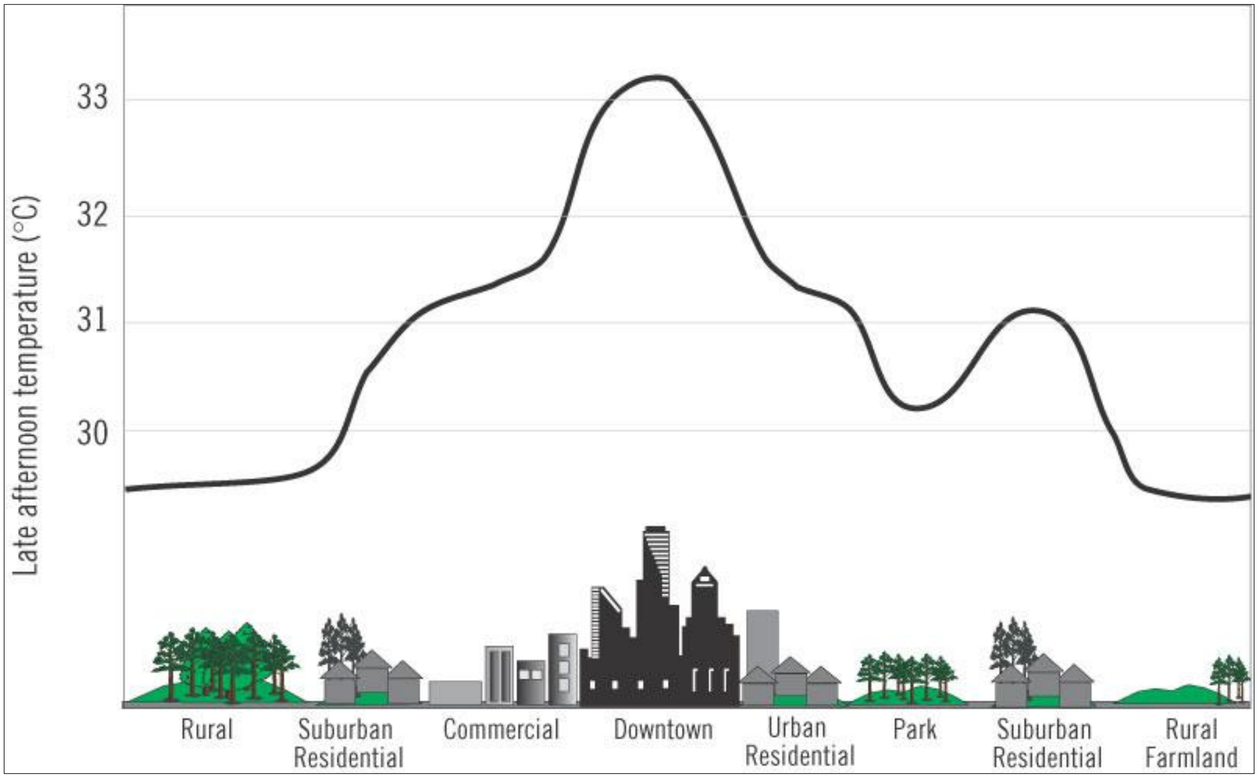
- A cluster of one or more block groups or census blocks each of which has a population density of at least 1,000 people per square mile at the time.
- Surrounding block groups and census blocks each of which has a population density of at least 500 people per square mile at the time.
- Less densely settled blocks that form enclaves or indentations or are used to connect discontiguous areas with qualifying densities (U.S. Census Bureau 2010).

As these urban areas develop and change, so does the landscape. Buildings, roads, and other infrastructure replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry. These changes cause urban areas to become warmer than the surrounding areas. This forms an 'island' of higher temperatures (EPA 2019).

The term 'heat island' describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with more than one million people can be between 1.8 ºF and 5.4ºF warmer than its surrounding areas. In the evening, the difference in air temperatures can be as high as 22ºF. Heat islands occur on the surface and in the atmosphere. On a hot, sunny day, the sun can heat dry, exposed urban surfaces to temperatures 50ºF to 90ºF hotter than the air. Heat islands can affect communities by increasing peak energy demand during the summer, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and death, and water quality degradation (EPA 2019).

The figure below illustrates an urban heat island profile. The graphic demonstrates that heat islands are typically most intense over dense urban areas. Further, vegetation and parks within a downtown area may help reduce heat islands (U.S. EPA 2019).

Figure 4.3.6-2. Urban Heat Island Profile



Source: EPA 2019
ºC: degrees as Centigrade

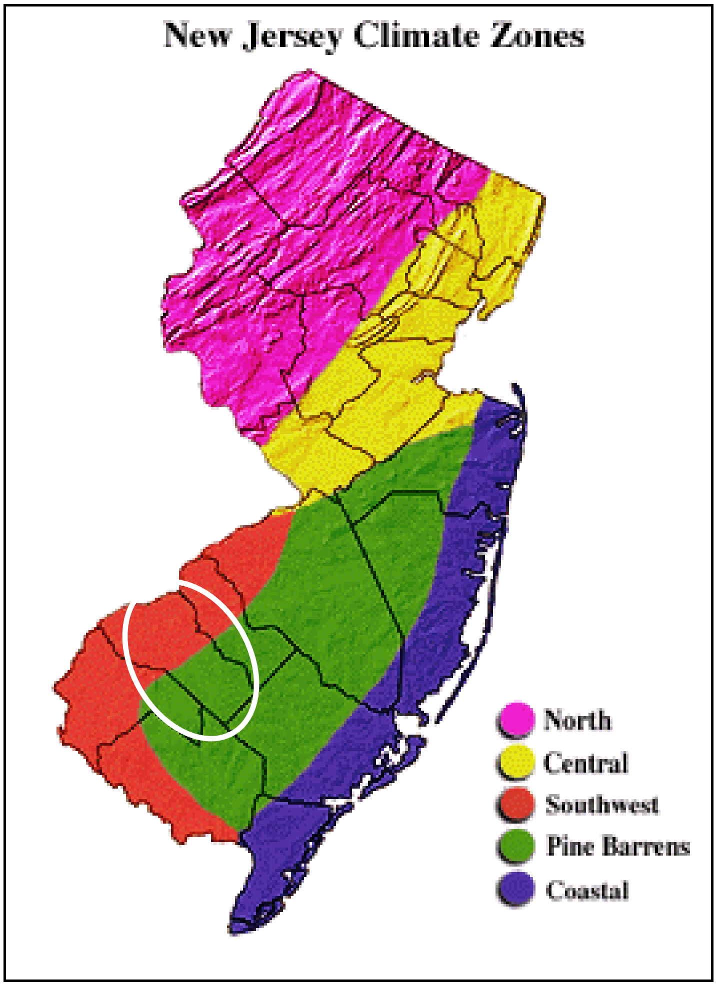
Location

According to the ONJSC, New Jersey has five distinct climate regions. Elevations, latitude, distance from the Atlantic Ocean, and landscape (e.g. urban, sandy soil) produce distinct variations in the daily weather between each of the regions. The five regions include: Northern, Central, Pine Barrens, Southwest, and Coastal (ONJSC 2021). Figure 4.3.6-3 depicts these regions. A majority of Gloucester County is located within the Southwest Climate Region with the southern section located in the Pine Barrens Region.

The Southwest Climate Region is located along the southwestern border stretching from Trenton all the way to the Delaware Bay. The region is relatively suburban with pockets of urbanized areas, especially in the central region along the Delaware River, across from Philadelphia. Due to the proximity to the Delaware Bay, this region adds a maritime influence on the climate, having some of the highest average daily temperatures as well as higher nighttime temperatures. In general, the region is drier than other parts of the state, and given its more inland characteristics, is not prone to major coastal storms. That being said, the region does have significant humidity during the summer, and making the high temperatures feel even hotter than recorded (Rutgers University 2019).

As for the Pine Barrens Zone which covers the southeastern portion of the county, unlike its neighboring Southwest Region, has relatively low temperatures due to solar radiation absorbed during the day and radiated back into space during the night. Compared to its surrounding regions, Pine Barrens Zone is 15-20 degrees cooler. In general, the region has porous and sandy soils which allow water to be absorbed quickly, causing the zone to be relatively dry, making it vulnerable to forest fires.

Figure 4.3.6-3. Climate Regions of New Jersey



Source: ONJSC Rutgers University, Date Unknown
Note: The white oval indicates the location of Gloucester County. The County is located in the Southwest and Pine Barrens Zone.

Extent

Extreme Cold

The extent (severity or magnitude) of extreme cold temperatures are generally measured through the Wind Chill Temperature (WCT) Index. Wind Chill Temperature is the temperature that people and animals feel when outside and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body is cooled at a faster rate causing the skin's temperature to drop (NWS 2021).

On November 1, 2001, the NWS implemented a new WCT Index. It was designed to more accurately calculate how cold air feels on human skin. The table below shows the new WCT Index. The WCT Index includes a frostbite indicator, showing points where temperature, wind speed, and exposure time will produce frostbite to humans. Figure 4.3.6-4 shows three shaded areas of frostbite danger. Each shaded area shows how long a person can be exposed before frostbite develops (NWS 2021).

Figure 4.3.6-4 NWS Wind Chill Index

NWS Windchill Chart

Temperature (°F)

Wind (mph) / Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: NWS 2021
°F degrees Fahrenheit
mph miles per hour

Extreme Heat

NOAA's heat alert procedures are based mainly on Heat Index values. The Heat Index is given in degrees Fahrenheit. The Heat Index is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature. To find the Heat Index temperature, the temperature and relative humidity need to be known. Once both values are known, the Heat Index will be the corresponding number with both values (Figure 4.3.6-5). The Heat Index indicates the temperature the body feels. Adverse effects of prolonged exposure to heat are displayed in Figure 4.3.6-6. It is important to know that the Heat Index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F. Strong winds, particularly with very hot dry air, can also be extremely hazardous (NWS 2021).

Figure 4.3.6-5 NWS Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: NWS 2013
°F degrees Fahrenheit
% percent

Figure 4.3.6-6 Adverse Effects of Prolonged Exposure to Heat on Individuals

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke / Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

Source: NWS 2021
°F degrees Fahrenheit

Warning Time

Meteorologists can accurately forecast extreme temperature event development and the severity of the associated conditions with several days lead time. These forecasts provide an opportunity for public health and other officials to notify vulnerable populations. For heat events, the NWS issues excessive heat outlooks when the potential exists for an excessive heat event in the next three to seven days. Watches are issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours. Excessive heat warning/advisories are issued when an excessive heat event is expected in the next 36 hours (NWS 2021). Winter temperatures may fall to extreme cold readings with no wind occurring. Currently, the only way to headline very cold temperatures is with the use of the NWS-designated Wind Chill Advisory or Warning products. When actual temperatures reach Wind Chill Warning criteria with little to no wind, extreme cold warnings may be issued (NWS 2021).

Previous Occurrences and Losses

Weather variability, coupled with concentrated population centers, can produce wide fluctuations in temperatures. The State and County have experienced multiple episodes of extreme temperatures, both hot and cold, that have resulted in cascading effects and even utility failure (Gloucester County 2016).

Many sources provided historical information regarding previous occurrences and losses associated with extreme temperatures throughout New Jersey and Gloucester County; therefore, the loss and impact information for many events could vary depending on the source. The accuracy of monetary figures discussed is based only on the available information in cited sources.

New Jersey has been experiencing an increase in extreme temperatures across the State. Historically, there has been an increase in temperature during the warmest months in New Jersey, with the majority of the extreme heat months occurring after 1990. Conversely, the months which set records for extreme cold temperatures tended to occur prior to 1930.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2020, neither Gloucester County or the State of New Jersey was not included in any major disaster (DR) or emergency (EM) declarations due to extreme temperatures. However, during the same time period, the Federal Emergency Management Agency (FEMA) included Gloucester County in six winter storm-related DR or EM declarations classified as one or a combination of the following disaster types: blizzard, severe winter storm, snowstorm, snow, ice storm, and winter storm (FEMA 2021).

Table 4.3.6-1. Winter Weather Related Disaster (DR) and Emergency (EM) Declarations 1954-2021

Declaration	Event Date	Declaration Date	Event Description
EM-3106	March 13-17, 1993	March 17, 1993	Snow: Severe Blizzard
DR-1088	January 7-12, 1996	January 13, 1996	Snow: Blizzard of 96 (Severe Snow Storm)
EM-3181	February 16-17, 2003	March 20, 2003	Snow: Snow
EM-1889	February 5-6, 2010	March 23, 2010	Severe Winter Storm and Snowstorm
DR-1873	December 19 - 20, 2009	February 5, 2010	Snowstorm

Source: FEMA 2021

U.S. Department of Agriculture Disaster Declarations

Agriculture-related heat/ cold disasters are quite common. Usually, they occur along with other weather events such as drought, winter storms, frosts, and even flooding. Overall, it is difficult to separate the agricultural loss caused by extreme temperatures from their partner weather events (drought, winter storm, etc.). However, on a cumulative scale these events can cause significant damage and as a result have been recorded as USDA disasters. Table 4.3.6-2 lists the disaster declarations related to extreme temperatures within Gloucester County between 2012 and 2021.

Table 4.3.6-2 USDA Disaster Declarations for Gloucester County 2012-2021

Declaration	Event Date	Declaration Date	Event Description
S4748	April 6- May 15, 2020	August 28, 2020	Severe freeze and frost. No agricultural loss was reported.
S4425	June 24 – July 21, 2018	April 31, 2018	Excessive heat and drought conditions. No agricultural loss was reported.
S4071	April 1 - September 9, 2016	October 5, 2016	Combined effects of freeze, excessive heat, and drought. No agricultural loss was reported.
S3930	April 1 – September 29, 2015	November 4, 2015	Excessive Heat and Drought. No agricultural loss was reported.
S3932	July 16 - September 29, 2015	November 4, 2015	Excessive Heat and Drought. No agricultural loss was reported.
S3487	June 28 – November 8, 2012	February 14, 2013	The combined effects of drought, high winds (Derecho), hail, excessive heat, excessive rain, flash flooding, Hurricane Sandy, snowstorm, and Nor'easter. No agricultural loss was reported.

Source: USDA 2021

Extreme Temperature Events

The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Storm Events database records and defines extreme temperature events as follows:

- Cold/Wind Chill is reported in the NOAA-NCEI database when a period of low temperatures or wind chill temperatures reach or exceed locally or regionally defined advisory conditions (typical value is -18 °F or colder).
- Excessive Heat is reported in the NOAA-NCEI database whenever heat index values meet or exceed locally or regionally established excessive heat warning thresholds.
- Extreme Cold/Wind Chill is reported in the NOAA-NCEI database when a period of extremely low temperatures or wind chill temperatures reaches or exceeds locally or regionally defined warning criteria (typical value around -35 °F or colder).
- Heat is reported in the NOAA-NCEI database whenever heat index values meet or exceed locally or regionally established advisory thresholds.

For this 2022 Plan Update, known extreme temperature events that have impacted Gloucester County between 2015 and 2020 are identified in Table 4.3.6-3. With extreme temperature documentation for New Jersey and Gloucester County being so extensive, not all sources have been identified or researched. Therefore, Table 4.3.6-3 may not include all events that have occurred in the County. Please see Section 9 for detailed information regarding impacts and losses to each municipality.

Table 4.3.6-3 Extreme Temperature Events in Gloucester County, 2015 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
January 7, 2015	Cold/wind Chill	N/A	No	Gloucester County	The arrival of an arctic air mass brought one of the coldest mornings of the month of January to most of New Jersey. Morning low temperatures were mainly in the single numbers above zero. In addition, gusty northwest winds continued into the morning and lowest hourly wind chill factors reached around degrees below zero throughout the state.
February 13, 2015	Cold/wind Chill	N/A	No	Gloucester County	Northwest winds that persisted into the morning of the 13th combined with an arctic air mass to produce wind chill factors of around 10 degrees below zero and low temperatures in the positive single numbers throughout most of New Jersey. Multiple deaths were recorded across the state.
February 15, 2015	Cold/wind Chill	N/A	No	Gloucester County	The combination of strong to high winds and an approaching arctic air mass-produced wind-chill factors of 10 to 15 degrees below zero during the first half of the day on the 15th in New Jersey. Many municipalities declared code blues. Plumbers were swamped with frozen pipe calls. Some say it was the busiest they have been in over 20 years. Shelters were full. Even oil lines were freezing. Some homes ran out of heating oil.
February 20, 2015	Cold/wind Chill	N/A	No	Gloucester County	The arrival of another arctic air mass brought some of the lowest wind chills as well as the lowest temperatures of the winter season to New Jersey on the 20th and 21st. As far as wind chill factors went, the first half of the day on the 20th was colder with wind chill factors as low as around 20 degrees below zero during the morning. Actual low temperatures were around zero. 2 degrees above zero was recorded in Sewell (Gloucester County).
February 24, 2015	Cold/wind Chill	N/A	No	Gloucester County	Unlike the two previous arctic outbreaks earlier this month, this one was not accompanied by strong winds during the first half of the day. Air and wind chill temperatures were nearly the same. Morning low temperatures averaged 25 to 35 degrees colder than normal. 2 degrees above zero was recorded in South Harrison (Gloucester County).
June 12, 2015	Heat	N/A	No	Gloucester County	An unseasonably hot and humid air mass caused high temperatures to reach the lower to mid-90s in southwest New Jersey on the 12th. Combined with relatively high dew points, peak hourly heat index values reached the upper 90s. The heat forced some schools, especially those without air conditioning, to dismiss children early.
June 23, 2015	Heat	N/A	No	Gloucester County	Unseasonably hot and humid weather occurred across southern New Jersey on the 23rd with high temperatures reaching into the lower to mid-90s and afternoon heat indices of around 100 degrees F. This air mass provided the necessary energy for a strong to severe squall line of thunderstorms that moved through the southern half of the state during the very late afternoon and early evening.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
July 19, 2015	Excessive Heat	N/A	No	Gloucester County	Unseasonably hot and humid weather affected most of New Jersey on the 19th and 20th. High temperatures in most areas reached into the lower to mid-90s both days. The 19th was slightly hotter and more humid overall. The combination of heat and humidity brought afternoon heat index values as high as 100 degrees F to 105 degrees F on the 19th. These were some of the highest heat index values of the entire summer. A dissipating cold front on the 20th brought slightly drier air into the region during the afternoon of the 20th and heat index values peaked around 100 degrees F A re-enforcing cold frontal passage on the 21st brought even cooler and drier air into the area and by the 22nd all high temperatures were less than 90 degrees in New Jersey.
February 14, 2016	Cold/wind Chill	N/A	No	Gloucester County	Bitter cold temperatures and strong northwest winds associated with an Arctic outbreak combined to create dangerous wind chill temperatures across the entire northeast quadrant of the county beginning Saturday morning, February 13th into Sunday afternoon, February 14th. Below zero minimum temperatures were common along and north of the I-78 corridor. Wind chill values at this same time ranged from -46 degrees at High Point to 10 degrees above zero near the waters of the back bays near the coast. The lowest wind chill values were reported at the following locations during the early morning hours of February 14th.
July 1, 2018	Excessive Heat	N/A	No	Gloucester County	Temperatures in the middle to upper 90s and dew points in the upper 60s to lower 70s led to excessive heat across New Jersey. Heat indices reached 111 degrees at the Somerset ASOS at 3 pm on July 3rd.

Source: NOAA-NCEI 2021 NWS 2021, FEMA 2021
°F degrees Fahrenheit

Probability of Future Occurrences

It is anticipated that Gloucester County will continue to experience extreme temperatures annually that may coincide with or induce secondary hazards such as snow, hail, ice or windstorms, thunderstorms, drought, human health impacts, and utility failures. Table 4.3.6-4 shows the annual number of events, recurrence interval, annual probability, and annual percent chance of occurrence for the hazards associated with extreme temperatures and reported in the NOAA-NCEI Storm Events Database.

Table 4.3.6-4 Probability of Occurrences of Extreme Temperature Events

Hazard Type	Number of Occurrences Between 1950 and 2020	% Chance of Occurring in Any Given Year
Cold/Wind Chill	25	36%
Excessive Heat	24	34%
Extreme Cold/Wind Chill	2	3%
Heat	61	87%
TOTAL	**112**	**100%**

Source: NOAA-NCEI 2021
Note: Probability was calculated using the available data provided in the NOAA-NCDC storm events database.

Based on these historical records and input from the Steering Committee, the probability of occurrence for extreme temperatures in Gloucester County is considered "occasional" (10-100 percent chance of annual occurrence) (Section 4.4 Hazard Ranking).

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (ONJSC 2021) which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo 2014) and the world (1.5° F [0.8° C]) (Meyer 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date (Runkle 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

4.3.6.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable. For the extreme temperature hazard, the entire county has been identified as exposed; therefore, all assets are potentially vulnerable. The following text estimated potential impacts of extreme temperatures on Gloucester County.

Impact on Life, Health and Safety

For the purposes of this HMP, the entire population of Gloucester County is exposed to extreme temperature events (population of 291,165 people, according to the 2019 American Community Survey population estimates). Extreme temperature events have potential health impacts including injury and death. According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include the following: 1) the elderly, who are less able to withstand temperatures extremes due to their age, health conditions, and limited mobility to access shelters; 2) infants and children up to four years of age; 3) individuals with chronic medical conditions (e.g., heart disease, high blood pressure), 4) low-income persons that cannot afford proper heating and cooling; and 5) the general public who may overexert during work or exercise during extreme heat events or experience hypothermia during extreme cold events (CDC 2017a).

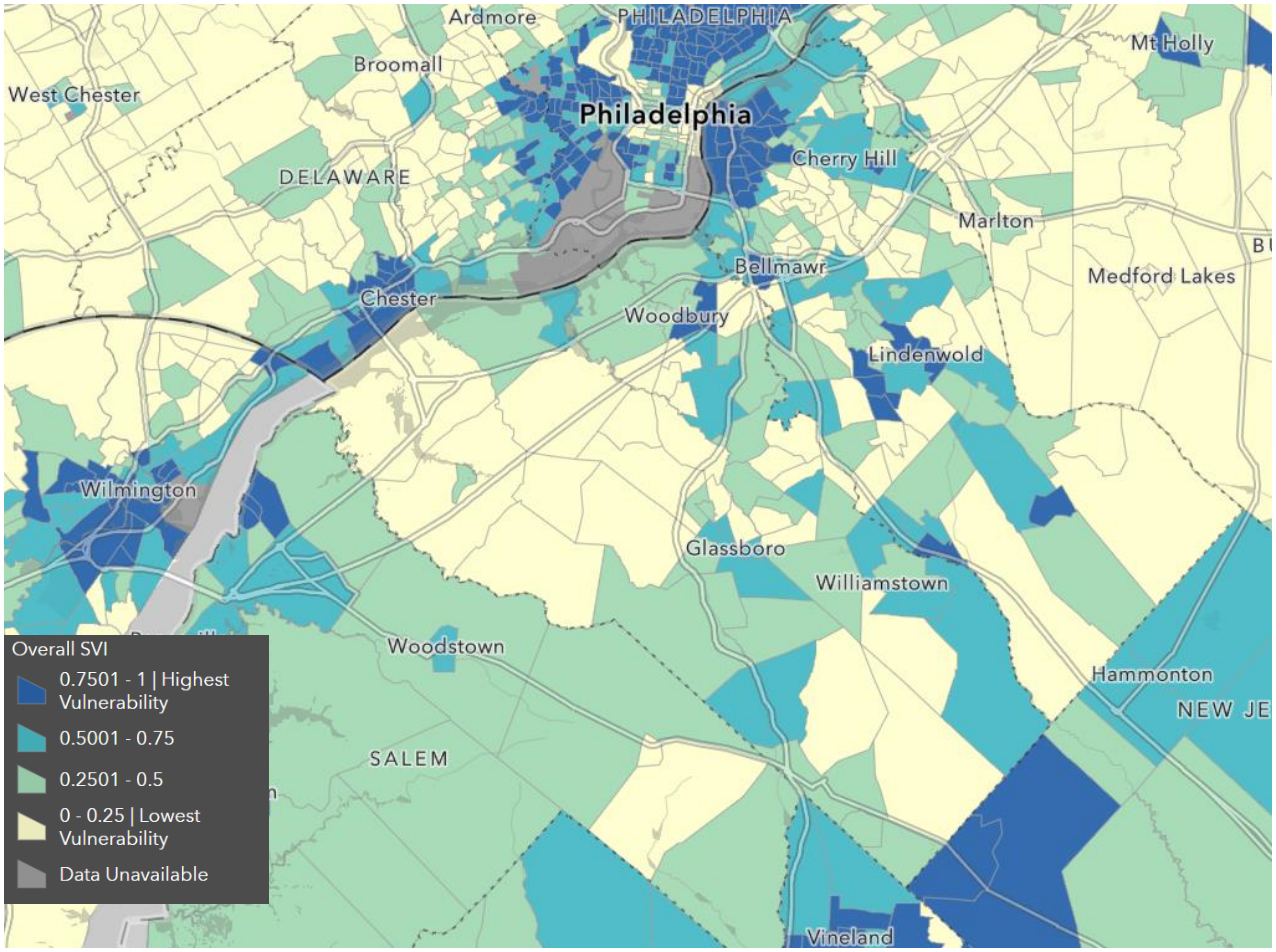
In Gloucester County, each municipality has areas of high concentration of elderly population (over 100 persons per square mile) with higher concentrations located in the more urban, densely populated areas of the County. Such urbanized areas include Glassboro, Monroe, and communities located along the Delaware River and New Jersey Turnpike. As a relatively suburban county, Gloucester County is fortunate to have areas of greenery which decrease the overall county’s vulnerability to heat waves. However, as the county increases development, preservation of such spaces can become more difficult thus increasing the population’s vulnerability, especially elderly to increased extreme temperature events.

Residents with low incomes might not have access to housing or their housing can be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). In Gloucester County, while the general composition of the population is middle to upper middle class, 6.2 percent are below the poverty line, most of which live in the more urbanized areas of the county. Refer to Figure 4-11 in Section 3 (County Profile) that displays the densities of low-income populations in Gloucester County (U.S. Census Bureau 2010).

The Centers for Disease Control’s (CDC) 2016 Social Vulnerability Index (SVI) ranks U.S. Census Tracts on socioeconomic status, household composition and disability, minority status and language, and housing and transportation. Census Tracts in Woodbury have been ranked in the highest vulnerability category with values between 0.75 and 1.0; Census Tract 5010.02 in Woodbury has the highest social vulnerability with a ranking of

0.93. Such Census Tracts in these communities might be more susceptible to impacts from extreme temperatures. The figure below displays the CDC 2016 SVI.

Figure 4.3.6-7. CDC's Social Vulnerability Index 2016



Source: CDC 2021

In addition, safety issues include not only health-related impacts, but domicile impacts as home fires occur more often in winter than any other season (FEMA 2020).

Meteorologists can accurately forecast extreme heat and cold event development and the severity of the associated conditions with several days of lead time. These forecasts provide an opportunity for public health and other officials to notify vulnerable populations, implement short-term emergency response actions, and focus on surveillance and relief efforts on those at greatest risk. Adhering to extreme temperature warnings and conducting appropriate mitigation and preparation measures can significantly reduce the risk of temperature-related deaths.

Impact on General Building Stock

All the building stock in the county is exposed to the extreme temperature hazard. Refer to Section 3 (County Profile), which summarizes the building inventory in Gloucester County. Extreme heat generally does not impact buildings; however, elevated summer temperatures increase the energy demand for cooling. Losses can be associated with the overheating of heating, ventilation, and air conditioning (HVAC) systems. Extreme cold temperature events can damage buildings through freezing/bursting pipes and freeze/thaw cycles, as well as increasing vulnerability to home fires. Additionally, manufactured homes (mobile homes) and antiquated or poorly constructed facilities can have inadequate capabilities to withstand extreme temperatures.

Impact on Critical Facilities

All critical facilities in the county are exposed to the extreme temperature hazard. Impacts to critical facilities are the same as described for general building stock. Additionally, it is essential that critical facilities remain operational during natural hazard events. Extreme heat events can sometimes cause short periods of utility failures, commonly referred to as *brown-outs*, due to increased usage from air conditioners and other energy-intensive appliances. Similarly, heavy snowfall and ice storms, associated with extreme cold temperature events, can cause power interruption. Backup power is recommended for critical facilities and infrastructure. Additionally, designating and developing emergency cooling or heating facilities can also enhance the resilience and safety of communities.

Impact on Economy

Extreme temperature events also have impacts on the economy, including loss of business function and damage to and loss of inventory. Business-owners can be faced with increased financial burdens due to unexpected repairs caused to the building (e.g., pipes bursting), higher than normal utility bills, or business interruption due to power failure (i.e., loss of electricity, telecommunications). In response to such vulnerabilities to the existing utility infrastructure, in July 2014 the State has established the New Jersey Energy Resilience Bank ("ERB" or the "Bank"), the first public infrastructure bank in the nation to focus on energy resilience (State of New Jersey 2021). The ERB is a direct and innovative approach to address significant energy infrastructure vulnerabilities arising in the aftermath of Superstorm Sandy. Utilizing $200 million through New Jersey's second Community Development Block Grant-Disaster Recovery (CDBG-DR) allocation, the ERB supports the development of distributed energy resources at critical facilities throughout the state that will enable them to remain operational during future outages.

Based on information from the 2017 Census of Agriculture, 580 farms were present in Gloucester County, encompassing 191 acres of total farmland. The average farm size was 85 acres. The total market value of agricultural products from Gloucester County farms was $176,644 (USDA 2017).

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development and Change in Population

The ability of new development to withstand extreme temperature impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. New development will change the landscape where buildings, roads, and other infrastructure potentially replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry. These changes cause urban areas to become warmer than the surrounding areas forming (heat islands as described above). Specific areas of recent and new development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 (Jurisdictional Annexes) of this plan.

According to population projections from the State of New Jersey Department of Labor and Workforce Development, Gloucester County will experience an increase in population between 2010 and 2030 by 30.4 percent and is projected to continue to lead the state's population growth in the next two decades. Population change is not expected to have a measurable effect on the overall vulnerability of the county's population over time. However, drastic increases less densely populated areas of the County may require utility system upgrades to keep up with utility demands (e.g., water, electric) during extreme temperature events to prevent increased stresses on these systems. Additionally, by increasing development, green space preservation will need to continue to be a priority to mitigate increased heat islands. Refer to Section 3 (County Profile) for a detailed discussion on population changes.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures. As the climate warms, extreme cold events might decrease in frequency, while extreme heat events might increase in frequency; the shift in temperatures could also result in hotter extreme heat events. With increased temperatures, vulnerable populations could face increased vulnerability to extreme heat and its associated illnesses, such as heatstroke and cardiovascular and kidney disease. Additionally, as temperatures rise, more buildings, facilities, and infrastructure systems may exceed their ability to cope with the heat. Thus, building efficiency and upgrading heating and cooling technology/HVAC will become an increasingly important issue for businesses and homeowners over the coming years.

Change of Vulnerability Since the 2016 HMP

Overall, the entire county remains vulnerable to extreme temperatures. As existing development and infrastructure continue to age, they can be at increased risk to failed utility systems (e.g., HVAC) if they are not properly maintained or upgraded. Similarly, an increase in the elderly population remaining in the county increases the vulnerable population.

4.3.7 Flood

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the flood hazard in Gloucester County.

2022 HMP Update Changes

- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2015 and 2021.

4.3.7.1Profile

Hazard Description

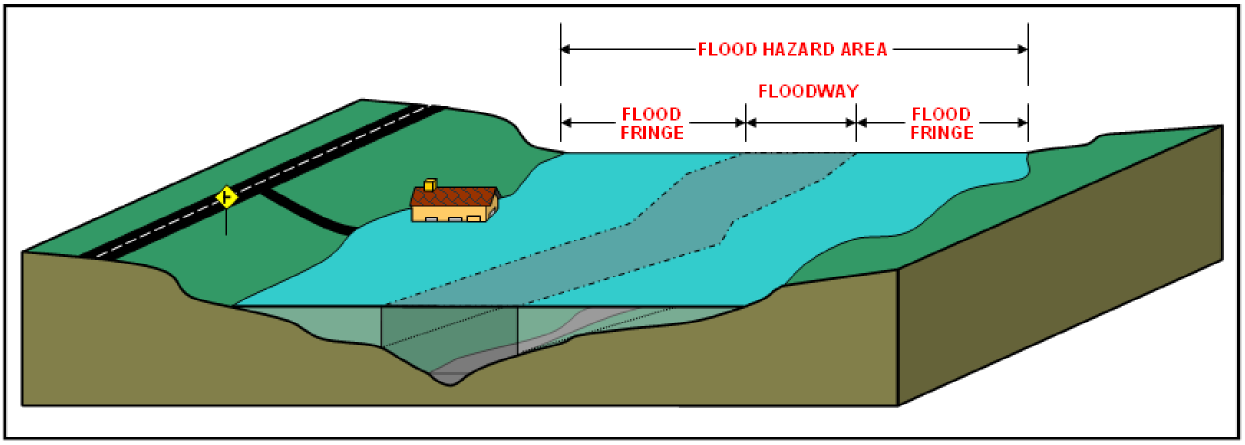
A flood is the inundation of normally dry land resulting from the rising and overflowing of a body of water. They can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, coastlines and multiple counties or states) (FEMA 2007). Floods are frequent and costly natural hazards in New Jersey in terms of human hardship and economic loss, particularly to communities that lie within flood-prone areas or floodplains of a major water source.

The flood-related hazards most likely to impact Gloucester County are coastal flooding, riverine (inland) flooding, ice jam flooding, and flooding as a result of a dam or levee failure. In addition, Gloucester County also experiences urban flooding which is the result of precipitation and insufficient drainage. Dam and levee failure is discussed in Section 4.3.2 (Dam and Levee Failure). Coastal flooding as a result of sea level rise is discussed in Section 4.3.1 (Coastal Erosion and Sea Level Rise). Coastal flooding as a result of storm surge is discussed in Section 4.3.10 (Hurricane).

Riverine (Inland) Flooding

A floodplain is defined as the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that becomes inundated with water during a flood. In Gloucester County, floodplains line the rivers, streams, and lakes of the County. The boundaries of the floodplains are altered as a result of changes in land use, the amount of impervious surface, placement of obstructing structures in floodways, changes in precipitation and runoff patterns, improvements in technology for measuring topographic features, and utilization of different hydrologic modeling techniques. Figure 4.3.7-1 depicts the flood hazard area, the flood fringe, and the floodway areas of a floodplain.

Figure 4.3.7-1. Floodplain



Source: New Jersey Department of Environmental Protection (NJDEP) Date Unknown

Ice Jam Flooding

As per the Northeast States Emergency Consortium and FEMA, an ice jam is an accumulation of ice that acts as a natural dam and restricts flow of a body of water. Ice jams occur when warm temperatures and heavy rains cause rapid snowmelt. The melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and often pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding (FEMA 2015a). Ice jams may also be caused by frazil ice, which forms when mist freezes and then floats down a river, stream, or creek.

There are two different types of ice jams: freeze-up and breakup. Freeze-up jams occur in the early to mid-winter when floating ice may slow or stop due to a change in water slope as it reaches an obstruction to movement. Breakup jams occur during periods of thaw, generally in late winter and early spring. The ice cover breakup is usually associated with a rapid increase in runoff and corresponding river discharge due to a heavy rainfall, snowmelt, or warmer temperatures (White 2013).

Although potential exists, Gloucester County does not have a history of ice jam events (USACE CRREL 2021).

Urban Flooding

Heavy rainfall that overwhelms a developed area's stormwater infrastructure causing flooding is commonly referred to as urban flooding. Urban flooding can be worsened by aging and inadequate infrastructure and over development of land. The growing number of extreme rainfall events that produce intense precipitation are resulting in increased urban flooding (Center for Disaster Resilience 2016). While riverine and coastal flooding is mapped and studied by FEMA, urban flooding is not.

NOAA defines urban flooding as the flooding of streets, underpasses, low lying areas, or storm drains. (NOAA 2009). Urban drainage flooding is caused by increased water runoff due to urban development and inadequate drainage systems. Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and other urban areas. The systems make use of a closed conveyance system that channels water away from an urban area to surrounding streams. This bypasses the natural processes of water filtration through the ground, containment, and evaporation of excess water. Because drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding in those streams can occur more quickly and reach greater depths than prior to development in that area (Harris 2008).

High groundwater levels can be a concern and cause problems even where there is no surface flooding. Basements are susceptible to high groundwater levels. Seasonally high groundwater is common in many areas, while elsewhere high groundwater occurs only after a long period of above-average precipitation (FEMA 1997).

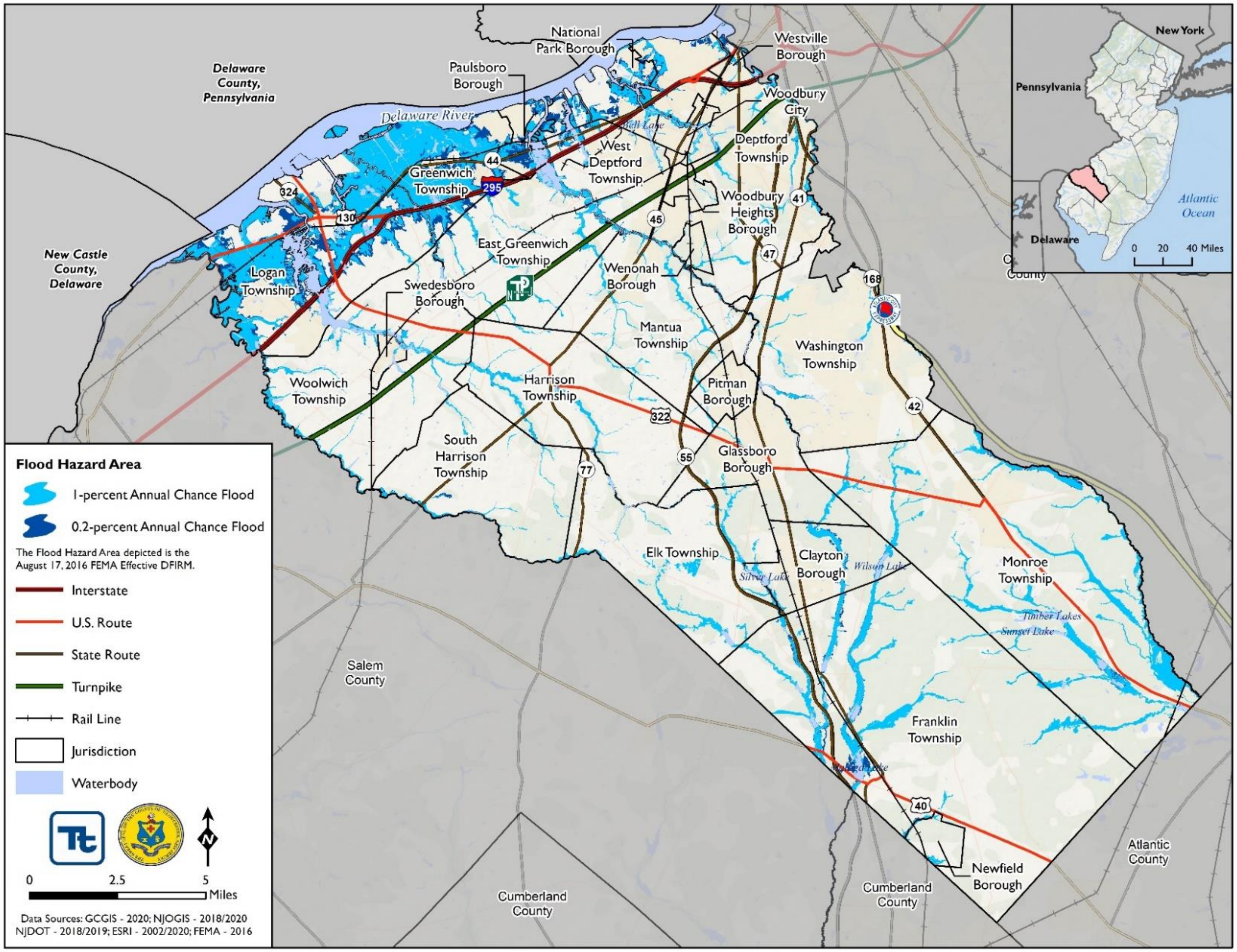
Location

Flooding potential is influenced by climatology, meteorology and topography. Extensive development can impact flooding potential as it leaves fewer natural surfaces available to absorb rainwater, forcing water directly into streams, rivers, and existing drainage systems swelling them more than when more natural surface buffered the runoff rate.

Flooding in Gloucester County is often the direct result of frequent weather events such as thunderstorms, heavy rains, tropical storms, and hurricanes. Floods can happen almost anywhere in County, although they do tend to occur in and around areas near existing bodies of water, such as rivers and streams.

The 1-percent annual chance of flood hazard zones are widely dispersed in Gloucester County, generally following riverine corridors as shown in significant portions of the Township of Greenwich and the Township of Logan (refer to Figure 4.3.7-2). In addition to the areas along riverine corridors, 1-percent annual chance flood hazard zones are concentrated in low lying areas near the Delaware River, including significant portions of the Township of Greenwich and the Township of Logan.

Figure 4.3.7-2. FEMA Flood Hazard Areas in Gloucester County



Watersheds in Gloucester County

Watersheds in New Jersey are referred to as the name of the water body to which the land area drains and the corresponding Hydrologic Unit Code (HUC). The HUC can range from 2 to 16 digits long- the longer the numeric code, the smaller the watershed area. NJDEP also has divided the state into 21 Watershed Management Areas (WMAs) based on large scale drainage pattern. Each WMA encompasses a particular group of major rivers. Gloucester County falls within parts of three regions: WMA 18: Lower Delaware; WMA 15: Great Egg Harbor; and WMA 17: Maurice, Salem, and Cohansey. These areas delineate the principal stream systems that drain the County's land area. WMA 17 and WMA 18 drain to the Delaware River and WMA 15 drains to the Atlantic Ocean (NJDEP 2007).

Flood Insurance Study (FIS)

According to the FEMA Flood Insurance Study for Gloucester County (FEMA 2016) a history of flooding throughout Gloucester County indicates that flooding may be experienced during any season of the year. Flooding during the winter months is less frequent. However, the Delaware River overflows most frequently during late winter and early spring because of snowmelt, with ice jams as an occasional factor increasing flooding conditions. Extensive flooding has occurred in the late summer and fall, usually being associated with thunderstorms, hurricanes and nor'easters along the Atlantic coast.

Principal Flood Problems

- Principal flood problems for Gloucester County are identified in the 2016 FIS. The Mantua Creek basin has suffered the greatest flood damages of any area of Gloucester County (FEMA 2016).
- Although the Township of Deptford is subject to both tidal and fluvial flooding from Big Timber Creek and South Branch Timber Creek, there has been only minor flood damage reported (FEMA 2016).
- In the Township of East Greenwich, historically, the community of Mount Royal has been subject to the worst flooding (FEMA 2016).
- In the Township of Franklin, aside from extremely large storms, the major flooding problem is located along Little Ease Run at the railroad crossing (FEMA 2016).
- Flooding in the Borough of Glassboro is caused by the overflow of Mantua Creek, Raccoon Creek, and Still Run #1. Historically, flooding has been confined to undeveloped lands and fruit orchards. Only a few isolated residences are within the floodplain (FEMA 2016).
- In the Township of Greenwich, with the exception of the Gibbstown residential area, the residential area adjacent to Paulsboro, and the oil storage facilities on Clonmell Road, much of the township is marshland which is subject to tidal flooding. Included in the flood-prone area are the DuPont explosives complex, and residential streets at the outskirts of Gibbstown. These include Willow Street, Allen Drive, Morse Street, Memorial Avenue, and those side streets which intersect these roads. In addition, the dead end streets between Ladner Avenue and Clonmell Creek in the Paulsboro area are subject to flooding. All major roads including state and interstate highways have sections which would be impassable during times of major flooding (FEMA 2016).

- Low-lying areas of the Township of Logan are subject to inundation by high tides from the Delaware River. Extreme high tides flood these lowlands to the same elevation as reached in the Delaware River. Flooding in Logan is most likely to occur in the late summer and fall when hurricanes are prevalent (FEMA 2016).
- According to Township of Monroe officials, the township has experienced no riverine-associated flooding problems. Damage from storms comes mainly from high water table seepage. Residents along the lakeside area have reported that they have never seen the lake water surface rise significantly (FEMA 2016).
- Because the floodplains of Fourmile Branch are uninhabited, little information on past flooding is available. However, the poor drainage characteristics as evidenced by the marshlands adjacent to the stream indicate that wide inundation will occur with moderate increases in water-surface elevation (FEMA 2016).
- In the Borough of National Park, several blocks are in an area with the potential to flood from tidal, riverine, or a combination of both flows. Areas susceptible to flooding from the 1-percent annual chance flood are: Riverview Avenue, Grove Street (south of Woodlawn Avenue), Temple Avenue, Jefferson Avenue, and Belmont Avenue. Most flooding in these areas would be tidal and therefore would have a low velocity (FEMA 2016).
- Low-lying areas of the Borough of Swedesboro in the vicinity of Raccoon Creek Reach 1 are subject to being inundated by high tidal flooding from the Delaware River. Extreme high tides would flood these lowlands to the same elevation as reached in the Delaware River (FEMA 2016).
- Washington Township is subject to fluvial flooding from Mantua Creek and South Branch Big Timber Creek, and their tributaries. Despite the numerous streams which traverse the township, flooding has been relatively minor. This is due to the fact that, until recently, development within Washington has been minimal (FEMA 2016).
- Several other areas along Mantua Creek are also in the floodplain. They include the River Drive Road and Heppard Road area. In addition, a trailer park at the intersection of Paradise Road and Crown Point Road is partially inundated by tidal flow along Little Mantua Creek (FEMA 2016).
- Several areas in the eastern portion of the township are susceptible to flooding from Woodbury Creek and its tributaries, Matthews Branch and Hessian Run. A trailer park between Hessian Run and Woodbury Creek is vulnerable to flooding from tides as low as the 1- percent annual chance recurrence interval. Parts of Watson Street, Edwin Street, Ellwood Avenue, Atkins Avenue, and Miller Avenue are all subject to flooding from Hessian Run. Homes on Lancing Road and Lynn Avenue are just out of the 1- percent annual chance recurrence interval floodplain of Woodbury Creek, however, three industrial structures at the end of Frances Avenue would be vulnerable to flooding. There is minor flooding along Matthews Branch at Myrtle Avenue and Queen Street, and an unnamed tributary to the Delaware River causes flooding along the streets between the river and Belmont Avenue (Red Bank Avenue) (FEMA 2016).
- Low-lying areas of the Township of Woolwich in the vicinity of Raccoon Creek are subject to being inundated by high tidal flooding from the Delaware River. Extreme high tides would flood these

lowlands to the same elevation as reached in the Delaware River. Flooding in this area would most likely occur in the late summer and early fall during the hurricane season (FEMA 2016).

- Please refer to Section 9 for information regarding specific areas of flooding within each municipality.

Flood Protection Measures

There are several dams in the Maurice River Basin. These include Willow Grove Lake dam on the Maurice River, Malaga Lake dam on Scotland Run and Iona Lake dam on Still Run #1. Scotland Run and Still Run #1 are both tributaries of the Maurice River. While the purpose of these dams is not for flood control, they do have the effect of reducing flooding downstream of them. This is especially true if the dams are not full when a storm hits (FEMA 2016).

In the Township of Greenwich, for protection against storm surge, flood gates have been installed on Repaupo Creek, White Sluice Race, Clonmell Creek, and Sand Ditch. The tops of these gates are at a high enough elevation to protect against a 2-percent annual chance storm surge, however, low spots in the berm between the gates will allow a 10-percent annual chance storm surge (6.6 feet) to inundate the area (FEMA 2016).

In December 2009 a project was completed to rebuild the floodgate and levee along Repaupo Creek by the Gloucester County Improvement Authority. However, the repaired system does not provide protection against the 1-percent annual chance flood (FEMA 2016).

In the Township of Logan, near the coastline of the Delaware River levees have been built to protect areas inland from some degree of coastal flooding from the Delaware River. However, these levees do not provide protection against the 1-percent annual chance flood (FEMA 2016).

In the Township of Monroe, the dams which impound water to form Diamond Lake and Timber Lake will act to dampen the peak flood discharges downstream. This effect was considered in the hydrologic analysis (FEMA 2016).

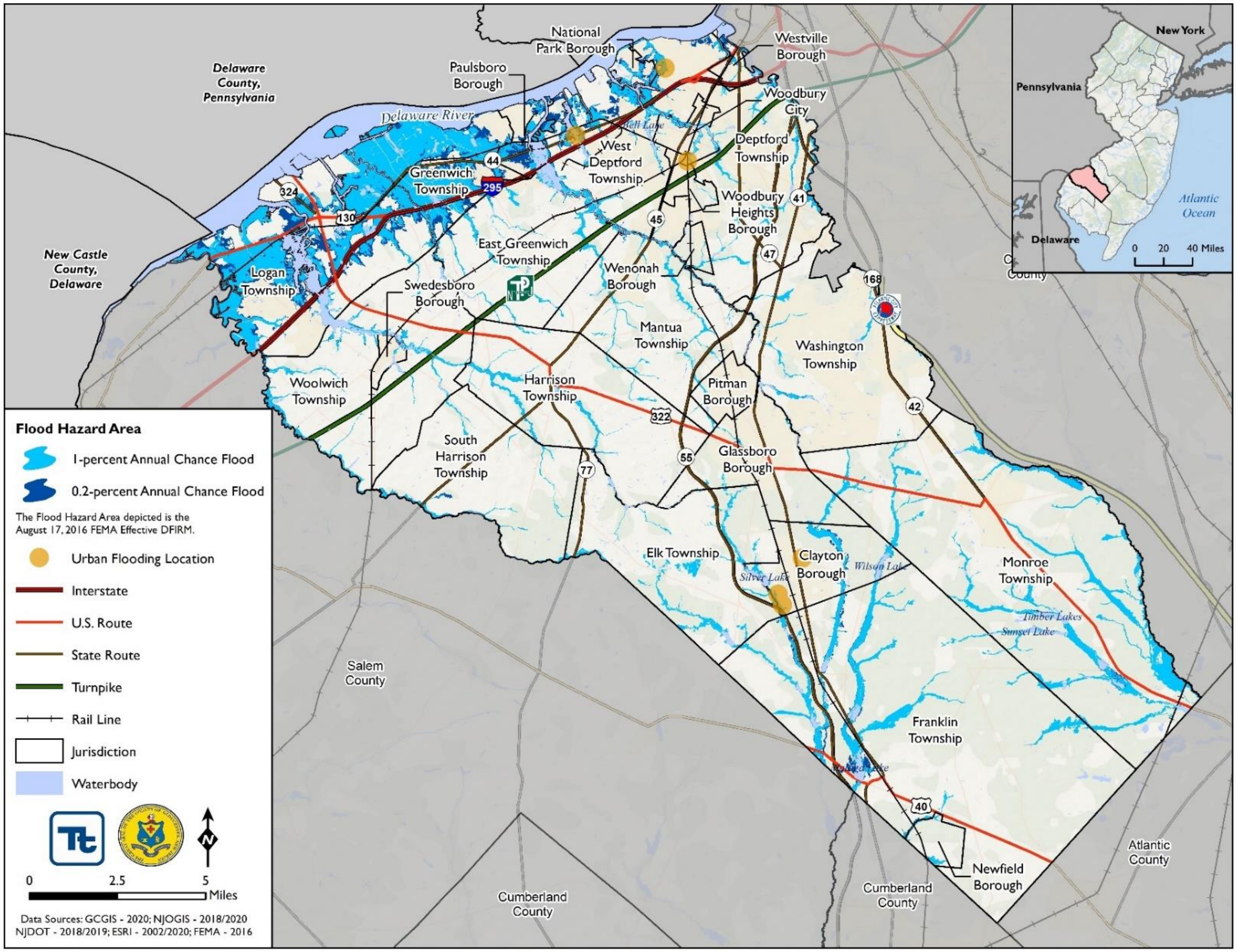
Within the Townships of Greenwich, Logan, and Pennsauken, existing levees along the Delaware River do not protect against the 1-percent annual chance flood (FEMA 2016).

A number of man-made structures commonly called agricultural or salt-hay levees have been identified in this County. These structures do not meet the definition of a levee for the purpose of the NFIP (FEMA 2016).

Urban Flooding

Throughout Gloucester County, low-lying surface flooding and interior shallow ponding occurs as a result of heavy rainfall and inadequate capacity of stormwater systems. While riverine flooding is mapped by FEMA, urban flooding is not. Each municipality was asked to identify areas that flood outside the FEMA-mapped floodplain in an attempt to identify problem areas and assist with identifying mitigation solutions. Figure 4.3.7-3 illustrates the urban flood areas identified by the municipalities participating in the 2022 HMP update

Figure 4.3.7-3. Urban Flood Areas Identified in Gloucester County



Natural and Beneficial Floodplain Areas

Although typically associated as a hazard area, floodplains also serve beneficial and natural functions (on ecological/environmental, social, and economic levels). Some of the more well-known water-related functions for floodplains include:

- Natural flood and erosion control
  - Provide flood storage and conveyance
  - Reduce flood velocities
  - Reduce flood peaks
  - Reduce sedimentation
- Surface water quality maintenance
  - Filter nutrients and impurities from runoff
  - Process organic wastes
  - Moderate temperatures of water
- Groundwater recharge
- Promote infiltration and aquifer recharge
- Reduce frequency and duration of low surface flows (FEMA)

Areas in the floodplain that typically provide these natural functions are wetlands, riparian areas, sensitive areas, and habitats for rare and endangered species. According to NJ DEP 2019 the County has several floodplain areas that could serve natural and beneficial functions. This information is summarized in Tables 4.3.7-1 and 4.3.7-2.

Table 4.3.7-1. Acreage of Wetlands by Municipality

Municipality	Total Area (acres)	Wetland Area (acres)	Percent of Total
Clayton (B)	4,646	1,093	23.5%
Deptford (Twp)	11,246	1,197	10.6%
East Greenwich (Twp)	9,550	1,548	16.2%
Elk (Twp)	12,366	2,656	21.5%
Franklin (Twp)	36,082	6,283	17.4%
Glassboro (B)	5,994	1,141	19.0%
Greenwich (Twp)	7,485	2,600	34.7%
Harrison (Twp)	12,171	1,048	8.6%
Logan (Twp)	16,840	5,542	32.9%
Mantua (Twp)	10,296	772	7.5%
Monroe (Twp)	30,029	5,465	18.2%
National Park (B)	928	86	9.2%
Newfield (B)	1,115	80	7.2%

Municipality	Total Area (acres)	Wetland Area (acres)	Percent of Total
Paulsboro (B)	1,703	117	6.9%
Pitman (B)	1,444	31	2.2%
South Harrison (Twp)	10,210	1,365	13.4%
Swedesboro (B)	495	26	5.3%
Washington (Twp)	13,789	1,123	8.1%
Wenonah (B)	646	38	5.9%
West Deptford (Twp)	11,421	1,542	13.5%
Westville (B)	871	42	4.8%
Woodbury (C)	1,346	33	2.5%
Woodbury Heights (B)	804	30	3.8%
Woolwich (Twp)	13,689	1,245	9.1%
Gloucester County Total	**215,166**	**35,103**	**16.3%**

Source: NJDEP 2019

Table 4.3.7-2. Natural and Beneficial Land in Gloucester County

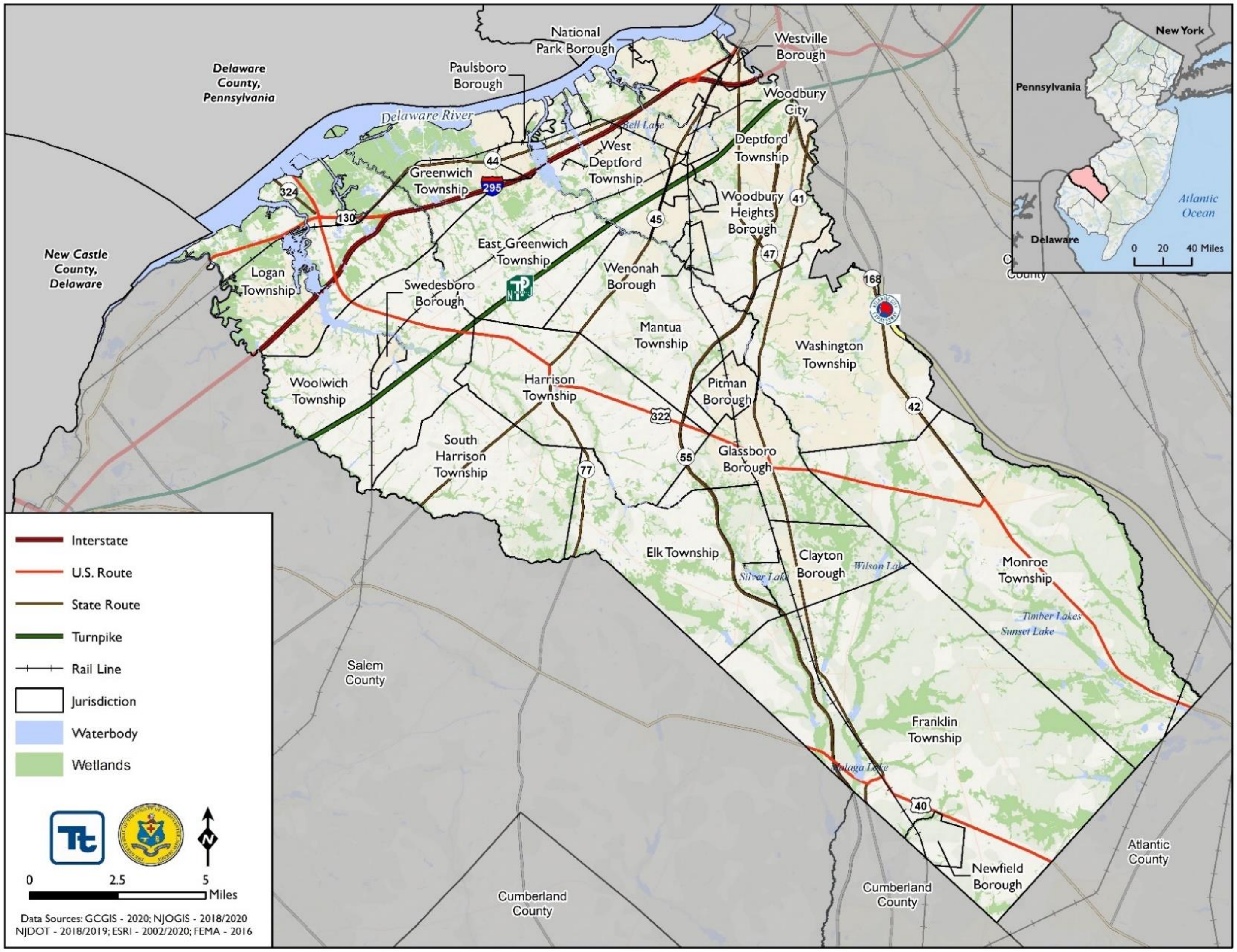
Wetlands	Area (acres)	Forest	Area (acres)	Endangered Species	Area (acres)
Agricultural Wetlands (Modified)	1,420	Coniferous Brush/Shrubland	682	Special Concern	23,508
Altered Lands	18	Coniferous Forest (>50% Crown Closure)	3,001	State Endangered	9,511
Atlantic White Cedar Wetlands	910	Coniferous Forest (10-50% Crown Closure)	442	State Threatened	3,362
Cemetery On Wetland	1	Deciduous Brush/Shrubland	1,882		
Commercial/Services	5	Deciduous Forest (>50% Crown Closure)	23,503		
Coniferous Scrub/Shrub Wetlands	111	Deciduous Forest (10-50% Crown Closure)	2,681		
Coniferous Wooded Wetlands	1,636	Mixed Deciduous/Coniferous Brush/Shrubland	2,636		
Cropland And Pastureland	0	Mixed Forest (>50% Coniferous With >50% Crown Closure)	3,333		
Deciduous Scrub/Shrub Wetlands	2,380	Mixed Forest (>50% Coniferous With 10-50% Crown Closure)	492		
Deciduous Wooded Wetlands	18,345	Mixed Forest (>50% Deciduous With >50% Crown Closure)	6,190		
Disturbed Tidal Wetlands	8	Mixed Forest (>50% Deciduous With 10-50% Crown Closure)	648		

Wetlands	Area (acres)	Forest	Area (acres)	Endangered Species	Area (acres)
Disturbed Wetlands (Modified)	517	Old Field (< 25% Brush Covered)	2,249		
Extractive Mining	1	Phragmites Dominate Old Field	386		
Former Agricultural Wetland (Becoming Shrubby, Not Built-Up)	93	Plantation	24		
Freshwater Tidal Marshes	1,636				
Herbaceous Wetlands	862				
Industrial	8				
Managed Wetland In Built-Up Maintained Rec Area	76				
Managed Wetland In Maintained Lawn Greenspace	192				
Mixed Scrub/Shrub Wetlands (Coniferous Dom.)	81				
Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	258				
Mixed Wooded Wetlands (Coniferous Dom.)	1,547				
Mixed Wooded Wetlands (Deciduous Dom.)	2,495				
Old Field (< 25% Brush Covered)	0				
Orchards/Vineyards/Nurseries/Horticultural Areas	0				
Other Agriculture	2				
Other Urban Or Built-Up Land	0				
Phragmites Dominate Coastal Wetlands	364				
Phragmites Dominate Interior Wetlands	1,693				
Phragmites Dominate Urban Area	25				
Residential, Rural, Single Unit	7				
Residential, Single Unit, Low Density	3				
Residential, Single Unit, Medium Density	0				

Wetlands	Area (acres)	Forest	Area (acres)	Endangered Species	Area (acres)
Stormwater Basin	6				
Transitional Areas	19				
Transportation/Communication/Utilities	1				
Upland Rights-Of-Way Undeveloped	0				
Wetland Rights-Of-Way	448				

Source: NJDEP 2019

Figure 4.3.7-4. Wetlands in Gloucester County



According to the Landscape Project data, Gloucester County contains potential habitats for over 30 endangered species from multiple taxonomic classes, including Aves, Bivalvia, Insecta, Mammalia, and Reptilia. Habitats for about 22 of these species are located within the 1-percent annual chance floodplain. These species include, the Indiana bat, the bald eagle, the blue-spotted salamander, and the bog turtle.

Extent

The frequency and severity of riverine flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels.

Floodplains are often referred to as 100-year floodplains. A 100-year floodplain is not a flood that will occur once every 100 years; the designation indicates a flood that has a 1-percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time. Due to this misleading term, FEMA has properly defined it as the 1-percent annual chance flood, or the SFHA. Similarly, the 500-year floodplain will not occur every 500 years but is an event with a 0.2-percent chance of being equaled or exceeded each year. The "1-percent annual chance flood" is now the standard term used by most federal and state agencies and by the National Flood Insurance Program (NFIP) (FEMA 2003). The 1-percent annual chance floodplain establishes the area that has flood insurance and floodplain management requirements and is also referenced as the regulatory floodplain.

The NJDEP is mandated to delineate and regulate flood hazard areas pursuant to N.J.S.A. 58:16A-50 et seq., the Flood Hazard Area Control Act. This Act authorizes the DEP to adopt land use regulations for development within the flood hazard areas, to control stream encroachments and to integrate the flood control activities of the municipal, County, state and federal governments. The State's Flood Hazard Area delineations are defined by the New Jersey Flood Hazard Area Design Flood which is equal to a design flood discharge 25 percent greater in flow than the 1-percent annual chance flood. In addition, the floodway shall be based on encroachments that produce no more than a 0.2-foot water surface rise above the 1-percent annual chance flood.

The USGS National Water Information System (NWIS) collects surface water data from more than 850,000 stations across the country. The time-series data describes stream levels, streamflow (discharge), reservoir and lake levels, surface water quality, and rainfall. The data is collected by automatic recorders and manual field measurements at the gage locations. Gloucester County has roughly 20 active USGS stream gages; in addition, stream gauges are located upstream in neighboring counties.

In the case of riverine flood hazard, once a river reaches flood stage, the flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category has a definition based on property damage and public threat:

- Minor Flooding - minimal or no property damage, but possibly some public threat or inconvenience.

- Moderate Flooding - some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- Major Flooding - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations (NWS 2011).

The severity of a flood depends not only on the amount of water that accumulates in a period of time, but also on the land's ability to manage this water. The size of rivers and streams in an area and infiltration rates are significant factors. When it rains, soil acts as a sponge. When the land is saturated or frozen, infiltration rates decrease and any more water that accumulates must flow as runoff (Harris 2008).

Currently, there is no measurement used to further define the frequency and severity of urban flooding.

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with flooding throughout Gloucester County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events may vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2021, Gloucester County was included in two declarations for flood-related events. Table 4.3.7-3 lists these events.

Table 4.3.7-3. Flood-Related Disaster (DR) and Emergency (EM) Declarations 1954-2021

Declaration	Event Date	Declaration Date	Event Description
DR-310	September 4, 1971	September 4, 1971	Flood: Heavy Rains & Flooding
DR-477	July 23, 1975	July 23, 1975	Flood: Heavy Rains, High Winds, Hail & Tornadoes

Source: FEMA 2021

U.S. Department of Agriculture Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated County. Between 2015 and 2021, Gloucester County was not included in any flood related agricultural disaster declarations (USDA 2021a, USDA 2021b).

Flood Events

The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Storm Events database records and defines flood events as follows:

- Coastal Flood is reported in the NOAA-NCEI database for flooding of coastal areas due to the vertical rise above normal water level caused by strong, persistent onshore wind, high astronomical tide, and/or low atmospheric pressure, resulting in damage, erosion, flooding, fatalities, or injuries. Coastal areas are defined as those portions of coastal land zones (coastal County/parish) adjacent to the waters, bays, and estuaries of the oceans.

- Flash Flood is reported in the NOAA-NCEI database for a life-threatening, rapid rise of water into a normally dry area beginning within minutes to multiple hours of the causative event (e.g., intense rainfall, dam failure, ice jam).
- Flood is reported in the NOAA-NCEI database for any high flow, overflow, or inundation by water which causes damage. In general, this would mean the inundation of a normally dry area caused by an increased water level in an established watercourse, or ponding of water, that poses a threat to life or property.

Flood events that have impacted Gloucester County between 2015 and 2021 are identified in Table 4.3.7-4. With flood documentation for New Jersey and Gloucester County being so extensive, not all sources have been identified or researched. Therefore, Table 4.3.7-4 may not include all events that have occurred in the County. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

Table 4.3.7-4. Flooding Events in Gloucester County, 2015 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
June 1, 2015	Flash Flood	N/A	N/A	Franklin Township, Monroe Township	A nearly stationary frontal boundary and a low pressure system moving along it combined to develop thunderstorms that produced isolated damaging wind gusts as well as more widespread flash flooding across the southern half of New Jersey during the afternoon and evening of June 1st. The second wave of thunderstorms with very heavy rain caused flash flooding of smaller creeks and roadways in Franklin and Monroe Townships near the border with Atlantic County. Event precipitation totals included 4.91 inches in Piney Hollow (Franklin Township) and 3.12 inches in South Harrison Township.
July 15, 2015	Flash Flood	N/A	N/A	Franklin Township, Washington Township	Double barrel cold fronts helped trigger a series of showers and thunderstorms across southern New Jersey during the morning of the 15th. Thunderstorms that were accompanied by very heavy rain caused flash flooding in parts of Salem, Gloucester, Atlantic and Ocean Counties. The flash flooding in Gloucester and Salem Counties was exacerbated because of the heavy rain and flooding that occurred just the previous morning. Thunderstorms with very heavy caused small creek and roadway flash flooding in Franklin Township. Sections of Marshall Mill Road and New Jersey State Route 47 were flooded and closed near the Malaga Branch. Two day event precipitation totals included 4.33 inches in Franklin Township. Thunderstorms with very heavy caused small creek and roadway flash flooding in Washington Township in the Bells Lake drainage basin. Sections of Greentree Road and the Black Horse Pike (New Jersey State Route 42) were flooded and closed. Doppler Radar storm total estimates reached 2.5 inches in the Township.
September 10-11, 2015	Flash Flood	N/A	N/A	Greenwich Township, Logan Township, Woodbury Township, Mantua	A series of thunderstorms which rode along a wavy cold frontal boundary brought heavy rain into New Jersey on the 10th. The heaviest rain fell along the Interstate 95/295 corridor (especially in Gloucester County) and along coastal sections of New Jersey. This caused poor drainage as well as some creek flash flooding, mainly in Gloucester County where some event precipitation totals exceeded 5 inches.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
				Township, Wenonah Borough, Pitman Borough	A nearly stationary thunderstorm caused flash flooding from Gibbstown (Greenwich Township) through northern East Greenwich Township and Paulsboro. Many roadways were flooded in the area and closed. Vehicles were stuck in flood waters, but no serious injuries were reported. Two event precipitation totals from East Greenwich Township were 4.28 inches and 4.05 inches respectively. A nearly stationary thunderstorm caused flash flooding in Logan Township. The flash flooding affected Interstate 295 as the left and center southbound lanes between exits 11 and 14 were flooded and closed. A nearly stationary thunderstorm caused flash flooding in Woodbury. Vehicles were stuck in flood waters at the intersection of Glassboro Road and Evergreen Avenue near the Hesters Branch. No serious injuries were reported. Slow moving thunderstorms caused flash flooding in Mantua Township and Wenonah Borough in the Mantua Creek Basin. In Mantua Township, New Jersey State Route 45 was closed and a few vehicles were trapped in the flood waters. No serious injuries were reported. Event precipitation totals included 5.79 inches in Wenonah and 2.88 inches in Pitman.
July 28, 2016	Flood	N/A	N/A	Pitman Borough	A cold frontal boundary moved southward into the region. This led to the development of afternoon showers and thunderstorms. Some of thunderstorms became severe with locally heavy rainfall as well. Many locations saw between 2 and 3 inches of heavy rainfall total for this event in Southern NJ. Minor street flooding occurred in Pitman due to heavy rainfall with thunderstorms.
September 19, 2016	Flood	N/A	N/A	Monroe Township	The remnants of tropical storm Julia and a frontal boundary interacted leading to several rounds of rainfall over the region. Water in Williamstown in Monroe Township was a foot or two deep on some roads.

TETRA TECH

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
March 31, 2017	Flood	N/A	N/A	Washington Township	Low pressure with an occluding frontal boundary moved through the region. With this system periods of heavy rain fell on the 31st. The heavy rain led to localized flooding issues. Flooding took place on the Black Horse Pike in Washington Township.
July 24, 2017	Flash Flood	N/A	N/A	Rowan University	A stalled frontal boundary was the focus for several rounds of thunderstorms that produced damaging winds and flooding in spots. Several thousand people lost power throughout the state. Dorms at Rowan University were evacuated due to flash flooding.
August 23, 2017	Flood	N/A	N/A	West Deptford	Severe thunderstorms formed in a hot and humid airmass ahead of a cold front. NJ 45 closed at the intersection with 130 due to flooding.
February 11, 2018	Flood	N/A	N/A	Clayton Borough	Several waves of heavy rainfall moved along a slow moving frontal boundary which led to flooding in a few spots. Rainfall of one to four inches occurred across the state. The highest totals over three inches were in southwestern New Jersey. NJ 47 southbound was reported to be flooded in Clayton.
April 16, 2018	Coastal Flood	N/A	N/A	Gloucester County	An extended period of onshore flow occurred, beginning with east-northeast winds Saturday Night, which then shifted to the southeast on Sunday Night into Monday Morning April 16th. Widespread winds gusts of 40 to 50 mph occurred in the east-northeast flow Saturday Night and Sunday, with a lull Sunday Night, then occasionally again in the south-southeast flow along and just in advance of a heavy line of showers and thunderstorms on Monday Morning. The onshore flow, and to a lesser extent the heavy rainfall, lead to multiple rounds of coastal flooding along the oceanfront and back bays with the high tide cycles on Sunday evening and again on Monday Morning. Moderate coastal flooding along the tidal Delaware River and its tidal tributaries. There were a number of road closures including New Jersey Route 47 in Westville and US Route 130 in Logan Township. Peak tide was 9.47 feet MLLW at Philadelphia.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
June 11, 2018	Flood	N/A	N/A	Deptford Township, Westville Borough	Torrential rain occurred on the night of June 10 across parts of southeastern Pennsylvania, and central and southern New Jersey. Rainfall totals up to 3 to 6 inches were reported. Flooding on State Highway 45 southbound at U.S. Highway 130. Lane restrictions in place.
July 3, 2018	Flash Flood	N/A	N/A	Westville Borough	Severe thunderstorms caused wind damage across portions of southwestern New Jersey on the evening of July 3. Rainfall amounts of 1 to 3 inches fell along the Interstate 95/New Jersey Turnpike Corridor in a short amount of time. A few locations received 3 to 4 inches of rain. Several streets in Westville were reported under water.
September 7, 2018	Flash Flood	N/A	N/A	Westville Borough, West Deptford Township, Deptford Township	Locally heavy rain fell in the northwestern parts of Gloucester County and Camden County during the late afternoon and evening of September 7. Rainfall totals ranged from 3 to 5 inches. A supercell developed along a boundary and produced isolated wind damage. The southbound lanes of both US Route 130 and NJ Route 45 in Westville were closed due to flash flooding. There were lane closures on Interstate 295 near Interchange 23 in West Deptford Township. Widespread flash flooding took place on the New Jersey Turnpike in Deptford Township resulting in lane closures. A vehicle was trapped in flood waters on NJ Route 55 at Interchange 56 in Deptford Township.
September 10, 2018	Coastal Flood	N/A	N/A	Gloucester County	A persistent onshore flow and unusually high astronomical tides associated with the new moon resulted in widespread moderate coastal flooding along the bays and other tidal waterways in central and southern New Jersey. The flooding occurred across three consecutive high tide cycles, from the evening of September 9 through the early hours of September 11. Moderate flooding occurred along the Delaware River and its tidal tributaries in Gloucester County. The tide gauge at Philadelphia reached 9.65 feet MLLW.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
October 11, 2018	Flash Flood	N/A	N/A	Pitman Borough	Rainfall totals of 3 to 5 inches fell in parts of northeastern Maryland, Delaware, and southern and central New Jersey on the night of October 11. There were a few reports of rainfall amounts in excess of 5 inches. Minor flooding occurred along the Mantua Creek at Pitman.
November 26, 2018	Coastal Flood	N/A	N/A	Gloucester County	A coastal storm resulted in tidal flooding along the northern part of the New Jersey coast and along the tidal Delaware River. Moderate tidal flooding occurred along the tidal Delaware River and its tidal tributaries. Some roads were flooded. The tide gauge at Marcus Hook, Pennsylvania reached 8.77 feet MLLW.
June 19-20, 2019	Flash Flood	N/A	N/A	Mantua Township, Greenwich Township, Logan Township, West Deptford Township, Westville Borough	Showers and thunderstorms produced heavy rainfall and flash flooding from the afternoon of June 19 into the nighttime hours. Rainfall amounts of 3 to near 6 inches were reported in the counties of Gloucester, Camden and Burlington. Significant flash flooding occurred in those counties. A state of emergency was declared by Governor Phil Murphy. NJ Route 45 in Mantua Township was closed in both directions due to flash flooding. NJ Route 44 was closed in both directions in Gibbstown (Greenwich Township) due to flash flooding. Flash flooding resulted in lane closures on Interstate 295 in Logan Township between Interchanges 13 and 14. Flood waters blocked all northbound lanes of the New Jersey Turnpike in West Deptford Township. NJ Route 47 was closed in Westville due to flash flooding. A total of 50 residents were evacuated from an apartment complex on Broadway in Westville.
July 6, 2019	Flash Flood	N/A	N/A	Paulsboro Borough	Thunderstorms brought locally heavy rain to parts of New Jersey on the afternoon of July 6. Rainfall amounts of 2 to near 3 inches occurred in sections of

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
					Warren County and Gloucester County. Rainfall totals of 3 to over 5 inches fell in parts of Ocean County. NJ Route 44 was closed due to flash flooding around Delaware Street in Paulsboro.
June 20, 2020	Flash Flood	N/A	N/A	Pitman Township, Washington Township	Thunderstorms brought heavy rain to parts of Gloucester County on the afternoon of June 20. There were localized rainfall amounts of 2.5 to 3.5 inches. Minor flooding occurred along Mantua Creek in Pitman and Washington Township.
July 10, 2020	Tropical Storm Fay, Flash Flood	N/A	N/A	Swedesboro Borough, South Harrison Township, Deptford Township, Mantua Township, Glassboro Borough, Pitman Township	Tropical Storm Fay moved northward along the coasts of Delaware and New Jersey on the afternoon and evening of July 10. The storm produced rainfall totals up to 3 to 6 inches in New Jersey, with the highest totals occurring in the southern part of the state. Some areas also experienced a period of tropical storm force winds, especially near the coast. Overall impacts from wind were limited. Widespread roadway flooding occurred in Swedesboro, with some streets becoming impassable. NJ Route 45 was closed between Oldmans Creek and Harrisonville Road in South Harrison Township due to flooding. Mantua Creek overflowed onto Glassboro Road in the vicinity of the border between Deptford Township and Mantua Township. NJ Route 47 was closed to the south of US Route 322 in Glassboro due to flooding. Minor flooding occurred along the Mantua Creek near Pitman.
August 4, 2020	Tropical Storm	N/A	N/A	Mantua Township	Tropical Storm Isaias brought high winds, heavy rain, several tornadoes, and coastal flooding to the mid-Atlantic region, becoming the most impactful tropical cyclone to impact most of the region since Sandy in 2012.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
	Isaias, Flash Flood				NJ Route 45 was closed near Berkley Road in Mantua Township due to flooding.
August 7, 2020	Flash Flood	N/A	N/A	Logan Township, Swedesboro Borough, Woolwich Township, South Harrison Township, Franklin Township	An impulse riding along a west to east boundary stalled near the Mason-Dixon line produced severe thunderstorms and heavy rain across sections of South Jersey from late afternoon through the evening hours on August 7th. Strong winds knocked down trees, and torrential downpours on ground already saturated from the remnants of Hurricane Isaias produced flash flooding on many roadways and small streams in the area. Several vehicles were trapped in flood waters in Logan Township. Widespread roadway flooding occurred in Swedesboro. A section of Oliphant's Mill Road in Woolwich Township was washed away by flood waters. The New Jersey Turnpike was closed in Woolwich Township, south of Interchange 2, due to flooding. NJ Route 45 was closed near Harrisonville Road in South Harrison Township due to flooding. NJ Route 47 was closed north of US Route 40 in Franklin Township due to flooding.
August 12, 2020	Flash Flood	N/A	N/A	Deptford Township, Mantua Township, Woodbury Heights Borough	Thunderstorms brought locally heavy rain to southern New Jersey on the afternoon of August 12. Rainfall amounts were as high as 2 to 4 inches. Sections of Princeton Boulevard in Deptford Township were inundated. Parts of Glassboro Road and Livingstone Road in Mantua Township were closed due to flooding. Bridgeton Road was closed at Barry Drive in Mantua Township due to flooding. About 3 feet of water covered parts of the northbound side of the New Jersey Turnpike in Woodbury Heights. Three cars and a tractor trailer were stranded in the flood waters.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
August 29, 2020	Flash Flood	N/A	N/A	Pitman Township	Showers and thunderstorms associated with the remnants of Hurricane Laura brought locally heavy rain to southwestern New Jersey during the morning and early afternoon of August 29. Rainfall totals as high as 3 to 5 inches were reported. Minor flooding occurred along Mantua Creek in Pitman.

Source: FEMA 2021; NOAA-NCEI 2021; NWS 2021; SPC 2021; NJOEM 2019

Note: Not all events that have occurred in Gloucester County are included due to the extent of documentation and the fact that not all sources have been identified or researched.

K: Thousand

DR Disaster Declaration (FEMA)

FEMA Federal Emergency Management Agency

Mph miles per hour

N/A Not Applicable

Probability of Future Occurrences

Based on the historic and more recent flood events in Gloucester County, it is clear that the County has a high probability of flooding for the future. The fact that the elements required for flooding exist and that major flooding has occurred throughout the County in the past suggests that many people and properties are at risk from the flood hazard in the future. It is estimated that Gloucester County will continue to experience direct and indirect impacts of flooding events annually that may induce secondary hazards such as infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences.

According to the NOAA National Climate Data Center (NCDC) and the CRREL database, Gloucester County experienced 52 flood events between 1950 and 2021, including 28 coastal floods, 28 floods, 48 flash floods, and no ice jams. The table below shows these statistics, as well as the annual average number of events and the percent chance of these individual flood hazards occurring in Gloucester County in future years (NOAA NCEI 2021).

Table 4.3.7-5. Probability of Future Flood Events

Hazard Type	Number of Occurrences Between 1950 and 2021	Percent chance of occurrence in any given year
Coastal Flood	28	38.89
Flood	28	38.89
Flash Flood	48	66.67
Ice Jams	0	0
Total	**104**	**100**

Source: NOAA-NCEI 2021; CRREL 2021

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for flood in the County is considered 'frequent' (100 percent annual probability; a hazard event may occur multiple times per year, as presented in Table 4.4-1). The ranking of the flood hazard for individual municipalities is presented in the jurisdictional annexes.

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation. Changes in winter temperatures could result in a change in the frequency of ice jam events.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli et al. 2020).

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

4.3.7.2 Vulnerability Assessment

To assess Gloucester County's risk to the flood hazard, a spatial analysis was conducted using the FEMA Risk Map products dated 2016. The 1- and 0.2-percent annual chance flood events were examined to determine the assets located in the hazard areas and to estimate potential loss using the FEMA Hazus model. These results are summarized below. Refer to Section 4.2 (Methodology and Tools) for additional details on the methodology used to assess flood risk.

Impact on Life, Health and Safety

The impact of flooding on life, health, and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time is provided to residents. Exposure represents the population living in or near floodplain areas that could be impacted should a flood event occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but everyone who may be affected by the effects of a hazard event (e.g., people are at risk while traveling in flooded areas, or their access to emergency services is compromised during an event). The degree of that impact will vary and is not strictly measurable.

To estimate population exposure to the 1-percent- and 0.2-percent annual chance flood events, the DFIRM flood boundaries were used. Based on the spatial analysis, there are an estimated 4,305 residents living in the SFHA (or 1-percent annual chance floodplain), or 1.5-percent of the County's total population. There are an estimated 8,715 residents living in the 0.2-percent annual chance floodplain, or 3.0-percent of the County's total population. The Township of Greenwich has the greatest number of residents living in the floodplain with approximately 1,330 residents living in the 1-percent annual chance floodplain and 2,377 residents in the 0.2-percent annual chance floodplain. Table 4.3.7-6 summarizes the population exposed to the flood hazard by jurisdiction.

Table 4.3.7-6. Estimated Gloucester County Population Exposed to the 1-percent and 0.2-percent Flood Hazard Area

Jurisdiction	Total Population	Estimated Population Exposed to the Flood Hazard Areas			
		1-percent Annual Chance Flood	Percent of Total	0.2-percent Annual Chance Flood	Percent of Total
Clayton (B)	8,626	28	0.3%	42	0.5%
Deptford (Twp)	30,448	207	0.7%	210	0.7%
East Greenwich (Twp)	10,488	18	0.2%	31	0.3%
Elk (Twp)	4,135	9	0.2%	9	0.2%
Franklin (Twp)	16,440	48	0.3%	172	1.0%
Glassboro (B)	19,826	4	0.0%	4	0.0%
Greenwich (Twp)	4,831	1,330	27.5%	2,377	49.2%
Harrison (Twp)	12,995	3	0.0%	9	0.1%
Logan (Twp)	5,924	286	4.8%	397	6.7%
Mantua (Twp)	14,941	22	0.1%	29	0.2%
Monroe (Twp)	36,789	181	0.5%	231	0.6%
National Park (B)	2,959	338	11.4%	712	24.0%
Newfield (B)	1,521	2	0.1%	2	0.1%
Paulsboro (B)	5,904	526	8.9%	2,232	37.8%
Pitman (B)	8,805	0	0.0%	0	0.0%
South Harrison (Twp)	3,148	16	0.5%	18	0.6%
Swedesboro (B)	2,579	3	0.1%	3	0.1%
Washington (Twp)	47,833	12	0.0%	18	0.0%
Wenonah (B)	2,259	0	0.0%	0	0.0%

Jurisdiction	Total Population	Estimated Population Exposed to the Flood Hazard Areas			
		1-percent Annual Chance Flood	Percent of Total	0.2-percent Annual Chance Flood	Percent of Total
West Deptford (Twp)	21,149	813	3.8%	1,410	6.7%
Westville (B)	4,169	306	7.4%	642	15.4%
Woodbury (C)	9,861	116	1.2%	116	1.2%
Woodbury Heights (B)	2,986	0	0.0%	0	0.0%
Woolwich (Twp)	12,549	37	0.3%	50	0.4%
Gloucester County (Total)	**291,165**	**4,305**	**1.5%**	**8,715**	**3.0%**

Sources: American Community Survey 2019 5-year estimates; FEMA 2016
Note: B – Borough; C - City; Twp – Township; % = Percent

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. This is due to many factors including their physical and financial ability to react or respond during a hazard. Of the population exposed, the most vulnerable include the economically disadvantaged and the population over the age of 65. There are 21,340 persons below the poverty level and 44,794 persons that are over 65 years old in the County. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact to their family. The population over the age of 65 is more vulnerable because they are more likely to seek or need medical attention which may not be available to due isolation during a flood event and they may have more difficulty evacuating. Special consideration should be taken when planning for disaster preparation, response, and recovery for these vulnerable groups.

In addition, displaced populations were estimated for the 1-percent annual chance flood event. Using 2010 U.S. Census data, Hazus estimates 208 people may seek short-term sheltering. These statistics, by jurisdiction, are presented in Table 4.3.7-7.

Table 4.3.7-7 Estimated Population Displaced or Seeking Short-Term Shelter from the 1-percent Annual Chance Flood Event

Jurisdiction	Total Population	Persons Seeking Short-Term Sheltering
Clayton (B)	8,626	0
Deptford (Twp)	30,448	5
East Greenwich (Twp)	10,488	0
Elk (Twp)	4,135	0
Franklin (Twp)	16,440	1
Glassboro (B)	19,826	4
Greenwich (Twp)	4,831	48
Harrison (Twp)	12,995	0
Logan (Twp)	5,924	1
Mantua (Twp)	14,941	0
Monroe (Twp)	36,789	1
National Park (B)	2,959	7
Newfield (B)	1,521	0
Paulsboro (B)	5,904	51
Pitman (B)	8,805	0
South Harrison (Twp)	3,148	0

Jurisdiction	Total Population	Persons Seeking Short-Term Sheltering
Swedesboro (B)	2,579	0
Washington (Twp)	47,833	20
Wenonah (B)	2,259	0
West Deptford (Twp)	21,149	21
Westville (B)	4,169	17
Woodbury (C)	9,861	32
Woodbury Heights (B)	2,986	0
Woolwich (Twp)	12,549	0
Gloucester County (Total)	291,165	208

Sources: ACS 2019; Hazus 4.2; FEMA 2016
Note: B – Borough; C - City; Twp – Township

The total number of injuries and casualties resulting from flooding is generally limited based on advance weather forecasting, blockades, and warnings. Therefore, injuries and deaths generally are not anticipated if proper warning and precautions are in place. Ongoing mitigation efforts should help to avoid the most likely cause of injury, which results from persons trying to cross flooded roadways or channels during a flood.

Cascading impacts may also include exposure to pathogens such as mold. After flood events, excess moisture and standing water contribute to the growth of mold in buildings. Mold may present a health risk to building occupants, especially those with already compromised immune systems such as infants, children, the elderly and pregnant women. The degree of impact will vary and is not strictly measurable. Mold spores can grow in as short a period as 24-48 hours in wet and damaged areas of buildings that have not been properly cleaned. Very small mold spores can easily be inhaled, creating the potential for allergic reactions, asthma episodes, and other respiratory problems. Buildings should be properly cleaned and dried out to safely prevent mold growth (CDC 2020).

Molds and mildews are not the only public health risk associated with flooding. Floodwaters can be contaminated by pollutants such as sewage, human and animal feces, pesticides, fertilizers, oil, asbestos, and rusting building materials. Common public health risks associated with flood events also include:

- Unsafe food
- Contaminated drinking and washing water and poor sanitation
- Mosquitos and animals
- Carbon monoxide poisoning
- Secondary hazards associated with re-entering/cleaning flooded structures
- Mental stress and fatigue

Current loss estimation models such as Hazus are not equipped to measure public health impacts. The best level of mitigation for these impacts is to be aware that they can occur, educate the public on prevention, and be prepared to deal with these vulnerabilities in responding to flood events.

Impact on General Building Stock

After considering the population exposed and potentially vulnerable to the flood hazard, the built environment was evaluated. Exposure includes those buildings located in the flood zone. Potential damage is the modeled loss that could occur to the exposed inventory, including structural and content replacement cost values. Table 4.3.7-8 summarizes these results County-wide.

In summary, there are 2,106 buildings located in the 1-percent annual chance flood boundary with an estimated $2.7 billion of replacement cost value (i.e., building and content replacement costs). In total, this represents approximately 2.8-percent of the County's total general building stock inventory. In addition, there are 4,248 buildings located in the 0.2-percent annual chance flood boundary with an estimated $5.7 billion of building stock and contents exposed. This represents approximately 5.8-percent of the County's total general building stock inventory.

The Hazus flood model estimated potential damages to the buildings in Gloucester County at the structure level using the custom structure inventory developed for this HMP and the depth grid generated using the effective DFIRM data. The estimated potential damage estimated by Hazus to the general building stock inventory associated with the 1-percent annual chance flood is greater than $284 million or less than 1-percent of the total building stock replacement cost value. The Township of Greenwich has the greatest amount of estimated building loss—approximately $148 million (i.e. 5.4-percent of the total replacement cost value). Refer to Table 4.3.7-9 for the estimated losses by jurisdiction, which also shows the estimated losses for residential, commercial, and other occupancy structures, respectively.

Table 4.3.7-8. Estimated General Building Stock Located in the FEMA Flood Zones - All Occupancies

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value	Estimated Building Stock Exposed to the Flood Hazard Areas							
			Number of Buildings - 1-percent Annual Chance Flood	Percent of Total	Replacement Cost Value Exposed - 1-percent Annual Chance Flood	Percent of Total	Number of Buildings - 0.2-percent Annual Chance Flood	Percent of Total	Replacement Cost Value Exposed - 0.2-percent Annual Chance Flood	Percent of Total
Clayton (B)	3,295	$1,933,299,905	11	0.3%	$3,681,479	0.2%	16	0.5%	$5,508,279	0.3%
Deptford (Twp)	11,284	$10,081,159,584	76	0.7%	$82,167,813	0.8%	78	0.7%	$82,780,216	0.8%
East Greenwich (Twp)	4,346	$2,927,045,409	12	0.3%	$15,145,184	0.5%	21	0.5%	$29,158,395	1.0%
Elk (Twp)	2,339	$1,784,179,937	12	0.5%	$5,815,138	0.3%	12	0.5%	$5,815,138	0.3%
Franklin (Twp)	8,432	$5,637,186,975	27	0.3%	$30,891,619	0.5%	85	1.0%	$50,791,052	0.9%
Glassboro (B)	5,959	$5,816,332,907	4	0.1%	$43,604,375	0.7%	4	0.1%	$43,604,375	0.7%
Greenwich (Twp)	2,807	$2,734,741,222	721	25.7%	$605,150,365	22.1%	1,273	45.4%	$1,234,816,681	45.2%
Harrison (Twp)	4,817	$4,828,239,008	3	0.1%	$2,252,723	0.0%	5	0.1%	$3,126,532	0.1%
Logan (Twp)	2,805	$6,591,573,691	192	6.8%	$886,244,791	13.4%	343	12.2%	$1,967,386,876	29.8%
Mantua (Twp)	6,569	$4,738,271,524	12	0.2%	$8,906,343	0.2%	15	0.2%	$12,158,031	0.3%
Monroe (Twp)	12,553	$8,458,118,166	59	0.5%	$36,593,935	0.4%	74	0.6%	$42,646,713	0.5%
National Park (B)	1,483	$781,021,288	174	11.7%	$66,628,650	8.5%	357	24.1%	$136,815,759	17.5%
Newfield (B)	891	$622,948,021	7	0.8%	$23,209,639	3.7%	7	0.8%	$23,209,639	3.7%
Paulsboro (B)	2,615	$2,076,864,026	296	11.3%	$368,373,748	17.7%	1,036	39.6%	$918,921,038	44.2%
Pitman (B)	3,521	$2,916,470,733	2	0.1%	$7,434,815	0.3%	2	0.1%	$7,434,815	0.3%
South Harrison (Twp)	1,726	$1,494,748,661	9	0.5%	$6,222,624	0.4%	10	0.6%	$7,403,314	0.5%
Swedesboro (B)	1,040	$936,236,069	3	0.3%	$3,603,255	0.4%	3	0.3%	$3,603,255	0.4%
Washington (Twp)	17,413	$13,732,374,547	13	0.1%	$25,988,210	0.2%	20	0.1%	$30,172,382	0.2%
Wenonah (B)	930	$778,702,966	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
West Deptford (Twp)	7,561	$9,201,121,261	278	3.7%	$204,551,082	2.2%	550	7.3%	$621,895,802	6.8%
Westville (B)	1,733	$1,529,846,612	131	7.6%	$200,755,745	13.1%	263	15.2%	$320,628,760	21.0%
Woodbury (C)	3,605	$4,139,381,075	52	1.4%	$140,772,569	3.4%	55	1.5%	$231,994,353	5.6%
Woodbury Heights (B)	1,295	$1,265,332,236	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Woolwich (Twp)	4,074	$4,551,585,778	12	0.3%	$4,483,019	0.1%	19	0.5%	$11,312,422	0.2%
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**2,106**	**1.9%**	**$2,772,477,118**	**2.8%**	**4,248**	**3.8%**	**$5,791,183,828**	**5.8%**

Sources: FEMA 2016; Gloucester County Planning Partners - 2021; HIFLD - 2020; EPA - 2021
Note: B – Borough; C - City; Twp – Township;

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Table 4.3.7-9. Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event

Jurisdiction	Total Replacement Cost Value	All Occupancies		Residential		Commercial		Agricultural, Industrial, Religious, Education and Government	
		Estimated Loss	Percent of Total Replacement Cost Value	Estimated Loss	Percent of Total Replacement Cost Value	Estimated Loss	Percent of Total Replacement Cost Value	Estimated Loss	Percent of Total Replacement Cost Value
Clayton (B)	$1,933,299,905	$135,401	0.0%	$135,401	0.0%	$0	0.0%	$0	0.0%
Deptford (Twp)	$10,081,159,584	$9,732,287	0.1%	$7,900,914	0.1%	$1,831,373	0.0%	$0	0.0%
East Greenwich (Twp)	$2,927,045,409	$832,453	0.0%	$644,171	0.0%	$184,610	0.0%	$3,672	0.0%
Elk (Twp)	$1,784,179,937	$87,675	0.0%	$29,867	0.0%	$57,807	0.0%	$0	0.0%
Franklin (Twp)	$5,637,186,975	$2,490,708	0.0%	$440,913	0.0%	$2,049,795	0.0%	$0	0.0%
Glassboro (B)	$5,816,332,907	$28,866	0.0%	$0	0.0%	$28,866	0.0%	$0	0.0%
Greenwich (Twp)	$2,734,741,222	$148,142,785	5.4%	$51,057,549	1.9%	$11,636,914	0.4%	$85,448,322	3.1%
Harrison (Twp)	$4,828,239,008	$22,650	0.0%	$0	0.0%	$22,650	0.0%	$0	0.0%
Logan (Twp)	$6,591,573,691	$35,697,807	0.5%	$6,988,845	0.1%	$20,419,548	0.3%	$8,289,414	0.1%
Mantua (Twp)	$4,738,271,524	$533,260	0.0%	$396,260	0.0%	$137,000	0.0%	$0	0.0%
Monroe (Twp)	$8,458,118,166	$1,092,794	0.0%	$1,031,352	0.0%	$0	0.0%	$61,441	0.0%
National Park (B)	$781,021,288	$19,459,725	2.5%	$10,634,205	1.4%	$3,092,608	0.4%	$5,732,912	0.7%
Newfield (B)	$622,948,021	$925,815	0.1%	$354,740	0.1%	$0	0.0%	$571,074	0.1%
Paulsboro (B)	$2,076,864,026	$19,189,342	0.9%	$6,968,043	0.3%	$10,191,511	0.5%	$2,029,788	0.1%
Pitman (B)	$2,916,470,733	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
South Harrison (Twp)	$1,494,748,661	$834,857	0.1%	$472,584	0.0%	$0	0.0%	$362,273	0.0%
Swedesboro (B)	$936,236,069	$13,732	0.0%	$0	0.0%	$13,732	0.0%	$0	0.0%
Washington (Twp)	$13,732,374,547	$596,313	0.0%	$150,311	0.0%	$398,181	0.0%	$47,821	0.0%
Wenonah (B)	$778,702,966	$312,037	0.0%	$0	0.0%	$312,037	0.0%	$0	0.0%
West Deptford (Twp)	$9,201,121,261	$21,949,656	0.2%	$12,464,109	0.1%	$5,199,674	0.1%	$4,285,874	0.0%
Westville (B)	$1,529,846,612	$12,782,139	0.8%	$6,207,242	0.4%	$6,284,833	0.4%	$290,065	0.0%
Woodbury (C)	$4,139,381,075	$8,779,768	0.2%	$4,682,991	0.1%	$3,476,397	0.1%	$620,381	0.0%
Woodbury Heights (B)	$1,265,332,236	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Woolwich (Twp)	$4,551,585,778	$724,887	0.0%	$706,495	0.0%	$0	0.0%	$18,392	0.0%
Gloucester County (Total)	**$99,556,781,602**	**$284,364,956**	**0.3%**	**$111,265,993**	**0.1%**	**$65,337,534**	**0.1%**	**$107,761,429**	**0.1%**

Sources: FEMA 2016; Gloucester County Planning Partners - 2021; HIFLD - 2020; EPA - 2021
Note: B – Borough; C - City; Twp – Township

NFIP Statistics

FEMA provided a list of properties with NFIP policies, past claims, and multiple claims. According to FEMA, a repetitive loss (RL) property is a NFIP-insured structure that has had at least two paid flood losses of more than $1,000 in any 10-year period since 1978. A severe repetitive loss (SRL) property is a NFIP-insured structure that has had four or more separate claim payments made under a standard flood insurance policy, with the amount of each claim exceeding $5,000 and with the cumulative amount of such claims payments exceeding $20,000; or at least two separate claims payments made under a standard flood insurance policy with the cumulative amount of such claim payments exceed the fair market value of the insured building on the day before each loss (FEMA 2018).

Table 4.3.7-10, Table 4.3.7-11, and Table 4.3.7-12 summarize the NFIP policies, claims, and repetitive loss statistics for Gloucester County. The majority of the RL and SRL properties are single-family residences (77.7-percent and 81.8-percent, respectively). This information is current as of September 30, 2019. The locations of repetitive flooding were geocoded and mapped. Figure 4.3.7-5 illustrates these properties with the understanding that there are varying tolerances between how closely the longitude and latitude coordinates correspond to the location of the property address.

Table 4.3.7-10. Occupancy Class of Repetitive Loss Structures in Gloucester County

Occupancy Class	Total Number of NFIP Repetitive Loss (RL) Properties (excludes SRL)	Total Number of NFIP Severe Repetitive Loss (SRL) Properties (excludes RL)	Total NFIP RL and SRL Properties
Business Non-Residential	3	0	3
Non-Residential	1	0	1
Single Family	60	1	61
Gloucester County (Total)	**64**	**1**	**65**

Source: FEMA 2019
Note: Policies, claims, repetitive loss and severe repetitive loss statistics provided by FEMA Region 2, and are current as of September 30, 2019.
**Valid means the Severe Repetitive Loss Indicator is equal to V, VN, VU, VNU, MV, and MVU. Repetitive Loss Properties include properties that have a Severe Repetitive Loss Indicator of P, PU, PNU, and are left blank. V = Valid Insured Residential SRL property; VN = Valid Insured Non-Residential SRL property; VU = Valid Uninsured Residential SRL property; VNU = Valid Uninsured Non-Residential SRL property; MV = Mitigated Valid Insured Residential SRL property; MVU = Mitigated Valid Uninsured Residential SRL property; P = Pending Insured Residential SRL property; PN = Pending Insured Non-Residential SRL property; PU = Pending Uninsured Residential SRL property; PNU = Pending Uninsured Non-Residential SRL property*

Table 4.3.7-11 Occupancy Class of Repetitive Loss Structures in Gloucester County, by Municipality

Jurisdiction	NFIP Repetitive Loss (RL) Properties (excludes SRL)			NFIP Severe Repetitive Loss (SRL) Properties		
	Business Non-Residential	Non-Residential	Single Family	Business Non-Residential	Non-Residential	Single Family
Clayton (B)	0	0	0	0	0	0
Deptford (Twp)	0	0	1	0	0	0
East Greenwich (Twp)	0	0	2	0	0	0
Elk (Twp)	0	0	1	0	0	0
Franklin (Twp)	0	0	1	0	0	0
Glassboro (B)	0	0	0	0	0	0

Jurisdiction	NFIP Repetitive Loss (RL) Properties (excludes SRL)			NFIP Severe Repetitive Loss (SRL) Properties		
	Business Non-Residential	Non-Residential	Single Family	Business Non-Residential	Non-Residential	Single Family
Greenwich (Twp)	0	0	4	0	0	0
Harrison (Twp)	0	0	0	0	0	0
Logan (Twp)	1	0	6	0	0	0
Mantua (Twp)	0	0	6	0	0	0
Monroe (Twp)	0	0	5	0	0	0
National Park (B)	1	0	6	0	0	0
Newfield (B)	0	0	0	0	0	0
Paulsboro (B)	0	1	0	0	0	0
Pitman (B)	0	0	0	0	0	0
South Harrison (Twp)	0	0	0	0	0	0
Swedesboro (B)	0	0	0	0	0	0
Washington (Twp)	0	0	1	0	0	0
Wenonah (B)	0	0	0	0	0	0
West Deptford (Twp)	1	0	18	0	0	1
Westville (B)	0	0	7	0	0	0
Woodbury (C)	0	0	1	0	0	0
Woodbury Heights (B)	0	0	0	0	0	0
Woolwich (Twp)	0	0	1	0	0	0
Gloucester County (Total)	**3**	**1**	**60**	**0**	**0**	**1**

Source: FEMA Region 2, 2019

Notes: Multi-family designation is defined as two to four families. Repetitive loss and severe repetitive loss statistics provided by FEMA Region 2 and are current as of September 2019. The statistics were summarized using the Community Name provided by FEMA Region 2.

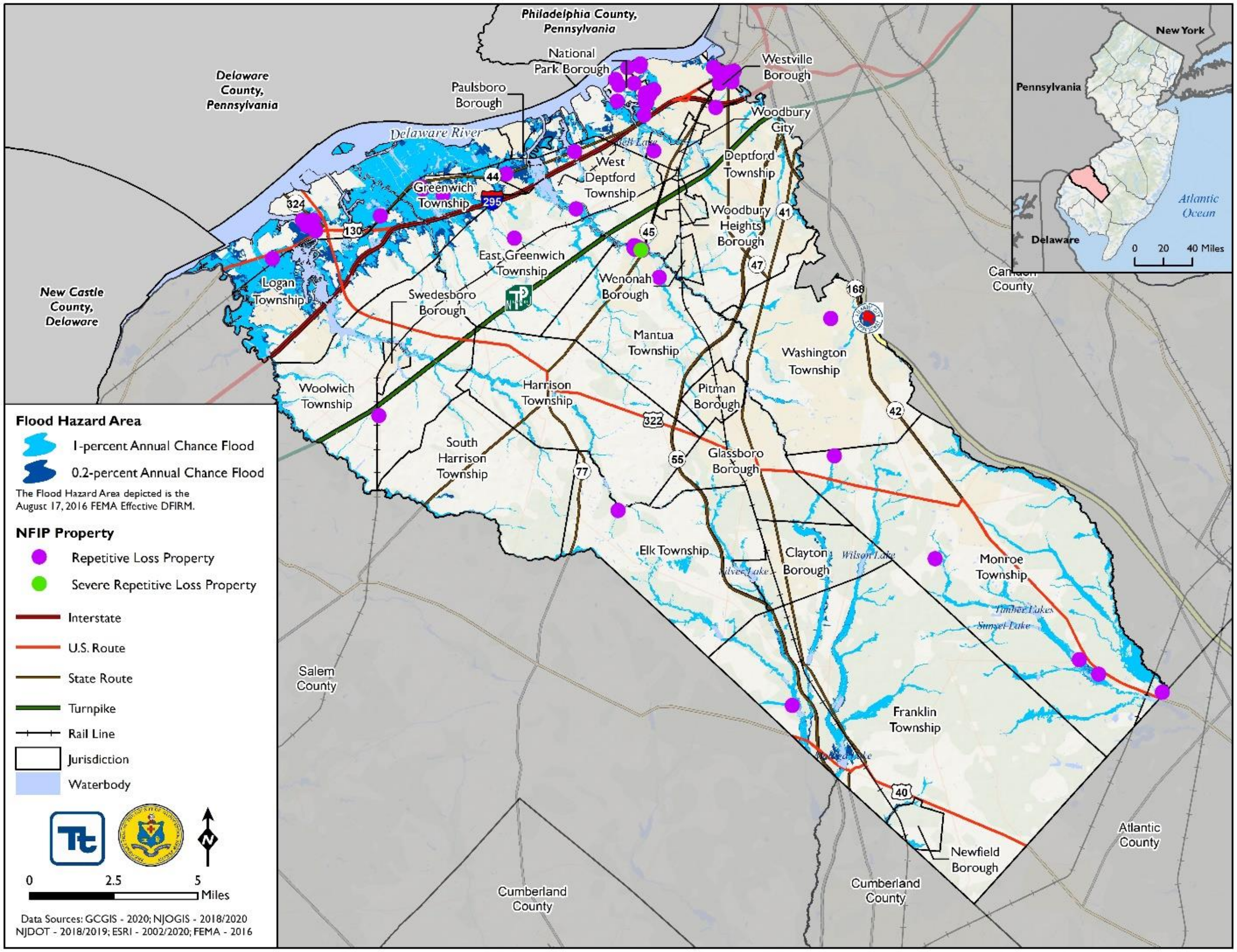
Table 4.3.7-12. NFIP Policies, Claims, and Repetitive Loss Statistics

Jurisdiction	Total Number of Policies	Total Claims	Total Payments	Number of NFIP Repetitive Loss (RL) Properties (Excludes SRL)	Number of NFIP Severe Repetitive Loss (SRL) Properties (Excludes RL)	Number of Mitigated RL/SRL Properties
Clayton (B)	13	8	$95,164	0	0	0
Deptford (Twp)	68	15	$81,400	1	0	0
East Greenwich (Twp)	17	10	$25,157	2	0	0
Elk (Twp)	11	8	$53,921	1	0	0
Franklin (Twp)	21	10	$106,635	1	0	0
Glassboro (B)	21	4	$3,033	0	0	0
Greenwich (Twp)	238	102	$189,353	4	0	0
Harrison (Twp)	16	2	$18,338	0	0	0
Logan (Twp)	59	31	$239,991	7	0	0
Mantua (Twp)	21	25	$342,122	6	0	0
Monroe (Twp)	63	43	$180,898	5	0	0
National Park (B)	69	67	$339,901	7	0	0
Newfield (B)	0	0	$0	0	0	0
Paulsboro (B)	48	37	$74,611	1	0	0
Pitman (B)	5	0	$0	0	0	0
South Harrison (Twp)	4	0	$0	0	0	0
Swedesboro (B)	2	3	$2,699	0	0	0
Washington (Twp)	43	9	$24,745	1	0	0
Wenonah (B)	3	0	$0	0	0	0
West Deptford (Twp)	88	143	$1,433,875	19	1	2

Jurisdiction	Total Number of Policies	Total Claims	Total Payments	Number of NFIP Repetitive Loss (RL) Properties (Excludes SRL)	Number of NFIP Severe Repetitive Loss (SRL) Properties (Excludes RL)	Number of Mitigated RL/SRL Properties
Westville (B)	66	82	$523,000	7	0	2
Woodbury (C)	21	9	$61,269	1	0	0
Woodbury Heights (B)	4	3	$118,015	0	0	0
Woolwich (Twp)	23	6	$129,747	1	0	0
Gloucester County (Total)	**924**	**617**	**$4,043,874**	**64**	**1**	**4**

Source: FEMA Region 2 2019; NFIP Bureau of Statistical Agency 2020
Notes: NFIP - National Flood Insurance Program
**Policies, claims, repetitive loss, and severe repetitive loss statistics provided by FEMA Region 2, and are current as of October 13, 2020 and September 30, 2019, respectively. The number of claims represents claims closed by October 13, 2020. FEMA noted that where there is more than one entry for a property, there may be more than one policy in force or more than one GIS possibility. A zero percentage denotes less than 1/100th percentage, and not zero damages or vulnerability, as may be the case.*

Figure 4.3.7-5. NFIP Repetitive and Severe Repetitive Loss Areas in Gloucester County



Impact on Critical Facilities and Lifelines

It is important to determine the critical facilities and infrastructure that may be at risk to flooding, and who may be impacted should damage occur. Critical services during and after a flood event may not be available if critical facilities are directly damaged or transportation routes to access these critical facilities are impacted. Roads that are blocked or damaged can isolate residents and can prevent access throughout the planning area to many service providers needing to reach vulnerable populations or to make repairs.

Critical facility exposure to the flood hazard was examined. Table 4.3.5-12 lists the critical facilities located in the 1-percent and 0.2-percent annual chance flood boundaries. There are 81 critical facilities located in the 1-percent annual chance flood event boundary. Additionally, there are 115 critical facilities located in the 0.2-percent annual chance flood event boundary. A majority of the critical facilities located in the 1-percent and 0.2-percent annual chance flood event boundaries are in the Township of West Deptford.

In cases where short-term functionality is impacted by flooding, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce flood impacts to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs.

Table 4.3.7-13. Critical Facilities Located in the 1-Percent and 0.2-Percent Annual Chance Event Floodplain

Jurisdiction	Total Number of Critical Facilities	Number of Critical Facilities Located in the 1-Percent Annual Chance Flood Zone	Number of Critical Facilities Located in the 0.2-Percent Annual Chance Flood Zone
Clayton (B)	25	0	0
Deptford (Twp)	77	5	5
East Greenwich (Twp)	46	0	0
Elk (Twp)	6	0	0
Franklin (Twp)	35	0	0
Glassboro (B)	137	4	4
Greenwich (Twp)	31	15	20
Harrison (Twp)	26	0	0
Logan (Twp)	50	7	13
Mantua (Twp)	30	1	2
Monroe (Twp)	26	0	0
National Park (B)	41	4	5
Newfield (B)	9	0	0
Paulsboro (B)	29	15	22
Pitman (B)	19	0	0
South Harrison (Twp)	12	0	0

Jurisdiction	Total Number of Critical Facilities	Number of Critical Facilities Located in the 1-Percent Annual Chance Flood Zone	Number of Critical Facilities Located in the 0.2-Percent Annual Chance Flood Zone
Swedesboro (B)	9	0	0
Washington (Twp)	75	0	0
Wenonah (B)	4	0	0
West Deptford (Twp)	149	18	29
Westville (B)	21	3	6
Woodbury (C)	59	8	8
Woodbury Heights (B)	9	0	0
Woolwich (Twp)	16	1	1
Gloucester County (Total)	**941**	**81**	**115**

Sources: FEMA 2016; Gloucester County Planning Partners - 2021; HIFLD - 2020; EPA – 2021
Note: B – Borough; C - City; Twp – Township

Table 4.3.7-14. Critical Facilities within the 1-percent Annual Chance Flood Boundary

Jurisdiction	Number of Critical Facilities Located in the 1-percent Annual Chance Flood Event Hazard Area													
	Dam	DPW	EMS	Fire Station	Hazardous Material Facility	Medical Center	Police Station	Port Facility	Post-Secondary Education	Potable Water Facility	Primary Education	Secondary Education	Wastewater Metering Station	Wastewater Pump Station
Clayton (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deptford (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	5	0
East Greenwich (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elk (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Franklin (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glassboro (B)	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Greenwich (Twp)	0	0	0	2	6	0	0	2	0	0	4	1	0	0
Harrison (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Logan (Twp)	0	0	0	0	3	0	0	1	0	3	0	0	0	0
Mantua (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Monroe (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
National Park (B)	0	0	0	0	1	0	0	1	0	1	0	0	0	1
Newfield (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paulsboro (B)	0	0	1	0	3	1	1	8	0	0	0	0	0	1
Pitman (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Harrison (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swedesboro (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wenonah (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Deptford (Twp)	0	0	0	0	1	0	0	2	0	0	1	2	2	10
Westville (B)	0	2	0	0	0	0	0	0	0	0	0	0	0	1
Woodbury (C)	1	0	0	0	0	1	0	1	0	0	0	1	4	0
Woodbury Heights (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Woolwich (Twp)	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Gloucester County (Total)	**1**	**2**	**1**	**2**	**14**	**2**	**1**	**16**	**4**	**4**	**5**	**4**	**12**	**13**

Sources: FEMA 2016; Gloucester County Planning Partners - 2021; HIFLD - 2020; EPA - 2021

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Note: B – Borough; C - City; Twp – Township
**Please note that only critical facilities exposed to the flood hazard area are represented in this table. Critical facility types that are found within each municipality but are not exposed to the flood hazard area may not be listed in the table.*

Table 4.3.7-15. Critical Facilities within the 0.2-percent Annual Chance Flood Boundary

Jurisdiction	Number of Critical Facilities Located in the 0.2-percent Annual Chance Flood Event Hazard Area																	
	Board of Education	County Building	Cultural Site	Dam	DPW	EMS	Fire Station	Food Pantry	Hazardous Material Facility	Medical Center	Police Station	Port Facility	Post-Secondary Education	Potable Water Facility	Primary Education	Secondary Education	Wastewater Metering Station	Wastewater Pump Station
Clayton (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deptford (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
East Greenwich (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elk (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Franklin (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glassboro (B)	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Greenwich (Twp)	2	0	0	0	0	0	2	0	7	0	0	3	0	0	4	2	0	0
Harrison (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Logan (Twp)	0	0	0	0	0	0	0	0	3	0	0	1	0	9	0	0	0	0
Mantua (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Monroe (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
National Park (B)	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	1
Newfield (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paulsboro (B)	0	0	0	0	0	2	2	0	4	1	2	9	0	0	1	0	0	1
Pitman (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Harrison (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swedesboro (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wenonah (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Deptford (Twp)	0	0	0	0	0	0	0	2	2	0	0	3	0	0	1	2	3	16
Westville (B)	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	1

Jurisdiction	Number of Critical Facilities Located in the 0.2-percent Annual Chance Flood Event Hazard Area																	
	Board of Education	County Building	Cultural Site	Dam	DPW	EMS	Fire Station	Food Pantry	Hazardous Material Facility	Medical Center	Police Station	Port Facility	Post-Secondary Education	Potable Water Facility	Primary Education	Secondary Education	Wastewater Metering Station	Wastewater Pump Station
Woodbury (C)	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1	4	0
Woodbury Heights (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Woolwich (Twp)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Gloucester County (Total)	**2**	**1**	**1**	**1**	**4**	**2**	**4**	**2**	**17**	**2**	**2**	**19**	**4**	**10**	**6**	**5**	**14**	**19**

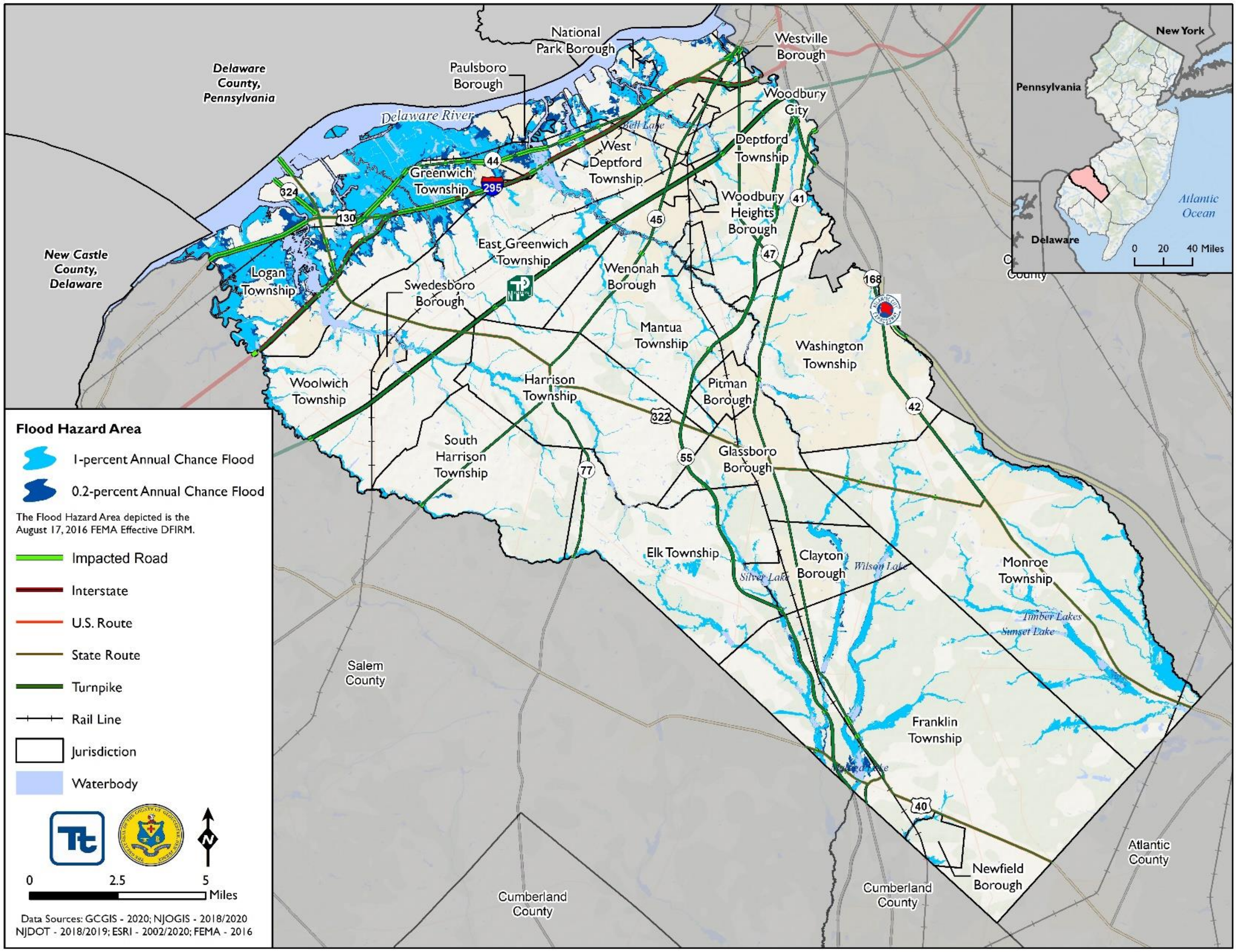
Sources: FEMA 2016; Gloucester County Planning Partners - 2021; HIFLD - 2020; EPA - 2021
Note: B – Borough; C - City; Twp – Township
**Please note that only critical facilities exposed to the flood hazard area are represented in this table. Critical facility types that are found within each municipality but are not exposed to the flood hazard area may not be listed in the table.*

An exposure analysis was conducted to determine how many miles of major highways may be impacted by flood events. Several major roadways are located in the 1-percent annual chance flood hazard area including I295, NJ-42, NJ-44, NJ-45, NJ-47, NJ-55, NJ 168, NJ-322, NJ-324, US-40, and US-130. Approximately 23.3-percent and 46-percent of the total roadway miles within the County are located in the 1-percent and 0.2-percent annual chance flood hazard areas (Table 4.3.7-16). Refer to Figure 4.3.7-6 which illustrates the roadways located in the FEMA flood hazard areas.

Table 4.3.7-16. Number of Miles of Roadway Located in the FEMA Floodplain

		Roadway Miles Located in the Flood Hazard Areas			
Road Type	Total Miles for County	Miles Located in the 1-Percent Annual Chance Flood Area	Percent of Total	Miles Located in the 0.2-Percent Annual Chance Flood Area	Percent of Total
Interstate	34	2	5.8%	7	20.5%
US Route	60	6	10%	9	15%
State Route	125	6	4.8%	10	8.0%
Turnpike	36	1	2.7%	1	2.7%
Gloucester County (Total)	**255**	**15**	**23.3%**	**27**	**46%**

Figure 4.3.7-6. Roads that Intersect the FEMA Floodplain



Impact on the Economy

Flood events can significantly impact the local and regional economy. This includes but is not limited to general building stock damages and associated tax loss, impacts to utilities and infrastructure, business interruption, impacts on tourism, and impacts on the tax base to Gloucester County. In areas that are directly flooded, renovations of commercial and industrial buildings may be necessary, disrupting associated services. Refer to the 'Impact on Buildings' subsection earlier which discusses direct impacts to buildings in Gloucester County. Other economic components such as loss of facility use, functional downtime and socio-economic factors are less measurable with a high degree of certainty.

Flooding can cause extensive damage to public utilities and disruptions to delivery of services. Loss of power and communications may occur and drinking water and wastewater treatment facilities may be temporarily out of operation.

Debris management may also be a large expense after a flood event. Hazus estimates the amount of debris generated from the 1-percent annual chance event. The model breaks down debris into three categories: (1) finishes (dry wall, insulation, etc.); (2) structural (wood, brick, etc.) and (3) foundations (concrete slab and block, rebar, etc.). The distinction is made because of the different types of equipment needed to handle the debris. Table 4.3.7-17 summarizes the debris Hazus estimates for these events. As a result of the 1-percent annual chance event, Hazus estimates approximately 13,134 tons of debris will be generated in total.

Table 4.3.7-17. Estimated Debris Generated from the 1-percent Annual Chance Flood Event

Jurisdiction	1-Percent Annual Chance Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Clayton (B)	6	6	0	0
Deptford (Twp)	856	496	210	150
East Greenwich (Twp)	139	138	0	0
Elk (Twp)	11	11	0	0
Franklin (Twp)	113	113	0	0
Glassboro (B)	74	74	0	0
Greenwich (Twp)	3,841	3,817	13	12
Harrison (Twp)	36	36	0	0
Logan (Twp)	1,122	966	95	60
Mantua (Twp)	121	115	3	2
Monroe (Twp)	57	57	0	0
National Park (B)	852	723	77	52
Newfield (B)	24	24	0	0
Paulsboro (B)	554	526	17	11
Pitman (B)	29	29	0	0
South Harrison (Twp)	161	59	60	42
Swedesboro (B)	72	72	0	0
Washington (Twp)	206	204	2	1
Wenonah (B)	29	29	0	0
West Deptford (Twp)	1,804	825	456	523
Westville (B)	553	553	0	0

Jurisdiction	1-Percent Annual Chance Flood Event Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Woodbury (C)	2,427	1,106	771	550
Woodbury Heights (B)	7	7	0	0
Woolwich (Twp)	40	40	0	0
Gloucester County (Total)	**13,134**	**10,028**	**1,703**	**1,403**

Sources: FEMA 2016; Gloucester County Planning Partners - 2021; HIFLD - 2020; EPA - 2021
Note: B – Borough; C - City; Twp – Township;

Impact on the Environment

Flood extents for the 1- and 0.2-percent annual flood events will continue to evolve alongside natural occurrences such as sea level rise, climate change, and/or severity of storms. Further, residents living in and around areas of wildfire may be at increased risk of flooding in the future due to changes in the natural landscape.

Flood events will inevitably impact Gloucester County's natural and local environment. Severe flooding not only influences the habitat of these natural land areas, but it can also be disruptive to species that reside in these natural habitats. Further, Table 4.3.7-20 lists the number of acres natural land use types within Gloucester County that are at risk to flooding.

Table 4.3.5-20. Acreage of Natural and Beneficial Land Located in the Floodplain

Wetlands	Area in the 1-Percent Annual Chance Floodplain (acres)	Area in the 0.2-Percent Annual Chance Floodplain (acres)
Wetlands	15,475	16,097
Forest	2,068	2,470

Source: NJDEP data used - 2015 LULC data was published in 2019, 2012 LULC data includes 2007 and 2012 LULC published in 2015

Cascading Impacts on Other Hazards

Flood events can exacerbate the impacts of disease outbreak and landslides. After a flooding event, runoff can pick up and transport pollutants from wildlife and soils. Such organisms can then appear in water drinking facilities and transmit illnesses water-borne and vector diseases to the population (WHO, 2020). Flooding can also put additional strain on dams, which may lead to dam failure. More information about these hazards of concern can be found in Section 4.3.1 (Dam and Levee Failure) and Section 4.3.2 (Disease Outbreak).

Future Changes That May Impact Vulnerability

Understanding future changes that affect vulnerability can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

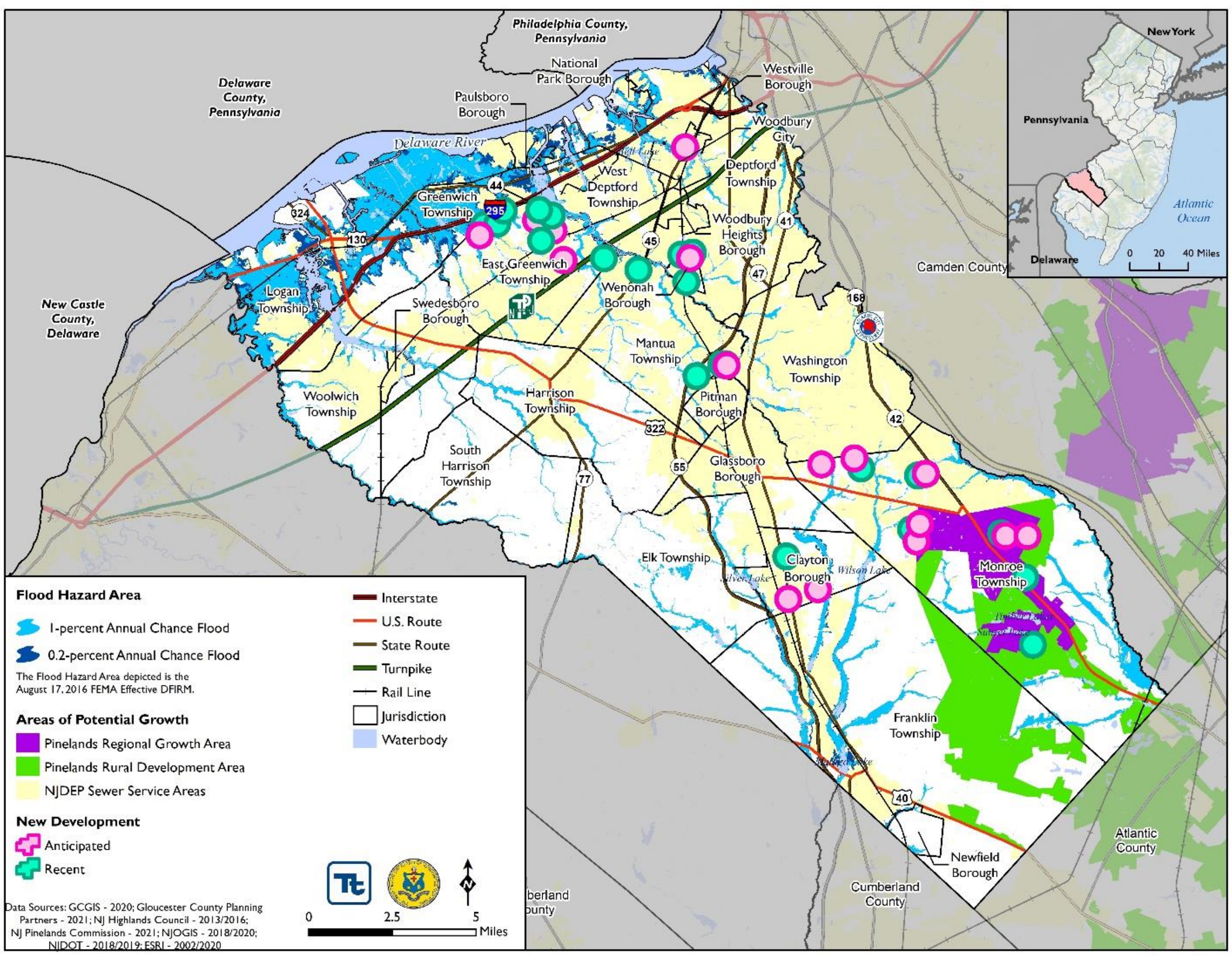
- Potential or projected development

- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. The New Jersey Pinelands Commission has identified areas of potential growth (Regional Growth Areas and Rural Development Areas) in Gloucester County, and NJDEP has delineated Sewer Service Areas that may provide insight as to where potential new development may occur. In addition, each community was requested to provide potential major new development and infrastructure over the next five years; summarized in Section 9 (Jurisdictional Annexes). According to the Gloucester County Planning Partners, there are 38 new development projects that have occurred in the last five years or are anticipated to occur in the next five years. Out of the total new development projects, no sites are located in the 1-percent annual chance flood area or the 0.2-percent annual chance flood area (Figure 4.3.7-7). This new development will be constructed in accordance with current building codes and standards.

Figure 4.3.7-7. Recent and Anticipated New Development and Flood Boundaries in Gloucester County



Projected Changes in Population

Gloucester County has experienced an increase in population of approximately 1.0-percent between 2010 and 2019. According to the ACS 5-year population estimates, in 2019 Gloucester County had a population of 291,165. The Township of Woolwich and the Borough of Glassboro have experienced the greatest increases with an increase of 23.0-percent and 6.7-percent, respectively. As the population increases, so may the number of people impacted by this hazard if an increased number of residents are moving into, or development is occurring the floodplain.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. Annual precipitation amounts in the region are projected to increase, primarily in the form of heavy rainfalls, which have the potential to increase the risk to flash flooding and riverine flooding, and flood critical transportation corridors and infrastructure. Increases in precipitation may alter and expand the floodplain boundaries and runoff patterns, resulting in the exposure of populations, buildings, and critical facilities and infrastructure that were previously outside the floodplain. This increase in exposure would result in an increased risk to life and health, an increase in structural losses, a diversion of additional resources to response and recovery efforts, and an increase in business closures affected by future flooding events due to loss of service or access.

Change of Vulnerability Since 2016 HMP

The FEMA flood maps have not changed since the 2016 HMP; however, the 2022 planning process has resulted in the collection of additional flood problem areas (urban flooding) not reflected on the flood maps. As a result of changes in storm frequency and intensity, it seems as though the County's flood risk continues to increase. This updated HMP utilized more current population statistics, buildings, and infrastructure to provide more accurate results for the exposure and loss estimation analysis. Gloucester County will continue to be vulnerable to the flood hazard.

4.3.8 Geological Hazards

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the geological hazards in Gloucester County.

2022 HMP Update Changes

- All subsections have been updated using best available data.
- Previous occurrences were updated with events that occurred between 2015 and 2021.
- Updated New Jersey Geological Survey and Water landslide susceptibility data (2016) was utilized for the risk assessment.

4.3.8.1Profile

Hazard Description

Geologic hazards are any geological or hydrological processes that pose a threat to humans and natural properties. Every year, severe natural events destroy infrastructure and cause injuries and deaths. Geologic hazards may include volcanic eruptions and other geothermal related features, earthquakes, landslides and other slope failures, mudflows, sinkhole collapses, snow avalanches, flooding, glacial surges and outburst floods, tsunamis, and shoreline movements. For the purpose of this HMP update, only landslides and land subsidence/sinkholes will be discussed.

Areas underlain by carbonate rock may contain surface depressions and open drainage passages making such areas unstable and susceptible to subsidence and surface collapse. As a result, the alteration of drainage patterns, placement of impervious coverage, grade changes or increased loads can result in land subsidence and sinkhole formation (New Jersey Office of Emergency Management 2019).

While fewer karst features have been mapped in existing urban areas, human activity can often be the cause of a subsidence or sinkhole event. Furthermore, the lack of karst features exhibited in maps of urban areas is likely a result of development activities that disguise, cover, or fill existing features rather than an absence of the features themselves. Leaking water pipes or structures that convey stormwater runoff may also result in areas of subsidence as the water dissolves substantial amounts of rock over time. In some cases, construction, land grading, or earthmoving activities that cause changes in stormwater flow can trigger sinkhole events. Subsidence or sinkhole events may occur in the presence of mining activity, especially in areas where the cover of a mine is thin, even in areas where bedrock is not necessarily conducive to their formation. The US Department of Interior indicated that sinkhole development normally occurs where the interval to the ground surface is less than three to five times the thickness of the extracted seam, and the maximum interval is up to ten times the thickness of the extracted seam (J. F. Abel 1980). Sub-surface (i.e. underground) extraction of materials such as oil, gas, coal, metal ores (copper, iron, and zinc), clay, shale, limestone, or water may result in slow-moving or abrupt shifts in the ground surface.

Landslides

According to the U.S. Geological Survey (USGS), the term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors (USGS 2013). Among the contributing factors are: (1) erosion by rivers, glaciers, or ocean waves which create over-steepened slopes; (2) rock and soil slopes weakened through saturation by snowmelt or heavy rains; (3) earthquakes which create stresses making weak slopes fail; and (4) excess weight from rain/snow accumulation, rock/ore stockpiling, waste piles, or man-made structures. Scientists from the USGS also monitor stream flow, noting changes in sediment load in rivers and streams that may result from landslides. All of these types of landslides are considered aggregately in USGS landslide mapping.

In New Jersey, there are four main types of landslides: slumps, debris flows, rockfalls, and rockslides. Slumps are coherent masses that move downslope by rotational slip on surfaces that underlie and penetrate the landslide deposit (Briggs E 2009). A debris flow, also known as a mudslide, is a form of rapid mass movement in which loose soil, rock, organic matter, air, and water mobilize as slurry that flows downslope. Debris flows are often caused by intense surface water from heavy precipitation or rapid snow melt. This precipitation loosens surface matter, thus triggering the slide. Rockfalls are common on roadway cuts and steep cliffs. These landslides are abrupt movements of geological material such as rocks and boulders. Rockfalls happen when these materials become detached. Rockslides are the movement of newly detached segments of bedrock sliding on bedrock, joint, or fault surfaces (Delano 2009).

Although gravity acting on an over-steepened slope is the primary reason for a landslide, there are other contributing factors that include:

- Erosion by rivers, glaciers, or ocean waves create over-steepened slopes
- Rock and soil slopes are weakened through saturation by snowmelt or heavy rains
- Earthquakes create stresses that make weak slopes fail
- Earthquakes of magnitude 4.0 and greater have been known to trigger landslides
- Volcanic eruptions produce loose ash deposits, heavy rain, and debris flows
- Excess weight from accumulation of rain or snow or stockpiling of rock or ore, from waste piles or man-made structures may stress weak slopes to fail (USGS 2021)

Landslides may be triggered by both natural and human-caused changes in the environment. Warning signs for landslide activity include:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavement, or sidewalk

- Soil moving away from foundations
- Ancillary structures, such as decks and patios, tilting and moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls, or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity
- Sudden increase in creek water levels while rain is still falling or just recently ended
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together (USGS, Landslide Preparedness 2021)

Subsidence/Sinkholes

Land subsidence can be defined as the sudden sinking or gradual downward settling of the earth's surface with little or no horizontal motion, owing to the subsurface movement of earth materials (USGS 2000). Subsidence often occurs through the loss of subsurface support in karst terrain, which may result from a number of natural- and human-caused occurrences. Karst describes a distinctive topography that indicates dissolution of underlying carbonate rocks (limestone and dolomite) by surface water or groundwater over time. The dissolution process causes surface depressions and the development of sinkholes, sinking stream, enlarged bedrock fractures, caves, and underground streams (New Jersey Office of Emergency Management 2019).

Sinkholes, the type of subsidence most frequently seen in the New Jersey, though more clustered in the northern part of the state, are a natural and common geologic feature in areas with underlying limestone, carbonate rock, salt beds, or other rocks that are soluble in water (The New Jersey Cooperator 2015). Over periods of time, measured in thousands of years, the carbonate bedrock can be dissolved through acidic rain water moving in fractures or cracks in the bedrock. This creates larger openings in the rock through which water and overlying soil materials will travel. Over time the voids will enlarge until the roof over the void is unable to support the land above will collapse forming a sinkhole. In this example the sinkhole occurs naturally, but in other cases the root causes of a sinkhole are anthropogenic. These anthropogenic causes can include those that involve changes to the water balance of an area such as: over-withdrawal of groundwater; diverting surface water from a large area and concentrating it in a single point; artificially creating ponds of surface water; and drilling new water wells. These actions can serve to accelerate the natural processes of creation of soil voids, which can have a direct impact on sinkhole creation (NJOEM 2019).

Both natural and man-made sinkholes can occur without warning. Slumping or falling fence posts, trees, or foundations, sudden formation of small ponds, wilting vegetation, discolored well water, and/or structural cracks in walls and floors, are all specific signs that a sinkhole is forming. Sinkholes can range in form from steep-walled holes, to bowl, or cone-shaped depressions. When sinkholes occur in developed areas they can cause severe property damage, disruption of utilities, damage to roadways, injury, and loss of life (NJOEM 2019).

Location

In general, while predicting where geologically vulnerable areas is difficult, there are specific areas in the County that have previously experienced these events or have been predicted to have increased vulnerability due to land use change, topographical manipulation, and other human-caused land modifications.

The County is largely composed of low-lying rivers and coastal plains. High elevation in the county is found in the area along Route 654 southeast of Cross Keys that reaches approximately 180 feet (55 m) above sea level; the lowest point is at sea level on the Delaware River. The area most susceptible to landslides is concentrated along the western border of Gloucester County (Peak Bagger 2020).

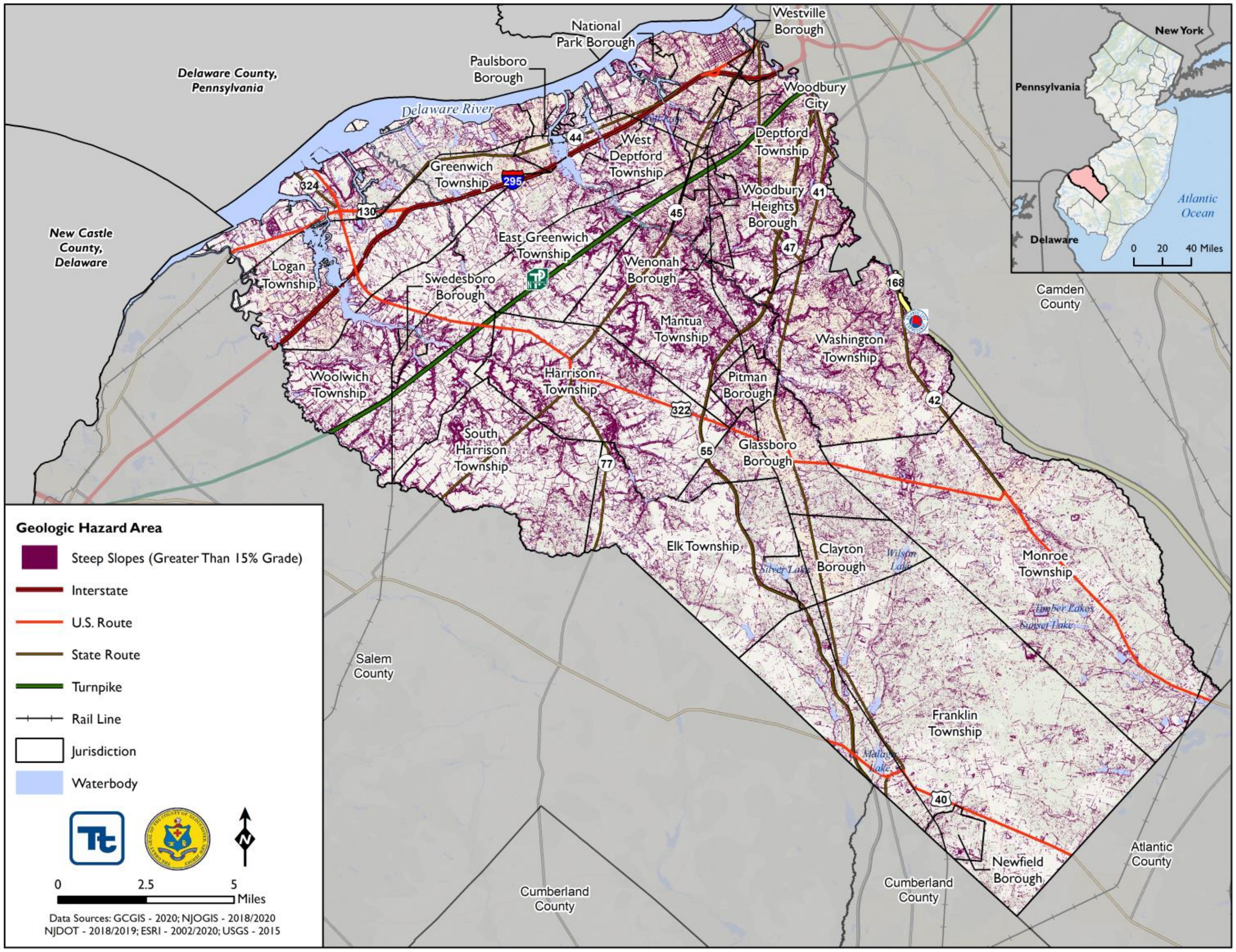
Landslides

Landslides are common in New Jersey, primarily in the northern region of the State. The New Jersey Geologic Survey (currently known as the New Jersey Geological and Water Survey) determined landslide susceptibility is highest in the northern counties. Areas within the northern region are classified into Class A, B, and C landslide susceptible classes, and several subclasses within the main classifications. These classes are consistent with HAZUS User Manual Table 9.2. Class A areas in New Jersey include classes AII, AIV, AVI which is strongly cemented rock at varying slope angles; Class B includes classes BIII, BIV, BV, and BVI which includes weakly cemented rock and soil at varying slope angles; and Class C includes classes CV, CVI, CVII, CIX, and CX which includes shale and clayey soil at varying slope angles.

According to the New Jersey Department of Water Supply and Geoscience, as of 2021, there have been no recorded incidents of landslides within Gloucester County. The closest incident was in northwest Camden County along the Delaware River and was reported to be related to debris flow. However, just because there have been no recorded landslide events, does not mean that the area is safe from any future occurrences. The figure below shows the areas of steep slope that are susceptible to landslide in Gloucester County.

This region is within the Cretaceous Geologic Age zone which is composed of sand, silt and clay which contribute to the susceptibility of landslides in communities along the river. The County has 42.7 square miles of land areas within the moderate susceptibility/low incidence class, which is one of the highest in New Jersey.

Figure 4.3.8-1. Areas of Steep Slopes (Greater Than 15% Grade) that are Susceptible to Landslides in Gloucester County



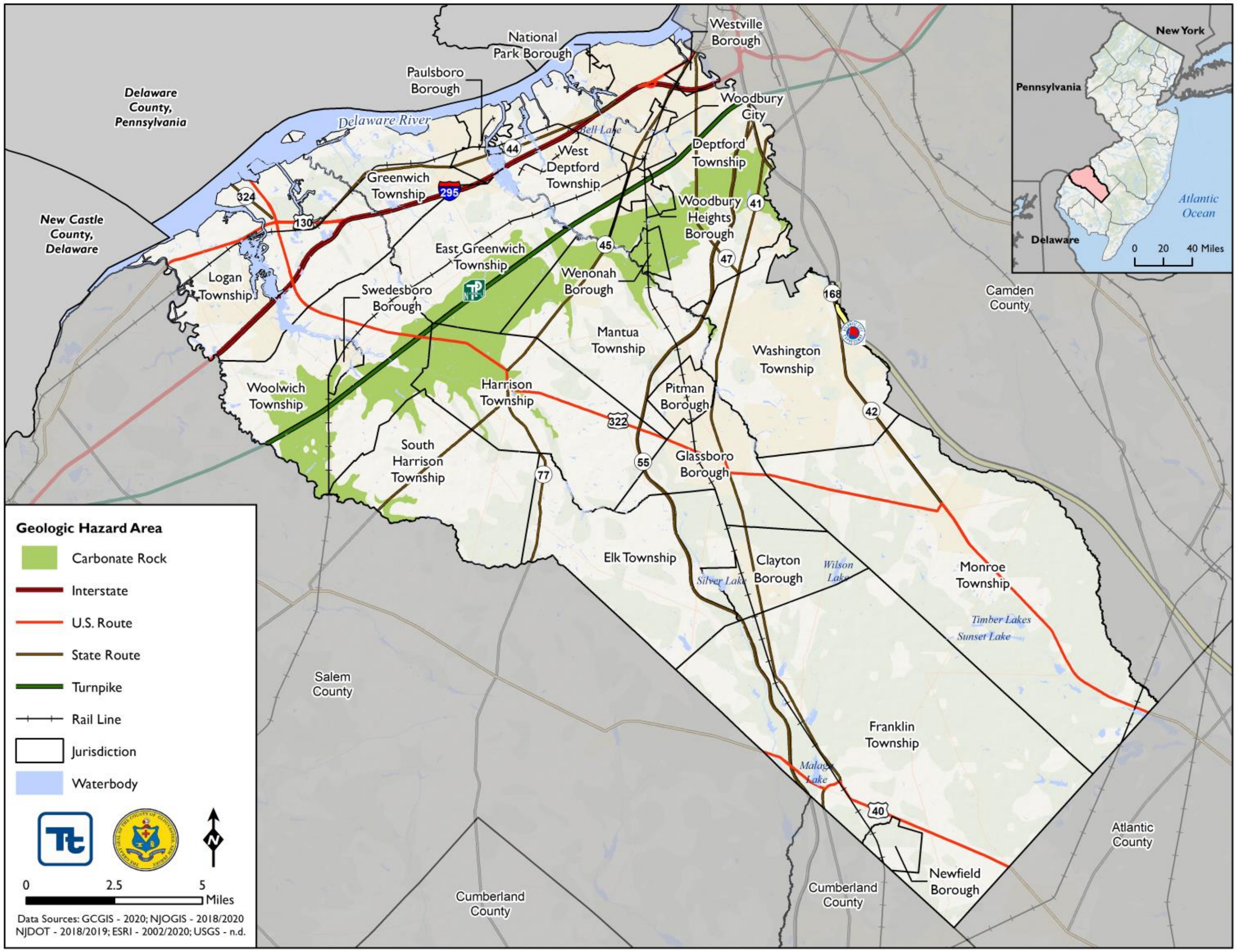
Subsidence/Sinkholes

New Jersey is susceptible to the effects of subsidence and sinkholes, primarily in the northern region of the State. The State's susceptibility to subsidence is due in part to the number of abandoned mines throughout New Jersey. The State historically was an iron-producing state and the first mines in New Jersey were drilled in the early 1700s, with operations continuing until 1986 when the last active mine was closed. Although mines have closed in New Jersey, continued development in the northern part of the State has been problematic because of the extensive mining there which has caused widespread subsidence. One problem is that the mapped locations of some of the abandoned mines are not accurate. Another issue is that many of the surface openings were improperly filled in, and roads and structures have been built adjacent to or on top of these former mine sites.

Naturally occurring subsidence and sinkholes in New Jersey occur within bands of carbonate bedrock. In northern New Jersey, there are more than 225 square miles that are underlain by limestone, dolomite, and marble which make the region more susceptible to subsidence, compared to the south. However, it is worth noting that there are regions within Gloucester County that are susceptible to land subsidence due to presence of carbonate rock.

Figure 4.3.8-2 illustrates the locations of carbonate-bearing geologic formations of New Jersey. These formations are areas of potential natural subsidence. These geologic units contain a high enough percentage of carbonate minerals such as calcite and/or dolomite for karst features such as sinkholes to form. Some of these units are more prone to sinkhole development than others due to a greater carbonate content in the rock. Although not every unit listed has documented sinkholes, all are susceptible to dissolution by groundwater so various karst features, including sinkholes, may be found on any of these units.

Figure 4.3.8-2. Carbonate Rock Locations in Gloucester County



Extent

Landslide

To determine the extent of a landslide hazard, the affected areas need to be identified and the probability of the landslide occurring within some time period needs to be assessed. Natural variables that contribute to the overall extent of potential landslide activity in any particular area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult, even under ideal conditions and with reliable information. As a result, the landslide hazard is often represented by landslide incidence and/or susceptibility, as defined below:

- Landslide incidence is the number of landslides that have occurred in a given geographic area. High incidence means greater than 15 percent of a given area has been involved in landsliding; medium incidence means that 1.5 to 15 percent of an area has been involved; and low incidence means that less than 1.5 percent of an area has been involved (Geological Hazards Program Date Unknown).
- Landslide susceptibility is defined as the probable degree of response of geologic formations to natural or artificial cutting, to loading of slopes, or to unusually high precipitation. It can be assumed that unusually high precipitation or changes in existing conditions can initiate landslide movement in areas where rocks and soils have experienced numerous landslides in the past. Landslide susceptibility depends on slope angle and the geologic material underlying the slope. Landslide susceptibility only identifies areas potentially affected and does not imply a time frame when a landslide might occur. High, medium, and low susceptibility are delimited by the same percentages used for classifying the incidence of landsliding Subsidence/Sinkhole (New Jersey Office of Emergency Management 2019).

Subsidence/Sinkholes

Subsidence and sinkholes occur slowly and continuously over time or abruptly for various reasons. Subsidence and sinkholes can occur due to either natural processes (karst sinkholes in areas underlain by soluble bedrock) or as a result of human activities. Subsidence in the U.S. has directly affected more than 17,000 square miles in 45 states, and associated annual costs are estimated to be approximately $125 million. The principal causes of subsidence are aquifer-system compaction, drainage of organic soils, underground mining, hydrocompaction, natural compaction, sinkholes, and thawing permafrost (USGS, Measuring Land Subsidence from Space 2000) There are several methods used to measure land subsidence. Global Positioning System (GPS) is a method used to monitor subsidence on a regional scale. Benchmarks (geodetic stations) are commonly space around four miles apart (California Department of Water Resources 2015).

Another method which is becoming increasingly popular is Interferometric Synthetic Aperture Radar (InSAR). InSAR is a remote sensing technique that uses radar signals to interpolate land surface elevation changes. It is a cost-effective solution for measuring land surface deformation for a region while offering a high degree of spatial detail and resolution (State of California 2014).

Previous Occurrences and Losses

Various sources provide historical information regarding previous occurrences and losses associated with geologic hazards throughout the State of New Jersey and Gloucester County; therefore, the loss and impact information for many events varies depending on the source. The accuracy of monetary figures discussed is based only on the available information in cited sources.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2020, FEMA issued a disaster (DR) or emergency (EM) declaration for the State of New Jersey for one geological hazard-related event, classified as a mudslide. Of those events, Gloucester County has not been included any declarations (EM and DR) (FEMA 2021).

U.S. Department of Agriculture Disaster Declarations

The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Gloucester County was not included in declarations related to geologic hazards from 2015 to 2021 (USDA 2021)

Previous Events

There are no reported geological hazard events in Gloucester County. There has only been one documented geological event that occurred in the region, specifically in Gloucester County (New Jersey Office of Emergency Management 2019).

Probability of Future Occurrences

Based upon risk factors for and past occurrences, it is unlikely, yet possible that geological hazards will occur in Gloucester County in the future. It is estimated that Gloucester County might see an increase in geological related events in the future, with increasing intense weather events, erosion, and decrepit and abandoned underground infrastructure.

In Section 4.1, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for geological hazards in the County is considered ‘unlikely’ (not likely to occur or less than 1 percent annual chance of occurring).

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020) which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo, Climate change impacts in the United States 2014) and the world (1.5° F [0.8° C]) (IPCC 2016). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (R. D. Horton 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date (Runkle, New Jersey State Climate Summary 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more (Walsh 2014) and with more intensity (Huang 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan 2014). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011).

A warmer atmosphere means storms have the potential to be more intense (Guilbert 2015) and occur more often (Broccoli 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

4.3.8.2 Vulnerability Assessment

To evaluate the geological hazard in Gloucester County, slopes above 15-percent were selected using the 2015 USGS 1-Meter Digital Elevation Model (DEM). Additionally, the USGS carbonate rock layer was used to identify the geologic hazard area. The following text summarizes the potential impact of geological hazards on the County. Refer to Section 4.2 (Methodology and Tools) for additional details on the methodology used to assess geological hazard risk.

Impact on Life, Health, and Safety

Generally, a landslide, subsidence or sink hole event is an isolated incidence and impacts the populations within the immediate area. Specifically, the population located downslope of the landslide hazard areas are particularly vulnerable. In addition to causing damages to residential buildings and displacing residents, geologic hazard events can block off or damage major roadways and inhibit travel for emergency responders or populations trying to evacuate the area.

Table 4.3.8-1 summarizes the population living on landscapes with carbonate bedrock susceptible to subsidence or sink hole events and on landscapes with slopes greater than or equal to 15-percent susceptible to landslide events. Overall, 32,985 persons and 6,619 persons are living on carbonate bedrock or landscapes with slopes greater than or equal to 15-percent, respectively. The Borough of Wenonah and the Township of Woolwich have the greatest proportion of their populations exposed to the carbonate bedrock geologic hazard area or landslide susceptible areas with landscape slopes greater than or equal to 15-percent, respectively.

Table 4.3.8-1. Estimated Population Living in the Geologic Hazard Areas

Jurisdiction	Total Population (American Community Survey 2015-2019)	Estimated Population Located in the Geologic Hazard Areas			
		Number of Persons Located in the Carbonate Rock Hazard Area	Percent of Total	Number of Persons Located in the Steep Slopes (Greater Than 15% Grade) Hazard Area	Percent of Total
Clayton (B)	8,626	0	0.0%	48	0.6%
Deptford (Twp)	30,448	12,475	41.0%	743	2.4%
East Greenwich (Twp)	10,488	3,108	29.6%	383	3.7%
Elk (Twp)	4,135	0	0.0%	108	2.6%
Franklin (Twp)	16,440	0	0.0%	64	0.4%
Glassboro (B)	19,826	0	0.0%	282	1.4%
Greenwich (Twp)	4,831	0	0.0%	28	0.6%
Harrison (Twp)	12,995	3,133	24.1%	754	5.8%
Logan (Twp)	5,924	0	0.0%	25	0.4%
Mantua (Twp)	14,941	4,810	32.2%	704	4.7%
Monroe (Twp)	36,789	0	0.0%	94	0.3%
National Park (B)	2,959	0	0.0%	19	0.6%
Newfield (B)	1,521	0	0.0%	10	0.6%
Paulsboro (B)	5,904	0	0.0%	10	0.2%
Pitman (B)	8,805	0	0.0%	126	1.4%
South Harrison (Twp)	3,148	57	1.8%	201	6.4%
Swedesboro (B)	2,579	619	24.0%	88	3.4%
Washington (Twp)	47,833	64	0.1%	1,233	2.6%
Wenonah (B)	2,259	2,218	98.2%	92	4.1%
West Deptford (Twp)	21,149	1,378	6.5%	254	1.2%
Westville (B)	4,169	0	0.0%	73	1.7%
Woodbury (C)	9,861	0	0.0%	97	1.0%
Woodbury Heights (B)	2,986	598	20.0%	150	5.0%

Jurisdiction	Total Population (American Community Survey 2015-2019)	Estimated Population Located in the Geologic Hazard Areas			
		Number of Persons Located in the Carbonate Rock Hazard Area	Percent of Total	Number of Persons Located in the Steep Slopes (Greater Than 15% Grade) Hazard Area	Percent of Total
Woolwich (Twp)	12,549	4,524	36.1%	1,033	8.2%
Gloucester County (Total)	**291,165**	**32,985**	**11.3%**	**6,619**	**2.3%**

Source: American Community Survey (ACS) 2015 – 2019; USGS 2015/n.d.

Notes: B = Borough, C = City, Twp = Township; % = Percent

Research has also shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. For example, persons over the age of 65 and people below the poverty level are most vulnerable to geologic hazards because of the potential limited access to mobilization or medical resources if a landslide, subsidence or sink hole event occurs. According to the 2019 ACS 5-Year Population Estimate, there are 44,794 persons over 65 years old and 21,340 persons living below the poverty level out of the total 291,165 persons that live in Gloucester County. For the two municipalities with the greatest proportion of its population in the geologic hazard areas; over 14-percent and 1.8-percent of the Borough of Wenonah's population is over the age of 65 or living under the poverty level, respectively; and over 10-percent and 3.2-percent of the Township of Woolwich's population is over the age of 65 or living under the poverty level, respectively.

Impact on General Building Stock

In general, the built environment is vulnerable to the geologic hazard if built on soil/geology susceptible to landsliding or sink holes such as carbonate bedrock or slopes that are greater than 15-percent. Geologic hazard areas may destabilize the foundation of structures resulting in monetary losses to businesses and residents. There are 12,425 buildings with a replacement cost value of approximately $9.9 billion built on lands with carbonate bedrock. Furthermore, there are 2,426 buildings with a replacement cost value of approximately $1.9 billion built on lands with slopes greater than 15-percent.

The Township of Deptford has the greatest number of buildings built on carbonate bedrock; 4,615 buildings (40.9-percent of its total building stock) with an estimated replacement cost of $3.8 billion. The Township of Washington has the greatest number of buildings built on landscapes with slopes greater than 15-percent; 433 buildings (2.5-percent of its total building stock) with an estimated replacement cost of $274.2 million. Table 4.3.8-2 and Table 4.3.8-3 summarize the number of buildings built on each geologic hazard area and the total replacement cost of these buildings by municipality.

Table 4.3.8-2. Number and Value of Buildings Built on Lands with Carbonate Bedrock by Municipality

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located in the Carbonate Rock Geologic Hazard Area			
			Number of Buildings Located in the Carbonate Rock Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located in the Carbonate Rock Hazard Area	Percent of Total
Clayton (B)	3,295	$1,933,299,905	0	0.0%	$0	0.0%
Deptford (Twp)	11,284	$10,081,159,584	4,615	40.9%	$3,805,674,797	37.8%
East Greenwich (Twp)	4,346	$2,927,045,409	1,243	28.6%	$736,619,735	25.2%
Elk (Twp)	2,339	$1,784,179,937	0	0.0%	$0	0.0%
Franklin (Twp)	8,432	$5,637,186,975	0	0.0%	$0	0.0%
Glassboro (B)	5,959	$5,816,332,907	0	0.0%	$0	0.0%
Greenwich (Twp)	2,807	$2,734,741,222	0	0.0%	$0	0.0%
Harrison (Twp)	4,817	$4,828,239,008	1,153	23.9%	$1,093,375,153	22.6%
Logan (Twp)	2,805	$6,591,573,691	0	0.0%	$0	0.0%
Mantua (Twp)	6,569	$4,738,271,524	2,042	31.1%	$1,239,253,342	26.2%
Monroe (Twp)	12,553	$8,458,118,166	0	0.0%	$0	0.0%
National Park (B)	1,483	$781,021,288	0	0.0%	$0	0.0%
Newfield (B)	891	$622,948,021	0	0.0%	$0	0.0%
Paulsboro (B)	2,615	$2,076,864,026	0	0.0%	$0	0.0%
Pitman (B)	3,521	$2,916,470,733	0	0.0%	$0	0.0%
South Harrison (Twp)	1,726	$1,494,748,661	70	4.1%	$72,820,627	4.9%
Swedesboro (B)	1,040	$936,236,069	240	23.1%	$204,969,585	21.9%
Washington (Twp)	17,413	$13,732,374,547	22	0.1%	$19,641,405	0.1%
Wenonah (B)	930	$778,702,966	914	98.3%	$753,782,490	96.8%
West Deptford (Twp)	7,561	$9,201,121,261	441	5.8%	$428,348,234	4.7%
Westville (B)	1,733	$1,529,846,612	0	0.0%	$0	0.0%
Woodbury (C)	3,605	$4,139,381,075	0	0.0%	$0	0.0%
Woodbury Heights (B)	1,295	$1,265,332,236	237	18.3%	$161,834,280	12.8%
Woolwich (Twp)	4,074	$4,551,585,778	1,448	35.5%	$1,410,692,807	31.0%
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**12,425**	**11.0%**	**$9,927,012,456**	**10.0%**

Source: Gloucester County GIS 2021; MODIV 2020; RS Means 2021; USGS n.d.
Notes: B = Borough, C = City, Twp = Township, % = Percent

Table 4.3.8-3. Number and Value of Buildings Built on Landscapes with Slopes Greater than 15-Percent by Municipality

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located in the Landslide Geologic Hazard Area			
			Number of Buildings Located in the Steep Slope (Greater Than 15% Grade) Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located in the Steep Slope (Greater Than 15% Grade) Hazard Area	Percent of Total
Clayton (B)	3,295	$1,933,299,905	18	0.5%	$6,952,231	0.4%
Deptford (Twp)	11,284	$10,081,159,584	268	2.4%	$207,433,441	2.1%
East Greenwich (Twp)	4,346	$2,927,045,409	148	3.4%	$86,574,864	3.0%
Elk (Twp)	2,339	$1,784,179,937	54	2.3%	$35,798,900	2.0%
Franklin (Twp)	8,432	$5,637,186,975	30	0.4%	$16,684,152	0.3%
Glassboro (B)	5,959	$5,816,332,907	81	1.4%	$56,793,862	1.0%
Greenwich (Twp)	2,807	$2,734,741,222	14	0.5%	$7,170,006	0.3%
Harrison (Twp)	4,817	$4,828,239,008	267	5.5%	$246,179,014	5.1%
Logan (Twp)	2,805	$6,591,573,691	14	0.5%	$18,062,493	0.3%
Mantua (Twp)	6,569	$4,738,271,524	305	4.6%	$220,335,692	4.7%
Monroe (Twp)	12,553	$8,458,118,166	34	0.3%	$24,899,411	0.3%
National Park (B)	1,483	$781,021,288	9	0.6%	$3,514,904	0.5%
Newfield (B)	891	$622,948,021	5	0.6%	$3,963,968	0.6%
Paulsboro (B)	2,615	$2,076,864,026	5	0.2%	$5,103,090	0.2%
Pitman (B)	3,521	$2,916,470,733	54	1.5%	$44,237,536	1.5%
South Harrison (Twp)	1,726	$1,494,748,661	93	5.4%	$92,258,414	6.2%
Swedesboro (B)	1,040	$936,236,069	36	3.5%	$46,119,682	4.9%
Washington (Twp)	17,413	$13,732,374,547	433	2.5%	$274,219,782	2.0%
Wenonah (B)	930	$778,702,966	38	4.1%	$30,993,054	4.0%
West Deptford (Twp)	7,561	$9,201,121,261	85	1.1%	$62,751,059	0.7%
Westville (B)	1,733	$1,529,846,612	29	1.7%	$23,628,586	1.5%
Woodbury (C)	3,605	$4,139,381,075	37	1.0%	$70,152,135	1.7%
Woodbury Heights (B)	1,295	$1,265,332,236	60	4.6%	$32,153,071	2.5%
Woolwich (Twp)	4,074	$4,551,585,778	309	7.6%	$331,283,693	7.3%
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**2,426**	**2.1%**	**$1,947,263,039**	**2.0%**

Source: Gloucester County GIS 2021; MODIV 2020; RS Means 2021; USGS 2015
Notes: B = Borough, C = City, Twp = Township, % = Percent

Impact on Critical Facilities and Lifelines

To estimate potential risk, the critical facility and lifeline inventory was overlaid upon the geologic hazard areas. There are 46 critical facilities built on lands with carbonate bedrock and 26 critical facilities built on landscapes with slopes greater than 15-percent grade. Of the critical facilities exposed to the carbonate bedrock and steep slope hazard areas 43 and 26 are considered lifelines for the County, respectively. Refer to Table 4.3.8-4 and Table 4.3.8-5 which summarize the number of critical facilities and lifelines exposed to the geologic hazard areas by municipality. Additionally, refer to Appendix E for more information about the distribution of critical facilities exposed to the geologic hazard area by type. Overall, education facilities and wastewater metering stations are the most common critical facilities exposed to geologic hazards caused by carbonate rock landscapes and primary education facilities are the most common critical facility type built on steep slopes with greater than 15-percent grade. The critical facilities exposed to the geologic hazard areas are also categorized by the FEMA lifeline categories, refer to Table 4.3.8-6. Out of the FEMA lifelines in the County, critical facilities that provide safety and security to the County are most at risk to impacts from the geologic hazard areas.

Table 4.3.8-4. Number of Critical Facilities and Lifelines Built on the Carbonate Bedrock Geologic Hazard Area

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Located in the Carbonate Rock Geologic Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	0	0.0%	0	0.0%
Deptford (Twp)	79	77	18	22.8%	17	22.1%
East Greenwich (Twp)	46	46	3	6.5%	3	6.5%
Elk (Twp)	6	6	0	0.0%	0	0.0%
Franklin (Twp)	35	35	0	0.0%	0	0.0%
Glassboro (B)	137	137	0	0.0%	0	0.0%
Greenwich (Twp)	31	31	0	0.0%	0	0.0%
Harrison (Twp)	26	26	1	3.8%	1	3.8%
Logan (Twp)	50	50	0	0.0%	0	0.0%
Mantua (Twp)	30	30	5	16.7%	5	16.7%
Monroe (Twp)	29	26	0	0.0%	0	0.0%
National Park (B)	41	41	0	0.0%	0	0.0%
Newfield (B)	9	9	0	0.0%	0	0.0%
Paulsboro (B)	29	29	0	0.0%	0	0.0%
Pitman (B)	19	19	0	0.0%	0	0.0%
South Harrison (Twp)	12	12	0	0.0%	0	0.0%
Swedesboro (B)	9	9	3	33.3%	3	33.3%
Washington (Twp)	75	75	0	0.0%	0	0.0%
Wenonah (B)	4	4	4	100.0%	4	100.0%
West Deptford (Twp)	157	149	4	2.5%	2	1.3%
Westville (B)	23	21	0	0.0%	0	0.0%
Woodbury (C)	59	59	0	0.0%	0	0.0%
Woodbury Heights (B)	9	9	0	0.0%	0	0.0%
Woolwich (Twp)	16	16	8	50.0%	8	50.0%
Gloucester County (Total)	**956**	**941**	**46**	**4.8%**	**43**	**4.6%**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; USGS 2015/n.d.
Notes: B = Borough, C = City, T = Township, % = Percent

Table 4.3.8-5. Number of Critical Facilities and Lifelines Built on the Steep Slope (Greater Than 15-Percent Grade) Geologic Hazard Area

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Located in the Steep Slope (Greater Than 15% Grade) Geologic Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	1	4.0%	1	4.0%
Deptford (Twp)	79	77	4	5.1%	4	5.2%
East Greenwich (Twp)	46	46	0	0.0%	0	0.0%
Elk (Twp)	6	6	0	0.0%	0	0.0%
Franklin (Twp)	35	35	1	2.9%	1	2.9%
Glassboro (B)	137	137	2	1.5%	2	1.5%
Greenwich (Twp)	31	31	2	6.5%	2	6.5%
Harrison (Twp)	26	26	0	0.0%	0	0.0%
Logan (Twp)	50	50	1	2.0%	1	2.0%
Mantua (Twp)	30	30	2	6.7%	2	6.7%
Monroe (Twp)	29	26	1	3.4%	1	3.8%
National Park (B)	41	41	1	2.4%	1	2.4%
Newfield (B)	9	9	0	0.0%	0	0.0%
Paulsboro (B)	29	29	2	6.9%	2	6.9%
Pitman (B)	19	19	0	0.0%	0	0.0%
South Harrison (Twp)	12	12	0	0.0%	0	0.0%
Swedesboro (B)	9	9	0	0.0%	0	0.0%
Washington (Twp)	75	75	0	0.0%	0	0.0%
Wenonah (B)	4	4	1	25.0%	1	25.0%
West Deptford (Twp)	157	149	4	2.5%	4	2.7%
Westville (B)	23	21	0	0.0%	0	0.0%
Woodbury (C)	59	59	2	3.4%	2	3.4%
Woodbury Heights (B)	9	9	2	22.2%	2	22.2%
Woolwich (Twp)	16	16	0	0.0%	0	0.0%
Gloucester County (Total)	**956**	**941**	**26**	**2.7%**	**26**	**2.8%**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; USGS 2015/n.d.
Notes: B = Borough, C = City, T = Township, % = Percent

Table 4.3.8-6. Number of Lifelines Categorized by FEMA Lifeline Categories Exposed to the Geologic Hazard Areas

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the Carbonate Rock Hazard Area	Number of Lifelines Located in the Steep Slope (Greater Than 15% Grade) Hazard Area
Energy	5	0	0
Food, Water, Shelter	214	15	6
Hazardous Materials	116	5	2
Health and Medical	102	6	0
Safety and Security	481	17	14
Transportation	23	0	4
Gloucester County (Total)	**956**	**43**	**26**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; USGS 2015/n.d.

In addition to critical facilities, a significant amount of infrastructure can be exposed to mass movements of geological material:

- *Roads*—Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations. Landslides can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems, and delays for public and private transportation. This can result in economic losses for businesses.
- *Bridges*—Landslides can significantly impact road bridges. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use.
- *Power Lines*—Power lines are generally elevated above steep slopes; but the towers supporting them can be subject to landslides. A landslide could trigger failure of the soil underneath a tower, causing it to collapse and ripping down the lines. Power and communication failures due to landslides can create problems for vulnerable populations and businesses.
- *Rail Lines*—Similar to roads, rail lines are important for response and recovery operations after a disaster. Landslides can block travel along the rail lines, which would become especially troublesome, because it would not be as easy to detour a rail line as it is on a local road or highway. Many residents rely on public transport to get to work around the County and a landslide event could prevent travel to and from work.

The number of miles major transportation routes are exposed to the geologic hazard areas of concern was assessed and is summarized in Table 4.3.8-7. Out of the 2,040 miles of transportation routes in the County, 235 miles are built on lands with carbonate bedrock. Local roads have the most miles at risk to the geologic hazard area, but the New Jersey Turnpike has the greatest proportion of its miles within the County at risk to the carbonate rock hazard area.

Table 4.3.8-7. Transportation Routes Located in the Carbonate Rock Geologic Hazard Area

Road Type	Total Miles for County	Roadway Miles Exposed to the Geologic Hazard Areas	
		Miles Exposed to the Carbonate Rock Hazard Area	Percent of Total
County Routes	405	44	10.9%
Interstate	55	0	0.0%
Local Roads	1,329	155	11.7%
State Highway	139	12	8.4%
Turnpike	39	20	51.1%
US Highway	73	4	5.8%
Gloucester County (Total)	**2,040**	**235**	**11.5%**

Source: USGS n.d., NJOIT 2017
Notes: % = Percent

Several other types of infrastructure may also be exposed to the geologic hazards, including water and sewer infrastructure. At this time, all critical facilities, infrastructure, and transportation corridors located within the hazard areas are considered vulnerable until more information becomes available.

Impact on the Economy

Geologic hazards can impose direct and indirect impacts on society. Direct costs include the actual damage sustained by buildings, property, and infrastructure due to ground failure, which also threatens transportation corridors, fuel and energy conduits, and communication lines (USGS 2020). Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity may also occur, but are difficult to measure.

Buildings susceptible to landslide events were summarized earlier in this section. Losses to these structures will impact the local tax base and economy.

Impact on the Environment

A landslide or sinkhole/subsidence event will alter the landscape. In addition to changes in topography, vegetation and wildlife habitats may be damaged or destroyed, forest productivity can decline, or massive wasting and erosion of natural surfaces may occur causing soil and sediment runoff (USGS 2020). Soil and sediment runoff can accumulate downslope potentially blocking waterways and roadways and impacting quality of streams and other water bodies. Habitats stripped of fertile soils can delay the growth of new vegetation post-landslide event.

Steep slopes within the Pinelands Region play an important ecological, recreational, scenic, and functional role. They provide specialized habitats for rare plant and animal species. Areas of steep slope provide recreational opportunities and contribute to the rural character of the Pinelands Region (NJ Pinelands Commission 2021).

Future Changes That May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. The New Jersey Highlands Council has identified areas of potential growth (Sewer Service Areas) that may provide insight as to where potential new development may occur in Gloucester County. Further, the New Jersey Pinelands Commission has identified Pinelands Management Area Boundaries, including regional growth areas and rural development areas that may also provide insight to where development and growth may occur in the County. In addition, each community was requested to provide recent and anticipated new development and infrastructure projects; summarized in Section 9 (Jurisdictional Annexes). According to the Gloucester County Planning Partnership, there are 38 recent or anticipated new development sites in Gloucester County. Of these new development sites, nine are located in the geologic hazard areas.

Gloucester County's municipalities have their own steep slope ordinances in place to regulate the intensity and use in areas of steep slope terrain in order to limit soil loss, erosion, excessive stormwater runoff, excessive removal of vegetation, the degradation of surface water and to maintain the natural topography of land and continuing replenishment of groundwater resources [(South Harrison n.d.), (Harrison n.d.)]. Refer to Figure 4.3.8-3 and Figure 4.3.8-4 which shows the distribution of new development projects and their proximity to the geologic hazard areas.

Projected Changes in Population

Gloucester County has experienced an increase in its population since 2010. According to the U.S. Census Bureau, the County's population increased by approximately 1-percent between 2010 and 2019 (U.S. Census Bureau 2020). Changes in population and density not only create issues for local residents during evacuation of a landslide or ground failure event but can also have an effect on commuters that travel into and out of the County for work, particularly during a geologic event that breaches major transportation corridors, which are also major commuter roads. Refer to Section 3 (County Profile) for more information about population trends in the County.

Climate Change

A direct impact of climate change on landslides is difficult to determine. Multiple secondary effects of climate change have the potential to increase the likelihood of landslides. Warming temperatures resulting in wildfires would reduce vegetative cover along steep slopes and destabilize the soils due to destruction of the root system; increased intensity of rainfall events would increase saturation of soils on steep slopes. Under these future conditions, the County's assets located on or at the base of these steep slopes will have an increased risk to landslides. Roadways and other transportation infrastructure located in these areas will also be at an increased risk of closure, which would impact the County's risk as described above.

Higher temperatures and the possibility of more intense, less frequent summer rainfall may lead to changes in water resource availability. Increase in average temperatures may lead to an increase in the frequency of droughts. Sinkhole activity intensifies in some karst areas during periods of drought. With an increase in drought periods, the number of sinkholes could increase. Additionally, changes to the water balance of an area including over-withdrawal of groundwater, diverting surface water from a large area and concentrating it in a single point, artificially creating ponds of surface water, and drilling new water wells will cause sinkholes. These actions can also serve to accelerate the natural processes of bedrock degradation, which can have a direct impact on sinkhole creation.

Vulnerability Changes Since the 2016 HMP

This updated HMP developed and utilized an updated building stock and critical facility/lifeline inventories to assess the County's risk to the geologic hazard. The building inventory was updated using RS Means 2021 values, which is more current and reflects replacement cost versus the building stock improvement values reported in the 2016 HMP. Further, the 2019 5-year population estimates from the ACS were used to evaluate the population exposed. Additionally, a carbonate rock layer from USGS and the 2015 1-meter Digital Elevation Model (DEM) from USGS were referenced to assess the County's assets to the geologic hazard.

Overall, changes in population, development and climate did not change the County's vulnerability to the geologic hazard. The County remains vulnerable to the geologic hazard.

Figure 4.3.8-3. Recent and Anticipated New Development and Areas of Steep Slopes (Greater than 15-Percent Slope)

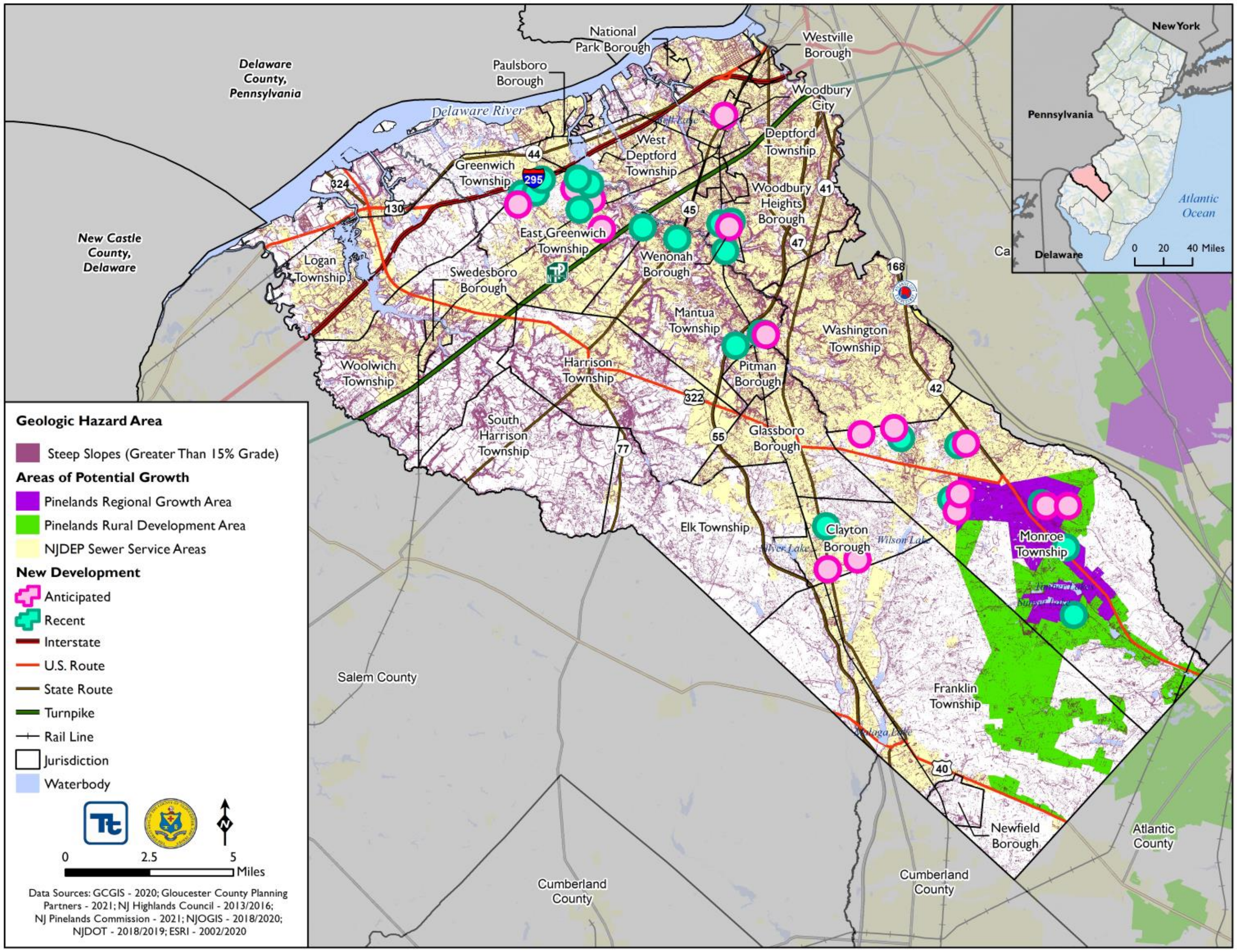
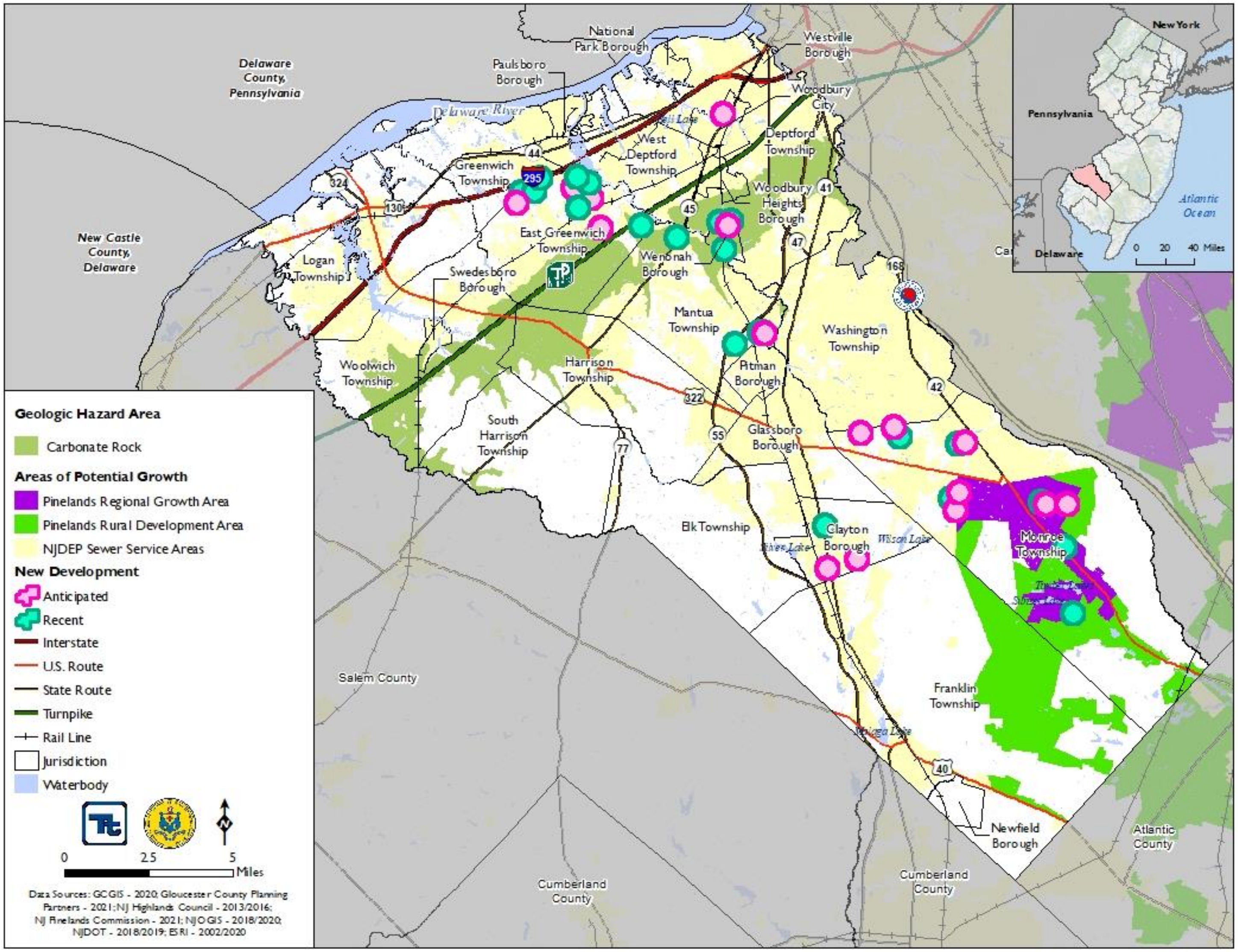


Figure 4.3.8-4. Recent and Anticipated New Development and Carbonate Rock Formations in Gloucester County



4.3.9 Hazardous Materials Release

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the hazardous materials hazard in Gloucester County.

2022 HMP Update Changes

- Hazardous Materials is a new hazard of concern for the 2022 plan update.

4.3.9.1 Profile

Hazard Description

Hazardous substances are materials that are considered severely harmful to human health and the environment, as defined by the United States Environmental Protection Agency (USEPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Superfund Law). Many are commonly used substances which are harmless in their normal uses but are quite dangerous if released. The Superfund law designates more than 800 substances as hazardous and identifies many more as potentially hazardous due to their characteristics and the circumstances of their release (USEPA 2013). Superfund's definition of a hazardous substance includes the following:

- Any element, compound, mixture, solution, or substance designated as hazardous under section 102 of CERCLA.
- Any hazardous substance designated under section 311(b)(2)(a) of the Clean Water Act (CWA), or any toxic pollutant listed under section 307(a) of the CWA. There are over 400 substances designated as either hazardous or toxic under the CWA.
- Any hazardous waste having the characteristics identified or listed under section 3001 of the Resource Conservation and Recovery Act.
- Any hazardous air pollutant listed under section 112 of the Clean Air Act, as amended. There are over 200 substances listed as hazardous air pollutants under the Clean Air Act (CAA).
- Any imminently hazardous chemical substance or mixture which the EPA Administrator has "taken action under" section 7 of the Toxic Substances Control Act (USEPA 2013).

If released or misused, hazardous substances can cause death, serious injury, long-lasting health effects, and damage to structures and other properties, as well as the environment. Many products containing hazardous substances are used and stored in homes and these products are shipped daily on highways, railroads, waterways, and pipelines.

Transportation of hazardous substances on highways involves tanker trucks or trailers, which are responsible for the greatest number of hazard substance release incidents. New Jersey is composed of approximately

39,000 miles of highway, many of which are used to transport hazardous substances (New Jersey Department of Transportation [NJDOT] 2019). These roads cross rivers and streams at many points; hazardous substance spills on roads have the potential to pollute watersheds that serve as domestic water supplies for parts of the State. Potential also exists for hazardous substance releases to occur along rail lines as collisions and derailments of train cars can result in large spills.

Oil is shipped by rail throughout New Jersey and it is anticipated that liquefied natural gas (LNG) will be shipped into and out of Gloucester County in the near future by rail onto ships. The adoption of hydraulic fracturing ("fracking") to extract oil and gas has led to an increase in the production and shipment of energy products. Lack of pipelines connecting the energy-producing regions with refineries or ports, coupled with the flexibility that railroad transportation provides, have resulted in significant shipments of oil by rail. Major commodities shipped by rail include petrochemicals (including plastic pellets and crude oil), construction materials, food products, raw materials and finished goods for manufacturers (NJ DOT 2018).

Pipelines can also transport hazardous liquids and flammable substances such as natural gas and petroleum. Incidents can occur when pipes corrode, when they are damaged during excavation, incorrectly operated, or damaged by other forces. In New Jersey, most of the large pipeline leaks have been caused by marine traffic hitting or the anchors of ships effecting pipelines in the waterways. In addition, hazardous substances can be transported by aircraft or by watercraft. Crashes, spills of materials, and fires on these vessels can pose a hazard.

Nuclear incidents can also be considered a form of environmental hazard. Nuclear incidents generally refer to incidents involving (1) release of significant levels of radioactive materials or (2) exposure of workers or the general public to radiation. Primary concerns following a nuclear incident or accident are: impact on public health from direct exposure to a radioactive plume; inhalation of radioactive materials; ingestion of contaminated food, water, and milk; and long-term exposure to deposited radioactive materials in the environment that may lead to either acute (radiation sickness or death) or chronic (cancer) health effects.

Location

Hazardous Substances Fixed Site

Historically, wastes were dumped on the ground, in rivers, or left out in the open. As a result, thousands of uncontrolled or abandoned contaminated sites were created. These sites included abandoned warehouses, manufacturing facilities, processing plants, and landfills. In response to concerns regarding health and environmental risks, Congress established the Superfund program in 1980 to clean up these sites. The Superfund program is administered by the USEPA in cooperation with individual states. In New Jersey, the Department of Environmental Protection (NJDEP) Site Remediation Program oversees the Superfund program (NJDEP 2020).

Federal regulations include the CERCLA and the Superfund Amendments and Reauthorization Act (SARA) required that a National Priorities List (NPL) of sites throughout the United States be maintained and revised at least annually (NJDEP 2020a).

Fixed-site facilities that use, manufacture, or store hazardous substances in New Jersey pose risk and must comply with Title III of the federal SARA. SARA was signed into law on October 17, 1986. It is a federal law that applies nationwide. It must be realized that this law is linked to N.J.S.A. 34:5A, the New Jersey Worker and Community Right to Know Act. SARA requires the governor of each state to establish a State Emergency Response Commission (SERC). New Jersey's SERC was established by Executive Order on February 13, 1987. SARA also requires that the emergency planning districts be established by the SERC. The Act specified that these districts can be existing political subdivisions. The function of the emergency planning district is to facilitate preparation and implementation of emergency plans. In New Jersey, all municipalities and counties have been designated emergency planning districts (total of 588). The Local Emergency Planning Committees (LEPC) is the policy body for the emergency planning district (New Jersey Division of Fire Safety 2021).

The State enacted the Toxic Catastrophe Prevention Act (TCPA), N.J.S.A. 13:1K-19 et seq. Currently, implementation of the requirements established under this Act is facilitated by the TCPA Program. Certain industrial facilities using materials considered extraordinarily hazardous must take steps to prevent releases and protect public safety. New Jersey has also mandated that facilities storing large quantities of hazardous substances take preventative measures to reduce the likelihood of a leak or discharge. Established under the New Jersey Spill Compensation and Control Act (N.J.S.A. 58:10-23.11), these requirements include testing and inspection of storage tanks, training of employees, and emergency response planning. The Discharge Prevention Containment and Countermeasure (DPCC) program facilitates implementation of these requirements. Regulations related to reporting of chemical and petroleum discharges are also administered under this program. The Program is sometimes referred to by the acronym DPCC, which refers to an important preparedness document that major facilities develop under the program (NJ 2019).

The Community Right to Know (CRTK) program collects, processes, and disseminates the chemical inventory, environmental release and materials accounting data required to be reported under the New Jersey Worker and Community Right to Know Act, N.J.S.A.34:5A and the federal Emergency Planning and Community Right to Know Act of 1986 (EPCRA). EPCRA is also known as Title III of the SARA. This information is used by the public, emergency planners, and first responders to determine the chemical hazards in the community (NJDEP 2020b).

The U.S. EPA Hazardous Waste Report, which is a biennial report, collects data on the generation, management, and minimization of hazardous waste. This report provides detailed data on the generation of hazardous waste from large quantity generators and data on waste management practices from treatment, storage, and disposal facilities. The 2019 report lists 51 facilities in Gloucester County (EPA 2019).

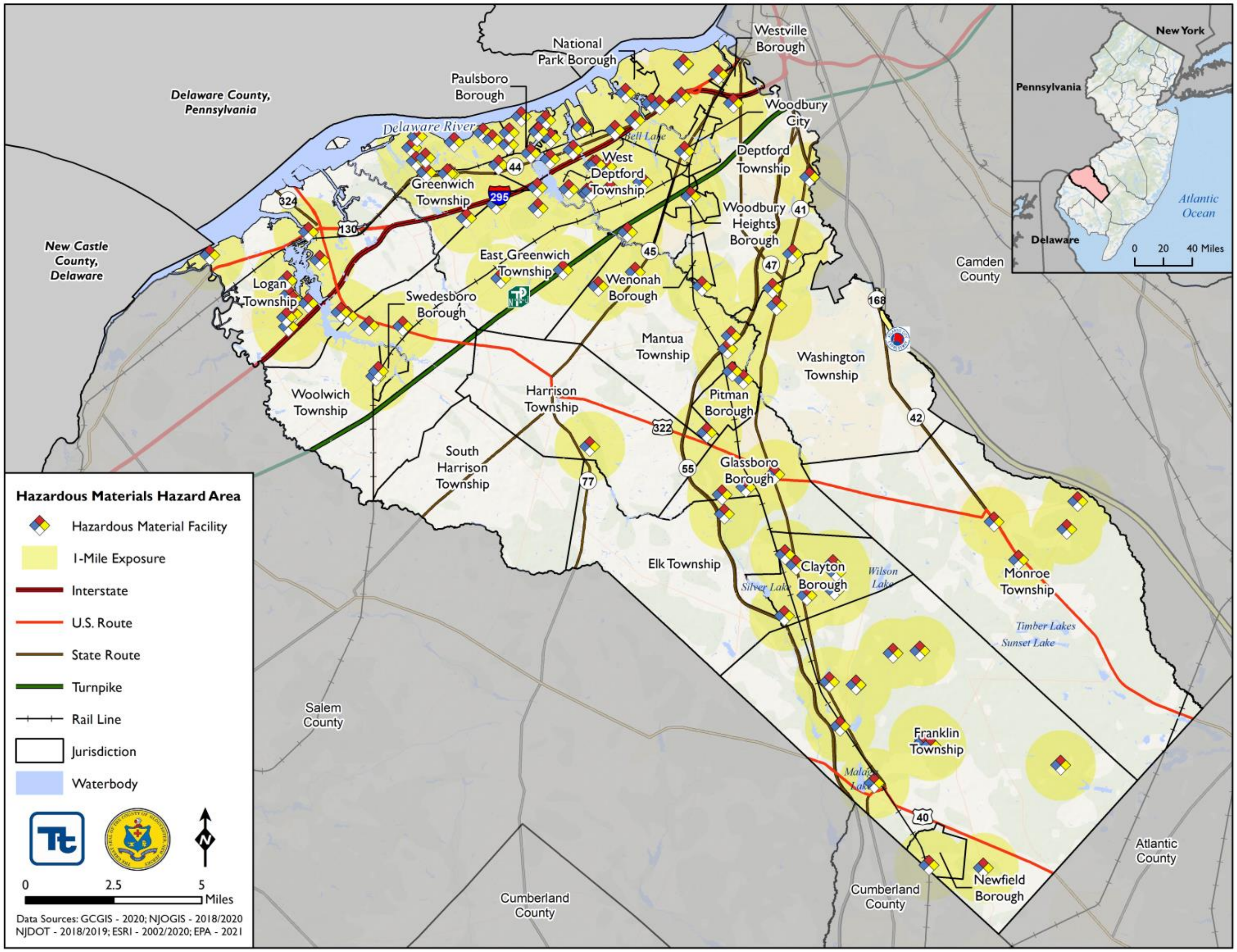
Superfund is a program administered by the U.S. EPA to locate, investigate, and cleanup the worst hazardous waste sites throughout the U.S. Data from the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database indicated that Gloucester County has ten Superfund sites located throughout the County, with the sites located in Bridgeport (2), Franklin Township, Mantua Township, Gibbstown, Pitman, Woolwich, Thorofare, Franklinville, and Newfield (U.S. EPA 2021b).

New Jersey employers, whose businesses are assigned North American Industry Classification System (NAICS) codes listed in the New Jersey Worker and Community Right to Know (CRTK) regulations, are required to submit CRTK surveys listing the environmental hazardous substances (EHSs) present at their facilities in quantities that exceed 500 pounds, unless the EHS is on the federal Emergency Planning and Community Right to Know Act (EPCRA) Section 302 list of extremely hazardous substances with a lower reporting threshold. In addition, Section 312 of EPCRA requires owners and operators of federal facilities and private sector facilities that are subject to the United States Occupational Safety and Health Administration's (OSHA) Hazard Communication Standard to report their inventories of any chemical that requires a Materials Safety Data Sheet (MSDS) and is present on site in quantities that exceed 10,000 pounds, unless the chemical is an Extremely Hazardous Substance with a lower reporting threshold (NJDEP 2018).

Owners and operators of manufacturing, and select non-manufacturing companies, having the equivalent of 10 or more full-time employees, and manufacturing, importing, processing or otherwise using toxic chemicals listed on the EPCRA Section 313 (TRI) list in quantities that exceed specified thresholds, are required to annually report their releases of these chemicals for the previous year. Approximately 500 New Jersey companies are required to file federal Toxic Chemical Release Inventory (TRI) forms. TRI Form R requires the listing of environmental releases, on-site waste management and off-site transfers while the simplified Form A Certification Statement requires the listing of the chemical only. These companies are also required to submit to NJDEP the Release and Pollution Prevention Report (RPPR) listing the quantities of environmental release, on-site waste management, waste transfer, and chemical throughput information. Most of these facilities are also subject to Pollution Prevention Planning Requirements and, therefore, required to report pollution prevention progress information on the RPPR (NJDEP 2018).

Figure 4.3.9-1 shows the locations of fixed site hazardous material facilities in Gloucester County.

Figure 4.3.9-1. Hazardous Material Facilities in Gloucester County

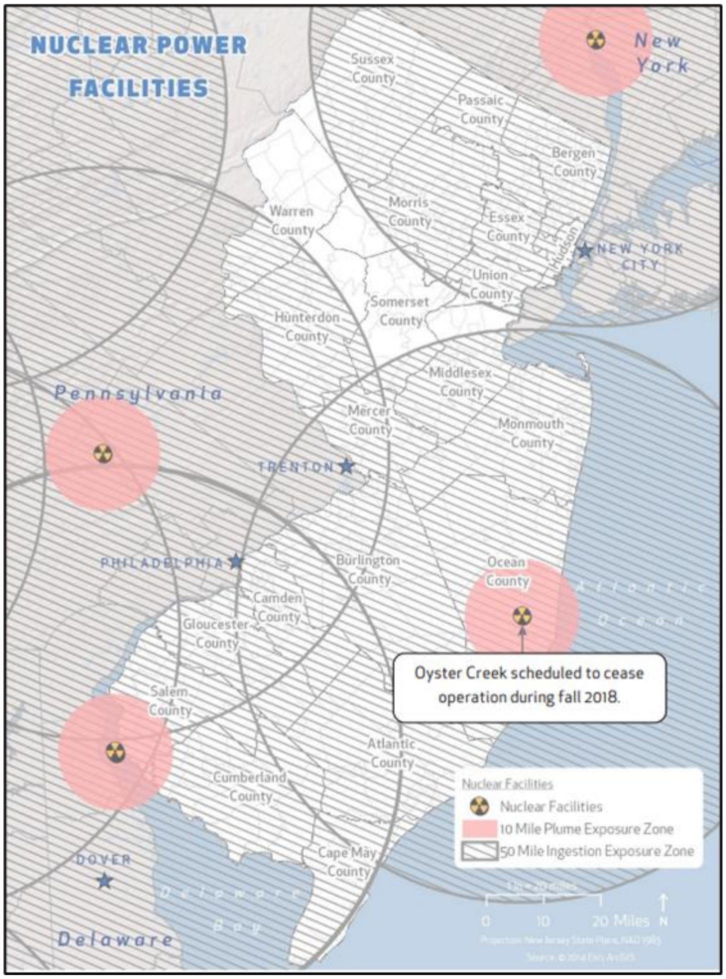


Nuclear Facilities

Although there are no nuclear facilities within Gloucester County limits, the County is within 20 miles of the Hope Creek Generating Station near Salem, New Jersey. The County is also approximately 35 miles from the Limerick Generating Station in Pottstown, Pennsylvania. Oyster Creek Generating Station is located in Forked River, New Jersey (Ocean County). It is in the process of being decommissioned (Holtec 2021). Additionally, Gloucester County is home to a site with low level radiation undergoing decommissioning. The site, Shieldalloy Metallurgical Corporation, is a Superfund site located in Newfield, NJ.

In nuclear preparedness planning, the 10 mile and 50 mile radiuses around nuclear facilities are important location boundaries. The Nuclear Regulatory Commission encourages the use of Probabilistic Risk Assessments (PRA) to estimate quantitatively the potential risk to public health and safety considering the design, operations, and maintenance practices at nuclear power plants. Preparedness plans typically consider the Plume Exposure Pathway Emergency Planning Zone (EPZ), which has a radius of 10 miles from the facility, and the Ingestion Exposure Pathway (IEP), which has a radius of 50 miles from each facility. Gloucester County is located within the 50-mile IEP. Should an accident occur at one of the three facilities within 50 miles of Gloucester County, the area within the IEP could receive some radioactive contamination. Figure 4.3.9-2 provides visual representation of where Gloucester County falls in relation to nuclear power facility’s EPZ and IEP.

Figure 4.3.9-2 EPZs and IEPs in Gloucester County



Source: NJOEM 2019

Hazardous Substances In-Transit

Incidents involving hazardous substances in transit can occur anywhere in Gloucester County. The County has dense and connective road networks, with major roadways such as Route 130, I-295, the New Jersey Turnpike, US-322, NJ Route 55, NJ Route 45, NJ Route 42, NJ Route 47, NJ Route 44, and NJ Route 77 passing through the County. As of November 2019, the portion of US-130/I-295 west of Greenwich saw an average of 71,216 vehicles each day (NJDOT 2021). Gloucester County's freight rail system moved 947,746 tons of freight in 2007 (NJDOT 2014) – the largest amount in South Jersey and the fourth largest in New Jersey overall. Figure 4.3.9-3 shows the major transportation routes in Gloucester County.

Hazardous substances can also be transported via pipeline across the State. New Jersey has an extensive network of natural gas and petroleum pipelines. Several of the petroleum pipelines originate in the Gulf Coast region (Colonial Pipeline and Sunoco Pipeline). Figure 4.3.9-4 shows the extent and locations of pipelines throughout the northeastern United States.

Figure 4.3.9-3. Major Transportation in Gloucester County

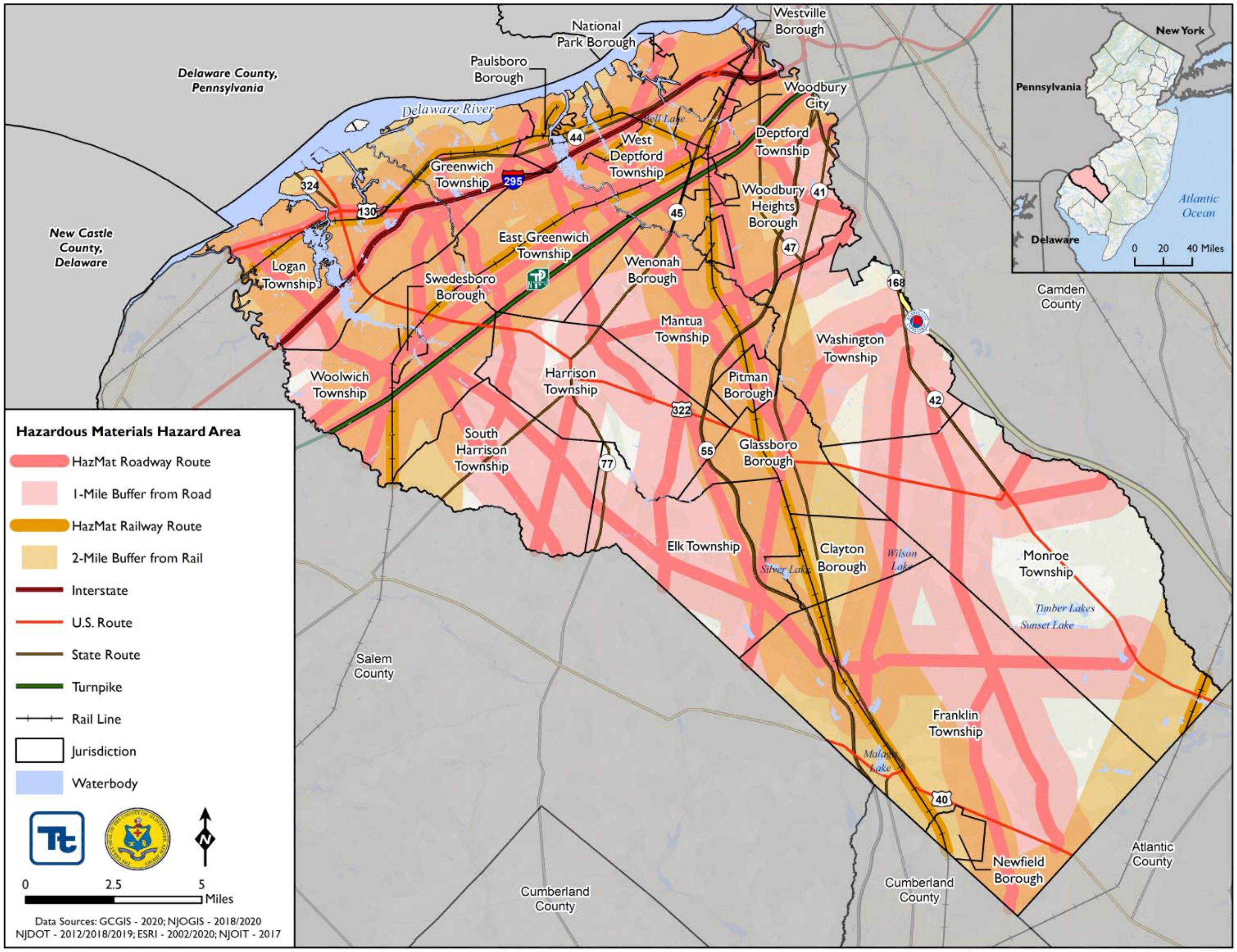
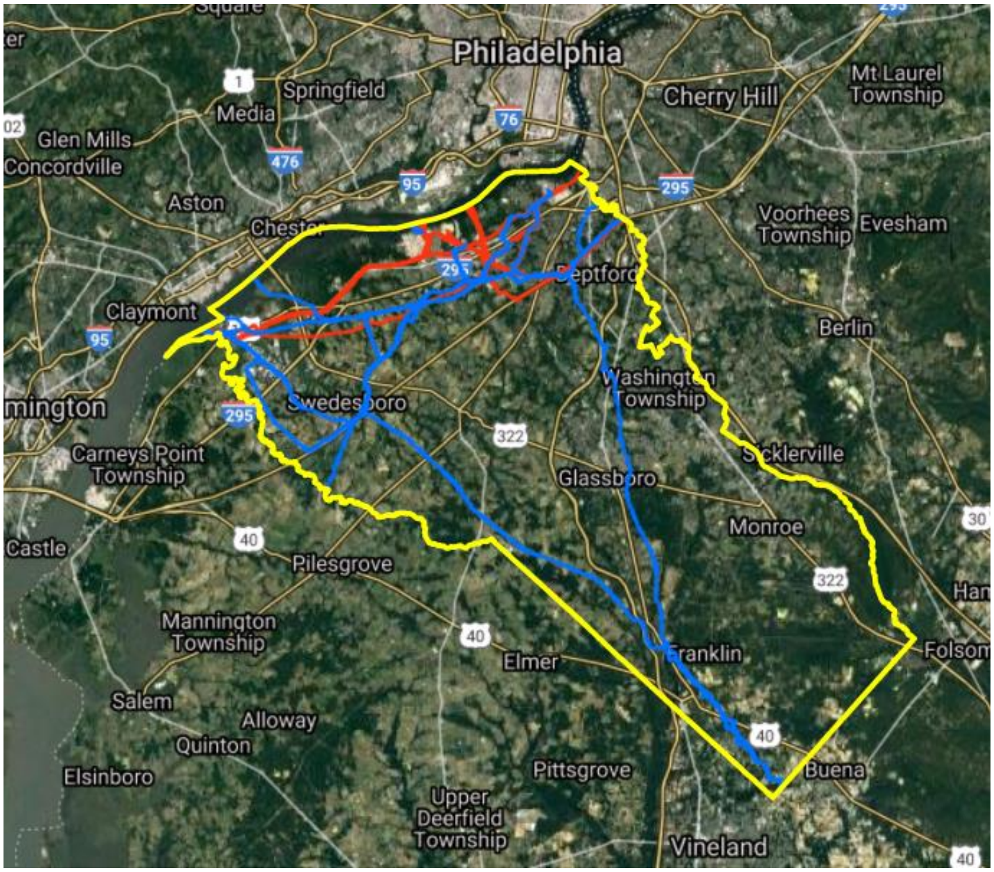


Figure 4.3.9-4. Interstate Natural Gas and Petroleum Pipelines in Gloucester County



Note: Red lines indicate petroleum pipelines; blue lines indicate natural gas pipelines

Gloucester County has a Hazardous Materials (HAZMAT) Response Team, a highly trained professional group that is specially equipped to respond to the release of the hazardous materials that threaten the citizens of our County, their property, or the environment. The Gloucester County HAZMAT Team consists of 30 responders who are on call 24 hours a day, 365 days a year to respond to hazardous material emergencies. (Gloucester County 2021).

Extent

The extent of a hazardous substance release will depend on whether it is from a fixed or mobile source, the size of impact, the toxicity and properties of the substance, duration of the release, and the environmental conditions (for example, wind and precipitation, terrain, etc.).

Hazardous substance releases can contaminate air, water, and soils, possibly resulting in death and/or injuries. Dispersion can take place rapidly when the hazardous substance is transported by water and wind. While often accidental, releases can occur as a result of human carelessness, intentional acts, or natural hazards. When caused by natural hazards, these incidents are known as secondary events. Hazardous substances can include toxic chemicals, radioactive substances, infectious substances, and hazardous wastes. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas.

With a hazardous substance release, whether accidental or intentional, several potentially exacerbating or mitigating circumstances will affect its severity or impact. Mitigating conditions are precautionary measures taken in advance to reduce the impact of a release on the surrounding environment. Primary and secondary containment or shielding by sheltering-in-place measures protects people and property from the harmful effects of a hazardous substance release. Exacerbating conditions, characteristics that can enhance or magnify the effects of a hazardous substance release, include:

- Weather conditions, which affect how the hazard occurs and develops
- Micro-meteorological effects of buildings and terrain, which alters dispersion of hazardous substances on-compliance with applicable codes (such as building or fire codes)
- Maintenance failures (such as fire protection and containment features), which can substantially increase the damage to the facility itself and to surrounding buildings

As discussed earlier, the severity of the incident is dependent not only on the circumstances described above, but also with the type of substance released and the distance and related response time for emergency response teams. The areas proximate to the releases are generally at greatest risk; however, depending on the agent, a release can travel great distances or remain present in the environment for a long period of time (i.e. centuries to millennia).

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with hazardous substance incidents throughout the State of New Jersey and Gloucester County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

FEMA Disaster Declarations

Between 1954 and 2021, neither Gloucester County or the State of New Jersey were included in any FEMA declared disasters (DR) or emergencies (EM) related to hazardous substances incidents (FEMA 2021).

USDA Disaster Declarations

Agriculture-related disasters are quite common. The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2015 and 2021, Gloucester County was not included in any hazardous substance related agricultural disaster declarations (USDA 2021a, USDA 2021b).

Hazardous Materials Events

For the 2021 HMP update, known hazardous substances incidents that have impacted Gloucester County between 2015 and 2021 are identified in Table 4.3.9-1. Refer to Section (Jurisdictional Annex) 9 for detailed information regarding impacts and losses to each municipality, where available.

Table 4.3.9-1. Hazardous Materials Events in Gloucester County, 2015 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Description
2015	Total Chemical Release	N/A	N/A	In 2015, 1,188,253 pounds of chemicals were released on-site and 277,832 pounds of chemicals were released off-site in Gloucester County.
January 26, 2015	Chemical Release	N/A	N/A	A lab incident involving chloric acid at the Kingsway Regional High School in Woolwich resulted in the evacuation of the school and the hospitalization of 20 students.
March 18, 2015	Chemical Release	N/A	N/A	A broken seat at the top of a tank at the PBF Refinery in Paulsboro resulted in the release of Naptha, which is a liquid hydrocarbon mixture. Sixteen students and two teachers at the nearby Paulsboro High School were transported to the Inspira Medical Center in Woodbury with irritation and respiratory issues.
2016	Total Chemical Release	N/A	N/A	In 2016, 1,479,489 pounds of chemicals were released on-site and 270,168 pounds of chemicals were released off-site in Gloucester County.
January 20, 2016	Petroleum Release	N/A	N/A	Natural force damage resulted in the loss of 1.4 barrels of refined petroleum product at the Sunoco facility near Eagle Point.
February 23, 2016	Petroleum Release	N/A	N/A	Equipment failure caused the release of 4.7 barrels of refined petroleum product at the PBF Energy refinery in Paulsboro.
May 3, 2016	Petroleum Release	N/A	N/A	Traffic on Crown Point Road was closed in both directions following an incident involving an overturned truck carrying diesel fuel. The truck leaked fuel into an adjacent tidal waterway in West Deptford.
October 11, 2016	Prop	N/A	N/A	Three freight cars derailed from a railroad track in Paulsboro. No materials were leaked from the cars. Hundreds of workers at the nearby Pureland Industrial Park were evacuated and two people were hospitalized.
2017	Total Chemical Release	N/A	N/A	In 2017, 1,275,780 pounds of chemicals were released on-site and 497,313 pounds of chemicals were released off-site in Gloucester County.
April 6, 2017	Gas Leak	N/A	N/A	A boiler equipment failure at Glassboro Intermediate School resulted in gas fumes entering the building. Thirty-seven students and three staff were hospitalized as a result of the incident.
May 25, 2017	Propylene Leak	N/A	N/A	Approximately 30,000 gallons of propylene leaked from a rail car in Logan Township.
June 15, 2017	Petroleum Release	N/A	N/A	An equipment failure at a gas station caused a spill of diesel fuel in West Deptford.
August 7, 2017	Hydrochloric Acid Leak	N/A	N/A	Route 45 in Woodbury was closed due to two five-gallon containers of hydrochloric acid falling from a truck. One of the containers leaked acid, though no injuries were reported.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Description
August 8, 2017	Hazardous Material Exposure	N/A	N/A	An undetermined substance found at the site of a domestic abuse resulted in the evacuation of six homes in Mantua. The substance was subject to a remote detonation.
2018	Total Chemical Release	N/A	N/A	In 2018, 1,322,191 pounds of chemicals were released on-site and 263,149 pounds of chemicals were released off-site in Gloucester County.
May 1, 2018	Petroleum Release	N/A	N/A	Equipment failure caused the release of 0.4 acres of refined petroleum product at the Colonial Pipeline facility along Kings Highway near West Deptford.
November 25, 2018	Chemical Release	N/A	N/A	The Croda Atlas Point facility in Delaware – located approximately nine miles southwest of Gloucester County in Delaware – released ethylene oxide. Ethylene oxide is a highly flammable gas, and the Delaware Memorial Bridge was closed as a precaution, causing considerable traffic congestion in both New Jersey and Delaware.
2019	Total Chemical Release	N/A	N/A	In 2019, 2,864,178 pounds of chemicals were released on-site and 220,646 pounds of chemicals were released off-site in Gloucester County.
June 30, 2020	Explosion	N/A	N/A	An asphalt tank at the Blue Knight Energy facility on Water Street in Gloucester City exploded. There were no injuries reported from the incident.
February 17, 2021	Fuel Leak	N/A	N/A	A serious motor vehicle crash occurred between a car and tractor-trailer on Route 40 in Newfield, resulting in a large fuel spill.

Source: NJOEM 2019; EPA TRI Explorer 2021; North American Hazmat Situations and Deployments Map 2021; CBS News 2018; 3 CBS Philly 2017
With hazardous substances incidents for New Jersey and Gloucester County being so extensive, not all sources have been identified or researched. Therefore, not all events that have occurred in the County may be included.

Probability of Future Occurrences

Predicting future hazardous substance incidents in Gloucester County is difficult. The incidents can occur at anytime and anywhere in the county. Incidents can be sudden without any warning or slowly develop. Small spills, both fixed site and in-transit, occur throughout the year and the probability for these events are high. The risk of major incidents in a given year is rare. It is estimated that the county will continue to experience direct and indirect impacts of hazardous substance incidents annually that may induce secondary hazards such as infrastructure deterioration or failure, water quality and supply concerns, and transportation delays, accidents and inconveniences.

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for the hazardous substances hazard in the county is considered 'rare' (between 1 and 10 percent annual probability). The ranking of the hazardous substances hazard for individual municipalities is presented in the jurisdictional annexes.

Climate Change Impacts

Hazardous substance incidents are non-natural incidents; however, their release may be the result from natural hazard events. As noted in the risk assessment, climate change may potentially increase the frequency and magnitude of flood and severe weather events which may lead to an increased release of hazardous substances at both fixed sites and in-transit.

4.3.9.2 Vulnerability Assessment

The following section discusses Gloucester County's vulnerability referencing an exposure analysis of the County's assets (i.e., population, buildings, critical facilities, and new development) built within a one mile buffer around hazardous material facilities, within two miles of all railways, and within one mile of roadways that are considered major transit routes for hazardous materials (i.e., County 500, I-295, US 130, NJ Turnpike, County Roads: 603, 607, 609, 620, 643, 651, 653, 655, 656, 667, 678, 684, 689, 694).

Impact on Life, Health and Safety

Depending on the type and quantity of chemicals released and the weather conditions, an incident can affect larger areas that cross jurisdictional boundaries. When hazardous substances are released in the air, water or on land they may contaminate the environment and pose greater danger to human health. Exposure may be either acute or chronic, depending upon the nature of the substance and extent of release and contamination.

Due to the varied location of different hazardous substances and waste sites in Gloucester County, the entire County is considered vulnerable to this hazard. Those particularly vulnerable include populations located along major transportation routes because of the quantities of chemicals transported on these major thoroughfares. Potential losses from hazardous substances incidences include human health and life and property resources. These types of incidents can lead to injury, illnesses, and/or death from both the involved persons and those living in the impacted areas.

Table 4.3.9-2 summarizes the estimated population located within one mile of fixed sites and major roadways, and two miles of rail lines. Of the 24 municipalities in Gloucester County, 10 have 100-percent of its population living within one mile of identified hazardous material roadway routes, four have 100-percent of its population living within one mile of a hazardous material facility site, and nine municipalities have 100-percent of its population living within two miles of a hazardous material railway route (refer to Table 4.3.9-2).

Table 4.3.9-2. Estimated Number of Persons Living Near Hazardous Materials Hazard Areas

Jurisdiction	Total Population (American Community Survey 2015-2019)	Estimated Population Located Within 1 Mile of Hazardous Materials Roadway Routes*		Estimated Population Located Within 1 Mile of Hazardous Materials Facilities		Estimated Population Located Within 2 Miles of Hazardous Materials Railway Routes	
		Number of People	Percent of Total	Number of People	Percent of Total	Number of People	Percent of Total
Clayton (B)	8,626	2,125	24.6%	7,948	92.1%	7,852	91.0%
Deptford (Twp)	30,448	30,174	99.1%	13,878	45.6%	22,961	75.4%
East Greenwich (Twp)	10,488	10,370	98.9%	7,690	73.3%	10,178	97.0%
Elk (Twp)	4,135	3,939	95.3%	1,350	32.7%	1,893	45.8%
Franklin (Twp)	16,440	12,766	77.6%	9,545	58.1%	9,859	60.0%
Glassboro (B)	19,826	19,007	95.9%	14,646	73.9%	19,241	97.0%
Greenwich (Twp)	4,831	4,818	99.7%	4,811	99.6%	4,831	100.0%
Harrison (Twp)	12,995	11,783	90.7%	1,156	8.9%	765	5.9%
Logan (Twp)	5,924	5,896	99.5%	4,088	69.0%	2,781	46.9%
Mantua (Twp)	14,941	14,939	100.0%	11,547	77.3%	13,525	90.5%
Monroe (Twp)	36,789	25,675	69.8%	15,066	41.0%	1,292	3.5%
National Park (B)	2,959	2,959	100.0%	2,955	99.9%	2,553	86.3%
Newfield (B)	1,521	509	33.5%	1,494	98.2%	1,521	100.0%
Paulsboro (B)	5,904	5,904	100.0%	5,904	100.0%	5,904	100.0%
Pitman (B)	8,805	8,805	100.0%	8,410	95.5%	8,805	100.0%
South Harrison (Twp)	3,148	2,947	93.6%	66	2.1%	219	7.0%
Swedesboro (B)	2,579	2,579	100.0%	2,579	100.0%	2,579	100.0%
Washington (Twp)	47,833	38,419	80.3%	6,233	13.0%	6,529	13.6%
Wenonah (B)	2,259	2,259	100.0%	1,519	67.2%	2,259	100.0%
West Deptford (Twp)	21,149	21,149	100.0%	20,699	97.9%	20,108	95.1%
Westville (B)	4,169	4,169	100.0%	4,169	100.0%	4,169	100.0%
Woodbury (C)	9,861	9,861	100.0%	9,855	99.9%	9,861	100.0%
Woodbury Heights (B)	2,986	2,986	100.0%	2,986	100.0%	2,986	100.0%
Woolwich (Twp)	12,549	12,371	98.6%	4,201	33.5%	11,859	94.5%
Gloucester County (Total)	**291,165**	**256,407**	**88.1%**	**162,795**	**55.9%**	**174,531**	**59.9%**

Source: American Community Survey 5-year Estimates 2015-2019; EPA 2021; NJOIT 2017; NJDOT 2012
Notes: B = Borough, C = City, Twp = Township; % = Percent
**Roadways that are considered major transit routes for hazardous materials include County 500, I-295, US 130, NJ Turnpike, County Roads: 603, 607, 609, 620, 643, 651, 653, 655, 656, 667, 678, 684, 689, 694.*

TETRA TECH

The U.S. EPA Hazardous Waste Report, which is a biennial report, collects data on the generation, management, and minimization of hazardous waste. This report provides detailed data on the generation of hazardous waste from large quantity generators and data on waste management practices from treatment, storage, and disposal facilities. The 2019 report lists 51 facilities in Gloucester County (EPA 2019).

Superfund is a program administered by the U.S. EPA to locate, investigate, and cleanup the worst hazardous waste sites throughout the U.S. Data from the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database indicated that Gloucester County has 60 Superfund sites (EPA 2021).

Impact on General Building Stock

Potential losses to the general building stock caused by a hazardous substance releases, whether in transit or at fixed sites, is difficult to quantify. The degree of damages depends on the scale of the incident. Potential losses may include inaccessibility, loss of service, contamination and/or potential structural and content losses if an explosion occurs. The closure of waterways, railroads, airports and highways as a result of a hazardous substance incident has the potential to impact the ability to deliver goods and services efficiently. Potential impacts may be local, regional, or statewide depending on the magnitude of the event and level of service disruptions.

An exposure analysis was conducted to estimate the number of buildings located within the specified area within the hazardous materials fixed sites, major roadways and rail lines. Refer to Table 4.3.9-3 through Table 4.3.9-5 for results per municipality.

Table 4.3.9-3. Estimated Number of Buildings and Replacement Cost Value Within One Mile of Hazardous Materials Roadway Routes

			Estimated Building Stock Located Within 1 Mile of Hazardous Materials Roadway Routes*			
Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Number of Buildings Within the Hazardous Materials Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located Within the Hazardous Materials Hazard Area	Percent of Total
Clayton (B)	3,295	$1,933,299,905	815	24.7%	$437,144,671	22.6%
Deptford (Twp)	11,284	$10,081,159,584	11,143	98.8%	$9,968,668,686	98.9%
East Greenwich (Twp)	4,346	$2,927,045,409	4,301	99.0%	$2,901,328,950	99.1%
Elk (Twp)	2,339	$1,784,179,937	2,246	96.0%	$1,723,473,567	96.6%
Franklin (Twp)	8,432	$5,637,186,975	6,462	76.6%	$4,361,957,742	77.4%
Glassboro (B)	5,959	$5,816,332,907	5,722	96.0%	$5,651,790,752	97.2%
Greenwich (Twp)	2,807	$2,734,741,222	2,767	98.6%	$2,662,516,220	97.4%
Harrison (Twp)	4,817	$4,828,239,008	4,365	90.6%	$4,351,046,261	90.1%

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located Within 1 Mile of Hazardous Materials Roadway Routes*			
			Number of Buildings Within the Hazardous Materials Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located Within the Hazardous Materials Hazard Area	Percent of Total
Logan (Twp)	2,805	$6,591,573,691	2,794	99.6%	$6,586,469,433	99.9%
Mantua (Twp)	6,569	$4,738,271,524	6,565	99.9%	$4,734,456,838	99.9%
Monroe (Twp)	12,553	$8,458,118,166	8,951	71.3%	$6,304,202,633	74.5%
National Park (B)	1,483	$781,021,288	1,483	100.0%	$781,021,288	100.0%
Newfield (B)	891	$622,948,021	277	31.1%	$184,464,734	29.6%
Paulsboro (B)	2,615	$2,076,864,026	2,608	99.7%	$2,054,428,709	98.9%
Pitman (B)	3,521	$2,916,470,733	3,521	100.0%	$2,916,470,733	100.0%
South Harrison (Twp)	1,726	$1,494,748,661	1,571	91.0%	$1,341,517,596	89.7%
Swedesboro (B)	1,040	$936,236,069	1,040	100.0%	$936,236,069	100.0%
Washington (Twp)	17,413	$13,732,374,547	14,060	80.7%	$11,371,133,078	82.8%
Wenonah (B)	930	$778,702,966	930	100.0%	$778,702,966	100.0%
West Deptford (Twp)	7,561	$9,201,121,261	7,547	99.8%	$9,117,531,468	99.1%
Westville (B)	1,733	$1,529,846,612	1,733	100.0%	$1,529,846,612	100.0%
Woodbury (C)	3,605	$4,139,381,075	3,605	100.0%	$4,139,381,075	100.0%
Woodbury Heights (B)	1,295	$1,265,332,236	1,295	100.0%	$1,265,332,236	100.0%
Woolwich (Twp)	4,074	$4,551,585,778	4,005	98.3%	$4,445,964,715	97.7%
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**99,806**	**88.3%**	**$90,545,087,029**	**90.9%**

Source: Gloucester County GIS 2021; MODIV 2020; RSMeans 2021; NJOIT 2017
Notes: B = Borough, C = City, Twp = Township; % = Percent
**Roadways that are considered major transit routes for hazardous materials include County 500, I-295, US 130, NJ Turnpike, County Roads: 603, 607, 609, 620, 643, 651, 653, 655, 656, 667, 678, 684, 689, 694.*

Table 4.3.9-4. Estimated Number of Buildings and Replacement Cost Value Within One Mile of Hazardous Materials Facilities

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located Within 1 Mile of Hazardous Materials Facilities			
			Number of Buildings Within the Hazardous Materials Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located Within the Hazardous Materials Hazard Area	Percent of Total
Clayton (B)	3,295	$1,933,299,905	3,042	92.3%	$1,802,398,187	93.2%
Deptford (Twp)	11,284	$10,081,159,584	5,231	46.4%	$5,058,558,668	50.2%
East Greenwich (Twp)	4,346	$2,927,045,409	3,211	73.9%	$2,270,232,711	77.6%
Elk (Twp)	2,339	$1,784,179,937	662	28.3%	$382,975,811	21.5%
Franklin (Twp)	8,432	$5,637,186,975	4,874	57.8%	$3,317,650,535	58.9%
Glassboro (B)	5,959	$5,816,332,907	4,462	74.9%	$4,407,362,223	75.8%

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located Within 1 Mile of Hazardous Materials Facilities			
			Number of Buildings Within the Hazardous Materials Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located Within the Hazardous Materials Hazard Area	Percent of Total
Greenwich (Twp)	2,807	$2,734,741,222	2,796	99.6%	$2,729,127,574	99.8%
Harrison (Twp)	4,817	$4,828,239,008	468	9.7%	$524,919,378	10.9%
Logan (Twp)	2,805	$6,591,573,691	1,967	70.1%	$5,844,474,982	88.7%
Mantua (Twp)	6,569	$4,738,271,524	5,014	76.3%	$3,612,063,277	76.2%
Monroe (Twp)	12,553	$8,458,118,166	4,907	39.1%	$3,822,269,013	45.2%
National Park (B)	1,483	$781,021,288	1,481	99.9%	$779,735,344	99.8%
Newfield (B)	891	$622,948,021	873	98.0%	$605,120,520	97.1%
Paulsboro (B)	2,615	$2,076,864,026	2,615	100.0%	$2,076,864,026	100.0%
Pitman (B)	3,521	$2,916,470,733	3,372	95.8%	$2,834,753,962	97.2%
South Harrison (Twp)	1,726	$1,494,748,661	32	1.9%	$25,492,687	1.7%
Swedesboro (B)	1,040	$936,236,069	1,040	100.0%	$936,236,069	100.0%
Washington (Twp)	17,413	$13,732,374,547	2,362	13.6%	$1,930,983,536	14.1%
Wenonah (B)	930	$778,702,966	626	67.3%	$597,558,994	76.7%
West Deptford (Twp)	7,561	$9,201,121,261	7,409	98.0%	$9,102,396,876	98.9%
Westville (B)	1,733	$1,529,846,612	1,733	100.0%	$1,529,846,612	100.0%
Woodbury (C)	3,605	$4,139,381,075	3,603	99.9%	$4,137,366,057	100.0%
Woodbury Heights (B)	1,295	$1,265,332,236	1,295	100.0%	$1,265,332,236	100.0%
Woolwich (Twp)	4,074	$4,551,585,778	1,409	34.6%	$1,981,963,799	43.5%
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**64,484**	**57.0%**	**$61,575,683,078**	**61.8%**

Source: Gloucester County GIS 2021; MODIV 2020; RSMeans 2021; EPA 2021
Notes: B = Borough, C = City, Twp = Township; % = Percent

Table 4.3.9-5. Estimated Number of Buildings and Replacement Cost Value Within Two Mile of Hazardous Materials Railway Routes

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located Within 2 Mile of Hazardous Materials Railway Routes			
			Number of Buildings Within the Hazardous Materials Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located Within the Hazardous Materials Hazard Area	Percent of Total
Clayton (B)	3,295	$1,933,299,905	3,003	91.1%	$1,783,086,438	92.2%
Deptford (Twp)	11,284	$10,081,159,584	8,431	74.7%	$6,912,753,641	68.6%
East Greenwich (Twp)	4,346	$2,927,045,409	4,223	97.2%	$2,853,808,919	97.5%
Elk (Twp)	2,339	$1,784,179,937	1,008	43.1%	$609,095,911	34.1%
Franklin (Twp)	8,432	$5,637,186,975	5,149	61.1%	$3,653,088,810	64.8%
Glassboro (B)	5,959	$5,816,332,907	5,798	97.3%	$5,723,361,232	98.4%
Greenwich (Twp)	2,807	$2,734,741,222	2,807	100.0%	$2,734,741,222	100.0%

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located Within 2 Mile of Hazardous Materials Railway Routes			
			Number of Buildings Within the Hazardous Materials Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located Within the Hazardous Materials Hazard Area	Percent of Total
Harrison (Twp)	4,817	$4,828,239,008	308	6.4%	$367,738,774	7.6%
Logan (Twp)	2,805	$6,591,573,691	1,519	54.2%	$5,476,809,151	83.1%
Mantua (Twp)	6,569	$4,738,271,524	5,885	89.6%	$4,263,663,039	90.0%
Monroe (Twp)	12,553	$8,458,118,166	453	3.6%	$302,472,040	3.6%
National Park (B)	1,483	$781,021,288	1,289	86.9%	$688,688,483	88.2%
Newfield (B)	891	$622,948,021	891	100.0%	$622,948,021	100.0%
Paulsboro (B)	2,615	$2,076,864,026	2,615	100.0%	$2,076,864,026	100.0%
Pitman (B)	3,521	$2,916,470,733	3,521	100.0%	$2,916,470,733	100.0%
South Harrison (Twp)	1,726	$1,494,748,661	172	10.0%	$170,097,613	11.4%
Swedesboro (B)	1,040	$936,236,069	1,040	100.0%	$936,236,069	100.0%
Washington (Twp)	17,413	$13,732,374,547	2,437	14.0%	$1,971,692,681	14.4%
Wenonah (B)	930	$778,702,966	930	100.0%	$778,702,966	100.0%
West Deptford (Twp)	7,561	$9,201,121,261	7,225	95.6%	$9,028,847,326	98.1%
Westville (B)	1,733	$1,529,846,612	1,733	100.0%	$1,529,846,612	100.0%
Woodbury (C)	3,605	$4,139,381,075	3,605	100.0%	$4,139,381,075	100.0%
Woodbury Heights (B)	1,295	$1,265,332,236	1,295	100.0%	$1,265,332,236	100.0%
Woolwich (Twp)	4,074	$4,551,585,778	3,845	94.4%	$4,304,695,583	94.6%
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**69,182**	**61.2%**	**$65,110,422,597**	**65.4%**

Source: Gloucester County GIS 2021; MODIV 2020; RSMeans 2021; NJDOT 2012
Notes: B = Borough, C = City, Twp = Township; % = Percent

Impact on Critical Facilities and Lifelines

Potential losses to critical facilities caused by a hazardous substances incident is difficult to quantify. Potential losses may include inaccessibility, loss of service, contamination and/or potential structural and content losses if an explosion occurs.

Table 4.3.9-6 through Table 4.3.9-9 summarize the number of critical facilities and lifelines built within the hazardous materials hazard areas by jurisdiction. Appendix E summarizes the distribution of critical facilities by critical facility type located in the hazardous material hazard areas by jurisdiction. Majority of the critical facilities exposed to the hazardous materials hazard areas are education facilities. Furthermore, critical facilities that provide safety and security lifeline services are the most exposed to the hazardous materials hazard areas (refer to Table 4.3.9-9).

Table 4.3.9-6. Estimated Number of Critical Facilities and Lifelines Located Within One Mile of Hazardous Materials Roadway Routes

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located Within 1 Mile of Hazardous Material Roadway Routes*			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	10	40.0%	10	40.0%
Deptford (Twp)	79	77	77	97.5%	75	97.4%
East Greenwich (Twp)	46	46	46	100.0%	46	100.0%
Elk (Twp)	6	6	6	100.0%	6	100.0%
Franklin (Twp)	35	35	31	88.6%	31	88.6%
Glassboro (B)	137	137	134	97.8%	134	97.8%
Greenwich (Twp)	31	31	27	87.1%	27	87.1%
Harrison (Twp)	26	26	25	96.2%	25	96.2%
Logan (Twp)	50	50	50	100.0%	50	100.0%
Mantua (Twp)	30	30	30	100.0%	30	100.0%
Monroe (Twp)	29	26	23	79.3%	20	76.9%
National Park (B)	41	41	40	97.6%	40	97.6%
Newfield (B)	9	9	0	0.0%	0	0.0%
Paulsboro (B)	29	29	25	86.2%	25	86.2%
Pitman (B)	19	19	19	100.0%	19	100.0%
South Harrison (Twp)	12	12	12	100.0%	12	100.0%
Swedesboro (B)	9	9	9	100.0%	9	100.0%
Washington (Twp)	75	75	63	84.0%	63	84.0%
Wenonah (B)	4	4	4	100.0%	4	100.0%
West Deptford (Twp)	157	149	154	98.1%	146	98.0%
Westville (B)	23	21	23	100.0%	21	100.0%
Woodbury (C)	59	59	59	100.0%	59	100.0%
Woodbury Heights (B)	9	9	9	100.0%	9	100.0%
Woolwich (Twp)	16	16	16	100.0%	16	100.0%
Gloucester County (Total)	**956**	**941**	**892**	**93.3%**	**877**	**93.2%**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; NJOIT 2017
Notes: B = Borough, C = City, Twp = Township; % = Percent
**Roadways that are considered major transit routes for hazardous materials include County 500, I-295, US 130, NJ Turnpike, County Roads: 603, 607, 609, 620, 643, 651, 653, 655, 656, 667, 678, 684, 689, 694.*

Table 4.3.9-7. Estimated Number of Critical Facilities and Lifelines Located Within One Mile of Hazardous Materials Facilities

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located Within 1 Mile of Hazardous Material Facilities			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	25	100.0%	25	100.0%
Deptford (Twp)	79	77	49	62.0%	48	62.3%
East Greenwich (Twp)	46	46	33	71.7%	33	71.7%
Elk (Twp)	6	6	1	16.7%	1	16.7%

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located Within 1 Mile of Hazardous Material Facilities			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Franklin (Twp)	35	35	26	74.3%	26	74.3%
Glassboro (B)	137	137	123	89.8%	123	89.8%
Greenwich (Twp)	31	31	31	100.0%	31	100.0%
Harrison (Twp)	26	26	5	19.2%	5	19.2%
Logan (Twp)	50	50	49	98.0%	49	98.0%
Mantua (Twp)	30	30	27	90.0%	27	90.0%
Monroe (Twp)	29	26	18	62.1%	18	69.2%
National Park (B)	41	41	40	97.6%	40	97.6%
Newfield (B)	9	9	9	100.0%	9	100.0%
Paulsboro (B)	29	29	29	100.0%	29	100.0%
Pitman (B)	19	19	17	89.5%	17	89.5%
South Harrison (Twp)	12	12	0	0.0%	0	0.0%
Swedesboro (B)	9	9	9	100.0%	9	100.0%
Washington (Twp)	75	75	21	28.0%	21	28.0%
Wenonah (B)	4	4	2	50.0%	2	50.0%
West Deptford (Twp)	157	149	153	97.5%	145	97.3%
Westville (B)	23	21	23	100.0%	21	100.0%
Woodbury (C)	59	59	59	100.0%	59	100.0%
Woodbury Heights (B)	9	9	9	100.0%	9	100.0%
Woolwich (Twp)	16	16	15	93.8%	15	93.8%
Gloucester County (Total)	**956**	**941**	**773**	**80.9%**	**762**	**81.0%**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; EPA 2021
Notes: B = Borough, C = City, Twp = Township; % = Percent

Table 4.3.9-8. Estimated Number of Critical Facilities and Lifelines Located Within Two Miles of Hazardous Materials Railway Routes

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located Within 2 Miles of Hazardous Material Railway Routes			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	25	100.0%	25	100.0%
Deptford (Twp)	79	77	62	78.5%	60	77.9%
East Greenwich (Twp)	46	46	46	100.0%	46	100.0%
Elk (Twp)	6	6	5	83.3%	5	83.3%
Franklin (Twp)	35	35	27	77.1%	27	77.1%
Glassboro (B)	137	137	136	99.3%	136	99.3%
Greenwich (Twp)	31	31	29	93.5%	29	93.5%
Harrison (Twp)	26	26	5	19.2%	5	19.2%
Logan (Twp)	50	50	43	86.0%	43	86.0%
Mantua (Twp)	30	30	28	93.3%	28	93.3%
Monroe (Twp)	29	26	0	0.0%	0	0.0%
National Park (B)	41	41	40	97.6%	40	97.6%
Newfield (B)	9	9	9	100.0%	9	100.0%

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located Within 2 Miles of Hazardous Material Railway Routes			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Paulsboro (B)	29	29	24	82.8%	24	82.8%
Pitman (B)	19	19	19	100.0%	19	100.0%
South Harrison (Twp)	12	12	1	8.3%	1	8.3%
Swedesboro (B)	9	9	9	100.0%	9	100.0%
Washington (Twp)	75	75	22	29.3%	22	29.3%
Wenonah (B)	4	4	4	100.0%	4	100.0%
West Deptford (Twp)	157	149	153	97.5%	145	97.3%
Westville (B)	23	21	23	100.0%	21	100.0%
Woodbury (C)	59	59	59	100.0%	59	100.0%
Woodbury Heights (B)	9	9	9	100.0%	9	100.0%
Woolwich (Twp)	16	16	16	100.0%	16	100.0%
Gloucester County (Total)	**956**	**941**	**794**	**83.1%**	**782**	**83.1%**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; NJDOT 2012
Notes: B = Borough, C = City, Twp = Township; % = Percent

Table 4.3.9-9. Estimated Number of Lifelines Categorized by FEMA Lifeline Categories Built Within the Hazardous Material Hazard Boundaries

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located within 1 Mile of Hazardous Materials Roadway Routes*	Number of Lifelines Located Within 2 Miles of Hazardous Materials Railway Routes	Number of Lifelines Located Within 1 Mile of Hazardous Materials Facilities
Energy	5	5	4	5
Food, Water, Shelter	214	206	195	183
Hazardous Materials	116	102	102	116
Health and Medical	102	89	68	67
Safety and Security	481	457	399	371
Transportation	23	18	14	20
Gloucester County (Total)	**956**	**892**	**782**	**762**

Source: Gloucester County Planning Partnership 2021; Gloucester County GIS 2021; FEMA 2020; NJOIT 2017; EPA 2021; NJDOT 2012
Notes: B = Borough, C = City, Twp = Township; % = Percent
**Roadways that are considered major transit routes for hazardous materials include County 500, I-295, US 130, NJ Turnpike, County Roads: 603, 607, 609, 620, 643, 651, 653, 655, 656, 667, 678, 684, 689, 694.*

Impact on Economy

If a significant hazardous substances incident occurred, not only would life, safety, and building stock be at risk, but the economy of Gloucester County may be impacted as well. A significant incident in an urban area may force businesses to close for an extended period of time because of contamination or direct damage caused by an explosion if one occurred. Estimating impacts on the economy is difficult to determine, given the uncertain nature of the size and scope of incidents.

Hazardous substance incidents have the potential to lead to major transportation route closures in Gloucester County. According to the County, roadways that are considered major transit routes for hazardous materials include I-295, US 130, NJ Turnpike, all 500-series County roads, and the following County 600-series roads: 603, 607, 609, 620, 643, 651, 653, 655, 656, 667, 678, 684, 689, 694. The closure of waterways, railroads, airports, and highways as a result of hazard material release incidents has the potential to impact the ability to deliver goods and services. Potential impacts may be local, regional, or statewide, depending on the magnitude of the event and the level of services disruptions.

Impact on Environment

Hazardous wastes that are released into the environment can be harmful to species and their habitat. Wastes that get into waterways will be disruptive and sometimes deadly to aquatic species. Consequentially, wastes that get into waterways can also contaminate drinking water supplies. Hazardous wastes can also leach into soils and travel with wind, which not only impacts the localized habitat, but can create issues for surrounding communities. Strict disposal regulations have been defined by organizations like the EPA to ensure that the environment and community is protected from these types of events (EPA 2020).

Future Changes That May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. The New Jersey Highlands Council has identified areas of potential growth (Sewer Service Areas) that may provide insight as to where potential new development may occur in Gloucester County. Further, the New Jersey Pinelands Commission has identified Pinelands Management Area Boundaries, including regional growth areas and rural development areas that may also provide insight to where development and growth may occur in the County. In addition, each community was requested to provide recent and anticipated new development and infrastructure projects; summarized in Section 9 (Jurisdictional Annexes).

According to the Gloucester County Planning Partnership, there are 38 recent or anticipated new development sites in Gloucester County. An exposure analysis found 34, 24, and 25 new development sites located within one mile of hazardous materials roadway routes, one mile of hazardous materials facilities, and two miles of hazardous materials railway routes, respectively (refer to Figure 4.3.9-5 and Figure 4.3.9-6). Development near the transit routes for hazardous materials and facilities will increase the County's overall risk. Therefore, the

County should take precautions with the location of new development and the development's proximity to hazardous material facilities and transit routes. The County may also want to consider implementing designs into the new development that enables improved evacuation or protection from residual impacts from the hazardous materials. Refer to Section 3 (County Profile) for more information about the County's anticipated and recent new development plans.

Projected Changes in Population

Gloucester County has experienced an increase in its population since 2010. According to the U.S. Census Bureau, the County's population increased by approximately 1-percent between 2010 and 2019 (U.S. Census Bureau 2020). An increase in the population will ultimately increase the number of persons requiring use of transit routes that may also be used as hazardous materials transit routes. Therefore, it is critical that the County has alternative evacuation routes in case there is a hazardous material outbreak along one of these routes.

Climate Change

As temperatures change, excessive heat on containers that contain hazardous materials may alter the material properties. In addition, hazardous substances stored at fixed locations in the floodplain may experience an increase in flood events due to the project changes in increased precipitation events; magnitude and frequency

Change of Vulnerability Since the 2016 HMP

Since the 2016 analysis, population statistics have been updated using the 2015-2019 American Community Survey population data. The updated building stock inventory was created using building footprints and parcels from the 2021 Gloucester County GIS dataset and updated 2020 tax assessor data from MODIV. RS Means 2021-dollar values were used to develop a structure-level building inventory and estimate replacement cost value for each building. The 2016 critical facility and lifeline inventory was also reviewed and updated by the Planning Partnership. These changes provide an up-to-date look at the entire building stock for Gloucester County and gives more accurate results for the exposure and loss estimation analysis.

Figure 4.3.9-5. Recent and Anticipated New Development in Gloucester County and the Hazardous Materials Roadway and Railway Routes

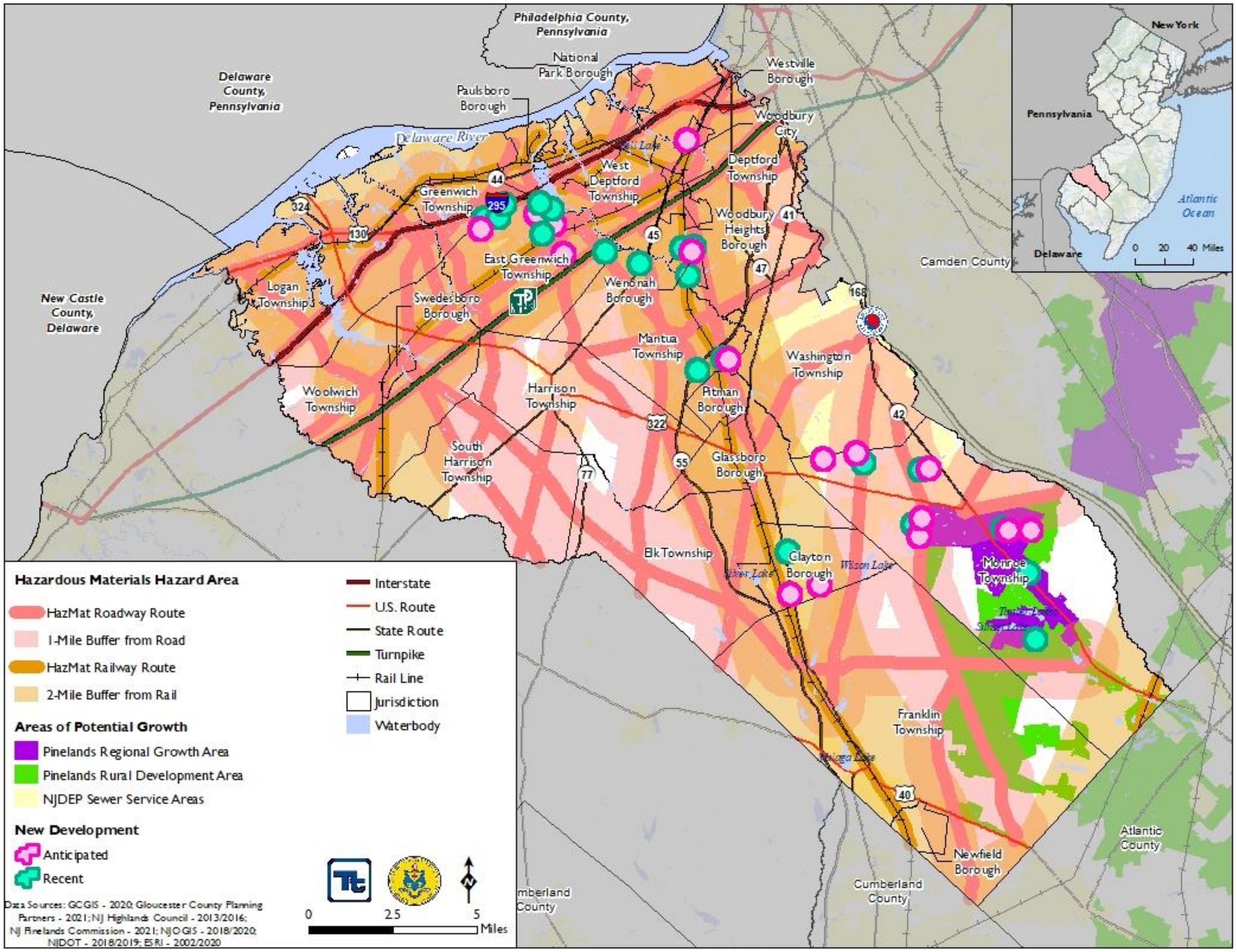
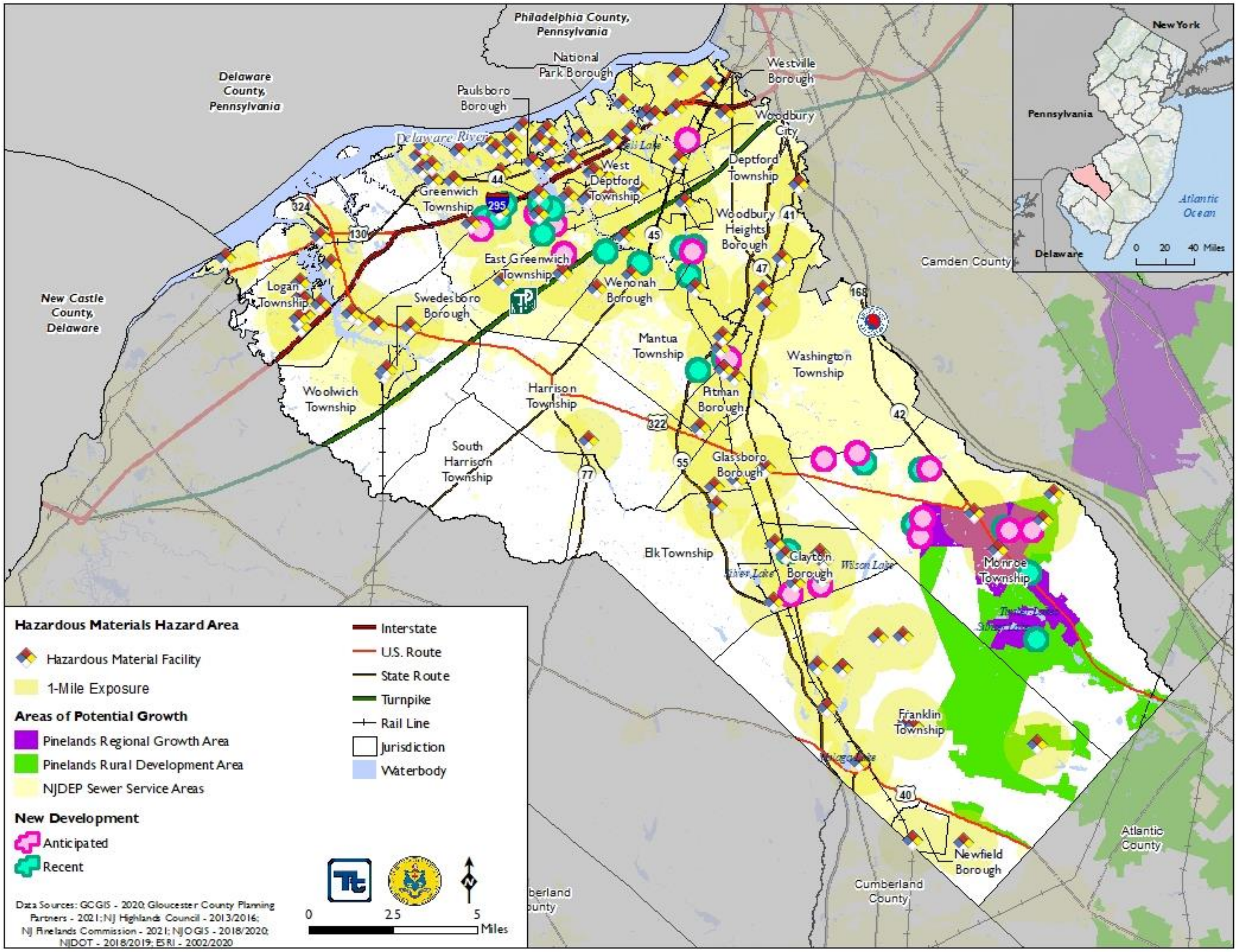


Figure 4.3.9-6. Recent and Anticipated New Development in Gloucester County and the One Mile Radius of Hazardous Materials Facilities



4.3.10 Hurricane and Tropical Storm

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the hurricane and tropical storm hazard in Gloucester County.

2022 HMP Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, probability of future occurrence, and potential change in climate and its impacts on the hurricane and tropical storm hazard.
- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2015 and 2021.
- A vulnerability assessment was conducted for the hurricane and tropical storm hazard using a more accurate and updated building inventory; Hazus v4.2 was also used to conduct a 100-year and 500-year Mean Return Period assessment; it now directly follows the hazard profile.

4.3.10.1 Profile

Hazard Description

A tropical cyclone is a rotating, organized system of clouds and thunderstorms that originates over tropical or sub-tropical waters and has a closed low-level circulation. Tropical depressions, tropical storms, and hurricanes are all considered tropical cyclones. These storms rotate counterclockwise around the center in the northern hemisphere and are accompanied by heavy rain and strong winds. Almost all tropical storms and hurricanes in the Atlantic basin (which includes the Gulf of Mexico and Caribbean Sea) form between June 1 and November 30 (hurricane season). August and September are peak months for hurricane development (NOAA NWS 2013).

Over a two-year period, the U.S. coastline is struck by an average of three hurricanes, one of which is classified as a major hurricane. Hurricanes, tropical storms, and tropical depressions pose a threat to life and property. These storms bring heavy rain, storm surge, and flooding (NOAA NWS 2013).The cooler waters off the coast of New Jersey can diminish the energy of storms that have traveled up the eastern seaboard. However, historical data show that a number of hurricanes/tropical storms have impacted New Jersey, often as the remnants of a larger storm hitting the Gulf or Atlantic Coast hundreds of miles south of New Jersey. These storms maintain sufficient wind and precipitation to cause substantial damage to the state.

Tropical cyclones most frequently affect New Jersey during the month of September, though the state has experienced tropical cyclones throughout the hurricane season, excluding November. Because of peak warm water temperatures in September, storms usually affect New Jersey during this time.

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For the purpose of this HMP update, this hazard profile will include hurricanes and tropical storms. Detailed information regarding these hazards in Gloucester County are discussed further in this section.

Hurricanes and Tropical Storm

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain (winds are at a lower speed than hurricane-force winds, therefore categorized as a tropical storm instead of a hurricane). Tropical storms strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. They are fueled by a different heat mechanism than other cyclonic windstorms such as Nor'easters and polar lows. The characteristic that separates tropical cyclones from other cyclonic systems is that at any height in the atmosphere, the center of a tropical cyclone will be warmer than its surroundings; a phenomenon called "warm core" storm systems (NOAA NHC 2011).

A hurricane is a tropical storm that attains hurricane status when its wind speed reaches 74 or more miles per hour (mph). Tropical systems may develop in the Atlantic between the Lesser Antilles and the African coast, or may develop in the warm tropical waters of the Caribbean and Gulf of Mexico. These storms may move up the Atlantic Coast of the United States and impact the Eastern Seaboard, or move into the United States through the states along the Gulf Coast, bringing wind and rain as far north as New England, before moving offshore and heading east.

NWS issues hurricane and tropical storm watches and warnings. These watches and warnings are issued or will remain in effect after a tropical cyclone becomes post-tropical, when such a storm poses a significant threat to life and property. The NWS allows the National Hurricane Center (NHC) to issue advisories during the post-tropical stage. The following are the definitions of the watches and warnings:

- *Hurricane/Typhoon Warning* is issued when sustained winds of 74 mph or higher are expected somewhere within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm force, the warning is issued 36 hours in advance of the anticipated onset of tropical storm-force winds. The warning can remain in effect when dangerously high water or combination of dangerously high water and waves continue, even though winds may be less than hurricane force.
- *Hurricane Watch* is issued when sustained winds of 74 mph or higher are possible within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm force, the hurricane watch is issued 48 hours prior to the anticipated onset of tropical storm-force winds.
- *Tropical Storm Warning* is issued when sustained winds of 39 to 73 mph are expected somewhere within the specified area within 36 hours in association with a tropical, subtropical, or post-tropical storm.

- *Tropical Storm Watch* is issued when sustained winds of 39 to 73 mph are possible within the specified area within 48 hours in association with a tropical, sub-tropical, or post-tropical storm. (NOAA NWS 2013).

Hurricanes and tropical storms often occur at the same time. Because of this, officials assign short, distinctive names to the storms to avoid confusion among weather stations, coastal bases, and ships at sea. Since 1953, Atlantic tropical storms have been named from lists originated by the National Hurricane Center. Currently, they are maintained and updated by the World Meteorological Organization. The list of names in the table below are used in rotation and recycled every 6 years. The only time there is a change in the list is if the named storm was so costly or deadly that the future use of it would be inappropriate. If that occurs, the World Meteorological Organization committee will select a new name to replace the one removed from the list. A storm is given a name once its winds reach a speed of 40 mph. In addition to the Atlantic list of names, there are ten other lists corresponding to other storm-prone regions of the world (NOAA NHC 2020). The table below lists the tropical cyclone names for 2021 through 2026.

Table 4.3.10-1. Tropical Cyclone Names for the Atlantic

2021	2022	2023	2024	2025	2026
Ana	Alex	Arlene	Alberto	Andrea	Arthur
Bill	Bonnie	Bret	Beryl	Barry	Bertha
Claudette	Colin	Cindy	Chris	Chantal	Cristobal
Danny	Danielle	Don	Debby	Dorian	Dolly
Elsa	Earl	Emily	Ernesto	Erin	Edouard
Fred	Fiona	Franklin	Francine	Fernand	Fay
Grace	Gaston	Gert	Gordon	Gabrielle	Gonzalo
Henri	Hermine	Harold	Helene	Humberto	Hanna
Ida	Ian	Idalia	Isaac	Imelda	Isaias
Julian	Julia	Jose	Joyce	Jerry	Josephine
Kate	Karl	Katia	Kirk	Karen	Kyle
Larry	Lisa	Lee	Leslie	Lorenzo	Leah
Mindy	Martin	Margot	Milton	Melissa	Marco
Nicholas	Nicole	Nigel	Nadine	Nestor	Nana
Odette	Owen	Ophelia	Oscar	Olga	Omar
Peter	Paula	Philippe	Patty	Pablo	Paulette
Rose	Richard	Rina	Rafael	Rebekah	Rene
Sam	Shary	Sean	Sara	Sebastien	Sally
Teresa	Tobias	Tammy	Tony	Tanya	Teddy
Victor	Virginie	Vince	Valerie	Van	Vicky
Wanda	Walter	Whitney	William	Wendy	Wilfred

Source: NOAA 2020

Storm Surge

Storm surges inundate coastal floodplains by dune overwash, tidal elevation rise in inland bays and harbors, and backwater flooding through coastal river mouths. Strong winds and wave action can create an increase in tide levels and water-surface elevations. Storm systems generate large waves that run up and flood coastal beaches. The combined effects create storm surges that affect the beach, dunes, and adjacent low-lying floodplains. Shallow, offshore depths can cause storm-driven waves and tides to pile up against the shoreline and inside bays.

Based on an area's topography, a storm surge may inundate only a small area (along sections of the northeast or southeast coasts) or storm surge may inundate coastal lands for a mile or more inland from the shoreline. Storm surge is further discussed in Section 4.3.7 (Flood).

Location

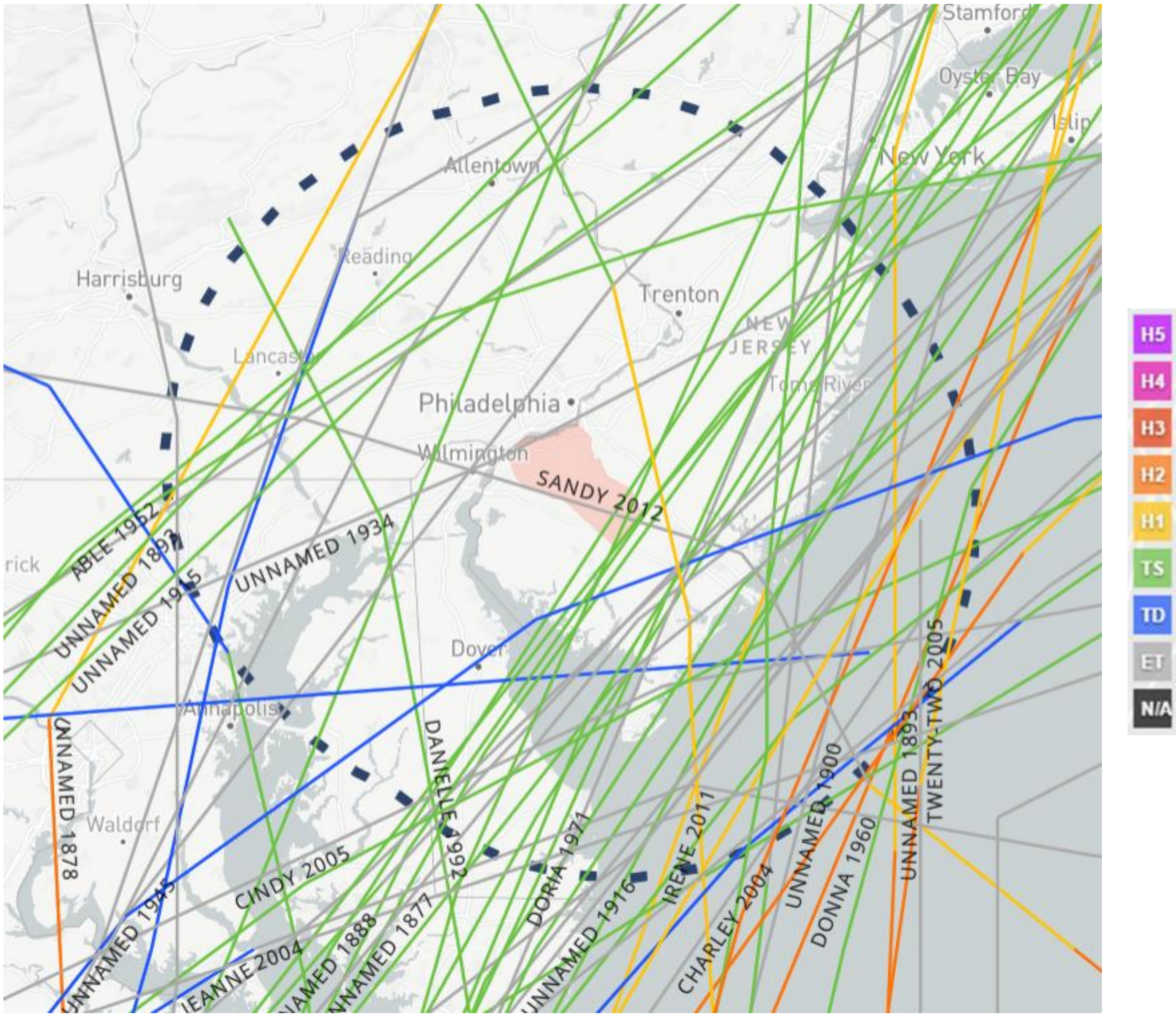
Storm surge hazards that are associated with hurricanes and other severe storms are responsible for coastal flooding and erosion along the New Jersey coastline. Storm surge can also impact interior areas as high winds push water into bays and rivers located inland from the coast. In Gloucester County, storm surge hazards can occur anywhere within the county but are concentrated along areas of the Delaware River and the tidal section of its tributaries near the western edge of the county. High winds can result in downed trees and utility failure as well as cascading floods. The riverfront communities are especially exposed to high winds which makes the western border of the county especially prone to hurricanes and storm surge.

The sluice gates along the Delaware River — which prevent flooding to some 10,000 Gloucester countians living in low-lying areas, are critical assets during hurricanes and tropical storms. Specifically, according to the South Jersey Levee Inventory, there are approximately 344 structures that are protected by flood structures that would otherwise be highly vulnerable to hurricanes and tropical storms. According to the 2016 Gloucester County Hazard Mitigation Plan, the county has identified old structures, especially those that are protected by levees, are especially prone to tropical storms and high winds. That is, based on existing information, the communities and structures along the Delaware River are especially prone to hurricanes and tropical storms, as noted above (Gloucester County 2016).

Tropical Storm and Hurricane Tracks

NOAA's Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool catalogs tropical cyclones that have occurred from 1842 to 2021 (latest date available from data source). Between 1842 and 2021, 44 tropical cyclones tracked within 65 nautical miles of Gloucester County. Figure 4.3.10-1 displays tropical cyclone tracks for Gloucester County that tracked between 1842 and 2021. Refer to the "Previous Events and Losses" section for further information regarding hurricane and tropical storm events that impacted Gloucester County (NOAA 2021).

Figure 4.3.10-1. Historical Tropical Storm and Hurricane Tracks 1842 to 2021

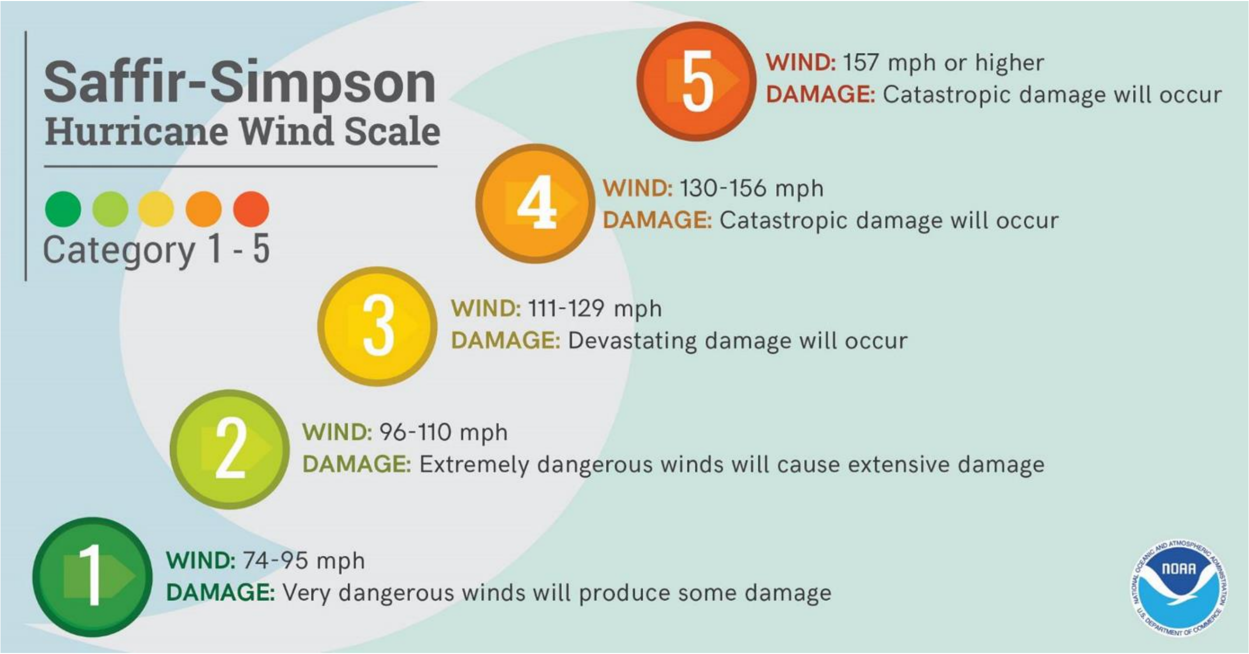


Source: NOAA 2021

Extent

The extent of a hurricane is categorized in accordance with the Saffir-Simpson Hurricane Scale. The Saffir-Simpson Hurricane Wind Scale is a 1-to-5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous and require preventative measures (NHC NWS 2013). Table 4.3.10-2 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes landfall.

Table 4.3.10-2. The Saffir-Simpson Hurricane Scale



Source: NOAA 2021
Notes:
mph Miles per hour
> Greater than

Mean Return Period

In evaluating the potential for hazard events of a given magnitude, an MRP is often used. The MRP provides an estimate of the magnitude of an event that may occur within any given year based on past recorded events. MRP is the average period of time, in years, between occurrences of a particular hazard event, equal to the inverse of the annual frequency of exceedance (Dinicola 2009).

Figure 4.3.10-2 and Figure 4.3.10-3 show the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP events. These peak wind speed projections were generated using FEMA's Hazus-MH wind model. The maximum 3-second gust wind speeds for Gloucester County range from tropical storm force to Category 1 hurricane force for the 100-year MRP event. The maximum 3-second gust wind speeds for Gloucester County range from Category 1 to Category 2 hurricane force. The storm tracks for the 100- and 500-year event were not available in Hazus 4.2. The associated impacts and losses from these 100-year and 500-year MRP hurricane events are discussed later in the Vulnerability Assessment subsection.

Figure 4.3.10-2. Wind Speeds for the 100-Year Mean Return Period Event

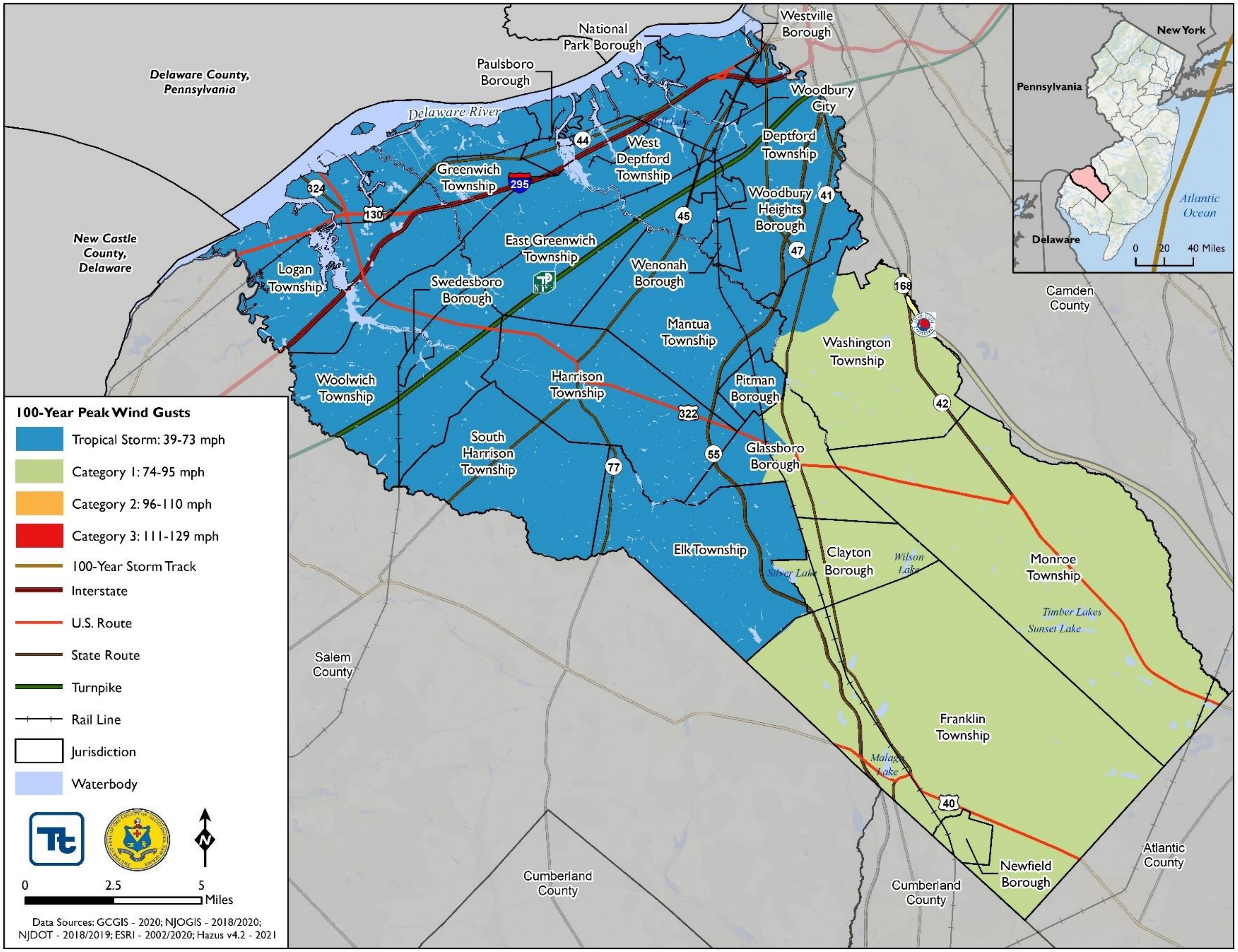


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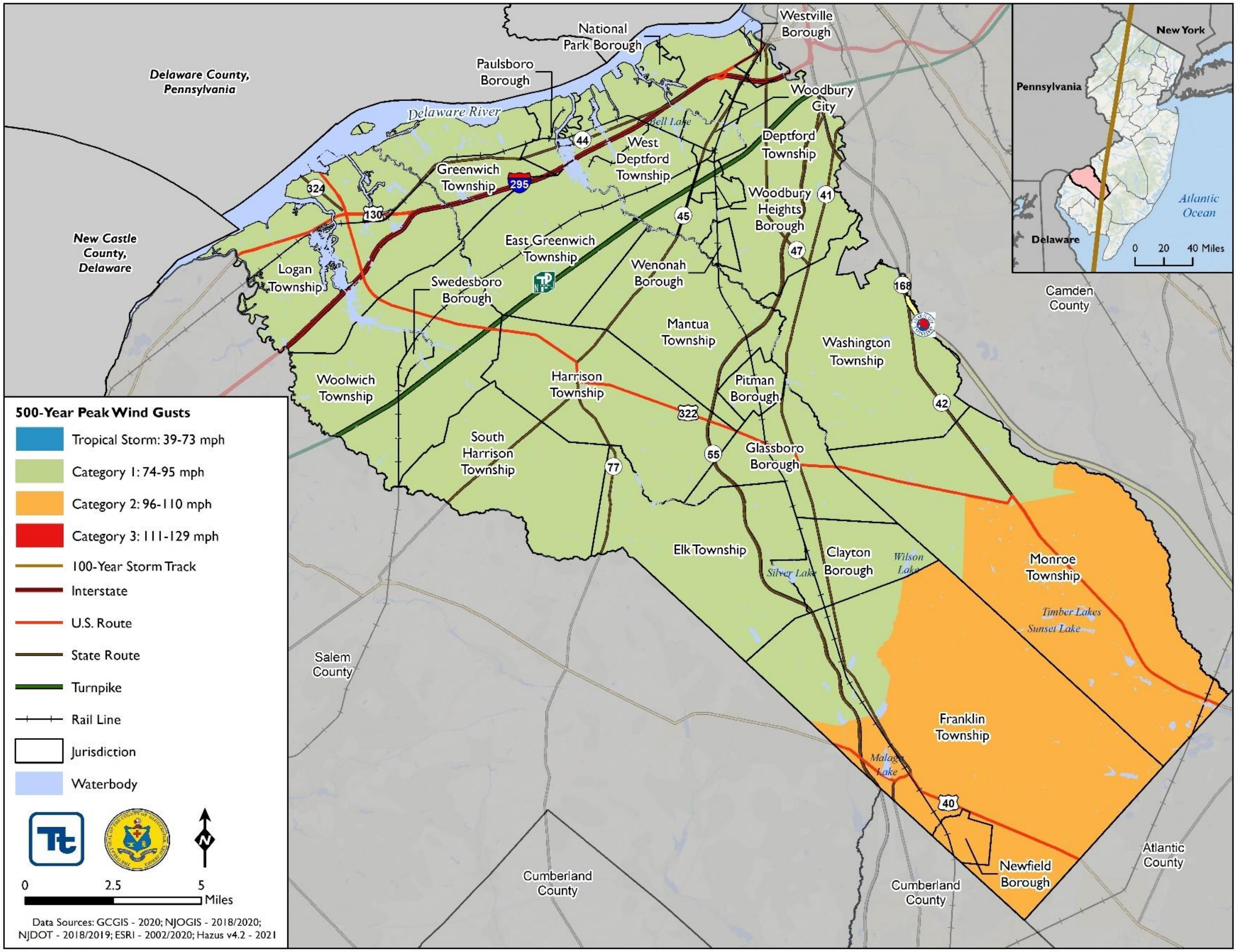
Figure 4.3.10-3. Wind Speeds for the 500-Year Mean Return Period Event



Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with hurricane and tropical storm throughout the State of New Jersey and Gloucester County; therefore, the loss and impact information for many events varies depending on the source. The accuracy of monetary figures discussed is based only on the available information in cited sources.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2021, FEMA issued a disaster (DR) or emergency (EM) declaration for the State of New Jersey for eight tropical cyclone-related events, classified as one or a combination of the following disaster types: one or a combination of the following disaster types: hurricane, tropical storm, severe storms, flooding, and tropical depression. Of those events, Gloucester County has been included in six hurricane and tropical storm-related declarations (EM and DR) (FEMA 2021). Table 4.3.10-3 lists FEMA DR and EM declarations for the County.

Table 4.3.10-3. Hurricane and Tropical Storm-Related FEMA DR and EM Declarations for Gloucester County

FEMA Declaration Number	Date(s) of Event	Declaration Date	Event Description
EM-3148	September 16, 1999 - September 18, 1999	September 17, 1999	Hurricane Floyd
EM-3332	August 27, 2011 - September 5, 2011	August 11, 2011	Hurricane Irene
DR-4021	August 27, 2011 - September 5, 2011	August 31, 2011	Hurricane Irene
EM-3354	October 26, 2012 - November 8, 2012	October 29, 2012	Hurricane Sandy
DR-4086	October 26, 2012 - November 8, 2012	October 30, 2012	Hurricane Sandy
DR-4574	August 4, 2020	December 11, 2020	Tropical Storm Isaias
DR-4614	September 1-3, 2021	September 5, 2021	Remnants of Hurricane Ida

Source: FEMA 2021
Note: Evacuation EM is not included.

U.S Department of Agriculture Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2015 and 2021, Gloucester County was included in one USDA agricultural disaster relating to hurricanes or tropical storms (USDA 2021).

Hurricane and Tropical Storm Events

For this 2021 Plan Update, known hurricane and tropical storm events that have impacted Gloucester County between 2015 and 2021 are identified are identified in Table 4.3.10-4. For events prior to 2015, refer to Appendix E.

Table 4.3.10-4. Hurricane and Tropical Storm Gloucester County, 2015-2021

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Description
August 4, 2020	Tropical Storm Isaias	DR-4574	Yes	Gloucester	Tropical Storm Isaias brought high winds, heavy rain, several tornadoes, and coastal flooding to the mid-Atlantic region, becoming the most impactful tropical cyclone to impact most of the region since Sandy in 2012. A number of reports of downed trees and power lines were received in the county. No confirmed observations of sustained tropical storm force winds were received, likely due to lack of available data, but damage reports and observations from surrounding areas suggest such winds likely occurred.
July 9, 2020 – July 12, 2020	Tropical Storm Fay	N/A	N/A	Gloucester	Tropical Storm Fay was the first tropical cyclone to make landfall in the U.S state of New Jersey since Hurricane Irene in 2011. Fay originated from a surface low that formed over the Northern Gulf of Mexico on July 3 and slowly drifted eastward, before crossing over the Florida Panhandle. The system subsequently drifted across the Southeastern United States as a well-defined low-pressure system, before emerging off the coast of North Carolina on July 8. From there, the storm utilized favorable conditions for development, or tropical cyclogenesis, and coalesced into a tropical storm on July 9. The storm intensified, reaching its peak intensity on July 10, with maximum 1-minute sustained winds of 60 mph (95 km/h) and a minimum central pressure of 998 millibars (29.5 inHg), while moving northward, making landfall on New Jersey later that day. South Harrison in Gloucester County picked up 6.17 inches of rain, Mullica Hill — also in Gloucester County — reported 5.84 inches, while nearby Franklin Township measured 5.28 inches. Margate in Atlantic County received 5.50 inches of rain.
August 4, 2020	Tropical Storm Isaias	DR-4574	Yes	Gloucester	Tropical Storm Isaias brought high winds, heavy rain, several tornadoes, and coastal flooding to the mid-Atlantic region, becoming the most impactful tropical cyclone to impact most of the region since Sandy in 2012.

TETRA TECH

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Description
					A number of reports of downed trees and power lines were received in the county. No confirmed observations of sustained tropical storm force winds were received, likely due to lack of available data, but damage reports and observations from surrounding areas suggest such winds likely occurred. NJ Route 45 was closed near Berkley Road in Mantua Township due to flooding.
September 1-3, 2021	Remnants of Hurricane Ida	DR-4614	Yes	Gloucester	Remnants from Hurricane Ida spurred numerous damaging tornados that traveled across Gloucester County (See Section 4.3.13 Severe Weather for more details).

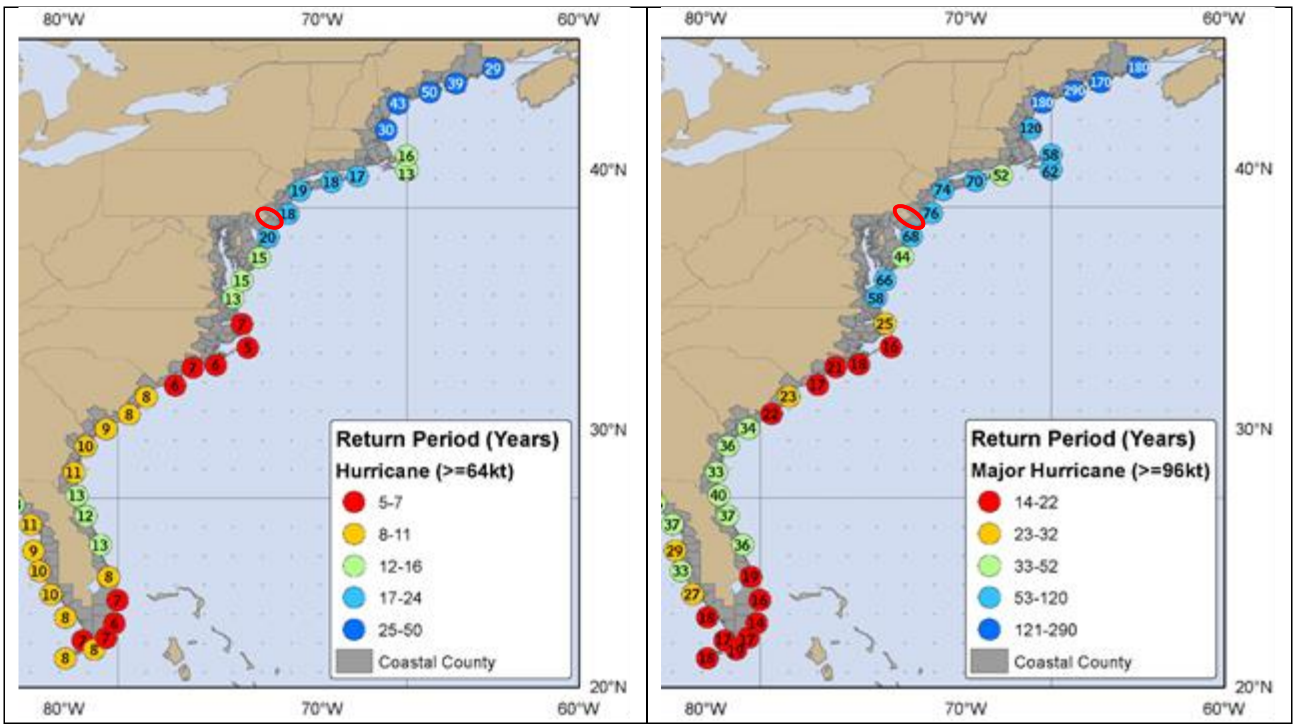
Sources: NOAA NCEI 2021, NHC 2021, FEMA 2021
DR Federal Disaster Declaration
EM Federal Emergency Declaration
FEMA Federal Emergency Management Agency
HMP Hazard Mitigation Plan
IA Individual Assistance
K Thousand ($)
M Million ($)
Mph Miles Per Hour
NCDC National Climate Data Center
NOAA National Oceanic Atmospheric Administration
NWS National Weather Service
PA Public Assistance
SHELDUS Spatial Hazard Events and Losses Database for the U.S

Probability of Future Occurrences

It is estimated that Gloucester County will continue to experience direct and indirect impacts of hurricane and tropical storms annually that may induce secondary hazards such as flooding, extreme wind, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents, and inconveniences.

Figure 4.3.10-4 illustrates the return period for hurricanes and major hurricanes along the eastern seaboard. According to these maps, Gloucester County can expect a hurricane ever 18-20 years and a major hurricane ever 68-76 years. Note that as Gloucester County is not a coastal county, it was not included within the analysis. However, given its proximity to the Delaware Bay and Atlantic Ocean, the numbers from the map are still relevant.

Figure 4.3.10-4. Return Period in Years for Hurricanes and Major Hurricanes



Source: (NOAA NHC 2011)
Note: The return period of hurricanes based on historical data. Gloucester County circled in red. The information on return period is generated with the 1987 HURISK program but uses data through 2010.

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for hurricane and tropical storms in the county is considered "occasional" (10 to 100 percent annual chance of occurrence).

Climate Change Impacts

Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo 2014) and the world (1.5° F [0.8° C]) (Meyer 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton 2015).

Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017).

According to NOAA, sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. Other secondary hazards that could occur along the Mid-Atlantic coast in response to sea level rise include:

- *Bluff and upland erosion* – Shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As sea level rises, the uplands are eroded and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments.
- *Overwash* – As sea level rise occurs, storm overwash will become more likely.
- *Shoreline retreat* - The combination of rising sea level and stronger storms can create the potential to accelerate shoreline retreat in many locations (USGS 2007).

A warmer atmosphere means storms have the potential to be more intense and occur more often (Broccoli 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh 2014), which is a faster rate than anywhere else in the United States (Huang et al. 2017). As temperatures increase so will the energy in a storm system, increasing the potential for more intense tropical storms (Huang 2017), especially those of Category 4 and 5

In Philadelphia, Pennsylvania and Reedy Beach, Delaware (the nearest tidal gages to Gloucester County on the Delaware River), sea-level has risen at a rate of approximately 0.11 to 0.15 inches per year since the beginning of the 20th century (NOAA 2021), and this rate will continue to increase (Kopp et al. 2019). The amount of greenhouse gases that are emitted is tied to rates of sea-level rise. By 2050, New Jersey will likely experience at least a 0.9 to 2.1-foot increase (above the levels in 2000; all emissions scenarios), 1.4 to 3.1-foot increase by

2070 (moderate emissions scenario), and potentially a 2.0 to 5.1-foot increase by 2100 (moderate emissions scenario).

Impacts of climate change can lead to shoreline erosion, coastal flooding, and water pollution; affecting man-made coastal infrastructures and coastal ecosystems. Coastal areas may be impacted by climate change in different ways. These areas are sensitive to sea level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures (USEPA 2017). As noted above, temperatures are predicted to increase in Gloucester County, which lead to an increase in intensity and frequency of severe storm. This increase may lead to more weather patterns that cause coastal erosion events. Rising sea levels will also exacerbate erosional issues.

4.3.10.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable. For the hurricane and tropical storm hazard, the entire county has been identified as exposed; therefore, all assets are potentially vulnerable. The following text estimated potential impacts of hurricanes and tropical storms on Gloucester County.

Impact on Life, Health and Safety

The impact of a hurricane on life, health and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time was provided to residents. For the purposes of this HMP, the entire population of Gloucester County (291,165 people) is exposed to winds associated with hurricane and tropical storm events (ACS 2010). Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing.

To estimate the population in the hurricane inundation zones, the sum of the population in all Census Blocks with their centroid located in the SLOSH zone was calculated for each municipality. Table 4.3.10-5 summarizes the approximate population located in the hurricane inundation zones based on 2010 Census data. This exposure analysis is limited by the Census Block and SLOSH zone configurations. If a Block’s centroid is not located within the underlying SLOSH zone it will not produce a result. Refer to Section 4.3.7 (Flood) for the population located in the coastal flood zones (V-zones).

Table 4.3.10-5. Approximate Population Located in the Hurricane Inundation Zones

Jurisdiction	Total Population (American Community Survey 2015-2019)	Number of Persons Located in the SLOSH Category 1 Storm Surge Hazard Area	Percent of Total	Number of Persons Located in the SLOSH Category 2 Storm Surge Hazard Area	Percent of Total	Number of Persons Located in the SLOSH Category 3 Storm Surge Hazard Area	Percent of Total	Number of Persons Located in the SLOSH Category 4 Storm Surge Hazard Area	Percent of Total
Clayton (B)	8,626	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Deptford (Twp)	30,448	0	0.0%	12	0.0%	92	0.3%	1,097	3.6%
East Greenwich (Twp)	10,488	3	0.0%	29	0.3%	260	2.5%	895	8.5%
Elk (Twp)	4,135	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Franklin (Twp)	16,440	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Glassboro (B)	19,826	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Greenwich (Twp)	4,831	898	18.6%	2,693	55.7%	4,305	89.1%	4,685	97.0%
Harrison (Twp)	12,995	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Logan (Twp)	5,924	174	2.9%	453	7.6%	1,320	22.3%	2,265	38.2%
Mantua (Twp)	14,941	0	0.0%	15	0.1%	56	0.4%	120	0.8%
Monroe (Twp)	36,789	0	0.0%	0	0.0%	0	0.0%	0	0.0%
National Park (B)	2,959	93	3.2%	816	27.6%	2,084	70.4%	2,322	78.5%
Newfield (B)	1,521	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Paulsboro (B)	5,904	5	0.1%	2,396	40.6%	3,757	63.6%	4,646	78.7%
Pitman (B)	8,805	0	0.0%	0	0.0%	0	0.0%	0	0.0%
South Harrison (Twp)	3,148	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Swedesboro (B)	2,579	0	0.0%	3	0.1%	23	0.9%	82	3.2%
Washington (Twp)	47,833	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Wenonah (B)	2,259	0	0.0%	0	0.0%	3	0.1%	18	0.8%
West Deptford (Twp)	21,149	161	0.8%	1,462	6.9%	5,449	25.8%	8,369	39.6%
Westville (B)	4,169	22	0.5%	685	16.4%	2,051	49.2%	3,381	81.1%
Woodbury (C)	9,861	0	0.0%	9	0.1%	153	1.6%	794	8.1%
Woodbury Heights (B)	2,986	0	0.0%	0	0.0%	0	0.0%	0	0.0%

Jurisdiction	Total Population (American Community Survey 2015-2019)	Number of Persons Located in the SLOSH Category 1 Storm Surge Hazard Area	Percent of Total	Number of Persons Located in the SLOSH Category 2 Storm Surge Hazard Area	Percent of Total	Number of Persons Located in the SLOSH Category 3 Storm Surge Hazard Area	Percent of Total	Number of Persons Located in the SLOSH Category 4 Storm Surge Hazard Area	Percent of Total
Woolwich (Twp)	12,549	0	0.0%	0	0.0%	88	0.7%	185	1.5%
Gloucester County (Total)	**291,165**	**1,355**	**0.5%**	**8,571**	**2.9%**	**19,640**	**6.7%**	**28,861**	**9.9%**

Source: U.S. Census 2010 and NOAA 2014
Notes: Cat = Category Hurricane
% - Percent; Pop = Population

Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Hazus-MH estimates there will be three displaced households and two people that may require temporary shelter due to a 100-year MRP event. For a 500-year MRP event, Hazus-MH estimates 73 households will be displaced and 47 people will require short-term sheltering. Refer to Table 4.3.10-6 which summarizes the sheltering estimates for the 100- and 500-year MRP events by municipality. Please note these estimates are based on wind speed only and do not account for sheltering needs associated with flooding and storm surge that may accompany coastal storm events.

Table 4.3.10-6. Estimated Sheltering Needs for the 100- and 500-year MRP Hurricane Event

Jurisdiction	100-Year Mean Return Period Hurricane		500-Year Mean Return Period Hurricane	
	Displaced Households	Persons Seeking Short-Term Sheltering	Displaced Households	Persons Seeking Short-Term Sheltering
Clayton (B)	0	0	4	2
Deptford (Twp)	0	0	11	6
East Greenwich (Twp)	0	0	0	0
Elk (Twp)	0	0	0	0
Franklin (Twp)	0	0	3	2
Glassboro (B)	0	0	12	10
Greenwich (Twp)	0	0	0	0
Harrison (Twp)	0	0	0	0
Logan (Twp)	0	0	0	0
Mantua (Twp)	0	0	1	1
Monroe (Twp)	3	2	20	12
National Park (B)	0	0	0	0
Newfield (B)	0	0	0	0
Paulsboro (B)	0	0	1	1
Pitman (B)	0	0	1	1
South Harrison (Twp)	0	0	0	0
Swedesboro (B)	0	0	0	0
Washington (Twp)	0	0	12	8
Wenonah (B)	0	0	0	0
West Deptford (Twp)	0	0	4	2
Westville (B)	0	0	2	1
Woodbury (C)	0	0	2	1
Woodbury Heights (B)	0	0	0	0
Woolwich (Twp)	0	0	0	0
Gloucester County (Total)	**3**	**2**	**73**	**47**

Source: Hazus 4.2 (U.S. Census 2010)

Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to evacuate. The population over the age of 65 is also more vulnerable and, physically, they may have more difficulty evacuating. The elderly are considered most vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention which may not be available due to isolation during a storm event. Please refer to Section 3 for the statistics of these populations.

Impact on General Building Stock

After considering the population exposed to the hurricane hazard, the value of general building stock exposed to and damaged by 100- and 500-year MRP hurricane wind event was considered. Potential damage is the modeled loss that could occur to the exposed inventory, including damage to structural and content value based on the wind-only impacts associated with a hurricane, followed by a consideration of storm surge impacts using the data and methodology described earlier.

Wind-Only Impacts

The entire study area is considered at risk to the hurricane wind hazard. Please refer to Section 3 (County Profile) which presents the total exposure value for general building stock by occupancy class for Gloucester County. Expected building damage was evaluated by Hazus-MH across the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 4.3.10-7 summarizes the definition of the damage categories.

Table 4.3.10-7. Description of Damage Categories

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
No Damage or Very Minor Damage Little or no visible damage from the outside. No broken windows, or failed roof deck. Minimal loss of roof over, with no or very; Limited water penetration.	≤2%	No	No	No	No	No
Minor Damage Maximum of one broken window, door or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for repair.	>2% and ≤15%	One window, door, or garage door failure	No	<5 impacts	No	No
Moderate Damage Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.	>15% and ≤50%	> one and ≤ the larger of 20% & 3	1 to 3 panels	Typically 5 to 10 impacts	No	No
Severe Damage Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	>50%	> the larger of 20% & 3 and ≤50%	>3 and ≤25%	Typically 10 to 20 impacts	No	No

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
Destruction Complete roof failure and/or, failure of wall frame. Loss of more than 50% of roof sheathing.	Typically >50%	>50%	>25%	Typically >20 impacts	Yes	Yes

Source: Hazus-MH Hurricane Technical Manual

Table 4.3.10-8 summarizes the building value (structure only) damage estimated for the 100- and 500-year MRP hurricane wind-only events. Damage estimates are reported for the County's probabilistic Hazus-MH model scenarios. The data shown indicates total losses associated with wind damage to building structure.

Table 4.3.10-8. Estimated Building Value (Structure Only) Damaged by the 100-Year and 500-Year MRP Hurricane-Related Winds

Jurisdiction	Building Replacement Cost Value	Estimated Building Losses Caused by the 100-Year Mean Return Period Hurricane	Percent of Total	Estimated Building Losses Caused by the 500-Year Mean Return Period Hurricane	Percent of Total	Estimated Building Losses Caused by the 100-Year Mean Return Period Hurricane for Residential Structures Only	Estimated Building Losses Caused by the 500-Year Mean Return Period Hurricane for Residential Structures Only	Estimated Building Losses Caused by the 100-Year Mean Return Period Hurricane for Commercial Structures Only	Estimated Building Losses Caused by the 500-Year Mean Return Period Hurricane for Commercial Structures Only
Clayton (B)	$1,933,299,905	$2,619,267	0.1%	$9,231,141	0.5%	$2,523,371	$8,641,630	$58,637	$327,139
Deptford (Twp)	$10,081,159,584	$4,565,710	0.0%	$30,200,489	0.3%	$4,321,628	$28,265,166	$165,578	$1,307,248
East Greenwich (Twp)	$2,927,045,409	$925,813	0.0%	$7,989,831	0.3%	$897,491	$7,697,383	$20,289	$192,675
Elk (Twp)	$1,784,179,937	$1,062,289	0.1%	$5,818,678	0.3%	$1,014,270	$5,291,926	$15,566	$165,945
Franklin (Twp)	$5,637,186,975	$10,673,592	0.2%	$28,207,391	0.5%	$9,971,716	$25,243,697	$487,784	$1,916,786
Glassboro (B)	$5,816,332,907	$4,461,004	0.1%	$19,776,291	0.3%	$4,203,668	$18,030,295	$154,893	$1,153,787
Greenwich (Twp)	$2,734,741,222	$240,883	0.0%	$3,156,994	0.1%	$240,851	$2,855,696	$17	$106,988
Harrison (Twp)	$4,828,239,008	$2,375,204	0.0%	$14,883,774	0.3%	$2,312,032	$14,082,770	$44,246	$569,684
Logan (Twp)	$6,591,573,691	$214,352	0.0%	$4,780,245	0.1%	$213,576	$3,749,269	$0	$845,336
Mantua (Twp)	$4,738,271,524	$2,149,970	0.0%	$14,852,250	0.3%	$2,042,537	$13,718,359	$85,421	$872,929
Monroe (Twp)	$8,458,118,166	$16,714,783	0.2%	$41,289,328	0.5%	$15,583,962	$36,786,822	$865,241	$3,452,925
National Park (B)	$781,021,288	$238,783	0.0%	$2,010,650	0.3%	$228,768	$1,897,031	$5,626	$64,561
Newfield (B)	$622,948,021	$1,133,844	0.2%	$2,905,874	0.5%	$1,031,082	$2,519,194	$65,174	$229,387
Paulsboro (B)	$2,076,864,026	$313,406	0.0%	$3,102,356	0.1%	$264,656	$2,763,252	$20,280	$173,029
Pitman (B)	$2,916,470,733	$1,625,727	0.1%	$8,896,418	0.3%	$1,508,169	$8,078,962	$72,778	$538,452
South Harrison (Twp)	$1,494,748,661	$582,501	0.0%	$4,286,377	0.3%	$572,043	$4,056,241	$6,374	$105,243
Swedesboro (B)	$936,236,069	$140,311	0.0%	$1,356,649	0.1%	$117,228	$1,150,097	$15,623	$162,728
Washington (Twp)	$13,732,374,547	$14,313,415	0.1%	$55,774,250	0.4%	$13,582,335	$50,727,830	$572,928	$3,937,690
Wenonah (B)	$778,702,966	$445,579	0.1%	$2,896,772	0.4%	$433,841	$2,772,492	$6,848	$78,676
West Deptford (Twp)	$9,201,121,261	$2,304,616	0.0%	$18,619,605	0.2%	$2,053,389	$16,150,120	$202,267	$2,134,302
Westville (B)	$1,529,846,612	$443,113	0.0%	$3,810,387	0.2%	$398,361	$3,401,628	$36,497	$318,975
Woodbury (C)	$4,139,381,075	$1,006,880	0.0%	$8,750,235	0.2%	$869,160	$7,410,423	$109,347	$1,123,112
Woodbury Heights (B)	$1,265,332,236	$465,758	0.0%	$3,281,823	0.3%	$432,975	$2,924,982	$19,789	$233,447
Woolwich (Twp)	$4,551,585,778	$686,861	0.0%	$9,027,375	0.2%	$686,816	$8,770,907	$30	$175,119

Jurisdiction	Building Replacement Cost Value	Estimated Building Losses Caused by the 100-Year Mean Return Period Hurricane	Percent of Total	Estimated Building Losses Caused by the 500-Year Mean Return Period Hurricane	Percent of Total	Estimated Building Losses Caused by the 100-Year Mean Return Period Hurricane for Residential Structures Only	Estimated Building Losses Caused by the 500-Year Mean Return Period Hurricane for Residential Structures Only	Estimated Building Losses Caused by the 100-Year Mean Return Period Hurricane for Commercial Structures Only	Estimated Building Losses Caused by the 500-Year Mean Return Period Hurricane for Commercial Structures Only
Gloucester County (Total)	$99,556,781,602	$69,703,663	0.1%	$304,905,184	0.3%	$65,503,925	$276,986,174	$3,031,232	$20,186,163

Source: Hazus 4.2; RS Means 2021; Gloucester County 2021
**Total Damages is sum of damages for all occupancy classes (residential, commercial, industrial, agricultural, educational, religious and government) based on improvement value.*

The total damage to buildings (structure only) for all occupancy types across the County is estimated to be $69.7 million for the 100-year MRP wind-only event, and approximately $304.9 billion for the 500-year MRP wind-only event. The majority of these losses are to the residential building category. Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. The damage counts include buildings damaged at all severity levels from minor damage to total destruction. Total dollar damage reflects the overall impact to buildings at an aggregate level.

According to FEMA, properly installed and maintained manufactured homes designed and installed to the 1994 HUD standard perform much better than older manufactured housing, particularly in areas with higher design wind speeds. However, even new manufactured homes are often damaged by high-wind events. Damage may include direct damage to the home itself and damage that results from failures in the home's anchorage system (FEMA 2007).

Storm Surge Hurricane Impacts on Buildings

To estimate potential building exposure to storm surge, the SLOSH inundation zones were overlaid with the updated building inventory. The structures with their centroid in the inundation zones were used to calculate the estimated exposure. Table 4.3.10-9 and Table 4.3.10-10 summarize the number of buildings and their estimated building replacement cost value exposed to hurricane storm surge by jurisdiction. The Township of Logan has the greatest estimated replacement cost value exposure, with over $5 billion or 78.6%, in the category 4 SLOSH inundation zone.

Table 4.3.10-9. Number of Buildings in the Hurricane Inundation Zones

Municipality	Total Number of Buildings	Number of Buildings in SLOSH Inundation Zones							
		Cat 1	% in Cat 1	Cat 2	% in Cat 2	Cat 3	% in Cat 3	Cat 4	% in Cat 4
Clayton (B)	3,295	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Deptford (Twp)	11,284	0	0.0%	7	0.1%	36	0.3%	393	3.5%
East Greenwich (Twp)	4,346	1	0.0%	19	0.4%	158	3.6%	450	10.4%
Elk (Twp)	2,339	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Franklin (Twp)	8,432	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Glassboro (B)	5,959	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Greenwich (Twp)	2,807	512	18.2%	1,439	51.3%	2,433	86.7%	2,727	97.1%
Harrison (Twp)	4,817	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Logan (Twp)	2,805	106	3.8%	378	13.5%	822	29.3%	1,283	45.7%
Mantua (Twp)	6,569	0	0.0%	7	0.1%	28	0.4%	60	0.9%
Monroe (Twp)	12,553	0	0.0%	0	0.0%	0	0.0%	0	0.0%
National Park (B)	1,483	53	3.6%	415	28.0%	1,041	70.2%	1,170	78.9%
Newfield (B)	891	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Paulsboro (B)	2,615	12	0.5%	1,125	43.0%	1,708	65.3%	2,074	79.3%
Pitman (B)	3,521	0	0.0%	0	0.0%	0	0.0%	0	0.0%
South Harrison (Twp)	1,726	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Swedesboro (B)	1,040	0	0.0%	3	0.3%	18	1.7%	43	4.1%
Washington (Twp)	17,413	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Wenonah (B)	930	0	0.0%	1	0.1%	3	0.3%	9	1.0%
West Deptford (Twp)	7,561	57	0.8%	573	7.6%	2,078	27.5%	3,130	41.4%
Westville (B)	1,733	9	0.5%	278	16.0%	870	50.2%	1,381	79.7%
Woodbury (C)	3,605	1	0.0%	8	0.2%	75	2.1%	321	8.9%
Woodbury Heights (B)	1,295	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Woolwich (Twp)	4,074	0	0.0%	2	0.0%	36	0.9%	71	1.7%
Gloucester County (Total)	**113,093**	**751**	**0.7%**	**4,255**	**3.8%**	**9,306**	**8.2%**	**13,112**	**11.6%**

Source: Gloucester County 2021; NOAA 2014; Hazus 4.2
Notes: Cat = Category Hurricane
% - Percent

Table 4.3.10-10. Building Replacement Cost Value in the Hurricane Inundation Zones

Municipality	Total Building Replacement Cost Value	Building Replacement Cost Values in SLOSH Inundation Zones							
		Cat 1	% in Cat 1	Cat 2	% in Cat 2	Cat 3	% in Cat 3	Cat 4	% in Cat 4
Clayton (B)	$1,933,299,905	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Deptford (Twp)	$10,081,159,584	$0	0.0%	$12,508,212	0.1%	$53,352,007	0.5%	$255,229,504	2.5%
East Greenwich (Twp)	$2,927,045,409	$415,454	0.0%	$24,230,354	0.8%	$220,066,430	7.5%	$463,772,576	15.8%
Elk (Twp)	$1,784,179,937	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Franklin (Twp)	$5,637,186,975	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Glassboro (B)	$5,816,332,907	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Greenwich (Twp)	$2,734,741,222	$549,474,508	20.1%	$1,252,857,423	45.8%	$2,406,752,008	88.0%	$2,701,612,040	98.8%
Harrison (Twp)	$4,828,239,008	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Logan (Twp)	$6,591,573,691	$170,394,231	2.6%	$1,652,920,916	25.1%	$2,912,492,721	44.2%	$5,182,642,371	78.6%
Mantua (Twp)	$4,738,271,524	$0	0.0%	$7,092,766	0.1%	$23,825,596	0.5%	$92,289,478	1.9%
Monroe (Twp)	$8,458,118,166	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
National Park (B)	$781,021,288	$30,651,864	3.9%	$197,576,956	25.3%	$537,068,567	68.8%	$620,519,663	79.4%
Newfield (B)	$622,948,021	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Paulsboro (B)	$2,076,864,026	$45,305,371	2.2%	$1,036,582,979	49.9%	$1,528,968,090	73.6%	$1,710,299,177	82.4%
Pitman (B)	$2,916,470,733	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
South Harrison (Twp)	$1,494,748,661	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Swedesboro (B)	$936,236,069	$0	0.0%	$2,412,285	0.3%	$27,864,725	3.0%	$51,604,866	5.5%
Washington (Twp)	$13,732,374,547	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Wenonah (B)	$778,702,966	$0	0.0%	$2,205,856	0.3%	$4,508,609	0.6%	$7,687,296	1.0%
West Deptford (Twp)	$9,201,121,261	$25,815,668	0.3%	$376,174,338	4.1%	$1,993,870,281	21.7%	$3,410,257,168	37.1%
Westville (B)	$1,529,846,612	$5,992,588	0.4%	$226,976,073	14.8%	$735,838,441	48.1%	$1,094,414,808	71.5%
Woodbury (C)	$4,139,381,075	$2,205,856	0.1%	$22,008,060	0.5%	$630,012,495	15.2%	$926,288,394	22.4%
Woodbury Heights (B)	$1,265,332,236	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Woolwich (Twp)	$4,551,585,778	$0	0.0%	$498,516	0.0%	$27,077,876	0.6%	$97,581,216	2.1%
Gloucester County (Total)	**$99,556,781,602**	**$830,255,540**	**0.8%**	**$4,814,044,733**	**4.8%**	**$11,101,697,844**	**11.2%**	**$16,614,198,555**	**16.7%**

Source: Gloucester County 2021; NOAA 2014; Hazus 4.2
Notes: Cat = Category Hurricane
% - Percent

Impact on Critical Facilities

Overall, all critical facilities are exposed to the wind hazard. Hazus-MH estimates the probability that critical facilities (i.e., medical facilities, fire, police, EOC, schools, and user-defined facilities such as shelters and municipal buildings) may sustain damage as a result of 100- and 500-year MRP wind-only events. Additionally, Hazus-MH estimates the loss of use for each facility in number of days. Due to the sensitive nature of the critical facility dataset, individual facility estimated loss is not provided. Table 4.3.10-11 and Table 4.3.10-12 summarize the potential damages to the critical facilities in Gloucester County as a result of the 100- and 500-year MRP wind events.

Table 4.3.10-11. Estimated Impacts to Critical Facilities for the 100- Year Mean Return Period Hurricane-Related Winds

Facility Type	100-Year Mean Return Period Hurricane				
		Percent-Probability of Sustaining Damage			
	Loss of Days	Minor	Moderate	Severe	Complete
EOC	0	0.5% - 1.0%	0.0%	0.0%	0.0%
Medical Facilities	0	0.1% - 1.2%	0.0% - <0.1%	0.0%	0.0%
Police Stations	0	0.3% - 2.6%	0.0% - <0.1%	0.0%	0.0%
Fire Stations/EMS	0	0.2% - 1.2%	0.0% - <0.1%	0.0%	0.0%
Schools	0	0.1% - 2.4%	0.0% - 0.4%	0.0%	0.0%

Source: Hazus 4.2

Table 4.3.10-12. Estimated Impacts to Critical Facilities for the 500-Year Mean Return Period Hurricane-Related Winds

Facility Type	500-Year Mean Return Period Hurricane				
		Percent-Probability of Sustaining Damage			
	Loss of Days	Minor	Moderate	Severe	Complete
EOC	0	3.1% - 5.1%	0.1% - 0.5%	<0.1%	0.0%
Medical Facilities	0	1.4% - 5.3%	<0.1% - 1.2%	0.0%	0.0%
Police Stations	0	2.0% - 8.5%	<0.1% - 1.5%	<0.1% - 0.2%	0.0%
Fire Stations/EMS	0	0.9% - 4.0%	<0.1% - 0.7%	0.0% - <0.1%	0.0%
Schools	0	1.8% - 7.5%	0.2% - 4.3%	0.0% - <0.1%	0.0%

Source: Hazus 4.2

To estimate potential building exposure to storm surge, the SLOSH inundation zones were used. The critical facilities and utilities located in the Category 1 through 4 inundation zones are summarized by municipality in Table 4.3.10-13 through Table 4.3.10-16.

Table 4.3.10-13. Critical Facilities and Utilities Located in the Category 1 SLOSH Inundation Zone

Jurisdiction	Number of Critical Facilities Located in the SLOSH Category 1 Storm Surge Hazard Area						
	Fire Station	Hazardous Material Facility	Port Facility	Potable Water Facility	Primary Education	Secondary Education	Wastewater Pump Station
Clayton (B)	0	0	0	0	0	0	0
Deptford (Twp)	0	0	0	0	0	0	0
East Greenwich (Twp)	0	0	0	0	0	0	0
Elk (Twp)	0	0	0	0	0	0	0
Franklin (Twp)	0	0	0	0	0	0	0
Glassboro (B)	0	0	0	0	0	0	0
Greenwich (Twp)	2	5	0	0	4	1	0
Harrison (Twp)	0	0	0	0	0	0	0
Logan (Twp)	0	0	1	0	0	0	0
Mantua (Twp)	0	0	0	0	0	0	0
Monroe (Twp)	0	0	0	0	0	0	0
National Park (B)	0	1	0	1	0	0	1
Newfield (B)	0	0	0	0	0	0	0
Paulsboro (B)	0	1	2	0	0	0	0
Pitman (B)	0	0	0	0	0	0	0
South Harrison (Twp)	0	0	0	0	0	0	0
Swedesboro (B)	0	0	0	0	0	0	0
Washington (Twp)	0	0	0	0	0	0	0
Wenonah (B)	0	0	0	0	0	0	0
West Deptford (Twp)	0	0	0	0	0	0	0
Westville (B)	0	0	0	0	0	0	0
Woodbury (C)	0	0	0	0	0	0	0
Woodbury Heights (B)	0	0	0	0	0	0	0

Jurisdiction	Number of Critical Facilities Located in the SLOSH Category 1 Storm Surge Hazard Area						
	Fire Station	Hazardous Material Facility	Port Facility	Potable Water Facility	Primary Education	Secondary Education	Wastewater Pump Station
Woolwich (Twp)	0	0	0	0	0	0	0
Gloucester County (Total)	**2**	**7**	**3**	**1**	**4**	**1**	**1**

Table 4.3.10-14. Critical Facilities and Utilities Located in the Category 2 SLOSH Inundation Zone

Jurisdiction	Number of Critical Facilities Located in the SLOSH Category 2 Storm Surge Hazard Area														
	Board of Education	County Building	EMS	Fire Station	Food Pantry	Hazardous Material Facility	Medical Center	Police Station	Port Facility	Post Office	Potable Water Facility	Primary Education	Secondary Education	Wastewater Metering Station	Wastewater Pump Station
Clayton (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deptford (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
East Greenwich (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Elk (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Franklin (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glassboro (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greenwich (Twp)	2	0	0	2	0	7	0	0	2	0	0	4	2	0	0
Harrison (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Logan (Twp)	0	0	0	0	0	4	0	0	1	0	9	0	0	0	0
Mantua (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monroe (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
National Park (B)	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1
Newfield (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paulsboro (B)	0	0	2	2	0	3	1	2	3	0	0	1	0	0	1
Pitman (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Jurisdiction	Number of Critical Facilities Located in the SLOSH Category 2 Storm Surge Hazard Area														
	Board of Education	County Building	EMS	Fire Station	Food Pantry	Hazardous Material Facility	Medical Center	Police Station	Port Facility	Post Office	Potable Water Facility	Primary Education	Secondary Education	Wastewater Metering Station	Wastewater Pump Station
South Harrison (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swedesboro (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wenonah (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
West Deptford (Twp)	0	1	0	1	2	1	0	0	2	0	0	1	2	2	15
Westville (B)	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1
Woodbury (C)	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Woodbury Heights (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Woolwich (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gloucester County (Total)	**2**	**2**	**2**	**5**	**2**	**16**	**1**	**2**	**8**	**2**	**10**	**6**	**5**	**10**	**18**

Table 4.3.10-15. Critical Facilities and Utilities Located in the Category 3 SLOSH Inundation Zone

Jurisdiction	Number of Critical Facilities Located in the SLOSH Category 3 Storm Surge Hazard Area																							
	Board of Education	Bus Facility	County Building	Cultural Site	DPW	Electric Substation	EMS	EOC	Fire Station	Food Pantry	Fuel Facility	Hazardous Material Facility	Library	Medical Center	Municipal Building	Police Station	Port Facility	Post Office	Potable Water Facility	Primary Education	Secondary Education	Wastewater Metering Station	Wastewater Pump Station	Wastewater Treatment Facility
Clayton (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Jurisdiction	Number of Critical Facilities Located in the SLOSH Category 3 Storm Surge Hazard Area																							
	Board of Education	Bus Facility	County Building	Cultural Site	DPW	Electric Substation	EMS	EOC	Fire Station	Food Pantry	Fuel Facility	Hazardous Material Facility	Library	Medical Center	Municipal Building	Police Station	Port Facility	Post Office	Potable Water Facility	Primary Education	Secondary Education	Wastewater Metering Station	Wastewater Pump Station	Wastewater Treatment Facility
Deptford (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0
East Greenwich (Twp)	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	2	1	0
Elk (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Franklin (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glassboro (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greenwich (Twp)	2	0	0	0	0	0	0	0	2	0	0	13	0	0	0	2	2	0	0	5	2	0	0	0
Harrison (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Logan (Twp)	0	0	2	0	0	0	0	0	0	0	0	8	0	0	0	0	1	0	12	0	0	0	0	0
Mantua (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Monroe (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
National Park (B)	0	0	3	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	7	0	0	1	0
Newfield (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paulsboro (B)	1	0	0	0	0	0	2	0	2	0	0	5	0	1	0	2	4	0	0	1	1	0	1	0
Pitman (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Harrison (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swedesboro (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wenonah (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
West Deptford (Twp)	0	2	1	0	0	0	1	2	1	2	2	11	1	0	2	2	2	2	0	1	2	7	32	3
Westville (B)	0	0	0	1	8	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1	0	0	1	0

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Jurisdiction	Number of Critical Facilities Located in the SLOSH Category 3 Storm Surge Hazard Area																							
	Board of Education	Bus Facility	County Building	Cultural Site	DPW	Electric Substation	EMS	EOC	Fire Station	Food Pantry	Fuel Facility	Hazardous Material Facility	Library	Medical Center	Municipal Building	Police Station	Port Facility	Post Office	Potable Water Facility	Primary Education	Secondary Education	Wastewater Metering Station	Wastewater Pump Station	Wastewater Treatment Facility
Woodbury (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	2	0
Woodbury Heights (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Woolwich (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Gloucester County (Total)	**3**	**2**	**6**	**1**	**8**	**1**	**3**	**2**	**6**	**2**	**2**	**40**	**1**	**2**	**2**	**7**	**10**	**4**	**14**	**15**	**6**	**19**	**39**	**3**

Table 4.3.10-16. Critical Facilities and Utilities Located in the Category 4 SLOSH Inundation Zone

Jurisdiction	Number of Critical Facilities Located in the SLOSH Category 4 Storm Surge Hazard Area																										
	Board of Education	Bus Facility	County Building	Cultural Site	DPW	Electric Substation	EMS	EOC	Fire Station	Food Distribution	Food Pantry	Fuel Facility	Hazardous Material Facility	Library	Medical Center	Municipal Building	Police Station	Port Facility	Post Office	Potable Water Facility	Potable Water Tank	Potable Water Tower	Primary Education	Secondary Education	Wastewater Metering Station	Wastewater Pump Station	Wastewater Treatment Facility
Clayton (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deptford (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0
East Greenwich (Twp)	0	0	0	0	0	1	0	1	1	0	0	0	2	0	0	0	2	0	0	1	0	0	0	0	3	1	0
Elk (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Franklin (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Jurisdiction	Number of Critical Facilities Located in the SLOSH Category 4 Storm Surge Hazard Area																										
	Board of Education	Bus Facility	County Building	Cultural Site	DPW	Electric Substation	EMS	EOC	Fire Station	Food Distribution	Food Pantry	Fuel Facility	Hazardous Material Facility	Library	Medical Center	Municipal Building	Police Station	Port Facility	Post Office	Potable Water Facility	Potable Water Tank	Potable Water Tower	Primary Education	Secondary Education	Wastewater Metering Station	Wastewater Pump Station	Wastewater Treatment Facility
Glassboro (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greenwich (Twp)	2	0	0	0	0	0	0	0	2	0	0	0	14	0	0	0	2	2	0	0	0	0	5	2	0	0	0
Harrison (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Logan (Twp)	0	0	6	0	0	0	0	0	1	1	0	0	10	0	0	2	1	1	0	15	0	0	0	0	0	0	0
Mantua (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Monroe (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
National Park (B)	0	0	3	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	1	0	0	31	0	0	1	0
Newfield (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paulsboro (B)	1	0	0	0	0	0	2	0	2	0	0	0	6	0	1	0	2	4	0	0	0	0	1	1	0	1	0
Pitman (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Harrison (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swedesboro (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wenonah (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
West Deptford (Twp)	0	2	1	0	0	0	1	2	1	0	2	2	15	1	0	2	2	2	2	0	2	2	2	3	8	33	5
Westville (B)	0	0	0	1	8	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	1	0	0	1	0
Woodbury (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	2	2	3	2	0
Woodbury Heights (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Woolwich (Twp)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Gloucester County (Total)	**3**	**2**	**10**	**1**	**8**	**1**	**3**	**3**	**9**	**1**	**2**	**2**	**48**	**1**	**4**	**4**	**10**	**10**	**4**	**17**	**2**	**2**	**42**	**8**	**23**	**40**	**5**

TETRA TECH

Impact on Economy

Hurricanes and tropical storms also significantly impact the economy, including: loss of business function (e.g., tourism, recreation), damage to inventory, relocation costs, wage loss and rental loss due to the repair/replacement of buildings. Hazus-MH estimates the total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the "Impact on General Building Stock" subsection discussed earlier. Business interruption losses are the losses associated with the inability to operate a business because of the wind damage sustained during the storm or the temporary living expenses for those displaced from their home because of the event.

For the 100-year MRP wind event, Hazus-MH estimates $62.7 million in business interruption costs (income loss, relocation costs, rental costs and lost ages) and an estimated $45,000 in inventory losses. For the 500-year MRP wind only event, Hazus-MH estimates approximately $329.5 million in business interruption losses for the County, which includes loss of income, relocation costs, rental costs and lost wages, in addition to approximately $1.3 million in inventory losses.

Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting and goods transport) transportation needs. Utility infrastructure (power lines, gas lines, electrical systems) could suffer damage and impacts can result in the loss of power, which can impact business operations and can impact heating or cooling provision to the population.

Hazus 4.2 also estimates the amount of debris that may be produced a result of the 100- and 500-year MRP wind events. Table 4.3.10-17 summarizes the estimated debris by municipality. Because the estimated debris production does not include flooding, this is likely a conservative estimate and may be higher if multiple impacts occur.

According to the Hazus-MH Hurricane User Manual: '*The Eligible Tree Debris columns provide estimates of the weight and volume of downed trees that would likely be collected and disposed at public expense. As discussed in Chapter 12 of the Hazus-MH Hurricane Model Technical Manual, the eligible tree debris estimates produced by the Hurricane Model tend to underestimate reported volumes of debris brought to landfills for a number of events that have occurred over the past several years. This indicates that that there may be other sources of vegetative and non-vegetative debris that are not currently being modeled in Hazus. For landfill estimation purposes, it is recommended that the Hazus debris volume estimate be treated as an approximate lower bound. Based on actual reported debris volumes, it is recommended that the Hazus results be multiplied by three to obtain an approximate upper bound estimate. It is also important to note that the Hurricane Model assumes a bulking factor of 10 cubic yards per ton of tree debris. If the debris is chipped prior to transport or disposal, a bulking factor of 4 is recommended. Thus, for chipped debris, the eligible tree debris volume should be multiplied by 0.4*'.

Table 4.3.10-17. Debris Production for 100- and 500-Year Mean Return Period Hurricane-Related Winds

Jurisdiction	Brick and Wood (Tons)		Concrete and Steel (Tons)		Tree (Tons)		Eligible Tree Volume (Cubic Yards)	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Clayton (B)	156	870	0	2	939	3,051	3,133	10,180
Deptford (Twp)	279	2,614	0	0	934	5,443	5,315	27,351
East Greenwich (Twp)	23	606	0	0	477	4,285	1,177	10,573
Elk (Twp)	62	527	0	0	1,861	6,820	1,987	7,279
Franklin (Twp)	717	2,642	0	2	13,853	27,030	14,385	30,235
Glassboro (B)	262	1,822	0	0	925	3,528	4,403	15,923
Greenwich (Twp)	2	243	0	0	299	2,094	638	4,470
Harrison (Twp)	93	1,175	0	0	1,005	5,282	2,220	12,069
Logan (Twp)	2	352	0	0	740	4,440	1,031	6,185
Mantua (Twp)	131	1,250	0	0	1,022	5,274	3,239	16,909
Monroe (Twp)	1,296	4,281	0	1	12,343	23,232	23,592	48,960
National Park (B)	7	172	0	0	34	300	211	1,885
Newfield (B)	112	362	0	0	293	693	929	2,215
Paulsboro (B)	17	323	0	0	68	344	387	1,939
Pitman (B)	114	912	0	0	114	747	826	5,717
South Harrison (Twp)	12	346	0	0	529	4,618	528	4,605
Swedesboro (B)	7	136	0	0	25	175	203	1,421
Washington (Twp)	786	5,113	0	0	2,611	8,974	15,366	53,205
Wenonah (B)	22	216	0	0	63	347	525	2,890
West Deptford (Twp)	100	1,496	0	0	654	4,331	2,599	16,771
Westville (B)	39	406	0	0	69	344	503	2,513
Woodbury (C)	89	885	0	0	131	625	1,145	5,421
Woodbury Heights (B)	30	265	0	0	79	398	624	3,136
Woolwich (Twp)	2	628	0	0	679	4,081	1,325	7,953
Gloucester County (Total)	**4,360**	**27,642**	**0**	**5**	**39,746**	**116,453**	**86,291**	**299,807**

Source: Hazus 4.2

Future Changes that May Impact Vulnerability

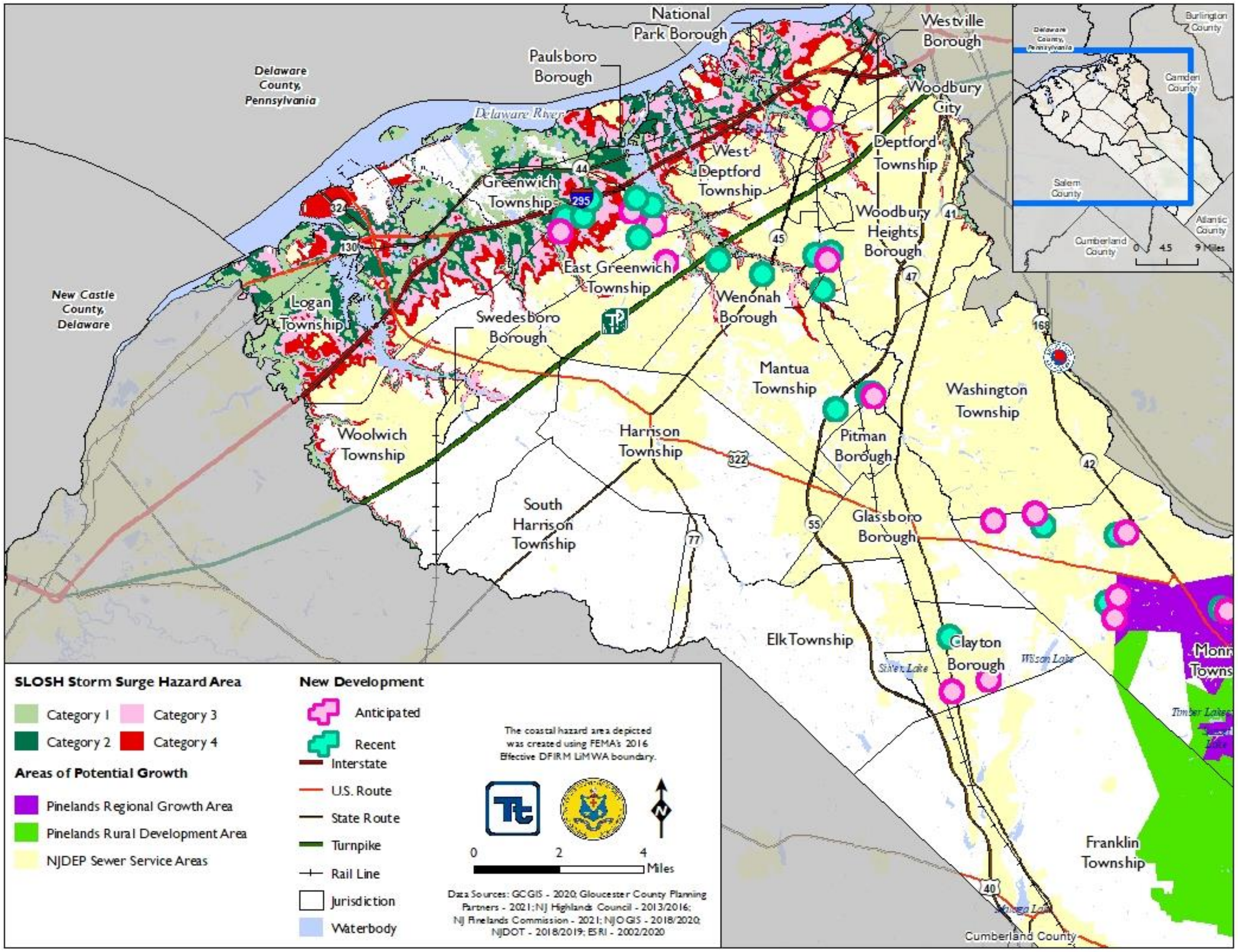
Understanding future changes that impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development and Change in Population

As discussed and illustrated in Sections 3 and 9, areas targeted for future growth and development have been identified across the County. Any areas of growth could be potentially impacted by the Hurricane and Tropical Storm hazard because the entire Planning Area is exposed and vulnerable to the impacts associated with these events. The development of new buildings in these areas must meet or exceed the standards in Section R301.2.1.1 of the International Building Code (IBC) which will assist with mitigating future potential damages and losses. Areas targeted for potential future growth and development in the next five (5) years have been identified across the County at the jurisdiction level. Figure 4.3.10-5 identifies areas of new development and SLOSH flood zones.

Figure 4.3.10-5. Potential New Development in Gloucester County and SLOSH



Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. An increase in temperatures may also lead to an increase in the frequency and intensity of coastal storms. More frequent and severe storms will increase the County's vulnerability to both wind-related and storm surge impacts.

The New Jersey Protecting Against Climate Threats Program has been implemented to minimize the impact of climate related changes (NJDEP 2020). This PACT highlights a series of regulatory action and goals that the State has set for its jurisdictions. Some of the resolutions relate to coastal storms including, issuing sea level rise guidance frameworks, reforming coastal zone management rules, freshwater wetlands rules, and flood hazard control rules.

Furthermore, the New Jersey Science and Technical Advisory Panel (STAP) on Sea-Level Rise and Coastal Storms published a report in 2019 that found New Jersey coastal areas have at least a 66-percent chance of experiencing sea level rise increasing 0.5 to 1.1 feet between 2000 and 2030, but less than 5-percent change of sea level rise exceeding 2.6 feet by 2050 (Rutgers University 2019). However, the study also found that these sea level rise predictions are extremely dependent on future greenhouse gas emissions. If emissions increase, sea level rise will also increase, which can have an impact on coastal communities in New Jersey. Consequentially, sea level rise will affect the baseline for flooding from high tides and coastal storms (Climate Change Institute 2020). This will exacerbate coastal storm impacts on Gloucester County.

Climate is defined not simply as average temperature and precipitation but also by the type, frequency, and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of events like hurricanes. While predicting changes to the prevalence or intensity of hurricanes and the events affects under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society, and the environment (USEPA 2020).

Change of Vulnerability Since the 2016 HMP

Gloucester County and its municipalities continue to be vulnerable to hurricanes and tropical storms. Overall, this vulnerability assessment using a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Gloucester County.

4.3.11 Infestation and Invasive Species

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the infestation hazard in Gloucester County.

2022 HMP Changes

- This is a new hazard of concern for Gloucester County.

4.3.11.1 Profile

Hazard Description

An infestation is defined as a state of being invaded or overrun by parasites that attack plants, animals and humans. Insect, fungi and parasitic infestations can result in destruction of various natural habitats and cropland, impact human health, and cause disease and death among native plant, wildlife and livestock. An infestation is the presence of a large number of pest organisms in an area or field, on the surface of a host, or in soil. They result from when an area is inhabited or overrun by these pest organisms, in numbers or quantities large enough to be harmful, threatening or obnoxious to native plants, animals and humans. Pests are any organism (insects, mammals, birds, parasite/pathogen, fungi, non-native species) that are a threat to other living species in its surrounding environment. Pests compete for natural resources or they can transmit diseases to humans, crops and livestock. Human populations are generally impacted by insect or animal infestations that can result in health impacts and can lead to potential epidemics or endemics.

For the purpose of this HMP Update, the infestation hazard profile will include the following: Emerald Ash Borer, Spotted Lanternfly, white-tailed deer, Canada Goose, and harmful algal bloom. For information on the spread of disease caused by mosquito infestations, refer to Section 4.3.3 (Disease Outbreak).

Emerald Ash Borer

Emerald Ash Borer (EAB) was first discovered in Somerset County in 2014 and first detected in Gloucester County in the Township of East Greenwich in 2019. This Asian beetle infests and kills North American ash tree species, including green, white, black and blue ash; making all native ash trees susceptible to this insect. The insect is typically present from late May through early September and is most common in June and July. Signs of infection include tree canopy dieback and yellowing and browning of leaves. Most trees die within two to four years of becoming infested (NJDA 2020).

Source: NJDA 2020

Spotted Lanternfly

Source: NJAES 2020

The spotted lanternfly (*Lycorma deliculta*) is an Asian plant hopper. The adults are quite colorful with a black head, grayish black spotted forewings, and reddish black spotted hind wings. Adults are approximately 1" in length and a 1/2" in width and are present from mid-July through the fall. During this time, SLF adults are mating and laying eggs. Egg masses are laid on smooth surfaces and appear like a patch of mud.

In the USA, spotted lanternfly is an invasive species that could be very devastating to some New Jersey crops and hardwood trees. This insect was accidentally introduced into Pennsylvania and was confirmed in September 2014. In 2018, spotted lanternfly populations were found in New Jersey and a state quarantine encompassing Gloucester, Hunterdon, and Warren counties has been established by the NJ Department of Agriculture (New Jersey Agricultural Experiment Station [NJAES] 2020).

The spotted lanternfly can feed on more than 70 plant species including cultivated grapes, fruit trees, and hardwood trees. One tree of particular importance is *Ailanthus altissima,* or the Tree of Heaven, which is abundant in New Jersey. Tree of Heaven typically grows in clumps in sunny areas along highways or disturbed habitats such as the edges of crop fields, open spaces, or parks. Other key tree hosts include black walnut; red maple; and agricultural crops such as grapes, hops, apples, and peaches.

As with all plant hoppers, the spotted lanternfly has sucking mouthparts that it inserts into plant tissues to remove the fluids it needs to survive. Adults and nymphs are phloem feeders that feed in large congregations on woody tissue. Although there are no numbers or estimates on the economic impact of the spotted lanternfly, this insect feeds in large numbers and thus can quickly cause damage. Feeding occurs on the trunk and limbs of plants, not on the fruit or leaf tissues. During feeding, the insect excretes significant amounts of sugar water, called honey dew. Honey dew deposits provide a food source for a sooty mold fungus that can grow on plant surfaces and fruit leading to reduced photosynthesis and plant vigor, leading to additional plant damage (NJAES 2020).

White-Tailed Deer


Source: NJDEP 2019

White-tailed deer can be found from southern Canada to South America. In summer months, they typically live in fields and meadows while during the winter, the deer generally keep to forests. White-tailed deer are herbivores and graze on most types of plants. There are not many natural predators to white-tailed deer which causes the deer population to grow too large for their environment and some areas may experience an overpopulation of deer (National Geographic 2015).

In New Jersey, white-tailed deer are a major component of the environment throughout the State, with the exception of the most urbanized areas. In the early 1900s, the deer population in New Jersey was minimal, but the population rebounded during the 20th century and is thriving today. White-tailed deer in New Jersey affect forests, farms, gardens, backyards and roadways. They can have negative impacts on humans, as they cause car accidents, depredation of agricultural and ornamental plantings, and the potential for harboring diseases that are transmissible to man or domestic animals (NJDEP 2020).

Deer populations have reached problematic numbers in numerous areas of the state. In an effort to help reduce these populations, the NJDEP Division of Fish and Wildlife has lengthened hunting seasons, increased limits on the number of deer that can be harvested (bag limit), increased the number of hunting permits issued, and offered incentives for hunters to harvest more does and fawns. However, in some areas, factors such as development patterns, properties where hunting is prohibited, regulations or ordinances that severely restrict or preclude hunting, and landowner decisions not to allow hunting, have reduced the effectiveness of hunting. Public open space with full hunter access typically has much lower deer densities than surrounding areas where hunting is not allowed or is restricted. Although New Jersey has some of the most liberal deer hunting regulations in the nation, the lack of or restricted hunter access results in undesirable deer densities in many areas of the state. In areas where sport hunting is not considered to be a practical management tool, the Division has permitted alternative methods of controlling deer populations under the Community-Based Deer Management Permit program. These alternative methods include controlled hunting, shooting by authorized agents, capture and euthanization, capture and removal, and fertility control. Farmers also get free permits to hunt on their property and free depredation permits to allow for taking deer during off-hunting season to mitigate agricultural damage (NJDEP 2019).

Canada Geese

The Canada Goose is a large, naturally occurring migratory waterfowl species. However, a portion of the population has adapted to become residential. These residential birds have overpopulated many urban and suburban areas that have expanses of short grass, abundant lakes and ponds, a lack of natural predators, limited hunting, and supplemental feeding. Resident geese are long-lived in suburban areas, living 20 or more years. A female goose may produce more than 50 young over her lifetime (NYSDEC 2007). The overpopulation of geese is a problem because their droppings and feathers accumulate on play areas and walkways, resulting in public health concerns at beaches and drinking water supplies, and environmental degradation in ponds due to increased nutrient loading. Furthermore, geese create a safety concern as nesting birds tend to be aggressive towards humans and create a safety hazard near roads and airports.

Harmful Algal Bloom

Algae blooms are caused by an excess of nutrients available in a waterbody, resulting in a rapid growth and reproduction of algae in what is commonly referred to as a “bloom.” Waterbodies that are impacted by runoff of nutrients at high levels of both naturally occurring and manmade, algae can experience overloading of nutrients and become more vulnerable to algal blooms.

Algae, like plants, photosynthesize, forming the basis of many aquatic and marine food chains. However, unlike plants, algae do not have roots for nutrient intake. Some species of macroalgae appear to have roots because they are attached to the bottom by a structure known as a holdfast, but the holdfast does not absorb and transfer nutrients in the same way that roots do. Instead, algae are able to draw their nutrients directly from the environment that surrounds them. Due to this phenomenon, high nutrients, warm temperatures, and low turbulence at the water's surface all increase the risk of algal blooms.

As the base of the food chain in aquatic systems, phytoplankton populations are under constant threat of being eaten by herbivores. Phytoplankton species employ a variety of natural defenses to limit the amount of population destruction that unabated grazing by herbivores can cause. These may include regulation of population size and seasonal occurrence, growth of spiny exteriors, and the creation of toxins. More than 40 cyanobacterial species are confirmed or suspected to produce toxins (Graham and Wilcox 2000). When these populations of algae grow out of control and produce toxins or have harmful effects, it is typically referred to as a *Harmful Algal Bloom or HAB*. Contact with water containing HABs can cause various health effects including diarrhea, nausea or vomiting; skin, eye, or throat irritation; and allergic reactions or breathing difficulties (NYSDOH 2017).

Traditional methods of in-home treatment systems such as boiling, disinfecting with chlorine/ultraviolet (UV), and water filtration units are not effective in removing HABs and their toxins. Public water is always the best option for drinking, preparing food, cooking, washing, and bathing, because water suppliers are required to treat, disinfect, and monitor their water supplies (NYSDOH 2017). Even after a HAB abates, toxins released by algae can remain in the water column for weeks. Water treatment plants with filtration systems can remove variable amounts of microcystin from drinking water; however, as much as 20 percent may escape the treatment process (Carmichael 1997), sometimes leading to plant and water system closures.

The presence of HABs will trigger official beach closures, drinking water restrictions, advisory signs, press releases, and notifications on websites such as the NJDEP Harmful Algal Blooms webpage (NJDEP 2019). Children and animals should be kept away from waters suspected of containing HABs, and fishing or eating fish should be prohibited. In Gloucester County, the primary threat from HABs is drinking water source contamination, followed by recreational precautions (and associated economic impacts) and the potential effects of the accumulation of toxins in fish for human consumption.

The appearance of HABs can vary greatly. According to the NJDEP, colors can include shades of green, blue-green, yellow, brown, red, or white. The physical appearance of these blooms can include floating dots or clumps and streaks on the water's surface as illustrated in Figure 4.3.11-1. Some blooms can also resemble spilled paint on the water's surface or change the appearance of water to that of pea soup (NJDEP 2019).

Figure 4.3.11-1. Examples of Harmful Algal Bloom Visual Appearance

HABs may look like parallel streaks, usually green, on the water surface.

HABs may look like green dots, clumps, or globs on the water surface.

HABs may look like blue, green, or white spilled paint on the water surface.

HABs may make the water look bright green or similar to pea soup.

Source: NJDEP 2019a

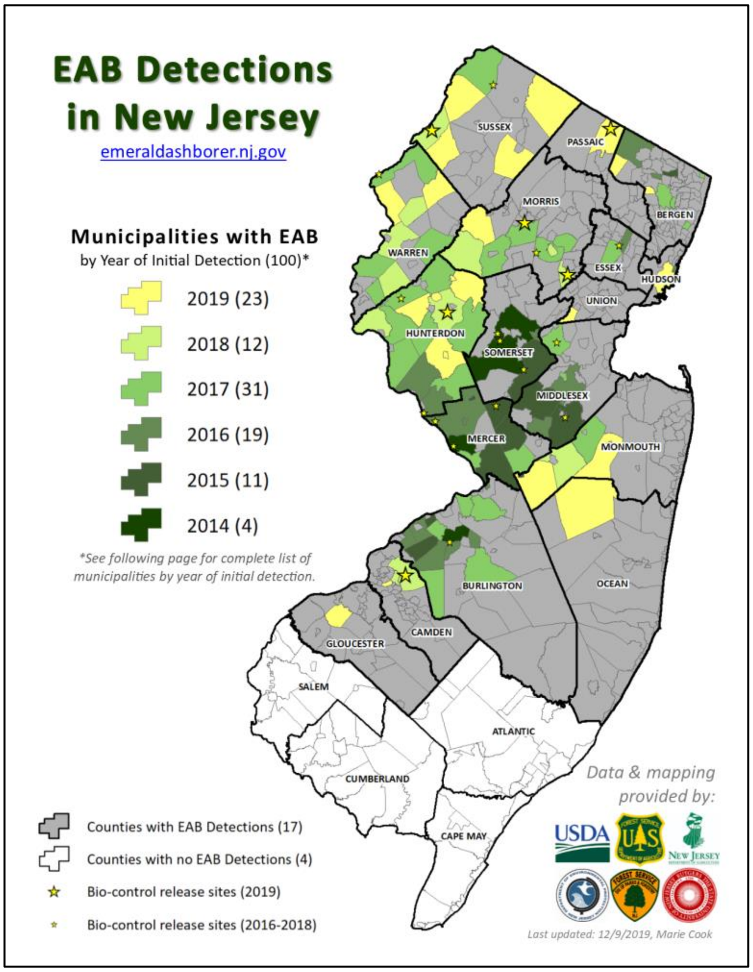
Location

Due to the diversity of landscape in Gloucester County, the entire County has the potential to be impacted by each of the species identified above.

Emerald Ash Borer

Three species of ash are native to Gloucester County an all are susceptible to EAB: white ash *(F. Americana),* green ash *(T. pennsylvanica*), and black ash (*F. nigra*). EAB was first detected in New Jersey in May 2014 and detected in Gloucester County (Township of East Greenwich) in 2019 (State of New Jersey Department of Agriculture 2021); refer to Figure 4.3.11-2.

Figure 4.3.11-2. Emerald Ash Borer Detections in New Jersey

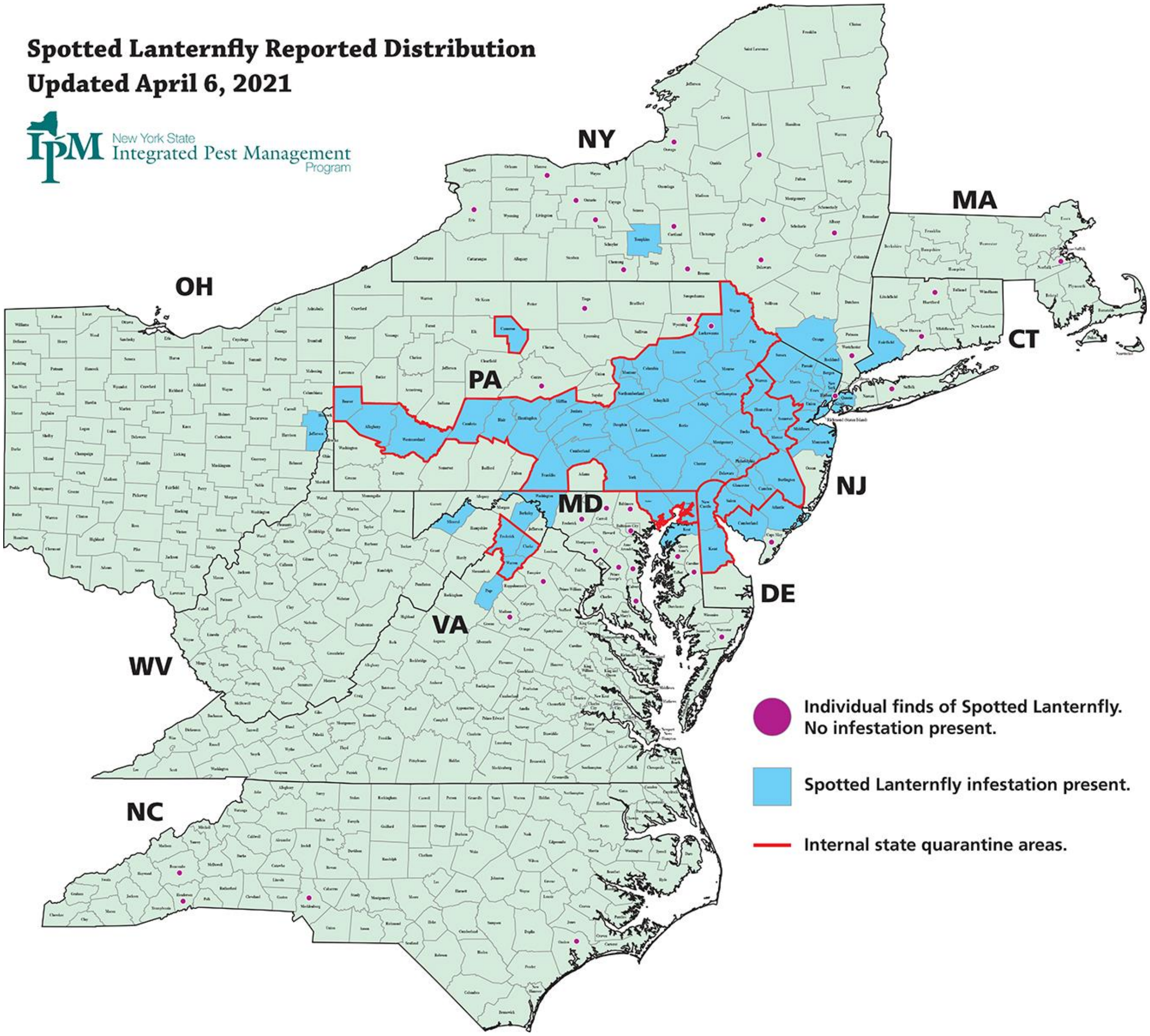


Source: State of New Jersey Department of Agriculture 2021

Spotted Lanternfly

According to NYSIPM, the spotted lanternfly infestation is present in Gloucester County as of April 2021. Gloucester County is included in the state quarantine area. The spotted lanternfly continues to spread across the mid-Atlantic region and increased occurrence within the County is likely in the near future unless successful mitigation occurs.

Figure 4.3.11-3. Spotted Lanternfly Reported Distribution as of March 2021



Source: NYSIPM 2021

White-Tailed Deer

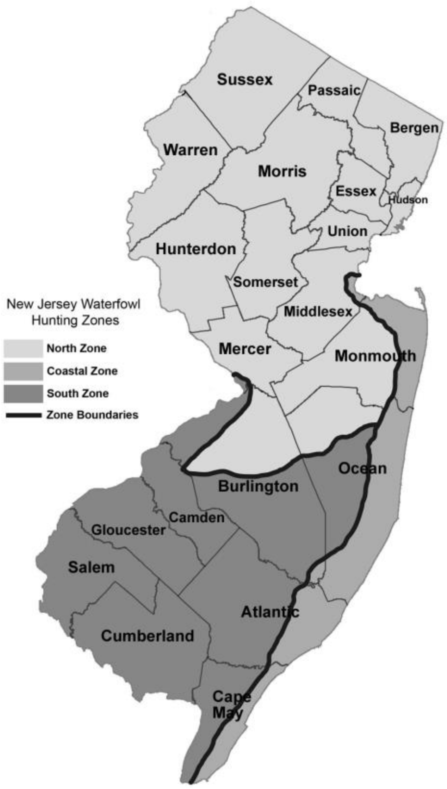
White-tailed deer populations vary throughout the state, based upon the habitat available. If deer were evenly distributed throughout the state, the 2017 population would average about 16.7 deer per square mile. However, urban areas typically have relatively few or no deer, and most suburban and rural areas with good deer habitat have more. Before recent culling efforts, Princeton Township had an estimated deer population of 114 per square mile and Hopewell Township estimated its deer population in 2010, prior to hunting season, as 54 per square mile (NJ DEP 2019).

Canada Geese

Within New Jersey there are three distinct populations of Canada geese: Atlantic Population, North Atlantic Population, and Resident Population. Atlantic Population Canada geese nest in the boreal forest and tundra of northern Quebec with the densest populations along the Ungava Bay and Hudson Bay coasts. North Atlantic Population geese nest further east in Newfoundland, Labrador, and Greenland. Collectively, Atlantic Population and North Atlantic Population geese are colloquially known as "migrant" geese since they breed in the sub-arctic and migrate south to spend winter. Resident Population geese breed in southern Canada and throughout the US and generally make no or relatively short migrations in winter. Although all three populations of geese readily mix in fall and winter, Resident Population geese are present in the states during spring and summer. Resident Population geese have readily adapted to human-dominated landscapes and are generally the goose population responsible for damage complaints regarding droppings and poor water quality (NJDEP 2018).

To manage and provide opportunity to hunt Resident Population geese, but avoid harvest of migratory geese, special seasons are designed to harvest Resident Population geese when and where possible. Gloucester County is included in the South Zone for hunting Canada Geese with the hunting season and bag limits set by the NJ DEP Division of Fish and Wildlife and the Fish and Game Council (NJDEP 2019).

Figure 4.3.11-4. New Jersey Waterfowl Hunting Zones

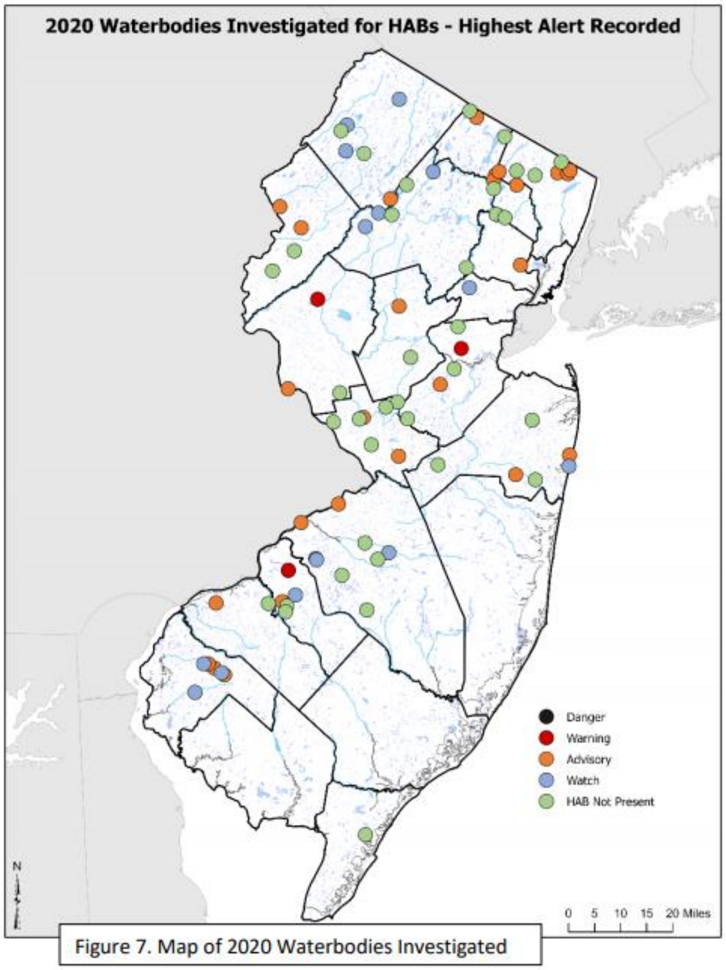


Source: NJ DEP 2019

Harmful Algal Bloom

HABs have the potential to impact waterbodies throughout Gloucester County and New Jersey. Waterbodies that are calm and have issues with eutrophication (overloading of nutrients), are the most susceptible to HABs. In Gloucester County, Greenwich Lake and Almonesson Lake are monitored for HAB's. In 2020, Greenwich Lake reached advisory levels for HAB's.

Figure 4.3.11-5. 2020 Waterbodies Investigated for HAB's, Highest Alert Recorded



Source: NJ DEP 2021

Wind currents can play a large role in the concentrations of algae that float at or near the water surface. Consistent winds can accumulate algae at downwind shorelines. Shorelines containing coves or other features that could capture floating algae may be more susceptible to HABs. In instances where freshwater intakes are impacted by these blooms, the extent may also include the area that is serviced by the impacted water utility or the private/residential intake.

Extent

The extent and location of infestations and invasive species depends on the preferred habitat of the species, as well as the species' ease of movement and establishment. However, each of these threats can impact many areas of Gloucester County. The magnitude of infestations and invasive species ranges from nuisance to widespread. The threat is typically intensified when the ecosystem or host species is already stressed, such as periods of drought. The already weakened state of the ecosystem causes it to more easily be impacted to an infestation.

Emerald Ash Borer

The NJ Emerald Ash Borer Task Force and other experts predict a 99% mortality rate for untreated ash trees. Peak die off of trees is likely to occur 9 to 10 years after the initial infestation. This suggests that Gloucester County will be dealing with large volumes of tree deaths in the next 15 years. Management options for EAB include tree removal, treating with insecticides, and biological controls (the release of wasps which act as parasitoids for egg and larvae). The United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA, APHIS, PPQ), operates the biological control production facility in Michigan which was designed to produce EAB parasitoids for release. In order to be considered for inclusion in the parasitoid release program, release sites must meet a certain criteria to be eligible: the site must be forested at least 40 acres in size; the site must contain no less than 25% ash of varying age classes; ash trees must be relatively healthy; and EAB must be detected in close proximity to the release site and be in low to moderate densities. The New Jersey Department of Agriculture (NJDA) is coordinating New Jersey's EAB biocontrol program.

Spotted Lanternfly

The Spotted Lantern Fly damages plants through the extraction of plant sap. Infestations of Spotted Lanternfly can result in decimation of crops, forest habitat, and landscaping (NJDA 2019). Due to the County's quarantine status, residents of Gloucester County are encouraged to inspect their cars for Spotted Lanternfly before leaving the County.

Canada Geese

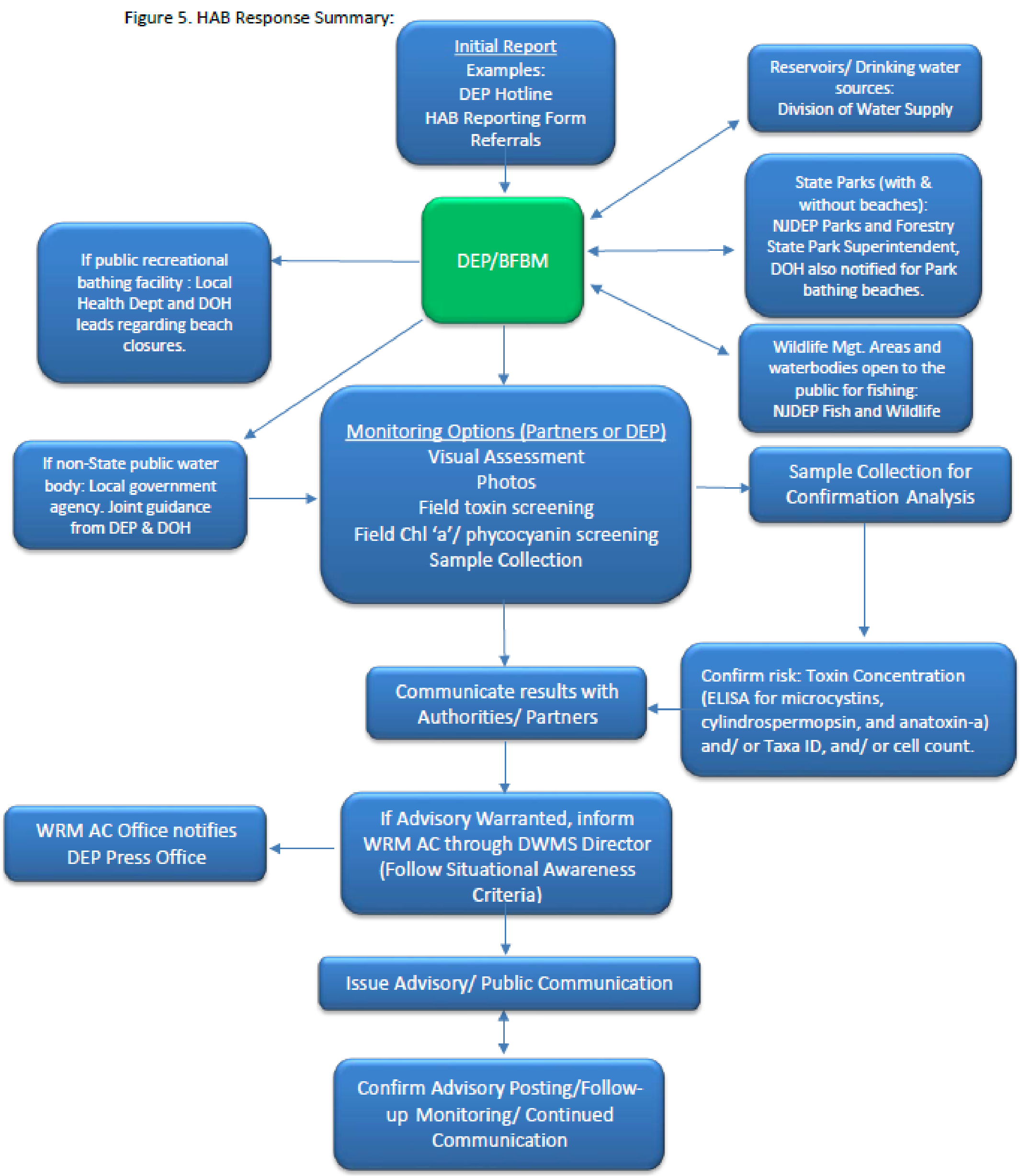
While most people find a few Canada Geese acceptable, problems develop as local flocks grow exponentially including:

- Over-grazed lawns
- Accumulations of droppings and feathers on play areas and walkways
- Nutrient loading to ponds
- Public health concerns at beaches and drinking water supplies
- Aggressive behavior by nesting birds
- Safety hazards near roads and airports (NYSDEC 2021)

Harmful Algal Bloom

The NJDEP uses visual observations, photographs, and laboratory sampling results to determine if blooms are comprised of cyanobacteria or other types of algae. Suspicious blooms are reported to NJDEP or local health departments (NJDEP 2019). The NJDEP has a Cyanobacterial Harmful Algal Freshwater Recreational Response Strategy which includes the DEP Division of Water Supply and Geoscience's Emergency Response Plan. This response plan is outlined below in Figure 4.3.11-6.

Figure 4.3.11-6. NJDEP/BFBM HAB Response Plan



Source: NJDEP 2018

NJ DEP will declare alert levels depending on the results of testing. Figure 4.3.11-7 displays the HAB alert levels, criteria, and recommendations for actions to take with each level.

Figure 4.3.11-7. 2020 HAB Alert Levels

HAB ALERT LEVEL	CRITERIA	RECOMMENDATIONS
NONE	HAB report investigated and no HAB found	None
WATCH *Suspected or confirmed HAB with potential for allergenic and irritative health effects*	Suspected HAB based on visual assessment or screening test **OR** Lab confirmed cell counts between 20k – 40k cells/mL **AND** No known toxins above public health thresholds	Public Bathing Beaches Open (dependent upon local health authority evaluation and assessment) Waterbody Accessible: • Use caution during primary contact (e.g. swimming) and secondary (e.g. non-contact boating) recreational activities Do not ingest water (people/pets/livestock) Do not consume fish
ALERT *Confirmed HAB that requires greater observation due to increasing potential for toxin production* **PUBLIC BATHING BEACHES INCREASE MONITORING**	Lab confirmed cell counts between 40k – 80k cells/mL **AND** No known toxins above public health threshold	**WATCH remains in effect.** **Public Bathing Beaches Open (dependent upon local health authority evaluation and assessment) and should observe and report changing bloom conditions** Waterbody Accessible: • Use caution during primary contact (e.g. swimming) and secondary (e.g. non-contact boating) recreational activities Do not ingest water (people/pets/livestock) Do not consume fish
ADVISORY *Confirmed HAB with **moderate risk of adverse health effects** and increased potential for toxins above public health thresholds*	Lab testing for toxins exceeds public health thresholds **OR** Lab confirmed cell counts above 80K cells/mL **OR** Field measurement evidence indicating HAB present and above guidance thresholds (e.g. phycocyanin readings)	Public Bathing Beaches Closed Waterbody Remains Accessible: • Avoid primary contact recreation (e.g. swimming) • Use caution for secondary contact recreation (e.g. boating without water contact) Do not ingest water (people/pets/livestock) Do not consume fish
WARNING *Confirmed HAB with **high risk of adverse health effects** due to high toxin levels*	Toxin (microcystin) 20 - 2000 µg/l **AND/OR** Additional evidence, including, expanding bloom, increasing toxin levels (i.e. duration, spatial extent or negative human or animal health impacts) indicates that additional recommendations are warranted	Public Bathing Beaches Closed Waterbody Remains Accessible: • Avoid primary contact recreation (e.g. swimming) • May recommend against secondary contact recreation (e.g. boating without water contact) with additional evidence Do not ingest water (people/pets/livestock) Do not consume fish
DANGER *Confirmed HAB with **very high risk of adverse health effects** due to very high toxin levels*	Toxin (microcystin) > 2000 µg/l **AND/OR** Additional evidence, including, expanding bloom, increasing toxin levels (i.e. duration, spatial extent or negative human or animal health impacts) indicates that additional recommendations are warranted	Closure of Public Bathing Beaches Possible closure of all or portions of waterbody and possible restrictions access to shoreline. Avoid primary contact recreation (e.g. swimming) May recommend against secondary contact recreation with additional evidence Do not ingest water (people/pets/livestock) Do not consume fish

Source: NJ DEP 2021

Previous Occurrences and Losses

Many sources provided information regarding infestations in Gloucester County; however, specific events and/or losses pertaining to the species discussed above were not identified. Testing for HAB's was limited prior to 2017. Invasive species may have occurred in Gloucester County prior to being officially identified and confirmed.

Federal Disaster Declarations

Between 1954 and 2021, FEMA included the State of New Jersey in one infestation-related emergency (EM) classified as a virus threat (EM-3156 in November 2000). Gloucester County was included in this declaration (FEMA 2021). For details regarding West Nile Virus in Gloucester County, refer to Section 4.3.3 (Disease Outbreak).

USDA Disaster Declarations

The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Gloucester County was not included in declarations related to infestation or invasive species from 2015 to 2021 (USDA 2021).

Infestation and Invasive Species Events

Infestation and invasive species events that have impacted Gloucester County between 2011 and 2021 are identified in Table 4.3.11-1. With documentation of infestations and invasive species for New Jersey and Gloucester County being so extensive, not all sources have been identified or researched. Therefore, Table 4.3.11-1 may not include all events that have occurred in the County and focuses primarily on the species of concern identified for this HMP. Testing and identification is limited prior to 2017 for HAB and 2014 for other species. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

Table 4.3.11-1. Infestation and Invasive Species Events in Gloucester County, 2011 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
2011	Canada Geese	N/A	N/A	Gloucester County	Municipal lakes in Gloucester County were reported to be closed, due in part to high bacteria counts attributed to Canada Geese overpopulation.
2019	Spotted Lanternfly	N/A	N/A	National Park	Spotted Lanternfly was first detected in Gloucester County at Red Bank Battlefield Park in National Park.
2019	Emerald Ash Borer	N/A	N/A	Township of East Greenwich	EAB was first detected in Gloucester County (Township of East Greenwich) in 2019
2020	Harmful Algal Bloom	N/A	N/A	Township of Greenwich	In 2020, Greenwich Lake in the Township of Greenwich reached advisory levels for HAB's.
2020	Spotted Lanternfly	N/A	N/A	Gloucester County	Gloucester County was included in the list of counties under quarantine for Spotted Lanternfly infestation.

Source: FEMA 2021; NJ DEP 2021, NYSIPM 2021, NJOEM 2019, Patch.com 2019, NJ.com 2011
DR Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
N/A Not Applicable

Probability of Future Occurrences

Based on historical documentation, increased incidences of infestation throughout the State of New Jersey and the overall impact of changing climate trends, it is estimated that Gloucester County and its jurisdictions will continue to experience infestation events that may induce secondary hazards and health threats to the County population if infestations are not prevented, controlled or eradicated effectively. Based on these historical records and input from the Steering Committee and Planning Committee, the probability of occurrence for infestation and invasive species in Gloucester County is considered "frequent". Refer to Section 4.4. (Hazard Ranking) for more information.

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli et al. 2020).

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

The following provides information on the different infestations impacted Gloucester County and how they may be affected by climate change.

Emerald Ash Borer and Spotted Lanternfly

A warmer climate would extend the active insect season and allow for species that are not as cold tolerant to move north and expand their range. This increases the impact of the emerald ash borer and spotted lanternfly and their related impacts.

White-Tailed Deer

It is difficult to predict the impacts of climate change on the white-tailed deer population. A warmer climate with more mild winters could result in a population increase, as severe winters can cause female mortality (PSU 2015). However, an increase in extreme weather and disease are potential climate-driven stressors on white-tailed deer. Warmer temperatures will likely increase the midge population, which transmits hemorrhagic disease to white-tailed deer resulting in fatalities, as midges are killed by cold temperatures. Additionally, white-tailed deer serve as hosts for many tick species which may similarly increase in population due to warmer temperatures.

Harmful Algal Bloom

The projected increase in precipitation is expected to occur via heavy downpours and less in the form of light rains. Rising air temperatures intensify the water cycle by increasing evaporation and precipitation, which can cause an increase in rain totals during storm events, with longer dry periods between those events. Alternating periods of drought and heavy rainfall increase the likelihood of nutrient runoff into waterways, which can fuel algal blooms (EPA 2017a).

Warmer temperatures could lead to an increase of the length of the algal growing season and increase the likelihood of algal blooms. In addition to warmer temperatures and heavy precipitation events, carbon dioxide levels are forecast to continue to increase. Higher levels of carbon dioxide in the atmosphere and water can lead to increased algal growth, particularly for cyanobacteria that float at the surface (EPA 2017a).

4.3.11.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable. For the infestation and invasive species hazard, the entire County is exposed. The following discusses Gloucester County's vulnerability, in a qualitative nature, to the infestation and invasive species hazard.

Impact on Life, Health and Safety

The entire population of Gloucester County is vulnerable to infestations and invasive species. According to the 2019 American Community Survey (ACS) 5-year Estimate, Gloucester County had a population of 291,165. Of that total population, the elderly population and people with suppressed immune systems are most susceptible to the effects of infestations such as Harmful Algal Blooms. The ACS has identified that there are 35,699 persons over the age of 65 in Gloucester County.

As discussed earlier, infestations can have an impact on agricultural commodities. The NJDA has indicated that New Jersey farmers lose $290 million annually in direct crop loss or damage caused by agricultural pests (New Jersey Department of Agriculture n.d.). This destruction of crop may include consumable resources that are sold to persons in the County. Section 5.4.4 (Drought) discusses the number of farms that are operating in the County (i.e., 580 farms). Based on the Department of Agriculture's study, it is reasonable to assume that the farms in Gloucester County also experience losses in crops. This not only impacts the livelihood of the farmers; it also affects the community that relies on these crops for food or other commodities.

Additionally, the impacts of harmful algal blooms on life, health, and safety depend on several factors, including the severity of the event and whether citizens and tourists have become exposed to waters suspected of containing toxins associated with cyanobacteria. Routes of exposure include consumption, inhalation, and dermal exposure. The population living near or visiting waterbodies is at risk for exposure as well as those that use those waterbodies for recreation, fishing, and water supply. Contact with water containing harmful algal blooms can cause various health effects including diarrhea, nausea or vomiting; skin, eye, or throat irritation; and allergic reactions or breathing difficulties (CDC 2020).

Further, the population living near waterbodies is at risk for exposure to HABs as well as those that use those waterbodies for recreation, fishing, and water supply. Therefore, exposure should not be limited to only those who reside in a defined hazard zone, but visitors to Gloucester County waterbodies as well. Contact with water containing HABs can cause various health effects including diarrhea, nausea or vomiting; skin, eye, or throat irritation; and allergic reactions or breathing difficulties (NJDEP 2020).

Cyanobacteria blooms are one of the most common freshwater HABs and have been identified by NJ DEP as being present in Gloucester County blooms. Cyanobacteria are known to produce toxins from the following classes:

- **Endotoxins:** Endotoxins associated with cyanobacteria have been tied to fever and inflammation in humans that have come in contact with water that contains cyanobacterial blooms.
- **Hepatotoxins:** Hepatotoxins are commonly tied to animal poisonings that are associated with cyanobacterial blooms. Animals may exhibit weakness, heavy breathing, paleness, cold extremities, vomiting, diarrhea, and bleeding in the liver. In humans, hepatotoxins have been indicated to promote tumors and may lead to increases in liver cancer. Some types of hepatotoxins, such as microcystin, can persist in fresh water for up to 2 weeks before being naturally broken down (algae).
- **Neurotoxins:** Neurotoxins act to block transfers between neurons. Extreme cases can result in paralysis (EPA 2014).

The EPA has established an incident checklist for HAB incidents impacting water utilities (EPA 2017). This tool is available to help utilities detect, identify, and monitor a bloom. Locations in Gloucester County that rely on surface water intake for drinking water are most exposed to the impacts of HABs. Purchasing water may make some users more vulnerable if the utility has less control over the quality of the source. Coordinating with the supplier to ensure that the water is clear of harmful algae, thus maintaining the safety of users of the purchased water, is recommended.

Impact on General Building Stock

Structures are not anticipated to be directly affected by infestation or invasive species; however, EAB may cause a catastrophic loss of ash trees throughout the County, which could result in stream bank instability, erosion, and increased sedimentation, impacting ground stabilization and possibly cause foundation issues for nearby structures. Additionally, with an increased number of dead trees, there is an increased risk of trees falling on roadways, power lines, and buildings.

Some invasive plants have been shown to destabilize soil due to high densities and shallow root systems, negatively impacting nearby buildings and septic systems. Other invasive plant species have been known to clog culverts and streams, increasing flooding risk.

Impact on Critical Facilities

Water treatment plants could be impacted by infestation and invasive species because of similar issues that the general building stock may experience. Water that becomes polluted due to increased sedimentation and erosion will require additional treatment. If the system becomes clogged with these pollutants, the ability of water treatment plants to operate may become impaired. Additionally, soil that becomes unstable due to decaying vegetation can impact critical facilities that are built on or around these soils.

The typical impact harmful algal blooms have on critical facilities are shutdowns of water intakes from the surface waters that are impacted by blooms and their toxins. Water treatment plants can remove variable amounts of microcystin from drinking water depending on the active removal process used by the water treatment plant (EPA 2020). However, applying the wrong treatment process at a specific state in treatment could damage the facility and release cyanotoxins rather than remove them. The EPA has summarized the effectiveness of treatment options for harmful algal blooms (refer to Table 4.3.11-2).

Table 4.3.11-2. Assessment of Treatment Options for HABs

Treatment Process	Relative Effectiveness
Intracellular Cyanotoxins Removal (Intact Cells)	
Pre-treatment oxidation	Oxidation often stresses or lyses cyanobacteria cells releasing the cyanotoxin to the water. If oxidation is required to meet other treatment objectives, consider using lower doses of an oxidant less likely to lyse cells. If oxidation at higher doses must be used, sufficiently high doses should be used to not only lyse cells but also destroy total toxins present (see extracellular cyanotoxin removal).

TETRA TECH

Treatment Process	Relative Effectiveness
Coagulation/ Sedimentation/ Filtration	Effective for the removal of intracellular toxins (cyanobacteria cells). Ensure that captured cells accumulated in sludge are removed frequently to release toxins. Ensure that sludge supernatant is not returned to the supply after sludge separation.
Membranes	Effective for removal of intracellular cyanotoxins (cyanobacteria cells). Microfiltration and ultrafiltration are effective when cells are not allowed to accumulate on membranes for long periods of time. More frequent cleaning may be required during a bloom event.
Flotation	Flotation processes, such as Dissolved Air Flotation (DAF), are effective for removal of intracellular cyanotoxins since many of the toxin-forming cyanobacteria are buoyant.
Extracellular (Dissolved) Cyanotoxins Removal	
Membranes	Depends on the type of cyanotoxin, membrane material, membrane pore size distribution, and influent water quality. Nanofiltration is generally effective in removing extracellular microcystins. Reverse osmosis filtration is generally applicable for removal of microcystins and cylindrospermopsin. Cell lysis is highly likely. Further research is needed to characterize performance.
Potassium Permanganate	Effective for oxidizing microcystins and anatoxins. Further research is needed for cylindrospermopsin. Not effective for oxidizing saxitoxin.
Ozone	Very effective for oxidizing microcystins, anatoxin-a, and cylindrospermopsin. Not effective for oxidizing saxitoxin.
Chloramines	Not effective.
Chlorine dioxide	Not effective at doses typically used in drinking water treatment.
Free Chlorine	Effective for oxidizing microcystins as long as the pH is below 8. Effective for oxidizing cylindrospermopsin and saxitoxin. Not effective for oxidizing anatoxin-a.
UV Radiation	UV radiation alone is not effective at oxidizing microcystins and cylindrospermopsin at doses typically used in drinking water treatment. When UV radiation is coupled with ozone or hydrogen peroxide (called "advanced oxidation"), the process is effective at oxidizing anatoxin-a, cylindrospermopsin, and with high UV doses, microcystins.
Activated Carbon Adsorption	Powdered activated carbon (PAC): Effectiveness of PAC adsorption varies based on type of carbon, pore size, type of cyanotoxin, and other water quality parameters such as natural organic matter (NOM) concentration. Wood-based activated carbons are generally the most effective at microcystins adsorption. More research is needed to evaluate PAC's effectiveness at adsorbing cylindrospermopsin, anatoxin-a, and saxitoxin, however the limited research has demonstrated promising results. Doses in excess of 20mg/L may be needed for complete toxin removal, especially if NOM concentrations are high. Granular activated carbon (GAC): Effectiveness of GAC adsorption varies based on type of carbon, pore size, type of cyanotoxin, and other water quality parameters such as NOM concentration. GAC is effective for microcystins, and likely effective for cylindrospermopsin, anatoxin-a and saxitoxin. The condition of the carbon is an important factor in determining GAC's effectiveness for cyanotoxin removal. GAC may need to be regenerated more frequently to ensure adequate adsorption capacity for HAB season.

Source: EPA 2020

Impact on Economy

Impacts of infestation and invasive species and infestations on the economy and estimated dollar losses are difficult to measure and quantify. Costs associated with activities and programs implemented to conduct surveillance and address invasive species and infestations have not been quantified in available documentation. However, as indicated by the NJDA, farmers across the State may collectively revenue because of crop losses from invasive species and infestations (New Jersey Department of Agriculture n.d.). In 2017, there were 35,554 acres of cropland in Gloucester County with $94,853,000 in crops sold (USDA 2017). Therefore, it is reasonable to believe that Gloucester County farmers have experienced monetary losses from infestations.

The New Jersey Forest Service has indicated that 9-percent of New Jersey forests are susceptible to EAB attacks (NJDEP 2016). The emerald ash borer can infect nursery stock and mature trees, which could reduce the timber value of hardwood exports (CFIA 2014). In 2010, the USDA Northern Research Station conducted computer simulations of EAB spread to estimate the cost of ash tree treatment, removal, and replacement (re-planting of new trees) between 2009 and 2019. The simulations predicted an EAB infestation covering 25 states, and assumed treatment, removal, and replacement of more than 17 million ash trees on developed land within established communities. The total costs were estimated at $10.7 billion. This figure doubled when the model was reset to include developed land outside, as well as inside, human communities (USDA 2013).

HAB-related economic impacts on Gloucester County would largely focus on the agricultural and recreation sector. News of a closure of a body of water can result in visitors avoiding the area. Even after closures are lifted, negative public reaction can persist and continue to impact local revenue and property values. As mentioned, there is a price tied to programs that protect water bodies from harmful algal blooms. The cost to operate and monitor these programs will vary depending on the extent of the blooms. Additional costs may include money spent on nutrient reduction programs for agricultural commodities, purchasing backup water sources, and costs to implement advanced drinking water treatment. Agricultural producers may need to develop better strategies to reduce the nutrient runoff that cause harmful algal blooms, which may increase production costs for their commodities and overall costs for their buyers.

Impact on the Environment

As previously discussed, Gloucester County's parks, forests, landscaping, and agricultural areas are vulnerable to spotted lanternfly and EAB. Species that cause eventual destabilization of soil, such as invasive insects that destroy plants or invasive plants that outcompete native vegetation but have less effective root systems, can increase runoff into waterbodies. This can lead to increased harmful algal blooms and negative impact on drinking water supplies. Soil destabilization can also increase the likelihood of mudslides in areas with a steep slope.

The New Jersey Forest Service has indicated that the EAB will first infest the top of the tree's crown. This leads to the crown dying, bark splitting, and exit holes are created on lower parts of the tree. Trees that are infested only live on average of 3 to 4 years (NJDEP 2016).

Harmful algal blooms can release toxins that can kill fish and invertebrate (EPA 2019). Animals that prey on fish and invertebrates in surface waters, such as birds and mammals, may be affected if they ingest impacted prey. Both harmful and non-harmful algal blooms can have drastic impacts on oxygen levels in surface waters. When algae begin to die off following a bloom, bacteria begin to decompose the organic material. This decomposition consumes dissolved oxygen and releases carbon dioxide. If the bloom and die off is large enough, dissolved oxygen levels in aquatic systems can rapidly crash. Anoxic conditions connected to algal blooms have resulted in large fish and invertebrate kills.

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development and Change in Population

As discussed in Sections 4 (County Profile) and 9 (Jurisdictional Annexes), areas targeted for future growth and development have been identified across Gloucester County. Changes in land use have the potential to render some habitats more susceptible to invasive species, as clearing the land provides opportunities for invasive species to inhabit the area. Clearing the land may also reduce the habitat for predator species that could manage the spread of invasive species naturally. The specific areas of development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this plan.

Infestation to cropland and nurseries can have a wider impact on persons outside of Gloucester County if the farmers within the County supply resources to neighboring communities. Being aware of trends occurring around the County may reveal that infestations within agricultural commodities provided by the County impacts a greater number of persons.

Climate Change

Climate is defined not simply as average temperature and precipitation but also by the type, frequency, and intensity of weather events. Changing weather patterns could create a change in the migration patterns for when these species move into and out of Gloucester County. If the species have a more prolonged existence in the County, there may also be a greater number of infestation events or a higher value of loss tied to infestation. Warmer temperatures could lead to an increase of the length of the algal growing season and increase the likelihood of algal blooms. Increased alternation of drought and heavy precipitation could result in additional nutrient runoff into local waterbodies, providing more fuel for algal blooms. Higher carbon dioxide levels in the atmosphere and surface waters could create a more favorable growing environment for HABs (EPA 2017a).

Vulnerability Change Since the 2016 HMP

Infestations and invasive species is a new hazard section added to the County's HMP. More frequent events of infestations and blooms have made this hazard an area of interest that will be monitored more frequently in municipalities throughout the County, particularly those that contain major bodies of water that are used for drinking water, recreation, and economic purposes.

4.3.12 Nor'Easter

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the Nor'Easter hazard in Gloucester County.

2022 HMP Update Changes

- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2015 and 2021.
- A qualitative vulnerability assessment was conducted for the Nor'Easter hazard and it now directly follows the hazard profile.

4.3.12.1 Profile

Hazard Description

A Nor'Easter is a cyclonic storm that moves along the East Coast of North America. It is called a Nor'Easter because the damaging winds over coastal areas blow from a northeasterly direction. Nor'Easters can occur any time of the year but are most frequent and strongest between September and April. These storms usually develop between Georgia and New Jersey within 100 miles of the coastline and typically move from southwest to northeast along the Atlantic Coast of the United States (NWS 2013). A Nor'Easter event can cause storm surges, waves, heavy rain, heavy snow, wind, and coastal flooding. Nor'Easters have diameters that can span 1,200 miles, impacting large areas of coastline. The forward speed of a Nor'Easter is usually much slower than a hurricane, so with the slower speed, a Nor'Easter can linger for days and cause tremendous damage to those areas impacted.

In order to be called a Nor'Easter, a storm must have the following conditions, as per the Northeast Regional Climate Center (NRCC):

- Must persist for at least a 12-hour period
- Have a closed circulation
- Be located within the quadrilateral bounded at 45°N by 65°W and 70°W and at 30°N by 85°W and 75°W
- Show general movement from the south-southwest to the north-northeast
- Contain wind speeds greater than 23 miles per hour (mph) (NJOEM 2019)

A Nor'Easter event can cause storm surges, waves, heavy rain, heavy snow, wind, and coastal flooding. Nor'Easters have diameters that can span 1,200 miles, impacting large areas of coastline. The forward speed of a Nor'Easter is usually much slower than a hurricane, so with the slower speed, a Nor'Easter can linger for days and cause tremendous damage to those areas impacted. Approximately 20 to 40 Nor'Easters occur in the northeastern United States every year, with at least two considered severe (Storm Solutions USA n.d.). New Jersey can be impacted by 10 to 20 Nor'Easters each year, with approximately five to 10 of those having significant impact on the State. The intensity of a Nor'Easter can rival that of a tropical cyclone in that, on occasion, it may flow or stall off the mid-Atlantic coast resulting in prolonged episodes of precipitation, coastal flooding, and high winds.

For the purpose of this HMP, only Nor'Easter events are being further discussed within this hazard profile, due to their significant historical impact on Gloucester County and the South Jersey region. For information flooding related to Nor'Easters, refer to Section 4.3.7 (Flood) and Section 4.3.10 (Hurricane). For information on severe winter storms, refer to Section 4.3.14.

Location

The entire State of New Jersey, including Gloucester County, is susceptible to the effects of Nor'Easters; however, coastal communities and other low-lying areas are particularly vulnerable. Nor'Easters usually form off the east coast near the Carolina, and then follow a track northwards along the coast until they blow out to sea. Although the county is inland in comparison to other parts of New Jersey, Gloucester County does border the eastern part of the Delaware River and is in relatively close proximity to the Atlantic Ocean. The County is therefore exposed to the direct and indirect impacts of a Nor'Easter including rain, snow, wind, and coastal flooding in tidally influenced areas, such as those along the Delaware River (Encyclopedia Britannica 2021).

Extent

The magnitude or severity of a severe winter storm or Nor'Easter depends on several factors including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, and time of occurrence during the day (e.g., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. NOAA's National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5. It is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population (based on the 2000 Census). The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA 2011). Table 4.3.12-1 presents the five RSI ranking categories.

Table 4.3.12-1. RSI Ranking Categories

Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18

Category	Description	RSI Value
5	Extreme	18.0+

Source: NOAA-NCDC 2011
Note: RSI = Regional Snowfall Index

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with Nor'Easters throughout the State of New Jersey and Gloucester County; therefore, the loss and impact information for many events varies depending on the source. The accuracy of monetary figures discussed is based only on the available information in cited sources.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2020, FEMA included the State of New Jersey in seven Nor'Easter-related major disaster (DR) or emergency (EM) declarations classified as one or a combination of the following disaster types: severe storm, snow storm, high tides, flooding, coastal storm, coastal flooding, or tropical depression. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Gloucester County has been included in seven Nor'Easter-related declarations. Table 4.3.12-2 lists FEMA DR and EM declarations for Gloucester County.

Table 4.3.12-2. FEMA Declarations for Nor'Easter Events in Gloucester County

FEMA Declaration Number	Date(s) of Event	Date Declared	Event Type
EM-3181	February 16, 2003 - February 17, 2003	March 20, 2003	Snowstorm
DR-1588	April 1, 2005 - April 3, 2005	April 19, 2005	Severe Storms and Flooding
DR-1694	April 14-20, 2007	April 26, 2007	Severe Storms and Inland and Coastal Flooding
DR-1873	December 19-20, 2009	February 5, 2010	Severe Snowstorm
DR-1897	March 12-April 15, 2010	May 7, 2010	Severe Storms and Flooding
DR-4033	August 13, 2011 - August 15, 2011	September 15, 2011	Severe Storms and Flooding
DR-4231	June 23, 2015	July 22, 2015	Severe Storm

Source: FEMA 2021

U.S Department of Agriculture Disaster Declarations

The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Gloucester County was not included in declarations related to Nor'Easters from 2015 to 2021 (USDA 2021).

For this 2022 Plan update, other known Nor'Easter events that have impacted Gloucester County between 2015 and 2021 are identified in Table 4.3.12-3. Events identified in the 2015 Plan are included in Appendix E. For detailed information on damages and impacts to each municipality, refer to Section 9 (jurisdictional annexes).

TETRA TECH

Table 4.3.12-3. Nor'Easter Events in Gloucester County, 2015 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
February 16-17, 2015	Heavy Snow	N/A	N/A	Gloucester County	A low pressure system emerged east off the North Carolina coast and spread snow throughout New Jersey, with heavy snow occurring across central to southern New Jersey from the evening of the 16th into the morning of the 17th. Snowfall totals primarily between 4 to 7 inches occurred across central to southern New Jersey, with mainly less than 4 inches occurring across northern New Jersey. The snow caused accidents and impacted the morning commute on the 17th.
March 5, 2015	Heavy Snow	N/A	N/A	Gloucester County	Waves of low pressure that formed along a sinking cold front brought New Jersey heavy snow and the southern half of the state its heaviest snow of the season. Snowfall averaged 4 to 9 inches with the highest amounts in central New Jersey.
April 20, 2015	Heavy Rain	N/A	N/A	Westville Township, NJ	Heavy rain caused poor drainage flooding on the New Jersey Turnpike north of Interchange 2 (U.S. Route 322) in Gloucester County. Precipitation totals through the morning included 1.88 inches in Mullica Hill, 1.77 inches in Logan Township and 1.40 inches in Beckett.
July 14, 2015	Heavy Rain	N/A	N/A	Franklin Township, NJ	Heavy rain from thunderstorms fell across extreme southern Gloucester County during the late morning of the 14th. A CoCoRaHS observer measured 2.94 inches of rain.
January 22-24, 2016	Winter Storm	DR-4264	N/A	Gloucester County	An impulse from the west coast traversed the midsection of the country, then developed into a low pressure system as it tracked across the Gulf states before intensifying along the Carolina coast into a major nor'easter, producing record snowfall in parts of New Jersey on January 23rd. It then moved out to sea after passing by the mid-Atlantic coast early on January 24th. Snow began falling during the Friday afternoon on January 22nd, then continued, heavy at times, Friday night into early Sunday morning. Wind gusts up to 60 MPH produced blizzard conditions as visibilities dropped to one-quarter mile or less in spots. Schools and many businesses recessed early on Friday afternoon in anticipation of the storm. Philadelphia International Airport canceled all Saturday flights, and 155 departures and 133 arrivals scheduled for Sunday.

TETRA TECH

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
July 16, 2016	Heavy Rain	N/A	N/A	Washington Township, NJ	A cold frontal boundary along with several shortwaves and a sea breeze produced numerous showers and thunderstorms across the southern and central portions of New Jersey during the afternoon and evening hours of the 16th. Almost two and a half inches of rain fell from thunderstorms. Just over two inches of heavy rain fell from thunderstorms. Two inches of rain fell from thunderstorms.
July 28, 2016	Heavy Rain	N/A	N/A	Newfield Township, NJ	A cold frontal boundary moved southward into the region. This led to the development of afternoon showers and thunderstorms. Some of thunderstorms became severe with locally heavy rainfall as well. Many locations saw between 2 and 3 inches of heavy rainfall total for this event in Southern NJ. Almost three inches of rain fell in an hour with thunderstorms.
July 29, 2016	Heavy Rain	N/A	N/A	Washington Township, NJ	A cold frontal boundary moved southward into the region. This led to the development of afternoon showers and thunderstorms. Some of thunderstorms became severe with locally heavy rainfall as well. Many locations saw between 2 and 3 inches of heavy rainfall total for this event in Southern NJ. Almost three inches of heavy rain fell with thunderstorms.
September 19, 2016	Heavy Rain	N/A	N/A	Gloucester County	The remnants of tropical storm Julia and a frontal boundary interacted leading to several rounds of rainfall over the region.
January 7, 2017	Winter Storm	N/A	N/A	Gloucester County	Snow began falling around dawn on January 7th, then continued heavy at times through the day before moving off the coast around sunset. Total snowfall reports ranged between 6 and 8 inches including 7.0 inches in Pitman, 6.1 inches in Williamstown, and 6.0 inches in West Deptford. Strong winds the following day produced blowing and drifting snow.
March 14, 2017	Winter Storm	N/A	N/A	Gloucester County	Low pressure systems across the Ohio Valley and Carolinas phased. This led to a rapidly developing storm which tracked just offshore. A few inches of snow fell across the county with a sharp gradient in totals. ice accumulations were up to 1/4 inch.
May 5, 2017	Heavy Rain	N/A	N/A	Washington Township, NJ	Low pressure moving from Tennessee into western New York state lifted a warm front north through the state late Friday morning into early Friday afternoon on May 6, 2017. In advance of a cold front, which

TETRA TECH

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
					followed Friday evening, several rounds of heavy rainfall with embedded thunder traversed the state Friday morning into the afternoon. Heavy rainfall over 2 inches fell in Gloucester County.
July 23, 2017	Heavy Rain	N/A	N/A	Clayton Township, NJ	A stalled frontal boundary was the focus for several rounds of thunderstorms that produced damaging winds and flooding in spots. Several thousand people lost power throughout the state. Just over three inches of rain fell with almost half an inch in five minutes. CWOP station in Washington Township recorded just over four inches of rain.
July 24, 2017	Heavy Rain	N/A	N/A	Washington Township	A stalled frontal boundary was the focus for several rounds of thunderstorms that produced damaging winds and flooding in spots. Several thousand people lost power throughout the state. Almost five inches of rain fell. Rainfall total from last night of almost three inches.
August 23, 2017	Heavy Rain	N/A	N/A	West Deptford Township, NJ	Severe thunderstorms formed in a hot and humid airmass ahead of a cold front. Just over three inches of rain fell in Gloucester County.
January 4, 2018	Winter Storm	N/A	N/A	Gloucester County	An area of low pressure tracked up the east coast interacting with a cold front which lead to rapid development of a winter storm across the state. Snowfall ranged from 4 to 6 inches across the county.
March 6, 2018	Winter Storm	N/A	N/A	Gloucester County	A broad area of low pressure extending from the Ohio Valley to the Piedmont of South Carolina consolidated off the Virginia Capes during the early morning of March 7th. This new primary low moved northeast and gradually deepened as it passed east of the Delaware and New Jersey coasts on March 7th. The snow fell heavy at times away from the coast. Snowfall amounts near the New Jersey Turnpike generally ranged from 6 to 12 inches, with a sharp decrease to the southeast. Banding and thundersnow produced pockets of heavy snow in the western sections of the county, closer to the Delaware River. Further east, snow mixed with rain during parts of the event which tempered snowfall amounts. Some reported snowfall totals include: 6.5 inches in West Deptford, 6.5 inches in Sewell, 6.5 inches in Mantua, 5.5 inches in Williamstown, and 5.0 inches in Pitman.
March 21, 2018	Winter Storm	N/A	N/A	Gloucester County	A complex area of low pressure over the middle Atlantic, which involved several individual centers, slowly consolidated off the Virginia Capes

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
					Tuesday morning, March 20th into Wednesday March 21st along a frontal boundary. Precipitation began as rain during the evening hours on March 20th. After a lull during the overnight hours, rain mixed with snow during the morning and early afternoon hours of the 21st before changing over to all snow around noon, falling heavy at times through the evening hours. Some reported snowfall amounts include: 12.0 inches at West Deptford, 9.1 inches at Pitman, 8.0 inches at Sewell, and 7.8 inches near Turnersville.
April 16, 2018	Coastal Flood	N/A	N/A	Gloucester County	A strong backdoor cold front moved from northeast to southwest across the area late Saturday afternoon April 15th into Sunday morning April 16th. Not only was there a significant drop in temperature coinciding with the passage of the front, but also a stark difference between high temperatures on Saturday and Sunday. Moderate coastal flooding along the tidal Delaware River and its tidal tributaries. There were a number of road closures including New Jersey Route 47 in Westville and US Route 130 in Logan Township. Peak tide was 9.47 feet MLLW at Philadelphia.
September 10, 2018	Coastal Flood	N/A	N/A	Gloucester County	A persistent onshore flow and unusually high astronomical tides associated with the new moon resulted in widespread moderate coastal flooding along the bays and other tidal waterways in central and southern New Jersey. The flooding occurred across three consecutive high tide cycles, from the evening of September 9 through the early hours of September 11. Moderate flooding occurred along the Delaware River and its tidal tributaries in Gloucester County. The tide gauge at Philadelphia reached 9.65 feet MLLW.
November 26, 2018	Coastal Flood	N/A	N/A	Gloucester County	A coastal storm resulted in tidal flooding along the northern part of the New Jersey coast and along the tidal Delaware River. Moderate tidal flooding occurred along the tidal Delaware River and its tidal tributaries. Some roads were flooded. The tide gauge at Marcus Hook, Pennsylvania reached 8.77 feet MLLW.

Source: NOAA NRCS 2021, FMEA 2021, NOAA NCEI 2021
Note: Unless explicitly stated, no property damage or crop loss was reported for the events.

Probability of Future Occurrences

Gloucester County will continue to experience the direct and indirect impacts of Nor'Easters. Secondary hazards may include flooding, extreme wind, erosion, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents, and inconveniences.

As with any weather phenomenon, it is nearly impossible to assign probabilities to Nor'Easters, except over the long-term. High activity seasons are when storm activity exceeds the historical 75th percentile. This means that seasons with this number of storms are expected to occur during one out of four years. Lower activity seasons are defined as when storm activity falls below the historical 75th percentile; meaning this number of storms are expected to occur during three out of four years (Cornell University 2013)

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for nor'easter in the county is considered 'frequent' (100 percent annual probability; a hazard event may occur multiple times per year). The ranking of the nor'easter hazard for individual municipalities is presented in the jurisdictional annexes.

Climate Change Impacts

Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3° F (1.67° C) increase in the State's average temperature (ONJSC 2021), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo 2014) and the world (1.5° F [0.8° C]) (Meyer 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton 2015).

Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh 2014) and with more intensity (Huang 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan 2014).

According to NOAA, sea level rise can amplify factors that currently contribute to Nor'Easters and other types of severe weather: high tides, storm surge, high waves, and high runoff from rivers and creeks. Other secondary hazards that could occur along the Mid-Atlantic coast in response to sea level rise include:

- *Bluff and upland erosion* – Shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As sea level rises, the uplands are eroded and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments.
- *Overwash* – As sea level rise occurs, storm overwash will become more likely.

- *Shoreline retreat* - The combination of rising sea level and stronger storms can create the potential to accelerate shoreline retreat in many locations (Gutierrez 2007).

A warmer atmosphere means storms have the potential to be more intense and occur more often (Coumou 2012). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh 2014) which is a faster rate than anywhere else in the United States (Huang 2017). As temperatures increase so will the energy in a storm system, increasing the potential for more intense tropical storms (Huang et al. 2017), especially those of Category 4 and 5 (Melillo 2014).

In Philadelphia, Pennsylvania and Reedy Beach, Delaware (the nearest tidal gages to Gloucester County on the Delaware River), sea-level has risen at a rate of approximately 0.11 to 0.15 inches per year since the beginning of the 20th century (NOAA 2021), and this rate will continue to increase. The amount of greenhouse gases that are emitted is tied to rates of sea-level rise. By 2050, New Jersey will likely experience at least a 0.9 to 2.1-foot increase (above the levels in 2000; all emissions scenarios), 1.4 to 3.1-foot increase by 2070 (moderate emissions scenario), and potentially a 2.0 to 5.1-foot increase by 2100 (moderate emissions scenario).

Impacts of climate change can lead to shoreline erosion, coastal flooding, and water pollution; affecting man-made coastal infrastructures and coastal ecosystems. Coastal areas may be impacted by climate change in different ways. These areas are sensitive to sea level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures (EPA 2017). As noted above, temperatures are predicted to increase in Gloucester County, which lead to an increase in intensity and frequency of severe storm. This increase may lead to more weather patterns that cause coastal erosion events. Rising sea levels will also exacerbate erosional issues.

4.3.12.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. For the Nor'Easter hazard, all of Gloucester County has been identified as potentially exposed or vulnerable. Therefore, all assets in the County (population, structures, critical facilities and lifelines), as described in Section 3, are vulnerable to a Nor'Easter.

Impact on Life, Health and Safety

The impact of a Nor'Easter on life, health and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time was provided to residents. Typically, a Nor'Easter has a longer duration (potentially lasting days) than a hurricane or tropical storm event, which normally pass through an area in a matter of hours. It is assumed that the entire County's population could be exposed to this hazard (wind and rain/snow) and secondary impacts discussed earlier associated with a Nor'Easter. Further, residents may be displaced or require temporary to long-term sheltering. Refer to Figures 5.4.6-2 and 5.4.6-3 in Section 4.3.10 (Hurricanes and Tropical Storms) which display the peak gust wind speeds of the 100- and 500-year mean return period probabilistic wind events modeled in Hazus v4.2.

Impact on General Building Stock

The entire County's building stock is exposed to the wind and/or rain/snow from the Nor'Easter hazard. Gloucester County is estimated to have 113,093 buildings, with a replacement cost value (structure and content) of approximately $59.3 billion. Refer to Section 4.3.7 (Flood), Section 4.3.10 (Hurricane), Section 4.3.13 (Severe Weather), and Section 4.3.14 (Severe Winter Weather) for more information about the wind, rain, and snow hazard impacts to the building stock in Gloucester County.

Impact on Critical Facilities

All of Gloucester County's critical facilities are exposed to the wind and/or rain/snow from the Nor'Easter hazard. All of Gloucester's critical facilities are also considered lifelines. Refer to Section 4.3.7 (Flood), Section 4.3.10 (Hurricane), Section 4.3.13 (Severe Weather), and Section 4.3.14 (Severe Winter Weather) for more information about the wind, rain, and snow hazard impacts to the critical facilities in Gloucester County.

Impact on the Economy

Nor'Easter events can greatly impact the economy, including: loss of business function, damage to inventory (utility outages), relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Damages to buildings can impact a community's economy and tax base. In addition, damages to buildings and critical infrastructure, as well as road closures, can delay emergency response services during these events.

Future Changes That May Impact Vulnerability

Understanding future changes that affect vulnerability can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. Several factors are examined in this section to assess hazard vulnerability.

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. Any areas of growth could be potentially impacted by a Nor'Easter event if structures do not consider current mitigation measures against flooding, rain, wind, and snow. Therefore, it is the intention of the County and all participating municipalities to discourage development in vulnerable areas or to encourage higher regulatory standards at the local level.

Projected Changes in Population

According to the 2019 5-year population estimates from the American Community Survey, the population of Gloucester County (i.e., 291,165 persons) has increased by approximately 1.0-percent since 2010. Even though the population has decreased, any changes in the density of population can impact the number of persons exposed to Nor'Easter events. Refer to Section 3 (County Profile) for more information about population trends in the County.

Climate Change

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of events like hurricanes. The projections of increasing precipitation are characteristic of a large area of the Northern Hemisphere in the northern middle latitudes, as well as increases in heavy precipitation events. This may result in increased coastal and inland flooding risks. Over the last century, global sea level has risen by about 8 inches. Sea level has risen faster along the coastal and inland shores of New Jersey as compared to the global average (NOAA 2021).

While predicting changes to the prevalence or intensity of Nor'Easter events and their affects under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (EPA 2020).

Change of Vulnerability Since the 2016 HMP

Overall, the County's vulnerability has not yet changed significantly; the entire County continues to be exposed and potentially vulnerable to the Nor'Easter hazard. Hazards that relate to Nor'Easter events (i.e., flood, hurricane, severe weather, and severe winter weather) use an updated building stock and critical facility data to assess the County's risk to flood, wind, rain, and snow. The building inventory was updated using RS Means 2020 values, which is more current and reflects replacement cost versus the building stock improvement values reported in the 2016 HMP. As a result, this analysis is an improvement to the overall risk assessment for the County.

4.3.13 Severe Weather

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the severe weather hazard in Gloucester County.

2022 HMP Update Changes

- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2015 and 2021.
- A vulnerability assessment was conducted for the severe weather hazard using a more accurate and updated building inventory.

4.3.13.1 Profile

Hazard Description

For the purpose of this HMP Update and as deemed appropriated by the Gloucester County Hazard Mitigation Planning Committee, the severe weather hazard includes high winds, tornadoes, thunderstorms and lightning, derechos, and hail which are defined below.

Thunderstorms

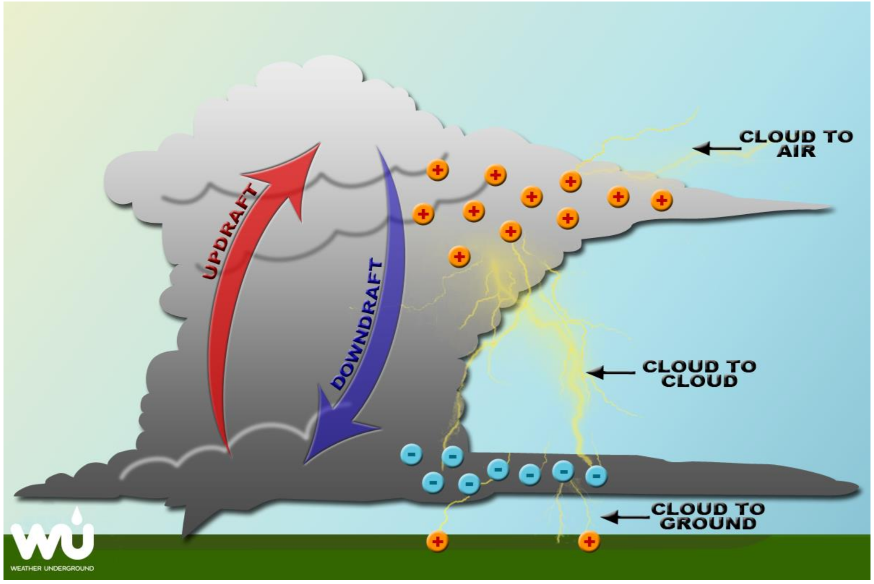
A thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (NWS 2009). A thunderstorm forms from a combination of moisture; rapidly rising warm air; and a force capable of lifting air, such as a warm front, cold front, a sea breeze, or a mountain. Thunderstorms form from the equator to as far north as Alaska. Although thunderstorms generally affect a small area when they occur, they have the potential to become dangerous due to their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and lightning.

Thunderstorms can lead to heavy rain induced flooding, landslides, strong winds, and lightning. Roads may become impassable from flooding, downed trees or power lines, or a landslide. Downed power lines can lead to loss of utility services, such as water, phone, and electricity. Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes. During the summer, thunderstorms are responsible for most of the rainfall.

Lightning

Lighting is a bright flash of electrical energy produced by a thunderstorm. The resulting clap of thunder is the result of a shock wave created by the rapid heating and cooling of the air in the lightning channel. All thunderstorms produce lightning and are very dangerous. Lightning ranks as one of the top weather killers in the United States, killing approximately 50 people and injuring hundreds each year. Lightning can occur anywhere there is a thunderstorm. Lightning can be cloud to air, cloud to cloud, and cloud to ground. Figure 4.3.13-1 demonstrates the variety of lightning types.

Figure 4.3.13-1. Types of Lightning

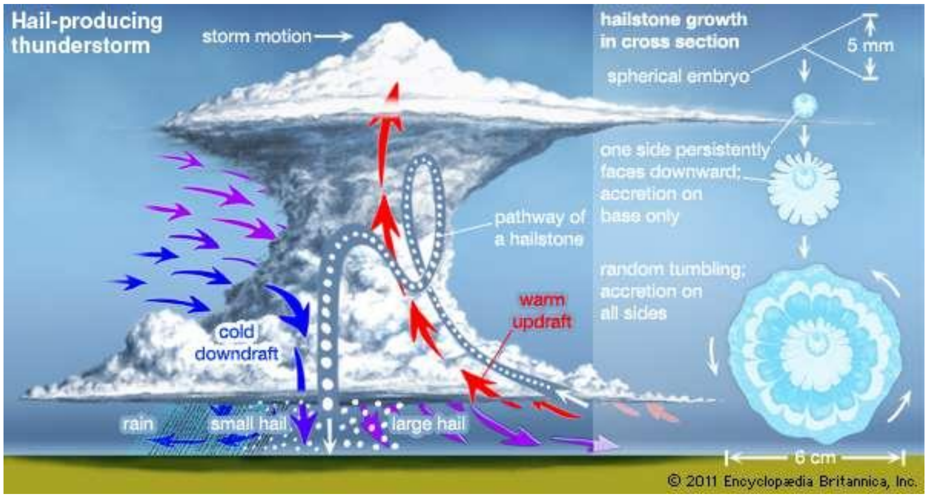


Source: Weather Underground 2014

Hailstorms

Hail forms inside a thunderstorm or other storms with strong updrafts of warm air and downdrafts of cold water. If a water droplet is picked up by the updrafts, it can be carried well above the freezing level. Water droplets freeze when temperatures reach 32 degrees Fahrenheit (°F) or colder. As the frozen droplet begins to fall, it may thaw as it moves into warmer air toward the bottom of the thunderstorm. However, the droplet may be picked up again by another updraft and carried back into the cold air and re-freeze. With each trip above and below the freezing level, the frozen droplet adds another layer of ice. The frozen droplet, with many layers of ice, falls to the ground as hail. Most hail is small and typically less than 2 inches in diameter (NWS 2010). Figure 4.3.13-2 shows how hail is formed within thunderstorms.

Figure 4.3.13-2. Hail Formation in Thunderstorms



Source: Encyclopedia Britannica 2011

Windstorms

Wind begins with differences in air pressures and occurs through rough horizontal movement of air caused by uneven heating of the earth's surface. Wind occurs at all scales, from local breezes lasting a few minutes to global winds resulting from solar heating of the earth. High winds are often associated with other severe weather events such as thunderstorms, tornadoes, nor'easters, hurricanes, and tropical storms.

Tornadoes

A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 250 miles per hour (mph). Damage paths can be greater than 1 mile wide and 50 miles long. Tornadoes typically develop from either a severe thunderstorm or hurricane as cool air rapidly overrides a layer of warm air. Tornadoes typically move at speeds between 30 and 125 mph and can generate combined wind speeds (forward motion and speed of the whirling winds) exceeding 300 mph. The lifespan of a tornado rarely is longer than 30 minutes (FEMA 1997). Tornadoes can occur at any time of the year, with peak seasons at different times for different states (NSSL 2013).

Derechos

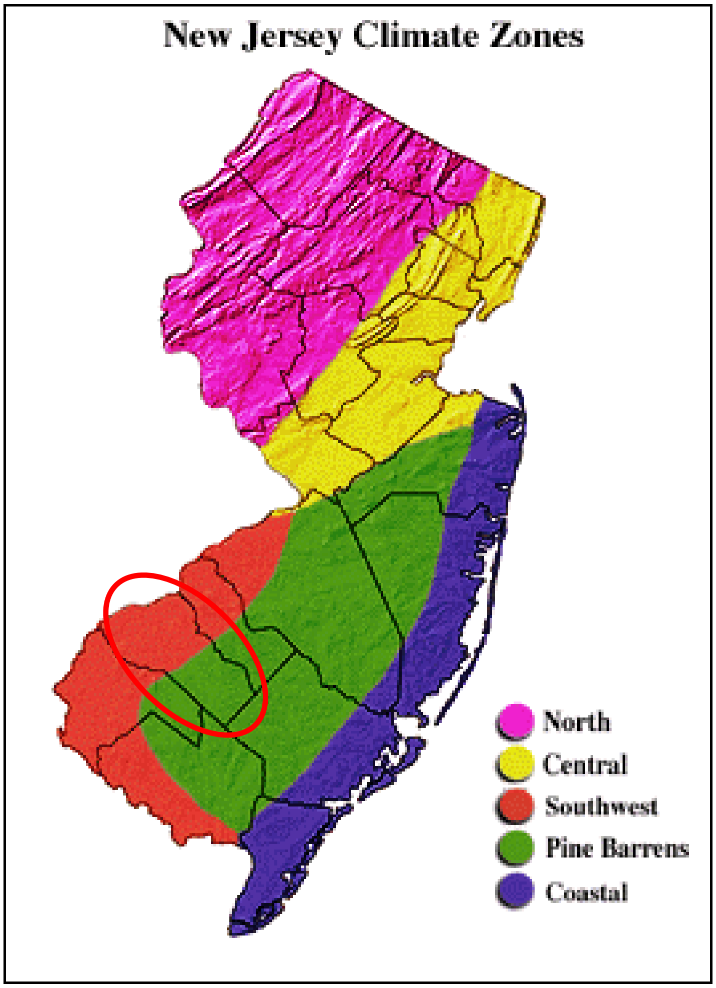
A derecho is a long-lived windstorm that is associated with a rapidly moving squall line of thunderstorms. It produces straight-line wind gusts of at least 58 mph and often has isolated gusts exceeding 75 mph. This means that trees generally fall and debris is blown in one direction. To be considered a derecho, these conditions must persist along a path of at least 240 miles. Derechos are more common in the Great Lakes and Midwest regions of the United States, though on occasion can persist into the Mid-Atlantic and Northeast (ONJSC 2021).

Location

All of Gloucester County is exposed to high wind, tornadoes, thunderstorms and lightning, derechos, and hailstorms. Additionally, all of the County is subject to high winds from severe weather events, especially communities along the Delaware River. According to the FEMA Winds Zones of the United States map, Gloucester County and the entire State of New Jersey is located within Wind Zone II. In this zone, wind speeds can reach up to 160 mph. Additionally, the County is located within a "Hurricane Susceptible Region", meaning Gloucester County is susceptible to hurricanes and other tropical cyclone events.

According to the ONJSC, New Jersey has five distinct climate regions. Elevations, latitude, distance from the Atlantic Ocean, and landscape (e.g. urban, sandy soil) produce distinct variations in the daily weather between each of the regions. The five regions include: Northern, Central, Pine Barrens, Southwest, and Coastal (ONJSC Rutgers University n.d.). Figure 4.3.13-3 depicts these regions. Gloucester County is located within the Southwest and Pine Barrens region.

Figure 4.3.13-3 Climate Regions of New Jersey



Source: Rutgers University Climate Lab 2021

Extent

The extent (severity or magnitude) of a severe storm is largely dependent upon the most damaging aspects of each type of severe weather. This section describes the extent of thunderstorms, lighting, hail, windstorms, and tornadoes in Gloucester County. Historical data presented in Table 4.3.13-1 shows the most powerful severe weather records in Gloucester County.

Table 4.3.13-1. Severe Storm Extent in Gloucester County (1950-2020)

Extent of Severe Storms in Gloucester County	
Largest Hailstone on Record	2 inches
Strongest Tornado on Record	F-2
Highest Wind Speed on Record	56 knots

Source: NOAA-NCEI 2021

High Winds

The following table provides the description of winds used by the NWS during wind-producing events.

Table 4.3.13-2. NWS Wind Descriptions

Descriptive Term	Sustained Wind Speed (mph)
Strong, dangerous, or damaging	≥40
Very windy	30-40
Windy	20-30
Breezy, brisk, or blustery	15-25
None	5-15 or 10-20
Light or light and variable wind	0-5

Source: NWS 2009

NWS issues advisories and warnings for winds, which are normally site-specific. High wind advisories, watches, and warnings are issued by the NWS when wind speeds may pose a hazard or may be life threatening. The criterion for each of these varies from state to state. Wind warnings and advisories for New Jersey are as follows:

- *High Wind Warnings* are issued when sustained winds of 40 mph or greater are forecast for 1 hour or longer, or wind gusts of 58 mph or greater are forecast for any duration.
- *Wind Advisories* are issued when sustained winds of 30 to 39 mph are forecast for one 1 hour or longer, or wind gusts of 46 to 57 mph are forecast for any duration (NWS 2021).

Tornadoes

The magnitude or severity of a tornado is categorized using the Enhanced Fujita Tornado Intensity Scale (EF Scale). This is the scale now used exclusively for determining tornado ratings by comparing wind speed and actual damage. Figure 4.3.13-4 illustrates the relationship between EF ratings, wind speed, and expected tornado damage.

Figure 4.3.13-4. Explanation of EF-Scale Ratings

EF Rating	Wind Speeds	Expected Damage		
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.		
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.		
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.		
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.		
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.		
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.		

Source: NWS 2021

Thunderstorms

Severe thunderstorm watches and warnings are issued by the local NWS office and SPC. The NWS and SPC will update the watches and warnings and will notify the public when they are no longer in effect. Watches and warnings for thunderstorms in New Jersey are as follows:

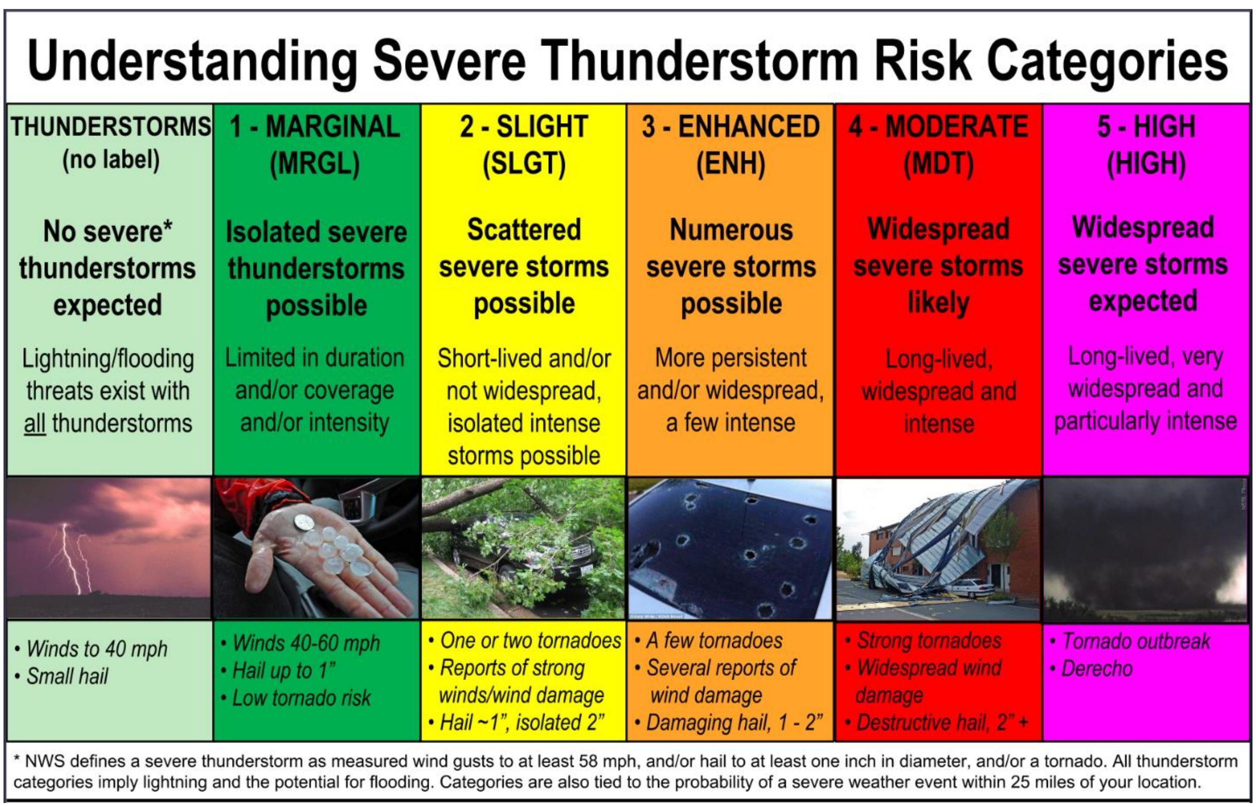
Severe Thunderstorm Warnings are issued when there is evidence based on radar or a reliable spotter report that a thunderstorm is producing, or forecast to produce, wind gusts of 58 mph or greater, structural wind damage, and/or hail one-inch in diameter or greater. A warning will include where the storm was located, what municipalities will be impacted, and the primary threat associated with the severe thunderstorm warning. After it has been issued, the NWS office will follow up periodically with Severe Weather Statements which contain updated information on the severe thunderstorm and will let the public know when the warning is no longer in effect (NWS 2010).

Severe Thunderstorm Watches are issued by the SPC when conditions are favorable for the development of severe thunderstorms over a larger-scale region for a duration of at least three hours. Tornadoes are not expected in such situations, but isolated tornado development may also occur. Watches are normally issued well in advance of the actual occurrence of severe weather. During the watch, the NWS will keep the public informed on what is happening in the watch area and also let the public know when the watch has expired or been cancelled (NWS 2009).

Special Weather State for Near Severe Thunderstorms are issued for strong thunderstorms that are below severe levels, but still may have some adverse impacts. Usually, they are issued for the threat of wind gusts of 40 to 58 mph or small hail less than one-inch in diameter (NWS 2009).

In addition, the SPC issues severe thunderstorm risk maps based on the likelihood of different severities of thunderstorms. Figure 4.3.13-5 shows the SPC's severe thunderstorm risk categories.

Figure 4.3.13-5. Severe Thunderstorm Risk Categories



Source: NOAA 2021

Lightning

Lightning is associated with moderate to severe thunderstorms. Lightning severity is determined by the frequency of lightning strikes during a storm. Multiple devices are available to track and monitor the frequency of lightning.

Derechos

In order for an event to be identified as a derecho, it must have wind gusts of at least 58 mph or greater along most of its length. While derecho winds typically are less than 100 mph, gusts as high as 130 mph have been recorded. Winds associated with derechos are not constant and may vary considerably along the path of the derecho. The winds associated with derechos are not constant and may vary considerably along the derecho path, sometimes being below severe limits (57 mph or less), and sometimes being very strong (from 75 mph to greater than 100 mph) (NOAA 2021).

Figure 4.3.13-6. Hail Size Chart

Source: NWS 2010

Hailstorms

Duration, hail size, and geographic extent determine hailstorm severity. Hail can exhibit a variety of sizes, though only the very largest hail stones pose serious risk to people, if exposed (NYSDHSES 2019). The size of hail is estimated by comparing it to a known object. Figure 4.3.13-7 shows the different sizes of hail and the comparison to real-world objects.

Previous Occurrences and Losses

Numerous sources provided historical information regarding previous occurrences and losses associated with severe weather events affecting Gloucester County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events may vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

FEMA Disaster Declarations

Between 1954 and 2020, the State of New Jersey was included in 18 FEMA declared severe weather-related disasters (DR) or emergencies (EM) classified as one or a combination of the following hazards: coastal storms, severe storm, straight-line winds, heavy rains, flooding, hail, tornadoes, and high wind. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Of those declarations, Gloucester has been included in five declarations classified as severe storms (FEMA 2021). Table 4.3.13-3 lists FEMA DR and EM declarations for Gloucester County.

Table 4.3.13-3. FEMA DR and EM Declarations for Severe Weather Events in Gloucester County

FEMA Declaration Number	Date(s) of Event	Date of Declaration	Event Type
DR-1588-NJ	April 1-4, 2005	April 20, 2005	Severe Storm(s)
DR-1694-NJ	April 14-27, 2007	April 26, 2007	Severe Storm(s)
DR-1897-NJ	March 12 -April 15, 2010	April 2, 2010	Severe Storm(s)
DR-4033-NJ	August 13-15, 2011	September 15, 2011	Severe Storm(s)
DR-4231-NJ	June 23-24, 2015	July 22, 2015	Severe Storm(s)

Source: FEMA 2021

U.S. Department of Agriculture Disaster Declarations

Between 2015 and 2021, the period for which data was available, Gloucester County was included in three USDA Disaster Declarations with no reported crop loss (USDA 2021), according to Table 4.3.13-4.

Table 4.3.13-4 USDA Disaster Declarations for Gloucester County

Disaster Declaration Number	Dates of Event	Type of Event
S3931	May 28 - July15, 2015	Excessive rain, flash flooding, high winds, and lightning.
S3712	May 22, 2015	Excessive Rain and Related Flooding, High Winds, and Hail.
S3603	May 1 - September 24, 2014	Excessive rain, related flooding, high winds, and hail

Source: USDA 2021

Severe Weather Events

For this 2022 Plan Update, known severe weather events, including FEMA disaster declarations, which have impacted Gloucester County between 2015 and 2021 are identified in Table 4.3.13-5. With documentation of severe storms for the State of New Jersey and Gloucester County being extensive, not all sources have been identified or researched. Therefore, the table may not include all events that occurred in the County. For events prior to 2015, refer to Appendix E (Risk Assessment Supplement). For detailed information on damages and impacts to each municipality, refer to Section 9 (Jurisdictional Annexes).

Table 4.3.13-5 Severe Weather Events in Gloucester County, 2015 to 2021

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Location	Event Details*
February 2, 2015	Strong Wind	N/A	N/A	Countywide	Strong, gusty northwest winds occurred in the wake of a departing and intensifying low pressure system during the late afternoon into the middle of the evening on the 2nd in New Jersey. Peak wind gusts average around 50 mph and knocked down weak trees, tree limbs and wires. Scattered power outages occurred. This was further exacerbated by snow and ice on tree limbs in the northwest part of the state. A total of $2,000 of property damage was reported.
February 15, 2015	Strong Wind	N/A	N/A	Countywide	The increasing pressure difference (gradient) between a rapidly intensifying low pressure system offshore and an arctic high pressure system moving east from the Great Lakes caused strong to high damaging northwest winds to occur in New Jersey from the late evening of the 14th into the afternoon of the 15th. A total of $5,000 of property damage was reported.
April 22, 2015	Thunderstorm Wind	N/A	N/A	Glassboro Borough, Pitman Borough, Monroe Township	A severe thunderstorm knocked down a large tree onto a house on West Olive Street in Westville. The tree crashed through the top floor and the home was deemed unsafe to continue to be occupied. No injuries were reported. A wind gust of 71 mph was measured with the same storm at the Philadelphia International Airport. A severe thunderstorm uprooted a large tree in Glassboro. It took down wires and also damaged a sidewalk. The severe thunderstorm also took down another tree that blocked access to a homeowner's driveway. A Skywarn Spotter estimated wind gusts to 60 mph as a severe thunderstorm moved through Pitman. A Skywarn Spotter estimated 60 mph as a severe thunderstorm moved through Williamstown. A total of $55,000 of property damage was reported
May 27, 2015	Thunderstorm Wind	N/A	N/A	Washington Township, Sewell (Mantua Township) Glassboro Borough, Westville Borough	A severe thunderstorm knocked down a couple of trees in far northern Gloucester County. Hardest hit was in Westville where a few trees were knocked down along Walnut Street. Gloucester County in sections of Washington Township, Sewell (Mantua Township) and Glassboro. A couple of fallen trees damaged vehicles in Washington Township. Trees and/or

TETRA TECH

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Location	Event Details*
					power lines were reported knocked down in Glassboro on Wilmer Street and in Sewell along East Holly Avenue, White Pine Drive, Hemlock Road and Hurffville-Crosskeys Road.
June 23, 2015	Thunderstorm Wind	N/A	N/A	Swedesboro Borough, Greenwich Township, East Greenwich Township, Mantua Township, Wenonah Borough, Deptford Township, Westville, Paulsboro Borough, Glassboro Borough, Monroe Township, Washington Township	A Skywarn Spotter estimated a wind gust of 60 mph as a severe thunderstorm moved through Swedesboro Borough. The wind damage from a powerful macroburst started to cause considerable wind damage in eastern parts of Greenwich Township. This then continued farther to the southeast in Gloucester County. There were multiple reports of hundreds of trees and wires down in the Gibbstown area of the township. The roof of Saint Michael's Convent was damaged after it was lifted 10 to 15 feet into the air from the rest of the convent. The roof of a pet store also collapsed. A tree fell through a home on Cucinotta Road. Telephone poles fell across Harmony Road. The wind damage from a powerful macroburst maximized across eastern sections of East Greenwich Township. A survey estimated peak wind gusts of 85 mph. Power poles were snapped in the area of East Chawkin Road and Paul Mills Road along Kings Highway (County Route 551) in the Clarksboro section. Shingle damage occurred to numerous homes and sheds were blown over. Many roads were impassable because of downed trees and wires. Wind damage extended to the Mantua Township border through Windsor Way and Carriage Court where one building's roof was completely destroyed. The township estimated 2,800 trees and 100 poles were knocked down. The macroburst wind damage continued into Mantua Township. There were multiple reports of trees and wires knocked down. In addition, the roof of the township fire department building was badly damaged. Wind damage continued through the Sewell section of the township. The macroburst wind damage continued through Wenonah Borough where numerous and massive trees including oaks were knocked down. The macroburst wind damage clipped western Deptford Township and included the Deptford Mall. A vehicle was flipped by the damaging winds

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Location	Event Details*
					in the mall parking lot. Mall and store signs along Clements Bridge Road were damaged. A Paulsboro refinery was struck by lightning which caused a loss of power. The refinery then off gassed. No evacuations were needed. A severe thunderstorm knocked over a few trees in Westville Borough. One tree fell onto and damaged a pool. A severe thunderstorm knocked down dozens of trees in Woodbury Heights. Downed trees also caused the closure of the southbound lanes of the New Jersey Turnpike in the Borough. A severe thunderstorm knocked down numerous trees in Pitman Borough. A severe thunderstorm knocked down several trees including one along Greentree Road in Glassboro Borough. A severe thunderstorm knocked down numerous trees in Turnersville as well as other locations within Washington Township. At least one home was damaged by fallen trees. A Kohl's Department store sign was left dangling in a shopping center. A severe thunderstorm knocked down numerous trees in Williamstown within Monroe Township. The squall line of severe thunderstorms caused agricultural damage in Gloucester County. Within Monroe Township, one farmer lost all of his cage free hens. A total of $1.7 million of property damage was reported
July 9, 2015	Thunderstorm Wind	N/A	N/A	Pitman Borough, Washington Township	A line of strong to severe thunderstorms formed in the warm sector of the Susquehanna Valley and moved through southern New Jersey during the during the evening on the 9th. A severe thunderstorm knocked down large tree limbs and wires in Pitman Borough. A severe thunderstorm knocked down large tree limbs and wires in Washington Township. A total of $1,000 of property damage was reported.
October 2, 2015	Strong Wind	N/A	N/A	Countywide	A persistent onshore flow caused periods of heavy rain, strong to high winds, beach erosion, and minor to moderate tidal flooding to occur along the Atlantic coast of New Jersey and into Delaware Bay from the 1st through the 4th.

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Location	Event Details*
February 16, 2016	Thunderstorm Wind	N/A	N/A	Deptford Township, City of Woodbury	Severe wind gusts associated with a cold front moving through the area brought down trees and traffic lights on Delsea Drive in Deptford Township. A wind gust of 47 mph was measured at Philadelphia International Airport with this cold front at 1238EST just across the Delaware River. Severe wind gusts associated with a cold front moving through the area knocked down numerous trees on Cooper Street in Woodbury.
April 2, 2016	Hail	N/A	N/A	Monroe Township	Thunderstorms associated with a strong cold front moving across the area during the early morning hours on the 3rd produced three-quarter inch hail in Williamstown.
June 5, 2016	Thunderstorm Wind	N/A	N/A	Gloucester Township	Many wind gusts from 60 to over 70 MPH were recorded across the region. The highest gust was in Gloucester Township at 74 mph. Several trees were uprooted due to thunderstorm winds. Several trees were down due to wind. Power out- remove. Large limbs were downed due to winds. Wind gusts estimated over 60 MPH. Trees and powerlines downed due to wind.
June 8, 2016	Thunderstorm Wind	N/A	N/A	Countywide	A fast-moving line of thunderstorms produced widespread wind damage and gusts up to 52 mph.
January 23, 2017	Strong Winds	N/A	N/A	Countywide	An area of low pressure over North Carolina on the 23rd strengthened and moved northeast to a location just off the New Jersey Coastline on the morning of the 24th. A measured 51 mph gust was reported.
February 13, 2017	High Winds	N/A	N/A	Countywide	Wind speeds up to 54 mph were reported, leading to downed power lines and wires.
February 25, 2017	Thunderstorm Wind	N/A	N/A	Countywide	Several days of record warmth came to an abrupt end as a strong cold front moved through the state. Moisture and instability were sufficient to develop a line of showers and thunderstorms ahead of the front. These showers and thunderstorms produced damaging winds and hail across western portions of the state. Measured wind gust.
April 6, 2017	Thunderstorm Wind	N/A	N/A	Countywide	Moisture and instability was drawn northwest ahead of the front which led to locally heavy showers and thunderstorms. Some of thunderstorms were strong to severe with gusty winds. A couple of trees were taken down due to thunderstorm wind gusts.

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Location	Event Details*
June 19, 2017	Thunderstorm Wind	N/A	N/A	Logan Township	Wind damage was reported from a complex of thunderstorms that moved into the region. Downed trees and wires on Bridgeton Pike near 4H Fairgrounds.
June 24, 2017	Thunderstorm Wind	N/A	N/A	Countywide	A band of gusty convective showers moved through during the morning hours in association with the remnants of Tropical Storm Cindy. Trees and wires were reported down.
July 14, 2017	Lightning	N/A	N/A	Franklin Township	A hot and humid airmass was present ahead of a frontal boundary which slowly moved southeast toward and then through the state. Several rounds of thunderstorms moved through the region ahead of this front over the course of a few days. A transformer was struck by lightning. Trees were taken down from thunderstorm winds near route 322.
July 17, 2017	Hail	N/A	N/A	Countywide	Measured hail three quarters of an inch in diameter.
July 23-24, 2017	Heavy Rain; Lightning	N/A	N/A	Mantua Township, Swedesboro Borough	Multiple rounds of thunderstorms were reported due to a frontal boundary moving through the area. A tree was taken down by thunderstorm winds onto Jackson road.
August 2, 2017	Thunderstorm Wind	N/A	N/A	East Greenwich Township	A hot and humid airmass with weak boundaries led to slow moving strong to severe thunderstorms with damaging winds, hail and flooding. Several trees downed due to thunderstorm winds. Over 2,000 people lost power.
October 24, 2017	Strong Wind	N/A	N/A	Countywide	A strong low pressure system over the Great Lakes and a departing high pressure system to our east lead to a tight pressure gradient and a round of strong winds. Over 25,000 homes and businesses lost power.
March 2, 2018	High Wind	N/A	N/A	Washington Township	Strong winds and flooding causing $100,000 in damage resulted from a stalled cold front from a deep area of low pressure. Recorded wind speeds were up to 71 mph the night of the 2nd. Numerous downed trees were reported throughout the county due to strong winds. A 65 mph wind gust in Washington Township at 1455EST on March 2nd was reported by a trained spotter.
July 3, 2018	Thunderstorm Winds	N/A	N/A	Countywide	Severe thunderstorms caused wind damage across portions of southwestern New Jersey on the evening of July 3. Rainfall amounts of 1 to 3 inches fell along the Interstate 95/New Jersey Turnpike Corridor in a short amount of time. A few locations received 3 to 4 inches of rain.

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Location	Event Details*
February 25, 2019	High Winds	N/A	N/A	Countywide	A severe weather outbreak impacted much of the East Coast, causing widespread straight line wind damage and a few tornadoes. Based on surrounding reports and observations, winds likely gusted to 50 kts across the county.
April 15, 2019	Thunderstorm Wind	N/A	N/A	Countywide	A severe weather outbreak impacted much of the East Coast, causing widespread straight line wind damage and a few tornadoes. Multiple trees were reported down.
April 26, 2019	Thunderstorm Wind	N/A	N/A	Logan Township	A strong low pressure system tracked through the eastern Great Lakes on April 26. A warm front moved through the mid-Atlantic that morning with an initial round of locally strong but sub-severe convection. A tree was reported down on US 322 eastbound west of I-295 in Logan Township.
May 28, 2019	Hail	N/A	N/A	Countywide	A frontal boundary that had been stalled over the mid-Atlantic had lifted north of the region by the morning of June 29. The combination of strong frontal forcing and a warm, unstable environment ahead of the front led to widespread severe thunderstorms developing. Quarter size hail was recorded in Gloucester County.
June 2, 2019	Thunderstorm Wind	N/A	N/A	Franklin Township	Several trees and power lines down. Time estimated from radar.
June 13, 2019	Tornado	N/A	N/A	Deptford Township, Gloucester Township	A tornado formed in the development near Saddle Court in Mullica Hill. This caused damage to fencing at one residence, and ripped a gutter off another residence. Backyard furniture was lifted approximately 50 yards. From there, the tornado moved in a northeasterly direction and caused a narrow path of tree damage before lifting southwest of Highway 322. The same storm which earlier produced a tornado in Mullica Hill, NJ later produced a second, slightly stronger tornado. This tornado took a non-continuous path from Deptford Township in Gloucester County into the Blackwood section of Gloucester Township in Camden County. There were |several locations of tree damage, including snapped and uprooted |hardwood trees. There was damage to three residences in Deptford |Township when portions of trees fell on these residences. In |Blackwood, an uprooted tree caused damage to an apartment building.

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Location	Event Details*
June 29, 2019	Thunderstorm Wind/ Hail	N/A	N/A	Deptford Township	Severe thunderstorms generating 51 mph formed from a stalled frontal boundary that over the mid-Atlantic that left the region during the day and then returned. Quarter size hail. Two trees were blown down. An mPing report was received of trees and power lines down at this location.
July 6, 2019	Thunderstorm Wind	N/A	N/A	Elk Township	A camping trailer was blown over at Oldmans Creek Campground in Elk Township. Time estimated from radar.
July 17, 2019	Thunderstorm Wind	N/A	N/A	Paulsboro Borough, Logan Township Washington Township	The remnants of Hurricane Barry moved near and west of the mid-Atlantic on July 17, in tandem with a frontal system which was absorbing the former tropical cyclone. A downed tree closed one or two lanes of US-130 northbound at NJ-44. Time estimated from radar. An mPing report of 3 inch tree limbs or power poles broken. A downed tree closed one or two lanes of US-130 northbound at NJ-44. Time estimated from radar. An mPing report of 3 inch tree limbs or power poles broken. A tree was downed on the NJ-42 southbound exit ramp to College Dr. The ramp was closed due to the obstruction. Time estimated from radar.
July 22, 2019	Thunderstorm Wind	N/A	N/A	Countywide	A stalled frontal boundary generated and upper level trough spurred severe weather with wind speeds of 51mph recorded in the County. A tree was downed on the I-295 northbound ramp from Exit 10.
February 7, 2020	Thunderstorm Wind	N/A	N/A	Countywide	A line of low topped but intense convection developed, and despite producing little thunder and lightning it produced a long swath of wind damage over the mid-Atlantic, along with a few tornadoes between Virginia and Maryland. A tree was downed on the New Jersey Turnpike southbound north of interchange 2 Time estimated from radar.
March 3, 2020	Thunderstorm Winds	N/A	N/A	Countywide	A warm front moved north through parts of the mid-Atlantic during the late morning and afternoon of March 3. A cold front followed closely behind it in association with strengthening low pressure moving through the eastern Great Lakes. An mPing report of tree or shingle damage.
April 9, 2020	Thunderstorm/ Hail	N/A	N/A	Countywide	A warm front moved through the mid-Atlantic on the morning of April 9. Estimated wind gusts of 60 mph.
April 13, 2020	Thunderstorm Wind; High Wind	N/A	N/A	Countywide	A warm front moved through the mid-Atlantic, mixing with a low level jet with strong wind gusts, particularly near the coast. Later in the day, a

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Location	Event Details*
					strong cold front entered the region, bringing extreme wind shear. Heating produced strong to severe thunderstorms and 70 mph winds. .
April 21, 2020	Thunderstorm Wind; Hail	N/A	N/A	Countywide	An unseasonable strong cold front brought a squall line through the region. Destabilized air masses brought 60 mph winds and a tornado off the coast. A pole struck by lightning caught fire and downed wires and power lines were reported in Gloucester. Power lines were reported down in the area.
April 30, 2020	High Wind	N/A	N/A	Deptford Township	Slow moving low pressure tracked through the Great Lakes region on April 30. As it did so, an associated cold front began to approach the coastal mid-Atlantic. A few reports of tree and utility damage including a social media report of multiple large trees damaged in Deptford.
June 3-4, 2020	Thunderstorm	N/A	N/A	Pitman Borough, Glassboro Borough	Strong winds and rain caused numerous areas to report power outage and downed trees across the county, causing subsequent flooding and road closure. Downed tree on Interstate 295 south of Exit 15 in Gibbstown. Downed tree on State Highway 47 near Broadway Avenue in Cherry Hill. Downed tree on New Jersey Turnpike southbound south of Exit 3 near Runnemeade. Time estimated from radar. Downed tree on Interstate 295 at Exit 15. Multiple large trees down near and along Fish Pond Road east of Rowan University. Downed tree limbs and damage to shed and fence near Pitman. A tree fell onto two mobile home trailers. Time estimated from radar. Downed tree and wires on US Rt. 322 in both directions west of Harvard Road. All lanes closed. Time estimated from radar.
July 30, 2020	Thunderstorm Wind	N/A	N/A	Glassboro Borough	A stalled frontal boundary was draped in the area of southern New Jersey and Delmarva on July 30. Meanwhile, another cold front was approaching the region from the northwest. Several reports were received of downed power lines in the Fairview and Jericho area. Wires were downed near Pennsylvania Ave in Glassboro. Time estimated from radar. Time estimated from radar.
August 3, 2020				Washington Township	A diffuse, slow moving frontal boundary was present over the mid-Atlantic on August 3 as an upper level trough also approached from the west.

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Location	Event Details*
					Power lines were downed near Mantua Blvd in Sewell. Time estimated from radar.
August 7, 2020	Thunderstorm Wind	N/A	N/A	Deptford Township	An impulse riding along a west to east boundary stalled near the Mason-Dixon line produced severe thunderstorms and heavy rain across sections of South Jersey from late afternoon through the evening hours on August 7th. Strong winds knocked down trees, and torrential downpours on ground already saturated from the remnants of Hurricane Isaias produced flash flooding on many roadways and small streams in the area. Downed tree, pole, and wires on NJ 41, both directions, north of Good Intent Road in Deptford Township. All lanes closed. Time estimated from radar.
August 12, 2020	Thunderstorm Wind	N/A	N/A	Woodbury City, Woodbury Heights Borough	Tree limbs and wires were downed near Girard St in Woodbury. Time estimated from radar. Several reports of downed tree limbs and wires in West Deptford and Woodbury. Time estimated from radar. Tree limbs and wires were downed near the intersection of Lake Ave and Park Ave in Woodbury Heights. Time estimated from radar. A large tree was downed on New St. Time estimated from radar.
November 15, 2020	Thunderstorm Wind	N/A	N/A	Countywide	Strong low pressure moved through the Great Lakes on November 15, 2020. As it did so, it pushed a warm front through the mid-Atlantic during the late morning and early afternoon hours, causing unseasonably warm conditions to develop. An mPing report of trees and power lines down. Time estimated from radar.
December 24-25, 2020	High Wind	N/A	N/A	Pittman Township	Strong low pressure tracked through the Great Lakes region early on December 24. Later on the 24th, a secondary area of low pressure began to develop over the Southeast along the trailing cold front from the primary low. A trained spotter in Pitman reported a measured wind gust of 58 mph. Several reports of tree and utility damage were also received.
September 1, 2021	Tornado	Pending	Yes	South Harrison Township, Harrison Township, Deptford Township	The remnants of Hurricane Ida passed over the region. Combined with a warm-front, resulting in severe weather. A tornado touched down in Harrisonville and ran through Mullica Hill and Deptford along a 12.6 miles long path with a width up to 400 yards. 2 injuries occurred and many homes were heavily damaged or destroyed. Peak strength was at a rating

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Location	Event Details*
					of EF-3 with winds of 150 mph making it one of the most powerful tornados on record in the state.

Source(s): FEMA 2021; NOAA-NCEI 2021; NJ OEM 2019
** Unless explicitly stated, no property or crop damage was reported.*
FEMA Federal Emergency Management Agency
HMP Hazard Mitigation Plan
NCDC National Climatic Data Center
NOAA National Oceanic and Atmospheric Administration
NWS National Weather Service

Probability of Future Occurrences

Predicting future severe weather events in a constantly changing climate has proven to be a difficult task. Predicting extremes in New Jersey and Gloucester County is particularly difficult because of their geographic location. Both are positioned roughly halfway between the equator and the North Pole and are exposed to both cold and dry airstreams from the south. The interaction between these opposing air masses often leads to turbulent weather across the region (UCAR 2021).

Table 4.3.13-6 summarizes data regarding the probability of occurrences of severe weather events in Gloucester County based on the historic record. The information used to calculate the probability of occurrences is based solely on NOAA-NCEI storm events database results and FEMA disaster declarations.

Table 4.3.13-6. Probability of Future Occurrences of Severe Weather Events

Hazard Type	Number of Occurrences Between 1950 and 2020	% Chance of Occurring in Any Given Year
Funnel Cloud	2	3
Hail	32	45
High Wind	34	48
Lightning	22	31
Strong Wind	95	100
Thunderstorm Wind	242	100
Tornado	11	16
Total	**438**	**100**

Source: NOAA-NCEI 2021
Note: Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected storm events since 1968. Due to limitations in data, not all severe storm events occurring between 1954 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.

It is estimated that Gloucester County will continue to experience direct and indirect impacts of severe weather events annually that may induce secondary hazards such as flooding, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences. It is estimated that the County will continue to experience these events annually.

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for severe weather events in the County is considered ‘frequent’ (100 percent chance of event occurring; occurs multiple times a year).

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (ONJSC 2021) which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo 2014) and the world (1.5° F [0.8° C]) (Meyer 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date. The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (ONJSC 2021). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh 2014) and with more intensity (Huang 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan 2014). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli 2020).

A warmer atmosphere means storms have the potential to be more intense (Guilbert 2015) and occur more often (Broccoli 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

4.3.13.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable. For the severe weather hazard, the entire County is exposed. The following section discusses Gloucester County's vulnerability, in a qualitative nature, to the summer weather hazard.

Impact on Life, Health, Safety

The impact of a severe weather on life, health and safety is dependent upon several factors including the severity of the event and whether adequate warning time was provided to residents. The entire population of

Gloucester County (291,165) is exposed to this hazard (2015-2019) American Community Survey 5-Year Population Estimate).

Lightning can be responsible for deaths, injuries, and property damage. Lightning-based deaths and injuries typically involve heart damage, inflated lungs, or brain damage, as well as loss of consciousness, amnesia, paralysis, and burns, depending on the severity of the strike. Additionally, most people struck by lightning survive, although they may have severe burns and internal damage. People located outdoors (i.e., recreational activities and farming) are considered most vulnerable to hailstorms, thunderstorms, and tornadoes because there is little to no warning, and shelter might not be available. Moving to a lower risk location will decrease a person's vulnerability.

Downed trees, damaged buildings, and debris carried by high winds from hurricanes, tropical storms, or tornadoes can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on several factors, including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing.

Impact on General Building Stock

All buildings are exposed to summer weather hazards such as hailstorms and lightning strikes. Refer to Section 3 (County Profile), which summarizes the building inventory in Gloucester County. While hailstorms are not frequently known to cause major injuries or damage in New Jersey, an extreme event can carry hail stones traveling at speeds greater than 100 miles per hour (NOAA 2021). This could cause structural damage for the general building stock in the County. Severe summer weather that causes lightning could be a threat to the County's general building stock if the lightning starts a fire. Over 22,000 fires caused by lightning occurred annually throughout the U.S. between 2007 and 2011, which was valued at approximately $450 million of damages per year (National Fire Protection Association 2013).

Impact on Critical Facilities and Lifelines

Critical facilities are at risk of being impacted by high winds associated with structural damage, or falling tree limbs/flying debris, which can result in the loss of power. Power loss can greatly impact households, business operations, public utilities, and emergency personnel. Emergency personnel such as police, fire, and EMS will not be able to effectively respond in a power loss event to maintain the safety of its citizens unless backup power and fuel sources are available. Loss of power can impact other public utilities, including potable water, wastewater treatment, and communications. In addition to public water services, property owners with private wells might not have access to potable water until power is restored.

All critical facilities in the County are exposed to the extreme temperature hazard with similar risks as discussed for the general building stock. It is essential that critical facilities remain operational during natural hazard events. Extreme heat events can sometimes cause short periods of utility failures, commonly referred to as "brown-outs", due to increased usage from air conditioners, appliances, etc. Similarly, heavy snowfall and ice storms, associated with extreme cold temperature events, can cause power interruption as well. Backup power is recommended for critical facilities and infrastructure. Where backup power is needed for critical facilities that provide essential services, municipalities identified mitigation actions in Section 9 (Jurisdictional Annexes).

Impact on Economy

Severe weather events can have short- and long-lasting impacts on the economy. When a business is closed during storm recovery, there is lost economic activity in the form of day-to-day business and wages to employees. Overall, economic impacts include the loss of business function (e.g., tourism, recreation), damage to inventory, relocation costs, wage loss and rental loss due to the repair/replacement of buildings. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting and goods transport) transportation needs. Utility infrastructure (power lines, gas lines, electrical systems) could suffer damage and impacts can result in the loss of power, which can impact business operations and can impact heating or cooling provision to the population.

According to the State of New Jersey 2019 HMP, hail alone causes $2 billion worth of crop and property damage on an annual basis in the United States (State of NJ 2019). Even though New Jersey is estimated to experience an average of two hailstorm events per year, the outcome of these events could be detrimental depending on the cost it would take for the community to recover from the damages. Likewise, these costs can add up for other severe weather events such as tornados destroying key infrastructure and level local businesses, or extreme rain events flooding out shopping centers or transportation hubs.

Impact on the Environment

The impact of severe weather events on the environment varies, but researchers are finding that the long-term impacts of more severe weather can be destructive to the natural and local environment. National organizations such as USGS and NOAA have been studying and monitoring the impacts of extreme weather phenomena as it impacts long term climate change, streamflow, river levels, reservoir elevations, rainfall, floods, landslides, erosion, etc. (USGS 2017). For example, severe weather that creates longer periods of rainfall can erode natural banks along waterways and degrade soil stability for terrestrial species. Tornadoes can tear apart habitats causing fragmentation across ecosystems. Researchers also believe that a greater number of diseases will spread across ecosystems because of impacts that severe weather and climate change will have on water supplies (NOAA 2013c). Overall, as the physical environment becomes more altered, species will begin to contract or migrate in response, which may cause additional stressors to the entire ecosystem within Gloucester County. Refer to Sections 4.3.3 (Disease Outbreak) for more information about these stressors.

Future Changes that May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures.

Gloucester County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

The ability of new development to withstand extreme summer weather hazard impacts lies in sound land use practices, building design considerations (e.g., Leadership in Energy and Environmental Design [LEED]), and consistent enforcement of codes and regulations for new construction. New development will change the landscape where buildings, roads, and other infrastructure potentially replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry, potentially making them more susceptible to fires caused by lightning.

The Pinelands Commission has identified Pinelands Management Area Boundaries, including regional growth areas and rural development areas that may also provide insight to where development and growth may occur in the County. In addition, each community was requested to provide recent and anticipated new development and infrastructure projects; summarized in Section 9 (Jurisdictional Annexes).

Specific areas of recent and new development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 (Jurisdictional Annexes) of this plan.

Projected Changes in Population

Gloucester County has experienced population increase since 2010. According to the U.S. Census Bureau, the County's population has increased 1.0-percent between 2010 and 2019 (U.S. Census Bureau 2021). Any changes in the density of population can impact the number of persons exposed to the severe weather hazard.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures. As the climate warms, the intensity of summer weather may change, with the potential to create more frequent events with lightning and/or hail.

Change of Vulnerability Since the 2016 HMP

Overall, the County's vulnerability has not changed, and the entire County will continue to be exposed and vulnerable to severe weather events. As existing development and infrastructure continue to age, they can be at increased risk to failed utility and transportation systems if they are not properly maintained and do not adapt to the changing environment.

4.3.14 Severe Winter Weather

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the severe winter weather hazard in Gloucester County.

2022 HMP Update Changes

- New and updated figures from federal and state agencies are incorporated.
- A new table explaining prior severe winter weather events was added.
- Previous occurrences were updated with events that occurred between 2015 and 2021.
- A vulnerability assessment was conducted for the severe winter weather hazard using a more accurate and updated building inventory.

4.3.14.1 Profile

Hazard Description

A winter storm is a weather event in which the main types of precipitation are snow, sleet, or freezing rain. They can be a combination of heavy snow, blowing snow, and dangerous wind chills. According to the National Severe Storms Laboratory (NOAA 2021), the three basic components needed to make a winter storm include the following:

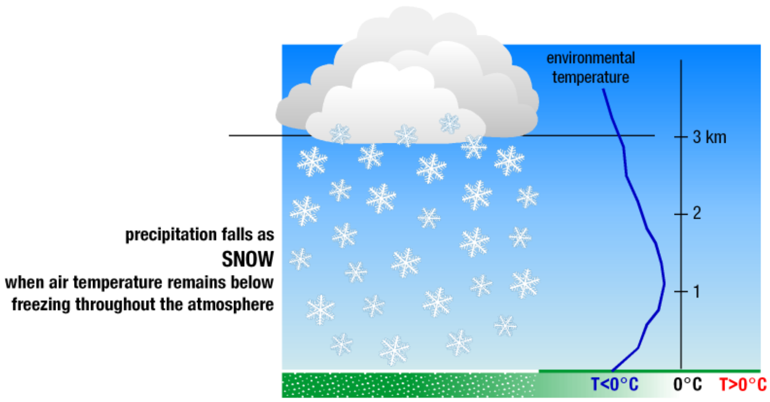
- Below freezing temperatures (cold air) in the clouds and near the ground to make snow and ice.
- Lift, something to raise the moist air to form clouds and cause precipitation, such as warm air colliding with cold air and being forced to rise over the cold dome or air flowing up a mountainside (oliographic lifting).
- Moisture to form clouds and precipitation, such as air blowing across a large lake or the ocean.

Some winter storms can immobilize an entire region, while others might only affect a single community. Winter storms typically are accompanied by low temperatures, high winds, freezing rain or sleet, and heavy snowfall. The aftermath of a winter storm can have an impact on a community or region for days, weeks, or even months; potentially causing cold temperatures, flooding, storm surge, closed and blocked roadways, downed utility lines, and power outages. Gloucester County's winter storms include, but are not limited to blizzards, snowstorms, sleet, and ice storms. For details regarding Nor'Easters, refer to Section 4.3.12.

Heavy Snow

According to the National Snow and Ice Data Center (NSIDC), snow is precipitation in the form of ice crystals. It originates in clouds when temperatures are below the freezing point (32 °F) and water vapor in the atmosphere condenses directly into ice without going through the liquid stage. Once an ice crystal has formed, it absorbs and freezes additional water vapor from the surrounding air, growing into snow crystals or a snow pellet, which then falls to the earth. Snow falls in different forms: snowflakes, snow pellets, or sleet. Snowflakes are clusters of ice crystals that form from a cloud. Figure 4.3.14-1 depicts snow creation.

Figure 4.3.14-1. Snow Creation



Source: NOAA 2021

Snow pellets are opaque ice particles in the atmosphere. They form as ice crystals fall through super-cooled cloud droplets, which are below freezing but remain a liquid. The cloud droplets then freeze to the crystals.

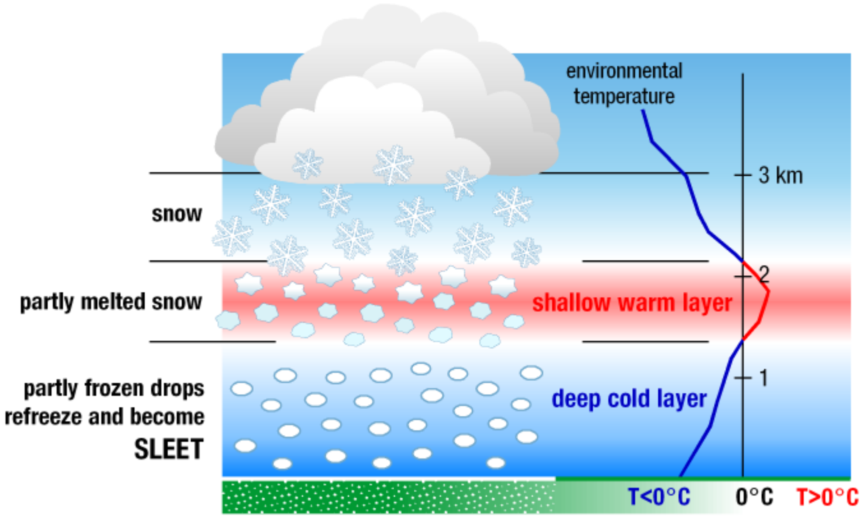
Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 miles per hour (mph) or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile, as the predominant conditions over a 3-hour period. Extremely cold temperatures often are associated with blizzard conditions but are not a formal part of the definition. The hazard, created by the combination of snow, wind, and low visibility, significantly increases when temperatures are below 20°F. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero. Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm, moister air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions caused by the blowing snow (Lam 2019).

Sleet

Sleet is made up of drops of rain that freeze into ice as they fall. They are usually smaller than 0.30 inch in diameter (NSIDC 2013). A sleet storm involves significant accumulations of solid pellets, which form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces, posing a hazard to pedestrians and motorists (NSIDC 2013).

Figure 4.3.14-2. Sleet Creation

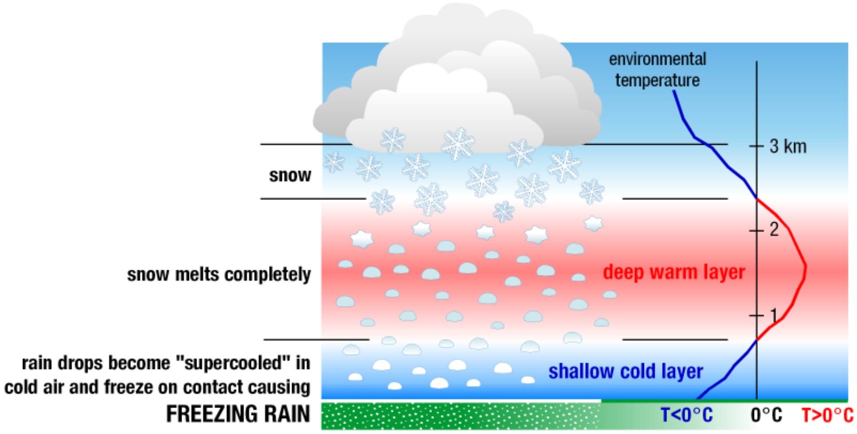


Source: NOAA 2021

Ice Storms

An ice storm describes those events when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations typically are accumulations of 0.25-inches or greater (NWS 2013). Heavy accumulations of ice can bring down trees, power lines, utility poles, and communication towers. Ice can disrupt communications and power for days. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians (NWS 2020).

Figure 4.3.14-3. Freezing Rain Creation



Source: NOAA 2021

Location

Snow and Blizzards

Heaviest snowfall from winter storms is typically within a 150-mile wide swath to the northwest of what are generally southwest to northeast moving storms. The trajectory of the snowstorm will determine the location of heaviest snowfalls. In Gloucester County the average yearly snowfall is between 20" and 25". There is, however, significant variation from year to year. February is the month when maximum accumulations on the ground are usually reached. The southeastern third of Gloucester County receives slightly less snowfall most likely due to the coastal influences moderating temperatures slightly. Snow may fall from about October 15 to April 30 in the highlands and from about November 15 to April 15 in southern counties, including Gloucester (Rutgers University 2021).

Ice Storms

All regions across New Jersey are subject to ice storms. In addition to temperature, their occurrence depends on the regional distribution of the pressure systems, as well as local weather conditions. The occurrence and intensity of ice storms often coincides with general distribution of snow. In Gloucester County, a cold rain may be falling near the Atlantic County border in the southeastern part of the county, transforming into freezing rain in the central region, and snow over the northwestern portion as a coastal storm moves northeastward offshore. A locality's distance to the passing storm center is often the crucial factor in determining the temperature and type of precipitation during a winter storm, especially given the confined geographical region the storms often reach and affect. Based on data from 1948–2000, Gloucester County can anticipate 2-4 days with freezing rain per year. Based on data from 1932–2001, the County can anticipate 9-15 total hours of freezing rain per year (MRCC 2021).

Extent

The magnitude or severity of a severe winter storm depends on several factors, including snowfall rates, regional climatological susceptibility to snowstorms, snowfall amounts, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day and week (e.g., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. NOAA's National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5. It is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population based on the 2010 Census. The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA 2021). Table 5.4.7-1 presents the five RSI ranking categories.

Table 4.3.14-1. RSI Ranking Categories

Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6

TETRA TECH

Category	Description	RSI Value
3	Major	6-10
4	Crippling	10-18
5	Extreme	18.0+

Source: NOAA 2021
Note: RSI = Regional Snowfall Index

The NWS operates a widespread network of observing systems such as geostationary satellites, Doppler radars, and automated surface observing systems that feed into the current state-of-the-art numerical computer models to provide a look into what will happen next, ranging from hours to days. The models are then analyzed by NWS meteorologists who then write and disseminate forecasts.

The NWS uses winter weather watches, warnings and advisories to ensure that people know what to expect in the coming hours and days. A winter storm watch means that severe winter conditions (heavy snow, ice, etc.) may affect a certain area, but its occurrence, location and timing are uncertain. A watch is issued to provide 12 to 48 hour notice of the possibility of severe winter weather. A watch is upgraded to a winter storm warning when hazardous winter weather, in the form of heavy snow, heavy freezing rain or heavy sleet, is imminent or occurring. They are usually issued 12 to 24 hours before the event is expected to begin. Winter weather advisories inform people that winter weather conditions are expected to cause significant inconveniences that may be hazardous. The NWS may also issue a blizzard warning when snow and strong winds combine and produce a blinding snow, deep drifts, and wind chill (NWS 2021).

Previous Occurrences and Losses

Winter storms occur frequently enough in Gloucester County to be a threat to people and property. Generally, the winter storm season in the Gloucester County runs from December to March. The NCDC reports there have been 180 snow and ice events in Gloucester County between 1950 and 2020. Although the query results begin in 1950 the first reported event is in 1995. This is likely the case because weather events were reported using different methods prior to this year and thus are not consistent with those after 1995, according to the National Weather Service (NWS 2021). The probability of winter storms occurring in the future is relatively high, based on previous data. On average, between 7 and 10 winter storms occur every year in Gloucester County (Gloucester County 2016).

It is worth noting that NCEI database indicates that between 1950 and 2020, there have been no ice storm events reported in Gloucester County. However, according to the 2009 Gloucester County Hazard Mitigation Plan , there have been two ice storms that have impacted Gloucester County between 1950 and 2007. One of the two events listed in the HMP occurred on February 15th and 16th, 1995 when a warm front associated with a storm system over the Great Lakes helped push warmer air aloft above a dome of cold, dry air near the ground. As warmer air moved in aloft, precipitation mainly fell as freezing rain the afternoon and evening of the 15th. Once the sun set, many roadways in Gloucester County became slippery and ice-covered. Transportation and commerce were disrupted as driving on icy roadways became extremely hazardous. This discrepancy in records can be attributed to the categorization of the event reporting, as the NCEI also reports that there have been eight other reported events that were similar to but were not categorized as ice storms. These included sleet events in 2001, 2002, and 2003; and Frost Freeze incidents in 2007. While these events had disruptive impacts in Gloucester County, there were no reported property or crop damages, according to the National Centers for Environmental Information (NOAA 2021).

FEMA Disaster Declarations

Between 1954 and 2020, FEMA declared that the State of New Jersey experienced six winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe winter storm, severe storm, snowstorm, blizzard, and ice conditions. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Gloucester was included in five of these declarations. Table 4.3.14-2 lists FEMA DR and EM declarations that included Gloucester County.

Table 4.3.14-2. FEMA Declarations for Severe Winter Weather Events in Gloucester County

FEMA Declaration Number	Date(s) of Event	FEMA Declaration Date(s)	Event Type
DR-528	February 8, 1977	February 8, 1977	Ice Conditions
EM-3106	March 13-17, 1993	March 17, 1993	Severe Blizzard
DR-1088	January 7-12, 1996	January 13, 1996	Blizzard of '96 (severe snow storm)
EM-3181	February 16-17, 2003	March 20, 2003	Snow
DR-1873	December 19-20, 2009	February 5, 2010	Winter Storm
DR-1889	February 5-6, 2010	Mar 23, 2010	Severe Winter Storm and Snowstorm

Source: FEMA 2021

U.S. Department of Agriculture Disaster Declarations

Agriculture-related winter disasters are quite common. The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. From 2015-2021, Gloucester County was not included in any USDA disaster declarations for winter storm events (USDA 2021).

Severe Winter Weather Events

The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Storm Events database records and defines severe winter storm events as follows:

- Blizzard is reported in the NOAA-NCEI database when a winter storm which produces the following conditions for 3 consecutive hours or longer: (1) sustained winds or frequent gusts 30 knots (35 mph) or greater, and (2) falling and/or blowing snow reducing visibility frequently to less than 1/4 mile.
- Heavy snow is reported in the NOAA-NCEI database whenever snow accumulation meets or exceed locally/regionally defined 12 and/or 24 hour warning criteria.
- Ice storm is reported in the NOAA-NCEI database when ice accretion meets or exceed locally/regionally defined warning criteria (typical value is 1/4 or 1/2 inch or more).

- Sleet is reported in the NOAA-NCEI database whenever sleet accumulations meet or exceed locally/regionally defined warning criteria (typical value is ½ inch or more).
- Winter storm is reported in the NOAA-NCEI database whenever a winter weather event has more than one significant hazard (i.e., heavy snow and blowing snow; snow and ice; snow and sleet; sleet and ice; or snow, sleet and ice) and meets or exceeds locally/regionally defined 12 and/or 24 hour warning criteria for at least one of the precipitation elements.

For this 2022 HMP update, winter weather events were summarized from 2015 to 2021. For information regarding severe winter weather events prior to 2015, refer to Appendix E (Supplementary Data). For detailed information on damages and impacts to each municipality, refer to Section 9 (Jurisdictional Annexes).

Table 4.3.14-3. Severe Winter Weather Events in Gloucester County, 2016-2021

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Event Details*
January 6, 2015	Winter Weather	N/A	N/A	Countywide	A quick moving Alberta Clipper, dropping southeast from Canada and through the Northern Plains, tracked across the Ohio Valley and into the Mid Atlantic by the morning of the 6th. Snow began falling across New Jersey during the morning commute before tapering off from west to east across the state through the afternoon to early evening. With temperatures mainly in the 20s and snow to liquid ratios in the 15 to 1 range for most of the area, the snow quickly accumulated and adversely affected the morning commute.
January 18, 2015	Winter Weather	N/A	N/A	Countywide	Freezing rain at the onset of a protracted precipitation event helped cause hundreds of accidents across central and northern New Jersey on the morning into the mid-afternoon of the 18th. New Jersey State Police alone responded to 428 accidents and 186 calls for assistance. A couple of accidents resulted in fatalities. There were also numerous pedestrian slip and fall accidents.
January 21, 2015	Winter Weather	N/A	N/A	Countywide	A clipper low pressure system dropped 1 to 3 inches of snow across the southern half and less than an inch across the northern half of New Jersey during the afternoon and evening on the 21st. The snow helped cause slippery traveling conditions and accidents. There were about three dozen accidents or incidents on major roadways in the southern half of the state.
January 23-24, 2015	Winter Weather	N/A	N/A	Countywide	A winter storm dropped heavy snow in Northwest New Jersey and a mixture of snow, sleet and freezing rain in the central and southwest part of New Jersey on the evening of the 23rd into the morning of the 24th. Overall less wintry precipitation (a faster switch to rain) occurred progressively farther to the south and southeast in the state.
January 26-27, 2015	Winter Weather	N/A	N/A	Countywide	A complex winter storm that buried Long Island and southern New England under heavy snow and blizzard conditions spared most of New Jersey. The state was too far west to remain under heavier wrap-around snow for a prolonged period of time and the state was not affected much by a clipper low pressure system that preceded it from the west.
February 1 - 2, 2015	Winter Weather	N/A	N/A	Countywide	A winter storm brought a heavy mixture of snow, some sleet and freezing rain to the Raritan Valley and northwest New Jersey with less of a wintry impact to the rest of central and southwest New Jersey on the first into the second. Precipitation fell as rain in the southeast part of the state throughout the event. In southwest New Jersey, the snow transitioned briefly to sleet and then rain early on the 2nd.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Event Details*
February 9-10, 2015	Winter Weather	N/A	N/A	Countywide	A protracted event of light snow, sleet and especially freezing rain caused traveling difficulties and accidents in northern and southwest New Jersey on the 8th and 9th. While precipitation occurred intermittently and amounts were overall light, untreated roadways were treacherous.
February 14-15, 2015	Winter Weather	N/A	N/A	Countywide	A vigorous cold front and a rapidly intensifying low pressure system east of the Delmarva Peninsula combined to drop 2 to 5 inches of snow across most of New Jersey (with some locally higher amounts in Ocean and Monmouth Counties) from the late morning on the 14th into the morning on the 15th.
February 16-17, 2015	Heavy Snow	N/A	N/A	Countywide	Snowfall totals primarily between 4 to 7 inches occurred across central to southern New Jersey, with mainly less than 4 inches occurring across northern New Jersey. The snow caused accidents and impacted the morning commute on the 17th.
February 21, 2015	Winter Storm	N/A	N/A	Countywide	A winter storm produced a protracted mixture of snow, sleet and freezing rain across most of New Jersey during the afternoon into the overnight of the 21st and lasted through the entire overnight in far northwest New Jersey where precipitation fell mainly as snow. Snowfall averaged 3 to 6 inches, with slightly lower amounts in the southeast part of the state.
February 26, 2015	Winter Weather	N/A	N/A	Countywide	A low pressure system that moved off the South Carolina coast brought snow into mainly southeast New Jersey on the 26th. Speed restrictions were in place on the New Jersey Turnpike and Garden State Parkway in the southern third of New Jersey.
March 1, 2015	Winter Storm	N/A	N/A	Countywide	Double barrel low pressure systems brought a winter storm to New Jersey on the 1st. A combination of snow, sleet and especially freezing rain in southern New Jersey affected the state.
March 3, 2015	Winter Weather	N/A	N/A	Countywide	An approaching warm front generated a mixture of snow, sleet and freezing rain in New Jersey during the afternoon and evening of the 3rd. The wintry mix led to hazardous conditions on non treated surfaces and many traffic accidents.
March 5, 2015	Heavy Snow	N/A	N/A	Countywide	Waves of low pressure that formed along a sinking cold front brought New Jersey heavy snow and the southern half of the state its heaviest snow of the season. Snowfall averaged 4 to 9 inches with the highest amounts in central New Jersey. Nearly all schools and universities in the state were closed on the 5th.
March 20, 2015	Winter Weather	N/A	N/A	Countywide	A winter storm on the first day of astronomical spring dropped snow across most of New Jersey on the 20th. Before precipitation ended, it transitioned to rain in the southern half of New Jersey. Snowfall averaged 3 to 7 inches from Gloucester and inland Atlantic Counties northward and two inches or less elsewhere in southern New Jersey. The snow also caused traveling difficulties and accidents during the afternoon

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Event Details*
					and evening. Speed restrictions were in place on major roadways. Some schools dismissed children early. The snow caused more than 1,150 flights to be cancelled on the 20th in the northeastern United States.
January 22-24, 2016	Winter Storm	DR-4264	Yes	Countywide	A storm impulse from the west coast developed into a nor'easter over the Carolinas, resulting in blizzard conditions to the County. A 62-year-old male from East Greenwich (Gloucester County) died from a heart attack on Saturday evening, January 23rd, while he and his wife were walking home after his car got stuck in a snowdrift just up the street from his house. The storm, known as Jonas, caused widespread power failures and flooding throughout the County. Philadelphia International Airport canceled all Saturday flights, and 155 departures and 133 arrivals scheduled for Sunday.
February 5, 2016	Winter Weather	N/A	N/A	Countywide	Precipitation associated with a low pressure system moving north along a nearby offshore front began as light rain during the evening hours on the 4th, then turned to snow during the overnight hours. Reported snowfall totals included: 3.0 inches in Williamstown, 2.8 inches in Pitman, and 1.5 inches in Washington Township.
February 15-16, 2016	Winter Weather	N/A	N/A	Countywide	Precipitation from a low pressure system moving north from the Tennessee River Valley began as snow early Monday afternoon as it ran into colder air established over the area the previous few days. A strong southerly flow associated with this low brought with it very warm air, which turned the snow over to freezing rain, then plain rain, from south to north Monday night and early Tuesday. 1.6 inches of snow was reported in Williamstown, 1.2 inches in Pittman, and 1.0 inches in Sewell. Between 0.01 and 0.05 inches of ice accumulation was reported from freezing rain.
March 3-4, 2016	Winter Storm	N/A	N/A	Countywide	A light snow began late Thursday evening and continued into the beginning of the Friday morning commute, with accumulations mainly on grassy surfaces and some slush on untreated roads. Snowfall totals include 3.0 inches in Williamstown, 2.0 inches in Deptford Township, and 1.8 inches near Pitman. By Friday afternoon, most of the snow had melted.
April 9, 2016	Winter Weather	N/A	N/A	Countywide	A vigorous upper level low pressure system, combined with unseasonably cold air, produced rain and snow showers during the daytime hours on the 9th. Most of the accumulating snow was confined to grassy surfaces, so human impact was minimal. By late in the day, precipitation had moved out of the area. 3.5 inches of snow was reported in Franklin Township, 3.0 inches in Mullica Hill, 3.0 inches in Swedesboro, and 2.0 inches in Newfield. All other reports from the county were less than 2.0 inches.
December 17, 2016	Winter Weather	N/A	N/A	Countywide	Low pressure developed to the lee of the Rockies over the Central Plains on December 16 and moved eastward to the Appalachians on December 17. A warm front moved

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Event Details*
					slowly north across New Jersey, leading to a wintry mix of precipitation during the morning hours of December 17. In Gloucester County, storm total snowfall was generally below 1.0 inches, and ice glaze amounts were generally below 0.1 inches.
January 5-6, 2017	Winter Weather	N/A	N/A	Countywide	Generally between one and two inches of snow fell from this event, with 2.0 inches in Mantua, 1.5 inches in Franklin Township, and 1.2 inches in Elk Township.
January 7, 2017	Winter Storm	N/A	N/A	Countywide	Snow began falling around dawn on January 7th, then continued heavy at times through the day before moving off the coast around sunset. Total snowfall reports ranged between 6 and 8 inches, including 7.0 inches in Pitman, 6.1 inches in Williamstown, and 6.0 inches in West Deptford. Strong winds the following day produced blowing and drifting snow.
March 10, 2017	Winter Storm	NA	N/A	Countywide	A cold frontal boundary moved through New Jersey early in the morning of the 10th. As a result, rain changed to snow. Spotters measured 2-3 inches of snow on grass in several locations throughout the days.
March 14, 2017	Winter Storm	NA	N/A	Countywide	A few inches of snow fell across the county with a sharp gradient in totals. ice accumulations were up to 1/4 inch.
December 9, 2017	Winter Weather	N/A	N/A	Countywide	Approximately three inches of snow were recorded in the coastal and southwestern sections of New Jersey following a low pressure system moving up the coast. Some mixed precipitation was recorded.
January 4, 2018	Winter Storm	N/A	N/A	Countywide	Snowfall ranged from 4 to 6 inches across the county. In other parts of the state, an emergency declaration was declared due to severe blizzard conditions.
March 2, 2018	Winter Storm	N/A	N/A	Countywide	A heavy, wet snow accumulated to a depth of up to 4 inches in the county. Some snowfall totals include 3.5 inches in South Harrison Township, 3.2 inches near Turnersville, 3.0 inches in Mantua, 2.5 inches in West Deptford, and 2.0 inches in East Greenwich Township. A wind gust of 65 MPH was reported in Washington Township at 1455EST on March 2nd.
March 6-7, 2018	Winter Storm	N/A	N/A	Countywide	Banding and thundersnow produced pockets of heavy snow in the western sections of the county, closer to the Delaware River. Further east, snow mixed with rain during parts of the event which tempered snowfall amounts. Some reported snowfall totals include: 6.5 inches in West Deptford, 6.5 inches in Sewell, 6.5 inches in Mantua, 5.5 inches in Williamstown, and 5.0 inches in Pitman.
March 21, 2018	Winter Storm	N/A	N/A	Countywide	Precipitation in Gloucester County began as rain during the evening hours on March 20th. After a lull during the overnight hours, rain mixed with snow during the morning and early afternoon hours of the 21st before changing over to all snow around noon,

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Event Details*
					falling heavy at times through the evening hours and accumulating up to 12 inches in parts of the county.
November 15, 2018	Winter Weather	N/A	N/A	Countywide	Early season Winter Storm. Total snow accumulation ranged from 4.0 in West Deptford to 0.7 in East Greenwich Township.
December 5, 2018	Winter Weather	N/A	N/A	Countywide	Localized snowfall was recorded which resulted in total snow accumulation ranging from 4.2 in Newfield to 1.2 4 WSW of Turnersville.
January 12-13, 2019	Winter Weather	N/A	N/A	Countywide	Gloucester County was struck by a weekend winter storm, yielding total snow accumulation from 4.5 in Malaga to 3.0 in Pitman.
February 10, 2019	Winter Weather	N/A	N/A	Countywide	Light snow was recorded in the southern mid-Atlantic region, which was followed by the second part of the storm that brought wintry mix and rain.
February 11, 2019	Winter Weather	N/A	N/A	Countywide	This event was the second part of a multi-day storm that impacted the region with light snow changing to a wintry mix and then to rain. Snow and ice totals were less across Delmarva than other locations farther north and west.
February 20, 2019	Winter Weather	N/A	N/A	Countywide	Mixed precipitation amounting to several inches of snow and freezing rain was recorded in the region following a complex area of low pressure. A trained spotter in West Deptford Twp reported 3.0 inches of snow. Trace amounts of ice were also reported in Washington.
March 1, 2019	Winter Weather	N/A	N/A	Countywide	Two to four inches fell over a three-hour period during a brief but intense winter weather event. A trained spotter in Washington Twp reported 2.0 inches of snow.
January 18, 2020	Winter Weather	NA	N/A	Countywide	A light mix of snow and freezing rain occurred across Gloucester County. Snowfall amounts were less than one inch, with trace amounts of icing.

Sources: FEMA 2021; NOAA-NCEI 2021; SPC 2021; NJOSC 2021; NJOEM 2019

* *Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table. No property damage or crop loss was reported by NOAA and USDA.*

DR Major Disaster Declaration (FEMA)

FEMA Federal Emergency Management Agency

Mph Miles per Hour

NCEI National Centers for Environmental Information

NJOSC New Jersey State Climatologist

NOAA National Oceanic and Atmospheric Administration

N/A Not Applicable

Probability of Future Occurrences

Severe winter weather is a common occurrence each winter season in New Jersey. The majority of the State will receive at least one measurable snow event during the winter months. The months of January, February, March, April, October, November and December are typically when a vast majority of New Jersey has been observed to receive measurable snow. Generally, counties in the northern region experience more snow events than those in the southern region. It is estimated that Gloucester County will continue to experience the direct and indirect impacts of severe winter weather events annually that many induce secondary hazards such as: structural damage (snow and ice load), wind damage, impact to life safety, disruption of traffic, loss of productivity, economic impact, loss of ability to evacuate, taxing first-responder capabilities, service disruption (power, water, etc.), and communication disruption.

Table 5.4.9-4 summarizes data regarding the probability of occurrences of severe winter weather events in Gloucester County based on the historic record. To calculate the probability, the NOAA-NCEI database was queried for all winter weather-related events in Gloucester County. Table 5.4.9-4 shows the number of occurrences and the percent chance of the event occurring in any given year. The information used to calculate the probability of occurrences is based solely on NOAA-NCEI storm events database results.

Table 4.3.14-4. Probability of Future Occurrence of Severe Winter Weather Events

Hazard Type	Number of Occurrences Between 1950 and 2021	% Chance of Occurring in Any Given Year
Blizzard	1	1.4
Ice Storm	0	0
Heavy Snow	32	45.7
Sleet	0	0
Winter Storm	25	35.7
Winter Weather	114	100
Total	**128**	**100**

Source: *NOAA-NCEI 2021*
Note: *Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected storm events since 1950. Due to limitations in data, not all severe winter weather events occurring between 1950 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.*

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Partnership, the probability of occurrence for severe winter weather in the County is considered 'frequent' (100 percent chance occurring each year, occurring multiple times a year).

Climate Change Impacts

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (ONJSC 2021) which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo 2014) and the world (1.5° F [0.8° C]) (Meyer 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date. The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation (Broccoli 2020).

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (ONJSC 2021). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh 2014) and with more intensity (Huang 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan 2014).

4.3.14.2 Vulnerability Assessment

For the severe winter weather hazard, all of Gloucester County has been identified as the hazard area. Therefore, all assets in the County (population, structures, critical facilities and lifelines), as described in the County Profile (Section 3), are vulnerable to a winter storm event. The following subsections discuss the County's vulnerability, in qualitative nature, to the severe winter weather hazard.

Impact on Life, Health and Safety

The entire population of Gloucester County (291,165 people) is exposed to severe winter weather events (ACS, 2019). According to the NOAA National Severe Storms Laboratory (NSSL); every year, winter weather indirectly and deceptively kills hundreds of people in the U.S., primarily from automobile accidents, overexertion and exposure. Winter storms are often accompanied by strong winds creating blizzard conditions with blinding wind-driven snow, drifting snow and extreme cold temperatures and dangerous wind chill. They are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. People can die in traffic accidents on icy roads, heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold (NSSL 2020).

The homeless and elderly are considered most susceptible to this hazard. The elderly are considered susceptible to this hazard due to their increased risk of injuries and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice. According to the 2019 American Community Survey 5-Year population estimate, there are 35,699 persons over 65 years old that reside in the County that are considered vulnerable to severe winter weather. In addition, severe winter storm events can reduce the ability of these populations to access emergency services.

Additionally, the homeless and residents below the poverty level may not have access to housing or their housing could be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). Residents with low incomes might not have access to housing or their housing can be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). In Gloucester County, the Township of Deptford has the highest population below the poverty level (2,021 persons). Refer to Section 3 (County Profile) that displays the distribution of low-income populations in Gloucester County.

Impact on General Building Stock

The entire general building stock inventory is exposed and vulnerable to the severe winter storm hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Table 4.3.14-5 presents the total exposure value for general building stock for each participating municipality. Current modeling tools are not available to estimate specific losses for this hazard. As an alternate approach, this plan considers percentage damages that could result from severe winter storm conditions. Table 4.3.14-5 below summarizes the estimated loss based on 1-, 5-, and 10-percent losses. Given professional knowledge and the currently available information, the potential loss for this hazard is considered to be overestimated because of varying factors (building structure type, age, load distribution, building codes in place, etc.). Therefore, the following information should be used as estimates only for planning purposes with the knowledge that the associated losses for severe winter storm events vary greatly.

Table 4.3.14-5. General Building Stock Exposure and Estimated Losses from Severe Winter Storm Events

Jurisdiction	Total Replacement Cost Value (RCV)	1-Percent Exposure/Loss	5-Percent Exposure/Loss	10-Percent Exposure/Loss
Clayton (B)	$1,933,299,905	$19,332,999	$96,664,995	$193,329,990
Deptford (Twp)	$10,081,159,584	$100,811,596	$504,057,979	$1,008,115,958
East Greenwich (Twp)	$2,927,045,409	$29,270,454	$146,352,270	$292,704,541
Elk (Twp)	$1,784,179,937	$17,841,799	$89,208,997	$178,417,994
Franklin (Twp)	$5,637,186,975	$56,371,870	$281,859,349	$563,718,697
Glassboro (B)	$5,816,332,907	$58,163,329	$290,816,645	$581,633,291
Greenwich (Twp)	$2,734,741,222	$27,347,412	$136,737,061	$273,474,122
Harrison (Twp)	$4,828,239,008	$48,282,390	$241,411,950	$482,823,901
Logan (Twp)	$6,591,573,691	$65,915,737	$329,578,685	$659,157,369
Mantua (Twp)	$4,738,271,524	$47,382,715	$236,913,576	$473,827,152
Monroe (Twp)	$8,458,118,166	$84,581,182	$422,905,908	$845,811,817
National Park (B)	$781,021,288	$7,810,213	$39,051,064	$78,102,129
Newfield (B)	$622,948,021	$6,229,480	$31,147,401	$62,294,802
Paulsboro (B)	$2,076,864,026	$20,768,640	$103,843,201	$207,686,403
Pitman (B)	$2,916,470,733	$29,164,707	$145,823,537	$291,647,073

Jurisdiction	Total Replacement Cost Value (RCV)	1-Percent Exposure/Loss	5-Percent Exposure/Loss	10-Percent Exposure/Loss
South Harrison (Twp)	$1,494,748,661	$14,947,487	$74,737,433	$149,474,866
Swedesboro (B)	$936,236,069	$9,362,361	$46,811,803	$93,623,607
Washington (Twp)	$13,732,374,547	$137,323,745	$686,618,727	$1,373,237,455
Wenonah (B)	$778,702,966	$7,787,030	$38,935,148	$77,870,297
West Deptford (Twp)	$9,201,121,261	$92,011,213	$460,056,063	$920,112,126
Westville (B)	$1,529,846,612	$15,298,466	$76,492,331	$152,984,661
Woodbury (C)	$4,139,381,075	$41,393,811	$206,969,054	$413,938,107
Woodbury Heights (B)	$1,265,332,236	$12,653,322	$63,266,612	$126,533,224
Woolwich (Twp)	$4,551,585,778	$45,515,858	$227,579,289	$455,158,578
Gloucester County (Total)	$99,556,781,602	$995,567,816	$4,977,839,080	$9,955,678,160

Source: Gloucester County 2021; RS Means 2021

A specific area that is vulnerable to the severe winter storm hazard is the floodplain. Severe winter storms can cause flooding through blockage of streams or through snow melt. At-risk residential infrastructures are presented in the flood hazard profile (Section 4.3.7). Generally, losses resulting from flooding associated with severe winter storms should be less than that associated with a 100-year flood. Please refer to the Hurricanes and Tropical Storms (Section 4.3.10) profile and Nor'Easter (Section 4.3.12) profile for losses resulting from high winds which may also accompany severe winter weather.

Impact on Critical Facilities

Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL 2020).

Full functionality of critical facilities such as police, fire and medical facilities is essential for response during and after a severe winter storm event. These critical facility structures are largely constructed of concrete and masonry; therefore, they should only suffer minimal structural damage from severe winter storm events. Because power interruption can occur, backup power is recommended. Infrastructure at risk for this hazard includes roadways that could be damaged due to the application of salt and intermittent freezing and warming conditions that can damage roads over time. Severe snowfall requires the clearing roadways and alerting citizens to dangerous conditions; following the winter season, resources for road maintenance and repair are required (NSSL 2020).

Impact on Economy

Heavy accumulations of ice can bring down trees and power lines, disabling electric power and communications for days or weeks. Heavy snow can immobilize a region and paralyze a city, shutting down all air and rail transportation and disrupting medical and emergency services. Storms near the coast can cause coastal flooding and beach erosion as well as sink ships at sea. The economic impact of winter weather each year is huge, with costs for snow removal, damage and loss of business in the millions (NOAA 2021).

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. Another impact on the economy includes impacts on commuting into, or out of, the area for work or school. The loss of power and closure of roads prevents the commuter population traveling to work within and outside of the County.

Impact on the Environment

Severe winter weather can have a major impact on the environment. Not only does winter weather create changes in natural processes, the residual impacts of a community's methods to maintain its infrastructure through winter weather maintenance may also have an impact on the environment. For example, an excess amount of snowfall and earlier warming periods may affect natural processes such as flow within water resources (USGS 2020). Rain-on-snow events can also exacerbate runoff rates with warming winter weather. Consequentially, these flow rates and excess volumes of water can erode banks, tear apart habitat along the banks and coastline, and disrupt terrestrial plants and animals. Road-salt runoff can cause groundwater salinization, modify the soil structure, and result in loss or reduction in lake turnover. Additionally, road salt can cause changes in the composition of aquatic invertebrate assemblages and pose threats to birds, roadside vegetation, and mammals (Tiwari and Rachlin).

> Chemically based winter maintenance practices have its own effect on the natural environment. Melting snow and ice that carry de-icing chemicals onto vegetation and into soils can contaminate the local waterways. Elevated salt levels may hinder vegetation from absorbing nutrients, slowing plant growth.

Future Changes That May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Project Development

As discussed in Sections 3 and 9, areas targeted for future growth and development have been identified across Gloucester County. Any areas of growth could be potentially impacted by the severe winter storm hazard because the entire planning area is exposed and vulnerable. Any areas of growth could be potentially impacted by the severe winter weather hazard because the entire County is exposed and vulnerable. However, due to increased standards and codes, new development may be less vulnerable to the severe winter weather hazard compared with the aging building stock in the County.

Projected Changes in Population

Between 2010 and 2019, the County's population increased by about 1 percent., a trend that is expected to continue. Overall, aging infrastructure may result in increased stress on existing infrastructure and related services. Municipalities that experience increases in population may require utility system upgrades to keep up with utility demands (e.g., water, electric) during winter weather events to prevent increased stresses on these systems. Refer to Section 3 (County Profile) for a detailed discussion on population change in Gloucester County.

Climate Change

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such winter storms. While predicting changes of winter storm events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA] 2016).

Both northern and southern New Jersey have become wetter over the past century. Northern New Jersey's 1971-2000 precipitation average was over five inches (12 percent) greater than the average from 1895-1970. Southern New Jersey became two inches (5 percent) wetter late in the 20th century (Office of New Jersey State Climatologist). Average annual precipitation is projected to increase in the region by 5 percent by the 2020s and up to 10 percent by the 2050s. Most of the additional precipitation is expected to come during the winter months (New York City Panel on Climate Change [NPCC] 2009).

In terms of snowfall and ice storms in New Jersey, there is a lack of quantitative data to predict how future climate change will affect this hazard. It is likely that the number of winter weather events may decrease, and the winter weather season may shorten; however, it is also possible that the intensity of winter storms may increase. The exact effect on winter weather is still highly uncertain (Sustainable Jersey Climate Change Adaptation Task Force 2013). Future enhancements in climate modeling will provide an improved understanding of how the climate will change and impact the Northeast.

Change of Vulnerability Since 2016 HMP

Overall, the County's exposure and vulnerability have not changed, and the entire County will continue to be exposed and vulnerable to severe winter storm events.

4.3.15 Wildfire

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the wildfire hazard in Gloucester County.

2022 HMP Update Changes

- Previous occurrences were updated with events that occurred between 2015 and 2021.
- A vulnerability assessment was conducted for the wildfire hazard; it now directly follows the hazard profile. To determine exposure, a spatial analysis was conducted using the NJFFS Fuel Hazard Area guidelines.

4.3.15.1 Profile

Hazard Description

A wildland fire can be defined as any non-structural fire that occurs in the wildland. Three distinct types of wildland fires have been defined and include: naturally occurring wildfire, human-caused wildfire, and prescribed fire. Many of these are highly destructive and can be difficult to control. They occur in forested, semi-forested, or less developed areas. Wildland fires can be caused by lightning, human carelessness, and arson. Most frequently, wildland fires in the State of New Jersey are caused by humans. Wildfires result in the uncontrolled destruction of forests, brush, field crops, grasslands, real estate, and personal property, and have secondary impacts on other hazards such as flooding, by removing vegetation and destroying watersheds.

Wildfires can increase the probability of other natural disasters, specifically floods and mudflows. Wildfires, particular large-scale fires, can dramatically alter the terrain and ground conditions, making land already devastated by fire susceptible to floods. Lands impacted by wildfire increase the risk of flooding and mudflow in those areas impacted by wildfire. Normally, vegetation absorbs rainfall, reducing runoff. However, wildfires leave the ground charred, barren, and unable to absorb water; thus, creating conditions perfect for flash flooding and mudflows. Flood risk in these impacted areas remain significantly higher until vegetation is restored, which can take up to five years after a wildfire (FEMA 2013).

Flooding after a wildfire is often more severe, as debris and ash left from the fire can form mudflows. During and after a rain event, as water moves across charred and denuded ground, it can also pick up soil and sediment and carry it in a stream of floodwaters. These mudflows have the potential to cause significant damage to impacted areas. Areas directly affected by fires and those located below or downstream of burn areas are most at risk for flooding (FEMA 2013). For detailed information regarding flooding, see Section 4.3.7 (Flood).

The height of wildland fire season in New Jersey is typically in spring (March through May) and culminates in early May, corresponding with the driest live fuel moisture periods of the year. Although the spring months are the most severe, the summer and fall months may also experience extensive fires in the state. While the spring season is historically the period in which wildfire danger is the highest, wildland fires can occur every month of the year. Drought, snow pack, and local weather conditions can expand the length of the fire season. The early and late shoulders of the fire season usually are associated with human-caused fires. Lightning generally is the cause of most fires in the peak season.

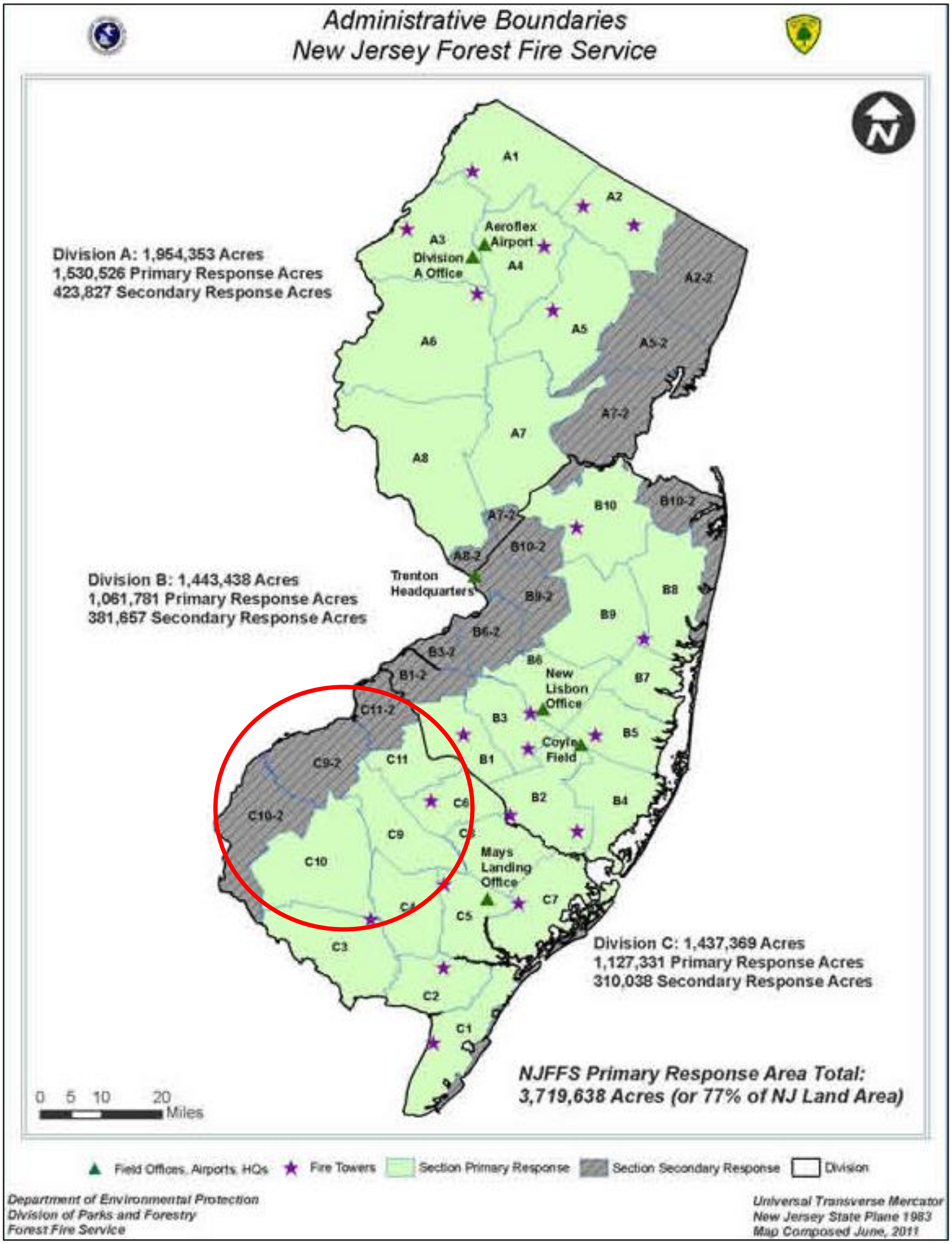
Location

According to the U.S. Fire Administration (USFA), the fire problem in the U.S. varies from region to region. This often is a result of climate, poverty, education, demographics, and other causal factors (USFA 2021). In Gloucester County, wildfires have the potential to occur anywhere in the County.

NJFFS, a division of the New Jersey Department of Environmental Protection (NJDEP), is responsible for protecting the 3.25 million acres of wildland in the State. NJFFS is under the direction of the State fire warden and is headquartered in Trenton. NJFFS has 85 full-time employees that provide an array of services including staffing the State's 21 fire towers, which are operational during the months of March, April, May, October, and November.

NJFFS divides the State into three regions (Northern, Central, Southern) each totaling about 1,250,000 acres. There are 29 125,000 acre sections with a dedicated forest fire warden in each; and 269 districts each consisting of 15,000-20,000 acres In total, 29 section forest fire wardens, 269 district forest fire wardens and 2,000 trained crew members respond to fires on an as-needed basis (NJFFS 2015). Figure 4.3.15-1 illustrates the NJFFS region divisions within the State. Gloucester County is located in Division C (Southern NJ).

Figure 4.3.15-1. Fire Divisions of New Jersey



Source: *NJDEP 2015*

Note: *The red circle indicates the location of Gloucester County. The County is located in Fire Division C.*

Wildfire Fuel Hazard Areas

NJFFS developed Wildfire Fuel Hazard data for the entire state based on NJDEP data. For details on the information was developed, refer to: https://www.state.nj.us/dep/gis/njfh.html. A majority of Gloucester County has low fuel hazard and low risk; refer to Figure 4.3.15-2. Every municipality in Gloucester County has at least a small portion of the community located within the high to extreme risk area, with Township of Monroe having largest percentage of land within the high to extreme risk area (20.5 percent). Table 4.3.15-1 summarizes the amount of land in each of the wildfire fuel hazard ranking zones for Gloucester County. Table 4.3.15-2 summarizes the approximate area in the NJFFS risk areas in the County.

Table 4.3.15-1. Area in the Wildfire Fuel Hazard Ranking Zones in Gloucester County

Hazard Area	Area (Square Miles)
Extreme	12.2
Very High	19.8
High	5.2

Source: NJDEP 2009

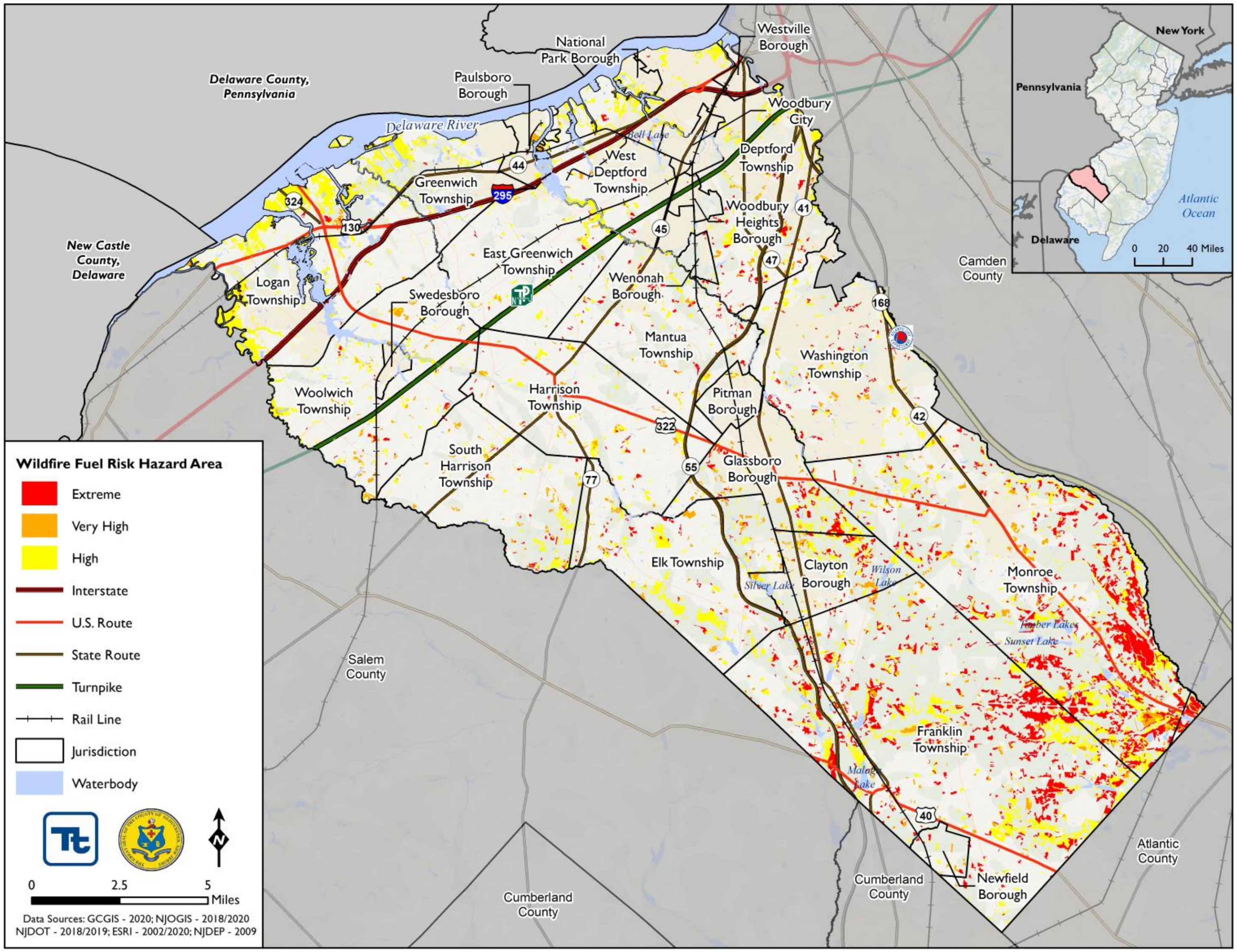
Table 4.3.15-2. Approximate Area in Wildfire Fuel Hazard Ranking Zones in Gloucester County

Municipality	Total Area (Square Miles)	New Jersey Forest Fire Service Risk Areas	
		High to Extreme (Square Miles)	Percent in Hazard Area
Clayton Borough	7.3	1.1	15.7%
Deptford Township	17.6	1.7	9.5%
East Greenwich Township	14.9	0.6	4.3%
Elk Township	19.3	1.8	9.2%
Franklin Township	56.4	9.0	15.9%
Glassboro Borough	9.4	1.1	11.3%
Greenwich Township	9.3	1.0	11.0%
Harrison Township	19.0	0.8	4.1%
Logan Township	22.1	3.9	17.7%
Mantua Township	16.1	0.9	5.4%
Monroe Township	46.9	9.6	20.5%
National Park Borough	1.0	0.2	17.7%
Newfield Borough	1.7	0.1	6.4%
Paulsboro Borough	2.1	0.2	9.4%
Pitman Borough	2.3	0.0	1.9%
South Harrison Township	16.0	0.9	5.8%
Swedesboro Borough	0.8	0.0	2.0%
Washington Township	21.5	1.0	4.7%
Wenonah Borough	1.0	0.1	5.4%
West Deptford Township	15.7	1.7	10.7%
Westville Borough	1.1	0.1	5.9%

Municipality	Total Area (Square Miles)	New Jersey Forest Fire Service Risk Areas High to Extreme (Square Miles)	Percent in Hazard Area
Woodbury City	2.1	0.0	1.3%
Woodbury Heights Borough	1.3	0.0	1.3%
Woolwich Township	21.4	1.4	6.3%
Gloucester County Total	**326.2**	**37.2**	**11.4%**

Source: NJDEP 2009

Figure 4.3.15-2. Wildfire Fuel Hazard for Gloucester County



New Jersey Pinelands

The southeastern corner of Gloucester County is located in the New Jersey Pinelands National Reserve. The New Jersey Pinelands is a fire-adapted forest ecosystem that depends on wildfire for reproduction and the control of fuel buildup. This forest community is one of the most hazardous wildland fuel types in the nation. Pinelands fires burn extremely hot and spread rapidly. New Jersey has a high population density and more people are moving from urban areas to build homes in rural wildland areas. With more people living in and enjoying the State's wildlands for various forms of recreation, the number of potential fire starts and the seriousness of their consequences increases. A potentially explosive combination is created when hazardous wildland fuels, home development, and an increased risk of human-caused ignition come together under extreme fire weather conditions (NJOEM 2019)

The New Jersey Pine Barrens are characterized by low, dense forests of pine and oak, ribbons of cedar and hardwood swamps bordering drainage courses, pitch pine lowlands, and bogs and marshes combined to produce an expansive vegetative mosaic unsurpassed in the northeastern United States. The Pine Barrens was recognized as a nationally and internationally important ecological region when, in 1978, Congress created the Pinelands National Reserve, the United States' first National Reserve and a United States Biosphere Reserve of the Man and the Biosphere Program. The Pinelands National Reserve encompasses approximately 1.1 million acres statewide, occupying 22-percent of New Jersey's land area and covering portions of seven counties and all or parts of 56 municipalities. It is the largest area of open space on the Mid-Atlantic seaboard between Richmond and Boston, and is underlain by aquifers containing 17 trillion gallons of some of the purest water in the region. Through the creation of the Pinelands Commission, the State of New Jersey formed the necessary partnerships to preserve, protect, and enhance the natural and cultural resources of the Pinelands. The Commission oversees many development and management decisions within the Pinelands National Reserve (NJDEP 2021).

Extent

The extent (that is, magnitude or severity) of wildfires depends on weather (dryness/drought) and human activity. To determine the potential for wildfires, the NJFFS uses two indices to measure and monitor the dryness of forest fuels and the possibility of fire ignitions becoming wildfires. This includes the National Fire Danger Rating Systems Buildup Index and the Keetch-Byram Drought Index. Both are used for fire preparedness planning, which includes the following initiatives: campfire and burning restrictions, fire patrol assignments, staffing of fire lookout towers, and readiness status for both observation and firefighting aircraft.

- The ***Buildup Index*** is a number that reflects the combined cumulative effects of daily drying and precipitation fuels with a 10-day time lag constant. It is a rating of the total amount of fuel available for combustion.
- The ***Keetch-Byram Drought Index*** (KBDI) is an index used to determining forest fire potential. The drought index is based on a daily water balance, where a drought factor is balanced with precipitation

and soil moisture (assumed to have a maximum storage capacity of 8-inches) and is expressed in hundredths of an inch of soil moisture depletion.

In addition to the two indices, the NJFFS uses the National Fire Danger Rating System (NFDRS) to provide a measure of relative seriousness of burning conditions and threat of fire in the State. It allows the NJFFS to estimate the daily fire danger for a given area. The NFDRS uses a five-color coded system to help the public understand fire potential. The NJFFS slightly adapted the color system for their purposes. The NFDRS, with the NFFS color scheme, is as follows:

Table 4.3.15-3. Fire Danger Rating and Color Code

Fire Danger Rating and Color Code	Description
Low (L) (Green)	Fuels do not ignite readily from small firebrands although a more intense heat source, such as lightning, may start fires in duff or punky wood. Fires in open cured grasslands may burn freely a few hours after rain, but woods fires spread slowly by creeping or smoldering, and burn in irregular fingers. There is little danger of spotting.
Moderate (M) (Blue)	Fires can start from most accidental causes, but with the exception of lightning fires in some areas, the number of starts is generally low. Fires in open-cured grasslands will burn briskly and spread rapidly on windy days. Timber fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel, especially draped fuel, may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and control is relatively easy.
High (H) (Yellow)	All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High-intensity burning may develop on slopes or in concentrations of fine fuels. Fires may become serious and their control difficult unless they are attacked successfully while small.
Very High (VH) (Orange)	Fires start easily from all causes and, immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high-intensity characteristics such as long-distance spotting and fire whirlwinds when they burn into heavier fuels.
Extreme (E) (Red)	Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious. Development into high-intensity burning will usually be faster and occur from smaller fires than in the very high fire danger class. Direct attack is rarely possible and may be dangerous except immediately after ignition. Fires that develop headway in heavy slash (trunks, branches, and tree tops) or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions the only effective and safe control action is on the flanks until the weather changes or the fuel supply lessens.

Source: NJFFS 2020

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with flooding throughout Gloucester County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events may vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2021, New Jersey was included in two FEMA fire management assistance (FMA) declarations. Generally, these disasters cover a wide range of the State; therefore, the disaster may have impacted many counties. Gloucester County was not included in either FEMA FMA declaration (FEMA 2021).

U.S. Department of Agriculture Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2015 and 2021, Gloucester County was not included in any USDA disaster declarations related to wildfire (USDA 2021).

Wildfire Events

Major wildfire events that have impacted Gloucester County between 2015 and 2021 are identified in Table 4.3.15-4. With wildfire documentation for New Jersey and Gloucester County being so extensive, not all sources have been identified or researched. Therefore, Table 4.3.15-4 may not include all events that have occurred in the County. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

Table 4.3.15-4. Wildfire Events in Gloucester County, 2015 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
January 16, 2019	Wildfire	N/A	N/A	Clayton Borough	Firefighters battled a 30-acre forest fire in the Glassboro Wildlife Management Area. Six trucks and a dozen firefighters were on scene.

Source: FEMA 2021; NOAA-NCEI 2021; NJOEM 2019, NJ.com 2019
Note: Not all events that have occurred in Gloucester County are included due to the extent of documentation and the fact that not all sources have been identified or researched.
K: Thousand
DR Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
Mph miles per hour
N/A Not Applicable

Probability of Future Occurrences

Estimating the approximate number of wildfires to occur in Gloucester County is difficult to predict in a probabilistic manner. This is because a number of variable factors impact the potential for a fire to occur and because some conditions (for example, ongoing land use development patterns, location, fuel sources, and construction sites) exert increasing pressure on the WUI zone. Based on available data, urban fires and wildfires will continue to present a risk to Gloucester County. Given the numerous factors that can impact urban fire and wildfire potential, the likelihood of a fire event starting and sustaining itself should be gauged by professional fire managers on a daily basis.

According to the NOAA, Gloucester County experienced 8 severe wildfire events between 1950 and 2021. The table below shows these statistics, as well as the annual average number of events and the percent chance of the wildfire occurring in Gloucester County in future years (NOAA NCEI 2021).

Table 4.3.15-5. Probability of Future Occurrence of Wildfire Events

Hazard Type	Number of Occurrences Between 1950 and 2021	Percent chance of occurrence in any given year
Wildfire	8	11.11

Source: NOAA-NCEI 2021

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for wildfire in the county is considered 'occasional' (between 10 and 100 percent annual probability of a hazard event occurring., as presented in Table 4.4-1). The ranking of the wildfire hazard for individual municipalities is presented in the jurisdictional annexes.

Climate Change Impacts

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New

Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011).

A gradual change in temperatures will alter the growing environment of many tree species throughout the United States and New Jersey, reducing the growth of some trees and increasing the growth of others. Tree growth and regeneration may be affected more by extreme weather events and climatic conditions than by gradual changes in temperature or precipitation. Warmer temperatures may lead to longer dry seasons and multi-year droughts, creating triggers for wildfires, insects, and invasive species. Increased temperature and change in precipitation will also affect fuel moisture during wildfire season and the length of time during while wildfires can burn during a given year (U.S. Department of Agriculture [USDA] 2012). Climate change may also increase the frequency of lightning strikes. A warmer atmosphere holds more moisture which is one of the key items for triggering a lightning strike. Lightning strikes cause approximately half the wildfires in the United States. If the frequency of lightning strikes increases, the potential for wildfires from these strikes also increases (Lee 2014). Wildfire incidents are predicted to increase throughout the United States due to climate change, causing at least a doubling of areas burned within the next century (USDA 2012).

As stated above, according to the temperature projections for Northern New Jersey, including Gloucester County, this area can expect warmer and drier conditions which may increase the frequency and intensity of wildfires. Higher temperatures are expected to increase the amount of moisture that evaporates from land and water. These changes have the potential to lead to more frequent and severe droughts, which, in turn, increases the likelihood of wildfires (U.S. EPA 2009).

4.3.15.2 Vulnerability Assessment

A spatial analysis was conducted using the 2009 NJDEP Wildfire Fuel Hazard spatial layer. For the purposes of the assessment, an asset (population, structures, critical facilities, and lifelines) is considered exposed and potentially vulnerable to the wildfire hazard if it is located in the 'extreme', 'very high' and 'high' wildfire fuel hazard areas. Refer to Section 4.2 for additional details on the methodology used to assess wildfire risk.

Impact on Life, Health, and Safety

Wildfires have the potential to impact human health and life of residents and responders, structures, infrastructure, and natural resources. The most vulnerable populations include emergency responders and those within a short distance of the interface between the built environment and the wildland environment. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. Table 4.3.15-6 summarizes the estimated population exposed to the wildfire hazard by municipality.

Based on the analysis, an estimated 3,786 residents, or 1.3-percent of the County's population, are located in the extreme, high, and very high wildfire hazard areas. Overall, the Township of Monroe has the greatest number of individuals located in the extreme, very high, and high hazard areas (i.e., 525 persons) and the Township of Harrison has the greatest proportion of its population exposed to the extreme, very high, and high hazard areas (i.e., 7.0-percent).

Of the population exposed, the most vulnerable include the economically disadvantaged and the population over age 65. In Gloucester County, there are 21,340 persons living below the poverty level and 44,794 persons over 65 years old. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on net economic impacts on their families. The population over age 65 is also more vulnerable because they are more likely to seek or need medical attention that may not be available due to isolation during a wildfire event, and they may have more difficulty evacuating.

Table 4.3.15-6 Population in Wildfire Fuel Hazard Areas

Jurisdiction	Total Population (American Community Survey 2015-2019)	Estimated Population Located Within the High, Very High, and Extreme Wildfire Fuel Hazard Area	
		Number of People	Percent of Total
Clayton (B)	8,626	186	2.2%
Deptford (Twp)	30,448	294	1.0%
East Greenwich (Twp)	10,488	113	1.1%
Elk (Twp)	4,135	93	2.2%
Franklin (Twp)	16,440	323	2.0%
Glassboro (B)	19,826	190	1.0%
Greenwich (Twp)	4,831	0	0.0%
Harrison (Twp)	12,995	536	4.1%
Logan (Twp)	5,924	20	0.3%
Mantua (Twp)	14,941	213	1.4%
Monroe (Twp)	36,789	1,111	3.0%
National Park (B)	2,959	0	0.0%
Newfield (B)	1,521	16	1.0%
Paulsboro (B)	5,904	0	0.0%
Pitman (B)	8,805	0	0.0%
South Harrison (Twp)	3,148	57	1.8%
Swedesboro (B)	2,579	0	0.0%
Washington (Twp)	47,833	64	0.1%
Wenonah (B)	2,259	13	0.6%
West Deptford (Twp)	21,149	363	1.7%
Westville (B)	4,169	0	0.0%
Woodbury (C)	9,861	0	0.0%
Woodbury Heights (B)	2,986	3	0.1%
Woolwich (Twp)	12,549	192	1.5%
Gloucester County (Total)	**291,165**	**3,786**	**1.3%**

Source: American Community Survey 2019 5-year estimates; NJDEP 2009
Note: B – Borough; T – Town; Twp – Township; -percent - Percent

Impact on General Building Stock

Buildings located within the NJDEP identified extreme, very high or high fuel hazard areas are exposed and considered vulnerable to the wildfire hazard. Buildings constructed of wood or vinyl siding are generally more likely to be impacted by the fire hazard than buildings constructed of brick or concrete. Table 4.3.15-7 summarizes the estimated building stock inventory located in the hazard area by municipality. Approximately 1.2-percent ($1.2 billion) of the County's building replacement cost value is located in the extreme/very high/high hazard area. The Township of Monroe has the greatest number of buildings located in the wildfire hazard area (396 structures – 3.2-percent of its total), and the Township of Harrison has the greatest proportion of its buildings located in the wildfire hazard area (i.e., 3.8-percent).

Table 4.3.15-7 Probability of Future Occurrence of Wildfire Events

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located Within the High, Very High, and Extreme Wildfire Fuel Hazard Area			
			Number of Buildings Within the Wildfire Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located Within the Wildfire Hazard Area	Percent of Total
Clayton (B)	3,295	$1,933,299,905	69	2.1%	$36,950,955	1.9%
Deptford (Twp)	11,284	$10,081,159,584	106	0.9%	$99,913,254	1.0%
East Greenwich (Twp)	4,346	$2,927,045,409	45	1.0%	$31,716,695	1.1%
Elk (Twp)	2,339	$1,784,179,937	43	1.8%	$27,127,980	1.5%
Franklin (Twp)	8,432	$5,637,186,975	153	1.8%	$134,584,008	2.4%
Glassboro (B)	5,959	$5,816,332,907	57	1.0%	$45,705,518	0.8%
Greenwich (Twp)	2,807	$2,734,741,222	0	0.0%	$0	0.0%
Harrison (Twp)	4,817	$4,828,239,008	183	3.8%	$118,169,500	2.4%
Logan (Twp)	2,805	$6,591,573,691	12	0.4%	$18,773,825	0.3%
Mantua (Twp)	6,569	$4,738,271,524	97	1.5%	$121,883,512	2.6%
Monroe (Twp)	12,553	$8,458,118,166	396	3.2%	$256,546,997	3.0%
National Park (B)	1,483	$781,021,288	1	0.1%	$3,782,219	0.5%
Newfield (B)	891	$622,948,021	8	0.9%	$7,241,163	1.2%
Paulsboro (B)	2,615	$2,076,864,026	1	0.0%	$58,794	0.0%
Pitman (B)	3,521	$2,916,470,733	0	0.0%	$0	0.0%
South Harrison (Twp)	1,726	$1,494,748,661	25	1.4%	$29,727,010	2.0%
Swedesboro (B)	1,040	$936,236,069	0	0.0%	$0	0.0%
Washington (Twp)	17,413	$13,732,374,547	47	0.3%	$88,986,922	0.6%
Wenonah (B)	930	$778,702,966	5	0.5%	$6,697,034	0.9%
West Deptford (Twp)	7,561	$9,201,121,261	114	1.5%	$99,638,733	1.1%
Westville (B)	1,733	$1,529,846,612	0	0.0%	$0	0.0%
Woodbury (C)	3,605	$4,139,381,075	1	0.0%	$2,205,856	0.1%
Woodbury Heights (B)	1,295	$1,265,332,236	1	0.1%	$716,136	0.1%
Woolwich (Twp)	4,074	$4,551,585,778	60	1.5%	$75,203,332	1.7%
Gloucester County (Total)	**113,093**	**$99,556,781,602**	**1,424**	**1.3%**	**$1,205,629,442**	**1.2%**

Source: Gloucester County GIS 2020; RS Means 2020; NJDEP 2009
Note: B – Borough; T – Town; Twp – Township; -percent - Percent

Impact on Critical Facilities

In Gloucester County, there are 18 critical facilities and lifelines located in the wildfire hazard area. The Borough of Glassboro has the greatest number of facilities located in the wildfire fuel hazard areas. Refer to Table 4.3.15-8 which summarizes the number of exposed critical facilities and lifelines by jurisdiction.

Additionally, Table 4.3.15-9 summarizes the distribution of critical facilities exposed to the wildfire fuel hazard area by facility type. There are six hazardous materials facilities and eight safety and security lifelines located in the wildfire fuel hazard area; refer to Table 4.3.15-10.

Table 4.3.15-8. Estimated Number of Critical Facilities and Lifelines Located in the Wildfire Fuel Hazard Area

Jurisdiction	(Total) Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Located in the High, Very High, Extreme Wildfire Fuel Hazard Areas			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Clayton (B)	25	25	0	0.0%	0	0.0%
Deptford (Twp)	79	77	2	2.5%	2	2.6%
East Greenwich (Twp)	46	46	1	2.2%	1	2.2%
Elk (Twp)	6	6	0	0.0%	0	0.0%
Franklin (Twp)	35	35	1	2.9%	1	2.9%
Glassboro (B)	137	137	4	2.9%	4	2.9%
Greenwich (Twp)	31	31	0	0.0%	0	0.0%
Harrison (Twp)	26	26	1	3.8%	1	3.8%
Logan (Twp)	50	50	0	0.0%	0	0.0%
Mantua (Twp)	30	30	0	0.0%	0	0.0%
Monroe (Twp)	29	26	1	3.4%	1	3.8%
National Park (B)	41	41	0	0.0%	0	0.0%
Newfield (B)	9	9	1	11.1%	1	11.1%
Paulsboro (B)	29	29	0	0.0%	0	0.0%
Pitman (B)	19	19	1	5.3%	1	5.3%
South Harrison (Twp)	12	12	0	0.0%	0	0.0%
Swedesboro (B)	9	9	0	0.0%	0	0.0%
Washington (Twp)	75	75	3	4.0%	3	4.0%
Wenonah (B)	4	4	0	0.0%	0	0.0%
West Deptford (Twp)	157	149	2	1.3%	2	1.3%
Westville (B)	23	21	0	0.0%	0	0.0%
Woodbury (C)	59	59	0	0.0%	0	0.0%
Woodbury Heights (B)	9	9	0	0.0%	0	0.0%
Woolwich (Twp)	16	16	1	6.3%	1	6.3%
Gloucester County (Total)	**956**	**941**	**18**	**1.9%**	**18**	**1.9%**

Source: Gloucester County GIS 2020; NJDEP 2009
Note: B – Borough; C – City; Twp – Township; -percent - Percent

Table 4.3.15-9. Distribution of Critical Facilities Exposed to the Wildfire Fuel Hazard Area

Jurisdiction	Number of Critical Facilities Located in the High, Very High, and Extreme Wildfire Fuel Hazard Area								
	Assisted Living	Board of Education	EMS	Hazardous Material Facility	Municipal Building	Post-Secondary Education	Potable Water Well	Primary Education	Wastewater Metering Station
Clayton (B)	0	0	0	0	0	0	0	0	0
Deptford (Twp)	0	0	0	0	1	0	0	1	0
East Greenwich (Twp)	0	0	0	1	0	0	0	0	0
Elk (Twp)	0	0	0	0	0	0	0	0	0
Franklin (Twp)	0	0	0	1	0	0	0	0	0
Glassboro (B)	0	0	0	0	0	3	1	0	0
Greenwich (Twp)	0	0	0	0	0	0	0	0	0
Harrison (Twp)	0	0	0	1	0	0	0	0	0
Logan (Twp)	0	0	0	0	0	0	0	0	0
Mantua (Twp)	0	0	0	0	0	0	0	0	0
Monroe (Twp)	0	0	1	0	0	0	0	0	0
National Park (B)	0	0	0	0	0	0	0	0	0
Newfield (B)	0	1	0	0	0	0	0	0	0
Paulsboro (B)	0	0	0	0	0	0	0	0	0
Pitman (B)	0	0	0	0	0	0	0	0	1
South Harrison (Twp)	0	0	0	0	0	0	0	0	0
Swedesboro (B)	0	0	0	0	0	0	0	0	0
Washington (Twp)	1	1	0	0	0	0	0	1	0
Wenonah (B)	0	0	0	0	0	0	0	0	0
West Deptford (Twp)	0	0	0	2	0	0	0	0	0
Westville (B)	0	0	0	0	0	0	0	0	0
Woodbury (C)	0	0	0	0	0	0	0	0	0
Woodbury Heights (B)	0	0	0	0	0	0	0	0	0
Woolwich (Twp)	0	0	0	1	0	0	0	0	0
Gloucester County (Total)	**1**	**2**	**1**	**6**	**1**	**3**	**1**	**2**	**1**

Source: Gloucester County GIS 2020; NJDEP 2009
Note: B – Borough; C – City; T – Town; Twp – Township

Table 4.3.15-10. Estimated Number of Lifelines Categorized by FEMA Lifeline Categories Exposed to the Wildfire Fuel Hazard Area

FEMA Lifeline Category	Total Number of Lifelines in the County	Number of Lifelines Located in the High, Very High, and Extreme Wildfire Fuel Hazard Area
Energy	5	0
Food, Water, Shelter	214	2
Hazardous Materials	116	6
Health and Medical	102	2
Safety and Security	481	8
Transportation	23	0

FEMA Lifeline Category	Total Number of Lifelines in the County	Number of Lifelines Located in the High, Very High, and Extreme Wildfire Fuel Hazard Area
Gloucester County (Total)	**956**	**18**

Source: Gloucester County GIS 2020; NJDEP 2009; FEMA 2020

As mentioned previously, wildfires can have an impact on the water supplies throughout the County because of residual pollutants like char or debris landing in water resources which can clog wastewater pipes, culverts, etc. Wildfires may also impact transportation routes, blocking residents and commuters from getting in and out of the County during a wildfire event because of char and debris polluting the air making it difficult to drive, or the flames having close proximity to the roadways making the route an unsafe passageway. Table 4.3.15-11 summarizes the number of miles roadways are built in the wildfire fuel hazard areas; a total of 1.2-percent. In general, roads and bridges surrounding the areas of fire risk are important because they provide ingress and egress to large areas and, in some cases, to isolated neighborhoods. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers

Table 4.3.15-11. Major Transportation Routes Exposed to the Wildfire Fuel Hazard Areas

Road Type	Total Miles for County	Roadway Miles Exposed to the Wildfire Hazard Areas	
		Miles	Percent of Total
Turnpike	36	0	0.0%
State Routes	124	2	1.6%
US Highways	60	1	1.6%
Interstate	34	0	0.0%
Gloucester County (Total)	**254**	**3**	**1.2%**

Source: Gloucester County GIS 2020; NJDEP 2009, NJDOT 2019

Impact on the Economy

Wildfire events can have major economic impacts on a community from the initial loss of structures and the subsequent loss of revenue from destroyed business. These events may cost thousands of taxpayer dollars to suppress and control and may involve hundreds of operating hours on fire apparatus and thousands of volunteer man hours from the volunteer firefighters. There are also many direct and indirect costs to local businesses that excuse volunteers from working to fight these fires.

Impact on the Environment

According to the USGS, post-fire runoff polluted with debris and contaminates can be extremely harmful to ecosystem and aquatic life (USGS 2018). Studies show that urban fires in particular are more harmful to the environment compared to forest fires (USGS 2018). The age and density of infrastructure within Gloucester County can exacerbate consequences of fires on the environment because of the increased amount of chemicals and contaminates that would be released from burning infrastructure. These chemicals, such as iron lead, and zinc, may leach into the storm water, contaminate nearby streams, and impair aquatic life.

Future Changes That May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. Changes in the natural environment and built environment and how they interact can also provide insight about ways to plan for the future.

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. Any changes in development can impact the County's risk to the wildfire hazard of concern. Therefore, the County should implement wildfire management strategies in existing building code to protect structures against the residual impacts from wildfire such as heat, debris, and char. Furthermore, development should be built with access to transit routes that will enable easier evacuation during a wildfire event.

Projected Changes in Population

According to the 2019 5-year population estimates from the American Community Survey, the population of Gloucester County (i.e., 291,165 persons) has increased by approximately 0.9-percent since 2010. Any changes in the density of population can impact the number of persons exposed to the wildfire hazard. Fire suppression capabilities are high at the State and local levels. However, new development and changes in population with a mix of additional structures, ornamental vegetation, and wildland fuels will require continued assessment of the hazard and mitigation risk.

Climate Change

According to the USDA Forest Service, climate change will likely alter the atmospheric patterns that affect fire weather. Changes in fire patterns will, in turn, impact carbon cycling, forest structure, and species composition (EPA 2020). Climate change associated with warmer temperatures, changes in rainfall, and increased periods of drought may create an atmospheric and fuel environment that is more conductive to large, severe fires (USDA 2013). Under a changing climate, wildfires exceeding 50,000 acres has increased over the past 30 years (USDA 2013). However, a study from the National Interagency Fire Center of the USGS shows that the number of acres burned by wildfires in New Jersey has decreased by 0.25 acres per square mile from events that took place in 2000 to 2014 compared to events that took place in 1984 and 1999 (EPA 2020).

Understanding the climate/fire/vegetation interactions is essential for addressing issues associated with climate change that include:

- Effects on regional circulation and other atmospheric patterns that affect fire weather
- Effects of changing fire regimes on the carbon cycle, forest structure, and species composition, and
- Complications from land use change, invasive species and an increasing WUI.

As discussed earlier, average temperatures are anticipated to increase in New Jersey, therefore, suitability of habitats for specific types of trees potentially changes, altering the fire regime and resulting in more frequent fire events and changes in intensity. Prolonged and more frequent heat waves have the potential to increase the likelihood of a wildfire. The increased potential combined with stronger winds may make it harder to contain fires and thus increase the County's vulnerability to this hazard.

Change of Vulnerability Since the 2016 HMP

The 2022 HMP has been updated to reflect 2015-2019 ACS 5-year estimates for population changes. The building stock inventory was updated using data from Gloucester County. Further, the building stock inventory replacement cost values were updated using RS Means 2021 values providing an overall update to the assets assessed in this risk assessment. The NJDEP Wildfire Fuel Hazard spatial layer has not been updated since the last HMP; therefore, changes and any increases in overall wildfire hazard exposure are attributed to increases in population and new development.

4.3.16 Utility Interruption

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the utility interruption hazard in Gloucester County.

2022 HMP Update Changes

- Utility Interruption was discussed as a characteristic of severe weather, severe winter weather, hurricane/tropical storm, and nor'easter in their respective hazard profiles. Given the frequency of utility interruption, utility interruption is being included as a stand-alone hazard of concern for 2022.

4.3.16.1 Profile

Hazard Description

Utility interruption is defined as any disruption or loss of a public service which includes, but is not limited to: electrical service, potable water, and natural gas caused by disruption of power transmission caused by accident, sabotage, natural hazards, or equipment failure (also referred to as a utility failure or utility outage). A significant utility interruption is defined as any incident of a long duration, which would require the involvement of the local and/or State emergency management organizations to coordinate provision of food, water, heating, cooling, and shelter.

Utility interruption is commonly caused by the impacts of natural hazard events on the utility system. For more information on extreme temperature events, refer to Section 4.3.6. For more information on severe weather events, refer to Section 4.3.13. For more information on severe winter weather events, refer to Section 4.3.14. For more information on hurricanes and tropical storms, refer to Section 4.3.10. For more information on nor'easters, refer to Section 4.3.12.

Widespread power outages can occur without warning or as a result of a natural disaster. Generally warning times will be short in the case of technological failure, such as a fire at a sub-station, traffic accident, human error or terrorist attack. In cases where a power failure is caused by natural hazards, greater warning time is possible. For example, high wind events such as tornados and hurricanes often cause widespread power failure and are often forecasted before they affect a community. Additionally, severe winter weather conditions such as ice storms, blizzards, and snowstorms often cause power failure. Incidents such as these often have plenty of warning time, thus utility response crews can stage resources to prepare for utility failure.

Power failures can cause secondary hazards and have an effect on the health of residents. One potential secondary hazard is chemical accidents that occur after power is restored to industrial facilities. Power interruptions at chemical handling plants are of particular concern because of the potential for a chemical spill during restart (EPA 2001). Chemical spills in turn can have significant health and environmental impacts. For more information on hazardous material spills, refer to Section 4.3.9.

Another secondary hazard that can result from power failure is a loss of communications capability by first responders, which may in turn have negative impacts on public safety. Amateur radio operators may be used to supplement emergency communications during events of power outage. Power outages can also lead to instances of civil disturbance, including looting. Power failure may also lead to an increase in traffic accidents. Traffic accidents may increase because of the lack of traffic control devices such as stoplights and railroad crossing advisory signals. Power outages lasting a long duration will force law enforcement officials to man traffic control points to prevent accidents.

Power failure can have vast secondary impacts on the health of the community. During periods of extreme heat or extreme cold, vulnerable populations such as the elderly and medically frail can be affected and are susceptible to hypothermia or heat stroke. Additionally, power failure can lead to food spoilage, which has negative impacts on public health.

Wastewater and potable water utility interruption may occur as a result of a power failure or due to equipment failure. These critical utilities are essential to community continuity, emergency services and recovery. Their interruption of service may have cascading economic, environmental, and emergency response impacts.

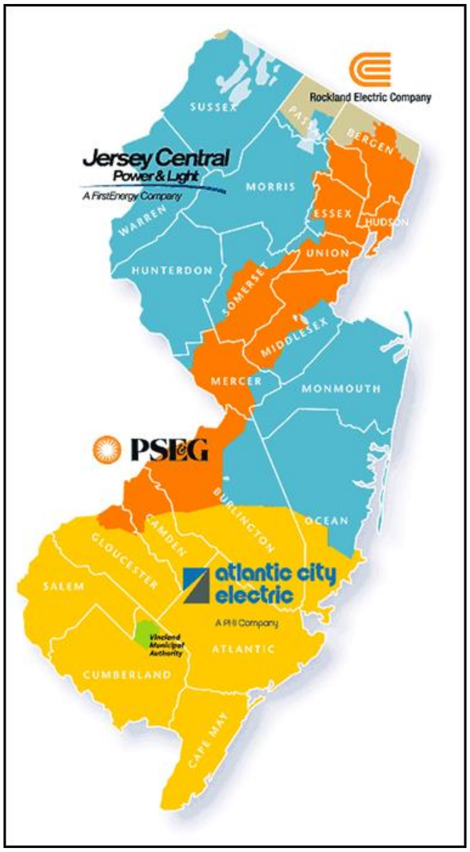
Interruption of water utilities can lead to disruption in daily life for the residents (i.e., loss of potable water) and can have also have serious impacts on firefighting and emergency response capabilities. Failures can occur from natural hazards or due to aging utility infrastructure.

Location

Power failures in New Jersey are usually localized and are usually the result of a natural hazard event involving high winds or ice storms. New Jersey's power systems are overseen by the State of New Jersey Board of Public Utilities. Under New Jersey law, consumers can shop for electric suppliers through a variety of third-party vendors. While the *supply* portion of energy is open to competition, the *delivery* of electricity is limited geographically to the following service providers:

- Atlantic City Electric
- Jersey Central Power and Light (JCP&L)
- Rockland Electric Company
- Public Service Electric and Gas (PSE&G)

Figure 4.3.16-1. Electric Service Delivery Companies in New Jersey



Source: New Jersey Clean Energy Program 2013

These service providers are responsible for maintaining power throughout their respective regions. Figure 4.3.16-1 shows the locations of electric service delivery providers across New Jersey. This figure indicates that Gloucester County is serviced primarily by Atlantic City Electric with a small northern portion of the county serviced by PSE&G.

Water interruptions can range from localize events to larger scale water outages. Water interruptions can occur from a direct impact from a natural hazard or a failure due to the age of the utility infrastructure. Water supply throughout Gloucester County is provided through both private and municipally operated water providers.

- Aqua New Jersey Inc.
- Borough of Glassboro Water and Sewer
- Swedesboro Water Department

Extent

The extent and severity of a utility interruption depends on the cause, location, duration, and time of year. It can range from a small, localized event to a countywide power outage. Impacts from a utility failure can be significant to the County and its residents. Utility interruptions typically occur because of, or in combination with, aging infrastructure, other emergency or disaster incidents, such as severe weather and flooding, and can exacerbate such emergencies. It also depends on the utility distribution system affected.

Power failures lead to the inability to use electric-powered equipment, such as: lighting; heating, ventilation, and air conditioning (HVAC) and necessary equipment; communication equipment (telephones, computers, etc.); fire and security systems; small appliances such as refrigerators, sterilizers, etc.; and medical equipment. This all can lead to food spoilage, loss of heating and cooling, basement flooding due to sump pump failure, and loss of water due to well pump failure.

Utility gas failures can lead to a drastic reduction for residents of Gloucester County to heat their homes as previously mentioned. Current procedures of shutting off utility gas distribution before severe weather events could also hinder the ability to provide backup power if residents have generators power by utility gas. Interruptions of water supply can lead to decreased potable water supply and also a decreased firefighting capability.

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with flooding throughout Gloucester County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events may vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2021, FEMA included the State of New Jersey in one power outage-related disaster (DR) or emergency (EM) declaration. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Gloucester County was not included in this disaster. However, the County has been included in declarations for numerous events which resulted in power outages. Refer to Sections 4.3.10 (Hurricane), 4.3.12 (Nor'Easters), 4.3.13 (Severe Weather), and 4.3.14 (Severe Winter Weather) for declarations relating to severe weather, severe winter weather, nor'easter, and hurricane/tropical storm.

U.S. Department of Agriculture Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Utility interruption is a non-natural hazard and is not responsible for any agricultural impacts that could lead to disaster declarations. However, the natural hazard events that may cause utility failure may also result in agricultural damages that result in declarations.

Utility Failure Events

For the 2021 HMP update, utility failure events that have impacted Gloucester County between 2015 and 2021 are identified in Table 4.3.16-1. With flood documentation for New Jersey and Gloucester County being so extensive, not all sources have been identified or researched. Therefore, Table 4.3.16-1 may not include all events that have occurred in the County. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

Table 4.3.16-1. Utility Interruption Events in Gloucester County, 2015 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Description
April 22, 2015	Thunderstorm Wind	N/A	N/A	An approaching cold front helped trigger a line of showers and thunderstorms that produced some wind damage as it moved through central New Jersey during the afternoon of the 22nd. Even though they weakened, the gust front from the storm continued to produce strong wind gusts all the way to the coast. The severe thunderstorm caused wind damage to a few homes and also resulted in about 1,200 Atlantic City Electric customers losing power.
June 23, 2015	Thunderstorm Wind	DR-4231	Yes	The combination of an unseasonably hot and humid air mass, an approaching cold front and strong winds aloft caused a squall line of severe thunderstorms to move through southern New Jersey during the very late afternoon and early evening of the 23rd. Estimated wind gusts as high as around 85 mph knocked down thousands of trees and caused structural damage to homes and vehicles, mainly from fallen trees. Four direct injuries were reported. Many roadways were closed because of downed trees into the 24th. Hardest hit were Burlington, Camden, Atlantic and in particular Gloucester County. Gloucester County declared a state of emergency. The region suffered approximately 31 million dollars in property damage and was declared a presidential disaster area. A couple of severe thunderstorms also occurred in northwest New Jersey during the afternoon of the 23rd. While there was one report of a funnel cloud and a waterspout in Barnegat Bay, no confirmed tornadoes occurred. About 410,000 homes and businesses in southern New Jersey lost power. The 280,000 customers that lost service in the Atlantic City Electric's service area represented a greater number than what occurred during Superstorm Sandy (220,000) and the Derecho of 2012 (206,000). The utility reported that several high transmission lines, five substations, twenty other transmission lines, hundreds of poles as well as 372 incidents of wire damage occurred. The utility received assistance from repair crews as far away as Ohio and New England. About 210,000 of its customers were still without power on the morning of the 24th, 180,000 the afternoon of the 24th, 121,500 the afternoon of the 25th, 84,000 the morning of the 26th and 48,000 the evening of the 26th. Thunderstorms on the 27th slowed restoration efforts and full restoration did not occur until the 30th. Public Service Electric & Gas reported 130,000 of its customers lost power. Full restoration occurred on the 26th. The utility's substations in Collingswood, Maple Shade, Medford and Southampton were damaged.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Description
				Because of the prolonged power outages, water and ice distribution centers were opened and the American Red Cross assisted with displaced families. In Gloucester County, two comfort stations were opened by the Red Cross. The worst wind damage occurred from Greenwich Township east through Mantua Township. About 11,000 homes and businesses were still without power on the morning of the 28th. In Camden County, the county dispatch office fielded ten times the normal call volume for assistance. The County Public Safety Office fielded 3,522 calls vs 2,432 calls for the entire duration of Superstorm Sandy. Hardest hit was the central part of the county from Gloucester Township east through Cherry Hill and Voorhees Township. In Burlington County, Evesham and Medford Townships were hardest hit. Crop damage impacted mainly Camden and Gloucester Counties. Most of the initial damage was physical in nature to buildings, facilities and ditches. Verizon cell phone service was also lost in parts of southwest New Jersey on the 23rd and restored by the 24th.
July 9, 2015	Thunderstorm Wind	N/A	N/A	A line of strong to severe thunderstorms formed in the warm sector of the Susquehanna Valley and moved through southern New Jersey during the during the evening on the 9th. In addition, some flash flooding occurred with the line of thunderstorms. About 7,000 homes and businesses lost power in the southern half of New Jersey. A warm front lifted northeast into central New Jersey during the afternoon of the 9th. This permitted sufficient daytime heating preceding an approaching cold front for thunderstorms to gain strength and severity.
January 22, 2016	Winter Storm	DR-4264	No	An impulse from the west coast traversed the midsection of the country, then developed into a low pressure system as it tracked across the Gulf states before intensifying along the Carolina coast into a major nor'easter, producing record snowfall in parts of New Jersey on January 23rd. At one point during the storm, up to 270,000 customers were without power. Outages were concentrated closer to the coast where the strongest winds occurred.
February 16, 2016	Thunderstorm Wind	N/A	N/A	A strong cold front moved west to east through New Jersey late Tuesday morning and early Tuesday afternoon. Heavy downpours associated with this front brought strong to severe wind gusts down to the surface, causing property damage in some places. Thousands were left without power due to the strong wind gusts. Around 30,000 customers lost power.
June 5, 2016	Thunderstorm Wind	N/A	N/A	A cold front moving into an unstable air mass over New Jersey set off numerous showers and thunderstorms during the late afternoon hours on the 5th. Lightning with these thunderstorms was somewhat limited, so straight-line winds and heavy downpours were the

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Description
				major threat as these storms moved through the area. Thousands of people lost power as a result of the storms. Many wind gusts from 60 to over 70 MPH were recorded across the region. The highest gust was in Gloucester TWP at 74 mph.
June 8, 2016	Thunderstorm Wind	N/A	N/A	A trough of low pressure moving through the region produced a quick moving line of thunderstorms around noontime. These thunderstorms produced widespread wind damage across most of Southern and Central NJ with numerous power outages.
January 23, 2017	Strong Wind	N/A	N/A	An area of low pressure over North Carolina on the 23rd strengthened and moved northeast to a location just off the New Jersey Coastline on the morning of the 24th. With a very tight pressure gradient, winds increased ahead of the storm reaching in excess of 50 mph that led to some damage reports. Power outages from the storm were estimated at around 20,000.
February 25, 2017	Thunderstorm Wind	N/A	N/A	Several days of record warmth came to an abrupt end as a strong cold front moved through the state. Moisture and instability were sufficient to develop a line of showers and thunderstorms ahead of the front. These showers and thunderstorms produced damaging winds and hail across western portions of the state. Several thousand people lost power as well.
June 24, 2017	Tropical Storm Cindy	N/A	N/A	A band of gusty convective showers moved through during the morning hours in association with the remnants of Tropical Storm Cindy. Several reports of damage were reported from the winds. Thousands lost power.
July 23, 2017	Thunderstorm Wind	N/A	N/A	A stalled frontal boundary was the focus for several rounds of thunderstorms that produced damaging winds and flooding in spots. Several thousand people lost power throughout the state.
August 2, 2017	Thunderstorm Wind	N/A	N/A	A hot and humid airmass with weak boundaries led to slow moving strong to severe thunderstorms with damaging winds, hail and flooding. Over 2,000 people lost power.
October 24, 2017	Strong Wind	N/A	N/A	A strong low pressure system over the Great Lakes and a departing high pressure system to our east lead to a tight pressure gradient and a round of strong winds. Over 25,000 homes and businesses lost power. Several school districts had to close because of the power loss.
January 4, 2018	Winter Storm	N/A	N/A	An area of low pressure tracked up the east coast interacting with a cold front which lead to rapid development of a winter storm across the state. This storm quickly moved out by the 5th. However, snowfall accumulations and gusty winds occurred with the storm. Top wind gusts were generally around 40 mph across the state. Snow amounts were highest in southern and coastal New Jersey with over 6 inches, totals were only a few inches further northwest. A state of Emergency was declared during the height of the storm. Several

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Description
				hundred vehicles were stranded and hundreds of thousands were without power at some point.
March 2, 2018	Winter Weather, High Wind	N/A	N/A	A large and very deep area of low pressure moved slowly east over the open waters of the North Atlantic Ocean through Sunday March 4th. This lead to a variety of weather hazards during this time frame. Strong Northwest winds with gusts up to around 60 mph occurred on March 2nd and 3rd. This led to widespread damage to trees and power lines, causing extensive power outages across the region.
March 6, 2018	Winter Storm	DR-4368	No	A broad area of low pressure extending from the Ohio Valley to the Piedmont of South Carolina consolidated off the Virginia Capes during the early morning of March 7th. This new primary low moved northeast and gradually deepened as it passed east of the Delaware and New Jersey coasts on March 7th. Precipitation gradually overspread the region during the overnight hours of March 6th to the 7th. To the east of the NJ Turnpike/Interstate 95, precipitation began as rain or a mix of rain and snow. Further west, precipitation fell mainly as snow. During the daylight hours of the 7th, precipitation to the east of the NJ Turnpike/Interstate 95 turned over to snow, as colder air worked in from the north and west. The snow fell heavy at times away from the coast. The snow contained large amounts of liquid, making it heavy and wet. This resulted in downed trees, limbs, and wires, leading to numerous power outages across portions of New Jersey, especially where the heaviest snow was reported. Many customers were still without power from the previous storm when this storm struck. Governor Murphy estimated about 350,000 customers state-wide lost power as a result of this second storm.
June 3, 2020	Strong Wind	N/A	N/A	A derecho developed just southeast of Lake Erie during the early morning hours of June 3, 2020, then moved rapidly southeast across Pennsylvania before exiting the central New Jersey coast during the early afternoon hours, approximately 130 PM. Damaging winds in excess of 60 MPH were sporadic over western and central Pennsylvania, but as the thunderstorm complex moved into increasingly unstable air in the eastern part of the state just before noon, wind damage reports became more numerous and widespread. Most of these reports were confined within a 50-mile wide swath extending from Berks County eastward to the Philadelphia metro area, then further east to the Ocean County shoreline in New Jersey. Wind gust reports between 60 and 70 MPH were common within this swath. In addition to these destructive wind gusts, frequent to continuous cloud to ground lightning and heavy downpours were also reported throughout the area. Over 112,000 power outages were reported in southern New Jersey as a result of fallen trees on power lines. Some

TETRA TECH

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Description
				localities were without power for several days. Because this derecho moved off the coast by 200 PM, the warm afternoon sun was able to sufficiently destabilize the atmosphere for the formation of another round of severe thunderstorms over some of the same areas that experience them earlier in the day. Reported wind gusts associated with these thunderstorms generally ranged between 45 and 65 MPH.

Source: NOAA-NCEI 2021; FEMA 2021

Note: Events recorded to NOAA-NCEI as resulting in "scattered" power outages were considered minor and not included.

Probability of Future Occurrences

While the probability of future utility interruption incidents in Gloucester County is difficult to predict, the historic record indicates that significant failures have occurred as a result of high winds, lightning, severe weather, winter weather, technological failures, and age of utility infrastructure. As infrastructure ages beyond its intended lifespan, it is likely to become less reliable leading to a higher likelihood of failure Data were not readily available on the frequency of smaller utility interruptions across the County; however, it is reasonable to assume that utility failure events of shorter duration will continue to occur in the future. In addition, future changes in climate may also impact the frequency and probability of future utility failure occurrences.

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Steering Committee and Planning Committee, the probability of occurrence for utility interruptions in the County is considered ‘frequent’.

Climate Change Impacts

Several implications for climate change are related to the utility interruption hazard. Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State’s average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation. Changes in winter temperatures could result in a change in the frequency of utility failure events. Extreme temperatures are predicted to increase as well. During the hot summer months, the potential for power overload will increase as demand for power increases.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli et al. 2020). An increase in precipitation, particularly winter precipitation, may lead to more frequent power failures.

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017). More storms with higher winds will increase the chance that the power infrastructure will be impacted.

4.3.16.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. The following discusses Gloucester County's vulnerability, in a qualitative nature, to the utility interruption hazard.

Impact on Life, Health and Safety

The entire population in Gloucester County is vulnerable to utility interruption events. Refer to Section 3 (County Profile) for a summary of population statistics for the County.

Utility failure is particularly problematic for homes that are heated with electricity. Widespread power outages during the winter months can directly impact vulnerable populations such as the elderly and medically frail. According to the 2015 – 2019 American Community Survey, 106,705 (78.4 percent) homes across Gloucester County are heated with utility gas, 11,035 (10.3 percent) homes are heated with fuel oil and kerosene; and 8,368 (78.4 percent) are heated by electricity. PSE&G currently maintains databases for homes/facilities with individuals that need power supplied for medical reasons. Utility interruption events have potential health impacts including injury and death. Other issues from power outages include food safety from lack of refrigeration and carbon monoxide poisoning from misuse of generators.

Individuals with medical needs are vulnerable to power failures, because medical equipment such as oxygen concentrators requires electricity to operate. The elderly and low-income populations of Gloucester County are also vulnerable to the effects of power failure, as power failure has the potential to expose them to extreme heat or extreme cold. During power failure events, water purification systems may not be functioning. Further, populations on private wells will not have access to potable water. Many power outage events are caused by storm events that can lead to flooding. Without electricity, residents would be unable to pump water from their basements potentially causing structural and content damage to their homes.

Individuals powering their homes with generators are subjected to carbon monoxide poisoning if proper ventilation procedures are not followed. Improperly connected portable generators are capable of 'back feeding' power lines which may cause injury or death to utility works attempting to restore power and may damage house wiring and/or generators (NJOEM 2019).

As noted above, interruptions of water supply can lead to decreased potable water supply and a decreased firefighting capability. Interruption of potable water distribution also has a considerable impact on the firefighting capabilities of many fire departments within Gloucester County. Should frequent or widespread water interruption occur, there will be an increased risk for structural fire and wildfire occurrence within the County.

Water systems and thus distribution may also be impacted by other hazards such as extreme weather events. A good example is Superstorm Sandy where storm surge damaged critical water supply infrastructure along the coast and high winds impacted energy distribution across the State which in turn impacted the ability to supply water. As a result, NJDEP has developed new guidance aimed to ensure that repairs, reconstruction, new facilities and operations/maintenance are focused on enhancing the resilience of critical infrastructure (NJOEM 2019).

Impact on General Building Stock

All of the building stock in the County is exposed to the utility interruption hazard. Refer to Section 3 (County Profile) which summarizes the building inventory in Gloucester County. Impacts sustained from utility interruption are likely to be secondary impacts. Should potable water distribution be reduced or not available, then structures could be at increased risk for structural fire since current fire suppression is dependent accessing water supply from hydrants.

Impact on Critical Facilities

All critical facilities in the County are exposed to the utility interruption hazard. It is essential that critical facilities remain operational during natural hazard events. Backup power is recommended for critical facilities and infrastructure. Loss of power can have serious impacts on the health and welfare of residents, continuity of business, and the ability of public safety agencies to respond to emergencies. Interruption of utility gas or water distribution could also reduce the effectiveness of critical facilities to operate at full capacity.

Impact on Economy

During a utility interruption event, the County may experience losses because of an interruption of critical services. Further, increased costs such as providing shelters, and costs related to cooling and heating centers may be incurred. Extended power outages will require officials to shelter victims who require heat and power for activities of daily living.

A prolonged power failure in Gloucester County may impact the County's economy. The County possesses an extensive transportation network, including many ports and bus services (Gloucester 2021). Transportation systems include freight rail lines and roadways. Major highways accessible to Gloucester County include the New Jersey Turnpike, and Routes 40, 45, 44, 130, 295, and 322. The County also has 6 small-scale airports. All of these systems and supporting resources provide services locally, regionally, nationally, and internationally. Disruption in any of these services would mean that many workers, residents, and travelers would not be able to go where needed.

Power interruptions can cause economic impacts stemming from lost income, spoiled food and other goods, costs to the owners/operators of the utility facilities, and costs to government and community service groups. FEMA's benefit-cost analysis methodology measures the loss of electrical service on a per-person-per-day-of-lost-service basis for the service area affected.

Interruption of utility gas or potable water distribution could also cause significant economic impacts such as: additional costs for bringing in water tenders to maintain fire suppression capabilities; opening additional warming centers should electric and utility gas utility be interrupted to residential areas; and distribution of potable water for public consumption. There could be significant costs associated with reimbursing fire departments from other counties within New Jersey to travel, staff, and maintain water tenders within Gloucester County during the duration of a water outage event.

Potential modeling of economic impacts from utility interruption would be calculating interruption of service costs which is derived from a standard value per person per day multiplied out by the number of customers served. This would help to provide an estimate of the impact of the interrupted utility service but may not be representative of the complete economic impact of a prolonged utility interruption.

The FEMA BCA Toolkit version 5.3 uses the following standard values per person per day:

- Electric: $148.00
- Potable Water: $105.00
- Wastewater: $49.00

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development and Change in Population

As discussed in Sections 4 and 9, areas targeted for future growth and development have been identified across Gloucester County. Any areas of growth could be potentially impacted by the utility interruption hazard because the entire County is exposed and vulnerable. Please refer to the specific areas of development indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this plan.

According to population projections from the State of New Jersey Department of Labor and Workforce Development, Gloucester County will experience an increase in population through 2034 (approximately 20,000 people between 2019 and 2034). An increase in population within Gloucester County could potentially lead to a higher likelihood of utility failure due to an increased demand on aging infrastructure. If utility infrastructure is not maintained and enhanced to accommodate for future demands, then there is a higher likelihood for more frequent utility interruptions. Increased frequency of utility interruptions will lead to an increased risk for socially vulnerable populations and also a heighted risk for structural and wildfire because of the current reliance of fire hydrants for fire suppression in Gloucester County.

Climate Change

Several implications for climate change are related to the power failure hazard. Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate Change in New Jersey: Trends and Projections describes changes in temperature, precipitation, and sea level rise. Each section of the report summarizes observed recent changes in climate in New Jersey. Observations are based on recorded climate data collected by the ONJSC and other institutions, and on other reports summarizing climate change in the northeastern United States. Each section also presents a synthesis of the most current projections for future climate changes based on climate science modeling and techniques. The projections reflect potential average climate over a span of future years (2020, 2050, and 2080). The projections in the report illustrate the potential climate changes that could impact the northeastern United

States based on future emissions scenarios (A2, A1B, and B1 – high, medium, and low scenarios). Each emissions scenario would result in a range of potential climate outcomes in the State (Rutgers 2013).

Climatologists predict an increase in the number and intensity of severe weather events. More storms with higher winds will increase the chance that the power infrastructure will be impacted. Extreme temperatures are predicted to increase as well. During the hot summer months, the potential for power overload will increase as demand for power increases. Additionally, climatologists predict an increase in precipitation, which may lead to more winter weather thus causing additional power failures and utility interruptions.

Change of Vulnerability Since the 2016 HMP

Overall, the County's vulnerability has not changed, and the entire County will continue to be exposed and vulnerable to the utility interruption events.

4.4 HAZARD RANKING

2022 HMP Changes

- The hazard ranking section has been relocated to Section 4.4.
- The 2022 HMP Update hazard ranking methodology was expanded to include adaptive capacity and climate change.
- The probability of occurrence category was adjusted to include the benchmark value ‘unlikely’, and modifications to the remaining categories so that ‘frequent’ aligned with an event that has an annual probability.

A comprehensive range of hazards that pose a significant risk to Gloucester County were selected and considered during the development of this plan; see Section 4.1 (Identification of Hazards of Concern). However, each community has differing levels of exposure and vulnerability to each of these hazards. It is important for each community participating in this plan to recognize those hazards that pose the greatest risk to their community and direct their attention and resources accordingly to most effectively and efficiently manage risk and reduce losses. The hazard ranking for the County and each participating jurisdiction can be found in their jurisdictional annexes in Volume II, Section 9 (Jurisdictional Annexes) of this plan.

To this end, a hazard risk ranking process was conducted for Gloucester County and its municipalities using the method described below. This method includes four risk assessment categories—probability of occurrence, impact (population, property and economy), adaptive capacity, and changing future conditions (i.e., climate change). Each was assigned a weighting factor to calculate an overall ranking value for each hazard of concern. Depending on the calculation, each hazard was assigned a high, medium, or low ranking. Details regarding each of these categories is described below.

4.4.1 Hazard Ranking Methodology

Estimates of hazard risk for the County were developed using methodologies promoted by FEMA’s hazard mitigation planning guidance, generated by FEMA’s Hazus risk assessment tool, and input from Gloucester County and participating jurisdictions.

As described in Section 4.2 (Methodology and Tools), three different levels of analysis were used to estimate potential impacts: 1) historic loss/qualitative analysis; 2) exposure analysis; and 3) loss estimation. All three levels of analysis are suitable for planning purposes; however, with any risk analysis, there is underlying uncertainty resulting from assumptions used to describe and assess vulnerability and the methodologies available to model impacts. Impacts from any hazard event within the County will vary from the analysis presented here based on the factors described for each hazard of concern; namely location, extent, warning time, and mitigation measures in place at the time of an event.

The hazard ranking methodology for some hazards of concern is based on a scenario event, while others are based on their potential risk to the County as a whole. In order to account for these differences, the quantitative hazard ranking methodology was adjusted using professional judgement and subject-matter input; assumptions are included, as appropriate, in the following subsections. The limitations of this analysis are recognized given the scenarios do not have the same likelihood of occurrence; nonetheless, there is value in summarizing and comparing the hazards using a standardized approach to evaluate relative risk. The following categories were considered when evaluating the relative risk of the hazards of concern.

- **Probability of Occurrence** - The probability of occurrence of the scenario evaluated was estimated by examining the historic record and/or calculating the likelihood of annual occurrence. When no scenario was assessed, an examination of the historic record and judgement was used to estimate the probability of occurrence of an event that will impact the County.
- **Impact**—The following three hazard impact subcategories were considered: impact to people; impact to buildings; and impact to the economy. The results of the updated risk assessment and/or professional judgement were used to assign the numeric values for these three impact subcategories. A factor was applied to each subcategory, giving impact on population the greatest weight.
  - Population—Numeric value x 3
  - Buildings—Numeric value x 2
  - Economy—Numeric value x 1
- **Adaptive Capacity -** Adaptive capacity describes a jurisdiction's current ability to protect from or withstand a hazard event. This includes capabilities and capacity in the following areas: administrative, technical, planning/regulatory and financial. Mitigation measures already in place increases a jurisdiction's capacity to withstand and rebound from events (e.g. codes/ordinances with higher standards to withstand hazards due to design or location; deployable resources; or plans and procedures in place to respond to an event). In other words, assigning 'weak' for adaptive capacity means the jurisdiction does not have the capability to effectively respond, which increases vulnerability; whereas 'strong' adaptive capacity means the jurisdiction does have the capability to effectively respond, which decreases vulnerability. These ratings were assigned using the results of the core capability assessment with subject-matter input from each jurisdiction.
- **Climate Change (Changing Future Conditions)** - Current climate change projections were considered as part of the hazard ranking to ensure the potential for an increase in severity/frequency of the hazard was included. This was important to Gloucester County to include because the hazard ranking helps guide and prioritize the mitigation strategy development, which should have a long-term future vision to mitigate the hazards of concern. The potential impacts climate change may have on each hazard of concern is discussed in Sections 4.3.1 through 4.3.16. The benchmark values in the methodology are similar to confidence levels outlined in the National Climate Assessment 2017.

Hazard Ranking Equation

[Probability of Occurrence x 0.3] + [(Impact on Population x 3) + (Impact on Property x 2) + (Impact on Economy x 1) x 0.3] + [Adaptive Capacity x 0.3] + [Climate Change x 0.1]

Table 4.4-1 summarizes the categories, benchmark values, and weights used to calculate the risk factor for each hazard. Using the weighting applied, the highest possible risk factor value is 6.9. The higher the number, the greater the relative risk. Based on the total for each hazard, a priority ranking is assigned to each hazard of concern (high, medium, or low). The rankings were categorized as follows: Low = Values less than 3.9; Medium = Values between 3.9 and 4.9; High = Values greater than 4.9.

Table 4.4-1. Summary of Hazard Ranking Approach

Category		Level / Category	Degree of Risk / Benchmark Value	Numeric Value	Weighted Value
Probability of Occurrence		Unlikely	A hazard event is not likely to occur or is unlikely to occur with less than a 1% annual chance probability.	0	30%
		Rare	Between 1 and 10% annual probability of a hazard event occurring.	1	
		Occasional	Between 10 and 100% annual probability of a hazard event occurring.	2	
		Frequent	100% annual probability; a hazard event may occur multiple times per year.	3	
Impact (Sum of all 3)	Population (Numeric Value x 3)	Low	14% or less of your population is exposed to a hazard with potential for measurable life safety impact, due to its extent and location.	1	30%
		Medium	15% to 29% of your population is exposed to a hazard with potential for measurable life safety impact, due to its extent and location.	2	
		High	30% or more of your population is exposed to a hazard with potential for measurable life safety impact, due to its extent and location.	3	
	Property (Numeric Value x 2)	Low	Property exposure is 14% or less of the total number of structures for your community.	1	
		Medium	Property exposure is 15% to 29% of the total number of structures for your community.	2	
		High	Property exposure is 30% or more of the total number of structures for your community.	3	
	Economy (Numeric Value x 1)	Low	Loss estimate is 9% or less of the total replacement cost for your community.	1	
		Medium	Loss estimate is 10% to 19% of the total replacement cost for your community.	2	
		High	Loss estimate is 20% or more of the total replacement cost for your community.	3	
Adaptive Capacity		Weak	Weak/outdated/inconsistent plans, policies, codes/ordinances in place; no redundancies; limited to no deployable resources; limited capabilities to respond; long recovery.	1	30%
		Moderate	Plans, policies, codes/ordinances in place and meet minimum requirements; mitigation strategies	0	

Category	Level / Category	Degree of Risk / Benchmark Value	Numeric Value	Weighted Value
		identified but not implemented on a widespread scale; county/jurisdiction can recover but needs outside resources; moderate county/Jurisdiction capabilities.		
	Strong	Plans, policies, codes/ordinances in place and exceed minimum requirements; mitigation/protective measures in place; county/jurisdiction has ability to recover quickly because resources are readily available, and capabilities are high.	-1	
Climate Change	Low	No local data is available; modeling projections are uncertain on whether there is increased future risk; confidence level is low (inconclusive evidence).	1	10%
	Medium	Studies and modeling projections indicate a potential for exacerbated conditions due to climate change; confidence level is medium to high (suggestive to moderate evidence).	2	
	High	Studies and modeling projections indicate exacerbated conditions/increased future risk due to climate change; very high confidence level (strong evidence, well documented and acceptable methods).	3	

Note: A numerical value of zero is assigned if there is no impact.
**For the purposes of this exercise, "impacted" means exposed for population and property and estimated loss for economy. For non-natural hazards, although they may occur anywhere in the County, an event will not likely cause countywide impacts; therefore, impact to population was scored using an event-specific scenario.*

In an attempt to summarize the confidence level regarding the input utilized to populate the hazard ranking, a gradient of certainty was developed. A certainty factor of high, medium or low was selected and assigned to each hazard to provide a level of transparency and increased understanding of the data utilized to support the resulting ranking. The following scale was used to assign a certainty factor to each hazard:

- High—Defined scenario/event to evaluate; probability calculated; evidenced-based/quantitative assessment to estimate potential impacts through hazard modeling.
- Moderate—Defined scenario/event or only a hazard area to evaluate; estimated probability; combination of quantitative (exposure analysis, no hazard modeling) and qualitative data to estimate potential impacts.
- Low—Scenario or hazard area is undefined; there is a degree of uncertainty regarding event probability; majority of potential impacts are qualitative.

Table 4.4-2 summarizes the hazard scenario or hazard area evaluated; highlights key impacts to population, buildings/critical assets and the economy; and lists the associated certainty factor assigned for each hazard to convey the level of confidence in the data used. This table is not intended to be a complete and comprehensive list of all hazard impacts determined in the risk assessment and considered for the hazard ranking exercise. Refer to Sections 4.3.1 to 4.3.16 for a complete summary of all estimated impacts for each hazard.

Table 4.4-2. Overview of the Hazard Scenario and Associated Estimated Impacts Considered in the Hazard Ranking

Hazard of Concern	Hazard/ Scenario Area Evaluated	Population		Buildings		Economy[a]		Certainty Factor
Coastal Erosion	Exposure to the Coastal Erosion Hazard Area	Coastal Erosion Hazard Area:	21	Coastal Erosion Hazard Area:	13	Coastal Erosion Hazard Area:	$6,441,846	Low
Dam/ Levee Failure	Partial or complete failure of a dam. There are 39 dams in the County; 3 are high hazard according to USACE.	Population impacted is dependent on the location and capacity of the dam, the extent of the dam failure inundation area and the severity of the failure.		The number of buildings impacted is dependent on the capacity of the dam, the extent of the dam failure inundation area and the severity of the failure.		Economic impacts include dam/building/infrastructure repairs; debris removal/disposal; utility impacts.		Medium
Disease Outbreak	Disease outbreaks include: West Nile Virus, Eastern Equine Encephalitis virus, St. Louis Encephalitis, Lyme disease, Influenza, Ebola virus, and Coronavirus.	Population impacted is dependent on the disease and severity of the outbreak; in some cases, immuno-compromised persons are more vulnerable.		Structural impacts due to disease outbreak would be limited.		Economic losses can include County financial impacts to monitor/address outbreaks; lost wages or commercial interruptions; depends on the severity and type of disease outbreak.		Moderate
Drought	Prolonged drought event - the County is serviced by private wells or water suppliers who primarily get water from surface water, reservoirs and unconfined groundwater sources.	Entire population exposed. Population on surface water supplies may be impacted first; water restrictions/contamination; increased wildfire risk.		Droughts are not expected to cause direct damage to buildings.		Losses include aesthetic, landscape/nursery/agricultural industry impacts		Moderate
Earthquake*	100 and 500-Year MRP events NJDOT Seismic Soils D	NJDOT Seismic Soils:	107,065	NJDOT Seismic Soils:	43,255	NJDOT Seismic Soils:	$38,793,573,609	Low

Hazard of Concern	Hazard/ Scenario Area Evaluated	Population		Buildings		Economy[a]		Certainty Factor
Extreme Temperature	Extreme hot and cold events	All residents/commuters/visitors are exposed; socially-vulnerable populations may be at increased risk.		All buildings are exposed; the degree of impact depends on the scale of the incident.		Business and commercial losses due to long-term utility outages; repairs to power and utility lines.		Moderate
Flood*	100-MRP event	1% annual chance (100-year)	4,305	1% annual chance (100-year)	2,106	1% annual chance (100-year)	$2,772,477,118	Moderate
Geological Hazards	Steep slope areas and areas developed over carbonate rock and abandoned mines with increased vulnerability to subsidence.	Steep Slope:	6,619	Steep Slope:	2,426	Steep Slope	$1,947,263,039	Low
		Carbonate Bedrock:	32,985	Carbonate Bedrock:	12,425	Carbonate Bedrock:	$9,927,012,456	
Hazardous Materials[b]	Release of a hazardous substance from a fixed site or in-transit.	Within 1 mile of HazMat Roadway Routes:	256,407	Within 1 mile of HazMat Roadway Routes:	99,806	Within 1 mile of HazMat Roadway Routes:	$90,545,087,029	High
		Within 1 mile of HazMat Facility:	162,795	Within 1 mile of HazMat Facility:	64,484	Within 1 mile of HazMat Facility:	$61,575,683,078	
Hurricane and Tropical Storm	100-Year and 500-MRP events	Entire population exposed; the degree of impact to the population depends on the scale of the incident and warning time.		Entire building stock is exposed; the degree of impact depends on the scale of the incident.		100-Year MRP Estimated Damages	$69,703,663	Moderate
						500-Year MRP Estimated Damages	$304,905,184	
Infestation and Invasive Species	Infestation and Invasive Species including insects, white-tailed deer and Canada geese, harmful algal bloom	Population impacted will depend on the type and severity of infestation and may cause an increased risk for disease outbreak or car strikes.		Physical impacts will be limited to indirect impacts from invasive species which affect crops, vegetation and trees. Compromised/falling trees may put buildings, infrastructure and public safety at risk.		Economic impact will depend on the type and severity of infestation and harmful algal bloom (i.e., recreation).		Moderate
Nor'Easter	100-Year and 500-Year Mean Return Period Events	Entire population exposed; the degree of impact to the population		Entire building stock is exposed; The degree of		100-Year MRP Estimated Damages	$69,703,663	Moderate

TETRA TECH

Hazard of Concern	Hazard/ Scenario Area Evaluated	Population		Buildings		Economy[a]		Certainty Factor
		depends on the scale of the incident.		impact depends on the scale of the incident.		500-Year MRP Estimated Damages	$304,905,184	
Severe Weather*	Tornado, Thunderstorm, Lightning, Hail, Strong Wind	Entire population exposed; the degree of impact to the population depends on the scale of the incident.		Entire building stock is exposed; The degree of impact depends on the scale of the incident.		Economic impacts depend upon the degree of impact.		High
Severe Winter Weather	Blizzard, Snow, Ice	All residents/commuters/visitors are exposed; socially-vulnerable populations may be at increased risk.		All buildings are exposed; the degree of impact depends on the scale of the incident and condition of structures.		The cost of snow and ice removal and repair of roads/infrastructure can impact operating budgets.		Moderate
Wildfire	Wildfire Fuel Hazard areas (High, Very High, Extreme)	Population residing in the hazard area:	3,786	Number of buildings the hazard area:	1,424	Replacement cost value of buildings located in the hazard area:	$1,205,629,442	Moderate
Utility Failure	Utility Outages from Hazard Events	All residents/commuters/visitors are exposed; socially-vulnerable populations may be at increased risk.		All buildings are exposed; the degree of impact depends on the scale of the incident.		Business and commercial losses due to long-term utility outages; repairs to power and utility lines.		Moderate

Notes:
a Estimated loss in replacement cost values as available from HAZUS-MH.
b The impacts and vulnerability from a hazardous materials event are greatly dependent on the material and its physical and chemical properties, the quantity released, weather conditions, micro-meteorological effects of buildings and terrain, maintenance/mechanical failures, and distance and related response time for emergency response teams.
** Hazus estimated potential losses based on probabilistic models for the wind hazard; refer to Hurricane.*
Exposed = This refers to the number of assets located in the hazard area; all of which may not incur losses as a result of the event.
MRP = Mean Return Period
SFHA = Special flood hazard area (1-percent annual chance flood event)
RCV = Replacement cost value based on 2021 RSMeans

Table 4.4-3 summarizes the projected changes in hazard event occurrences in terms of location, extent or intensity and frequency and/or duration. In addition, it lists the associated value assigned to each hazard in the risk factor calculation (i.e., confidence in changing future conditions). Refer to Sections 4.3.1 to 4.3.16 for a more detailed discussion of all factors of change discussed for each hazard of concern.

Table 4.4-3. Overview of Projected Future Changes for each Hazard of Concern

Hazard	Projected Change			Confidence in Changing Future Conditions [a]
	Location	Extent/ Intensity	Frequency/ Duration	
Coastal Erosion	-	-	-	Likely
Dam/ Levee Failure	-	-	-	Uncertain
Disease Outbreak	↑	↑	-	Likely
Drought	-	↑	↑	Likely
Earthquake	-	-	-	Likely
Extreme Temperature	-	↑	↑	Likely
Flood	↑	↑	↑	Highly Likely
Geological Hazards	-	-	-	Uncertain
Hazardous Materials	-	-	-	Uncertain
Hurricane and Tropical Storm	↑	↑	↑	Highly Likely
Infestation and Invasive Species	-	↑	↑	Likely
Nor'Easter	↑	↑	↑	Likely
Severe Weather	↑	↑	↑	Highly Likely
Severe Winter Weather	↑	↑	↑	Highly Likely
Wildfire	-	↑	↑	Likely
Utility Failure	↑	↑	↑	Likely

Notes:
Arrow direction indicates a projected increase or decrease based on literature review as described in Sections 4.3.1 through 4.3.16
— *Straight line indicates uncertain and/or no change known at this time.*
a Similar to confidence levels outlined in the National Climate Assessment 2018
Highly Likely = Studies and modeling projections indicate exacerbated conditions/increased future risk due to climate change; very high confidence level (strong evidence, well documented and acceptable methods).
Likely = Studies and modeling projections indicate a potential for exacerbated conditions due to climate change; confidence level is medium to high (suggestive to moderate evidence).
Uncertain = No local data is available; modeling projects are uncertain on whether there is increased future risk; confidence level is low (inconclusive evidence).
No Change = Studies and modeling projections indicate there is no evidence at this time to indicate conditions may change in the future.

4.4.1 Hazard Ranking Results

Using the process described above, the ranking for the identified hazards of concern was determined for Gloucester County (refer to Table 4.4-4). The hazard ranking is detailed in the subsequent tables that present the stepwise process for the ranking. The countywide ranking includes the entire planning area and may not reflect the highest risk indicated for any of the participating jurisdictions. The resulting ranks of each municipality indicate the differing degrees of risk exposure and vulnerability. The results support the appropriate selection and prioritization of initiatives to reduce the highest levels of risk for each municipality. Both the County and the participating jurisdictions have applied the same methodology to develop the countywide risk and local rankings to ensure consistency in the overall ranking of risk; jurisdictions had the ability to alter rankings based on local knowledge and experience in handling each hazard.

This hazard ranking exercise serves four purposes: 1) to describe the probability of occurrence for each hazard; 2) to describe the impact each would have on the people, property, and economy; 3) to evaluate the capabilities a community has with regards to the hazards of concern; and 4) to consider changing future conditions (i.e., climate change) in Gloucester County.

Table 4.4-4. Ranking for Hazards of Concern for Gloucester County

Hazard of Concern	Probability		Impact										Adaptive Capacity	Climate Change
			Population			Property			Economy					
	Category	Numeric Value	Impact	Numeric Value	Weighted Value (x3)	Impact	Numeric Value	Weighted Value (x2)	Impact	Numeric Value	Weighted Value (x1)	Total Impact Value		
Coastal Erosion	Occasional	2	L	1	3	L	1	2	L	1	1	6	Moderate	H
Dam/ Levee Failure	Occasional	2	M	2	6	M	2	4	M	2	2	12	Moderate	M
Disease Outbreak	Occasional	2	M	2	6	L	1	2	L	1	1	9	Moderate	M
Drought	Occasional	2	M	2	6	L	1	2	M	2	2	10	Moderate	H
Earthquake	Unlikely	0	M	2	6	M	2	4	M	2	2	12	Moderate	L
Extreme Temperature	Occasional	2	M	2	6	L	1	2	M	2	2	10	Moderate	H
Flood	Occasional	2	M	2	6	M	2	4	H	3	3	13	Moderate	H
Geological Hazards	Unlikely	0	L	1	3	L	1	2	L	1	1	6	Moderate	M
Hazardous Materials	Rare	1	H	3	9	H	3	6	H	3	3	18	Moderate	M
Hurricane and Tropical Storm	Occasional	2	M	2	6	M	2	4	M	2	2	12	Moderate	H
Infestation and Invasive Species	Occasional	2	L	1	3	L	1	2	M	2	2	7	Moderate	H
Nor'Easter	Frequent	3	M	2	6	L	1	2	L	1	1	9	Moderate	H
Severe Weather	Frequent	3	H	3	9	L	1	2	M	2	2	14	Moderate	H
Severe Winter Weather	Frequent	3	H	3	9	L	1	2	L	1	1	12	Moderate	M
Wildfire	Frequent	3	L	1	3	M	2	4	L	1	1	8	Moderate	M
Utility Failure	Frequent	3	M	2	6	L	1	2	M	2	2	10	Moderate	M

H = High; L = Low; M = Medium

Table 4.4-5 presents the total calculations for each hazard ranking value for the hazards of concern.

Table 4.4-5. Total Hazard Ranking Values for the Hazards of Concern for Gloucester County

Hazard of Concern	Probability x 30%	Total Impact x 30%	Adaptive Capacity x 30%	Changing Future Conditions x 10%	Total Hazard Ranking Value
Coastal Erosion	0.6	1.8	0	0.3	2.7
Dam/ Levee Failure	0.6	3.6	0	0.2	4.4
Disease Outbreak	0.6	2.7	0	0.2	3.5
Drought	0.6	3	0	0.3	3.9
Earthquake	0	3.6	0	0.1	3.7
Extreme Temperature	0.6	3	0	0.3	3.9
Flood	0.6	3.9	0	0.3	4.8
Geological Hazards	0	1.8	0	0.2	2
Hazardous Materials	0.3	5.4	0	0.2	5.9
Hurricane and Tropical Storm	0.6	3.6	0	0.3	4.5
Infestation and Invasive Species	0.6	2.1	0	0.3	3
Nor'Easter	0.9	2.7	0	0.3	3.9
Severe Weather	0.9	4.2	0	0.3	5.4
Severe Winter Weather	0.9	3.6	0	0.2	4.7
Wildfire	0.9	2.4	0	0.2	3.5
Utility Failure	0.9	3	0	0.2	4.1

Low = Values less than 3.9; Medium = Values between 3.9 and 4.9; High = Values greater than 4.9

These rankings have been used as one of the bases for identifying the jurisdictional hazard mitigation strategies included in Section 9 (Jurisdictional Annexes) of this plan. The summary rankings for the County reflect the results of the vulnerability analysis for each hazard of concern and vary from the specific results of each jurisdiction. For example, the severe storm hazard may be ranked low in one jurisdiction, but due to the exposure and impact countywide, it is ranked as a high hazard and is addressed in the County's mitigation strategy accordingly. Jurisdictional ranking results are presented in each local annex in Section 9 (Jurisdictional Annexes) of this plan.

SECTION 5. CAPABILITY ASSESSMENT

2022 HMP Changes

- In the 2017 NJ4HMP, the capability assessment section was presented in Section 4 as part of the mitigation strategy. For the 2022 HMP update, the capability assessment was expanded and presented in Section 5 as a stand-alone section with capabilities expanded in each jurisdictional annex as well (Section 9 [Jurisdictional Annexes]).

According to FEMA's Mitigation Planning How-To Guide #3, a capability assessment is an inventory of a community's missions, programs, and policies and an analysis of its capacity to carry them out. Each jurisdiction has a unique set of capabilities available to accomplish mitigation and reduce long-term vulnerable to future hazard events. Capabilities include authorities, policies, programs, staff, and funding. Reviewing existing capabilities helps identify capabilities that currently implement mitigation and leads to loss reductions or that have the potential to be implemented in the future.

This assessment is an integral part of the planning process. The assessment process enables identification, review, and analysis of current federal, state, and local programs, policies, regulations, funding, and practices that could either facilitate or hinder mitigation.

During the original planning process, the county and all jurisdictions identified and assessed their capabilities in the areas of planning and regulatory, administrative, and technical, and fiscal. By completing this assessment, the Planning Committee and each jurisdiction learned how or whether they would be able to implement certain mitigation actions by determining the following:

- Limitations that could exist on undertaking actions.
- The range of local and state administrative, programmatic, regulatory, financial, and technical resources available to assist in implementing their mitigation actions.
- Actions deemed infeasible, as they are currently outside the scope of capabilities.
- Types of mitigation actions that could be technically, legally (regulatory), administratively, politically, or fiscally challenging or infeasible.
- Opportunities to enhance local capabilities to support long term mitigation and risk reduction.

During the 2022 plan update process, all participating jurisdictions were tasked with developing or updating their capability assessment, paying particular attention to evaluating the effectiveness of these capabilities in supporting hazard mitigation and identifying opportunities to enhance local capabilities to integrate hazard mitigation into their plans, programs, and day-to-day operations.

County and municipal capabilities in the areas of planning and regulatory, administrative and technical, and fiscal may be found in the Capability Assessment section of their jurisdictional annexes in Section 9 (Jurisdictional Annexes).

5.1 UPDATE PROCESS SUMMARY

The purpose of the capability assessment is to understand the planning, regulatory, administrative, technical, and financial capabilities present in Gloucester County. This assessment helps the County and its jurisdictions identify strengths and opportunities that can be used to reduce losses from hazard events and reduce risks throughout Gloucester County.

To complete the capability assessment, the contracted consultant met with Gloucester County and each municipality virtually to review the capability assessment from the 2016 HMP and update accordingly. In addition to virtual meetings, the consultant reviewed plans and codes/ordinances to enhance the information provided by the jurisdictions.

A summary of the various federal and state capabilities available to promote and support mitigation and reduce risk in Gloucester County are presented below. Information provided by the County and municipalities are presented in Volume II, Section 9 (Jurisdictional Annexes) of this plan update.

5.2 PLANNING AND REGULATORY CAPABILITY

Planning and regulatory capabilities are based on the implementation of ordinances, policies, local laws and state statutes, and plans and programs that relate to guiding and management growth and development. Planning and regulatory capabilities refer not only to the current plans and regulations, but also to the jurisdiction’s ability to change and improve those plans and regulations as needed. The following provides the planning and regulatory capabilities for Gloucester County.

5.2.1 Planning and Regulatory Capabilities – County and Local

The following table summarizes the planning and regulatory capabilities available to Gloucester County, at the county and local level.

Table 5-1. Planning and Regulatory Capabilities – County and Local

Capability	Details	
Land Use Planning Policy	**Description:**	State of New Jersey Municipal Land Use Law L.1975, c. 291, s. 1, eff. Aug. 1, 1976, is the legislative foundation for the land use process, including decisions by Planning Boards and Zoning Boards of Adjustment, in the State of New Jersey. It defines the powers and responsibilities of boards and is essential to their functions and decisions. It also provides the required components of a municipal Master Plan. Every municipal agency shall adopt and may amend reasonable rules and regulations, not inconsistent with this act or with any applicable ordinance, for the administration of its functions, powers, and duties. These plans help jurisdictions review their land use plans and policies with public participation. The Municipal Land Use Law requires that each municipality prepare a comprehensive plan and update that plan every 6 years. The board of chosen freeholders may create a county planning board of not less than five nor more than nine members. The county planning board shall make and adopt a master plan for the physical development of the county. The master plan of a county, with the accompanying maps, plats, charts, and descriptive and explanatory matter, shall show the county planning board's recommendations for the development of the territory covered by the plan, and may include, among other things, the general location, character, and extent of streets or roads, viaducts, bridges, waterway and waterfront developments, parkways, playgrounds, forests, reservations, parks, airports, and other public ways, grounds, places and spaces; the general location and extent of forests, agricultural areas, and open development areas for purposes of conservation, food and water supply, sanitary and drainage facilities, or the protection of urban development, and such other features as may be important to the development of the county. The county planning board shall encourage the co-operation of the local municipalities within the county in any matters whatsoever which may concern the integrity of the county master plan and to advise the board of chosen freeholders with respect to the formulation of development programs and budgets for capital expenditures.
	Responsible Agency:	Local Planning Boards, Zoning Boards of Adjustment, and County Planning Board
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
gc2040, Community Visioning for Gloucester County	**Description:**	Gloucester County, New Jersey is in the midst of an extensive planning effort to update its County Master Plan, a public document reflecting the community's vision for how it should grow and change over time. There is urgency to this effort as the county has changed significantly since 1982, the date of the most recent plan, and will continue to experience significant development pressure over the next 25 years, the horizon for this planning process.

Capability	Details	
		Determining the Community Vision is the first step in the Master Plan update process as it describes the future the community wants. A Master Plan is a public document that reflects a community's vision for how it should grow and change over time. It usually covers a long-term time period–in this case, Gloucester County is planning for its future growth and development 25 years into the future. A Master Plan provides a framework within which to evaluate the community's progress toward its goals. Updating Gloucester County's Master Plan is critical–it was last updated in 1982 and is no longer consistent with current federal, state, regional, and municipal plans, and it does not reflect best practices in planning and management. Furthermore, because the plan is outdated. Gloucester County enlisted DVRPC's Office of Smart Growth to conduct public outreach to develop the Community Vision in order to update its County Master Plan.
	Responsible Agency:	Planning Board, Board of Chosen Freeholders
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Gloucester County Open Space and Farmland Preservation Programs	**Description:**	The objective of the Open Space Preservation Program is to expand the existing county and municipal park system in Gloucester County. Through this program the county has been able to expand all three county parks: Red Bank Battlefield in National Park, the James G. Atkinson Park in Washington Township and the Scotland Run Park in Clayton and Franklin Townships along with five additions of lands adjacent to the County golf course and greenway in Mantua Township. The County also assists municipalities in the purchase of recreational lands through this program. Funds can be used to purchase new parks, expand existing ones or develop greenways. In 2015, the office of Land Preservation, in cooperation with the State Green Acres Program, Mantua Township, and the South Jersey Land and Water Trust, was able to preserve the former Maple Ridge Golf Course in Mantua and Deptford Townships to create the Tall Pines State Preserve, the first state park in Gloucester County. The objective of the Farmland Preservation Program is to purchase development rights on farms so that the land is permanently preserved and restricted to only agricultural uses. Our office coordinates all acquisitions in accordance with the regulations set by the New Jersey State Agriculture Development Committee (SADC). The office also oversees the state and municipal eight-year development easement programs. Currently there are over 300 farms totaling more than 21,000 acres in farmland preservation.
	Responsible Agency:	County Planning Board and Freeholders
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards

<table>
<tr><th>Capability</th><th colspan="2">Details</th></tr>
<tr><td rowspan="4">Connections 2050 Plan for Greater Philadelphia, September 2021</td><td>Description:</td><td>The Connections 2050 Plan is a nine County greater Philadelphia regional plan. Five are Pennsylvania counties and four New Jersey counties, including Gloucester County.

The Plan is about transportation infrastructure. Infrastructure underpins the society and economy that makes much of what gets done possible. In order for the transportation network to continue to serve the region's residents and its economy, and to find the means to invest to modernize and improve the condition of the infrastructure, coordination is necessary across public and private sectors to make the necessary safety, information, multimodal, and reliability improvements needed for the digital age. At the same time, climate change and shifting ideologies around equity are joining with the Digital Revolution to drive change and reshape the region's economy, along with its environment, land use and communities, and the transportation network. DVRPC and its partners look forward to being a part of the dialogue and doing our part in making all these areas more equitable, sustainable, and resilient. A major focus going forward will be to incorporate the Plan's strategies into projects and investments undertaken throughout the nine-county region and to ensure that decision-making is consistent with the Plan's vision and goals. Many of the strategy recommendations contained within the Plan are for the region, and go beyond what DVRPC and its planning partners can do on their own. As a result, it is critical to continue to coordinate and build partnerships across the public and private sectors, as well as at the individual level to help implement the Plan.</td></tr>
<tr><td>Responsible Agency:</td><td>The DVRPC and the four NJ participating counties.</td></tr>
<tr><td>Provides Funding for Mitigation:</td><td>No</td></tr>
<tr><td>Hazard:</td><td>Climate Change and Sea Level Rise, Flood, Severe Weather</td></tr>
<tr><td>United We Ride Plan (2007)</td><td>Description:</td><td>In the State of New Jersey, NJ Transit assigned the responsibility for developing local United We Ride transportation plans to counties. Assigning this responsibility to counties was consistent with the current overall delivery of human services transportation since New Jersey law requires counties to develop an annual application to receive casino tax revenues through the Senior Citizen and Disabled Resident Transportation Assistance Program (SCDRTAP).

The following are the essential components of the UWR coordination plan:
o Designate lead contact by governing body
o Convene group of local stakeholders to participate in the development of a local plan based upon the "Framework for Action Self-Assessment for Communities"
o Conduct an analysis of transportation needs for people with disabilities, older adults and low-income residents
o Prepare an inventory of available resources and services
o Identify service gaps and duplication of services
o Identify coordination opportunities to address service gaps and attain service efficiencies
o Develop strategies for more efficient utilization of resources</td></tr>
</table>

Capability	Details	
		○ Prioritize implementation strategies Opportunities abound for transportation services to be improved throughout Gloucester County. From public transit initiatives, to initiatives in the area of paratransit, there continues to be a tremendous social and economic value to improving the current network of transportation services. Socio-economic factors such as: people living longer, people with disabilities being more active and working, working poor trying to get to their job, suburban employers, and increasing traffic congestion; all contribute to the conclusion that we need to invest in our transportation network. These factors suggest that additional well-placed investment is needed now, since waiting will result in diminished opportunity and only greater challenges ahead.
	Responsible Agency:	Board of Chosen Freeholders
	Provides Funding for Mitigation:	No
	Hazard:	Hurricane and Tropical Storm, Nor'Easter
Gloucester County Comprehensive Economic Development Strategy (CEDS) 2014	**Description:**	In 2008, Gloucester County adopted a Comprehensive Economic Development Strategy or CEDS. Two years later, the County prepared an Addendum to that CEDS which updated various goals, objectives and projects. This document represents an additional addendum or update to the 2008 CEDS. Gloucester County began 2013 with an unemployment rate well above the national average at 10.3%. As of April 2014 (the latest month for which N.J. Department of Labor figures are available) the unemployment rate had dropped to 6.6%. While not a short term strategy or plan, the CEDS is a vehicle for channeling U.S. Economic Development Administration (U.S. EDA) funds and other development financing to initiate projects that are essential for the county to attract, grow and sustain new business and industry. The following six (6) broad goals reflect the 2014 CEDS Plan priorities: 1. Work to expand and diversify the County's economic base to provide a broader range of new jobs and a more viable mix of industries. 2. Preserve existing jobs and industry and reduce unemployment, municipal distress and economic inequities throughout the County. 3. Focus development and jobs around centers of employment and population with an emphasis on the revitalization of the downtowns and the redevelopment of brownfield and underutilized commercial and industrial properties. 4. Improve the public transportation, highway circulation systems and public utilities access in the County to serve businesses and commercial centers more effectively.

Capability	Details	
		5. Enhance and coordinate Municipal, County and Regional marketing efforts to promote Gloucester County as a destination for new business. 6. Explore new opportunities for funding industrial and business development.
	Responsible Agency:	Board of Chosen Freeholders
	Provides Funding for Mitigation:	No
	Hazard:	Climate Change and Sea Level Rise, Flood, Severe Weather
Annual Report, Gloucester County Department Of Health (2017)	**Description:**	The Gloucester County Department of Health partners closely throughout the year with all 24 municipalities to provide a range of Nursing, Special Child Health and WIC activities, Consumer and Environmental Health services, public health information and health education sessions and Preparedness readiness efforts. The Gloucester County Department of Health has adopted the ten essential services of public health listed below, which guide our daily actions: 1. Monitor the health status of the community. 2. Investigate and diagnose health problems and hazards. 3. Inform and educate people regarding health issues. 4. Mobilize community partnerships to solve community problems. 5. Support policies and plans to achieve health goals. 6. Enforce laws and regulations to protect health and safety. 7. Link people to needed personal health services. 8. Ensure a skilled, competent public health workforce. 9. Evaluate effectiveness, accessibility and quality of health services. 10. Research and apply innovative solutions. The Gloucester County Department of Health remains committed to serving our residents with the guiding principles of HEALTH in mind, aspiring to deliver program assistance that is: Helpful; Excellent; Accountable; as Leaders in public health; with Teamwork; all while encouraging Healthy behaviors. 2018 Goals and objectives have been designed to advance the Department forward in achieving our Vision to "Strive for a healthier Gloucester County". With an overarching mission to: Prevent illness and injury; Promote positive health behaviors; Protect people and the environment; and Prepare for public health emergencies, this Department offers a multitude of programs and services.
	Responsible Agency:	Gloucester County Department of Health
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards

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Capability	Details	
Continuity of Operations Plan (COOP)	**Description:**	Continuity of Operations (COOP) planning is essential to ensure that the County can continue to function and provide services to its citizens following an emergency, disaster, or incident that disrupts the County's normal operations. Gloucester County is in need of the development of a single, County-level COOP Plan that prioritizes the County's critical functions and provides strategies for carrying these out during periods of disruption.
	Responsible Agency:	OEM
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Soil Survey of Gloucester County, New Jersey	**Description:**	Gloucester County is in southern New Jersey (fig. 1). It is along the southeast side of the Delaware River, south of the city of Camden. The county comprises about 215,500 acres, or nearly 337 square miles. It is in the Outer Coastal Plain and Inner Coastal Plain Physiographic Regions. This soil survey updates an earlier survey of Gloucester County (USDA SCS 1962). It provides a digital soil survey on orthophotography and contains additional interpretive information. The soils and miscellaneous areas in Gloucester County are in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the county and relating their position to specific segments of the landform, a soil scientist develops a concept or model of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.
	Responsible Agency:	Gloucester County Soils Division
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Floodplain Management Policy	**Description:**	New Jersey State Law Flood Hazard Area Control Act (NJSA 58:16A-52): The Act and regulations attempts to minimize damage to life and property from flooding caused by development within fluvial and tidal flood hazard areas, to preserve the quality of surface waters, and to protect the wildlife and vegetation that exist within and depend upon such areas for sustenance and habitat. While it does not require local adoption, as it is enforced by the NJDEP, the floodplain ordinances of each municipality need to be reviewed to be in compliance with this new regulation. All municipalities participate in the NFIP and have a Floodplain Ordinance. Communities are encouraged to adopt standards which exceed NFIP requirements. The State's minimum design base flood elevation is 1 foot above the designated base flood elevation.
	Responsible Agency:	NFIP, NJDEP
	Provides Funding for Mitigation:	No

Capability	Details	
	Hazard:	Flood
Building Codes Policy	**Description:**	Uniform Construction Code (Uniform Construction Code Act of 1975 [UCC]) is State mandated on local level under NJAC 5:23-3.14. International Building Code – New Jersey Edition, 2018, NJAC 5:24-3.14 Adopted 9/3/2019. The UCC adopts up-to-date building codes as its Building Subcode and One- and Two-Family Subcode. These Subcodes contain requirements that address construction in both A and V flood zones. Building and Fire codes mandate best practices and technology, much of which is designed to reduce or prevent damage from occurring when structures are under stress. New Jersey State Law requires that all municipalities adopt ordinances that follow the UCC. In January 2013, the State established by emergency rule the best available data from FEMA's latest flood maps, plus one foot of freeboard, as the general rebuilding standard to adapt to changing flood hazard risks and corresponding federal flood insurance rates. All municipalities in Gloucester County have an active building code.
	Responsible Agency:	Local Building Departments
	Provides Funding for Mitigation:	No
	Hazard:	Flood, Hurricane and Tropical Storm
Emergency Management Plan	**Description:**	According to State Police Directive 101, each County and municipality shall prepare, adopt and maintain an Emergency Operation Plan that meets the requirements of the State Emergency Operations Plan guidelines and checklist. The plan describes the hazards faced by the jurisdiction as well as the jurisdictions capabilities, needs, demands and emergency management structure. Gloucester County and each municipality have an Emergency Operations Plan.
	Responsible Agency:	County and Local Offices of Emergency Management
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Climate Change Vulnerability And Risk Assessment of New Jersey's Transportation Infrastructure (December 2011)	**Description:**	The primary objective of this project is to pilot the Federal Highway Administration's (FHWA) vulnerability and risk assessment Conceptual Model using New Jersey as a case study, providing feedback for the advancement of the Conceptual Model as well as a heightened awareness and understanding of the potential effects of climate change on transportation infrastructure in New Jersey. The project was led by the North Jersey Transportation Planning Authority (NJTPA). The Conceptual Risk Assessment Model was developed to assist transportation agencies in identifying infrastructure at risk for exposure to climate change stressors and determining which threats carry the most significant consequences. It incorporates the following summary steps: 1. Build an inventory of relevant assets and determine which are critical; 2. Gather information on potential future climate scenarios; 3. Assess the potential vulnerability and resilience of critical assets.

Capability	Details	
		A portion of the study is conducted for the Central Study Area to quantify the potential impact of climate change on the exiting riverine 1% annual chance floodplain. The central study area covers portions of Burlington, Camden, Gloucester, Mercer, Salem and Middlesex Counties, NJ. The impact of climate change on the riverine floodplain has been assessed through analysis of the effects of extreme precipitation as well rising temperatures. In this analysis, years 2050 and 2100 were considered.
	Responsible Agency:	NJTPA
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Best Management Practices for Creating and Maintaining Wildfire Fuelbreaks in New Jersey's Wildland Urban Interface, 2011	**Description:**	In New Jersey, residential communities and development continue to spread into new, previously undisturbed natural areas which create a "Wildland Urban Interface" (WUI) - where rural land and developed areas meet. This fragmented rural landscape has greater ignition sources and more frequent fires, which makes it difficult for the Forest Fire Service to manage land for wildfire protection and preparedness. This problem can be seen throughout the country and in New Jersey, especially with the state having such a rapidly growing population. In a study done by the American Planning Association, 46 percent of homes in New Jersey are located in the Wildland Urban Interface, which stresses the importance of the problem in New Jersey.
	Responsible Agency:	Federal, State & County
	Provides Funding for Mitigation:	No
	Hazard:	Wildfires

5.2.2 Planning and Regulatory Capabilities – Federal and State

The following table summarizes the planning and regulatory capabilities available to Gloucester County, at the federal and state level.

Table 5-2. Planning and Regulatory Capabilities – Federal and State

Capability	Details	
Disaster Mitigation Act (DMA)	**Description:**	The DMA is the current federal legislation addressing hazard mitigation planning. It emphasizes planning for disasters before they occur. It specifically addresses planning at the local level, requiring plans to be in place before Hazard Mitigation Assistance grant funds are available to communities. This plan is designed to meet the requirements of DMA, improving eligibility for future hazard mitigation funds.
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	HMPs designed to meet the requirements of DMA will remain eligible for future FEMA Hazard Mitigation Assistance funds

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Capability	Details	
	Hazard:	All-natural hazards
National Flood Insurance Program (NFIP)	**Description:**	The NFIP is a federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses in exchange for state and community floodplain management regulations that reduce future flood damages. The Flood Hazard Profile in Section 4.3.6 (Flood) provides information on recent legislation related to reforms to the NFIP. All municipalities in Gloucester County actively participate in the NFIP. As of April 2021, there were 924 policies in Gloucester County. There have been 617 claims made, totaling over $4 million for damages to structures and contents. There are 64 NFIP Repetitive Loss properties and 1 Severe Repetitive Loss property in the County.
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Full compliance and good standing under the NFIP are application prerequisites for all FEMA grant programs for which participating jurisdictions are eligible under this plan.
	Hazard:	Flood
NFIP Community Rating System (CRS)	**Description:**	As an additional component of the NFIP, CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS: (1) reduce flood losses, (2) facilitate accurate insurance rating, and (3) promote the awareness of flood insurance. Municipalities, and the county as a whole, could expect significant cost savings on premiums if enrolled in the CRS program. As of October 2021, 2 communities in Gloucester County participate in the CRS program. • Township of Greenwich, Class 9 • Borough of National Park, Class 8 Other communities in Gloucester County have noted they are exploring the possibility of participating in the program in the future.
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	CRS premium discounts on flood insurance range from 5 percent for Class 9 communities up to 45 percent for Class 1 communities.
	Hazard:	Flood
Municipal Land Use Law	**Description:**	The State of New Jersey Municipal Land Use Law, MLUL (L.1975, c. 291, s. 1, effective August 1, 1976) is the legislative foundation for the land use process in the State of New Jersey, including decisions by Planning Boards and Zoning Boards of Adjustment. It defines the powers and responsibilities of boards and is essential to their functions and decisions. It also provides the required components of a municipal master plan.

Capability	Details	
		Every municipal agency must adopt and can amend reasonable rules and regulations, consistent with this act or with any applicable ordinance, for the administration of its functions, powers, and duties. These plans help jurisdictions review their land use plans and policies with public participation. In 2017 the MLUL was amended to add a new subparagraph (f) to N.J.S.A. 40-55D-28.b.(2), which requires that any land use plan element adopted after the amendment include a statement of strategy concerning, smart growth, storm resiliency, and environmental sustainability. This section of the MLUL was further amended on February 4, 2021 to require that any land use plan element of the master plan adopted or amended after that date, must include a climate change-related hazard vulnerability assessment which shall include an analysis of current and future threats to ,and vulnerabilities of the municipality associated with climate change-related hazards, including many of those identified in this Hazard Mitigation Plan update. The Municipal Land Use Law requires that each municipality prepare a comprehensive plan and update that plan every 10 years.
	Responsible Agency:	State of New Jersey
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
State of New Jersey Hazard Mitigation Plan (2019 Update)	**Description:**	The State of New Jersey HMP includes an evaluation of the state's overall pre- and post-hazard mitigation policies, programs, and capabilities; the policies related to development in hazard-prone areas; and the state's funding capabilities. The State of New Jersey HMP thoroughly describes the federal and state programs available to Gloucester County to promote mitigation. The State of New Jersey HMP was used as a resource in developing Gloucester County's HMP update.
	Responsible Agency:	NJOEM
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Critical Area Protection Policy	**Description:**	The following NJDEP programs both protect critical natural resources, and provide funding for the State, municipalities, and counties to purchase land for open-space preservation and recreation, which may directly or indirectly support hazard mitigation efforts: • Green Acres Program • Blue Acres Program • Historical Preservation Program • Farmland Preservation • Wetlands Act of 1970 (N.J.S.A. 13:9A) • Soil and Erosion and Sediment Control Act (N.J.S.A. 4:24)

Capability	Details	
		The Wetlands Act of 1970 (N.J.S.A. 13:9A) provide rules and regulations governing development in wetland areas of New Jersey. New Jersey has 15 soil conservation districts, following county boundaries that implement the New Jersey Soil Erosion and Sediment Control Act (N.J.S.A. 4:24), which governs certain aspects of new development. Both the Farmland and Open Space Preservation Programs are funded partially through grants administered by the NJ State Agriculture Development Committee and the New Jersey Green Acres Program. The objective of the Open Space Preservation Program is to expand the existing county and municipal park system in Gloucester County. Through this program the county has been able to expand all three county parks: Red Bank Battlefield in National Park, the James G. Atkinson Park in Washington Township and the Scotland Run Park in Clayton and Franklin Townships along with five additions of lands adjacent to the County golf course and greenway in Mantua Township. Gloucester County also uses a voter-supported County Open Space Tax for land preservation acquisitions. Gloucester County voters over the years have approved a $0.04 supplement to the fund, indicating their support of the County's land preservation program and improvements to the County's current open space properties. In addition, the Board of County Commissioners has passed a number of bond acts over the years as needed to supplement the County fund. By implementing this proactive tactic, County residents are ensured of the continuation of our rich and thriving agricultural heritage (County 2021).
	Responsible Agency:	County
	Provides Funding for Mitigation:	Yes. The Open Space Fund program provides funding to acquire land and properties and turn into open space and preserve as farmland
	Hazard:	Flood, Severe Weather
Uniform Construction Code (UCC)	**Description:**	Building codes mandate best practices and technology, much of which is designed to reduce or prevent damage from occurring when structures are under stress. The UCC adopts up-to-date building codes as its Building Subcode and One- and Two-Family Subcode. These Subcodes contain requirements that address construction in both A and V flood zones. Also, all new construction is required to comply with the UCC for flood zone construction. New Jersey has enacted legislation directing the Department of Community Affairs (NJ DCA) to adopt a radon hazard code or revise the state building code to establish “adequate and appropriate standards to ensure that schools and residential buildings within tier one areas [as defined by the state] … are constructed in a manner that minimizes radon gas and radon progeny entry and facilitates any subsequent remediation that might prove necessary.” See N.J. Stat. Ann. 52:27D-123a.

Capability	Details	
		The Department then adopted a radon hazard sub-code which does not reference existing model standards or guidance, but which sets forth the basic requirements for a passive sub-slab or sub-membrane depressurization system. See N.J. Admin. Code 5:23-10.4. The radon control standards and procedures apply to new residential construction (and school construction) in "tier one" areas, as defined by the state, and Appendix 10-A of the sub-code lists the specific municipalities that are designated as tier one areas.
	Responsible Agency:	NJ DCA
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Floodplain Management Policy	**Description:**	New Jersey State Law Flood Hazard Area Control Act (NJSA 58:16A-52): The Act and regulations attempts to minimize damage to life and property from flooding caused by development within fluvial and tidal flood hazard areas, to preserve the quality of surface waters, and to protect the wildlife and vegetation that exist within and depend upon such areas for sustenance and habitat. While it does not require local adoption, as it is enforced by the NJDEP, the floodplain ordinances of each municipality need to be reviewed to be in compliance with this new regulation.
	Responsible Agency:	New Jersey Department of Environmental Protection (NJDEP)
	Provides Funding for Mitigation:	No
	Hazard:	Flood
Growth Management Policy	**Description:**	Land preservation and recreation comprise one of the cornerstones of New Jersey's smart growth policy. The New Jersey Statewide Comprehensive Outdoor Recreation Plan provides Statewide policy direction to the State, local governments, and conservation organizations in the preservation of open space and the provision of public recreation opportunities. The State Plan was prepared and adopted by the State Planning Commission according to the requirements of the State Planning Act of 1985 as amended (NJSA 52:18A-196 et seq.) to serve as an instrument of State policy to guide State agencies and local government in the exercise of governmental powers regarding planning, infrastructure investment and other public actions and initiatives that affect and support economic growth and development in the State. Green Acres Program, Open Space Tax Program, and Development and Redevelopment Plan. The State Planning Act has enhanced the traditionally limited role of county land-use planning and control. Also provides tools for municipalities when preparing their master land use plans and better opportunity for a comprehensive approach to planning so not to harm or be in conflict with neighboring Municipalities' plans. New Jersey's Smart growth is growth that serves the environment, the economy, and the community equally. It attempts to concentrate development into already-existing communities when possible, and it addresses the inherent interconnections between environmental protection, social equity, public health, and economic sustainability.

Capability	Details	
	Responsible Agency:	State Planning Commission
	Provides Funding for Mitigation:	No
	Hazard:	All
U.S. Army Corps of Engineers – Dam Safety Program	**Description:**	The U.S. Army Corps of Engineers (USACE) is responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. USACE has inventoried dams and has surveyed each state and federal agency's capabilities, practices, and regulations regarding design, construction, operation, and maintenance of the dams. USACE has also developed guidelines for inspection and evaluation of dam safety (USACE 1997).
	Responsible Agency:	USACE
	Provides Funding for Mitigation:	Yes
	Hazard:	Flood

5.3 ADMINISTRATIVE AND TECHNICAL CAPABILITIES

Table 5-3 summarizes the administrative and technical capabilities in Gloucester County. Detailed information regarding administrative and technical capabilities in the County and the municipalities can be found in each jurisdictional annex found in Volume II, Section 9 (Jurisdictional Annexes).

Table 5-3. Administrative and Technical Capability – County and Local

Capability		
Gloucester County Department of Emergency Response	**Description:**	The mission of the Department of Emergency Response is centered on the advancement of the quality of life for the people of Gloucester County. In this regard, the department protects and enhances the safety and interests of every citizen of Gloucester County through an integrated system of public safety services and represents the interests of the county and its agencies in all public safety matters. The Gloucester County Office of Emergency Response is comprised of: • County Emergency Medical Services (EMS), Fire, EMS and Police Communications • County Radio Repair • Emergency Management • The Fire Marshal's Office • Hazardous Materials Response Team (CBRNE)

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<table>
<tr><th>Capability</th><th colspan="2"></th></tr>
<tr><td rowspan="4"></td><td></td><td>The Office of 911
Emergency Management led the 2022 update of the County’s Hazard Mitigation Plan and served on the Steering Committee throughout the planning process.</td></tr>
<tr><td>Responsible Agency:</td><td>Gloucester County Office of Emergency Management</td></tr>
<tr><td>Provides Funding for Mitigation:</td><td>Provides grant administration assistance</td></tr>
<tr><td>Hazard:</td><td>All Hazards</td></tr>
<tr><td rowspan="4">Gloucester County Planning Division</td><td>Description:</td><td>The Planning Division is responsible for the County's comprehensive planning: preparing, maintaining, and updating the County Master Plan and its various elements. Additional responsibilities include:
The Division also serves as a coordinator and advisor for municipal planning
In the area of transportation, the Division is responsible for a number of local and regional transit planning activities, as well as providing planning services for highway improvements. The division also applies for state and federal grants
The Division's environmental planning supports a number of activities related to improving and/or maintaining the County's environmental quality. These include, but are not limited to:
Air quality
Groundwater monitoring
Hazardous waste
Stormwater management
Water supply
Watershed planning
The Planning Division also serves as an affiliate for the New Jersey State Data Center
The Division is a resource center for data management and mapping (geographic information systems/GIS), providing information to other agencies, municipalities, and the public
The Division serves as staff to the County Planning Board, processing all site plans and subdivisions within the county
The Division represents the County at various levels including the:
Delaware Valley Regional Planning Commission (DVRPC)
South Jersey Resource Conservation and Development Council
State Planning Commission
Tri-County Water Quality Management Board</td></tr>
<tr><td>Responsible Agency:</td><td>Gloucester County Planning Division</td></tr>
<tr><td>Provides Funding for Mitigation:</td><td>Provides grant administration assistance</td></tr>
<tr><td>Hazard:</td><td>All Hazards</td></tr>
</table>

Capability		
Gloucester County Department of Public Works	**Description:**	The Gloucester County Public Works Department consists of four divisions: engineering, fleet management, highway, and planning. The Office of the County Engineer has the following principal responsibilities: • Direction of capital projects involving county roads, bridges, traffic control, and drainage. Provide in-house design or oversee consultants. Complete control of projects from conception, including: ○ Budgeting ○ Construction ○ Design ○ Inspection ○ Permitting ○ Related survey work • Bridge inspection and dam inspection for County owned facilities • Review of engineering of developers' plans submitted to the County Planning Board, relating to drainage affecting County roads and traffic safety • Investigation of all traffic problems on County roads including speed limits, traffic control devices, pavement markings, signs, etc. • Investigation of drainage problems and recommendation as to solution for County owned facilities • Coordination with New Jersey Department of Transportation and New Jersey Department of Environmental Protection for County projects • Installation, operation and maintenance of traffic signals on County roads • Provide land surveying services to the County The Gloucester County Office of Fleet Management is responsible for the repair and maintenance of all County owned vehicles, heavy-duty equipment and miscellaneous power equipment. The Office of Fleet Management also provides and ensures that all County departments have sufficient and reliable transportation in order to perform their assigned duties The Highway Division coordinates work programs under the direction of the Board of County Commissioners and the Director of Public Works. The Highway Division is involved with road and bridge maintenance repairs, this includes construction and reconstruction (asphalt overlay) of roads, and snow and ice control. The division also maintains drainage pipes, and culverts.

Capability		
		The department is responsible for the issuance of Road Opening Permits and the inspection of road openings and new accesses onto County roads. The Highway Division is responsible for maintaining a safe and secure County public roadway system for various modes of transportation. The primary function of the Highway Division is the operation, maintenance, and improvement of the County's 410 miles of road and 85 bridges. Administration and supporting activities are handled at our Clayton Complex. Maintenance functions are provided through our satellite yards in Mantua and Swedesboro. The division's highest priority is to provide the needed routine maintenance to protect the investment in existing roads and bridges. As described above, the Planning Division is responsible for the County's comprehensive planning: preparing, maintaining, and updating the County Master Plan and its various elements.
	Responsible Agency:	Gloucester County Department of Public Works
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Gloucester County Department of Health	**Description:**	The Gloucester County Department of Health is a service agency which operates under the auspices of the Gloucester County Board of Chosen Freeholders. By contract with all 24 municipalities, the Department of Health provides: a range of nursing activities, environmental health services, public health information, and health education sessions to all residents of Gloucester County. Many of these services focus upon protecting persons from health threats and assist our residents to adopt healthful lifestyles. Most of these programs are provided to county residents at no charge. The Environmental Health Division of the Department of Health provides technical assistance and enforces public health and environmental laws to ensure the protection of the environment and the health and safety of our residents.
	Responsible Agency:	Gloucester County Department of Health
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Gloucester County Division of Social Services	**Description:**	The Gloucester County Division of Social Services (formerly the Gloucester County Board of Social Services) was established in 1932 under the New Jersey Statutes Annotated, Title 44 to provide for widows and children. Through the years it has expanded to include many more services such as: • Cash assistance to families and adults • Child Support and Paternity • Emergency assistance and employment support activities • Food Stamps • Medicaid

Capability		
		It is the mission and the responsibility of the Gloucester County Division of Social Services to provide an opportunity for self-sufficiency to individuals and families through economic and social service programs designed for this purpose. The Division and its employees are committed to offering these services in an atmosphere of mutual trust and respect without regard to race, creed, disability, sex or national origin. The Division of Social Services is also dedicated to provide timely, efficient, cost-effective delivery of social, medical and economic programs in a compassionate and financially responsible manner.
	Responsible Agency:	Gloucester County Division of Social Services
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Gloucester County Utilities Authority	**Description:**	The Gloucester County Utilities Authority (GCUA) is a regional wastewater collection and treatment system serving 16 municipalities and several industrial customers in Gloucester County. Every year, the GCUA accepts and treats over 6.3 billion gallons of wastewater from the residents, businesses and industries it serves. Each and every year, the GCUA reclaims this 6.3 billion gallons of wastewater and returns it back into the environment as a high quality resource to be enjoyed by the people residing along the Delaware River Estuary. In addition to providing treatment of domestic wastewater, the GCUA owns and operates a septage pretreatment facility processing and disposing of thousands of gallons a day of trucked-in, non-hazardous waste streams, such as liquid, thickened and dewatered sewage sludges; non-hazardous industrial wastewater; domestic landfill leachate; non-petroleum oils and greases; grease and scum from domestic wastewater treatment facilities; domestic and commercial septage; and backwash slurries from potable water treatment facilities. The Authority's mission is to contribute toward the high quality of life expected and enjoyed by all residents of the Authority's service area, the county and the region by creatively applying the Authority's human, technical and financial resources. By following this general principle, the Authority will provide the facilities and services for meeting todays and tomorrow's environmental protection and economic development needs without compromising the accessibility to these resources for meeting the needs and desires of future Customers, Ratepayers and generations, at a reasonable cost. In more specific terms, the Authority's mission is to: • Protect the public's health and well-being • Protect, preserve and enhance the quality of our natural environment and ecological systems • Provide the appropriate wastewater facilities and services to support current and future economic development and redevelopment • Provide these facilities and services in a timely fashion • Provide these facilities and services at the Least Possible Cost

Capability		
		• Organizational Values The GCUA is always looking to improve processing methods, reduce operating costs and save energy. For example, the GCUA previously treated sewage sludge by using two Fluidized Bed Sludge Incinerators. Those sludge incinerators have been replaced with two Anaerobic Sludge Digestors. The sludge digestion process also includes a Methane Flare to burn off excess biogas. A current project underway will allow GCUA to reuse this biogas instead of flaring the biogas off. The biogas will be scrubbed clean, stored onsite, then used as fuel to power an electric engine which will produce electricity that will be used to power the GCUA Sewer Treatment Plant. This onsite electrical production will help GCUA daily, but also during emergency events when the electrical power grid may be under stress.
	Responsible Agency:	Gloucester County Utilities Authority
	Provides Funding for Mitigation:	No
	Hazard:	Flood, Severe Weather, Nor'Easter, Hurricane/Tropical Storm
Gloucester County Department of Parks and Recreation	**Description:**	Gloucester County Parks and Recreation is responsible for the organization and development of the recreational environment within the County. One of the objectives of the Parks Department is to acquire and develop park land which will enable the residents of our County to freely exercise their needs and desires for recreation in an atmosphere of open spaces. Our other main objective is to schedule recreational programs and activities in order to meet the great need for leisure participation.
	Responsible Agency:	County
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Gloucester County Department of Economic Development	**Description:**	Gloucester County Department of Economic Development will foster public/private partnerships in order to create an environment of sustainable growth through retaining, expanding, and attracting quality businesses (Business Development) and by developing an educated/trained workforce (Workforce Development WDB/WIOA). Also, enhancing tourism and open space while providing a suitable environment and expanding economic opportunities for all our citizens.
	Responsible Agency:	County
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Rutgers Cooperative Extension for Gloucester County	**Description:**	Rutgers New Jersey Agricultural Experiment Station (NJAES) Cooperative Extension helps the diverse population of New Jersey adapt to a rapidly changing society and improve their lives and communities through an educational process that uses science-based knowledge. Through science-based educational programs, Rutgers Cooperative Extension truly enhances the quality of life for residents of New Jersey and brings the wealth of knowledge of the state university to local communities.

Capability		
		Rutgers NJAES Cooperative Extension of Gloucester County was established in 1917. The office provides research-based information to county residents in the areas of: 4-H Youth Development, Agriculture & Natural Resources, and Family & Community Health Sciences. • 4-H Youth Development • Agriculture & Natural Resources • Family & Community Health Sciences
	Responsible Agency:	Rutgers University
	Provides Funding for Mitigation:	Yes
	Hazard:	Hurricane, Nor'Easter, Severe Weather, Severe Winter Weather
NJ Department of State Office of Planning Advocacy	**Description:**	The New Jersey State Planning Commission and the Office of State Planning (now the Office for Planning Advocacy) were established by New Jersey State Planning Act (N.J.S.A. 52:18A-196 et seq.; available for reference at the New Jersey Legislature) which was signed into law on January 5, 1986. The Act called for a State Development and Redevelopment Plan to be prepared through a statewide planning process called cross-acceptance
	Responsible Agency:	NJ Department of State Office of Planning Advocacy
	Provides Funding for Mitigation:	No
	Hazard:	All Hazards
Sustainable Jersey	**Description:**	Sustainable Jersey is a nonprofit organization that provides tools, training and financial incentives to support communities as they pursue sustainability programs. By supporting community efforts to reduce waste, cut greenhouse gas emissions, and improve environmental equity, Sustainable Jersey aims to empower communities to build a better world for future generations. The organization also offers a certification program. Sustainable Jersey certification is a designation for municipal governments in New Jersey. All actions taken by municipalities to score points toward certification must be accompanied by documentary evidence and is reviewed. The certification is free and completely voluntary. In Gloucester County, the following municipalities are certified: East Greenwich (bronze), Glassboro (bronze), Harrison (bronze), Monroe (bronze), National Park (bronze), Pitman (bronze), Washington (silver), Wenonah (bronze), Woodbury (bronze), and Woolwich (bronze) (Jersey 2021).
	Responsible Agency:	Sustainable Jersey
	Provides Funding for Mitigation:	Yes
	Hazard:	All
NJ Pinelands Commission	**Description:**	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. The Pinelands Commission has several programs and initiatives in place:

Capability		
		• The Pinelands Commission administers many resource protection programs relative to wetlands and other ecosystems, threatened and endangered species, vegetation, wildlife management, water resources, air quality, fire management and historic and cultural resources. • The Pinelands Commission manages regulatory programs relative to forestry, agriculture, resource extraction, and waste management. • The Pinelands Commission maintains comprehensive long-term economic and environmental monitoring programs to support its policy and regulatory decisions. As of June 2020, more than half of the Pinelands Area (479,000 acres) has been permanently preserved as open space through a variety of acquisitions, easements and other programs. • The State has acquired 5,771 acres under the Pinelands Limited Practical Use Program. • Non-profit organizations currently own and manage about 12,000 acres of permanently protected land (NJDEP, State of New Jersey Pinelands Commission 2021).
	Responsible Agency:	Pinelands Commission
	Provides Funding for Mitigation:	Yes
	Hazard:	Flood (riverine) and Wildfire

5.4 FISCAL CAPABILITIES

Fiscal capabilities are the resources that a jurisdiction has access to or is eligible to use to fund mitigation actions. The table below provides a list of programs, descriptions, and links for those jurisdictions seeking funding sources. This table is not intended to be a comprehensive list, but rather a tool to help begin identifying potential sources of funding.

Table 5-4. Fiscal Capabilities

Capability		
Federal		
Hazard Mitigation Grant Program	**Description:**	The HMGP is a post-disaster mitigation program. It is made available to states by FEMA after each Federal disaster declaration. The HMGP can provide up to 75% funding for hazard mitigation measures. The HMGP can be used to fund cost-effective projects that will protect public or private property in an area covered by a federal disaster declaration or that will reduce the likely damage from future disasters. Examples of projects include acquisition and demolition of structures in hazard prone areas, flood-proofing or elevation to reduce future damage, minor structural improvements and development of state or local standards. Projects must fit

Capability		
		into an overall mitigation strategy for the area identified as part of a local planning effort. All applicants must have a FEMA-approved Hazard Mitigation Plan (this plan). Applicants who are eligible for the HMGP are state and local governments, certain nonprofit organizations or institutions that perform essential government services, and Indian tribes and authorized tribal organizations. Individuals or homeowners cannot apply directly for the HMGP; a local government must apply on their behalf. Applications are submitted to NJ OEM and placed in rank order for available funding and submitted to FEMA for final approval. Eligible projects not selected for funding are placed in an inactive status and may be considered as additional HMGP funding becomes available. For additional information regarding HMGP, please refer to: https://www.fema.gov/hazard-mitigation-grant-program
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Flood Mitigation Assistance Program	**Description:**	The FMA program combines the previous Repetitive Flood Claims and Severe Repetitive Loss Grants into one grant program. The FMA provides funding to assist states and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the NFIP. The FMA is funded annually; no federal disaster declaration is required. Only NFIP insured homes and businesses are eligible for mitigation in this program. Funding for FMA is very limited and, as with the HMGP, individuals cannot apply directly for the program. Applications must come from local governments or other eligible organizations. The federal cost share for an FMA project is at least 75 percent. For the nom-federal share, at most 25 percent of the total eligible costs must be provided by a non-federal source; of this 25 percent, no more than half can be provided as in-kind contributions from third parties. At minimum, a FEMA-approved local flood mitigation plan is required before a project can be approved. The FMA funds are distributed from FEMA to the state. NJOEM serves as the grantee and program administrator for the FMA program. The FMA program is detailed on the FEMA website: https://www.fema.gov/flood-mitigation-assistance-grant-program.
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Yes
	Hazard:	Flood, Severe Weather
Building Resilient Infrastructure and Communities Program	**Description:**	Building Resilient Infrastructure and Communities (BRIC) will support states, local communities, tribes and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. BRIC is a new FEMA pre-disaster hazard mitigation program that replaces the existing Pre-Disaster Mitigation (PDM) program.

Capability		
		The BRIC program guiding principles are supporting communities through capability- and capacity-building; encouraging and enabling innovation; promoting partnerships; enabling large projects; maintaining flexibility; and providing consistency. For additional information regarding the BRIC program, please refer to: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Extraordinary Circumstances	**Description:**	For PDM and FMA project subawards, the (FEMA) Region may apply extraordinary circumstances when justification is provided and with concurrence from FEMA Headquarters (Risk Reduction and Risk Analysis Divisions) prior to granting an exception. If this exception is granted, a local mitigation plan must be approved by FEMA within 12 months of the award of the project subaward to that community. For HMGP, PDM, and FMA, extraordinary circumstances exist when a determination is made by the Applicant and FEMA that the proposed project is consistent with the priorities and strategies identified in the State (Standard or Enhanced) Mitigation Plan and that the jurisdiction meets at least one of the criteria below. If the jurisdiction does not meet at least one of these criteria, the Region must coordinate with FEMA Headquarters (Risk Reduction and Risk Analysis Divisions) for HMGP; however, for PDM and FMA the Region must coordinate and seek concurrence prior to granting an exception: •The jurisdiction meets the small, impoverished community criteria (see Part VIII, B.2). •The jurisdiction has been determined to have had insufficient capacity due to lack of available funding, staffing, or other necessary expertise to satisfy the mitigation planning requirement prior to the current disaster or application deadline. •The jurisdiction has been determined to have been at low risk from hazards because of low frequency of occurrence or minimal damage from previous occurrences as a result of sparse development. •The jurisdiction experienced significant disruption from a declared disaster or another event that impacts its ability to complete the mitigation planning process prior to award or final approval of a project award. •The jurisdiction does not have a mitigation plan for reasons beyond the control of the State, federally-recognized tribe, or local community, such as Disaster Relief Fund restrictions that delay FEMA from granting a subaward prior to the expiration of the local or Tribal Mitigation Plan. For HMGP, PDM, and FMA, the Applicant must provide written justification that identifies the specific criteria or circumstance listed above, explains why there is no longer an impediment to satisfying the mitigation planning requirement, and identifies the specific actions or circumstances that eliminated the deficiency.

Capability		
		When an HMGP project funding is awarded under extraordinary circumstances, the Recipient shall acknowledge in writing to the Regional Administrator that a plan will be completed within 12 months of the subaward. The Recipient must provide a work plan for completing the local or Tribal Mitigation Plan, including milestones and a timetable, to ensure that the jurisdiction will complete the plan in the required time. This requirement shall be incorporated into the award (both the planning and project subaward agreements, if a planning subaward is also awarded).
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Individual Assistance	**Description:**	Individual Assistance (IA) provides help for homeowners, renters, businesses, and some non-profit entities after disasters occur. This program is largely funded by the U.S. Small Business Administration. For homeowners and renters, those who suffered uninsured or underinsured losses could be eligible for a Home Disaster Loan to repair or replace damaged real estate or personal property. Renters are eligible for loans to cover personal property losses. Individuals are allowed to borrow up to $200,000 to repair or replace real estate, $40,000 to cover losses to personal property, and an additional 20 percent for mitigation. For businesses, loans could be made to repair or replace disaster damages to property owned by the business, including real estate, machinery and equipment, inventory, and supplies. Businesses of any size are eligible. Non-profit organizations, such as charities, churches, and private universities are eligible. An Economic Injury Disaster Loan provides necessary working capital until normal operations resume after a physical disaster but are restricted by law to small businesses only. IA is detailed on the FEMA website: https://www.fema.gov/individual-disaster-assistance.
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Public Assistance	**Description:**	Public Assistance (PA) provides cost reimbursement aid to local governments (state, county, local, municipal authorities, and school districts) and certain non-profit agencies that were involved in disaster response and recovery programs or that suffered loss or damage to facilities or property used to deliver government-like services. This program is largely funded by FEMA with both local and state matching contributions required. PA is detailed on the FEMA website: https://www.fema.gov/public-assistance-local-state-tribal-and-non-profit.
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards

Capability		
Department of Homeland Security Grant Program	**Description:**	The Homeland Security Grant Program (HSGP) plays an important role in the implementation of the National Preparedness System by supporting the building, sustainment, and delivery of core capabilities essential to achieving the National Preparedness Goal of a secure and resilient nation. In FY 2019, the total amount of funds available under HSGP was $1.095 billion. HSGP is comprised of three interconnected grant programs including the State Homeland Security Program, Urban Areas Security Initiative (UASI), and the Operation Stonegarden. Together, these grant programs fund a range of preparedness activities, including planning, organization, equipment purchase, training, exercises, and management and administration. Additional information regarding HSGP is available on the website: https://www.fema.gov/homeland-security-grant-program.
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Fire Management Assistance Grant Program	**Description:**	Assistance for the mitigation, management, and control of fires on publicly or privately-owned forests or grasslands that threaten such destruction as would constitute a major disaster. Provides a 75% federal cost share and the state pays the remaining 25% for actual cost. Information on this program is available on the website: https://www.fema.gov/fire-management-assistance-grant-program.
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Yes
	Hazard:	Wildfire
Assistance to Firefighters Grant Program	**Description:**	The primary goal of the Assistance to Firefighters Grants is to enhance the safety of the public and firefighters with respect to fire-related hazards by providing direct financial assistance to eligible fire departments, nonaffiliated Emergency Medical Services organizations, and State Fire Training Academies. This funding is for critically needed resources to equip and train emergency personnel to recognized standards, enhance operations efficiencies, foster interoperability, and support community resilience. Information regarding this grant program is available on the website: https://www.fema.gov/welcome-assistance-firefighters-grant-program.
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Yes
	Hazard:	Wildfire
High Hazard Potential Dams Grant Program	**Description:**	The Rehabilitation of High Hazard Potential Dams Grant Program provides technical, planning, design, and construction assistance in the form of grants to non-Federal governmental organizations or nonprofit organizations for rehabilitation of eligible high hazard

Capability		
		potential dams. Information regarding this program is available on the website: https://www.grants.gov/web/grants/view-opportunity.html?oppId=316238.
	Responsible Agency:	FEMA
	Provides Funding for Mitigation:	Yes
	Hazard:	Flood
Small Business Administration Loan	**Description:**	The Small Business Administration (SBA) provides low-interest disaster loans to homeowners, renters, business of all sizes, and most private nonprofit organizations. SBA disaster loans can be used to repair or replace the following items damaged or destroyed in a declared disaster: real estate, personal property, machinery and equipment, and inventory and business assets. Homeowners could apply for up to $200,000 to replace or repair their primary residence. Renters and homeowners could borrow up to $40,000 to replace or repair personal property-such as clothing, furniture, cars, and appliances that were damaged or destroyed in a disaster. Physical disaster loans of up to $2 million are available to qualified businesses or most private nonprofit organizations. Additional information regarding SBA loans is available on the SBA website: https://www.sba.gov/managing-business/running-business/emergency-preparedness/disaster-assistance.
	Responsible Agency:	SBA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Community Development Block Grant Program	**Description:**	CDBG are federal funds intended to provide low and moderate-income households with viable communities, including decent housing, a suitable living environment, and expanded economic opportunities. Eligible activities include community facilities and improvements, roads and infrastructure, housing rehabilitation and preservation, development activities, public services, economic development, and planning and administration. Public improvements could include flood and drainage improvements. In limited instances and during the times of "urgent need" (e.g., post disaster) as defined by the CDBG National Objectives, CDBG funding could be used to acquire a property located in a floodplain that was severely damaged by a recent flood, demolish a structure severely damaged by an earthquake, or repair a public facility severely damaged by a hazard event. Additional information regarding CDBG is available on the website: https://www.hudexchange.info/programs/cdbg-entitlement/.
	Responsible Agency:	HUD
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards

Capability		
Federal Highway Administration-Emergency Relief	**Description:**	The Federal Highway Administration (FHWA) Emergency Relief is a grant program through the U.S. Department of Transportation (DOT) that can be used for repair or reconstruction of federal-aid highways and roads on federal lands that have suffered serious damage as a result of a disaster. New Jersey Department of Transportation serves as the liaison between local municipalities and FHWA. Additional information regarding the FHWA Emergency Relief Program is available on the website: https://www.fhwa.dot.gov/programadmin/erelief.cfm.
	Responsible Agency:	U.S. DOT
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Federal Transit Administration - Emergency Relief	**Description:**	The Federal Transit Authority (FTA) Emergency Relief is a grant program that funds capital projects to protect, repair, reconstruct, or replace equipment and facilities of public transportation systems. Administered by the Federal Transit Authority at the U.S. DOT and directly allocated to Metropolitan Transit Authority (MTA) and Port Authority, this transportation-specific fund was created as an alternative to FEMA PA. Currently, a total of $5.2 billion has been allocated to New Jersey-related entities. Additional information regarding the FTA Emergency Relief Program is available on the website: https://www.transit.dot.gov/funding/grant-programs/emergency-relief-program/emergency-relief-program.
	Responsible Agency:	U.S. DOT
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Disaster Housing Program	**Description:**	Emergency assistance for housing, including minor repair of home to establish livable conditions, mortgage and rental assistance available through the U.S. Department of Housing and Urban Development (HUD). Information on this program is available on the website: https://www.hud.gov/program_offices/public_indian_housing/publications/dhap.
	Responsible Agency:	HUD
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
HOME Investment Partnerships Program	**Description:**	Grants to local and state government and consortia for permanent and transitional housing, (including financial support for property acquisition and rehabilitation for low income persons). Information on this program is available on the website: https://www.hud.gov/program_offices/comm_planning/affordablehousing/programs/home/.
	Responsible Agency:	HUD
	Provides Funding for Mitigation:	Yes

Capability		
	Hazard:	All Hazards
HUD Disaster Recovery Assistance	**Description:**	Grants to fund gaps in available recovery assistance after disasters (including mitigation). Information on this program is available on the website: https://www.hud.gov/info/disasterresources.
	Responsible Agency:	HUD
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Section 108 Loan Guarantee	**Description:**	Enables states and local governments participating in the CDBG program to obtain federally guaranteed loans for disaster-distressed areas. Information on this program is available on the website: https://www.hudexchange.info/programs/section-108/.
	Responsible Agency:	HUD
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Smart Growth Implementation Assistance program	**Description:**	The Smart Growth Implementation Assistance (SGIA) program through the U.S. Environmental Protection Agency (EPA) focuses on complex or cutting-edge issues, such as stormwater management, code revision, transit-oriented development, affordable housing, infill development, corridor planning, green building, and climate change. Applicants can submit proposals under 4 categories: community resilience to disasters, job creation, the role of manufactured homes in sustainable neighborhood design, or medical and social service facilities siting. Information on this program is available on the website: https://www.epa.gov/smartgrowth.
	Responsible Agency:	EPA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Partners for Fish and Wildlife	**Description:**	Financial and technical assistance to private landowners interested in pursuing restoration projects affecting wetlands and riparian habitats. Information on this program is available on the website: https://www.fws.gov/partners/.
	Responsible Agency:	U.S. Fish and Wildlife Service
	Provides Funding for Mitigation:	Yes
	Hazard:	All Natural Hazards
Transportation Investment Generating Economic Recovery (TIGER)	**Description:**	Investing in critical road, rail, transit and port projects across the nation. Information on this program is available on the website: https://www.transportation.gov/tags/tiger-grants.
	Responsible Agency:	U.S. DOT
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards

Capability		
Community Facilities Direct Loan & Grant Program	**Description:**	This program provides affordable funding to develop essential community facilities in rural areas. An essential community facility is defined as a facility that provides an essential service to the local community for the orderly development of the community in a primarily rural area, and does not include private, commercial or business undertakings. Information on this program is available on the website: https://www.rd.usda.gov/programs-services/community-facilities-direct-loan-grant-program.
	Responsible Agency:	USDA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Emergency Loan Program	**Description:**	USDA's Farm Service Agency provides emergency loans to help producers recover from production and physical losses due to drought, flooding, other natural disasters or quarantine. Information on this program is available on the website: https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/emergency-farm-loans/index.
	Responsible Agency:	USDA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Natural Hazards
Emergency Watershed Protection program	**Description:**	The Emergency Watershed Protection (EWP) program provides assistance to relieve imminent hazards to life and property caused by floods, fires, drought, windstorms, and other natural occurrences through the Natural Resources Conservation Service. Information on this program is available on the website: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/.
	Responsible Agency:	USDA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Natural Hazards
Financial Assistance	**Description:**	Financial assistance to help plan and implement conservation practices that address natural resource concerns or opportunities to help save energy, improve soil, water, plant, air, animal and related resources on agricultural lands and non-industrial private forest land. Information on this program is available on the website: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/.
	Responsible Agency:	NRCS
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Emergency Management Performance Grants (EMPG) Program	**Description:**	Assist local, tribal, territorial, and state governments in enhancing and sustaining all-hazards emergency management capabilities. Information on this program is available on the website: https://www.fema.gov/emergency-management-performance-grant-program.

Capability		
	Responsible Agency:	U.S. DHS
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
Reimbursement for Firefighting on Federal Property	**Description:**	Provides reimbursement only for direct costs and losses over and above normal operating costs. Information on this program is available on the website: https://www.usfa.fema.gov/grants/firefighting_federal_property.html.
	Responsible Agency:	U.S. DHS
	Provides Funding for Mitigation:	Yes
	Hazard:	Wildfire
Land & Water Conservation Fund	**Description:**	Matching grants to states and local governments for the acquisition and development of public outdoor recreation areas and facilities (as well as funding for shared federal land acquisition and conservation strategies). Information on this program is available on the website: https://www.nps.gov/subjects/lwcf/index.htm.
	Responsible Agency:	National Park Service
	Provides Funding for Mitigation:	Yes
	Hazard:	All Natural Hazards
State		
New Jersey Clean Energy Program	**Description:**	New Jersey's Clean Energy Program (NJCEP) promotes increased energy efficiency and the use of clean, renewable sources of energy including solar, wind, geothermal, and sustainable biomass. The results for New Jersey are a stronger economy, less pollution, lower costs, and reduced demand for electricity. NJCEP offers financial incentives, programs, and services for residential, commercial, and municipal customers. Refer to https://www.njcleanenergy.com/main/about-njcep/about-njcep for additional details on NJCEP. The program also offers a Community Energy Plan Grant for government entities (e.g. municipality, county, Green Team or environmental commission, or other Sustainable Jersey organization within a community or county). The grant will provide funding for an entity to create a Community Energy Master Plan to align local communities with the State Energy Master Plan
	Responsible Agency:	New Jersey Board of Public Utilities
	Provides Funding for Mitigation:	Yes
	Hazard:	Hazards impacted by climate change
Grant and Loan Programs	**Description:**	NJDEP offers a wide variety of funding opportunities for local governments and other types of organizations to fund numerous environmentally based projects. This includes funding for: air quality, energy, and sustainability; compliance and enforcement; engineering and construction; land use management; local government assistance; natural and historic resources; site remediation

Capability		
		and waste management programs; and water resource management. Information on each of the programs can be found on the NJDEP website: https://www.nj.gov/dep/grantandloanprograms/.
	Responsible Agency:	NJDEP
	Provides Funding for Mitigation:	Yes
	Hazard:	All
Green Acres Program	**Description:**	Green Acres was created to meet New Jersey's growing recreation and conservation needs. This program has helped preserve over 1.2 million acres of land in New Jersey. Gloucester County has used the Green Acres Program to acquire open space, with a majority of land being municipal- or county-owned. Between 1935 and 2020, Green Acres open space had been acquired in: Clayton, Deptford, East Greenwich, Elk, Franklin, Glassboro, Greenwich, Harrison, Logan Mantua, Monroe, National Park, Newfield, Pitman, South Harrison, Swedesboro, Washington Township, West Deptford, Woodbury, and Woolwich, amounting to 18,703 acres of Green Acres open space (NJDEP 2021).
	Responsible Agency:	NJDEP
	Provides Funding for Mitigation:	Yes
	Hazard:	All Natural Hazards
Blue Acres Program	**Description:**	The goal of the Blue Acres Program, which has historically served as part of DEP's Green Acres Program that purchases flood-prone properties, is to dramatically reduce the risk of future catastrophic flood damage and to help families to move out of harm's way. The Superstorm Sandy Blue Acres program launched in May 2013 and is recognized by the Federal Emergency Management Agency (FEMA) as a "National Best Practice." Blue Acres dates back to 1995, but activity expanded sharply after Hurricane Sandy in 2012. As of September 2019, the program has purchased approximately 1,000 properties (about 700 since Sandy) and plans to acquire hundreds more using a mix of state and federal funding. Blue Acres buyouts take 6 to 12 months from start to closing, depending on the homeowner's situation and needs; after closing, it will take another 6 to 12 months to complete demolition. This timeline is substantially faster than most FEMA-funded buyouts—but it has required extensive work to reach this point.
	Responsible Agency:	NJDEP
	Provides Funding for Mitigation:	Yes
	Hazard:	Flood, Severe Weather
New Jersey Water Bank	**Description:**	The New Jersey Water Bank (NJWB) is a partnership between the NJDEP and the NJEIT to provide low cost financing for the design, construction, and implementation of projects that help protect and improve water quality and help ensure safe and adequate drinking water.

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		The NJWB finances projects by utilizing two funding sources. The Trust issues revenue bonds which are used in combination with zero percent interest funds to provide very low interest loans for water infrastructure improvements. The NJDEP administers a combination of Federal State Revolving Fund capitalization grants, as well as the State's matching funds, loan repayments, State appropriations and interest earned on such funds.
	Responsible Agency:	NJDEP and New Jersey Environmental Infrastructure Trust
	Provides Funding for Mitigation:	Yes
	Hazard:	Flood, Severe Weather
New Jersey Redevelopment Authority	**Description:**	The New Jersey Redevelopment Authority (NJRA) is an independent state financing authority committed exclusively to the redevelopment of New Jersey's urban areas. NJRA offers several financing resources including site acquisition funding, predevelopment assistance, several development assistance resources, and technical assistance.
	Responsible Agency:	New Jersey Redevelopment Authority
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
New Jersey Department of Community Affairs	**Description:**	The New Jersey Department of Community Affairs (NJDCA) is a state agency created to provide administrative guidance, financial support, and technical assistance to local governments, community development organizations, businesses, and individuals to improve the quality of life in New Jersey. NJDCA offers a wide range of programs, funding, and services that respond to issues of public concern including fire and building safety, housing production, community planning and development, and local government management and finance. Among other funding sources, NJDCA administers CDBG funding and is typically the CDBG-Disaster Relief funding recipient for the State of New Jersey.
	Responsible Agency:	New Jersey Department of Community Affairs
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
New Jersey Board of Public Utilities	**Description:**	The New Jersey Board of Public Utilities (BPU) works with private utility companies to provide analysis of natural hazard information affecting the provision of electric power, telecommunications, public water, sewage collection and treatment, and other regulated public utilities. The data are used during response and recovery efforts in the event of emergency or disaster and is also used to analyze impact of mitigation plans and projects. BPU also provides technical assistance for the Energy Resiliency Program
	Responsible Agency:	BPU
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards

Capability		
Environmental Infrastructure Financing Program	**Description:**	Qualified borrowers receive loans in two equal parts: Approximately one half to three quarters comes from a 0-interest State Revolving Fund maintained by the NJDEP. The other portion comes from proceeds of highly rated tax-exempt revenue bonds sold by the Trust. Combining these two funds results in a loan that is 50 to 75% lower than traditional loan rates.
	Responsible Agency:	NJDEP
	Provides Funding for Mitigation:	Yes
	Hazard:	All Natural Hazards
New Jersey Small Cities Communities Development Block Grants	**Description:**	The New Jersey Small Cities Communities Development Block Grants provide funds for economic development, housing rehabilitation, community revitalization, and public facilities designated to benefit people with low and moderate incomes, or to address recent local needs for which no other source of funding is available to non-entitlement counties and municipalities. Information on the program is available on the website: https://www.nj.gov/dca/divisions/dhcr/offices/neighborhood.html.
	Responsible Agency:	NJDCA
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
New Jersey Conservation Foundation	**Description:**	The New Jersey Conservation Foundation (NJCF) is a private, not-for-profit organization. Through acquisition and stewardship, NJCF protects strategic lands, promotes strong land use policies, and forges partnerships to achieve conservation goals. Grants to help fund preservation activities. Information on the program is available on the website: https://www.njconservation.org/what-we-do/.
	Responsible Agency:	NJCF
	Provides Funding for Mitigation:	Yes
	Hazard:	All Natural Hazards
The New Jersey Infrastructure Bank	**Description:**	Two programs provide and administer low interest rate loans to qualified municipalities, counties, regional authorities, and water purveyors in New Jersey. Approximately $350 million is awarded annually. 1. NJEIT for the purpose of financing water quality infrastructure projects that enhance ground and surface water resources, ensure the safety of drinking water supplies, protect the public health and make possible responsible and sustainable economic development. 2. The New Jersey Transportation Infrastructure Bank (NJTIB) is an independent State Financing Authority responsible for providing and administering low interest rate loans to qualified municipalities, counties, and regional authorities in New Jersey for the purpose of financing transportation quality infrastructure projects. Information on the program is available on the website: https://www.njib.gov/.

Capability		
	Responsible Agency:	NJDEP
	Provides Funding for Mitigation:	Yes
	Hazard:	All Natural Hazards
Drinking Water State Revolving Fund	**Description:**	The DWSRF program assists water systems in financing the cost of infrastructure through the use of federal and New Jersey Infrastructure Trust funds. Additionally, the Water Supply program provides operator licensing and training support as well as financial assistance through the DWSRF program. Information on the program is available on the website: https://www.state.nj.us/dep/watersupply/dws_loans.html.
	Responsible Agency:	NJDEP
	Provides Funding for Mitigation:	Yes
	Hazard:	Drought
New Jersey Department of Transportation (NJDOT)	**Description:**	Funding of the Program is typically federal through the Federal Highway Administration or State through the Transportation Trust Fund. Information on the program is available on the website: https://www.state.nj.us/transportation/business/localaid/funding.shtm.
	Responsible Agency:	NJDOT
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards
County and Local		
Capital Improvement Plans	**Description:**	Capital Improvement Plans outline capital spending and investments necessary for public improvements. Many municipalities in Gloucester County have Capital Improvement Plans. These plans and budgets have been and may continue to be used to fund mitigation projects and demonstrate integration into daily operations. Refer to the jurisdictional annexes in Section 9 for further details.
	Responsible Agency:	County and Local Municipalities
	Provides Funding for Mitigation:	Yes
	Hazard:	All Hazards

5.5 PLAN INTEGRATION

Described earlier in this section and within each annex, participating jurisdictions identified integration of hazard risk management into their existing planning, regulatory, and operational/administrative framework ("integration capabilities") and intended integration promotion (integration actions). Volume II, Section 9 (Jurisdictional Annexes) provides details on how each jurisdiction integrates hazard mitigation into their existing capabilities.

5.5.1 Integration Process

Hazard mitigation is a sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards. Integrating hazard mitigation into a community's existing plans, policies, codes, and programs leads to development patterns that do not increase risk from known hazards or leads to redevelopment that reduces risk from known hazards. The Gloucester County Planning Partnership was tasked with identifying how hazard mitigation is integrated into existing planning mechanisms. Section 9 (Jurisdictional Annexes) details how this is done for each participating municipality and the County. During this process, many municipalities recognized the importance and benefits of incorporating hazard mitigation into future municipal planning and regulatory processes and have added new mitigation actions to support this effort.

The Planning Partnership representatives will continue to incorporate mitigation planning as an integral component of daily government operations. Planning Partnership representatives will continue to work with local government officials to integrate the newly adopted hazard mitigation goals and actions into the general operations of government and partner organizations. Further, the sample adoption resolution presented in Appendix A (Plan Adoption) includes a resolution item stating the intent of the local governing body to incorporate mitigation planning as an integral component of government and partner operations. By doing so, the Planning Partnership anticipates that:

1. Hazard mitigation planning will be formally recognized as an integral part of overall planning and emergency management efforts.
2. The Hazard Mitigation Plan, Master Plans, Emergency Management Plans, and other relevant planning mechanisms will become mutually supportive documents that work in concert to meet the goals and needs of County residents.

Section 7 (Plan Maintenance) provides for additional information on the implementation of the mitigation plan through existing programs.

SECTION 6. MITIGATION STRATEGY

2022 HMP Changes

- The, goals and objectives were updated to align with County and municipal priorities and the 2019 State HMP.
- A Strengths, Weaknesses, Obstacles and Opportunities exercise was conducted for the high-ranked hazards to inform the updated mitigation strategy.
- A mitigation toolbox was compiled and distributed to assist with the mitigation strategy update.
- Stakeholder conversations were held to obtain a comprehensive understanding of capabilities and problem areas to inform the updated mitigation strategy

6.1 INTRODUCTION

This section presents mitigation actions for Gloucester County to reduce potential exposure and losses identified as concerns in the Risk Assessment (Section 5). The County and planning partnership reviewed the risk assessment to identify and develop these mitigation actions, which are presented herein.

Hazard mitigation reduces the potential impacts of, and costs associated with, emergency and disaster-related events. Mitigation actions address a range of impacts, including impacts on the population, property, the economy, and the environment.

Mitigation actions can include activities such as: revisions to land-use planning, training and education, and structural and nonstructural safety measures.

This section includes:

- Background and Past Mitigation Accomplishments
- General Mitigation Planning Approach
- Strengths, Weaknesses, Obstacles, and Opportunities
- Review and Update of Mitigation Goals and Objectives
- Plan Integration
- Mitigation Strategy Development and Update

6.2 BACKGROUND AND PAST MITIGATION ACCOMPLISHMENTS

In accordance with DMA 2000 requirements, a discussion regarding past mitigation activities and an overview of past efforts is provided as a foundation for understanding the mitigation goals, objectives, and activities outlined in this HMP. The County, through previous and ongoing hazard mitigation activities, has demonstrated that it is pro-active in protecting its physical assets and citizens against losses from natural and human-caused hazards. Examples of previous and ongoing actions, projects and capabilities include the following:

- The County participated in the development of the 2016 Mitigation Plan for Four New Jersey Counties-Regional Hazard Mitigation Plan and facilitated the 2022 Update, which included the participation of all municipal governments in the County. The current planning process represents the regulatory five-year local plan update process.
- All 24 municipalities in Gloucester County participate in the National Flood Insurance Program (NFIP), which requires the adoption of FEMA floodplain mapping and certain minimum construction standards for building within the floodplain.
- Currently, 2 of the 24 municipalities in Gloucester County are participants in NFIP Community Rating System (CRS) program.
    - Township of Greenwich, Class 9
    - Borough of National Park, Class 8
- Many municipalities in Gloucester County have adopted regulatory standards regarding land-use and zoning that exceed minimum requirements and provide the communities with greater capability to manage development without increasing hazard risk and vulnerability.
- Municipalities have participated on a limited basis in available mitigation grant funding opportunities to implement mitigation projects, including the following:
    - Generators for the County, Mantua Township and Greenwich Township
    - Stormwater management in Washington Township
    - Property acquisitions related to riverine flooding in West Deptford Township
    - Stormwater management in the County
    - The County is a recipient of a PDM grant for preparation of the 2022 Hazard Mitigation Plan
- The County and municipalities have implemented mitigation actions to protect critical facilities and infrastructure throughout the planning area. These actions and others were identified in the County's Participation in the 2016 Mitigation Plan for Four New Jersey Counties.
- In 2015, Delaware Valley Regional Planning Commission assisted Gloucester County with developing a community vision as one of the first steps in updating their master plan and producing a Unified Land Use and Transportation Element for the County's master plan.
- Rutgers Cooperative Extension Office in Gloucester County provides research-based information to county residents in the areas of 4-H, agricultural and natural resources, and family and community health sciences.
- In 2020, the County and local municipalities responded to and worked to mitigate the impacts of the coronavirus pandemic through education of the public, enforcement of local and state social distancing and masking measures, and establishment of best practices to slow the spread of Covid-19.

These past and ongoing activities have contributed to the County's understanding of its hazard preparedness and future mitigation activity needs, costs, and benefits. These efforts provide an ongoing foundation for the planning partnership to use in developing this HMP update.

6.3 GENERAL MITIGATION PLANNING APPROACH

The overall approach used to update the County and local hazard mitigation strategies are based on FEMA and State of New Jersey regulations and guidance regarding local mitigation plan development, including:

- DMA 2000 regulations, specifically 44 CFR 201.6 (local mitigation planning).
- FEMA *Local Mitigation Planning Handbook*, March 2013.
- FEMA *Local Mitigation Plan Review Guide*, October 1, 2011.
- FEMA *Integrating Hazard Mitigation into Local Planning*, March 1, 2013.
- FEMA *Plan Integration: Linking Local Planning Efforts*, July 2015.
- FEMA *Mitigation Planning How-To Guide #3, Identifying Mitigation Actions and Implementing Strategies (FEMA 386-3)*, February 2013.
- FEMA *Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards*, January 2013.

The mitigation strategy update approach includes the following steps that are further detailed in later subsections of this section:

- Section 6.4 – Strengths, Weaknesses, Obstacles, and Opportunities (SWOO) exercise
- Section 6.5 – Review and update mitigation goals and objectives.
- Section 6.6 - Develop and prepare a mitigation strategy, including:
    - Review of the 2016 HMP mitigation actions
    - Identification of progress on previous county and local mitigation strategies
    - 2022 HMP Mitigation Action Plan
    - Mitigation best practices
    - Mitigation strategy evaluation and prioritization; and
    - Benefit/cost review.

6.4 STRENGTHS, WEAKNESSES, OBSTACLES, AND OPPORTUNITIES EXERCISE

A Strengths, Weakness, Obstacles and Opportunities exercise (SWOO) was completed by the planning partnership. Participants were asked to fill out the SWOO for each of the hazards of concern for the 2022 HMP update. The Planning Partnership was asked to begin the exercise by identifying county, local, and stakeholder strengths to mitigate the risk and potential future impacts of the hazards. Next, the weaknesses, challenges and obstacles the planning area faces to reduce each hazard's risk were identified. To conclude the discussion of each high-ranked hazard, the meeting attendees were asked to identify potential opportunities for enhanced mitigation. The results were compiled and presented to the planning partnership at the risk assessment presentation. The results were also used by the participants to help identify capabilities and potential mitigation actions. The following summarizes the general categories of potential opportunities identified during the exercise:

- Conduct surveys and assessments to provide current conditions so existing problems can be addressed before they become more severe.
- Standardized public information and outreach for the County and municipalities.
- Shared services throughout the County.
- The need for training for county and municipal staff.

6.5 REVIEW AND UPDATE OF MITIGATION GOALS AND OBJECTIVES

This section documents the efforts to update the guiding principles, and hazard mitigation goals and objectives established to reduce or avoid long-term vulnerabilities to the identified hazards.

6.5.1 Goals and Objectives

FEMA defines ***Goals*** as general guidelines that explain what should be achieved. Goals are usually broad, long-term, policy statements, and represent a global vision.

FEMA defines ***Objectives*** as strategies or implementation steps to attain mitigation goals. Unlike goals, objectives are specific and measurable, where feasible.

FEMA defines ***Mitigation Actions*** as specific actions that help to achieve the mitigation goals and objectives.

According to CFR 201.6(c)(3)(i): "The hazard mitigation strategy shall include a description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards." Further, FEMA mitigation planning guidance recommends establishing objectives to better tie mitigation goals to specific mitigation strategies (e.g. projects, activities, and initiatives).

The goals established in the 2016 Mitigation Plan for Four New Jersey Counties were presented to the Steering Committee and Planning Partnership for review and amendment throughout the planning process. This review was made with consideration of the hazard events and losses since the 2016 plan, the updated hazard profiles and vulnerability assessment, and the goals and objectives established in the updated 2019 State HMP.

The 2016 HMP included objectives (referred to as strategies in the last plan) as part of their planning process. As part of the 2022 update, the Steering Committee reviewed the objectives from the 2016 HMP and chose to

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align objectives with each goal. The Steering Committee met on June 23, 2021 to review the 2016 goals and objectives and provided input on updated goals and objectives. These updates were presented to the Planning Partnership during the August 2021 Mitigation Strategy Workshop. As a result of these efforts, Table 6-3 presents Gloucester County's updated goals and objectives for the 2022 Hazard Mitigation Plan update. *Italicized* text indicates the updates made to the goals and objectives.

Table 6-1. 2016 HMP Mitigation Goals

Goal #	2016 HMP Goal Statement
1	Improve education and outreach efforts regarding potential risk of natural hazards and appropriate mitigation measures that can be used to reduce risk (including programs, activities, and projects)
2	Improve data collection, use, and sharing to reduce the risk of natural hazards
3	Improve capabilities and coordination at municipal, county, and state levels to plan and implement hazard mitigation measures
4	Plan and implement projects to mitigate identified natural hazards, known problems, and areas of concern

Table 6-2. 2016 HMP Mitigation Strategies

2016 HMP Strategy Statement
Focus on projects to address known problems or areas of concern for critical facilities and vulnerable populations as initial risk reduction efforts
Identify additional areas of concern for critical facilities and vulnerable populations for future plan updates
Work with Municipal OEMs, engineering, and public works officials to resolve multi-jurisdictional mitigation measures
Work with Municipal OEMs to provide opportunities for residents and property owners to access available information about risk reduction and mitigation measures
Institutionalize hazard mitigation into Municipal and County activities and programs through regular interactions of the Municipal and County Working Groups and better integration of related regulatory programs and planning initiatives
Stay informed regarding changing conditions and related improvements in hazard and risk data due to future natural hazard events and increasing understanding of the effects of climate change and use the information as part of periodic evaluations of and refinements or additions to the Municipal and County mitigation programs

Table 6-3. Gloucester County 2022 Hazard Mitigation Plan Goals and Objectives

<table>
<tr><th>2022 HMP Update Goals</th><th>2022 HMP Update Objectives</th></tr>
<tr><td rowspan="4">Goal 1 – Protect Life</td><td>Objective 1-1: Identify the need for, and acquire, any special emergency services, training, and equipment to enhance response and recovery capabilities for specific hazards</td></tr>
<tr><td>Objective 1-2: Maintain and enhance local regulatory standards with new hazard and risk information including full and effective building code enforcement, floodplain management, land use planning mechanisms and other natural hazard vulnerability-reducing regulations</td></tr>
<tr><td>Objective 1-3: Incorporate hazard mitigation into community planning mechanisms and projects</td></tr>
<tr><td>Objective 1-4: Identify and protect socially vulnerable populations from hazard impacts.</td></tr>
<tr><td rowspan="2">Goal 2 – Protect Property</td><td>Objective 2-1: Pursue cost-effective mitigation actions to reduce the impacts of hazards on people, property and the economy</td></tr>
<tr><td>Objective 2-2: Protect, preserve and enhance natural resources and ecologically sensitive land, such as wetlands, wildlife habitat, waterways, slopes, mature woodlands, large stands of forests and ridge lines</td></tr>
</table>

2022 HMP Update Goals	2022 HMP Update Objectives
	Objective 2-3: Facilitate the development and timely submittal of project applications meeting state and federal guidelines for funding to reduce the number of repetitive and severe repetitive loss properties and hardening/retrofitting infrastructure and critical facilities and lifelines
	Objective 2-4: Encourage the use of sustainable nature based solutions to address riverine and stormwater flooding
	Objective 2-5: Encourage the use of green stormwater infrastructure to mitigate flooding and improve water quality
Goal 3 - Improve education and outreach efforts regarding potential risk of natural hazards and appropriate mitigation measures that can be used to reduce risk	Objective 3-1: Increase awareness of natural hazard risks and understanding of the advantages of mitigation to the general public, business and community members, and local government officials
	Objective 3-2: Increase local government official awareness regarding funding criteria and opportunities for mitigation
	Objective 3-3: Provide government officials and the public with educational opportunities and information regarding best practices for preparedness, hazard mitigation planning, project identification, and implementation
	Objective 3-4: Strengthen understanding of, and adaptation to, a changing climate
Goal 4 - Improve data collection, use, and sharing to reduce the risk of natural hazards	Objective 4-1: Improve data collection and sharing; and increase data availability to reduce the impacts of hazards and for future planning efforts
	Objective 4-2: Acquire and maintain detailed data regarding critical facilities and lifelines such that these sites can be prioritized and risk-assessed for possible mitigation actions
	Objective 4-3: Continue support of hazard mitigation planning, project identification, and implementation at the municipal and county level
Goal 5 - Improve capabilities and coordination at municipal, county, and state levels to plan and implement hazard mitigation measures	Objective 5-1: Support increased participation in the National Flood Insurance Program and Community Rating System
	Objective 5-2: Support increased integration of municipal/county hazard mitigation planning and floodplain management with effective municipal zoning regulation, and effective municipal/county subdivision regulation, and comprehensive planning
	Objective 5-3: Provide user-friendly hazard-data accessibility for mitigation planning, other planning efforts and for private citizens
Goal 6 - Support Continuity of Operations Pre-, During, and Post-Hazard Events	Objective 6-1: Ensure continuity of operations of government, non-government, commerce, private sector, and infrastructure
	Objective 6-2: Support and encourage the implementation of back-up and alternative energy sources
	Objective 6-3: Support and encourage the implementation of alternative energy sources
	Objective 6-4: Implement mitigation measures that promote the reliability of lifeline systems
Goal 7 - Address Long-Term Vulnerabilities from High Hazard Dams	Objective 7-1: Ensure dam infrastructure is maintained
	Objective 7-2: Ensure Emergency Action Plans are developed and updated
	Objective 7-3: Support the identification and access to funding to repair/replace dams

6.6 MITIGATION STRATEGY DEVELOPMENT AND UPDATE

As required by FEMA, the County and participating municipalities completed a comprehensive evaluation of the mitigation strategies and actions from the 2016 HMP and reported on the status of each. Their update may be found in each jurisdictional annex (Section 9). In addition, the County and participating municipalities were provided the opportunity to include new strategies or actions to include in the 2022 HMP Update. New actions were prioritized to ensure they are cost-effective, environmentally sound, and technically feasible using the methodology outlined below.

6.6.1 Review of the 2016 HMP Mitigation Action Plan

To evaluate progress on local mitigation actions, the planning consultant met with each participant to discuss the status of the mitigation actions identified in the 2016 plan. For each action, jurisdictions were asked to provide the status of each action (*No Progress, In Progress, Ongoing Capability, Discontinue, or Completed*) and provide review comments on each. Jurisdictions were requested to quantify the extent of progress and provide reasons for the level of progress or why actions were being discontinued. Each jurisdictional annex in Section 9 (Jurisdictional Annexes) provides a table identifying the jurisdiction's prior mitigation strategy, the status of those actions and initiatives, and their disposition within their updated strategy.

Local mitigation actions identified as *Complete*, and those actions identified as *Discontinued*, were removed from the updated strategies. Local mitigation actions identified as an *Ongoing Capability* were incorporated into the capability assessment of each jurisdictional annex. Those actions identified as *No Progress* or *In Progress* that remain a priority for the jurisdiction, have been carried forward into the updated mitigation strategy. Actions identified as *Ongoing Capabilities* which are fully integrated into the normal operational and administrative framework of the community have been identified within the capabilities section of each annex, and removed from the updated mitigation strategy.

At the May 2021 kick-off meeting and during subsequent local-level planning meetings (phone, email), all participating jurisdictions were requested to identify mitigation activities completed, ongoing, and potential/proposed. As new potential mitigation actions, projects, or initiatives became evident during the plan update process, including as part of the risk assessment update and as identified through the public and stakeholder outreach process detailed in Section 2 (Planning Process), jurisdictions were made aware of these either through direct communication (local meetings, email, phone), at Steering and Planning Committee meetings, or via their draft jurisdictional annexes.

Throughout the planning process, the planning consultant worked directly with each community (phone, email) to assist with the development and update of their annex and include mitigation strategies, focusing on identifying well-defined, implementable projects with a careful consideration of benefits (risk reduction, losses avoided), costs, and possible funding sources (including mitigation grant programs).

6.6.2 Identification and Analysis of Mitigation Techniques

Concerted efforts were made to assure that municipalities develop updated mitigation strategies that included activities and initiatives covering the range of mitigation action types described in recent FEMA planning guidance (FEMA "Local Mitigation Planning Handbook" March 2013), specifically:

- **Local Plans and Regulations** - These actions include government authorities, policies or codes that influence the way land and buildings are being developed and built.
- **Structure and Infrastructure Projects** - These actions involve modifying existing structures and infrastructure to protect them from a hazard or remove them from a hazard area. This could apply to public or private structures as well as critical facilities and infrastructure. This type of action also involves projects to construct manmade structures to reduce the impact of hazards.
- **Natural Systems Protection** - These are actions that minimize damage and losses, and also preserve or restore the functions of natural systems.
- **Education and Awareness Programs** - These are actions to inform and educate citizens, elected officials, and property owners about hazards and potential ways to mitigate them. These actions may also include participation in national programs, such as the National Flood Insurance Program and Community Rating System, StormReady (NOAA) and Firewise (NFPA) Communities.

6.6.3 2022 HMP Mitigation Action Plan

To help support the selection of an appropriate, risk-based mitigation strategy, each annex provides a summary of hazard vulnerabilities identified during the plan update process, either directly by municipal representatives, through review of available county and local plans and reports, and through the hazard profiling and vulnerability assessment process.

In August 2021, the planning partnership participated in a mitigation strategy development workshop co-led by NJOEM Mitigation Unit, FEMA Region II and the contract consultant, supplemented by emails and phone calls between jurisdictions and the contract consultant, for all participating jurisdictions to support the development of focused problem statements based on the impacts of natural hazards in the county and their communities. These problem statements were intended to provide a detailed description of the problem area, including its impacts to the municipality/jurisdiction; past damages; loss of service; etc. An effort was made to include the street address of the property/project location, adjacent streets, water bodies, and well-known structures as well as a brief description of existing conditions (topography, terrain, hydrology) of the site. These problem statements formed a bridge between the hazard risk assessment which quantifies impacts to each community with the development of actionable mitigation strategies.

As discussed within the hazard profiles in Section 4.3 (Risk Assessment), the long-term effects of climate change are anticipated to exacerbate the impacts of weather-related hazards including flood, hurricanes and tropical storm, nor'easter, severe weather, severe winter weather and wildfire. By way of addressing these climate change-sensitive hazards within their local mitigation strategies and integration actions, communities are working to evaluate and recognize these long-term implications and potential impacts, and to incorporate in planning and capital improvement updates.

A strong effort has been made to better focus local mitigation strategies to clearly defined, readily implementable projects and initiatives that meet the definition or characteristics of mitigation. Broadly defined mitigation actions were eliminated from the updated strategy unless accompanied by discrete actions, projects, or initiatives. Certain continuous or ongoing strategies that represent programs that are fully integrated into the normal operational and administrative framework of the community have been identified within the capabilities section of each annex and removed from the updated mitigation strategy.

To assist with the development of mitigation actions, municipalities were provided with the following:

- 2022 HMP goals and objectives
- 2016 HMP mitigation strategy
- Risk assessment results
- Outcome of the SWOO
- Mitigation catalog
- Stakeholder and public input (e.g. citizen and stakeholder survey results)
- FEMA resources

Overall, a comprehensive range of specific mitigation initiatives were considered by each plan participant to pursue in the future to reduce the effects of hazards. Some of these initiatives may be previous actions carried forward for this plan update. These initiatives are dependent upon available funding (grants and local match availability) and may be modified or omitted at any time based on the occurrence of new hazard events and changes in municipal priorities.

Throughout the course of the plan update process, additional regional and county-level mitigation actions were identified by the following processes:

- Review of the results and findings of the updated risk assessment.
- Review of available regional and county plans reports and studies;
- Direct input from county departments and other county and regional agencies
- Input received through the public and stakeholder outreach process.

6.6.4 Mitigation Best Practices

Catalogs of hazard mitigation best practices were developed that present a broad range of alternatives to be considered for use in Gloucester County, in compliance with 44 CFR Section 201.6(c)(3)(ii). One catalog was developed for each natural hazard of concern evaluated in this plan; referred to as Appendix F (Mitigation Strategy Supplementary Data). The catalogs present alternatives that are categorized in two ways:

- By whom would have responsibility for implementation:
    - Individuals – personal scale

    - Businesses – corporate scale
    - Government – government scale
- By what each of the alternatives would do:
    - Manipulate the hazard
    - Reduce exposure to the hazard
    - Reduce vulnerability to the hazard
    - Build local capacity to respond to or be prepared for the hazard

The alternatives presented include actions that will mitigate current risk from hazards and actions that will help reduce risk from changes in the impacts of these hazards resulting from climate change. Hazard mitigation actions recommended in this plan were selected from among the alternatives presented in the catalog, as well as other resources made available to all jurisdictions (i.e., FEMA's Mitigation Ideas). The catalog provides a baseline of mitigation alternatives that are backed by a planning process, are consistent with the established goals and objectives, and are within the capabilities of the planning partners to implement. Some of these actions may not be feasible based on the selection criteria identified for this plan. The purpose of the catalog was to provide a list of what could be considered to reduce risk from natural hazards within the planning area. Actions in the catalog that are not included for the partnership's action plan were not selected for one or more of the following reasons:

- The action is not feasible
- The action is already being implemented
- There is an apparently more cost-effective alternative
- The action does not have public or political support.

6.6.5 Mitigation Strategy Evaluation and Prioritization

Section 201.c.3.iii of 44 CFR requires an action plan describing how the actions identified will be prioritized. Recent FEMA planning guidance (March 2013) identifies a modified STAPLEE (Social, Technical, Administrative, Political, Legal, Economic, and Environmental) mitigation action evaluation methodology that uses a set of 10 evaluation criteria suited to the purposes of hazard mitigation strategy evaluation. This method provides a systematic approach that considers the opportunities and constraints of implementing a particular mitigation action.

Based on this guidance, the Steering Committee has adopted and applied an action evaluation and prioritization methodology which includes an expanded set of 14 criteria to include the consideration of cost-effectiveness, availability of funding, anticipated timeline, and if the action addresses multiple hazards.

The 14 evaluation/prioritization criteria used in the 2022 update process are:

1) **Life Safety** – How effective will the action be at protecting lives and preventing injuries?

2) **Property Protection** – How significant will the action be at eliminating or reducing damage to structures and infrastructure?
3) **Cost-Effectiveness** – Are the costs to implement the project or initiative commensurate with the benefits achieved?
4) **Technical** – Is the mitigation action technically feasible? Is it a long-term solution? Eliminate actions that, from a technical standpoint, will not meet the goals.
5) **Political** – Is there overall public support for the mitigation action? Is there the political will to support it?
6) **Legal** – Does the municipality have the authority to implement the action?
7) **Fiscal** – Can the project be funded under existing program budgets (i.e., is this initiative currently budgeted for)? Or would it require a new budget authorization or funding from another source such as grants?
8) **Environmental** – What are the potential environmental impacts of the action? Will it comply with environmental regulations?
9) **Social** – Will the proposed action adversely affect one segment of the population? Will the action disrupt established neighborhoods, break up voting districts, or cause the relocation of lower income people?
10) **Administrative** – Does the jurisdiction have the personnel and administrative capabilities to implement the action and maintain it or will outside help be necessary?
11) **Multi-hazard** – Does the action reduce the risk to multiple hazards?
12) **Timeline** – Can the action be completed in less than 5 years (within our planning horizon)?
13) **Local Champion** – Is there a strong advocate for the action or project among the jurisdiction's staff, governing body, or committees that will support the action's implementation?
14) **Other Local Objectives** – Does the action advance other local objectives, such as capital improvements, economic development, environmental quality, or open space preservation? Does it support the policies of other plans and programs?

Specifically, for each mitigation action, the jurisdictions were asked to assign a numeric rank (-1, 0, or 1) for each of the 14 evaluation criteria, defined as follows:

- 1 = Highly effective or feasible
- 0 = Neutral
- -1 = Ineffective or not feasible

Further, jurisdictions were asked to provide a summary of the rationale behind the numeric rankings assigned, as applicable. The numerical results were totaled to assist each jurisdiction in selecting mitigation actions for the updated plan.

As step one in the prioritization process, actions that had a numerical value between 0 and 4 were initially prioritized as low; actions with numerical values between 5 and 9 were initially categorized as medium; and actions with numerical values between 10 and 14 were initially categorized as high. As step two, jurisdictions were then asked to consider the benefits and costs, as well as the desired timeline for implementation and project completion timeline when finalizing each action's priority as high/medium/low. These attributes are included in the mitigation strategy table and for FEMA-eligible projects in the mitigation worksheets (Section 9 – Jurisdictional Annexes).

For the plan update there has been an effort to develop more clearly defined and action-oriented mitigation strategies. These local strategies include projects and initiatives that are seen by the community as the most effective approaches to advance their local mitigation goals and objectives within their capabilities. In addition, each jurisdiction was asked to develop problem statements. With this process, participating jurisdictions were able to develop action-oriented and achievable mitigation strategies.

6.6.6 Benefit/Cost Review

Section 201.6.c.3iii of 44CFR requires the prioritization of the action plan to emphasize the extent to which benefits are maximized according to a cost/benefit review of the proposed projects and their associated costs. Stated otherwise, cost-effectiveness is one of the criteria that must be applied during the evaluation and prioritization of all actions comprising the overall mitigation strategy.

The benefit/cost review applied in for the evaluation and prioritization of projects and initiatives in this HMP update process was qualitative; that is, it does not include the level of detail required by FEMA for project grant eligibility under the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA) and Pre-Disaster Mitigation (PDM) grant programs. For all actions identified in the local strategies, jurisdictions have identified both the costs and benefits associated with project, action or initiative.

Costs are the total cost for the action or project, and may include administrative costs, construction costs (including engineering, design and permitting), and maintenance costs.

Benefits are the savings from losses avoided attributed to the implementation of the project, and may include life-safety, structure and infrastructure damages, loss of service or function, and economic and environmental damage and losses.

When possible, jurisdictions were asked to identify the actual or estimated dollar value for project costs and associated benefits. Having defined costs and benefits allows a direct comparison of benefits versus costs, and a quantitative evaluation of project cost-effectiveness. Often, however, numerical costs and/or benefits have not been identified, or may be impossible to quantitatively assess.

For the purposes of this planning process, jurisdictions were tasked with evaluating project cost-effectiveness with both costs and benefits assigned to "High", "Medium" and "Low" ratings. Where quantitative estimates of costs and benefits were available, ratings/ranges were defined as:

- Low = < $10,000
- Medium = $10,000 to $100,000
- High = > $100,000

Where quantitative estimates of costs and/or benefits were not available, qualitative ratings using the following definitions were used:

Table 6-4. Qualitative Cost and Benefit Ratings

Costs	
High	Existing funding levels are not adequate to cover the costs of the proposed project, and implementation would require an increase in revenue through an alternative source (e.g., bonds, grants, and fee increases).
Medium	The project could be implemented with existing funding but would require a re-apportionment of the budget or a budget amendment, or the cost of the project would have to be spread over multiple years.
Low	The project could be funded under the existing budget. The project is part of or can be part of an existing, ongoing program.
Benefits	
High	Project will have an immediate impact on the reduction of risk exposure to life and property.
Medium	Project will have a long-term impact on the reduction of risk exposure to life and property or will provide an immediate reduction in the risk exposure to property.
Low	Long-term benefits of the project are difficult to quantify in the short term.

Using this approach, projects with positive benefit versus cost ratios (such as high over high, high over medium, medium over low, etc.) are considered cost-beneficial and are prioritized accordingly. For some of the Gloucester County initiatives identified, the planning partnership may seek financial assistance under FEMA's HMGP or Hazard Mitigation Assistance (HMA) programs. These programs require detailed benefit/cost analysis as part of the application process. These analyses will be performed when funding applications are prepared, using the FEMA BCA model process. The planning partnership is committed to implementing mitigation strategies with benefits that exceed costs. For projects not seeking financial assistance from grant programs that require this sort of analysis, the planning partnership reserves the right to define "benefits" according to parameters that meet its needs and the goals and objectives of this HMP.

SECTION 7. PLAN MAINTENANCE

2022 HMP Changes

- In this update the maintenance process has been more clearly outlined to provide a roadmap for the annual monitoring of the plan. This includes a summary plan maintenance matrix that provides an overview of the planning partner responsibilities for monitoring, integrating, evaluating, and updating the plan.

This section details the formal process that will ensure that the HMP remains an active and relevant document and that the Planning Partnership maintains their eligibility for applicable funding sources. The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every five years. In addition, this section describes how public participation will be integrated throughout the plan maintenance and implementation process. It explains how the mitigation strategies outlined in this plan update will be incorporated into existing planning mechanisms and programs, such as comprehensive land use planning processes, capital improvement planning, and building code enforcement and implementation. The plan's format allows sections to be reviewed and updated when new data become available, resulting in a plan that will remain current and relevant.

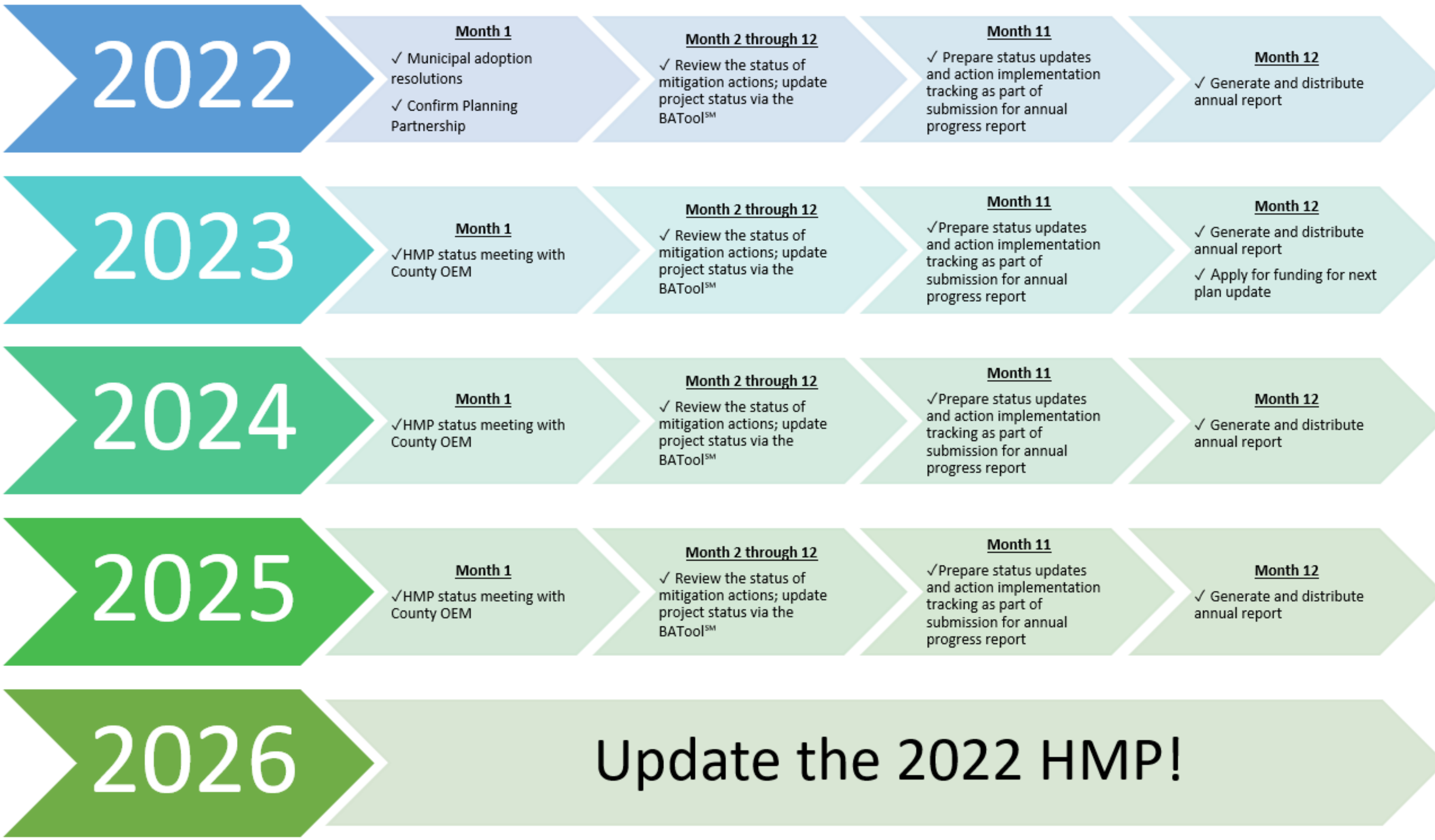
The plan maintenance matrix shown in Table 7-1 provides a synopsis of responsibilities for plan monitoring, evaluation, and update, which are discussed in further detail in the sections below.

Table 7-1. Plan Maintenance Matrix

Task	Approach	Timeline	Responsibility	Support Responsibility
Monitoring	Preparation of status updates and action implementation tracking as part of submission for Annual Progress Report.	Meet annually or upon major update to Master Plan or major disaster declaration	Jurisdictional points of contact identified in Section 8 (Planning Partnership) and Section 9 (Jurisdictional Annexes)	Jurisdictional implementation lead identified in Section 8 (Planning Partnership) and Section 9 (Jurisdictional Annexes)
Integration	In order for integration of mitigation principles action to become an organic part of the ongoing county and municipal activities, the County will incorporate the distribution of the safe growth worksheet for annual review and update by all participating jurisdictions.	April each year with interim email reminders to address integration in county and municipal activities.	HMP Coordinator and jurisdictional points of contact identified in Section 8 (Planning Partnership) and Section 9 (Jurisdictional Annexes)	HMP Coordinator

Task	Approach	Timeline	Responsibility	Support Responsibility
Evaluation	Review the status of previous actions as submitted by the monitoring task lead and support to assess the effectiveness of the plan; compile and finalize the Annual Progress Report	Finalized progress report completed by October 14 of each year	Steering Committee; Plan Maintenance element	Jurisdictional points of contacts identified in Section 9 (Jurisdictional Annexes)
Update	Reconvene the planning partners, at a minimum, every 5 years to guide a comprehensive update to review and revise the plan.	Every 5 years or upon major update to Master Plan or major disaster	Gloucester County HMP Coordinator	Jurisdictional points of contacts identified in Section 9 (Jurisdictional Annexes)

Figure 7-1. Plan Maintenance Timeline



7.1 MONITORING, EVALUATING, AND UPDATING THE PLAN

The procedures for monitoring, evaluating, and updating the plan are provided below.

The HMP Coordinator is assigned to manage the maintenance and update of the plan during its performance period. The HMP Coordinator will chair the Steering Committee and be the prime point of contact for questions regarding the plan and its implementation as well as to coordinate incorporation of additional information into the plan.

The Planning Partnership shall fulfill the monitoring, evaluation and updating responsibilities identified in this section which is comprised of a representative from each participating jurisdiction. Each jurisdiction is expected to maintain a representative on the Planning Partnership throughout the plan performance period (five years from the date of plan adoption). As of the date of this plan, primary and secondary mitigation planning representatives (points-of-contact) are identified in each jurisdictional annex in Section 9 (Jurisdictional Annexes).

Regarding the composition of the committee, it is recognized that individual commitments change over time, and it shall be the responsibility of each jurisdiction and its representatives to inform the HMP Coordinator of any changes in representation. The HMP Coordinator will strive to keep the committee makeup as a uniform representation of planning partners and stakeholders within the planning area.

Currently, the Gloucester County HMP Coordinator is designated as:

Name:	Dennis McNulty
Title:	Director, Gloucester County Office of Emergency Management
Email Address:	dmcnulty@co.gloucester.nj.us

7.1.1 Monitoring

The Planning Partnership shall be responsible for monitoring progress on, and evaluating the effectiveness of, the plan, and documenting annual progress. Each year, beginning one year after plan development, Gloucester County and local Planning Partnership representatives will collect and process information from the departments, agencies and organizations involved in implementing mitigation projects or activities identified in their jurisdictional annexes (Section 9) of this plan, by contacting persons responsible for initiating and/or overseeing the mitigation projects.

In the first year of the performance period, this will be accomplished by utilizing an online performance progress reporting system, the BATool^{SM} which will enable municipal and county representatives to directly access mitigation initiatives to easily update the status of each project, document successes or obstacles to implementation, add or delete projects to maintain mitigation project implementation. It is anticipated that all participating partners will be prompted by the tool to update progress annually, providing an incentive for participants to refresh their mitigation strategies and to continue implementation of projects. It is expected that this reporting system will support the submittal of an increased number of project grant fund applications due to the functionality of the system which facilitates the sorting and prioritization of projects.

In addition to progress on the implementation of mitigation actions, including efforts to obtain outside funding; and obstacles or impediments to implementation of actions, the information that Planning Partnership representatives shall be expected to document, as needed and appropriate include:

- Any grant applications filed on behalf of any of the participating jurisdictions
- Hazard events and losses occurring in their jurisdiction,
- Additional mitigation actions believed to be appropriate and feasible,
- Public and stakeholder input.
- Plan monitoring for years 2 through 4 of the plan performance periods will be similarly addressed via the BATool^{SM} or manually.

7.1.2 Integration Process of the HMP into Municipal Planning Mechanisms

Hazard mitigation is sustained action taken to reduce or eliminate the long-term risk to human life and property from natural hazards. Integrating hazard mitigation into a community's existing plans, policies, codes, and programs leads to development patterns that do not increase risk from known hazards or leads to redevelopment that reduces risk from known hazards. The Gloucester County HMP Planning Partnership was tasked with identifying how hazard mitigation is integrated into existing planning mechanisms. Refer to Section 9 (Jurisdictional Annexes) for how this is done for each participating municipality. During this process, many municipalities recognized the importance and benefits of incorporating hazard mitigation into future municipal planning and regulatory processes.

The Planning Partnership representatives will incorporate mitigation planning as an integral component of daily government operations. They will work with local government officials to integrate the newly adopted hazard mitigation goals and actions into the general operations of government and partner organizations. Further, the sample adoption resolution (Appendix A – Adoption Resolution) includes a resolution item stating the intent of the local governing body to incorporate mitigation planning as an integral component of government and partner operations. By doing so, the Planning Partnership anticipates that:

- Hazard mitigation planning will be formally recognized as an integral part of overall planning and emergency management efforts;

- The Hazard Mitigation Plan, Master Plans, Emergency Operations Plans and other relevant planning mechanisms will become mutually supportive documents that work in concert to meet the goals and needs of County residents.

During the HMP annual review process, each participating municipality will be asked to document how they are utilizing and incorporating the Gloucester County HMP into their day-to-day operations and planning and regulatory processes. Additionally, each municipality will identify additional policies, programs, practices, and procedures that could be modified to accommodate hazard mitigation actions and include these findings and recommendations in the Annual HMP Progress Report. The following checklist was adapted from FEMA's Local Mitigation Handbook (2013), Appendix G, Worksheet #4. This checklist (Table 7-2) will help a community analyze how hazard mitigation is integrated into local plans, ordinances, regulations, ordinances, and policies. By completing the checklist, it will help municipalities identify areas that integrate hazard mitigation currently and where to make improvements and reduce vulnerability to future development. In this manner, the integration of mitigation into municipal activities will evolve into an ongoing culture within the County and its municipalities.

Table 7-2. Safe Growth Checklist

Planning Mechanisms	Do you do this? Yes	No	Notes: How is it being done or how will this be utilized in the future?
Operating, Municipal and Capital Improvement Program Budgets			
• When constructing upcoming budgets, hazard mitigation actions will be funded as budget allows. Construction projects will be evaluated to see if they meet the hazard mitigation goals.			
• Annually, during adoption process, the municipality will review mitigation actions when allocating funding.			
• Do budgets limit expenditures on projects that would encourage development in areas vulnerable to natural hazards?			
• Do infrastructure policies limit extension of existing facilities and services that would encourage development in areas vulnerable to natural hazards?			
• Do budgets provide funding for hazard mitigation projects identified in the County HMP?			
Human Resource Manual			
• Do any job descriptions specifically include identifying and/or implementing mitigation projects/actions or other efforts to reduce natural hazard risk?			
Building and Zoning Ordinances			
• Prior to, zoning changes, or development permitting, the municipality will review the hazard mitigation plan and other hazard analyses to ensure consistent and compatible land use.			
• Does the zoning ordinance discourage development or redevelopment within natural areas including wetlands, floodways, and floodplains?			
• Does it contain natural overlay zones that set conditions			
• Does the ordinance require developers to take additional actions to mitigate natural hazard risk?			
• Do rezoning procedures recognize natural hazard areas as limits on zoning changes that allow greater intensity or density of use?			
• Do the ordinances prohibit development within, of filling of, wetlands, floodways, and floodplains?			
Subdivision Regulations			

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Planning Mechanisms	Do you do this?		Notes:
	Yes	No	How is it being done or how will this be utilized in the future?
• Do the subdivision regulations restrict the subdivision of land within or adjacent to natural hazard areas?			
• Do the subdivision regulations restrict the subdivision of land within or adjacent to natural hazard areas?			
• Do the regulations provide for conservation subdivisions or cluster subdivisions in order to conserve environmental resources?			
• Do the regulations allow density transfers where hazard areas exist?			
Master Plan			
• Are the goals and policies of the plan related to those of the County HMP?			
• Does the future land use map clearly identify natural hazard areas?			
• Do the land use policies discourage development or redevelopment with natural hazard areas?			
• Does the plan provide adequate space for expected future growth in areas located outside natural hazard areas?			
Land Use			
• Does the future land use map clearly identify natural hazard areas?			
• Do the land use policies discourage development or redevelopment with natural hazard areas?			
• Does the plan provide adequate space for expected future growth in areas located outside natural hazard areas?			
Transportation Plan			
• Does the transportation plan limit access to hazard areas?			
• Is transportation policy used to guide growth to safe locations?			
• Are transportation systems designed to function under disaster conditions (e.g. evacuation)?			
Environmental Management			
• Are environmental systems that protect development from hazards identified and mapped?			
• Do environmental policies maintain and restore protective ecosystems?			

Planning Mechanisms	Do you do this? Yes	Do you do this? No	Notes: How is it being done or how will this be utilized in the future?
• Do environmental policies provide incentives to development that is located outside protective ecosystems?			
Grant Applications			
• Data and maps will be used as supporting documentation in grant applications.			
Municipal Ordinances			
• When updating municipal ordinances, hazard mitigation will be a priority			
Economic Development			
• Local economic development group will take into account information regarding identified hazard areas when assisting new businesses in finding a location.			
Public Education and Outreach			
• Does the municipality have any public outreach mechanisms / programs in place to inform citizens on natural hazards, risk, and ways to protect themselves during such events?			

7.1.3 Evaluating

The evaluation of the mitigation plan is an assessment of whether the planning process and actions have been effective, if the HMP goals are being achieved, and whether changes are needed. The HMP will be evaluated on an annual basis to determine the effectiveness of the programs, and to reflect changes that could affect mitigation priorities or available funding.

The status of the HMP will be discussed and documented at an annual plan review meeting of the Steering Committee and Planning Committee (Planning Partnership), to be held either in person or via teleconference approximately one year from the date of local adoption of this update, successively thereafter. At least two weeks prior to the annual review meeting, the Gloucester County HMP coordinator will advise the Planning Partnership of the meeting date, agenda, and expectations of the members. The HMP coordinator will also document the meeting with a sign-in and meeting minutes.

The Gloucester County HMP Coordinator will be responsible for calling and coordinating the annual plan review meeting and soliciting input regarding progress toward meeting plan goals and objectives. These evaluations will assess whether:

- Goals and objectives address current and expected conditions.
- The nature or magnitude of the risks has changed.
- Current resources are appropriate for implementing the HMP and if different or additional resources are now available.
- Actions were cost effective.
- Schedules and budgets are feasible.
- Implementation problems, such as technical, political, legal or coordination issues with other agencies are present.
- Outcomes have occurred as expected.
- Changes in county or municipal resources impacted plan implementation (e.g., funding, personnel, and equipment)
- New agencies/departments/staff should be included, including other local governments as defined under 44 CFR 201.6.

Specifically, the Planning Partnership will review the mitigation goals, objectives, and activities using performance-based indicators, including:

- New agencies/departments
- Project completion
- Under/overspending
- Achievement of the goals and objectives
- Resource allocation

- Timeframes
- Budgets
- Lead/support agency commitment
- Resources
- Feasibility

Finally, the Planning Partnership will evaluate how other programs and policies have conflicted or augmented planned or implemented measures, and shall identify policies, programs, practices, and procedures that could be modified to accommodate hazard mitigation actions ("Implementation of Mitigation Plan through Existing Programs" subsection later in this section discusses this process). Other programs and policies can include those that address:

- Economic development
- Environmental preservation
- Historic preservation
- Redevelopment
- Health and/or safety
- Recreation
- Land use/zoning
- Public education and outreach
- Transportation

The Planning Partnership should refer to the evaluation forms, Worksheets #2 and #4 in the FEMA 386-4 guidance document, to assist in the evaluation process (see Appendix H – Plan Maintenance Tools). Further, the Planning Partnership should refer to any process and plan review deliverables developed by the County or participating jurisdictions as a part of the plan review processes established for prior or existing local HMPs within the County.

The Gloucester County HMP Coordinator shall be responsible for preparing an Annual HMP Progress Report for each year of the performance period, based on the information provided by the Planning Partnership, information presented at the annual meeting, and other information as appropriate and relevant. These annual reports will provide data for the five-year update of this HMP and will assist in pinpointing any implementation challenges. By monitoring the implementation of the HMP on an annual basis, the Planning Partnership will be able to assess which projects are completed, which are no longer feasible, and what projects should require additional funding.

The Annual HMP Progress Report shall be posted on the Gloucester County Office of Emergency Management website to keep the public apprised of the plan's implementation (https://www.gloucestercountynj.gov/323/Emergency-Management). Additionally, the website provides details on the HMP update planning process. For communities who participate or might choose to join the NFIP CRS program, this report will also be provided to each CRS participating community in order to meet annual CRS recertification requirements. To meet this recertification timeline, the Planning partnership will strive to complete the review process and prepare an Annual HMP Progress Report by October 14th of each year.

The HMP will also be evaluated and revised following any major disasters, to determine if the recommended actions remain relevant and appropriate. The risk assessment will also be revisited to see if any changes are necessary based on the pattern of disaster damages or if data listed in the Section 4.3 of this plan has been collected to facilitate the risk assessment. This is an opportunity to increase the community's disaster resistance and build a better and stronger community.

7.1.4 Updating

> 44 CFR 201.6.d.3 requires that local hazard mitigation plans be reviewed, revised as appropriate, and resubmitted for approval in order to remain eligible for benefits awarded under the DMA 2000. It is the intent of Gloucester County to update this plan on a five-year cycle from the date of initial plan adoption.

To facilitate the update process, the Gloucester County HMP Coordinator, with support of the Planning Partnership, shall use the second annual meeting to develop and commence the implementation of a detailed plan update program. The Gloucester County HMP Coordinator shall invite representatives from NJOEM to this meeting to provide guidance on plan update procedures. This program shall, at a minimum, establish who shall be responsible for managing and completing the plan update effort, what needs to be included in the updated plan, and a detailed timeline with milestones to assure that the update is completed according to regulatory requirements.

At this meeting, the Planning Partnership shall determine what resources will be needed to complete the update. The Gloucester County HMP Coordinator shall be responsible for assuring that needed resources are secured.

Following each five-year update of the mitigation plan, the updated plan will be distributed for public comment. After all comments are addressed, the HMP will be revised and distributed to all planning group members and the New Jersey State Hazard Mitigation Officer.

7.1.5 Grant Monitoring and Coordination

Gloucester County recognizes the importance of having an annual coordination period that helps each planning partner become aware of upcoming mitigation grant opportunities and identifies multi-jurisdiction projects to pursue. Grant monitoring will be the responsibility of each municipal partner as part of their annual progress reporting. The Gloucester County HMP Coordinator will keep the planning partners apprised of FEMA Hazard Mitigation Assistance grant openings and assist in developing letters of intent for grant opportunities when practicable.

Gloucester County intends to be a resource to the planning partnership in the support of project grant writing and development. The degree of this support will depend on the level of assistance requested by the partnership during open windows for grant applications. As part of grant monitoring and coordination, Gloucester County intends to provide the following:

- Notification to planning partners about impending grant opportunities.
- A current list of eligible, jurisdiction-specific projects for funding pursuit consideration.
- Notification about mitigation priorities for the fiscal year to assist the planning partners in the selection of appropriate projects.

Grant monitoring and coordination will be integrated into the annual progress report or as needed based on the availability of non-HMA or post-disaster funding opportunities.

7.2 IMPLEMENTATION OF MITIGATION PLAN THROUGH EXISTING PROGRAMS

Effective mitigation is achieved when hazard awareness and risk management approaches and strategies become an integral part of public activities and decision-making. Within the County there are many existing plans and programs that support hazard risk management, and thus it is critical that this hazard mitigation plan integrate and coordinate with, and complement, those existing plans and programs.

Section 5 (Capability Assessment) provides a summary and description of the existing plans, programs and regulatory mechanisms at all levels of government (federal, state, county and local) that support hazard mitigation within the County. Within each jurisdictional annex in Section 9 (Jurisdictional Annexes), the County and each participating jurisdiction identified how each capability reduces risk and how they are integrating hazard risk management into their existing planning, regulatory, and operational/administrative framework. If they are currently not showing this, they indicate how they intend to promote this integration.

It is the intention of Planning Partnership representatives to continue to incorporate mitigation planning as an integral component of daily government operations. The Planning Partnership representatives will work with local government officials to integrate the newly adopted hazard mitigation goals and actions into the general operations of government and partner organizations. Further, the sample adoption resolution (Appendix A [Adoption Resolutions]) includes a resolution item stating the intent of the local governing body to incorporate mitigation planning as an integral component of government and partner operations. By doing so, the Steering Committee anticipates that:

1) Hazard mitigation planning will be formally recognized as an integral part of overall emergency management efforts;

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2) The Hazard Mitigation Plan, Master Plans, Emergency Operations Plans and other relevant planning mechanisms will become mutually supportive documents that work in concert to meet the goals and needs of county residents.

Other planning processes and programs to be coordinated with the recommendations of the hazard mitigation plan include the following:

- Emergency operations and response plans;
- Training and exercise of emergency response plans;
- Debris management plans;
- Recovery plans;
- Capital improvement programs;
- Municipal codes;
- Community design guidelines;
- Water-efficient landscape design guidelines;
- Stormwater management programs;
- Water system vulnerability assessments;
- Community Wildfire Protection Plans;
- Comprehensive Flood Hazard Management Plans;
- Resiliency plans;
- Community Development Block Grant-Disaster Recovery action plans; and
- Public information/education plans.

Some action items do not need to be implemented through regulation. Instead, these items can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation.

During the annual plan evaluation process, the Planning Partnership representatives will identify additional policies, programs, practices, and procedures that could be modified to accommodate hazard mitigation actions and include these findings and recommendations in the Annual HMP Progress Report.

7.3 CONTINUED PUBLIC INVOLVEMENT

Gloucester County and participating jurisdictions are committed to the continued involvement of the public in the hazard mitigation process. This HMP update will continue to be posted on-line: https://www.gloucestercountynj.gov/323/Emergency-Management

In addition, public outreach and dissemination of the HMP will include:

- Links to the plan on municipal websites of each jurisdiction with capability.

- Continued utilization of existing social media outlets (Facebook, Twitter) to inform the public of natural hazard events, such as floods and severe storms. Educate the public via the jurisdictional websites on how these applications can be used in an emergency situation.
- Development of annual articles or workshops on flood hazards to educate the public and keep them aware of the dangers of flooding.

The Steering Committee representatives and the Gloucester County HMP Coordinator will be responsible for receiving, tracking, and filing public comments regarding this HMP. The public will have an opportunity to comment on the plan via the hazard mitigation website at any time. The HMP Coordinator will maintain this website, posting new information and maintaining an active link to collect public comments.

The public can also provide input at the annual review meeting for the HMP and during the next five-year plan update. The Gloucester County HMP Coordinator is responsible for coordinating the plan evaluation portion of the meeting, soliciting feedback, collecting and reviewing the comments, and ensuring their incorporation in the five-year plan update as appropriate. Additional meetings might also be held as deemed necessary by the planning group. The purpose of these meeting would be to provide the public an opportunity to express concerns, opinions, and ideas about the mitigation plan.

The Steering Committee representatives shall be responsible to assure that:

- Public comment and input on the plan, and hazard mitigation in general, are recorded and addressed, as appropriate.
- Copies of the latest approved plan (or draft in the case that the five-year update effort is underway) are available for review, along with instructions to facilitate public input and comment on the HMP.
- Appropriate links to the Gloucester County Hazard Mitigation Plan webpage are included on municipal websites.
- Public notices are made as appropriate to inform the public of the availability of the plan, particularly during HMP update cycles.

The Gloucester County HMP Coordinator shall be responsible to assure that:

- Public and stakeholder comment and input on the plan, and hazard mitigation in general, are recorded and addressed, as appropriate.
- The Gloucester County HMP website is maintained and updated as appropriate.
- Copies of the latest approved plan are available for review at appropriate county facilities along with instructions to facilitate public input and comment on the plan.
- Public notices, including media releases, are made as appropriate to inform the public of the availability of the plan, particularly during plan update cycles.