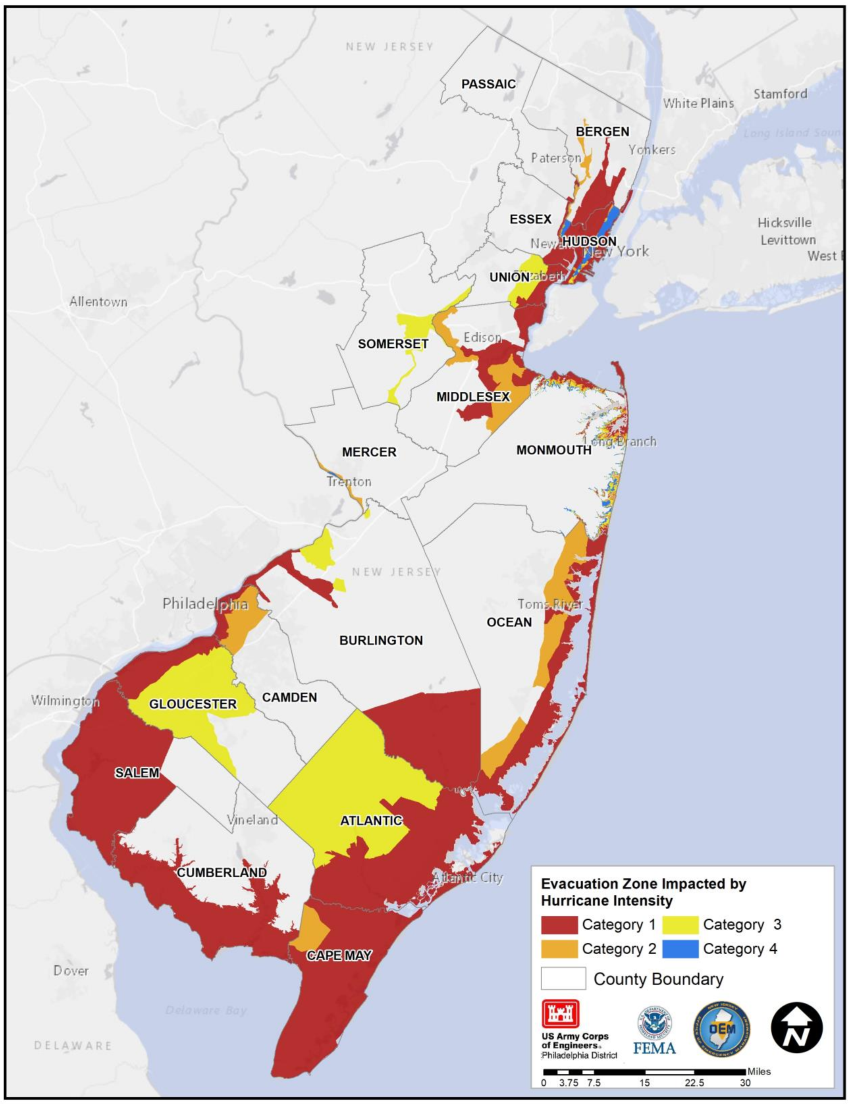
FINAL REPORT

New Jersey Hurricane Evacuation Study (NJHES) Re-Study Report

Contract No. W912BU-15-D-0004



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New Jersey Office of Emergency Management

APRIL 2023

FEMA NATIONAL HURRICANE PROGRAM

GBA ENGINEERS ★ SURVEYORS

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List of Acronyms and Abbreviations

American Community Survey	ACS
Catastrophic	CS
Countywide	CW
Delaware Valley Regional Planning Commission	DVRPC
Evacuation Zone	EZ
Federal Emergency Management Agency	FEMA
Geographic information system	GIS
High evacuation zone (participation rate)	High EZ
Hurricane Evacuation Behavioral Survey	HEBS
HURRicane EVACuation program	HURREVAC
Hurricane Evacuation Study	HES
Massachusetts Institute of Technology	MIT
Medium	Med
Medium evacuation zone (participation rate)	Med EZ
Medium surge zone (participation rate)	Med SZ
Maximum of Maximum Envelope of Water	MOM
National Hurricane Center	NHC
National Oceanic and Atmospheric Administration	NOAA
National Weather Service	NWS
New Jersey	NJ
New Jersey Department of Transportation	NJDOT
New Jersey Hurricane Evacuation Study Re-Study	NJHES Re-Study
New Jersey Office of Emergency Management	NJOEM
New Jersey State Police	NJSP
New York City	NYC
New York State - New York City Hurricane Evacuation Studies	NYSNYCHES
North Jersey Transportation Planning Authority	NJTPA
Northern Counties	NC
Real Time Evacuation Planning Model	RtePM
Sea, Lake, and Overland Surges from Hurricanes	SLOSH
South Jersey Transportation Planning Organization	SJTPO
Southern Counties	SC
Special Flood Hazard Area	SFHA
Surge Zone	SZ
Traffic Analysis Zone	TAZ
US Army Corps of Engineers	USACE
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Executive Summary

The New Jersey (NJ) Hurricane Evacuation Study (HES) Re-Study was completed under the National Hurricane Program, a multi-agency federal partnership led by the Federal Emergency Management Agency (FEMA), along with the US Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA). The NJHES Re-Study includes five main analyses: Hazard, Vulnerability, Behavioral, Shelter, and Transportation. The NJHES Re-Study helps to support state and local governments with ongoing hurricane evacuation planning efforts.

The last HES was completed in 2010. Several improvements have since been made including:

- Updated hazard maps using the NY3 (New York) and DE3 (Delaware Bay) Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model basins[1].
- Development and acceptance of updated evacuation zones for each county, which was an effort between NJ Office of Emergency Management, NJ Department of Transportation, USACE, FEMA, and NJ county emergency managers.
- Updated demographic data by county to estimate the 2020 population that is vulnerable and that may be ordered to evacuate.
- Updated behavioral assumptions using a 2017 behavioral survey conducted in NJ.
- Updated shelter location, capacity, and demand data, including a shelter vulnerability assessment to find which shelters may be impacted under certain storm surge conditions.
- Updated Transportation Analysis representing 2020 conditions (population and roadway network).

A notable change compared to previous studies is the use of Real Time Evacuation Planning Model (RtePM), a web-based transportation model designed to capture the impacts of traffic flow on a regional roadway network. The primary outputs of RtePM are the clearance times from an evacuation. A *clearance time* represents the time it takes to clear the roadway of all evacuating vehicles, measured from the moment an evacuation order is issued until the time when the final evacuating vehicle reaches its point of safety. RtePM also graphically shows the overall evacuation traffic flow on an hourly timestep. However, it is a macro-scale transportation model, is not designed to model the exact traffic flow, does not contain the entire roadway network, and approximates population, behavior, and traffic.

This report provides detailed information on the NJHES Re-Study Transportation Analysis, which resulted in the development of 252 different evacuation scenarios (36 catastrophic, statewide scenarios, and 216 regional scenarios) to provide emergency managers with an array of parameters and a range of clearance times to better plan for evacuation. In actuality, several

[1] In 2020, the Northeast (Ne1) SLOSH super basin was released, which provided updates to storm surge data in areas of the northeast U.S., including New Jersey. The Ne1 storm surge data was not used in developing the Hazards Analysis, evacuation zones, and scenarios during the study, as it was released after their completion. However, as the state and counties develop operational plans, they should familiarize themselves with the latest storm surge data when determining which evacuation zones to evacuate.

hundred additional simulations were run to ensure RtePM ran error-free and to test the sensitivity of different variables and scenarios.

The Transportation Analysis summarizes the assumptions, evacuation scenarios, and evacuation clearance time results, including scenarios with New York City (NYC) evacuees and scenarios in NJ with contraflow operations. **The results from the NJHES Re-Study do not supersede and do not dictate any changes to the existing New York State or New York City Hurricane Evacuation Studies**. The RtePM simulations only updated the clearance time results for the NJHES Re-Study.

Seventeen NJ counties are affected by storm surge and are part of the NJHES Re-Study. The counties were divided into the northern and southern regions. A new behavioral survey and analysis were conducted after Hurricane Sandy using surge zones (i.e., hurricane intensity). USACE released the New Jersey Hurricane Evacuation Behavioral Survey (NJ HEBS) Data Report in 2017. The data from the 2017 NJ HEBS report was used as a basis to determine the evacuation participation rates and other behavioral factors. The evacuation participation rates were then used to determine the total evacuating population for the Transportation Analysis scenarios. Three categories of rates were used:

1. Evacuation participation rate applied to the population who reside in the surge zone,
2. Evacuation participation rate applied to the population who reside in the evacuation zone,
3. 100% evacuation participation rate applied to the population who reside in the evacuation zone.

Evacuation scenarios were developed to model evacuation in RtePM. The three categories of evacuation participation rates were applied to the populations in the study area to determine the number of people participating in an evacuation. **Table ES-1** summarizes the ranges in clearance times for the NJHES Re-Study. **Appendix D** summarizes the inputs and results for the evacuation scenarios.

Table ES-1 Range of Clearance Times by Evacuation Participation Rate

	Evacuation Participation Rate Applied to Population within Surge Zone (Least Conservative)	Evacuation Participation Rate Applied to Population within Evacuation Zone	100% Evacuation Participation Rate Applied to Population within Evacuation Zone (Most Conservative)
All Coastal Counties[2]	31-41 hours	37-46 hours	49-59 hours
Northern Counties	19-28 hours	19-28 hours	24-42 hours
Southern Counties	25-41 hours	28-46 hours	35-52 hours

Several dozen evacuation scenarios evaluated the impact of contraflow operations (i.e., lane reversals). Improvements to evacuation clearance times when contraflow was employed were moderate based on transportation modeling results (up to 11 hours of clearance time improvement for some scenarios). Thus, given the planning and operational efforts, the detailed plans in place

[2] The Coastal Counties scenarios provided statewide evacuation scenarios modeled for Category 4 storms only.

completed by NJDOT, and the time and cost related to contraflow operations, it was recommended that the State of New Jersey continue to study and refine contraflow options and implementation.

The statewide and northern counties scenarios included NYC evacuees. Only a portion of the NYC evacuees traveled to NJ. The behavioral assumptions from the New York State/NYC HES were used and several approximations were made to account for this additional influx into NJ. The clearance time results showed minimal impact (0-2 hours) on the clearance time for the NJHES Re-Study due to how quickly the NYC population was set to respond to an evacuation order. The clearance times only increased significantly when very conservative behavioral and transportation assumptions were applied in sensitivity scenarios. Additional sensitivity scenarios included county-specific simulations with the evacuation of a progression of zones (Zone A, Zone A+B, Zone A+B+C, etc.). The results of the county-specific sensitivity scenarios were included in **Appendix E**.

The NJHES Re-Study was one of the first studies to utilize RtePM. It has contributed to improvements in the development of RtePM and continued progress in evacuation modeling and disaster planning. In particular, the size and scale of the NJHES Re-Study study area required the study team to work closely with the software developers. The benefit of leveraging RtePM is its ability to test many different evacuation scenarios, which makes this macro-scale model a useful tool in the development of HESs. The results and information can be shared between federal, state, and local levels of government to quickly make decisions and to better inform the general public when a storm approaches.

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1.0 Introduction

1.1 Background and Study Area

The goal of the HES was to provide support to state and local governments with ongoing hurricane evacuation planning efforts. Under the National Hurricane Program, the U.S Army Corps of Engineers (USACE) conducts Hurricane Evacuation Studies (HES) in partnership with the Federal Emergency Management Agency (FEMA) and the National Oceanic and Atmospheric Administration (NOAA), specifically the National Hurricane Center (NHC), which is part of the National Weather Service (NWS). These studies include different analyses: Hazard, Vulnerability, Behavioral, Shelter, and Transportation. The ultimate output of NJHES Re-Study is to determine *clearance times*, which represent the time it takes to clear the roadway of all evacuating vehicles, measured from the moment the evacuation order is issued until the time when the final evacuating vehicle reaches its point of safety.

Real Time Evacuation Planning Model (RtePM) was the tool of choice for several HESs for use in the Transportation Analysis. RtePM is a high-level, simulation-based traffic model designed to capture traffic impacts along regional highway networks to calculate evacuation clearance times. The primary outputs from RtePM were the clearance times and the overall evacuation flow. RtePM was not designed to model the exact traffic flow over time.

Demographic data used in the analysis of the vulnerable population were collected and organized in such a way to allow for direct integration into RtePM. Data related to shelter capacities and demand was brought into the RtePM model during the Transportation Analysis to model the movement of evacuees.

For the NJHES Re-Study, the 17 counties vulnerable to storm surge were divided into two regions: Northern Counties and Southern Counties (**Figure 1-1**):

Northern Counties

- Bergen County
- Essex County
- Hudson County
- Mercer County
- Middlesex County
- Monmouth County
- Passaic County
- Somerset County
- Union County

Southern Counties

- Atlantic County
- Burlington County
- Camden County
- Cape May County
- Cumberland County
- Gloucester County
- Ocean County
- Salem County

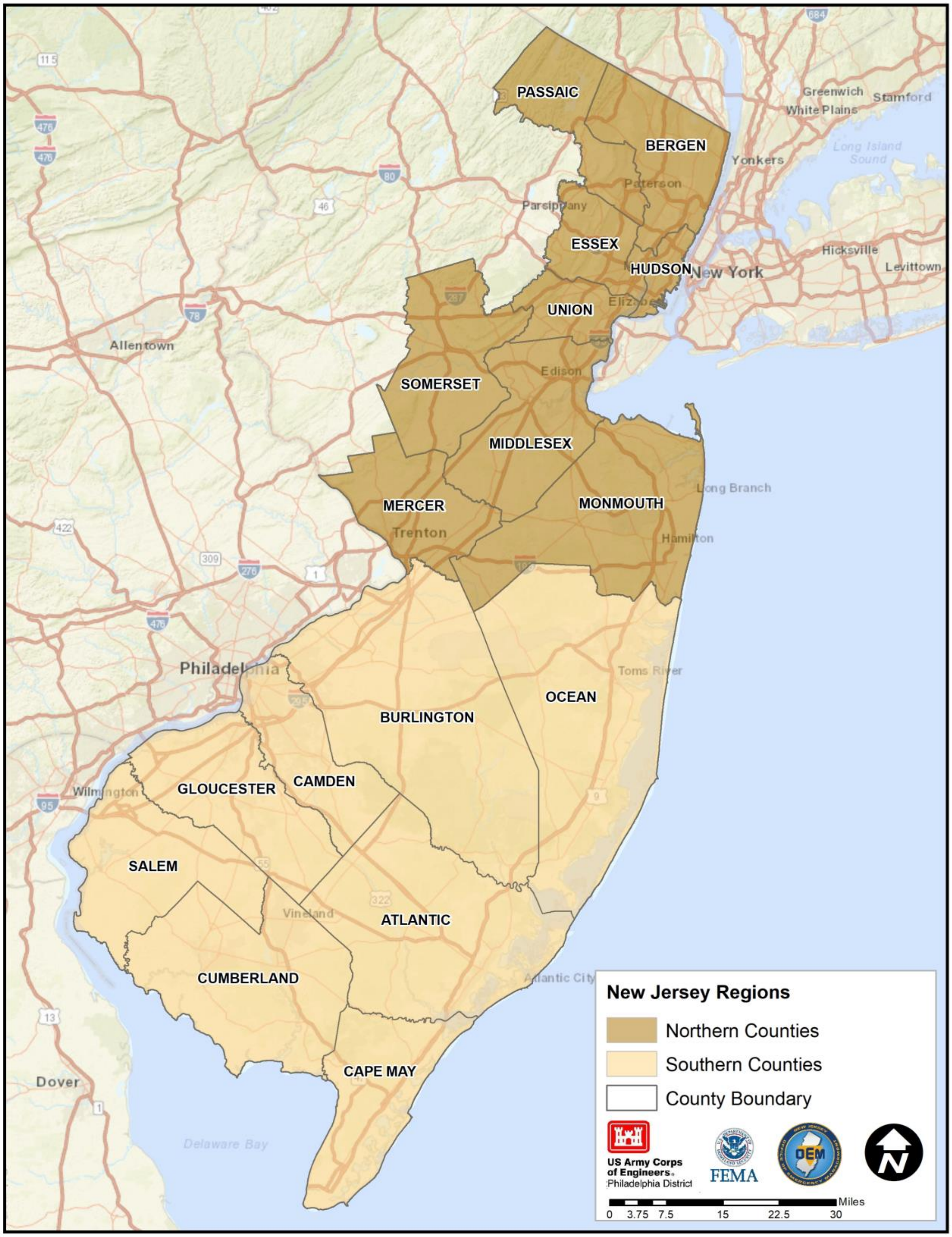

Figure 1-1 NJHES Re-Study Regional Map

1.1.1 Study Purpose

The ultimate objective of the NJHES Re-Study was to calculate evacuation clearance times that can be used by emergency managers for emergency management planning related to tropical cyclone evacuations. This report describes the various methodologies used to complete the five analyses included in a HES: Hazard, Vulnerability, Behavioral, Shelter, and Transportation. With NJ having been severely impacted by recent major disasters, including Hurricane Sandy (2012) and Hurricane Irene (2011), there was an inherent need to update evacuation and operational planning data and processes.

1.1.2 Funding

FEMA funded this effort in coordination with the USACE Philadelphia District. Through the USACE Philadelphia District and USACE Coastal Planning Center of Expertise, Gahagan & Bryant Associates/CDM Smith were contracted for this task work order to conduct several support activities to determine the best available data to inform the Transportation Analysis, develop evacuation scenarios, assess transportation modeling results, and produce clearance times.

1.1.3 Authority

The authority for USACE's participation in the NJHES Re-Study was Section 206 of the Flood Control Act of 1960, as amended (Public Law 86-645). FEMA's participation was authorized by the Disaster Relief Act of 1974, as amended (Public Law 93-288). These laws authorized the allocation of federal resources for planning activities related to hurricane preparedness.

1.2 HES Components

1.2.1 General

Since the last NJHES in 2010, NJ was severely impacted by several tropical cyclones. Updated storm surge modeling became available and resulted in an update of storm surge inundation maps and county-specific hurricane evacuation zones in 2016-2017. During this timeframe, behavioral surveys were also conducted to better understand NJ evacuation participation and behaviors during storm events. This data was combined with an analysis of shelter availability throughout the study area and then incorporated into the transportation modeling to determine clearance times for designated areas of risk throughout the state.

1.2.2 Hazard Analysis

The Hazard Analysis was completed in 2016, which developed updated storm surge inundation area maps using the best available data at that time. See Section 2.0 for discussion.

1.2.3 Vulnerability Analysis

The Vulnerability Analysis updated evacuation zones for the 17 counties in the study area using the storm surge inundation area maps developed during the Hazard Analysis. The evacuation zone development was completed in 2017 in coordination with FEMA, USACE, NJ Department of Transportation (NJDOT), NJ State Police (NJSP), and NJ Office of Emergency Management (NJOEM). A spatial analysis of critical infrastructure within evacuation zones was also developed and provided as reference data. See Section 2.0 for discussion.

1.2.4 Behavioral Analysis

The Behavioral Analysis and behavioral assumptions predicted the anticipated response of the study area population to determine: 1) percent of the population expected to evacuate, 2) probable destinations of evacuees, 3) public shelter use, and 4) utilization of available routes. The methodology used to develop the behavioral assumptions and transportation modeling inputs employed recent (i.e., after Hurricanes Irene and Sandy) behavioral survey data. Behavioral assumptions were derived from the behavioral survey results and used as an input into the Shelter and Transportation Analyses. See Section 3.0 for discussion.

1.2.5 Shelter Analysis

The Shelter Analysis was a comprehensive inventory of public shelters, shelter capacities, shelter locations in comparison to storm surge inundation areas, and shelter demand for each county. See Section 4.0 for results and discussion.

1.2.6 Transportation Analysis

The Transportation Analysis computed the evacuation clearance times needed to conduct a safe and timely evacuation for a range of conditions. The Real Time Evacuation Planning Model (RtePM), a free, web-based transportation modeling tool with updated population and transportation network data sources was used to model the Transportation Analysis. See Section 5.0 for discussion and Section 6.0 for results.

1.2.7 HURREVAC – Decision Tools

Evacuation clearance timetable spreadsheets were created in accordance with HURREVAC format. HURREVAC is a web-based decision support tool available from the National Hurricane Program, created specifically for use by government emergency managers. This tool tracks storms and uses HES-calculated clearance times, along with NHC forecast data, to help determine evacuation start times to completely evacuate an area before the arrival of tropical-storm-force winds.

2.0 Hazard and Vulnerability Analysis

2.1 Storm Surge Inundation Areas

During the NJHES Re-Study Hazard Analysis in 2016, storm surge inundation area maps were developed by USACE Philadelphia District based on the latest Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model data available at that time. The SLOSH basins used for this study area were NY3 (New York) and DE3 (Delaware Bay)[3]. By leveraging SLOSH model outputs for the Maximum of the Maximum Envelopes of Water (MOM)[4], digital elevation data, and GIS spatial analysis tools, storm surge inundation maps were developed which depicted the worst-case scenario storm surge inundation areas associated with Category 1, 2, 3, and 4 (Category 4 being the most severe for states in the northeastern coast of the U.S.) (**Figure 2-1**).

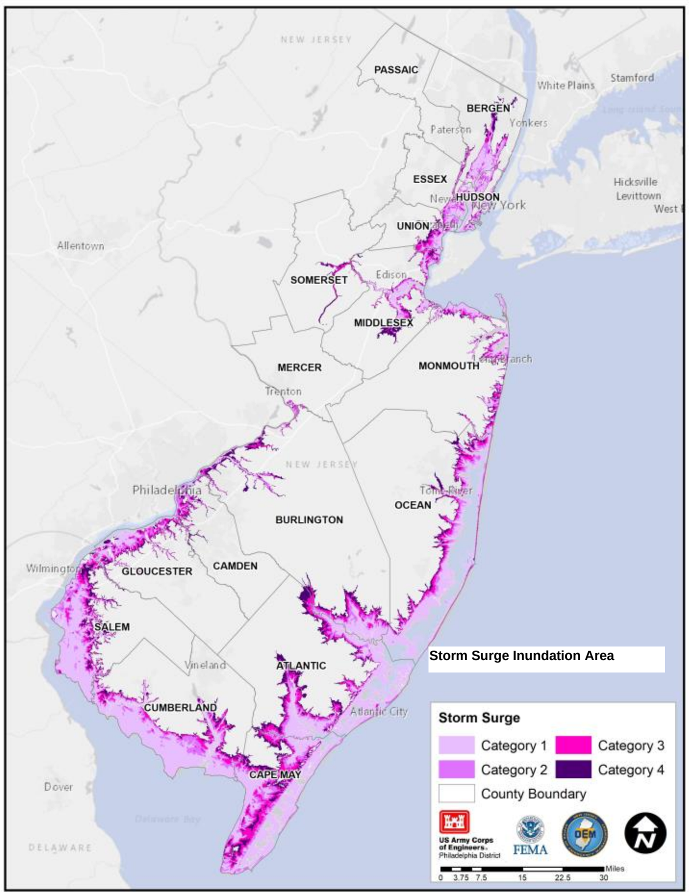

Figure 2-1 Storm Surge Inundation Areas for the NJHES Re-Study

[3] In 2020, the Northeast (Ne1) SLOSH super basin was released, which provided updates to storm surge data in areas of the northeast U.S., including New Jersey. The Ne1 storm surge data was not used in developing the Hazards Analysis, evacuation zones, and scenarios during the study, as it was released after their completion. However, as the state and counties develop operational plans, they should familiarize themselves with the latest storm surge data when determining which evacuation zones to evacuate

[4] For a detailed definition of a MOM, please visit: https://www.nhc.noaa.gov/surge/momOverview.php

2.2 New Jersey Evacuation Zones

During the 2017 NJHES Re-Study Vulnerability Analysis, hurricane evacuation zones were developed for each of the 17 counties in the study area through close coordination between USACE, FEMA, NJDOT, NJOEM, NJSP, and NJ county emergency managers. During the summer and fall of 2017, the team held meetings with each county and used the latest SLOSH storm surge inundation mapping results developed during the Hazard Analysis to delineate evacuation zones.

As a result of these meetings, there were 132 evacuation zones developed throughout the state, which included 7 letter zones (Zone A to Zone G) and between 3 to 17 evacuation shapes (A, A1, A2, B, B1, B2, etc.) for each county. Evacuation shapes provided an additional level of detail for evacuation zones. GIS shapefiles were developed for each county's evacuation zones and were overlayed with critical infrastructure datasets to better understand vulnerability within the study area[5]. The shapefiles were also uploaded to HURREVAC. NJDOT compiled meeting notes summarizing each county evacuation zone development meeting. These compiled meeting notes can be provided to stakeholders by the NHP, upon request[6].

In reviewing the evacuation zones for transportation modeling, the study team encountered several spatial inconsistencies due to a difference in methodology across counties that needed to be rectified for a consistent, regional approach applied in the Transportation Analysis. **Figure 2-2** compares evacuation zones for Middlesex and Monmouth Counties to demonstrate an example of how the evacuation shapes and evacuation zone development differed between NJ counties.

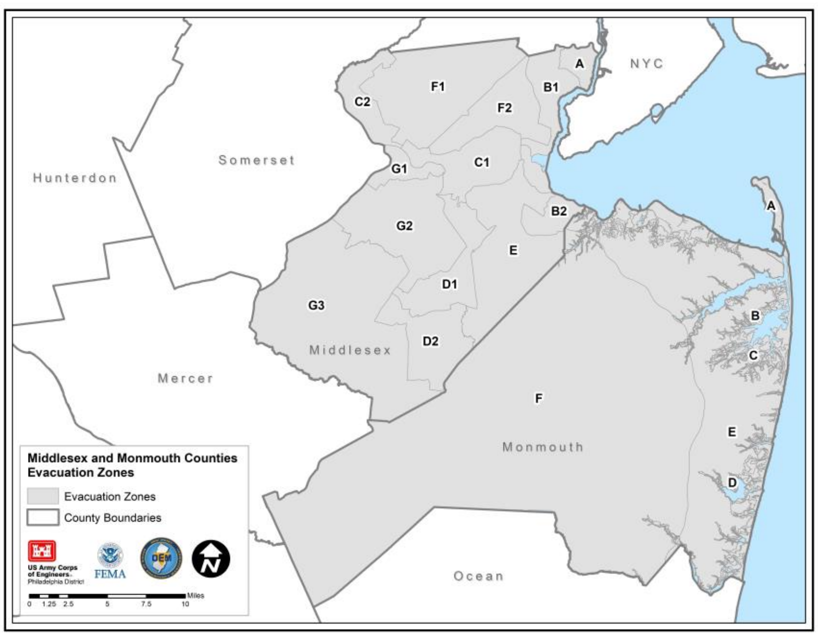

Figure 2-2 Middlesex and Monmouth Counties Evacuation Zones

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[5] Critical infrastructure layers (nursing homes, hospitals, police stations, and prisons) were overlayed with evacuation zones and storm surge maps. A spreadsheet detailing the critical infrastructure distribution in these areas (and associated GIS shapefile data) is provided with project supporting documents/ data.
[6] Personal communication with NJDOT. The National Hurricane Program can provide evacuation meeting minutes upon request by stakeholders, in coordination with NJDOT.

The following issues were encountered:

- From county to county, the inland extent of lettered zones differed. For example, an evacuation order of Zone A and Zone B in Middlesex County covered more inland areas as compared to a similar evacuation order in Monmouth County.
- Some evacuation zones were defined by shapes that were non-contiguous. For example, if Zone B was ordered to evacuate, some counties had multiple, disparate areas designated as Zone B (B1, B2, etc.). This resulted in the same lettered evacuation zones having different levels of impact from storm surge inundation of the same hurricane intensity.
- The behavioral study assumptions and data (Section 3.0) were limited to a particular hurricane intensity and did not tie behavioral responses to an evacuation zone.
- Several counties defined evacuation zones (Zone A to Zone G) that encompassed the entire county area, including all inland areas that were not impacted by storm surge. This was atypical if compared to other completed or ongoing HES but was an acceptable practice in defining evacuation zones. State and county emergency managers should define the evacuation zones as they see fit in their local disaster planning efforts (beyond flooding from hurricane impacts) for public communication. However, this methodology affected how available data were applied in the Behavioral Analysis and transportation modeling, as discussed in subsequent sections.
- Several counties defined evacuation zones for riverine areas impacted by freshwater flooding and were verified upon review of the FEMA special flood hazard area (SFHA). Riverine flooding is not typically used to define evacuation zones in HESs. These areas were low-lying and at risk of flooding. However, based on the SLOSH modeling, they were not impacted by storm surge inundation and thus were not correlated directly to hurricane intensity.

Therefore, the study team conducted the following analyses to determine a solution to develop a regional evacuation transportation modeling approach:

- In all instances, the study team maintained the originally defined evacuation zones. However, some evacuation shapes were merged for transportation modeling purposes.
- Due to differences in how evacuation orders were issued (i.e., which evacuation zone was ordered to evacuate) across counties, the study team conducted a GIS spatial analysis to determine the percent of land within each evacuation shape that was covered by Category 1 through Category 4 storm surge inundation. The GIS spatial analysis removed areas of existing water bodies and wetlands from evacuation zones for this calculation. **As a result of this exercise, storm surge inundation categories were assigned to evacuation zones.**

As an example, **Table 2-1** shows the percent of storm surge inundation areas in the Cape May County evacuation zones. After existing water bodies and wetland areas were removed from Cape May evacuation zones, 68.94% of Category 1 storm surge inundation area was within Cape May Zone A, 6.29% was in Zone B, and 0.45% was in Zone C. Therefore, Zone A and B would evacuate in Category 1, while Zone C would evacuate in Category 2, where the percent of wet area (i.e., storm surge inundation area) within Zone C was 5.66%. The study team conducted this calculation for all 17 counties and each evacuation zone. The threshold for initial categorization was between 1% to 5% but was county-specific based on the storm surge inundation extent, detailed notation of evacuation zone definition, and land use. Detailed maps for each county are located in **Appendix A** in addition to the calculations of storm surge inundation areas within the evacuation zone.

Table 2-1 Example of Percent of Storm Surge Inundation Areas in Cape May Evacuation Zones

Evacuation Zone	Percent of Storm Surge Inundation Area within an Evacuation Zone			
	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Cape May Zone A	68.94%	94.52%	98.70%	99.57%
Cape May Zone B	6.29%	24.98%	55.79%	77.59%
Cape May Zone C	0.45%	5.66%	16.50%	22.66%

Another complication that the study team encountered in preparation for the transportation modeling was a limitation on the number of files that could be imported into the RtePM graphical user interface. With the need to include NYC evacuation zones for large regional scenarios, evacuation zones were grouped to represent evacuation areas ordered to leave based on storm surge inundation and hurricane intensity. In total, 56 different evacuation areas were developed and used in the transportation modeling. This grouping was done for large, regional-scale evacuations where a consistent approach was necessary.

Table 2-2 summarizes the grouping of evacuation zones based on storm surge inundation area and hurricane intensity. The table was developed to show how evacuation zones are called in a cumulative progression as hurricane intensity increases, (e.g., a Category 2 hurricane includes Zone B1 and C, in addition to Zone A in Bergen County). Local and state emergency managers should continue to coordinate and use the evacuation zones that were previously developed in 2017 to refine existing emergency operational plans.

After reviewing the extents of storm surge inundation areas within the evacuation zones, the study team noted that Zone E1 in Bergen County; Zone F in Essex County; Zone F2 and Zone G2 in Middlesex County; and Zone F in Burlington County have limited storm surge inundation from a Category 4 hurricane as these areas were primarily affected by riverine flooding. The combination of riverine flooding and storm surge flooding evacuation was not the focus of this effort, but several county-specific sensitivity scenarios were simulated to address these risk areas (Appendix E). For the regional-scale scenarios (and due to the low exposure of the Category 4 storm surge inundation), these evacuation zones were considered "inland areas" during the transportation modeling.

Table 2-2 NJ Counties Evacuation Zone Assignments+

Region	County	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane	Inland Areas
Northern Counties	Bergen	(B1, C)	(B1, C), A	(B1, C), A	(B1, C), A	(B2, D, E2, F, E1)
	Essex	(A, B)	(A, B)	(A, B)	(A, B)	(C, D, E, G, F)
	Hudson	(A, B, C)	(A, B, C), D	(A, B, C), D, E	(A, B, C), D, E, (F, G)	
	Mercer		B	B	B, A	(C, D, E, F, G)
	Middlesex	(A, B1, B2, C1, D1)	(A, B1, B2, C1, D1), (C2, G1), E	(A, B1, B2, C1, D1), (C2, G1), E	(A, B1, B2, C1, D1), (C2, G1), E	(D2, F1, G3, F2, G2)
	Monmouth	A	A, B	A, B, C	A, B, C, D	(E, F)
	Passaic	(A1, A2)	(A1, A2)	(A1, A2)	(A1, A2)	(B, C, D, E1, E2, F, G)
	Somerset			A1	A1	(A2, B1, B2, C, D)
	Union	(A, B)	(A, B)	(A, B), C	(A, B), C	(D1, D2, D3, E, F1, F2, G1, G2)
Southern Counties	Atlantic	(A), (B, C2), (D)	(A), (B, C2), (D)	(A), (B, C2), (D), C1, E, F	(A), (B, C2), (D), C1, E, F	
	Burlington	A, B	A, B	A, B, (C, D, E)	A, B, (C, D, E)	(G, F)
	Camden	(A, B1, B2, C1, C2, C3)	(A, B1, B2, C1, C2, C3), (D1, D2, D3, D4, D5)	(A, B1, B2, C1, C2, C3), (D1, D2, D3, D4, D5)	(A, B1, B2, C1, C2, C3), (D1, D2, D3, D4, D5)	(E, F)
	Cape May	A, B	A, B, C	A, B, C	A, B, C	
	Cumberland	A	A	A	A	(B, C)
	Gloucester	(A, B)	(A, B)	(A, B), (C, D)	(A, B), (C, D)	
	Ocean	(A1, A2, A3, A4, A5, A6, A7), (B1, C1, C4, C5)	(A1, A2, A3, A4, A5, A6, A7), (B1, C1, C4, C5), (B2, B3, C2, C3)	(A1, A2, A3, A4, A5, A6, A7), (B1, C1, C4, C5), (B2, B3, C2, C3)	(A1, A2, A3, A4, A5, A6, A7), (B1, C1, C4, C5), (B2, B3, C2, C3)	(D, E)
	Salem	A, B	A, B	A, B	A, B	C

*Note: the parentheses surrounding evacuation shapes indicate the grouping used for the Transportation Analysis. This resulted in 56 different evacuation areas (including NYC) for transportation modeling. This grouping was done for large, regional-scale evacuations where a consistent approach was necessary.

+ The table was developed to show how evacuation zones are called in a cumulative progression as hurricane intensity increases, (e.g., a Category 2 hurricane includes Zone B1 and C, in addition to Zone A in Bergen County).

Figure 2-3 and **Figure 2-4** show the NJ evacuation zones by hurricane intensity and region. The figures include the zones that were listed as "limited exposure during a Category 4 event." **Figure 2-5** shows the evacuation zones modeled during the Transportation Analysis for the 17 NJ coastal counties.

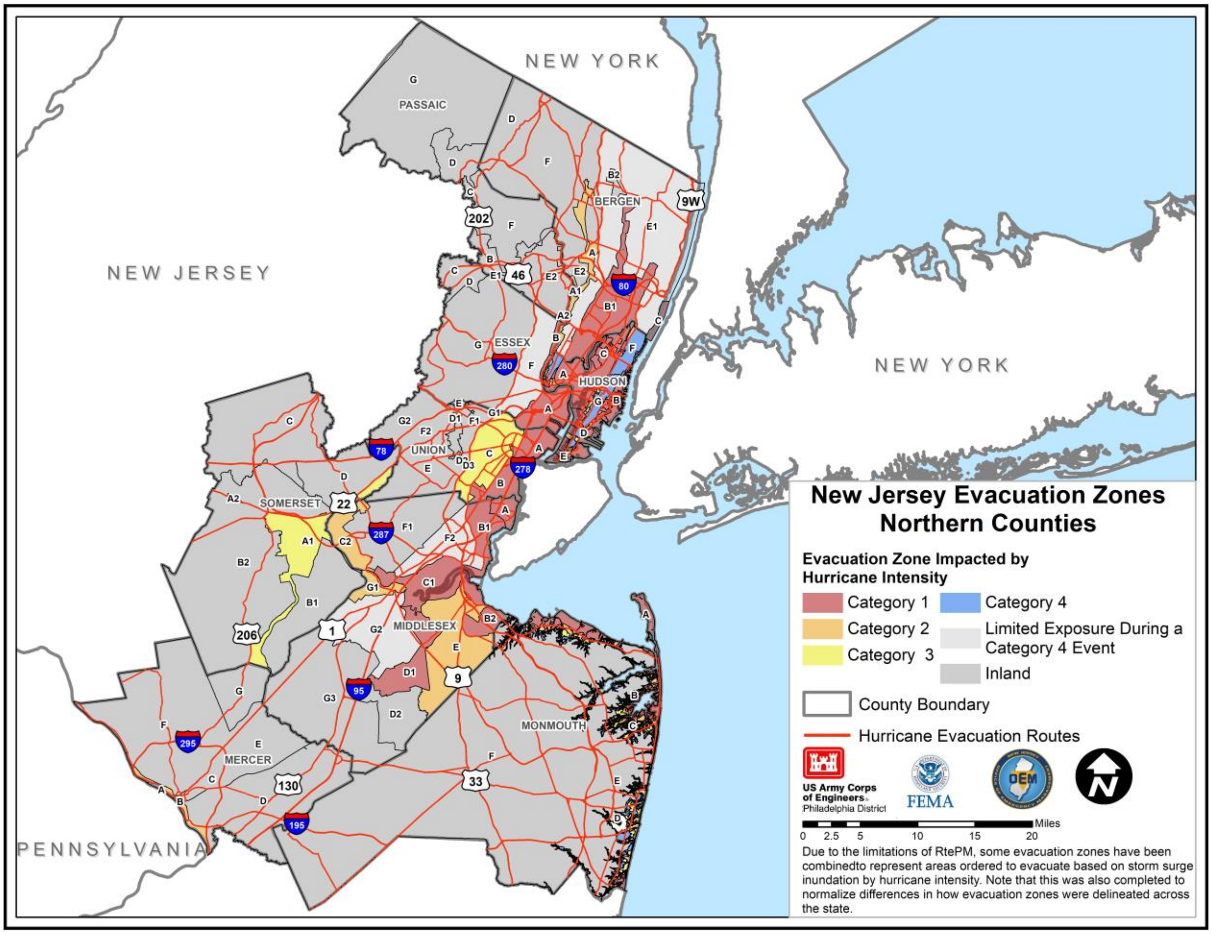

Figure 2-3 Northern Counties Evacuation Zones

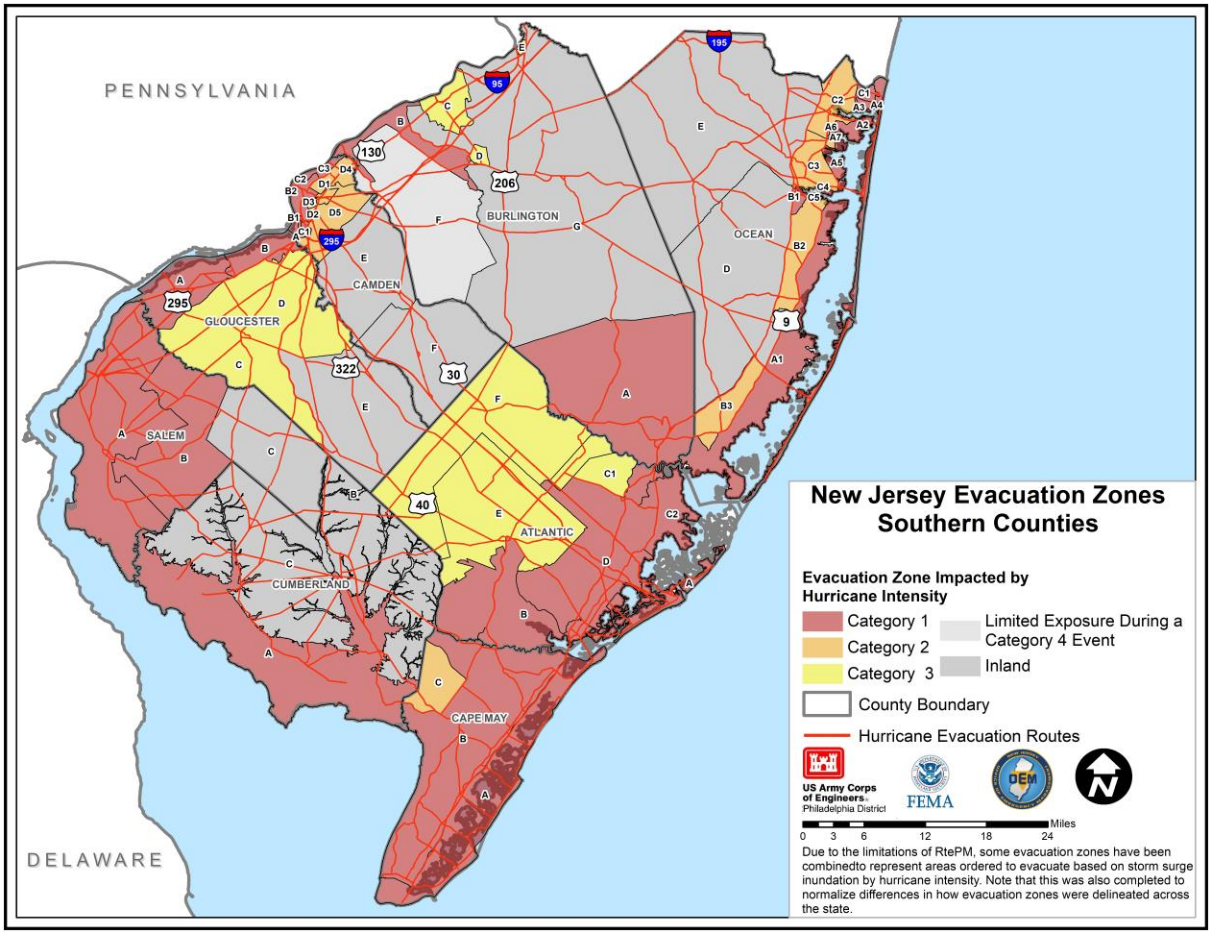

Figure 2-4 Southern Counties Evacuation Zones

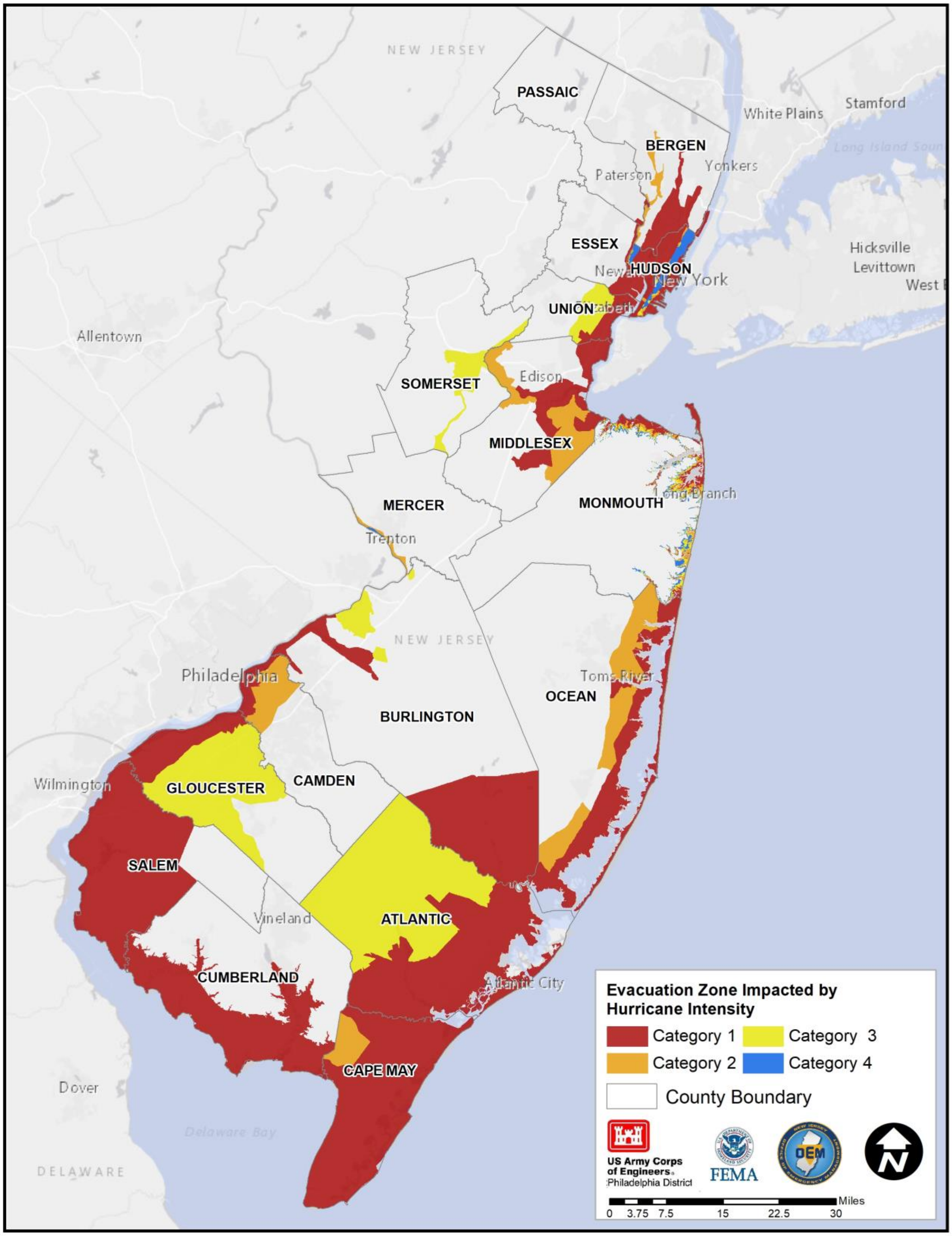

Figure 2-5 Evacuation Zones Modeled in RtePM for the Study Area

2.3 New York City Evacuation Zones

The effect of evacuees from New York City was also evaluated as part of the regional and statewide scenarios. New York City (NYC) has five boroughs: Brooklyn, Bronx, Manhattan, Queens, and Staten Island (**Figure 2-6**). Counties east of NYC (Nassau and Suffolk Counties) were not included in the Transportation Analysis since the NJHES Re-Study focused primarily on the impact of NYC evacuees on the NJ transportation network.

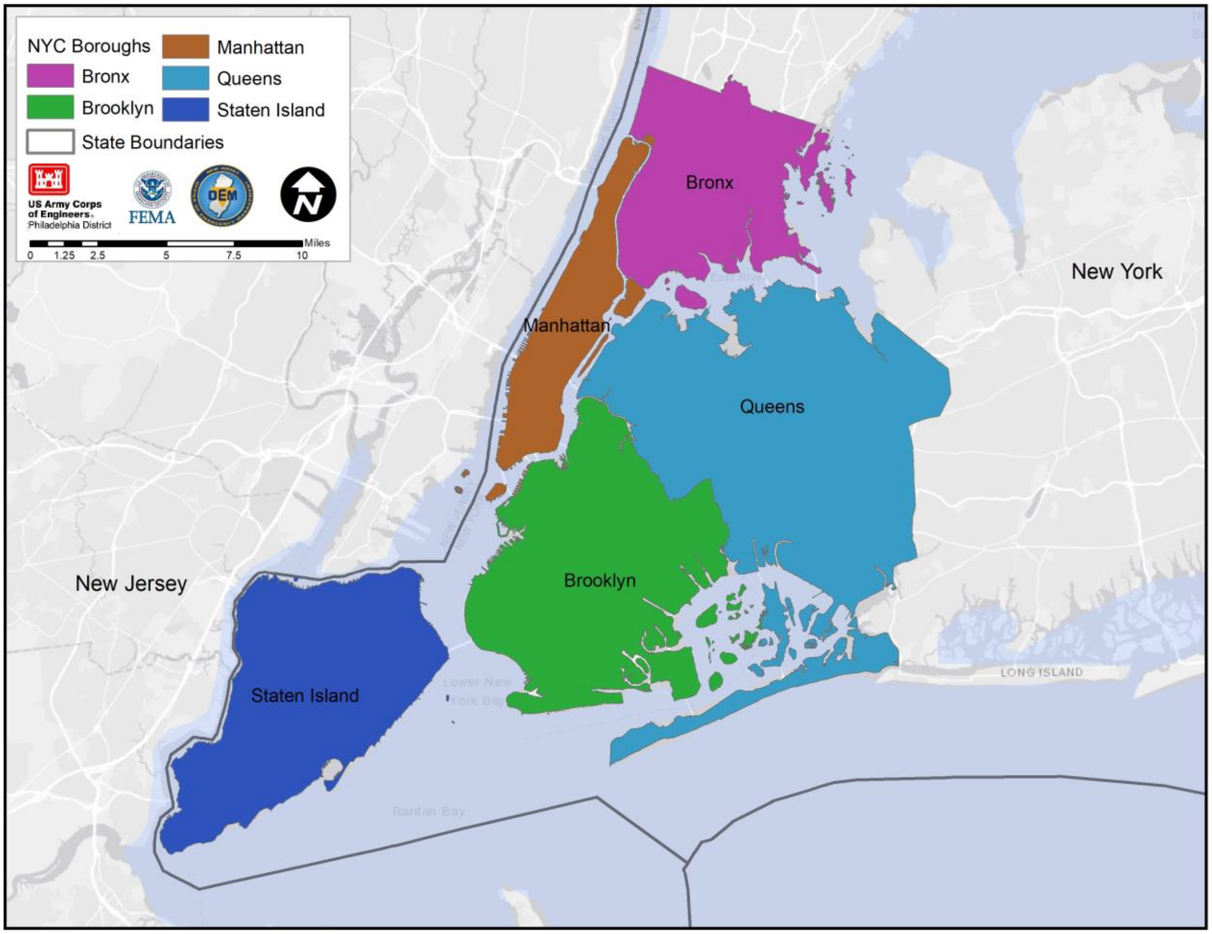

Figure 2-6 New York City Boroughs

In coordination with USACE New York District and the NYC Office of Emergency Management, NYC evacuation zones were provided to the study team. The July 2015 New York State (NYS) Hurricane Evacuation Study: New York City Analysis[7] (2015 NYSNYCHES), Appendix 2.1 of the NYC Analysis HES, and Chapter 6 Transportation Analysis from the 2009 New York State Hurricane Evacuation Study Technical Data[8] report was used as references for NYC-related information. The NYC

[7] FEMA, July 2015. "New York State Hurricane Evacuation Study Technical Report: New York City Analyses," for U.S. Army Corps of Engineers, New York State Office of Emergency Management, New York City Emergency Management.

[8] FEMA, April 2009. "New York State Hurricane Evacuation Study Technical Data Report for New York City, Nassau, Suffolk, and Westchester Counties: Chapter 6," U.S. Army Corps of Engineers, New York State Office of Emergency Management, New York City Emergency Management.

boroughs have six evacuation zones (Zone 1, 2, 3, 4, 5, and 6). **The following characterization of evacuation zones in Figure 2-7 was solely for alignment with the NJHES Re-Study and did not dictate any changes to the existing NYS/NYC HESs. The 2015 NYSNYCHES was the primary source of evacuating information for NYS and NYC.** NYC Zones 1 and 2 aligned with an evacuation for a Category 1 storm; NYC Zones 3 and 4 aligned with an evacuation for a Category 2 storm; NYC Zone 5 aligned with an evacuation in a Category 3 storm; and NYC Zone 6 aligned with an evacuation for a Category 4 storm. The NYC evacuation zones were grouped based on hurricane intensity for the NJHES Re-Study.

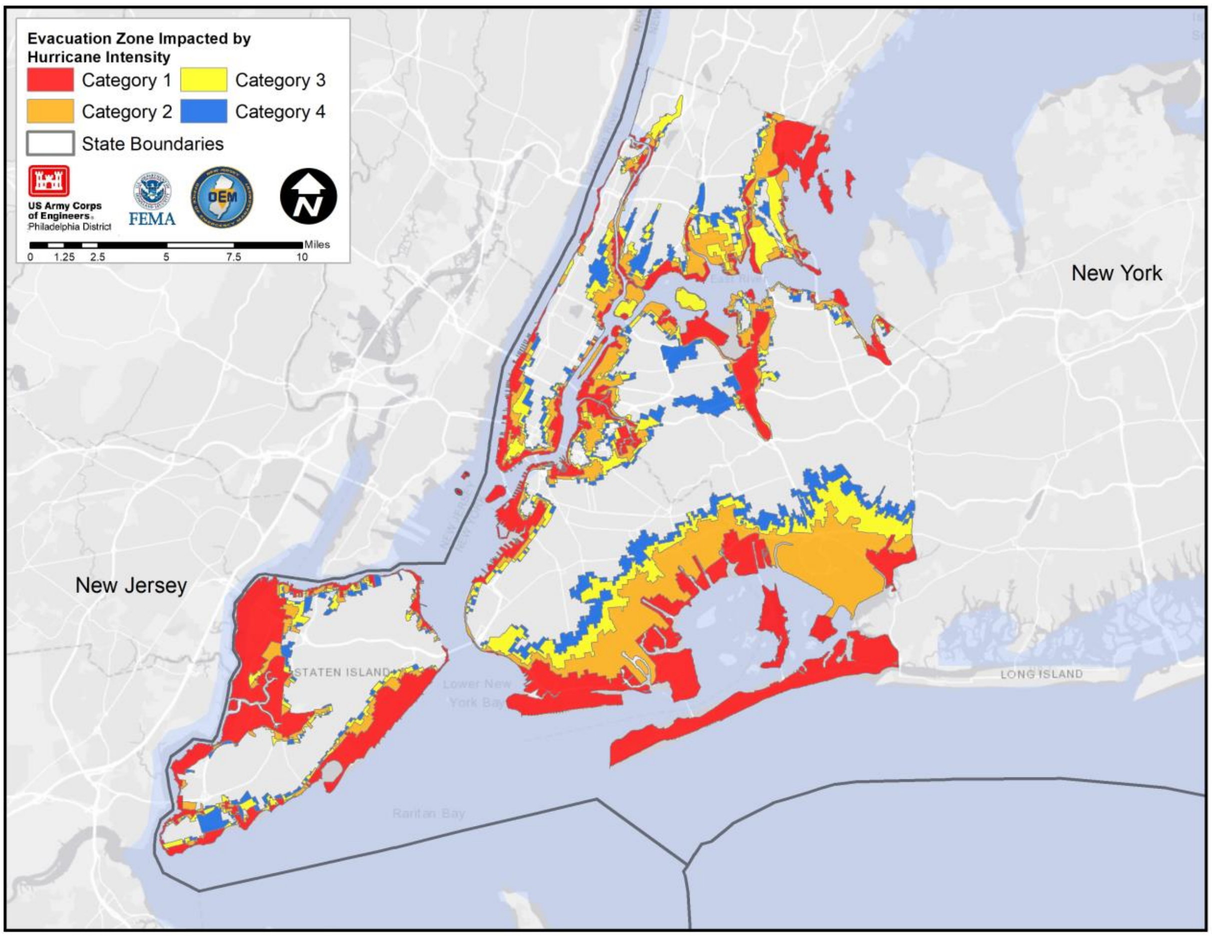

Figure 2-7 Evacuation Zones Modeled in RtePM for New York City

CDM Smith

3.0 Behavioral Analysis

3.1 Purpose

The purpose of this section is to document the development and resulting behavioral assumptions that were used to model evacuating traffic within the RtePM modeling interface. Behavioral assumptions were a critical element in hurricane evacuation modeling because they identified the populations—and subsequent behaviors—that respond to an evacuation order.

The three primary resources reviewed for behavioral data were the 2017 New Jersey Hurricane Evacuation Behavioral Analysis Recommendations for Planning Assumptions[9], 2017 New Jersey Hurricane Evacuation Behavioral Survey Data Report[10] (2017 NJ HEBS Report), and the 2007 New Jersey Hurricane Evacuation Study Transportation Analysis[11]. The 2017 NJ HEBS Report provided the most recent and useful behavioral data and was used for the NJHES Re-Study Transportation Analysis.

There were four primary behavioral parameters used in the NJHES Re-Study: participation rates, response curves, vehicle usage rates, and destination rates.

- *Participation rates* identified the percent of the population participating in an evacuation according to the hurricane intensity which was only applicable to the NJHES Re-Study.
  - Shadow evacuees, individuals who were not ordered to evacuate but leave as a result of a perceived threat, were accounted for in NJHES Re-Study participation rates.
- *Response curves* depicted the amount of time (in hours) evacuees take to respond to an evacuation order and enter the transportation network.
- *Vehicle usage rates* were related to the proportion of vehicles available to the evacuating household from each zone used during an evacuation order.
- *Destination rates* represented the proportion of the population traveling to different points of safety.
- Public shelter usage rates were a sub-component of the destination rates and represented the proportion of evacuees who travel to shelters as their point of safety.
  - The other destination rate evaluated is the endpoint assignment[12], which represents regional destination flows as the number of evacuees typically traveling north or west towards a point of safety.

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[9] Earl J. Baker, Hazards Management Group, Inc., July 2017. "New Jersey Hurricane Evacuation Behavioral Analysis Recommendations for Planning Assumptions," for USACE Philadelphia District.
[10] Earl J. Baker, Hazards Management Group, Inc., July 2017. "New Jersey Hurricane Evacuation Behavioral Survey Data Report," for USACE Philadelphia District.
[11] PBS&J, June 2007. "New Jersey Hurricane Evacuation Study Transportation Analysis," for USACE Philadelphia District.
[12] Evacuation endpoints within RtePM are the locations where evacuees leave the evacuation network toward a point of safety. Evacuees not traveling to public shelters will evacuate to one of the active endpoints on the network.

The RtePM interface allowed for the inclusion of participation rates, public shelter usage rates, response curves, vehicle usage rates, and other destination information in the form of routing/direction preferences. Behavioral assumptions for the transportation modeling were based on recent behavioral survey data and data requirements of RtePM.

Limited by the resolution of available behavioral data, behavioral assumptions developed for the NJHES Re-Study Transportation Analysis were regional or state-wide and not county-specific. The 2017 NJ HEBS Report grouped the areas into two regions: northern counties and southern counties. The Behavioral Analysis was based on 2,000 telephone survey interviews from storm surge vulnerable counties (1,000 in Northern NJ and 1,000 in Southern NJ). 40% of respondents were located in the Category 1 storm surge inundation areas, 20% in the Category 2 storm surge inundation areas, 20% in the Category 3 and 4 storm surge inundation areas, and 20% in the inland areas of coastal counties. The 2017 NJ HEBS Report incorporated questions and responses related to Hurricane Irene and Hurricane Sandy.

3.2 Evacuation Participation Rates

Evacuation participation rates used in the transportation modeling were developed using information from the 2017 NJ HEBS Report for both the northern and southern counties. The study reported various surveyed behaviors by storm surge inundation area for the entire coastal area under assessment, including:

- Overall evacuation participation rates,
- Out-of-county trip rates (indicating the percent of evacuees that seek refuge outside of their county),
- Percent of available vehicles used,
- Public shelter use rates, and
- Evacuation timing curves for planning (response curve).

The behavioral parameters in the 2017 NJ HEBS report were not broken down by evacuation zone. Instead, the participation rates were summarized by storm surge inundation area (also listed as "surge zone" in the 2017 HEBS Report[13]) and "inland of surge" for both NJ regions. The 2017 NJ HEBS Report used the terminology "storm threat scenario" instead of "hurricane intensity" to identify these areas. **Table 3-1** shows the participation rates identified in the 2017 NJ HEBS Report by region.

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[13] The terms "storm surge inundation area"/"storm surge zone," "inland areas"/"inland of surge," and "hurricane intensity"/"storm threat scenario" are used interchangeably in this report. The latter terms were used to behavioral reference data per the 2017 NJ HEBS report.

Table 3-1 Participation Rates from the 2017 NJ HEBS Report

Northern NJ Evacuation Rate (%)	Scenario			
Surge Zone	**Category 1 Hurricane**	**Category 2 Hurricane**	**Category 3 Hurricane**	**Category 4 Hurricane**
Category 1 Surge Zone	45%	55%	70%	80%
Category 2 Surge Zone	25%	50%	65%	75%
Category 3+4 Surge Zone	15%	30%	60%	60%
Inland of Surge	5%	10%	10%	15%

Southern NJ Evacuation Rate (%)	Scenario			
Surge Zone	**Category 1 Hurricane**	**Category 2 Hurricane**	**Category 3 Hurricane**	**Category 4 Hurricane**
Category 1 Surge Zone	50%	60%	75%	80%
Category 2 Surge Zone	35%	50%	70%	75%
Category 3+4 Surge Zone	15%	35%	60%	65%
Inland of Surge	5%	10%	10%	15%

When an evacuation is ordered, a portion of the population stays within their county while others travel farther away to a point of safety. In the transportation model, RtePM, those that evacuate primarily go inland to an endpoint (considered out-of-county in the model) or a public shelter. RtePM does not distinguish or account for in-county movements such as going to a family/friend's house. Therefore, evacuation participation rates (including for shadow evacuees as shown in Table 3-1) were modified to reflect the potential over-estimation of participating population. **Table 3-2** shows the out-of-county trip rates identified in the 2017 NJ HEBS Report by region.

Table 3-2 Out-of-County Trip Rates from 2017 NJ HEBS Report

Northern NJ Evacuation Rate (%)	Scenario			
Surge Zone	**Category 1 Hurricane**	**Category 2 Hurricane**	**Category 3 Hurricane**	**Category 4 Hurricane**
Category 1 Surge Zone	55%	55%	55%	55%
Category 2 Surge Zone	50%	50%	50%	50%
Category 3+4 Surge Zone	50%	50%	50%	50%
Inland of Surge	50%	50%	50%	50%

Table 3-2 Out-of-County Trip Rates from 2017 NJ HEBS Report (cont'd)

Southern NJ Evacuation Rate (%)	Scenario			
Surge Zone	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Category 1 Surge Zone	80%	80%	80%	80%
Category 2 Surge Zone	70%	70%	70%	70%
Category 3+4 Surge Zone	60%	60%	60%	60%
Inland of Surge	55%	55%	55%	55%

Evacuation participation rates were multiplied by out-of-county trip rates to determine what percent of the population would evacuate, enter the roadway network, and leave their home county. These participation rates were used to determine the final evacuation zone participation rates for both northern and southern counties. The values for surge zone areas and inland areas are reported in **Table 3-3**, which shows the out-of-county evacuation participation rates by region. This table also has grayed cells indicating shadow evacuees (as discussed in Section 3.2.1). **In the remainder of this report, the out-of-county evacuation participation rates will be simply referred to as the "evacuation participation rate."**

Table 3-3 Out-of-County Evacuation Participation Rates

Northern NJ Participation Rate (%)	Scenario			
Surge Zone	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Category 1 Surge Zone	25%	30%	39%	44%
Category 2 Surge Zone	13%	25%	33%	38%
Category 3+4 Surge Zone	8%	15%	30%	30%
Inland of Surge*	2%	5%	5%	7%

Southern NJ Participation Rate (%)	Scenario			
Surge Zone	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Category 1 Surge Zone	40%	48%	60%	64%
Category 2 Surge Zone	25%	35%	49%	53%
Category 3+4 Surge Zone	9%	21%	36%	39%
Inland of Surge*	2%	5%	5%	8%

*Note: the values in the Northern and Southern NJ tables were rounded to the nearest integer for display only in this table except for "inland of surge," which was rounded down (see discussion about shadow evacuees in Section 3.2.1). The subsequent calculations using participation rates were maintained with precision throughout the process until the rates were inputted to RtePM.

3.2.1 Shadow Evacuees

Shadow evacuees were also summarized in the 2017 NJ HEBS Report. If the population in Zone A was ordered to evacuate because of the trajectory of an oncoming storm, individuals in other evacuation zones within the county, as well as its inland area, may perceive a threat from potential flooding impacts and/or impacts from tropical storm-force winds. Depending on whether these individuals lived in vulnerable structures (e.g., mobile, or manufactured homes located near water bodies or other areas prone to flooding), these individuals may evacuate at the same time as those under the evacuation order.

The spatial discrepancy issues regarding evacuation zone development (as discussed in Section 2.2) also impacted the approach of incorporating shadow evacuees. The participation rates were applied as described in the previous sections. The evacuation zone assignment to a hurricane intensity (Table 2-2) was used to determine which zones would be ordered to evacuate during a hurricane incident, and which zones would have a percent of shadow evacuees. **Table 3-4** describes the shadow evacuee response by hurricane intensity.

Table 3-4 Shadow Evacuee Designation by Hurricane Intensity

Hurricane Intensity	Hurricane Intensity Assignment to Evacuation Zone (i.e., Based on Evacuation Order)	Shadow Evacuees from the Following Areas
Category 1	Category 1	Category 2, 3, and 4 Surge Zones and Inland Areas
Category 2	Category 1 and 2	Category 3 and 4 Surge Zones and Inland Areas
Category 3	Category 1, 2 and 3	Category 4 Surge Zone and Inland Areas
Category 4	Category 1, 2, 3, and 4	Inland Areas

Through an additional review of the evacuation zones, evacuation participation rates, and the 2017 NJ HEBS Report, it was noted that inland areas were also inconsistently defined. Due to the extent of the inland areas in evacuation zones, the location of dense population centers, and a comparison to the total evacuating population, the 2017 NJ HEBS shadow evacuee participation rates for only inland area evacuees were rounded down to the nearest integer for the transportation modeling efforts.

3.2.2 Development of High Evacuation Zone, Medium Evacuation Zone, and Medium Surge Zone Evacuation Participation Rates

Section 2.0 summarized the process used for assigning a hurricane intensity to an evacuation zone based on the extent of storm surge inundation within the evacuation zone. Since the 2017 NJ HEBS Report summarized participation rates by storm surge inundation, the study team identified the following issues:

- In neighboring counties, due to differences in how zones were defined and then assigned by hurricane intensity, the participation rate (if applied directly) created a discrepancy in the percent of population evacuating in each zone.
- In several counties, evacuation zones covered areas that were much greater than the storm surge inundation extents. If applied directly, the participation rate would create an overestimate of evacuating population. This may or may not be the case if individuals decided to evacuate due to the onset of tropical storm-force winds.

To resolve these issues and to provide a **spectrum of participation rates** for decision-making and RtePM modeling scenarios, the study team applied the following approach:

- High evacuation participation rates of 100% were applied to the entire population within the ordered evacuation zones. This is a typical evacuation planning approach and has been applied in other recent HESs. These were the maximum evacuation rates (considered worst-case) and were referred to as **High Evacuation Zone (EZ)** participation rates.

- Evacuation participation rates from the NJ HEBS Report (Table 3-3) were applied to the entire population within the ordered evacuation zones. These were referred to as **Medium Evacuation Zone (EZ)** participation rates.

- Lastly, to specifically address the portion of the population at risk of storm surge flooding within evacuation zones, evacuation participation rates from the NJ HEBS Report (Table 3-3) were applied to only the population at risk of flooding from storm surge within the evacuation zones. This method leveraged the RtePM US Census block group data and storm surge inundation areas developed during the Hazard Analysis. These rates were referred to as **Medium Surge Zone (SZ)** participation rates.

Although the Medium SZ rates generally produced the smallest evacuating populations, the term "low," with respect to evacuation participation rates, was deliberately avoided as it implied a lower rate number than medium and that it was uniformly applied. In other HESs, a low rate was consistently much lower than the medium rate. This was not the case for the Medium Surge Zone (SZ) rate, which varied depending on the extent of the inundation, the population affected by flooding, and the extent of the evacuation zone. The Medium SZ participation rate was a direct translation of the 2017 NJ HEBS Report and application of the behavioral assumptions to the population impacted by storm surge inundation.

In summary, **Table 3-5** and **Table 3-6** describe the medium (used in Medium SZ and Medium EZ) and high evacuation (used in High EZ) participation rates developed for the NJHES Re-Study for the northern and southern counties and used in the RtePM transportation modeling efforts. The medium evacuation participation rates for shadow evacuees were also applied to the High EZ shadow evacuee participation rates. The RtePM interface requires an integer percent for the evacuation participation rate. Grayed cells indicate the percent participation of shadow evacuees.

Table 3-5 Medium Evacuation Participation Rates by Hurricane Intensity

Northern NJ Evacuation Rate (%)	Hurricane Intensity			
Surge Zone	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Category 1 Surge Zone	25%	30%	39%	44%
Category 2 Surge Zone	13%	25%	33%	38%
Category 3+4 Surge Zone	8%	15%	30%	30%
Inland of Surge*	2%	5%	5%	7%

Southern NJ Evacuation Rate (%)	Hurricane Intensity			
Surge Zone	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Category 1 Surge Zone	40%	48%	60%	64%
Category 2 Surge Zone	25%	35%	49%	53%
Category 3+4 Surge Zone	9%	21%	36%	39%
Inland of Surge*	2%	5%	5%	8%

*Note: the values in the Northern and Southern NJ tables were rounded to the nearest integer for display only in this table except for "inland of surge," which were rounded down (see discussion about shadow evacuees in Section 3.2.1). The subsequent calculations using participation rates were maintained with precision throughout the process until the rates were inputted to RtePM.

Table 3-6 High Evacuation Participation Rates by Hurricane Intensity

Northern NJ Evacuation Rate (%)	Hurricane Intensity			
Surge Zone	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Category 1 Surge Zone	100%	100%	100%	100%
Category 2 Surge Zone	13%	100%	100%	100%
Category 3+4 Surge Zone	8%	15%	100%	100%
Inland of Surge*	2%	5%	5%	7%

Southern NJ Evacuation Rate (%)	Hurricane Intensity			
Surge Zone	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Category 1 Surge Zone	100%	100%	100%	100%
Category 2 Surge Zone	25%	100%	100%	100%
Category 3+4 Surge Zone	9%	21%	100%	100%
Inland of Surge*	2%	5%	5%	8%

*Note: the values in the Northern and Southern NJ tables were rounded to the nearest integer for display only in this table except for "inland of surge," which were rounded down (see discussion about shadow evacuees in Section 3.2.1). The subsequent calculations using participation rates were maintained with precision throughout the process until the rates were inputted to RtePM.

3.2.3 Comparison of Medium Evacuation Participation Rates (EZ versus SZ)

The 2017 NJ HEBS Report behavioral surveys were conducted on populations located inside storm surge inundation areas and were summarized by hurricane intensity. However, the RtePM modeling effort and Transportation Analysis required inputs that were based on evacuation zones and not storm surge inundation areas. Using the storm surge inundation areas in RtePM would defeat the purpose of the evacuation zones, which was why additional calculations were necessary to adjust the participation rates and reflect the impacted population for the Medium SZ participation rates scenarios. **Figure 3-1** shows a graphical representation of the differences between the EZ and SZ rates for Middlesex County.

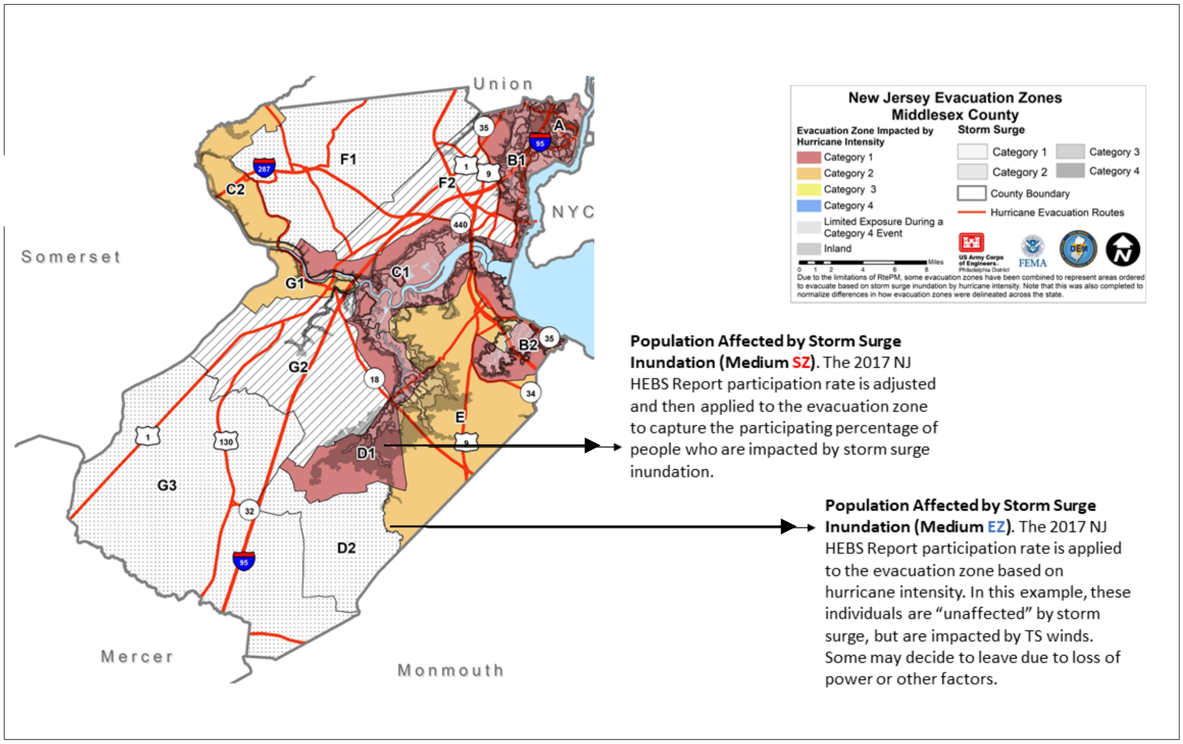


Figure 3-1 Graphical Comparison between Medium SZ to Medium EZ Participation Rates

Table 3-7 shows an example of the participation rates calculation for Bergen County. The first column, "hurricane intensity," is the assignment based on the area of the evacuation zone that was inundated from storm surge as discussed in Section 2.2. The second column, "evacuation zones," lists the evacuation zone shape and any grouping that occurred. The third column, "surge zones," lists the categorization of the hurricane intensity within the evacuation zone. The fourth column, "2020 Population," shows the projected 2020 population (including seasonal population) based on census block group data within the overlap of the storm surge inundation area and evacuation zone (Section 5.2 describes the population projection methodology).

The fifth and sixth columns, under "EZ Evacuation," show how the participation rates for a Category 1 storm were applied to the entire population of the evacuation zone. The values in all of the tables were rounded to the nearest integer for display only (i.e., 53,596 people in Bergen-Zone A multiplied by 12.5% is 6,699 people). The subsequent calculations using participation rates were maintained with precision throughout the entire process until the participation rates were inputted to RtePM.

The seventh and eighth columns, under “SZ Evacuation,” show the participation rates for a Category 1 storm and how they are applied to the evacuating population within the portion of the surge zones within the evacuation zone. They use the evacuation participation rates by hurricane intensity applied to the population that was impacted by storm surge flooding (i.e., 3% of inland in Zone A is 870 people, 25% of the Category 1 surge zone in Zone A is 303 people, 13% of the Category 2 surge zone in Zone A is 855 people, etc.). The additional columns to the right reflect higher intensity storms. The highlighted values (pink, orange, yellow, and blue) reflect the percent of evacuating the population. The participation rate calculations were developed for each of the 17 NJHES Re-Study counties (**Appendix B**).

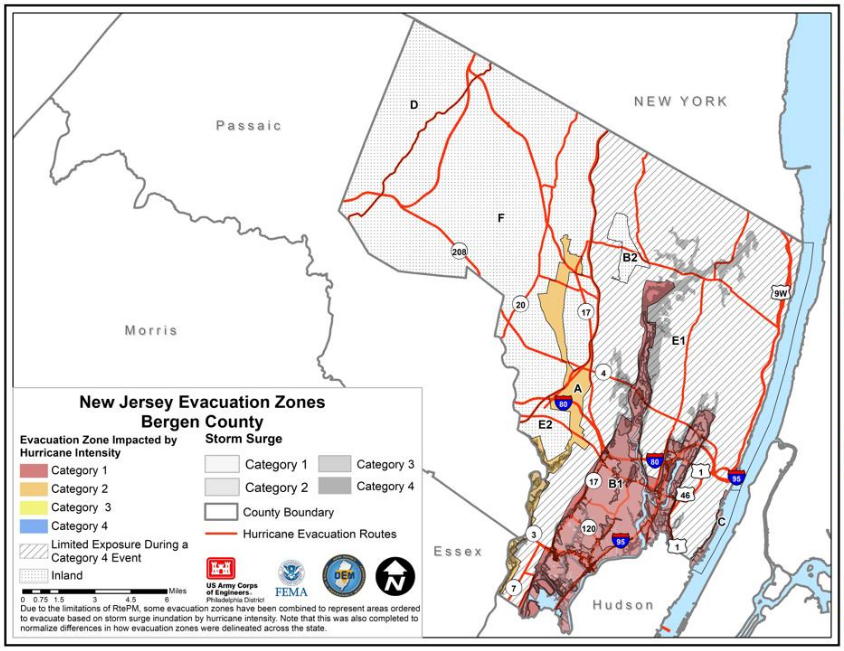
Table 3-7 Medium Evacuation Participation Rates Comparison (EZ vs. SZ)

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Bergen	Cat 2	A	Inland	34,805	13%	4,351	3%	870	25%	8,701	5%	1,740	33%	11,312	5%	1,740	38%	13,052	8%	2,610
		A	Cat 1	1,223	13%	153	25%	303	25%	306	30%	370	33%	398	39%	471	38%	459	44%	538
		A	Cat 2	6,677	13%	835	13%	835	25%	1,669	25%	1,669	33%	2,170	33%	2,170	38%	2,504	38%	2,504
		A	Cat 3	4,837	13%	605	8%	363	25%	1,209	15%	726	33%	1,572	30%	1,451	38%	1,814	30%	1,451
		A	Cat 4	6,052	13%	757	8%	454	25%	1,513	15%	908	33%	1,967	30%	1,816	38%	2,270	30%	1,816
				53,596	13%	6,699	5%	2,824	25%	13,399	10%	5,413	33%	17,419	14%	7,648	38%	20,098	17%	8,920
	Cat 1	B1,C	Inland	10,889	25%	2,695	3%	272	30%	3,294	5%	544	39%	4,192	5%	544	44%	4,791	8%	817
		B1,C	Cat 1	26,070	25%	6,452	25%	6,452	30%	7,886	30%	7,886	39%	10,037	39%	10,037	44%	11,471	44%	11,471
		B1,C	Cat 2	31,879	25%	7,890	13%	3,985	30%	9,643	25%	7,970	39%	12,273	33%	10,361	44%	14,027	38%	11,955
		B1,C	Cat 3	12,481	25%	3,089	8%	936	30%	3,776	15%	1,872	39%	4,805	30%	3,744	44%	5,492	30%	3,744
		B1,C	Cat 4	6,523	25%	1,614	8%	489	30%	1,973	15%	978	39%	2,511	30%	1,957	44%	2,870	30%	1,957
				87,842	25%	21,741	14%	12,135	30%	26,572	22%	19,251	39%	33,819	30%	26,643	44%	38,650	34%	29,943
	Inland	B2,D,E2,F,E1	Inland	760,210	3%	19,005	3%	19,005	5%	38,011	5%	38,011	5%	38,011	5%	38,011	8%	57,016	8%	57,016
		B2,D,E2,F,E1	Cat 1	570	3%	14	25%	141	5%	29	30%	173	5%	29	39%	220	8%	43	44%	251
		B2,D,E2,F,E1	Cat 2	931	3%	23	13%	116	5%	47	25%	233	5%	47	33%	303	8%	70	38%	349
		B2,D,E2,F,E1	Cat 3	6,390	3%	160	8%	479	5%	320	15%	959	5%	320	30%	1,917	8%	479	30%	1,917
		B2,D,E2,F,E1	Cat 4	30,045	3%	751	8%	2,253	5%	1,502	15%	4,507	5%	1,502	30%	9,013	8%	2,253	30%	9,013
				798,147	3%	19,954	3%	21,995	5%	39,907	5%	43,881	5%	39,907	6%	49,463	8%	59,861	9%	68,547

*Note: the values in the northern and southern NJ tables were rounded to the nearest integer for display only. The subsequent calculations using participation rates were maintained with precision throughout the process until the participation rates are applied to the evacuation zone shapes when entered into RtePM.

3.2.4 Summary Participation Rate Maps for Northern New Jersey Counties

The following figures (**Figure 3-2** through **Figure 3-10**) are summary graphics for Northern NJ in alphabetical order. Each map shows the evacuation zones (Zone A, B, C, etc.) compared to the storm surge inundation area (gray). The coloration of the evacuation zone within the table in the top right of each figure shows the hurricane intensity assignment and grouping based on the storm surge inundation area (these shapes were later inputted into the RtePM transportation model). The three tables outline the participation rates applied to the evacuation zones: the top table shows the Medium Surge Zone (SZ) participation rate (i.e., based on the percent of the population impacted by storm surge inundation), the middle table shows the Medium Evacuation Zone (EZ) participation rate, and the bottom table shows the High Evacuation Zone (EZ) participation rate. Gray cells indicate shadow evacuees. The participation rates were also used for the Shelter Analysis described in Section 4.0.



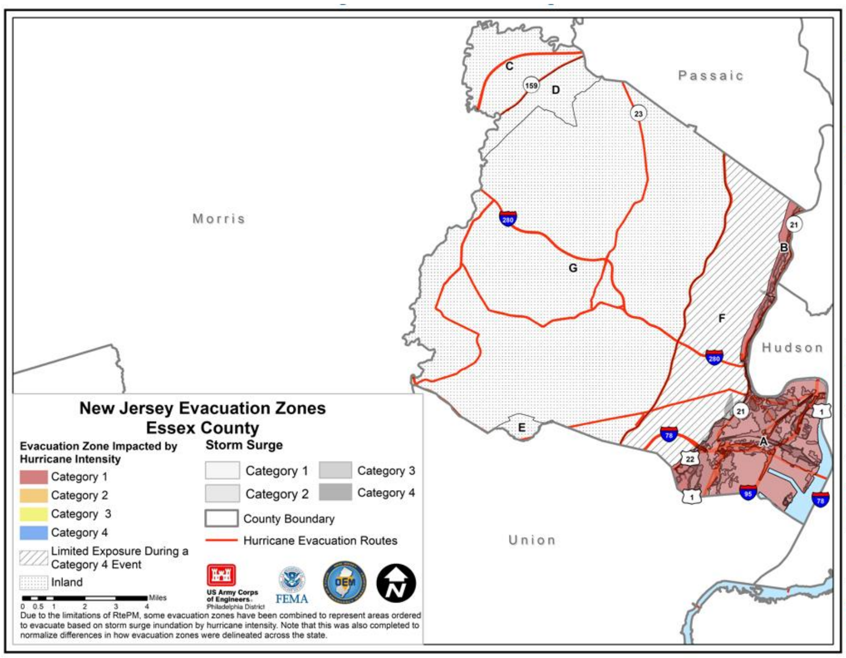
Storm Intensity	Evacuation Zones
Cat1	(B1, C)
Cat2	A, (B1, C)
Cat3	A, (B1, C)
Cat4	A, (B1, C)
Limited Exposure During a Category 4 Event	E1
Inland	(B2, D, E2, F)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
B1,C	14%	22%	30%	34%
A	5%	10%	14%	17%
B2,D,E2,F, E1	2%	5%	6%	8%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
B1,C	25%	30%	39%	44%
A	13%	25%	33%	38%
B2,D,E2,F, E1	2%	5%	5%	7%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
B1,C	100%	100%	100%	100%
A	13%	100%	100%	100%
B2,D,E2,F, E1	2%	5%	5%	7%

Figure 3-2 Bergen County Evacuation Zones and Participation Rates



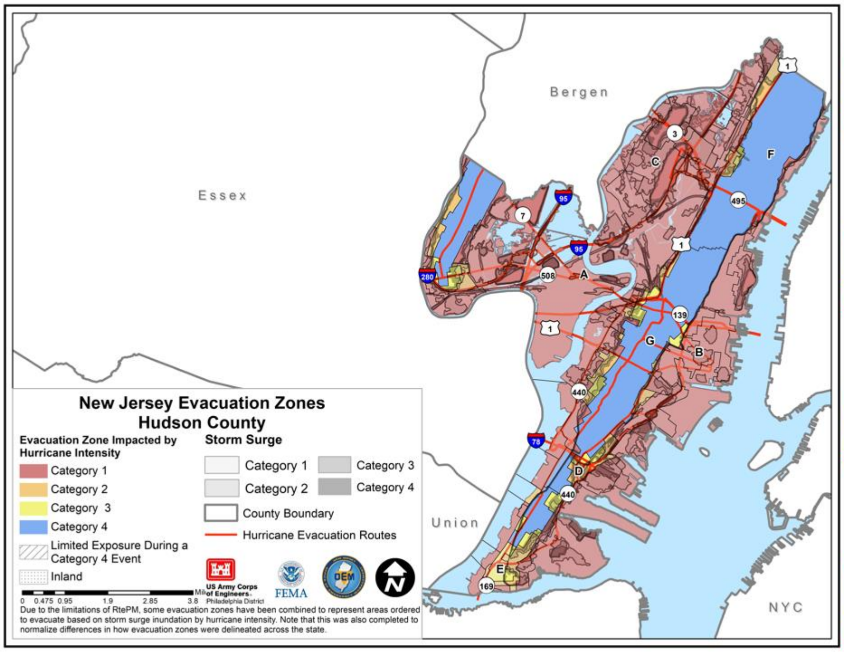
Storm Intensity	Evacuation Zones
Cat1	(A, B)
Cat2	(A, B)
Cat3	(A, B)
Cat4	(A, B)
Inland	(C, D, E, G, F)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B	12%	20%	29%	33%
C,D,E,G, F	2%	5%	5%	7%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B	25%	30%	39%	44%
C,D,E,G, F	2%	5%	5%	7%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B	100%	100%	100%	100%
C,D,E,G, F	2%	5%	5%	7%

Figure 3-3 Essex County Evacuation Zones and Participation Rates



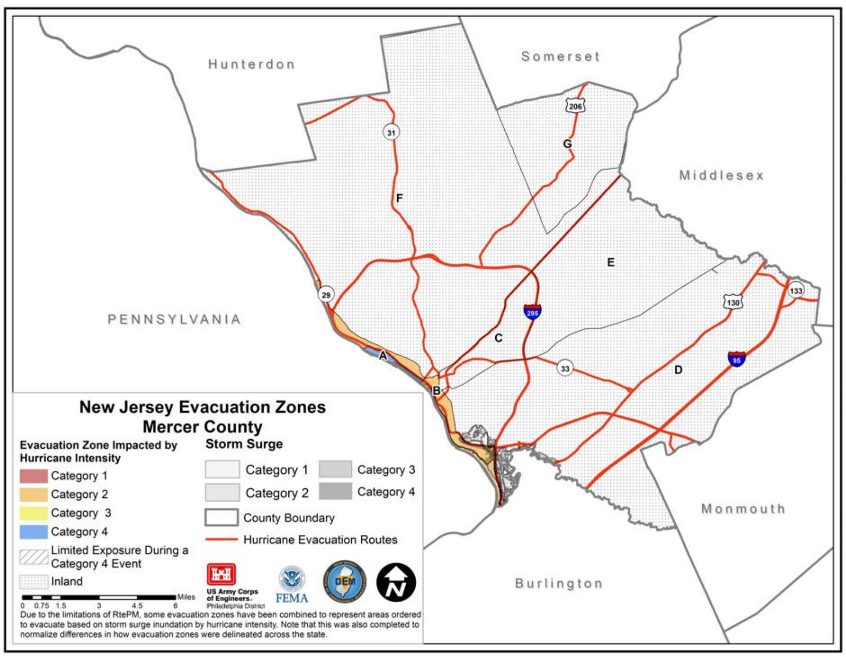
Storm Intensity	Evacuation Zones
Cat1	(A, B, C)
Cat2	(A, B, C), D
Cat3	(A, B, C), D, E
Cat4	(A, B, C), D, E, (F, G)
Inland	None

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B,C	19%	26%	34%	39%
D	9%	17%	26%	28%
E	9%	15%	23%	25%
F,G	3%	5%	6%	8%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B,C	25%	30%	39%	44%
D	13%	25%	33%	38%
E	8%	15%	30%	30%
F,G	8%	15%	30%	30%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B,C	100%	100%	100%	100%
D	13%	100%	100%	100%
E	8%	15%	100%	100%
F,G	8%	15%	100%	100%

Figure 3-4 Hudson County Evacuation Zones and Participation Rates



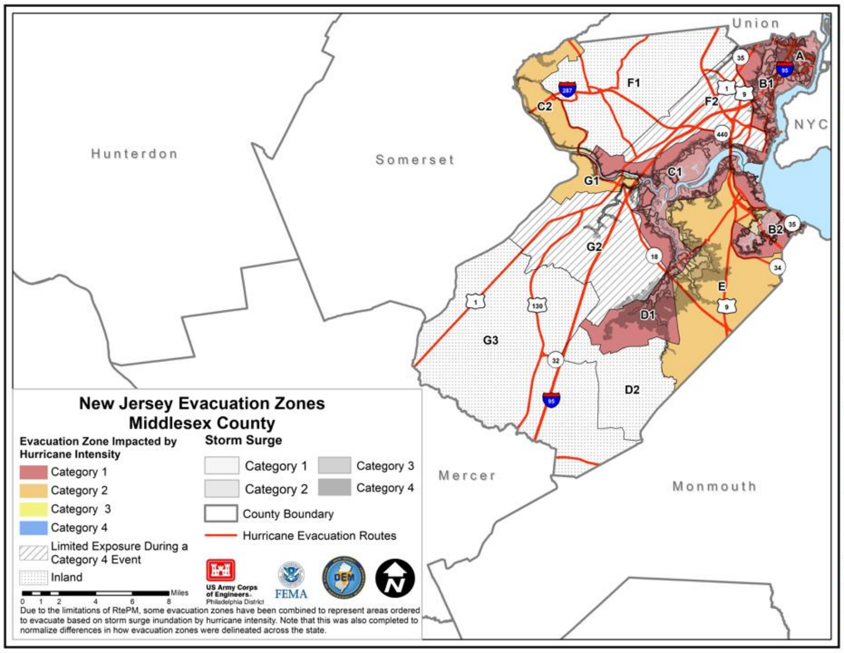
Storm Intensity	Evacuation Zones
Cat1	
Cat2	B
Cat3	B
Cat4	A, B
Inland	(C, D, E, F, G)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
B	3%	5%	6%	8%
A	3%	5%	6%	8%
C,D,E,F,G	2%	5%	5%	7%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
B	13%	25%	33%	38%
A	8%	15%	30%	30%
C,D,E,F,G	2%	5%	5%	7%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
B	13%	100%	100%	100%
A	8%	15%	100%	100%
C,D,E,F,G	2%	5%	5%	7%

Figure 3-5 Mercer County Evacuation Zones and Participation Rates



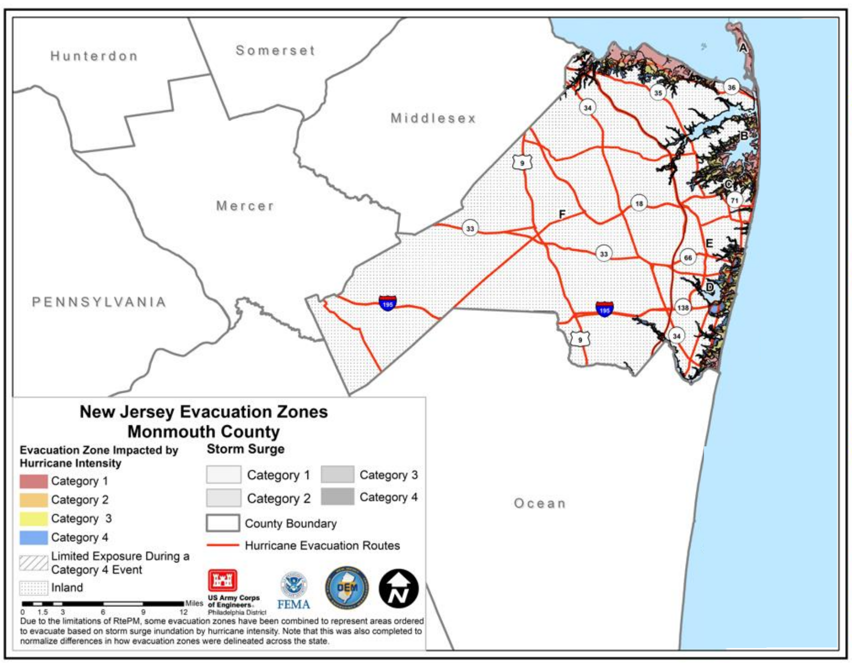
Storm Intensity	Evacuation Zones
Cat1	(A, B1, B2, C1, D1)
Cat2	(A, B1, B2, C1, D1), (C2, G1), E
Cat3	(A, B1, B2, C1, D1), (C2, G1), E
Cat4	(A, B1, B2, C1, D1), (C2, G1), E
Limited Exposure During a Category 4 Event	(F2, G2)
Inland	(D2, F1, G3)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B1,B2,C1,D1	8%	14%	20%	23%
C2,G1	3%	6%	7%	10%
E	4%	7%	9%	11%
D2,F1,G3, F2, G2	2%	5%	5%	7%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B1,B2,C1,D1	25%	30%	39%	44%
C2,G1	13%	25%	33%	38%
E	13%	25%	33%	38%
D2,F1,G3, F2, G2	2%	5%	5%	7%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B1,B2,C1,D1	100%	100%	100%	100%
C2,G1	13%	100%	100%	100%
E	13%	100%	100%	100%
D2,F1,G3, F2, G2	2%	5%	5%	7%

Figure 3-6 Middlesex County Evacuation Zones and Participation Rates



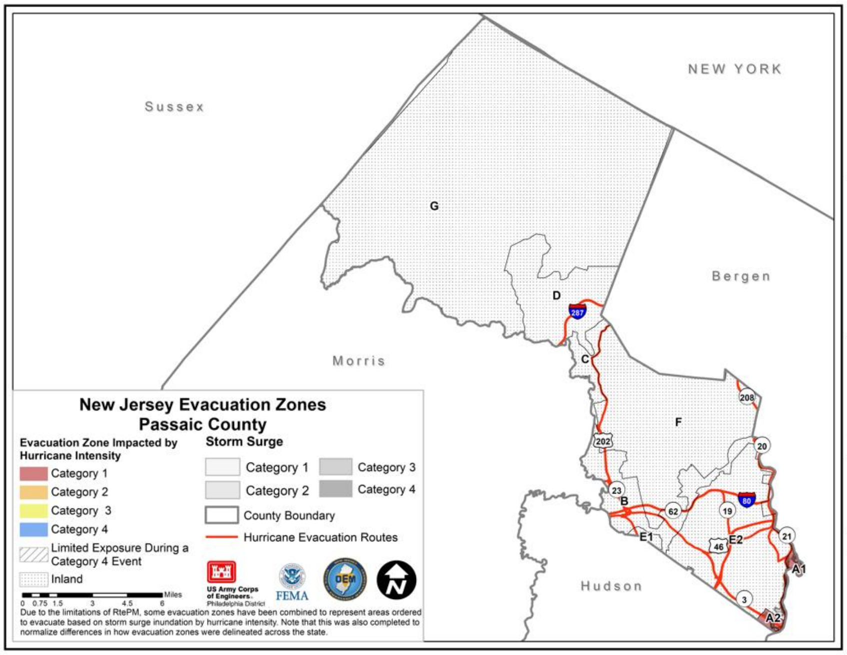
Storm Intensity	Evacuation Zones
Cat1	A
Cat2	A, B
Cat3	A, B, C
Cat4	A, B, C, D
Inland	(E, F)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	24%	30%	38%	43%
B	12%	24%	32%	37%
C	8%	15%	30%	30%
D	7%	14%	27%	28%
E,F	2%	5%	5%	7%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	25%	30%	39%	44%
B	13%	25%	33%	38%
C	8%	15%	30%	30%
D	8%	15%	30%	30%
E,F	2%	5%	5%	7%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	100%	100%	100%	100%
B	13%	100%	100%	100%
C	8%	15%	100%	100%
D	8%	15%	100%	100%
E,F	2%	5%	5%	7%

Figure 3-7 Monmouth County Evacuation Zones and Participation Rates



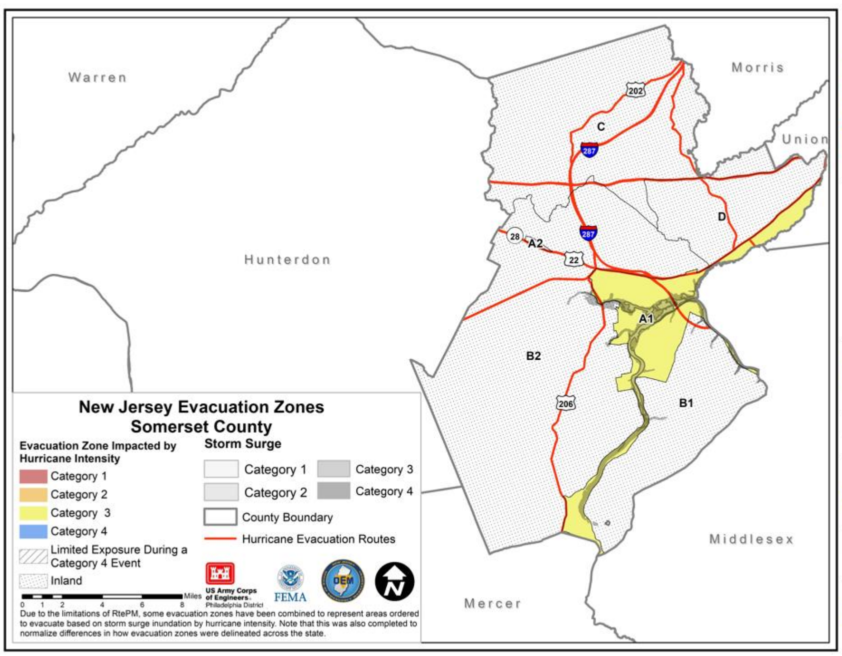
Storm Intensity	Evacuation Zones
Cat1	(A1, A2)
Cat2	(A1, A2)
Cat3	(A1, A2)
Cat4	(A1, A2)
Inland	(B, C, D, E1, E2, F, G)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A1,A2	6%	12%	19%	21%
B,C,D,E,F,G	2%	5%	5%	7%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A1,A2	25%	30%	39%	44%
B,C,D,E,F,G	2%	5%	5%	7%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A1,A2	100%	100%	100%	100%
B,C,D,E,F,G	2%	5%	5%	7%

Figure 3-8 Passaic County Evacuation Zones and Participation Rates



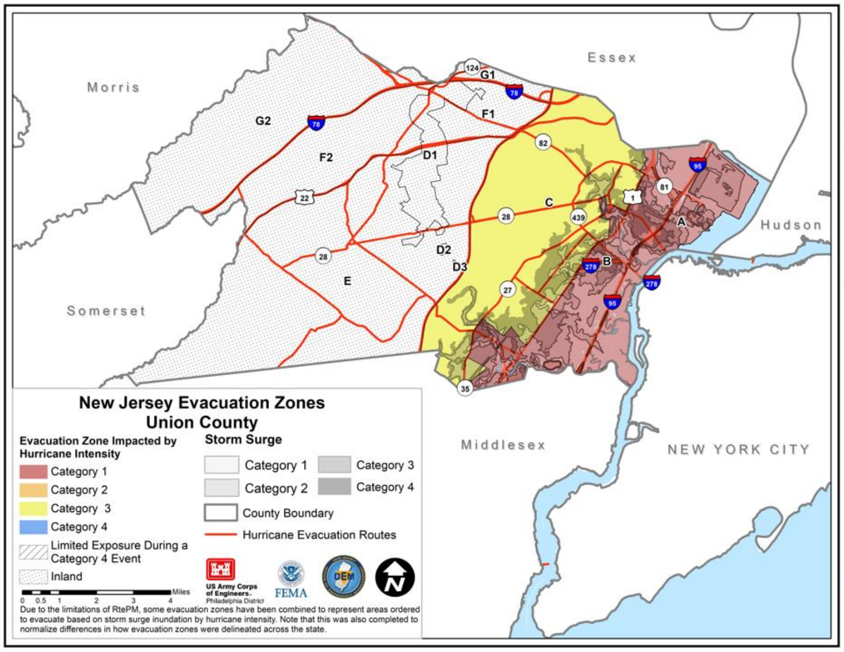
Storm Intensity	Evacuation Zones
Cat1	
Cat2	
Cat3	A1
Cat4	A1
Inland	(A2, B1, B2, C, D)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A1	3%	6%	8%	10%
A2,B,C,D	2%	5%	5%	7%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A1	8%	15%	30%	30%
A2,B,C,D	2%	5%	5%	7%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A1	8%	15%	100%	100%
A2,B,C,D	2%	5%	5%	7%

Figure 3-9 Somerset County Evacuation Zones and Participation Rates



Storm Intensity	Evacuation Zones
Cat1	(A, B)
Cat2	(A, B)
Cat3	(A, B), C
Cat4	(A, B), C
Inland	(D1, D2, D3, E, F1, F2, G1, G2)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B	11%	19%	30%	32%
C	4%	7%	11%	13%
D,E,F,G	2%	5%	5%	7%

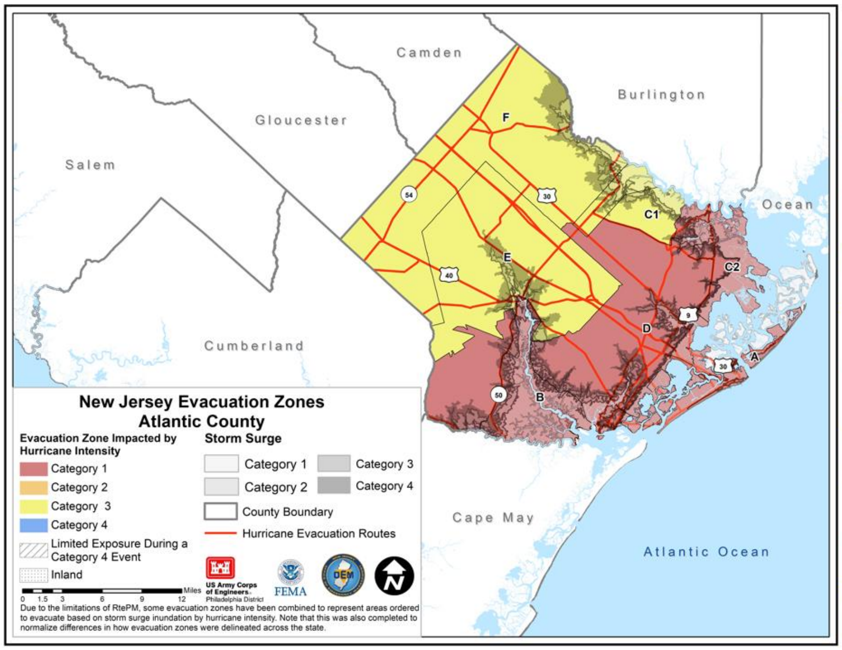
	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B	25%	30%	39%	44%
C	8%	15%	30%	30%
D,E,F,G	2%	5%	5%	7%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B	100%	100%	100%	100%
C	8%	15%	100%	100%
D,E,F,G	2%	5%	5%	7%

Figure 3-10 Union County Evacuation Zones and Participation Rates

3.2.5 Summary Participation Rate Maps for Southern New Jersey Counties

The following figures (**Figure 3-11** through **Figure 3-18**) are summary graphics for the southern counties in alphabetical order. Each map shows the evacuation zones (Zone A, B, C, etc.) compared to the storm surge inundation area (gray). The coloration of the evacuation zone within the table in the top right of each figure shows the hurricane intensity assignment and grouping based on the storm surge inundation area (these shapes were later inputted into the RtePM transportation model). The three tables outline the participation rates applied to the evacuation zones: the top table shows the Medium Surge Zone (SZ) participation rate (i.e., based on the percent of the population impacted by storm surge inundation), the middle table shows the Medium Evacuation Zone (EZ) participation rate, and the bottom table shows the High Evacuation Zone (EZ) participation rate. Gray cells indicate shadow evacuees. The participation rates were also used for the Shelter Analysis described in Section 4.0.



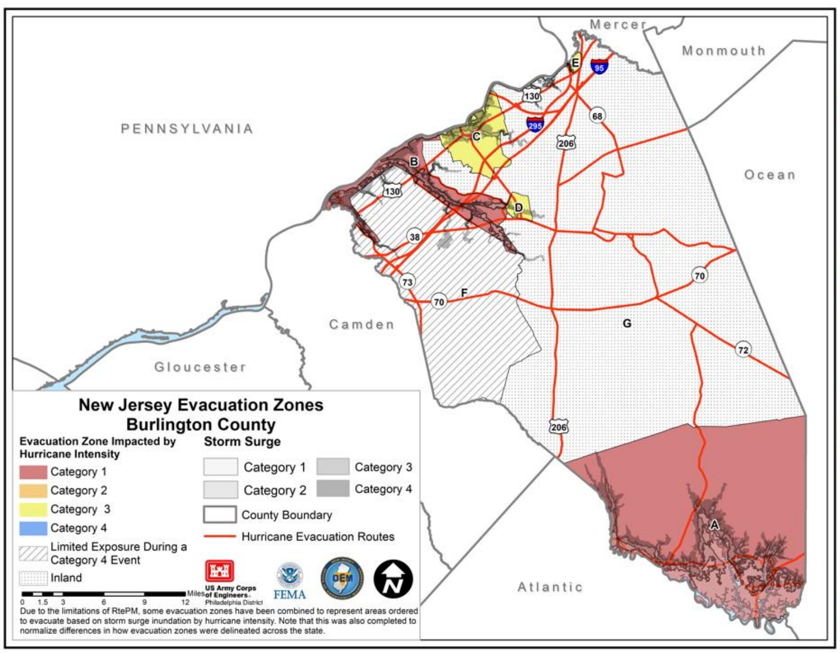
Storm Intensity	Evacuation Zones
Cat1	A, (B, C2), D
Cat2	A, (B, C2), D
Cat3	A, (B, C2), D, C1, E, F
Cat4	A, (B, C2), D, C1, E, F
Inland	None

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	34%	43%	56%	60%
B,C2	32%	41%	52%	56%
D	7%	12%	16%	19%
C1	4%	7%	8%	11%
E	4%	8%	11%	13%
F	3%	6%	6%	9%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	40%	48%	60%	64%
B,C2	40%	48%	60%	64%
D	40%	48%	60%	64%
C1	9%	21%	36%	39%
E	9%	21%	36%	39%
F	9%	21%	36%	39%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	100%	100%	100%	100%
B,C2	100%	100%	100%	100%
D	100%	100%	100%	100%
C1	9%	21%	100%	100%
E	9%	21%	100%	100%
F	9%	21%	100%	100%

Figure 3-11 Atlantic County Evacuation Zones and Participation Rates



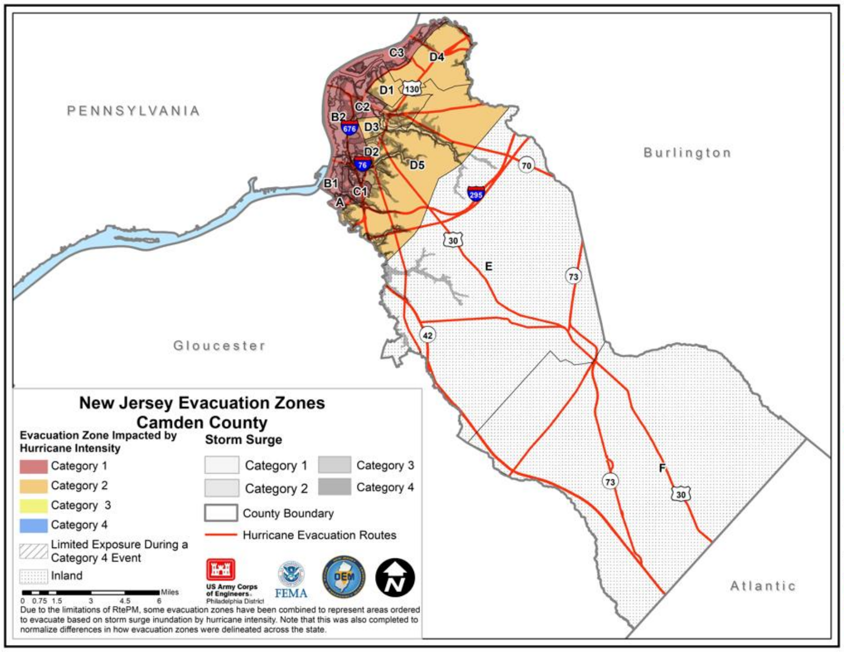
Storm Intensity	Evacuation Zones
Cat1	A, B
Cat2	A, B
Cat3	A, B, (C, D, E)
Cat4	A, B , (C, D, E)
Limited Exposure During a Category 4 Event	F
Inland	G

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	5%	9%	11%	14%
B	8%	16%	24%	27%
C,D,E	5%	10%	15%	18%
G, F	2%	5%	6%	8%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	40%	48%	60%	64%
B	40%	48%	60%	64%
C,D,E	9%	21%	36%	39%
G, F	2%	5%	5%	8%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	100%	100%	100%	100%
B	100%	100%	100%	100%
C,D,E	9%	21%	100%	100%
G, F	2%	5%	5%	8%

Figure 3-12 Burlington County Evacuation Zones and Participation Rates



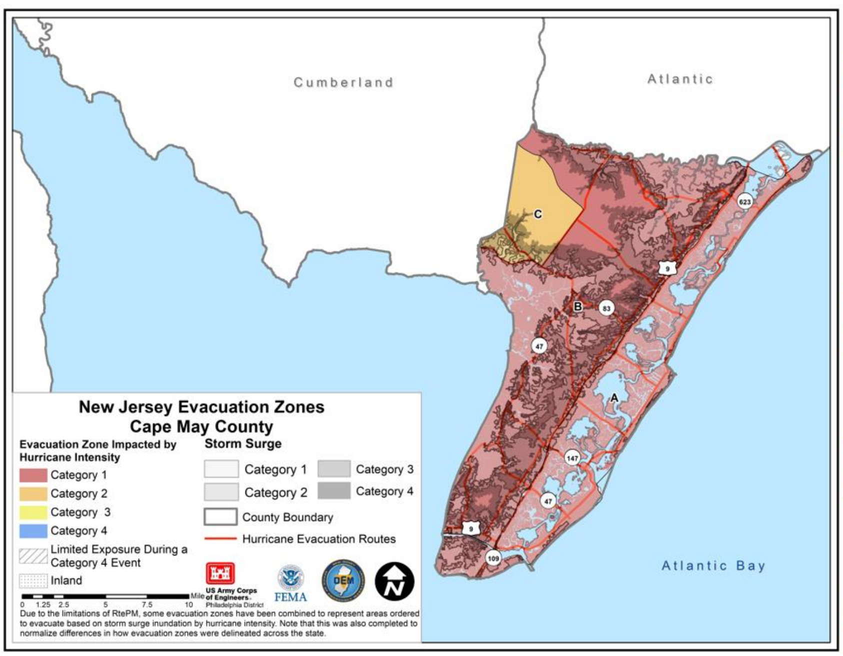
Storm Intensity	Evacuation Zones
Cat1	(A, B1, B2, C1, C2, C3)
Cat2	(A, B1, B2, C1, C2, C3), (D1, D2, D3,D4, D5)
Cat3	(A, B1, B2, C1, C2, C3), (D1, D2, D3,D4, D5)
Cat4	(A, B1, B2, C1, C2, C3), (D1, D2, D3,D4, D5)
Inland	(E, F)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B1,B2,C1,C2,C3	13%	23%	35%	39%
D1,D2,D3,D4,D5	5%	9%	12%	15%
E,F	2%	5%	5%	8%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B1,B2,C1,C2,C3	40%	48%	60%	64%
D1,D2,D3,D4,D5	25%	35%	49%	53%
E,F	2%	5%	5%	8%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B1,B2,C1,C2,C3	100%	100%	100%	100%
D1,D2,D3,D4,D5	25%	100%	100%	100%
E,F	2%	5%	5%	8%

Figure 3-13 Camden County Evacuation Zones and Participation Rates



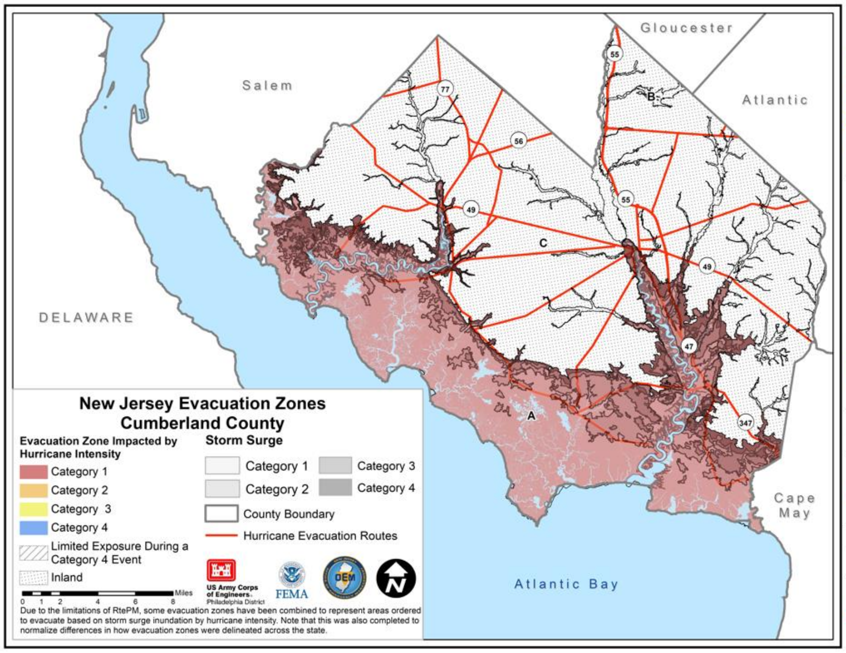
Storm Intensity	Evacuation Zones
Cat1	A, B
Cat2	A, B, C
Cat3	A, B, C
Cat4	A, B, C
Inland	None

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	37%	45%	58%	61%
B	14%	24%	37%	40%
C	5%	9%	12%	15%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	40%	48%	60%	64%
B	40%	48%	60%	64%
C	25%	35%	49%	53%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	100%	100%	100%	100%
B	100%	100%	100%	100%
C	25%	100%	100%	100%

Figure 3-14 Cape May County Evacuation Zones and Participation Rates



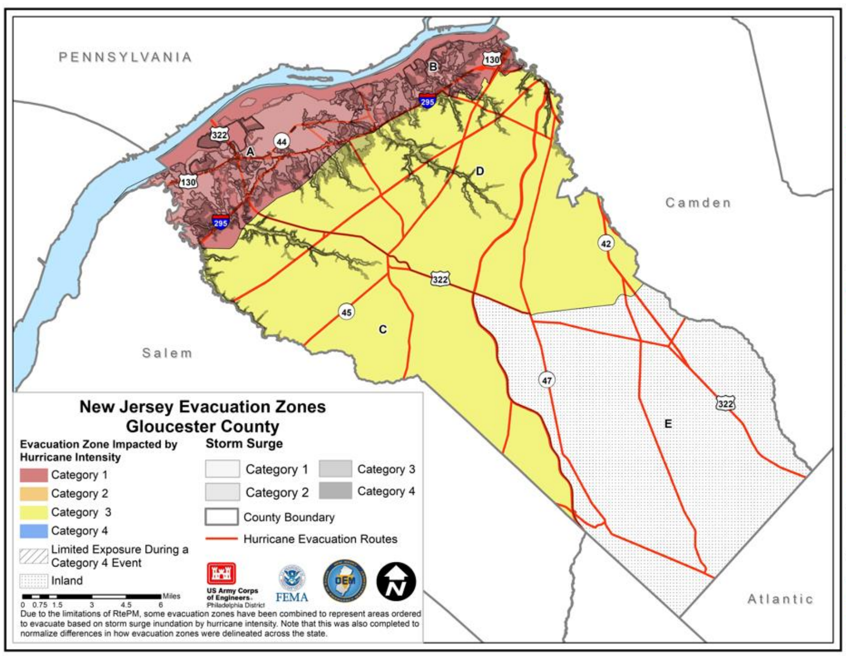
Storm Intensity	Evacuation Zones
Cat1	A
Cat2	A
Cat3	A
Cat4	A
Inland	(B, C)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	21%	32%	46%	49%
B,C	2%	5%	5%	8%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	40%	48%	60%	64%
B,C	2%	5%	5%	8%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	100%	100%	100%	100%
B,C	2%	5%	5%	8%

Figure 3-15 Cumberland County Evacuation Zones and Participation Rates



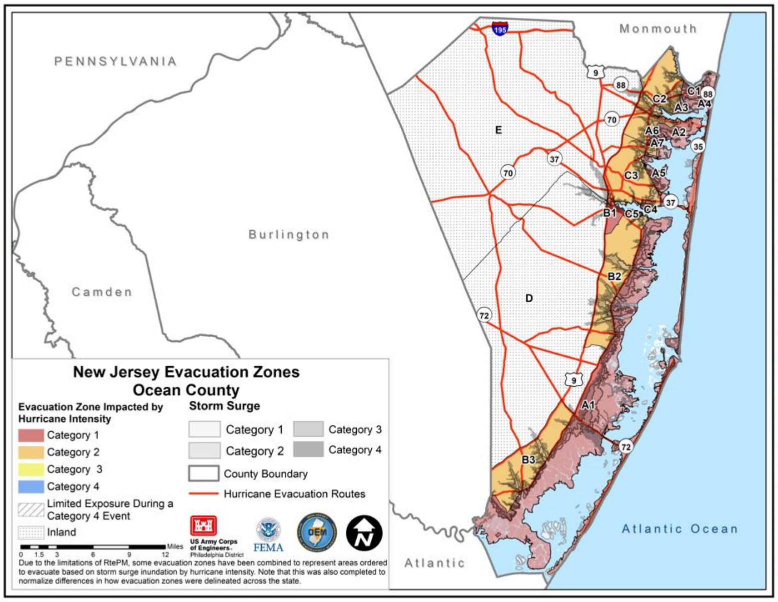
Storm Intensity	Evacuation Zones
Cat1	(A, B)
Cat2	(A, B)
Cat3	(A, B), (C, D)
Cat4	(A, B), (C, D)
Inland	E

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B	13%	22%	32%	35%
C,D	3%	7%	7%	10%
E	2%	5%	5%	8%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B	40%	48%	60%	64%
C,D	9%	21%	36%	39%
E	2%	5%	5%	8%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A,B	100%	100%	100%	100%
C,D	9%	21%	100%	100%
E	2%	5%	5%	8%

Figure 3-16 Gloucester County Evacuation Zones and Participation Rates



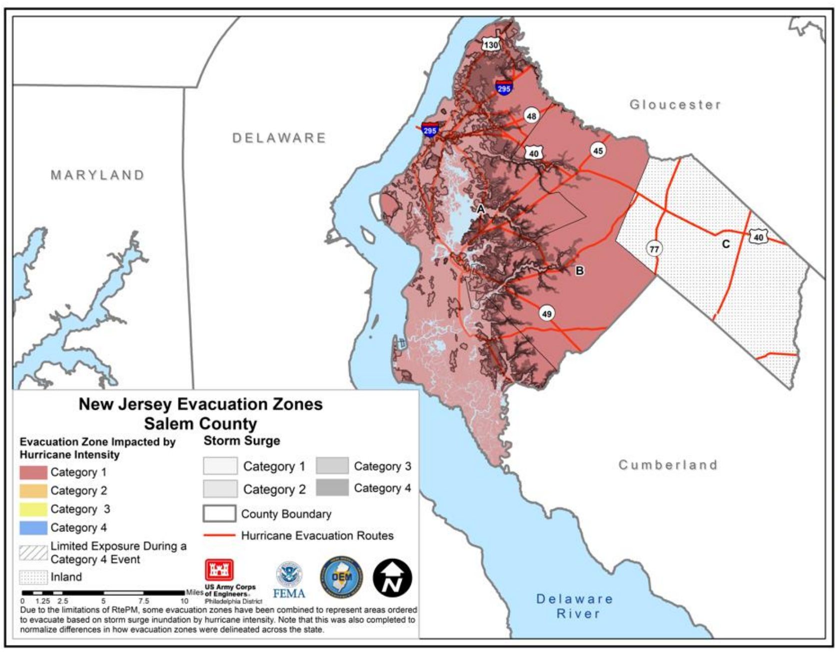
Storm Intensity	Evacuation Zones
Cat1	(A1, A2, A3, A4, A5, A6, A7), (B1, C1, C4, C5)
Cat2	(A1, A2, A3, A4, A5, A6, A7), (B1, C1, C4, C5), (B2, B3, C2, C3)
Cat3	(A1, A2, A3, A4, A5, A6, A7), (B1, C1, C4, C5), (B2, B3, C2, C3)
Cat4	(A1, A2, A3, A4, A5, A6, A7), (B1, C1, C4, C5), (B2, B3, C2, C3)
Inland	(D, E)

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A1,A2,A3,A4,A5,A	28%	37%	50%	54%
B1,C1,C4,C5	10%	18%	28%	31%
B2,B3,C2,C3	7%	13%	18%	21%
D,E	2%	5%	5%	8%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A1,A2,A3,A4,A5,A	40%	48%	60%	64%
B1,C1,C4,C5	40%	48%	60%	64%
B2,B3,C2,C3	25%	35%	49%	53%
D,E	2%	5%	5%	8%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A1,A2,A3,A4,A5,A	100%	100%	100%	100%
B1,C1,C4,C5	100%	100%	100%	100%
B2,B3,C2,C3	25%	100%	100%	100%
D,E	2%	5%	5%	8%

Figure 3-17 Ocean County Evacuation Zones and Participation Rates



Storm Intensity	Evacuation Zones
Cat1	A, B
Cat2	A, B
Cat3	A, B
Cat4	A, B
Inland	C

	Medium SZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	25%	34%	47%	50%
B	4%	8%	10%	12%
C	2%	5%	5%	8%

	Medium EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	40%	48%	60%	64%
B	40%	48%	60%	64%
C	2%	5%	5%	8%

	High EZ Participation Rates			
Evacuation zones	Cat 1	Cat 2	Cat 3	Cat 4
A	100%	100%	100%	100%
B	100%	100%	100%	100%
C	2%	5%	5%	8%

Figure 3-18 Salem County Evacuation Zones and Participation Rates

3.3 Response Curves

The amount of time it takes for evacuees, once they receive an evacuation order, to prepare and begin to evacuate from their homes to a point of safety was reported as an idealized *response curve*. Generally, an evacuation clearance time includes the response time and the time it takes for all of the evacuees to leave the area to a point of safety. **Figure 3-19** shows an excerpt from the 2017 NJ HEBS Report on evacuation timing. The graphic shows three response curves. The three response curves from the 2017 NJ HEBS Report were listed as *quick* (where the last person begins their evacuation at hour 12 and defined as “fast” in RtePM), *normal* (where the last person begins their evacuation at hour 18 and defined as “medium” in RtePM), and *slow* (where the last person begins their evacuation at hour 24 after the evacuation notice). The response curves were based on an evacuation notice issued at hour 0. An additional sensitivity analysis was conducted related to the response of Atlantic County Zone A and the need for the specific barrier island population to evacuate before other zones. The sensitivity analysis is documented in Appendix E.

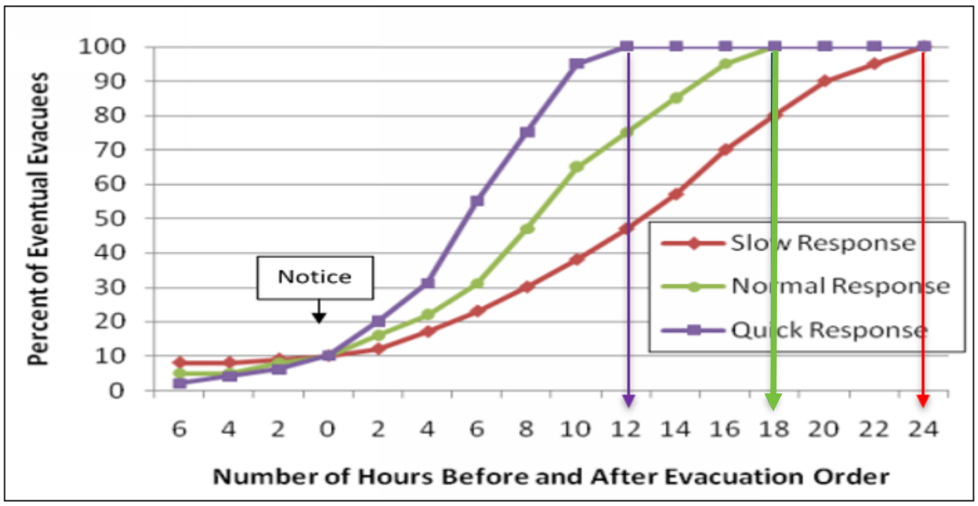


Figure 3-19 Evacuation Timing Curves for Planning (Excerpt from 2017 NJ HEBS Report)

3.4 Destination Rates

Destination rates identify the proportion and points of safety to where an evacuee travels during an evacuation event. As described in more detail in Section 5.3.1, two types of destinations were considered in the Transportation Analysis: an *endpoint* (a location at the edge of the transportation model network where the evacuee was considered safe) and a public shelter. Endpoint assignments defined the proportion of evacuees that travel to a particular endpoint based on their location. Shelter rates are discussed in more detail in Section 4.0 and Section 5.3.1.

In RtePM, endpoint assignments can be identified by the user or dynamically calculated by RtePM during the simulation. A user cannot define a specific route preference in RtePM but can define an endpoint assignment. Route preferences from the 2017 NJ HEBS Report were initially evaluated and used as endpoints. **Figure 3-20** lists the route preference percent rates taken from the 2017 NJ HEBS Report. However, further analysis showed that the route preferences do not necessarily reflect the endpoint assignment. For instance, the Garden State Parkway extends along the length of the state but has only one endpoint in RtePM located at the northernmost end of the study area.

It was expected that a portion of the evacuees from Southern NJ would use the Garden State Parkway but expecting that 31% of them would travel to the far northern end of the study area was unlikely. **Therefore, for the NJHES Re-Study, the Transportation Analysis was conducted using RtePM's internal logic to dynamically assign evacuees to endpoints during the simulation run.**

Route	Northern New Jersey	Southern New Jersey
Garden State Parkway	25.4	31.3
NJ Turnpike	22.4	11.2
I-195	6.0	8.5
I-78	7.7	1.1
I-80	7.2	.8
US 47	1.2	6.2
US 70	1.1	4.2
70	1.9	3.3
Other	27.0	36.0
Don't Know	21.6	17.7

Figure 3-20 Route Preferences by Percent (Excerpt from 2017 NJ HEBS Report)

4.0 Shelter Analysis

A shelter provides a safe place to stay for those who have been ordered to evacuate their homes before a storm. The purpose of the Shelter Analysis was to provide a summary of existing shelter facilities and their potential vulnerabilities to impacts from hurricanes, specifically from storm surge, and to assess if there is enough shelter capacity, i.e., the number of evacuees a public shelter can safely accommodate during an evacuation event, to satisfy demand during an evacuation. Shelters were considered in the transportation modeling as a point of safety in the Transportation Analysis.

This information provides state and local officials with the information necessary to anticipate and confirm that evacuees seeking public shelters have adequate and safe facilities to use. The information regarding shelter capacity and location was provided via correspondence from the NJ Department of Human Services Office of Emergency Management. **The shelter information used for this study did not consider any changes to capacity, location, or availability due to COVID-19.**

4.1 Shelter Behavioral Assumptions

First, the evacuation participation rates from Section 3.2 were applied to determine the proportion of the people that participate in a specific evacuation order. Then, behavioral assumptions regarding the proportion of the evacuating population that use a public shelter were applied. The primary source of the behavioral assumptions was the 2017 NJ HEBS Report. Shelter demands are summarized in Section 4.4.

Table 4-1 lists the behavioral assumptions by region/jurisdiction and the percent of evacuees that travel to public shelters during an evacuation event, using results from the 2017 NJ HEBS Report[14].

Based on the 2017 NJ HEBS Report, the "inland of surge zone" shelter rate for Northern NJ was 15%, and Southern NJ was 10%. The definition of "inland of surge zone" from the 2017 NJ HEBS Report encompassed the entire inland portion of NJ and did not define the extent of the inland populations impacted. Since the delineated evacuation zones extended beyond the storm surge inundation areas, and an inland portion was already accounted for – the shelter usage rates for those evacuating from "inland of surge" were assumed to be 0%.

[14] The study team noted that the 2017 NJ HEBS Report Planning Assumptions document characterized the Southern NJ public shelter use rates by "Evacuation Zone 1, Evacuation Zone 2, Evacuation Zone 3+4, and Inland of Evacuation Zones," which differs from the terminology used for the Northern NJ shelter rates and other Southern NJ related rates. Evacuation zones were not used and were not directly referred to in the 2017 NJ HEBS Report; thus, the study team assumed that this was a typographical error and that "surge zone" should replace "evacuation zone" in the planning assumptions document.

Table 4-1 Public Shelter Behavioral Assumptions for NJHES Re-Study

Northern NJ Public Shelter Usage Rate	Scenario			
Surge Zone	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Category 1 Surge Zone	10%	10%	10%	10%
Category 2 Surge Zone	10%	10%	10%	10%
Category 3+4 Surge Zone	10%	10%	10%	10%
Inland of Surge	0%	0%	0%	0%
Southern NJ Public Shelter Usage Rate	**Scenario**			
Surge Zone	**Category 1 Hurricane**	**Category 2 Hurricane**	**Category 3 Hurricane**	**Category 4 Hurricane**
Category 1 Surge Zone	3%	3%	3%	3%
Category 2 Surge Zone	5%	5%	5%	5%
Category 3+4 Surge Zone	10%	10%	10%	10%
Inland of Surge	0%	0%	0%	0%

4.2 Shelter Inventory and Capacities

A shelter inventory was developed to identify shelters that would be used during a hurricane evacuation. The inventory identified each shelter's name, location, capacity, and type. The capacity did not account for any reduction due to the COVID-19 pandemic. NJ has a total shelter capacity of 79,181. Shelters are typically meant to house people for 12 to 72 hours until the storm passes. The total shelter capacity was the total listed capacity and was not reduced to the post-storm shelter capacity designation as listed in the shelter database (**Appendix C**).

Table 4-2 lists available public shelter capacity by region, and **Figure 4-1** illustrates their locations within the study area.

Table 4-2 Overall Public Shelter Capacity Totals by Region/Jurisdiction

Region/Jurisdiction	Shelter Capacity
Northern Counties	**Northern Total: 26,193**
Bergen	4,096
Essex	3,189
Hudson	3,846
Mercer	2,502
Middlesex	3,400
Monmouth	5,000
Passaic	952
Somerset	1,927
Union	1,281
Southern Counties	**Southern Total: 35,287**
Atlantic	10,868
Burlington	2,550
Camden	3,139
Cape May	1,149
Cumberland	2,027
Gloucester	3,500
Ocean	7,229
Salem	4,825
Other NJ Counties	**Other Total: 17,701**
Hunterdon	4,452
Morris	2,895
Sussex	8,380
Warren	1,974
Total	**NJ Total: 79,181**

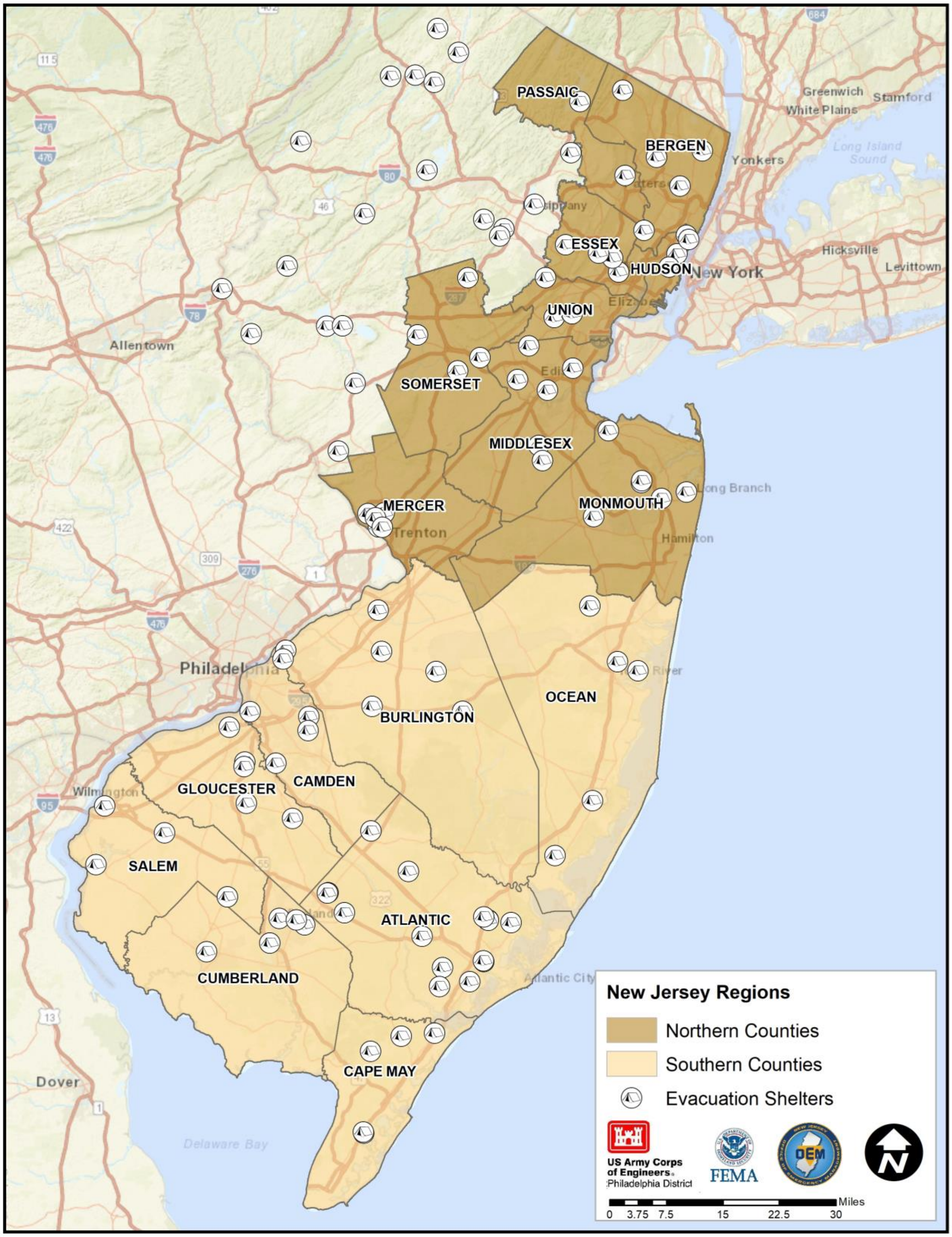


Figure 4-1 Public Shelter Locations by Region and County

4.3 Shelter Vulnerability Assessment

An assessment of the current shelter inventory was conducted to identify potential vulnerabilities to storm surge inundation caused by a hurricane. The shelter building footprint was compared to the storm surge inundation areas to identify whether the building could potentially flood. A comparison of first-floor elevation to storm surge inundation elevation was not considered as part of this assessment. **Table 4-3** summarizes the shelters in storm surge inundation areas that were impacted by specific hurricane intensities. As the storm surge inundation areas increased with hurricane intensity, the number of shelters that were impacted increased, and the available shelter capacity decreased. No shelters were considered vulnerable for the Category 1 storm surge inundation area. The shelter names listed in Table 4-3 align with the shelter location information provided in the shelter database (**Appendix C**).

Table 4-3 Vulnerable Shelters in Storm Surge Inundation Areas

County	Shelter Name	Shelter Capacity
Vulnerable Shelters in Storm Surge Inundation Area: Category 2		
Cape May	Middle Township HS	49
Ocean	Pinelands Reg Jr HS	1,000
Salem	Salem Community College	800
	Pennsville Mem HS	1,800
	Total	**3,649**
Vulnerable Shelters in Storm Surge Inundation Area: Category 3		
Bergen	FDU-Rothman Ctr	1,950
Cape May	Middle Township Elem Sch	150
	Middle Township HS	49
Ocean	Pinelands Reg Jr HS	1,000
Salem	Salem Community College	800
	Pennsville Mem HS	1,800
	Total	**5,749**
Vulnerable Shelters in Storm Surge Inundation Area: Category 4		
Atlantic	Atlantic Christian	235
	Northfield Comm Sch	1,037
Burlington	Palmyra Community Center	300
Camden	Gloucester City HS	260
Gloucester	West Deptford HS	500
Middlesex	Spotswood HS	500
Monmouth	Monmouth Park Race Tr	0
Bergen	FDU- Rothman Ctr	1,950
Cape May	Middle Township Elem Sch	150
	Middle Township HS	49
Ocean	Pinelands Reg Jr HS	1000
Salem	Salem Community College	800
	Pennsville Mem HS	1,800
	Total	**8,581**

Table 4-4 summarizes the change in shelter capacities for different hurricane intensities by county and NJ. For example, Atlantic County has a total shelter capacity of 10,868. The storm surge inundation associated with a Category 4 storm impacted the Atlantic Christian and Northfield Community Schools, thus reducing the Atlantic County shelter capacity down by 1,272 to 9,596.

Table 4-4 Public Shelter Capacities in Different Hurricane Intensities by County

Shelter Capacity	Hurricane Intensity			
County	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Atlantic	10,868	10,868	10,868	9,596
Bergen	4,096	4,096	2,146	2,146
Burlington	2,550	2,550	2,550	2,250
Camden	3,139	3,139	3,139	2,879
Cape May	1,149	1,100	950	950
Cumberland	2,027	2,027	2,027	2,027
Essex	3,189	3,189	3,189	3,189
Gloucester	3,500	3,500	3,500	3,000
Hudson	3,846	3,846	3,846	3,846
Hunterdon	4,452	4,452	4,452	4,452
Mercer	2,502	2,502	2,502	2,502
Middlesex	3,400	3,400	3,400	2,900
Monmouth	5,000	5,000	5,000	5,000
Morris	2,895	2,895	2,895	2,895
Ocean	7,229	6,229	6,229	6,229
Passaic	952	952	952	952
Salem	4,825	2,225	2,225	2,225
Somerset	1,927	1,927	1,927	1,927
Sussex	8,380	8,380	8,380	8,380
Union	1,281	1,281	1,281	1,281
Warren	1,974	1,974	1,974	1,974
NJ Total	**79,181**	**75,532**	**73,432**	**70,600**

4.4 Shelter Demand vs. Capacity Comparisons

Shelter demand referred to the number of evacuees who are expected to seek public shelter as a result of a hurricane evacuation. Typically, as hurricane intensity and evacuating population increase, so does shelter demand. More urbanized areas generated more demand than rural areas due to population density, depending on evacuation zone boundaries. To identify potential demand for shelter space during an evacuation, behavioral assumptions were applied to identify shelter-seeking populations within evacuation areas, inland areas, or areas that produced shadow evacuees.

It was noted that this analysis did not separately address and identify shelters that can or cannot meet the needs of special needs individuals and the elderly. In addition, the total population identified includes the number of potential evacuees from evacuation zones that use a public shelter as a point of safety. Four inland counties in NJ provided shelters for evacuees. The shelter capacity for Hunterdon was 4,452; Morris was 2,895; Sussex was 8,380; and Warren was 1,974. The total additional shelter capacity from these counties was 17,701.

The calculation for identifying the potential shelter demand was a two-step process:

- Apply the evacuation participation rates to the populations identified in each evacuation zone and inland area for each jurisdiction to estimate the evacuating population.

- Apply the public shelter rate assumptions to the estimated evacuating population to produce the number of potential evacuees from each evacuation zone and inland area that seek shelter.

For example, in Bergen County (refer to Table 3-7 in Section 3.2.3), if the evacuation participation rate was set to high (i.e., 100% of the evacuation zone would evacuate) and a Category 2 storm caused Zone A to evacuate (53,596 people) and Zone B1 and C to evacuate (87,842 people), then the total participating population was 141,438. If 10% of the population needed shelter (based on shelter usage rates in the 2017 NJ HEBS Report), then 14,144 evacuees would seek public shelter. The participation rate calculations and populations were developed for each of the 17 NJHES Re-Study counties (**Appendix B**).

Table 4-5 through **Table 4-7** describe the shelter demand for each county by hurricane intensity and by participation rate (High EZ [Table 4-5], Medium EZ [Table 4-6], and Medium SZ [Table 4-7]). If there was a deficit in shelter demand vs. capacity, the resulting value was shown in ***red***. Values in ***black*** indicated an excess capacity that meets shelter demand needs.

The High EZ participation rate assumes 100% of the ordered evacuation zone participate. This assumes a worst-case and a highly unlikely scenario showing deficits in nearly all counties, particularly those with dense urban populations in Northern NJ. When applying the Medium EZ and Medium SZ participation rates, shelter deficits continued to be observed in Northern NJ. Shelter availability existed in neighboring counties if resources needed to be shared across county boundaries.

Table 4-5 Public Shelter Demand vs. Capacity by County Using High Evacuation Zone (EZ) Participation Rate

Region	County	Total Shelter Demand by County				Shelter Demand vs. County Capacity			
		Cat 1	Cat 2	Cat 3	Cat 4	Cat 1	Cat 2	Cat 3	Cat 4
Northern Counties	Bergen	9,481	14,144	14,144	14,144	(5,385)	(10,048)	(11,998)	(11,998)
	Essex	7,825	7,825	7,825	7,825	(4,636)	(4,636)	(4,636)	(4,636)
	Hudson	24,999	31,085	68,223	68,223	(21,153)	(27,239)	(64,377)	(64,377)
	Mercer	237	1,776	1,864	1,864	2,265	726	638	638
	Middlesex	20,695	36,331	36,331	36,331	(17,295)	(32,931)	(32,931)	(33,431)
	Monmouth	6,596	10,807	17,838	17,838	(1,596)	(5,807)	(12,838)	(12,838)
	Passaic	1,435	1,435	1,435	1,435	(483)	(483)	(483)	(483)
	Somerset	621	1,164	7,762	7,762	1,306	763	(5,835)	(5,835)
	Union	9,502	10,986	29,009	29,009	(8,221)	(9,705)	(27,728)	(27,728)
Southern Counties	Atlantic	7,584	8,469	14,299	14,299	3,284	2,399	(3,431)	(4,703)
	Burlington	1,612	2,171	5,852	5,852	938	379	(3,302)	(3,602)
	Camden	4,073	10,542	10,542	10,542	(934)	(7,403)	(7,403)	(7,663)
	Cape May	3,589	3,664	3,664	3,664	(2,440)	(2,564)	(2,714)	(2,714)
	Cumberland	624	624	624	624	1,403	1,403	1,403	1,403
	Gloucester	2,844	5,202	20,732	20,732	656	(1,702)	(17,232)	(17,732)
	Ocean	6,932	13,009	13,009	13,009	297	(6,780)	(6,780)	(6,780)
	Salem	1,551	1,551	1,551	1,551	3,274	674	674	674
	Total	110,198	160,784	254,702	254,702	(48,718)	(102,953)	(198,971)	(201,803)

Table 4-6 Public Shelter Demand vs. Capacity by County Using Medium Evacuation Zone (EZ) Participation Rate

Region	County	Total Shelter Demand by County				Shelter Demand vs. County Capacity			
		Cat 1	Cat 2	Cat 3	Cat 4	Cat 1	Cat 2	Cat 3	Cat 4
Northern Counties	Bergen	2,893	3,975	5,194	5,902	1,203	121	(3,048)	(3,756)
	Essex	1,956	2,348	3,052	3,443	1,233	841	137	(254)
	Hudson	9,211	13,739	22,466	23,692	(5,365)	(9,893)	(18,620)	(19,846)
	Mercer	237	456	612	700	2,265	2,046	1,890	1,802
	Middlesex	6,926	10,001	13,091	14,907	(3,526)	(6,601)	(9,691)	(12,007)
	Monmouth	2,552	3,902	5,962	6,440	2,448	1,098	(962)	(1,440)
	Passaic	359	430	560	631	593	522	392	321
	Somerset	621	1,164	2,329	2,329	1,306	763	(402)	(402)
	Union	3,648	5,522	9,405	9,795	(2,367)	(4,241)	(8,124)	(8,514)
Southern Counties	Atlantic	3,432	4,871	6,808	7,306	7,436	5,997	4,060	2,290
	Burlington	896	1,551	2,393	2,580	1,654	999	157	(330)
	Camden	2,923	3,939	5,376	5,798	216	(800)	(2,237)	(2,919)
	Cape May	1,451	1,746	2,187	2,334	(302)	(646)	(1,237)	(1,384)
	Cumberland	250	299	374	399	1,777	1,728	1,653	1,628
	Gloucester	2,199	4,644	7,721	8,354	1,301	(1,144)	(4,221)	(5,354)
	Ocean	3,988	5,191	6,914	7,434	3,241	1,038	(685)	(1,205)
	Salem	620	744	930	992	4,205	1,481	1,295	1,233
	Total	44,161	64,522	95,375	103,039	17,319	(6,691)	(39,644)	(50,140)

Table 4-7 Public Shelter Demand vs. Capacity by County Using Medium Surge Zone (SZ) Participation Rate

Region	County	Total Shelter Demand by County				Shelter Demand vs. County Capacity			
		Cat 1	Cat 2	Cat 3	Cat 4	Cat 1	Cat 2	Cat 3	Cat 4
Northern Counties	Bergen	1,498	2,468	3,386	3,898	2,598	1,628	(1,240)	(1,752)
	Essex	939	1,565	2,269	2,582	2,250	1,624	920	607
	Hudson	5,778	8,508	11,122	13,118	(1,932)	(4,662)	(7,276)	(9,272)
	Mercer	56	93	112	149	2,446	2,409	2,390	2,353
	Middlesex	2,091	3,732	5,096	6,103	1,309	(332)	(1,696)	(3,203)
	Monmouth	2,415	3,818	5,740	6,260	2,585	1,182	(740)	(1,260)
	Passaic	86	172	273	301	866	780	679	651
	Somerset	233	466	621	776	1,694	1,461	1,306	1,151
	Union	1,707	2,967	4,674	5,254	(426)	(1,686)	(3,393)	(3,973)
Southern Counties	Atlantic	1,525	2,250	2,857	3,283	9,343	8,618	8,011	6,313
	Burlington	326	652	976	1,152	2,224	1,898	1,574	1,098
	Camden	680	1,217	1,706	2,041	2,459	1,922	1,433	838
	Cape May	890	1,217	1,683	1,793	259	(117)	(733)	(843)
	Cumberland	131	200	287	306	1,896	1,827	1,740	1,721
	Gloucester	729	1,612	1,720	2,342	2,771	1,888	1,780	658
	Ocean	1,780	2,699	3,715	4,145	5,449	3,530	2,514	2,084
	Salem	301	420	576	618	4,524	1,805	1,649	1,607
	Total	21,165	34,056	46,813	54,122	40,315	23,775	8,918	(1,223)

5.0 Transportation Analysis – Inputs and Model Setup

5.1 Purpose

The primary purpose of the Transportation Analysis was to compute the clearance times needed to conduct a safe and timely evacuation for a range of hurricane threats. This section describes the inputs used by RtePM to calculate clearance times and information on how the final roadway network used to model the clearance times was developed. Results of the clearance times and recommendations are summarized in Section 6.0.

As previously mentioned, the NJHES Re-Study used RtePM for conducting transportation modeling, and ultimately calculating clearance times. In RtePM, clearance times were generated when all evacuating vehicles leave the network to a point of safety.

RtePM Background

RtePM is a web-based transportation model designed to capture the impacts of traffic flow along a regional roadway network to calculate clearance times, which represents the time it takes to clear the roadway of all evacuating vehicles, measured from the moment the evacuation order is issued until the time when the final evacuating vehicle reaches its point of safety. RtePM allows users to set parameters and conditions including, but not limited to, the area to be evacuated by specifying roadways, the number of evacuees and vehicles involved in the evacuation, the speed at which evacuees respond to evacuation orders, and the destinations that evacuees travel to.

Johns Hopkins University Applied Physics Laboratory initially developed the model in 2009 for the U.S. Department of Homeland Security's Virtual USA initiative. From 2012 to 2015, the Old Dominion University Virginia Modeling, Analysis, and Simulation Center expanded on the work of Johns Hopkins University and made additional improvements to the model. Between 2018 and 2021, the Massachusetts Institute of Technology Lincoln Laboratory (MIT-LL) worked closely with the National Hurricane Program to further enhance the RtePM for modeling hurricane evacuation scenarios.

5.2 Population Data

The 2010 US Census block group was the base population data in RtePM and provided the boundaries for developing the socio-economic data. Since the population data in RtePM was based in 2010, the study team projected the population to the year 2020. This population projection did not reflect the ongoing 2020 US Census Survey data, which was in the process of being collected at the time of the transportation modeling. Future hurricane evacuation studies should be able to update the population data by changing the percent population growth within the RtePM interface to reflect any new or recent data. **Figure 5-1** shows an example (Cape May County) of the US Census block group boundaries in RtePM. The blue lines represent the evacuation roadway network in RtePM (Section 5.5).

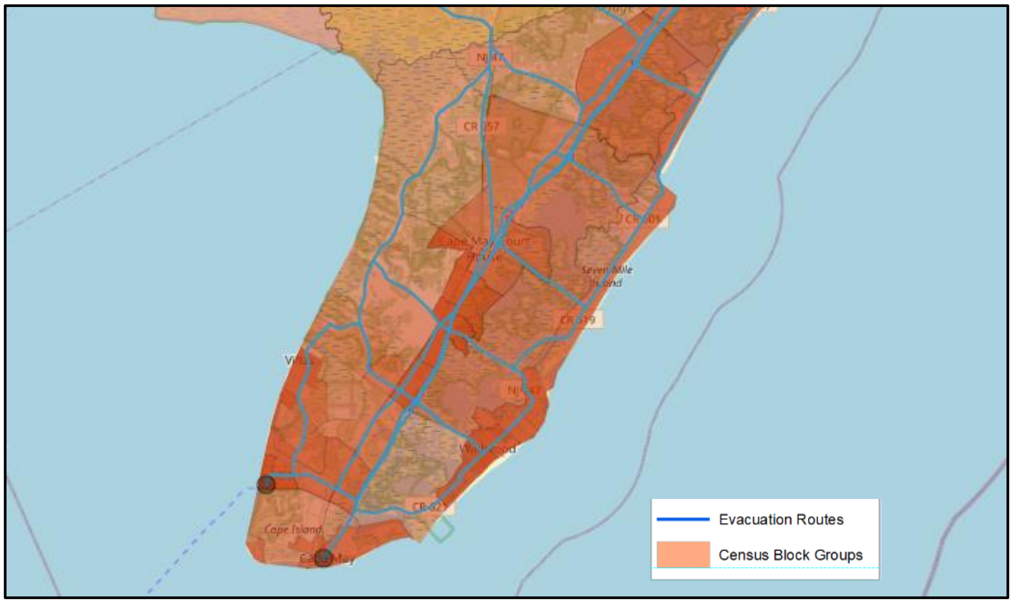


Figure 5-1 Example of US Census Block Group Boundaries in RtePM (Cape May County)

Population projections were developed using the 2015 and 2020 traffic analysis zone (TAZ) population data from the metropolitan planning organizations. The projections were adjusted to reflect 2020 population estimates available from the North Jersey Transportation Planning Authority[15] (NJTPA, 2017), South Jersey Transportation Planning Organization[16] (SJTPO, 2016), and the Delaware Valley Regional Planning Commission[17] (DVRPC, 2017). After the 2020 population projections were developed for each census block group, a GIS spatial analysis was conducted to determine the population within the evacuation zones.

For evacuation modeling purposes, the seasonal population was incorporated into the model via two methods:

- The “Seasonal Population” feature in RtePM was used to capture the *tourist population* at hotels, motels, and campgrounds (discussed in detail in Section 5.3.4).
- *Seasonally Occupied Residential Units,* which typically represent second/vacation homes, were incorporated into the total projected 2020 population and were based on the latest five-year (2013–2017) American Community Survey (ACS) estimates for NJ from the US Census website. The total 2020 population in RtePM was adjusted to include the population from seasonally occupied residential units. This allowed for a better spatial distribution of population throughout individual census block groups, rather than a single point of seasonal population, which was employed for tourist populations.

[15] North Jersey Transportation Planning Authority (NJTPA), November 2017. “Current NJTPA Board approved Municipal Forecasts and Socioeconomic data by TAZ/MCD.” https://www.njtpa.org/Data-Maps/Demographics-GIS/Forecasts.aspx
[16] South Jersey Transportation Planning Organization (SJTPO), July 2016. “2016 Update to the Regional Transportation Plan, Appendix C1, 2010-2040 Demographic Projections Methodology Report.” https://www.sjtpo.org/wp-content/uploads/2021/01/Transportation-Matters-Appendices.pdf
[17] Delaware Valley Regional Planning Commission (DVRPC), December 2017. “Connections 2045 Plan for Greater Philadelphia.” https://www.dvrpc.org/Reports/17039.pdf

In RtePM, an evacuation zone shape is uploaded, which may not accurately capture the population within the evacuation zone and census block group (i.e., water or wetland areas). Therefore, the study team conducted additional GIS spatial analysis within RtePM and applied a *percent population change* to capture an accurate 2020 population estimate. **Table 5-1** summarizes the 2020 population by county and evacuation zone grouping alphabetically. Section 2.0 discussed the evacuation zones and why the evacuation zones needed to be grouped for a consistent, regional approach to transportation modeling.

Table 5-1 Population per Evacuation Zone by Region

Region	County	Evacuation Zones and Zone Grouping in RtePM	Correlated to Storm Surge Inundation Area or Inland	2020 Population
Northern Counties	Bergen	A	Category 2	53,596
		B1, C	Category 1	87,842
		B2, D, E2, F, E1	Inland	798,147
			Total	**939,585**
	Essex	A, B	Category 1	78,253
		C, D, E, G, F	Inland	724,645
			Total	**802,897**
	Hudson	A, B, C	Category 1	210,512
		D	Category 2	34,798
		E	Category 3	25,806
		F, G	Category 4	411,114
			Total	**682,229**
	Mercer	A	Category 4	1,034
		B	Category 2	17,605
		C, D, E, F, G	Inland	360,449
			Total	**379,088**
	Middlesex	A, B1, B2, C1, D1	Category 1	183,591
		C2, G1	Category 2	96,497
		D2, F1, G3, F2, G2	Inland	484,757
		E	Category 2	83,224
			Total	**848,068**
	Monmouth	A	Category 1	53,912
		B	Category 2	41,751
		C	Category 3	40,582
		D	Category 4	42,134
		E, F	Inland	475,050
			Total	**653,430**
	Passaic	A1, A2	Category 1	14,350
		B, C, D, E, F, G	Inland	502,324
			Total	**516,674**

Region	County	Evacuation Zones and Zone Grouping in RtePM	Correlated to Storm Surge Inundation Area or Inland	2020 Population
Northern Counties	Somerset	A1	Category 3	77,619
		A2, B, C, D	Inland	258,530
			Total	**336,148**
	Union	A, B	Category 1	78,058
		C	Category 3	212,030
		D, E, F, G	Inland	268,748
			Total	**558,836**
Southern Counties	Atlantic	A	Category 1	13,655
		B, C2	Category 1	89,515
		C1	Category 3	2,548
		D	Category 1	127,478
		E	Category 3	34,355
		F	Category 3	36,893
			Total	**304,444**
	Burlington	A	Category 1	2,272
		B	Category 1	37,472
		C, D, E	Category 3	46,592
		G, F	Inland	373,933
			Total	**460,269**
	Camden	A, B1, B2, C1, C2, C3	Category 1	63,902
		D1, D2, D3, D4, D5	Category 2	172,490
		E, F	Inland	278,934
			Total	**515,326**
	Cape May	A	Category 1	55,963
		B	Category 1	62,848
		C	Category 2	1,986
			Total	**120,797**
	Cumberland	A	Category 1	20,792
		B, C	Inland	142,470
			Total	**163,262**
	Gloucester	A, B	Category 1	35,810
		C, D	Category 3	196,578
		E	Inland	75,624
			Total	**308,012**
	Ocean	A1, A2, A3, A4, A5, A6, A7	Category 1	133,730
		B1, C1, C4, C5	Category 1	29,797
		B2, B3, C2, C3	Category 2	162,061

Region	County	Evacuation Zones and Zone Grouping in RtePM	Correlated to Storm Surge Inundation Area or Inland	2020 Population
Southern Counties		D, E	Inland	309,394
			Total	**634,982**
	Salem	A	Category 1	37,881
		B	Category 1	13,806
		C	Inland	14,037
			Total	**65,724**

In addition, the study team reviewed the impact of the NYC population from the 2015 NYSNYCHES, which used 2010 US Census data. For NJHES Re-Study, the study team conducted a similar analysis using census block groups to project the NYC 2020 population based on the NYC 2010-2040 Population Projections[18]. This analysis did not reflect the 2020 US Census survey, which was being conducted at the time of the NJHES Re-Study transportation modeling.

The focus of this NJHES Re-Study was primarily on NJ, but the population from NYC impacts the roadway network and traffic flow into NJ on a normal daily basis and during an evacuation. For this study, only the permanent, non-seasonal population within the NYC evacuation zones was considered. **Table 5-2** compares the 2010 to 2020 NYC population within the NYC evacuation zones. There were more than 5 million additional people located in non-surge or inland areas of NYC that were not included in this summary, as the focus was directly on those that were impacted by a possible evacuation order and would travel to NJ. As discussed in Section 2.3, evacuation zones from NYC were used to define the areas that were evacuating and to calculate the evacuating population.

[18] NYC Department of City Planning, December 2013. "New York City Population Projections by Age/Sex & Borough, 2010-2040." https://www1.nyc.gov/assets/planning/download/pdf/planning-level/nyc-population/projections_report_2010_2040.pdf.

Table 5-2 Population in NYC Evacuation Zones

NYC Evacuation Zone	Correlated to Hurricane Intensity for NJHES Re-Study	2010 Population (from 2015 NYSNYCHES)	2020 Population (for NJHES Re-Study)
NYC Evacuation Zone 1 and 2	Category 1	622,236	727,524
NYC Evacuation Zone 3 and 4	Category 2	859,669	911,140
NYC Evacuation Zone 5	Category 3	764,684	801,564
NYC Evacuation Zone 6	Category 4	768,973	793,978
	Total	**3,015,562**	**3,234,206**

5.3 New Jersey Behavioral Assumptions

Section 3.0 and Section 4.0 described some of the inputs needed for a RtePM transportation model scenario: participation rates, response curves, public shelter usage rates, public shelter locations, and public shelter capacities. To leverage RtePM, additional modifications of the data were required to fit the functionality of the model, as described in the following subsections.

5.3.1 Participation Rates and Public Shelters

Section 3.0 describes the process and behavioral assumptions developed for the HES (including the transportation analysis). The evacuation participation rates (Section 3.2), and public shelter usage rates (Section 4.1) were used for the 17 counties within the study area. As discussed in Section 4.3, shelter capacities were adjusted if the shelter was impacted by storm surge inundation[19].

5.3.2 Background Traffic

Background traffic was a variable used in RtePM to simulate vehicles that were not actively participating in the evacuation but still remained present throughout the roadway network. For the NJHES Re-Study, the RtePM default for medium background traffic was used for the Category 1 and 2 hurricanes to include average background traffic for the area. Low background traffic was used for Category 3 and 4 hurricanes, assuming that fewer people would be going about their day-to-day activities and more people would be participating in the evacuation.

5.3.3 Vehicle Usage Rates and Vehicle Towing

RtePM utilizes the number of *people per vehicle* parameter to calculate the number of total vehicles evacuating. To calculate the number of people per vehicle in RtePM, the following inputs were used:

- Vehicle usage rates,

[19] The results of the Shelter Analysis showed that there was a potential for public shelter space deficits as the evacuating population increased and more individuals sought shelter. However, RtePM did not allow a simulation to run if there was insufficient shelter space. Therefore, "dummy" shelter locations near evacuation endpoints were created as overflow shelters for modeling purposes near the state boundary.

- Mean number of personal vehicles used per household during an evacuation, and
- Mean household size

Vehicle usage rates indicate the proportion of vehicles available to the evacuating household used in the evacuation, as reported in the 2017 NJ HEBS Report in **Table 5-3**.

Table 5-3 Vehicle Usage Rates by Region

Northern NJ Vehicle Usage Rates	Scenario			
Surge Zone	**Category 1 Hurricane**	**Category 2 Hurricane**	**Category 3 Hurricane**	**Category 4 Hurricane**
Category 1 Surge Zone	80%	80%	80%	80%
Category 2 Surge Zone	75%	75%	75%	75%
Category 3+4 Surge Zone	75%	75%	75%	75%
Inland of Surge	70%	70%	70%	70%

Southern NJ Vehicle Usage Rates	Scenario			
Surge Zone	**Category 1 Hurricane**	**Category 2 Hurricane**	**Category 3 Hurricane**	**Category 4 Hurricane**
Category 1 Surge Zone	80%	80%	80%	80%
Category 2 Surge Zone	75%	75%	75%	75%
Category 3+4 Surge Zone	75%	75%	75%	75%
Inland of Surge	70%	70%	70%	70%

The 2017 NJ HEBS Report provided a summary of the *average number of vehicles to be used* which indicated the average number of vehicles per household that were available and could be used during an evacuation (**Table 5-4**).

Table 5-4 Average Number of Vehicles per Households by Region

Region	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane	Inland Area
Northern Counties	1.50	1.41	1.51	1.51	1.43
Southern Counties	1.43	1.46	1.45	1.45	1.36

Using the 2013-2017 ACS census block group population data, the average household size was calculated for Northern NJ (2.85 persons per household) and Southern NJ (2.71 persons per household). Using the formula below, the *people per vehicle* was calculated, and the result, as shown in **Table 5-5**, was inputted in RtePM.

$$People\ per\ Vehicle = \frac{Average\ HH\ size}{Average\ Vehicle\ per\ HH * Vehicle\ Usage\ Rate}$$

Table 5-5 People per Vehicle by Region

Region	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane	Inland Area
Northern Counties	2.5	2.5	2.5	2.5	3.0
Southern Counties	2.5	2.5	2.5	2.5	3.0

The vehicle type and the percent of vehicles used during an evacuation was another input used in RtePM to calculate the total number of vehicles on the roadway network from each area. Based on the 2017 NJ HEBS Report, **Table 5-6** and **Table 5-7** show the percent of intended transport modes (private vehicle vs. public transit) by region. The percent of the population considered pedestrian during an evacuation was considered zero for all areas in NJ. Different vehicle usage assumptions were applied for NYC (Section 5.4.3).

Table 5-6 Percent Using Private Vehicle by Region

Region	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane	Inland Area
Northern Counties	96%	95%	99%	99%	97%
Southern Counties	100%	100%	97%	97%	98%

Table 5-7 Percent Using Public Transit by Region

Region	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane	Inland Area
Northern Counties	4%	5%	1%	1%	3%
Southern Counties	0%	0%	3%	3%	2%

RtePM has a feature to evaluate vehicle towing in the model. *Vehicle towing* indicates the percent of evacuating vehicles that tow motor homes or trailers as reported in the 2017 NJ HEBS Report. Vehicles which are towing can take up more road space, potentially affecting overall clearance times by creating congestion and slowing down evacuating traffic. **Table 5-8** shows vehicle towing values in the 2017 NJ HEBS Report.

Table 5-8 Vehicle Towing Percent by Region

Region	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane	Inland Area
Northern Counties	4%	5%	2%	2%	2%
Southern Counties	5%	8%	3%	3%	4%

5.3.4 Seasonal Population

Given the overlap of the high NJ tourist season with hurricane season, seasonal populations must be considered and included in evacuation scenario modeling. For evacuation modeling purposes, seasonal population included seasonal tourists staying at hotels, motels, and campgrounds and those that own vacation or seconds homes in the area and occupy them during the summer.

Seasonal Tourist Population

In RtePM, the "Seasonal Population" feature was used to capture the tourist population at hotels, motels, and campground locations, primarily focused along the shore. RtePM accounted for these populations through the placement of "point loads" that were assigned a value of population, then applied within an evacuation zone and a locality. The study team conducted outreach to several tourism bureaus within NJ to obtain seasonal population estimates but was not successful in obtaining information. Therefore, the study team searched through the state tourism website[20] and developed a database of the hotel, motel, and campground data for overnight tourists as of 2019. Tourist populations for Bergen, Essex, Hudson, Mercer, Middlesex, Passaic, Somerset, Union, Burlington, Camden, and Gloucester Counties were estimated by using the hotel, motel, campground data, and room counts.

Based on a report from the NJ Economic Development Authority Post-Hurricane Sandy tourism metrics,[21] the hotel occupancy rate varied between 60.8% to 68% from 2009 to 2013 during the high visitor season (June to August). The study team used 68% as the assumption for hotel occupancy, which appeared to be on the lower end for high tourist visitation during the summer holidays based on previous reports. The hotel occupancy rate did not account for the day-trippers who may drive from NYC or Philadelphia metropolitan areas to visit NJ coastal counties and not stay overnight. However, the study assumed that day trips were limited as visitors would not be driving to and from the coast on the day an evacuation would be ordered.

For Atlantic, Cape May, Cumberland, and Salem Counties, the tourist population was updated to reflect the 2020 seasonal population data from the South Jersey Transportation Planning Organization 2016 Regional Transportation Plan[22]. The seasonal population from this dataset was provided on a county-by-county basis. To distribute the population, a GIS spatial analysis was conducted using the density of hotels, motels, and campground locations. The inputs to RtePM represented the number of hotels, motels, and campground units or vehicles associated with the seasonal population. **Table 5-9** shows the tourist units calculated using the assumption of one vehicle per unit in RtePM.

The tourist destinations (and tourist behavior) in Monmouth and Ocean Counties were more similar to Atlantic County than to the other northern counties. Monmouth and Atlantic Counties were not part of the South Jersey Transportation Planning Organization and did not have detailed seasonal population estimates. In discussion with the Monmouth County Planning Department, the last study summarizing the summer coastal population in Monmouth County was conducted before November 2008[23] and used wastewater signals to estimate seasonal population trends. The range of seasonal population from the 2008 study was 74,072 to 112,026 overnight visitors for an average to a peak summer day, respectively. This data was outdated since the study was conducted

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[20] NJ Department of State, Division of Travel and Tourism. "https://www.visitnj.org/"
[21] MWW Group, December 2013. "Stronger than the Storm Recap Report." http://www.njeda.com/web/pdf/STTSReport.pdf, developed for New Jersey Economic Development Authority (NJEDA).
[22] South Jersey Transportation Planning Organization (SJTPO), July 2016. "2016 Update to the Regional Transportation Plan, Appendix C1, 2010-2040 Demographic Projections Methodology Report." https://www.sjtpo.org/wp-content/uploads/2021/01/Transportation-Matters-Appendices.pdf
[23] Monmouth County Planning Board, November 2008. "Monmouth County Summer Coastal Population Study." https://www.co.monmouth.nj.us/documents/24/Coastal%20Pop%20Study%20Report.pdf

in 2008 but provided a benchmark range of visitors to the county. Seasonal or tourist population data were not available for Ocean County either. Thus, the study team used detailed data for Atlantic County, the 2013-2017 ACS census block group data, and the locations of hotel, motel, and campground units and population for Monmouth and Ocean Counties. Seasonal tourist populations for Monmouth and Ocean Counties were estimated by using a ratio of Atlantic County seasonal tourist population to Atlantic City permanent population:

$$\frac{Atlantic\ County\ 2020\ Seasonal\ Population}{Atlantic\ County\ Permanent\ Population} = \frac{Ocean\ or\ Monmouth\ County\ 2020\ Seasonal\ Population}{Ocean\ or\ Monmouth\ County\ Permanent\ Population}$$

Table 5-9 Tourist Units (Hotels, Motels, Campgrounds) Used in RtePM by County

Region	County	Tourist Units
Northern Counties	Bergen	3,214
	Essex	2,062
	Hudson	3,274
	Mercer	0
	Middlesex	1,952
	Monmouth	76,359
	Passaic	157
	Somerset	242
	Union	1,855
Southern Counties	Atlantic	42,294
	Burlington	227
	Camden	1,307
	Cape May	71,463
	Cumberland	5,795
	Gloucester	605
	Ocean	72,562
	Salem	2,387

Seasonally Occupied Residential Units

Seasonally Occupied Residential Unit data representing second or vacation homes were available at a census block group resolution in the ACS population dataset. The seasonally occupied residential unit populations were included in the underlying RtePM population dataset to represent the spatial distribution of population more accurately across the census block group.

5.4 New York City Behavioral Assumptions

The behavioral assumptions for NYC included participation rates, evacuation response rates, and destination (i.e., those traveling to NJ) rates and were based on the 2015 NYSNYCHES. Given the scope of the NJHES Re-Study and the need to balance the total number of evacuation zone shapes inputted in RtePM, additional analyses were conducted for NYC, and several assumptions were required to characterize the NYC evacuation zones and population.

5.4.1 Participation and Destination Rates

Participation rates were developed to calculate the total evacuating population from NYC that would travel to NJ in RtePM. The population was correlated to the hurricane intensity based on the NYC evacuation zones. The 2015 NYSNYCHES assumed and reported the worst case 100% evacuation participation rate for each evacuation zone in addition to several hypothetical participation rates between 50% to 90%. Only a portion of those participating in an evacuation from NYC traveled out of the city and across bridges and tunnels to NJ. The destination rate for the population traveling to NJ ranged from 7% from the Bronx to 45% from Staten Island. Since the NYC evacuation zones were grouped in RtePM, an average of 22% was calculated across the boroughs and evacuating zones based on the maximum evacuating population.

Shadow evacuees are those that were not ordered to evacuate but leave because of a perceived threat. The 2015 NYS HES assumed a 1% shadow evacuation of other zones. **Table 5-10** shows the participation rates for NYC used in RtePM based on different hurricane intensities (Figure 2-7 shows the evacuation zones in NYC used in the NJHES Re-Study Transportation Analysis). Gray cells in Table 5-10 indicate shadow evacuees. **The following characterization was solely for alignment with the NJHES Re-Study and did not dictate any changes to the existing NYS/NYC HES. The 2015 NYSNYCHES was the primary source of evacuating information for NYS and NYC.**

Table 5-10 New York City Participation Rates (to NJ Only)

New York City Participation Rates	Hurricane Intensity			
NYC Evacuation Zone Groupings	Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Category 1 (NYC Evacuation Zone 1 and 2)	22%	22%	22%	22%
Category 2 (NYC Evacuation Zone 3 and 4)	1%	22%	22%	22%
Category 3 (NYC Evacuation Zone 5)	1%	1%	22%	22%
Category 4 (NYC Evacuation Zone 6)	1%	1%	1%	22%

Destination rates identify how many people evacuate to specific locations. As aforementioned, RtePM evaluated two types of destination rates: public shelter usage rates and endpoint assignment rates. For the NJHES Re-Study Transportation Analysis, it was assumed that evacuation scenarios with NYC evacuating populations traveled to NJ but did not use NJ shelters. It was also assumed that endpoint destination rates were dynamically calculated by RtePM during simulation runs.

5.4.2 Response Curves and Background Traffic

Response curves were used to determine the amount of time it takes evacuees to prepare to evacuate after an evacuation order was given. Response curves were reported in the New York State Hurricane Evacuation Study Technical Data Report for New York City, Nassau, Suffolk, and Westchester Counties. NYC had three curves: fast (or "rapid" of 3 hours), medium (6 hours), and slow (or "long" of 9 hours), as shown in **Figure 5-2**.

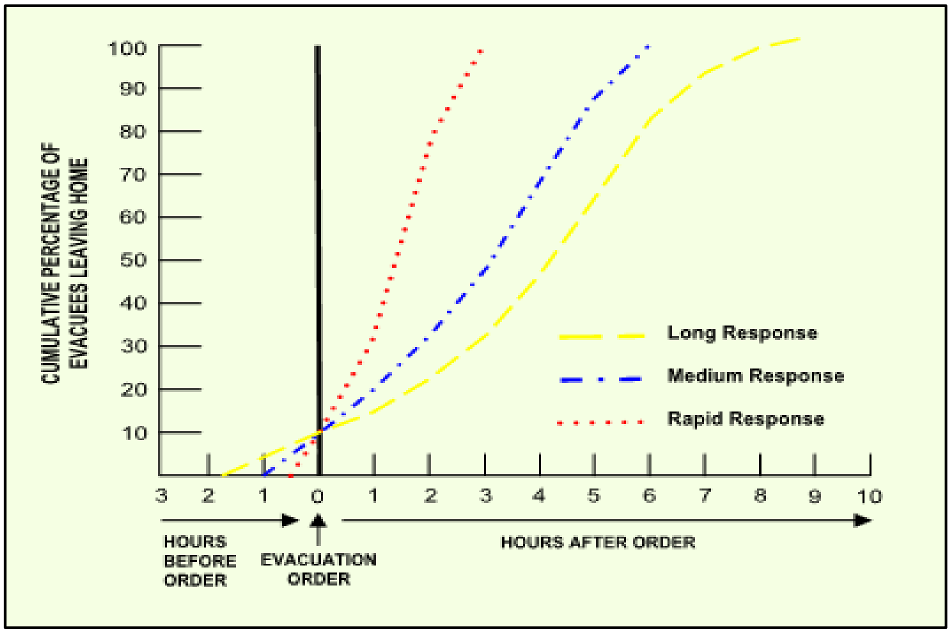

Figure 5-2 New York City Response Curves

For each evacuation scenario in RtePM, only one background traffic level can be selected for all of the evacuation zones. The background traffic used in the model for NYC was the same as the NJ scenarios, which was a medium background traffic curve for Category 1 and 2 storms, and a low background traffic curve for Category 3 and 4 storms (Section 5.3.2).

5.4.3 Vehicle Usage Rates

The type of transport mode used during evacuations is another factor utilized in RtePM for calculating the total evacuating population using private vehicles and the number of total vehicles on the network from each evacuation zone. The percentage of intended transport modes in NY was derived from the 2015 NYSNYCHES using tables reporting the maximum number of evacuating people, maximum number of evacuating vehicles, and maximum number of evacuating people using public transit. The maximum evacuating people using private vehicles was calculated by subtracting the total evacuating people from evacuating people using the train, the subway, or the bus. Since the NYC evacuation zones were grouped in RtePM, the calculation yielded an average of 60% private vehicles and 40% public transit.

RtePM also utilizes the *number of people per vehicle* parameter to calculate the number of total vehicles evacuating. The number of people per vehicle for NYC was derived from 2015 NYSNYCHES by using the total evacuating population and total evacuating vehicles.

$$Total\ Evacuating\ Population\ per\ Vehicle = \frac{Total\ Evacuating\ Population}{Total\ Evacuating\ Vehicles}$$

Based on the available data, the range across the NYC evacuation zones was calculated to be 3.0 to 3.5 people per vehicle.

CDM Smith

5.5 Evacuation Network

Identification of the evacuation network within RtePM was critical because it identified the roads that potential evacuees use for evacuation within the transportation model and was reflective of 2020 roadway conditions. The evacuation roadway network included designated evacuation routes and other roadways that support these routes and service all of the census block groups associated with the study area.

RtePM uses the HERE[24] transportation network data, which included highways, major arterials, minor arterials, and smaller roadways. RtePM provides the option of modifying existing roads and road networks and adding new roads when defining evacuation routes. This can be executed by identifying and editing *selected roads*, *evacuation endpoints*, *modified roads,* and other *additional roads*. These features are described below.

- **Selected Roads:** These are potential pathways out of an evacuation area. RtePM automatically selects the most efficient pathways from the evacuation area using the proprietary road network data. RtePM also allows for the designation of road classification to include in the selection process, including highways, major arterials, minor arterials, and other lower classified roadways.
- **Evacuation Endpoints:** These are the final destinations or the points from which evacuees leave the scenario to continue traveling to their final destinations. RtePM allows endpoints to be either active or inactive. Active endpoints are locations at the edge of the study area or other inland locations that users deemed to be reasonable destinations for evacuees to use for clearing the roadway network in the event of an evacuation order. Inactive endpoints are locations that may physically exist in the roadway network but may not be suitable evacuation destinations for a particular evacuation scenario.
- **Modified Roads:** RtePM allows users to select roadways that may be modified for road closures, contraflow, shoulder use, free-flow speed, or the number of lanes.
- **Additional Roads:** RtePM allows users to define additional roadways not included in the proprietary road network data.

Figure 5-3 illustrates designated evacuation routes within the study area provided by NJOEM. This did not include the necessary evacuation roadway network as shown or selected in RtePM; therefore, some roadways were added to the RtePM simulations to ensure public shelters were accessible and to allow census block groups to fully evacuate.

[24] HERE represents HERE Technologies (previously NAVTEQ, Inc.), a company that provides mapping, roadway networks, location data, and related services.

Figure 5-3 New Jersey Evacuation Routes

After the evacuation routes and the supporting roadway network were identified within RtePM, the network was upgraded to reflect 2020 conditions. The transportation improvement projects were identified and included in RtePM since they increased roadway capacity (e.g., new roadways, roadway widenings, new interstate ramps). Modified roads included the Route 66 Jumping Brook Road to Wayside Road widening of roadways[25], Interchange 109 improvements[24], and the third lane widening of the Atlantic City Expressway[26].

Figure 5-4 through **Figure 5-6** illustrate the evacuation roadway network identified for evacuation scenarios within RtePM. These figures are direct screenshots from the model interface and are better viewed in web format. The blue lines represent the evacuation roadway network. Roadway segments depicted in purple and surrounded by asterisks indicate roadways where construction projects were applied to upgrade to the study year (2020). Shaded polygons are census block groups.

Another critical step was identifying the location of the endpoints. Evacuation endpoints within RtePM are the locations where evacuees leave the evacuation network and head towards a point of safety. In the model, evacuees not traveling to public shelters evacuate to one of the active endpoints on the network. Figure 5-4 through Figure 5-6 show active evacuation endpoints were shown by yellow dots. Inactive evacuation endpoints were shown as gray dots and indicate that evacuees cannot use these points to leave the evacuation network. These figures show that flow was not permitted towards Cape May or Long Island. All traffic was directed towards the northern and western borders of NJ. The tourist population (assigned to point loads for hotels, motels, and campgrounds) is also shown on these figures.

[25] North Jersey Transportation Planning Authority (NJTPA) Online Transportation Information System (NOTIS), 2019. http://notis.njtpa.org/MapSearch.aspx

[26] Delaware Valley Regional Planning Commission (DVRPC) Transportation Improvement Program (TIP) , 2019. https://www.dvrpc.org/TIP/NJ/

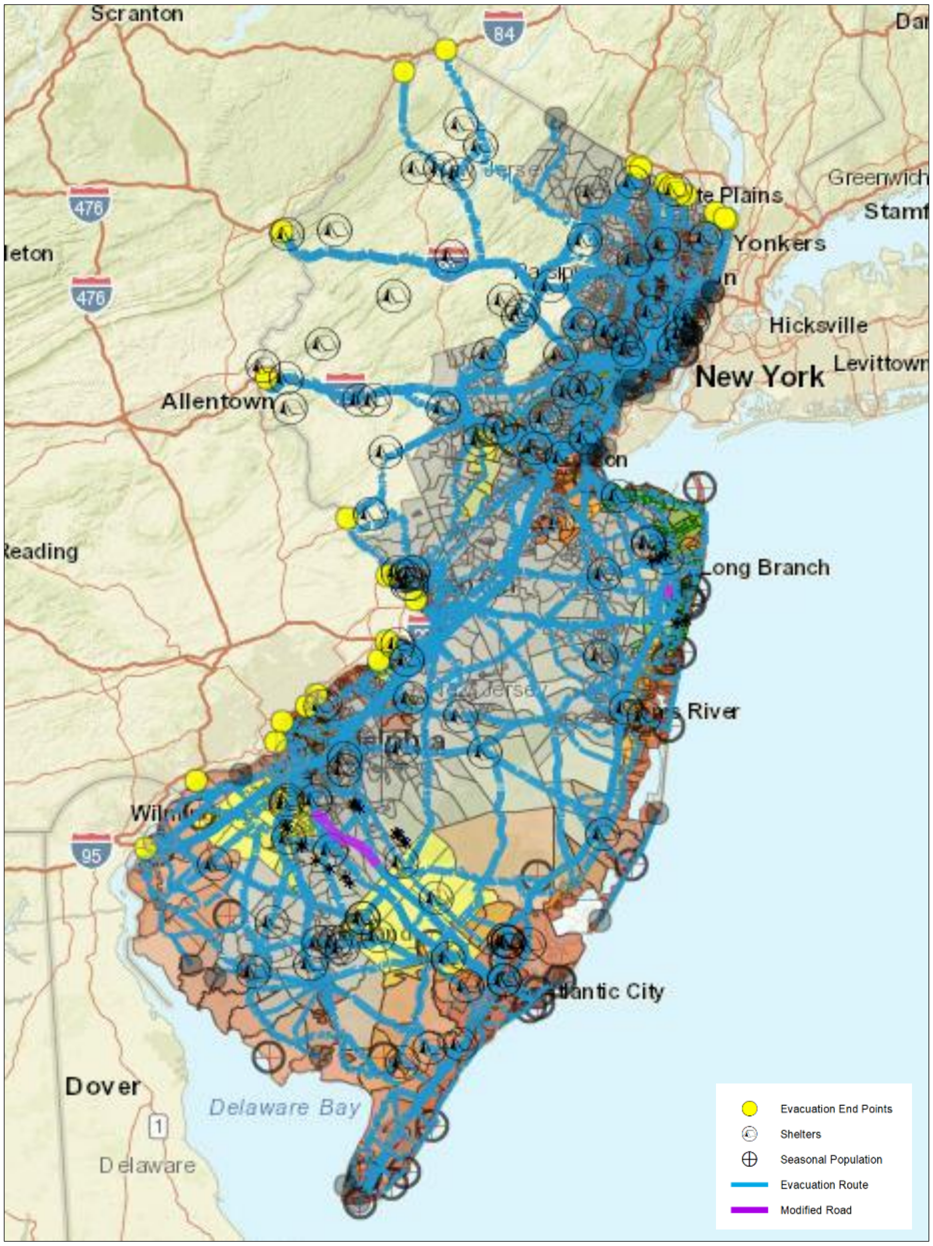

Figure 5-4 Evacuation Network Identified in RtePM

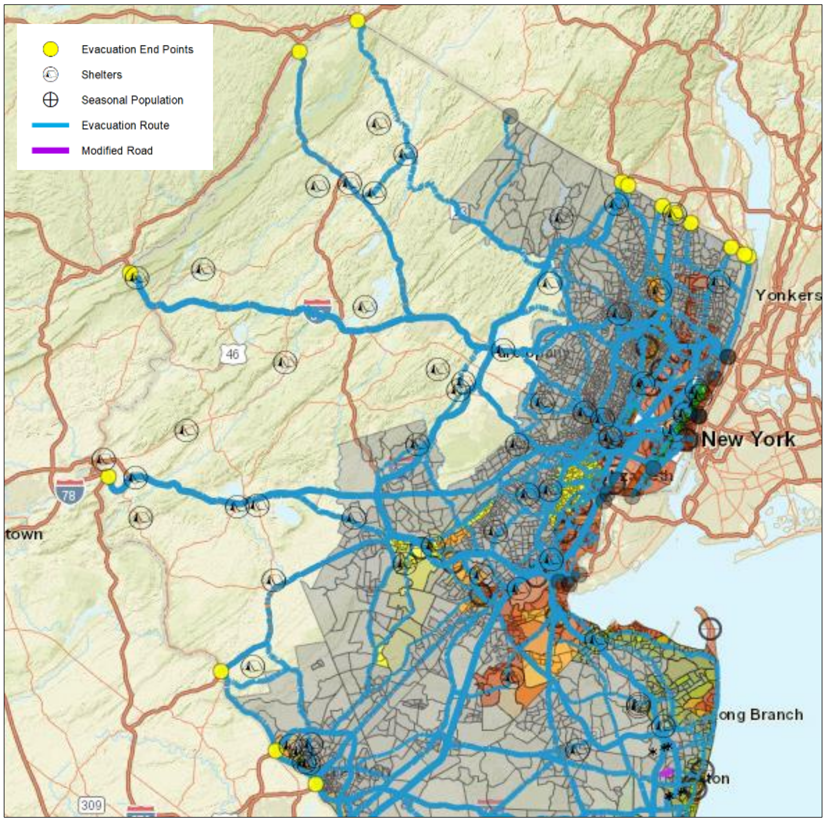

Figure 5-5 Evacuation Network Identified in RtePM (Northern Counties)

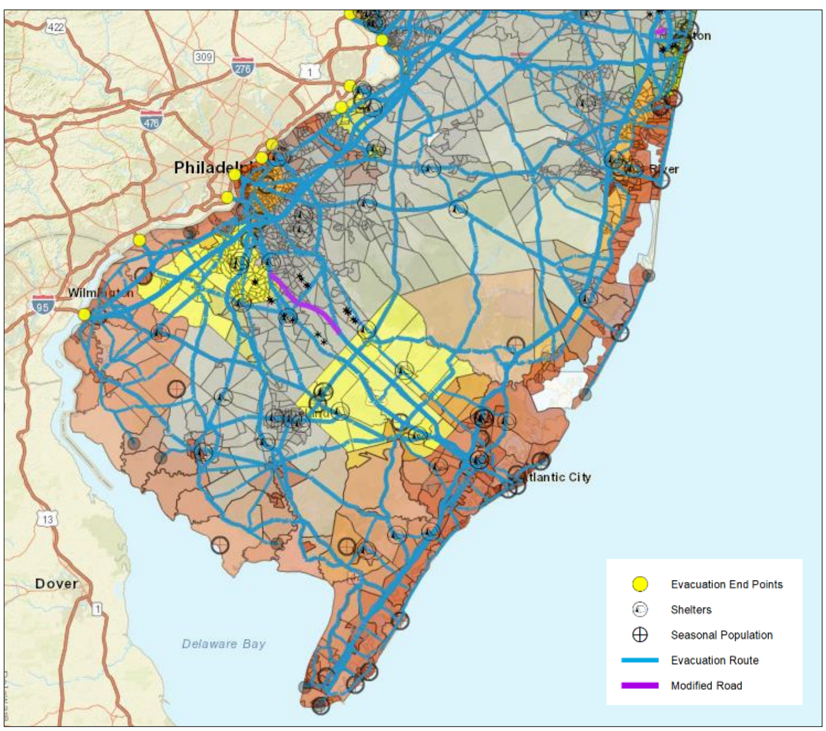

Figure 5-6 Evacuation Network Identified in RtePM (Southern Counties)

For modeled evacuation scenarios that included NYC evacuees, NYC evacuation routes were also added to RtePM, as shown in **Figure 5-7**. Evacuees from NYC were modeled to have two options: use the NYC endpoints to reach the boundary of Westchester County, NY or evacuate to NJ. For the NJHES Re-Study in RtePM, bridges and tunnels were limited to allow for travel from NYC to NJ only to minimize the number of evacuees that would go from NJ to the NYC endpoints.

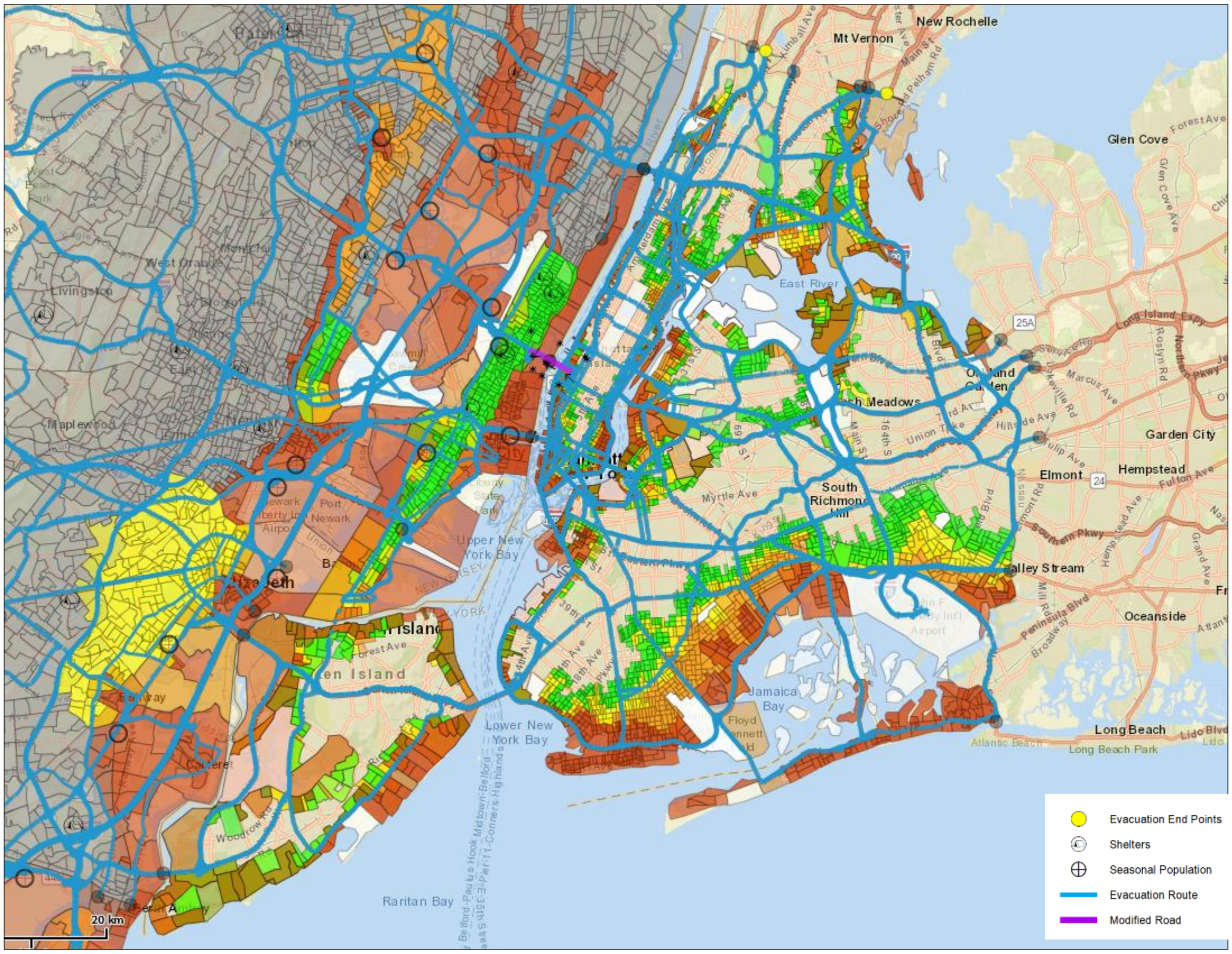

Figure 5-7 Evacuation Network Identified in RtePM for NYC

5.6 Contraflow Operations

To evaluate the impacts of contraflow (also referred to as lane reversal operations) during evacuations, the study team was provided a draft copy of the NJDOT contraflow plan and operational layout[27]. **Table 5-11** shows a summary of the contraflow plans in NJ that were incorporated into RtePM evacuation scenario simulations. RtePM allows the ability to assess contraflow operations within evacuation scenarios by specifying roadways with contraflow capability. Several other factors and road/ramp connections were added to assess evacuation

[27] Personal correspondence with NJDOT on draft contraflow operations. Received November 30, 2020.

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scenarios with contraflow operations, as described below. Contraflow operations were not incorporated for the NYC evacuation routes as part of the NJHES Re-Study.

Table 5-11 Contraflow Plans for the State of New Jersey

Route Name	Responsible Party	Specific Locations
Route 47/347	NJ Department of Transportation/NJ State Police	Milepost 16 to 21 in Dennis, and approximately milepost 32 to 35 in Maurice River. Milepost 0 in Dennis to about milepost 9 in Maurice River
Route 72	NJ Department of Transportation/ NJ State Police	Milepost 13.8 in Barnegat to approximately milepost 29 in Ship Bottom
I-195	NJ Department of Transportation/ NJ State Police	Milepost 6 in Robbinsville to about milepost 34 in Wall
Garden State Parkway	NJ Turnpike Authority	Milepost 0 in Lower Township to milepost 38 in Egg Harbor
Atlantic City Expressway	South Jersey Transportation Authority	The entire length from Atlantic City to Washington Township

Garden State Parkway contraflow operations were included in RtePM from Milepost 0 in Lower Township to Milepost 38 in Egg Harbor. **Figure 5-8** illustrates an example of contraflow operations for the Garden State Parkway. Several ramps in the roadway network were adjusted or reversed and some ramps were removed for the representation of contraflow in RtePM only.

The Atlantic City Expressway, Garden State Parkway, and the State Route 47/347 contraflow plans were leveraged to improve regional hurricane evacuation traffic flow and clearance times for the Southern NJ counties, specifically in Cape May, Atlantic, and Ocean Counties, due to high seasonal and tourist populations. The Route 72 contraflow plan was leveraged to improve clearance times for Ocean and Burlington Counties, and Long Beach Island. The I-195 contraflow plan was leveraged to improve clearance times for Monmouth and Ocean Counties. Since a portion of I-195 was located in Monmouth County, any transportation scenarios in the Northern NJ counties with contraflow included the I-195 plan only.

The study team used the contraflow plans to incorporate an accurate depiction of the roadway network in RtePM. Each contraflow plan provided detailed operational instructions and considerations for implementing contraflow, including timelines, resources, and decision actions. **Figure 5-9** shows the location and extent of the contraflow operations in **Table 5-11**.

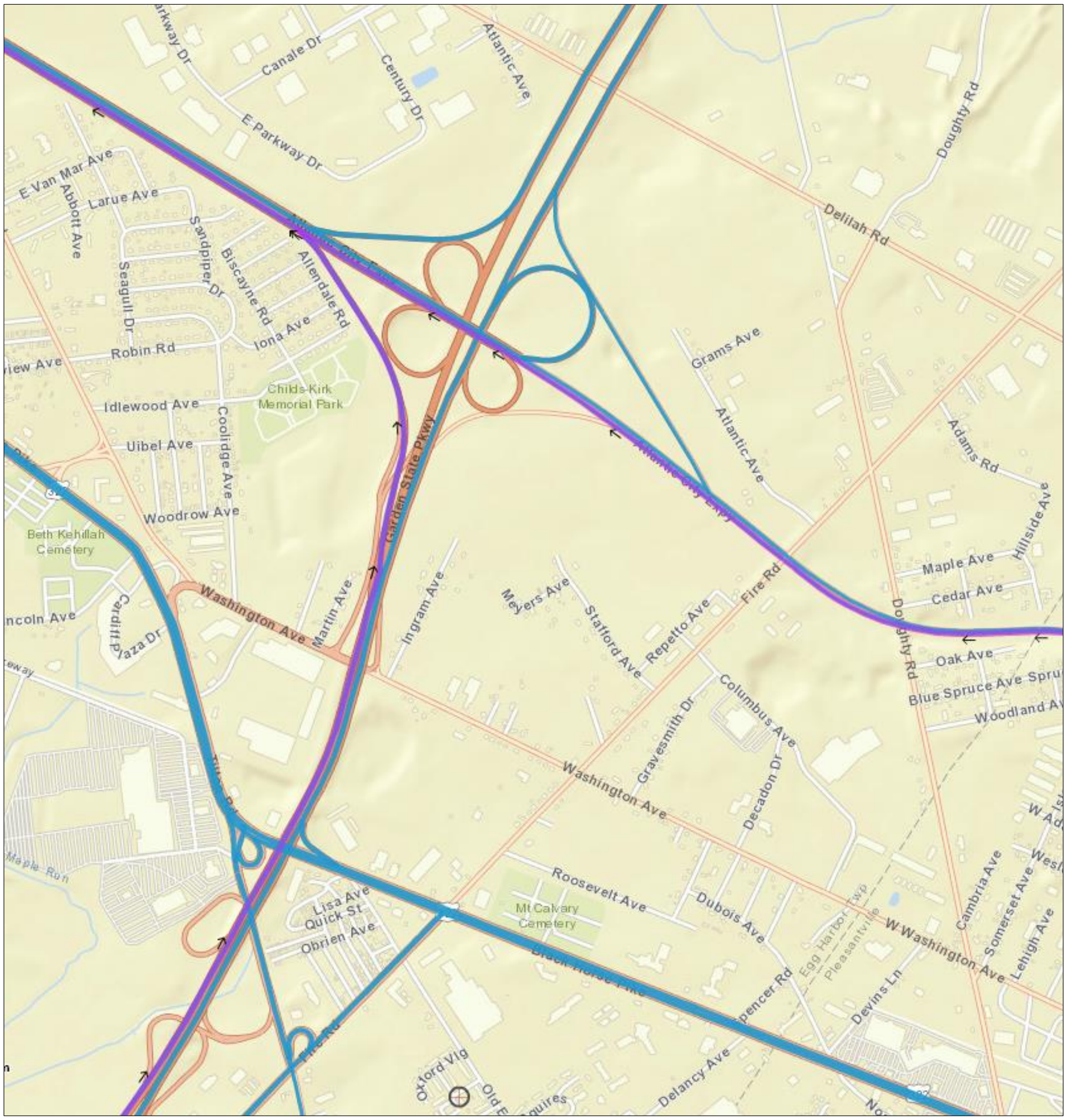

Figure 5-8 Contraflow Configuration Example for the Garden State Parkway in RtePM

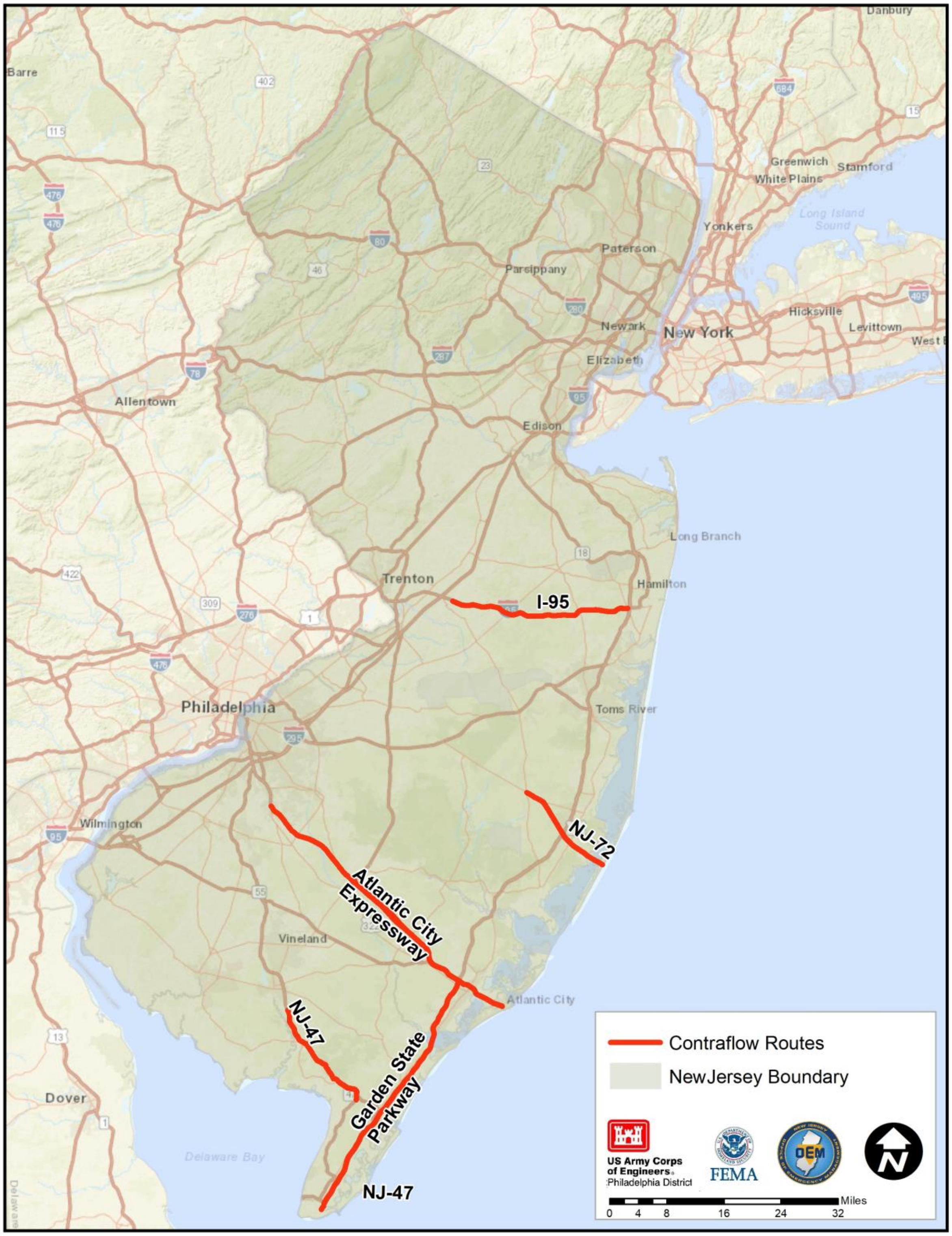

Figure 5-9 New Jersey Contraflow Routes

Draft contraflow operations plans were accompanied by a contraflow activation decision support matrix (**Figure 5-10**), which assists state, county, and local officials in formulating when a contraflow plan is recommended. Ultimately, the Governor of NJ, based on recommendations by the NJOEM State Director, will decide when to implement a contraflow strategy. There are four equally weighted factors listed below (hurricane intensity, storm track, population density, background conditions) that are assigned factor scores (ranges from 1 to 5). As stated in the decision matrix, contraflow plan activation is recommended if the total score of these factors was between 13 to 17, and activation is considered if the total score of these factors was between 9 to 12. Note that the contraflow matrix includes Category 5 hurricanes, but the NJHES Re-Study focuses on storms up to Category 4[28].

Contraflow Activation Decision Support Matrix

Storm Intensity		Storm Track		Population Density		Background Conditions	
Hurricane Category	Factor		Factor		Factor	Astronomical Tides/ Incipient Flooding	Factor
Category 1	1	*Landfall North of Ocean County*	1	***Low Tourist*** *Nov-March*	1	*Low Tides Low Flooding*	1
Category 2	2	*Parallel Track*	2	***Low Tourist*** *Sept-Oct, April-May*	2	*Medium Tides Medium Flooding*	2
Category 3	3	*Delaware Bay Exiting in Region*	3	***High Tourist*** *June*	3	*High Tides High Flooding*	3
Category 4	4	*Direct Strike*	4	***High Tourist*** *July-August*	4		
Category 5	5			*Holiday Special Event*	5		

Subtotals= [ ] + [ ] + [ ] + [ ]

= [ ]

Score	Activation Recommendation
4 to 8	No generally recommended
9 to 12	Activation may be considered
13 to 17	Activation recommended

Figure 5-10 Contraflow Activation Decision Support Matrix

[28] NHC modeling in the northeast portion of the U.S. considers Category 4 hurricanes as the worst-case. This is based on statistical analysis of historical storms.

Using the contraflow activation decision support matrix, there were 300 potential combinations with the sum of the individual scores that range between 4 to 17. The contraflow decision support matrix was filtered for scores with potential combinations greater than 13 where activation was recommended. **Table 5-12** lists the combinations, associated factors, and sorted scores in descending order.

The decision matrix demonstrates that there is only one combination of factors where a contraflow activation could be required for a Category 1 hurricane. Section 6.7 discusses evacuation scenario results with contraflow.

Table 5-12 Summary of Contraflow Decision Matrix Scores

Hurricane Intensity	Hurricane Intensity Factor	Storm Track	Storm Track Score	Population Density	Pop. Dens Score	Background Conditions	Background Score	Total Score
Category 5	5	Direct Strike	4	Holiday Special Event	5	High Tide	3	**17**
Category 5	5	Direct Strike	4	High Tourist July August	4	High Tide	3	**16**
Category 5	5	Direct Strike	4	Holiday Special Event	5	Medium Tide	2	**16**
Category 5	5	Delaware Bay Exiting in Region	3	Holiday Special Event	5	High Tide	3	**16**
Category 4	4	Direct Strike	4	Holiday Special Event	5	High Tide	3	**16**
Category 5	5	Direct Strike	4	High Tourist July August	4	Medium Tide	2	**15**
Category 5	5	Delaware Bay Exiting in Region	3	High Tourist July August	4	High Tide	3	**15**
Category 5	5	Direct Strike	4	High Tourist June	3	High Tide	3	**15**
Category 5	5	Direct Strike	4	Holiday Special Event	5	Low Tide	1	**15**
Category 5	5	Delaware Bay Exiting in Region	3	Holiday Special Event	5	Medium Tide	2	**15**
Category 5	5	Parallel Track	2	Holiday Special Event	5	High Tide	3	**15**
Category 4	4	Direct Strike	4	High Tourist July August	4	High Tide	3	**15**
Category 4	4	Direct Strike	4	Holiday Special Event	5	Medium Tide	2	**15**
Category 4	4	Delaware Bay Exiting in Region	3	Holiday Special Event	5	High Tide	3	**15**
Category 3	3	Direct Strike	4	Holiday Special Event	5	High Tide	3	**15**
Category 5	5	Direct Strike	4	High Tourist July August	4	Low Tide	1	**14**
Category 5	5	Delaware Bay Exiting in Region	3	High Tourist July August	4	Medium Tide	2	**14**
Category 5	5	Parallel Track	2	High Tourist July August	4	High Tide	3	**14**
Category 5	5	Direct Strike	4	High Tourist June	3	Medium Tide	2	**14**

Hurricane Intensity	Hurricane Intensity Factor	Storm Track	Storm Track Score	Population Density	Pop. Dens Score	Background Conditions	Background Score	Total Score
Category 5	5	Delaware Bay Exiting in Region	3	High Tourist June	3	High Tide	3	**14**
Category 5	5	Delaware Bay Exiting in Region	3	Holiday Special Event	5	Low Tide	1	**14**
Category 5	5	Parallel Track	2	Holiday Special Event	5	Medium Tide	2	**14**
Category 5	5	Landfall North of Ocean County	1	Holiday Special Event	5	High Tide	3	**14**
Category 4	4	Direct Strike	4	High Tourist July August	4	Medium Tide	2	**14**
Category 4	4	Delaware Bay Exiting in Region	3	High Tourist July August	4	High Tide	3	**14**
Category 4	4	Direct Strike	4	High Tourist June	3	High Tide	3	**14**
Category 4	4	Direct Strike	4	Holiday Special Event	5	Low Tide	1	**14**
Category 4	4	Delaware Bay Exiting in Region	3	Holiday Special Event	5	Medium Tide	2	**14**
Category 4	4	Parallel Track	2	Holiday Special Event	5	High Tide	3	**14**
Category 3	3	Direct Strike	4	High Tourist July August	4	High Tide	3	**14**
Category 3	3	Direct Strike	4	Holiday Special Event	5	Medium Tide	2	**14**
Category 3	3	Delaware Bay Exiting in Region	3	Holiday Special Event	5	High Tide	3	**14**
Category 2	2	Direct Strike	4	Holiday Special Event	5	High Tide	3	**14**
Category 5	5	Delaware Bay Exiting in Region	3	High Tourist July August	4	Low Tide	1	**13**
Category 5	5	Parallel Track	2	High Tourist July August	4	Medium Tide	2	**13**
Category 5	5	Landfall North of Ocean County	1	High Tourist July August	4	High Tide	3	**13**
Category 5	5	Direct Strike	4	High Tourist June	3	Low Tide	1	**13**
Category 5	5	Delaware Bay Exiting in Region	3	High Tourist June	3	Medium Tide	2	**13**
Category 5	5	Parallel Track	2	High Tourist June	3	High Tide	3	**13**
Category 5	5	Parallel Track	2	Holiday Special Event	5	Low Tide	1	**13**
Category 5	5	Landfall North of Ocean County	1	Holiday Special Event	5	Medium Tide	2	**13**
Category 5	5	Direct Strike	4	Low Tourist Nov March	1	High Tide	3	**13**
Category 5	5	Direct Strike	4	Low Tourist Sept Oct, Apr May	2	Medium Tide	2	**13**

Hurricane Intensity	Hurricane Intensity Factor	Storm Track	Storm Track Score	Population Density	Pop. Dens Score	Background Conditions	Background Score	Total Score
Category 5	5	Delaware Bay Exiting in Region	3	Low Tourist Sept Oct, Apr May	2	High Tide	3	**13**
Category 4	4	Direct Strike	4	High Tourist July August	4	Low Tide	1	**13**
Category 4	4	Delaware Bay Exiting in Region	3	High Tourist July August	4	Medium Tide	2	**13**
Category 4	4	Parallel Track	2	High Tourist July August	4	High Tide	3	**13**
Category 4	4	Direct Strike	4	High Tourist June	3	Medium Tide	2	**13**
Category 4	4	Delaware Bay Exiting in Region	3	High Tourist June	3	High Tide	3	**13**
Category 4	4	Delaware Bay Exiting in Region	3	Holiday Special Event	5	Low Tide	1	**13**
Category 4	4	Parallel Track	2	Holiday Special Event	5	Medium Tide	2	**13**
Category 4	4	Landfall North of Ocean County	1	Holiday Special Event	5	High Tide	3	**13**
Category 4	4	Direct Strike	4	Low Tourist Sept Oct, Apr May	2	High Tide	3	13
Category 3	3	Direct Strike	4	High Tourist July August	4	Medium Tide	2	13
Category 3	3	Delaware Bay Exiting in Region	3	High Tourist July August	4	High Tide	3	13

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6.0 Transportation Analysis – Evacuation Scenarios and Clearance Times

This section discusses the evacuation scenario development, and a summary of the evacuation clearance times for the NJHES Re-Study. The primary results from RtePM are clearance times and overall evacuation flow analysis for each evacuation scenario.

6.1 Evacuation Scenarios

In total, 252 evacuation scenarios were completed for the NJHES Re-Study. Many additional tests, troubleshooting, and sensitivity scenarios were also simulated in RtePM[29]. Additional sensitivity scenarios, including simulations for every evacuation zone in each of the 17 counties, are documented in **Appendix E**.

Appendix D includes a summary of the evacuation scenarios and clearance time results. Section 6.5 is a summary of scenarios and discusses the general trends of the evacuation scenarios with supporting graphs. **A companion MS Excel workbook with the evacuation scenarios and clearance time results is also included for ease of reference, sorting, and filtering of clearance time results. The workbook was also used to help integrate evacuation scenarios and clearances times in HURREVAC.**

The evacuation scenarios were grouped as follows:

- 36 catastrophic (statewide) scenarios (Section 6.2)
- 144 northern counties (regional) scenarios (Section 6.3)
- 72 southern counties (regional) scenarios (Section 6.4)

In addition to the evacuation clearance time for each of the groupings, a congestion review was conducted to identify key roadway segments that experience congestion as well as intersections that could experience delays during an evacuation. RtePM provides speed and density information on a given road link to illustrate congestion. RtePM also identified intersections or interchanges that are impacted by delays. Although the graphics and tables in this summary report are static, RtePM is a web-based environment with dynamic zooming capabilities and a database of completed scenarios. Individual scenario files exported from RtePM can be uploaded and reviewed. For future transportation scenarios, it may be possible to use RtePM's scenario interface to upload an existing scenario and change the response curve or other parameters to determine a clearance time.

Evacuation scenarios in all three groupings used varying behavioral assumptions, except for the following (which were held constant for all evacuation scenarios):

---

[29] It should be noted that the scenarios did not directly consider the directionality of hurricane tracks or the duration of flooding over a given tide cycle.

- Percent population change
  - In RtePM, percent population change was associated with each evacuation zone as it uses the 2010 census block group data. The methodology for determining the total population is discussed in Section 5.2 for the 2020 population. The percent population change parameter in RtePM was adjusted to match the 2020 population totals. However, this population projection did not reflect the ongoing 2020 US Census Survey data, which was in the process of being collected and summarized at the time of the transportation modeling.
- People per vehicle
- Vehicle towing
- Shelter locations and shelter participation rates
- Percent of the population using a private vehicle, public transit, or as a pedestrian
- Response curve starting hour (i.e., the default was hour 8)
- Seasonal tourist population and seasonally occupied residential unit population

The variable parameters which were manipulated during RtePM simulations included:

- Areas outside of NJ (i.e., with or without NYC [evacuation zones in Section 2.3, behavioral assumptions in Section 5.4])
- Contraflow operation (Section 5.6)
- Medium surge zone (Med SZ), medium evacuation zone (Med EZ), and high evacuation zone (High EZ) evacuation participation rates (Section 3.2).
- Response curve (slow, medium, fast [Section 3.3])
- Background traffic (Section 5.3.2)
  - Medium background traffic for a Category 1 or 2 hurricane
  - Low background traffic for Category 3 or 4 hurricane
- Shelter capacity (Section 4.0)
  - Shelters were closed or considered non-functional if the building footprint was located within a storm surge inundation area.
  - "Dummy" shelter capacities were adjusted depending on the hurricane intensity and shelter demand. Otherwise, RtePM did not run the simulation.

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6.2 Catastrophic Scenarios

Catastrophic (CS) scenarios were statewide evacuation scenarios for the 17 NJ counties affected by coastal storm surge. **Table 6-1** is a graphical crosswalk that shows scenario assumptions, clearance times, and a summary of the regional evacuating population. These were scenarios where large populations were ordered to evacuate based on Category 4 storm surge inundation, as this presented the worst-case scenario inundation. Shadow evacuees accounted for the participation of the inland area population, as described in Section 3.2.1.

Several CS scenarios included NYC evacuees and contraflow operation activation for the Atlantic City Expressway, Garden State Parkway, State Route 47/347, State Route 72, and I-195. Participation rates and response curves varied across the different scenarios as shown in the crosswalk diagram. The purpose of developing these scenarios, which combined different variables, was to provide a spectrum approach – a range of possible inputs and outcomes – to capture potential evacuation clearance time. Some results may be considered improbable, or worst-case, which was why other variables reducing participation rate or vehicle load onto the roadway network were considered.

Appendix D includes a summary of the evacuation scenarios and clearance time results, including for the CS simulations. Section 6.5 provides a summary which discusses the general trends of the evacuation scenarios with supporting graphs. **A companion MS Excel workbook with the evacuation scenarios and clearance time results is also included for ease of reference, sorting, and filtering of clearance time results. The workbook was also used to help integrate evacuation scenarios and clearances times in HURREVAC.**

The assumptions (and column header descriptions) used for CS scenarios included:

- Scenario ID: catastrophic scenarios (CS)
- 17 NJ counties:
  - Northern counties (Bergen, Essex, Hudson, Mercer, Middlesex, Monmouth, Passaic, Somerset, Union)
  - Southern counties (Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Ocean, Salem)
- Medium surge zone (Med SZ), medium evacuation zone (Med EZ), and high evacuation zone (High EZ) participation rates.
- Category 4 hurricane intensity
  - Evacuation zones impacted by a Category 1 through Category 4 storm surge inundation are ordered to evacuate (Table 2-2). Inland shadow evacuees were included for NJ.
- Low background traffic as described in Section 5.3.2

- Slow (24 hours), medium (18 hours), or fast (12 hours) response curves[30]
- With or Without (W/O) NYC evacuees
  - NYC evacuees used the behavioral assumptions from the 2015 NYSNYCHES (Section 5.4)
- Contraflow operations (Yes/No) for contraflow plans are described in Section 5.6.

Table 6-1 Catastrophic Scenario Input Parameters and Clearance Times

Scenario Title	Participation Rate			Hurricane Intensity				Response Curve			New York City		Contraflow Operations		Background Traffic		Clearance Time (hr.) *	Evacuating Population	Evacuating Vehicles
	Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
CS-1																	34	1,469,540	736,363
CS-2																	39	2,162,088	1,013,923
CS-3																	51	4,054,960	1,771,061
CS-4																	40	1,469,540	736,363
CS-5																	45	2,162,088	1,013,923
CS-6																	59	4,054,960	1,771,061
CS-7																	34	1,894,708	864,914
CS-8																	40	2,587,256	1,142,474
CS-9																	51	4,480,128	1,899,612
CS-10																	38	1,894,708	864,914
CS-11																	45	2,587,256	1,142,474
CS-12																	59	4,480,128	1,899,612
CS-13																	33	1,469,540	736,363
CS-14																	37	2,162,088	1,013,923
CS-15																	50	4,054,960	1,771,061
CS-16																	41	1,469,540	736,363
CS-17																	46	2,162,088	1,013,923
CS-18																	58	4,054,960	1,771,061
CS-19																	33	1,894,708	864,914
CS-20																	38	2,587,256	1,142,474
CS-21																	51	4,480,128	1,899,612
CS-22																	41	1,894,708	864,914
CS-23																	46	2,587,256	1,142,474
CS-24																	58	4,480,128	1,899,612
CS-25																	31	1,469,540	736,363
CS-26																	37	2,162,088	1,013,923
CS-27																	49	4,054,960	1,771,061
CS-28																	41	1,469,540	736,363
CS-29																	45	2,162,088	1,013,923
CS-30																	57	4,054,960	1,771,061
CS-31																	31	1,894,708	864,914
CS-32																	38	2,587,256	1,142,474
CS-33																	51	4,480,128	1,899,612
CS-34																	41	1,894,708	864,914
CS-35																	45	2,587,256	1,142,474
CS-36																	58	4,480,128	1,899,612

* All clearance times were rounded to the nearest hour in the table above. Note: When RtePM did not evacuate all vehicles, an assumption of an additional hour was added to the clearance time for conservatism.

[30] Atlantic County Zone A has modified response curves due to the need to evacuate the barrier island population before the other evacuation zones. The team conducted a sensitivity analysis on response curve timing for Atlantic County Zone A and documented it in Appendix E.

The range in clearance times was 31 to 59 hours for the catastrophic scenarios. With over 4 million people evacuating, RtePM simulations resulted in evacuation clearance time of at least 49 hours when the high participation rate (100% population evacuating within an evacuation zone) was used. A comparison of the contraflow scenarios revealed an improvement of approximately 4-10 hours in evacuation clearance time (i.e., CS-7 vs. CS-10 and CS-31 vs. CS-34) contraflow operations were applied.

<u>Congestion Summary</u>

Visual inspection of the hour-by-hour RtePM results for each CS scenario was conducted. Congestion was observed at the following locations:

- Route 17 and Interstate 287 (I-287) intersection near state boundary at Mahwah Township, NJ,
- Garden State Parkway from US-46 near Clifton, NJ to the state boundary at Montvale, NJ,
- Garden State Parkway from Corlies Avenue (Route 33) near Tinton Falls, NJ to Route 440 near Keasbey, NJ,
- I-195 from Garden State Parkway to US-130 near Haines Corner at Hamilton Township, NJ,
- North-South Freeway (Route 42) from Black Horse Pike near Hilltop, NJ to I-76 at Fairview, NJ.
- Atlantic City Expressway from Berlin Gross Keys Road to East Black Horse Pike (Route 42) near Turnersville, NJ.
    - When contraflow was activated, the Atlantic City Expressway congestion shifted from Mays Landing Road (Route 73) near Winslow Township, NJ to East Black Horse Pike (Route 42). Some congestion was observed near the NJ Turnpike exit and I-295 at Carneys Point Township, NJ.

Figure 6-1 shows example screenshots of hour 1 and hour 36 from the RtePM result mode for CS-12 (i.e., a total evacuation clearance time of 59[31] hours. The figures show examples of where congestion was highlighted (in red) based on traffic speed reduction on roadways.

Figure 6-2 shows roads with the most frequent congestion (from visual inspection) in the CS scenarios. With high participation rates, congestion was identified at:

- I-280 and I-80 intersection near Troy Hills, NJ.
- I-78 from I-287 to West Main Street at Clinton Town, NJ,
- I-287 from US-202 at Pluckemin, NJ to US-202 at Bridgewater, NJ,

[31] An hour was added since some of the vehicles did not clear the network in the simulation.

- I -295 in Ewing Township, NJ from Scotch Road to River Road,
- I -95 and NJ Turnpike intersection around Sharp Road at Mansfield Township, NJ,
- Route 55 at Deptford Township, NJ from North-South Freeway (Route 42) to Delsea Drive (Route 47),
- Atlantic City Expressway from Wrangleboro Road near McKee City, NJ to Laurel Dale (Route 50) near West Egg Harbor, NJ,
- NJ Turnpike from Swedesboro Road (US-322) at Woolwich Township, NJ to I-295 at Carneys Point Township, NJ,

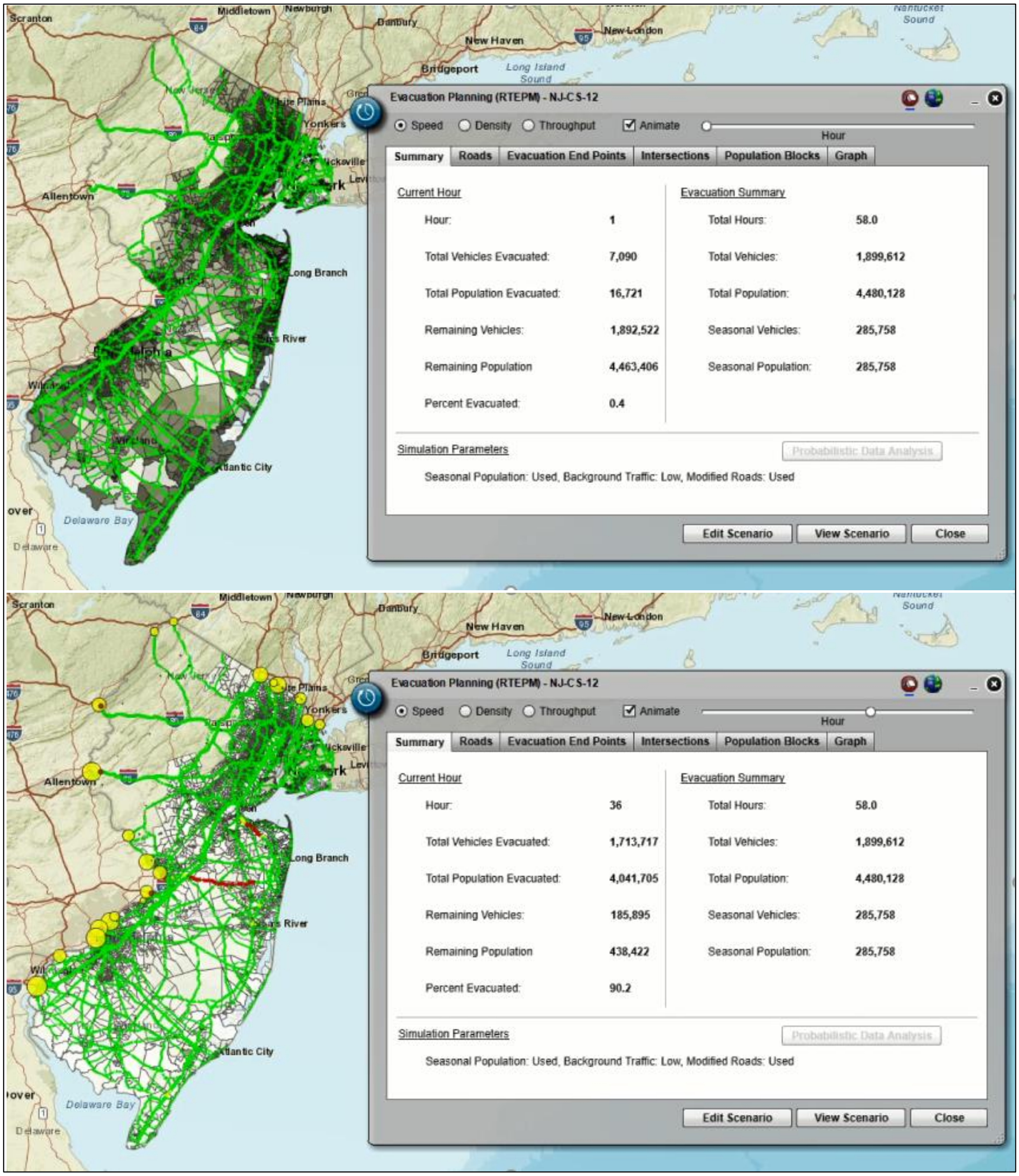

Figure 6-1 RtePM Screenshot for CS-12 (Top: Hour 1, Bottom: Hour 36. Clearance Time: 59 hours)

Figure 6-2 Catastrophic Scenarios - Congested Routes

6.3 Northern Counties Scenarios

In total, 144 scenarios were simulated in RtePM for the northern counties. Northern counties (NC) scenarios were regional scenarios where each evacuation scenario included the nine Northern NJ counties (Bergen, Essex, Hudson, Mercer, Middlesex, Monmouth, Passaic, Somerset, and Union). **Table 6-2** is a graphical crosswalk that shows scenario assumptions, clearance times, and a summary of the regional evacuating population. Several scenarios included NYC and I-195 contraflow operations.

Appendix D includes a summary of the evacuation scenarios and clearance time results, including for the NC simulations. Section 6.5 is a summary of scenarios and discusses the general trends of the evacuation scenarios with supporting graphs. **A companion MS Excel workbook with the evacuation scenarios and clearance time results is also included for ease of reference, sorting, and filtering of clearance time results. The workbook was also used to help integrate evacuation scenarios and clearances times in HURREVAC.**

The assumptions (and column header descriptions) used for the NC scenarios included:

- Scenario ID: northern counties scenarios (NC)
- Northern counties (Bergen, Essex, Hudson, Mercer, Middlesex, Monmouth, Passaic, Somerset, Union)
- Medium surge zone (Med SZ), medium evacuation zone (Med EZ), and high evacuation zone (High EZ) participation rates
- Hurricane intensity (i.e., Category 1, 2, 3, or 4)
  - Evacuation zones, which correspond to the hurricane intensity storm surge inundation areas (Table 2-2), were ordered to evacuate. Inland shadow evacuees were included for NJ.
- Low or medium background traffic as described in Section 5.3.2
- Slow (24 hours), medium (18 hours), or fast (12 hours) response curves
- With or Without (W/O) NYC evacuees
  - NYC evacuees used the behavioral assumptions from the 2015 NYSNYCHES (Section 5.4)
  - Section 6.6 discusses observations and sensitivity run results from NYC evacuees.
- Contraflow operations (Yes/No)
  - The I-195 contraflow plan was applied for the northern counties scenarios. The other contraflow plans were located in the southern counties.

Table 6-2 Northern Counties Scenarios Input Parameters and Clearance Times

Scenario Title	Participation Rate			Hurricane Intensity				Response Curve			New York City		Contraflow Operations		Background Traffic		Clearance Time (hr.) *	Evacuating Population	Evacuating Vehicles
	Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
NC-1	X			X				X				X	X			X	27	319,317	177,204
NC-2		X		X				X				X	X			X	27	464,322	235,225
NC-3			X	X				X				X	X			X	26^	1,026,247	459,977
NC-4	X				X			X				X	X			X	27	528,008	253,203
NC-5		X			X			X				X	X			X	28	717,700	329,066
NC-6			X		X			X				X	X			X	31	1,500,109	642,029
NC-7	X					X		X				X	X		X		28	637,197	296,375
NC-8		X				X		X				X	X		X		27	945,029	420,016
NC-9			X			X		X				X	X		X		39	2,250,130	942,057
NC-10	X						X	X				X	X		X		27	767,399	343,386
NC-11		X					X	X				X	X		X		27	1,074,936	466,953
NC-12			X				X	X				X	X		X		40	2,325,382	967,117
NC-13	X			X				X				X		X		X	27	319,317	177,204
NC-14		X		X				X				X		X		X	27	464,322	235,225
NC-15			X	X				X				X		X		X	27	1,026,247	459,977
NC-16	X				X			X				X		X		X	27	528,008	253,203
NC-17		X			X			X				X		X		X	28	717,700	329,066
NC-18			X		X			X				X		X		X	31	1,500,109	642,029
NC-19	X					X		X				X		X	X		28	637,197	296,375
NC-20		X				X		X				X		X	X		27	945,029	420,016
NC-21			X			X		X				X		X	X		40	2,250,130	942,057
NC-22	X						X	X				X		X	X		27	767,399	343,386
NC-23		X					X	X				X		X	X		27	1,074,936	466,953
NC-24			X				X	X				X		X	X		39	2,325,382	967,117
NC-25	X			X				X			X		X			X	27	428,342	213,484
NC-26		X		X				X			X		X			X	27	573,347	271,505
NC-27			X	X				X			X		X			X	27	1,135,272	496,257
NC-28	X				X			X			X		X			X	27	751,958	327,808
NC-29		X			X			X			X		X			X	27	941,650	403,671
NC-30			X		X			X			X		X			X	30	1,724,059	716,634
NC-31	X					X		X			X		X		X		27	962,078	399,837
NC-32		X				X		X			X		X		X		27	1,269,910	523,478
NC-33			X			X		X			X		X		X		40	2,575,011	1,045,519
NC-34	X						X	X			X		X		X		27	1,192,567	471,937
NC-35		X					X	X			X		X		X		27	1,500,104	595,504
NC-36			X				X	X			X		X		X		41	2,750,550	1,095,668
NC-37	X			X				X			X			X		X	27	428,342	213,484
NC-38		X		X				X			X			X		X	27	573,347	271,505
NC-39			X	X				X			X			X		X	27	1,135,272	496,257
NC-40	X				X			X			X			X		X	27	751,958	327,808
NC-41		X			X			X			X			X		X	28	941,650	403,671
NC-42			X		X			X			X			X		X	30	1,724,059	716,634
NC-43	X					X		X			X			X	X		27	962,078	399,837
NC-44		X				X		X			X			X	X		27	1,269,910	523,478
NC-45			X			X		X			X			X	X		40	2,575,011	1,045,519
NC-46	X						X	X			X			X	X		27	1,192,567	471,937
NC-47		X					X	X			X			X	X		27	1,500,104	595,504
NC-48			X				X	X			X			X	X		41	2,750,550	1,095,668

* All clearance times were rounded to the nearest hour in the table above. Note: When RtePM did not evacuate all vehicles, an assumption of an additional hour was added to the clearance time for conservatism.

^The RtePM scenario ended prematurely for NC-3 and yielded a result of 25 hours and 98.7% of the population evacuated. Other NC scenarios which ended prematurely did so with 99.1 to 99.8% of the population evacuated. A consistent rule was applied – only one hour was added to the reported clearance time for scenarios that ended prematurely.

Scenario Title	Participation Rate			Hurricane Intensity				Response Curve			New York City		Contraflow Operations		Background Traffic		Clearance Time (hr.) *	Evacuating Population	Evacuating Vehicles
	Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
NC-49	X			X					X			X	X			X	21	319,317	177,204
NC-50		X		X					X			X	X			X	21	464,322	235,225
NC-51			X	X					X			X	X			X	25	1,026,247	459,977
NC-52	X				X				X			X	X			X	21	528,008	253,203
NC-53		X			X				X			X	X			X	22	717,700	329,066
NC-54			X		X				X			X	X			X	32	1,500,109	642,029
NC-55	X					X			X			X	X		X		22	637,197	296,375
NC-56		X				X			X			X	X		X		22	945,029	420,016
NC-57			X			X			X			X	X		X		39	2,250,130	942,057
NC-58	X						X		X			X	X		X		21	767,399	343,386
NC-59		X					X		X			X	X		X		24	1,074,936	466,953
NC-60			X				X		X			X	X		X		39	2,325,382	967,117
NC-61	X			X					X			X		X		X	21	319,317	177,204
NC-62		X		X					X			X		X		X	21	464,322	235,225
NC-63			X	X					X			X		X		X	24	1,026,247	459,977
NC-64	X				X				X			X		X		X	21	528,008	253,203
NC-65		X			X				X			X		X		X	21	717,700	329,066
NC-66			X		X				X			X		X		X	32	1,500,109	642,029
NC-67	X					X			X			X		X	X		22	637,197	296,375
NC-68		X				X			X			X		X	X		23	945,029	420,016
NC-69			X			X			X			X		X	X		39	2,250,130	942,057
NC-70	X						X		X			X		X	X		21	767,399	343,386
NC-71		X					X		X			X		X	X		25	1,074,936	466,953
NC-72			X				X		X			X		X	X		40	2,325,382	967,117
NC-73	X			X					X		X		X			X	21	428,342	213,484
NC-74		X		X					X		X		X			X	21	573,347	271,505
NC-75			X	X					X		X		X			X	24	1,135,272	496,257
NC-76	X				X				X		X		X			X	21	751,958	327,808
NC-77		X			X				X		X		X			X	21	941,650	403,671
NC-78			X		X				X		X		X			X	32	1,724,059	716,634
NC-79	X					X			X		X		X		X		21	962,078	399,837
NC-80		X				X			X		X		X		X		23	1,269,910	523,478
NC-81			X			X			X		X		X		X		39	2,575,011	1,045,519
NC-82	X						X		X		X		X		X		21	1,192,567	471,937
NC-83		X					X		X		X		X		X		26	1,500,104	595,504
NC-84			X				X		X		X		X		X		40	2,750,550	1,095,668
NC-85	X			X					X		X			X		X	21	428,342	213,484
NC-86		X		X					X		X			X		X	21	573,347	271,505
NC-87			X	X					X		X			X		X	24	1,135,272	496,257
NC-88	X				X				X		X			X		X	21	751,958	327,808
NC-89		X			X				X		X			X		X	21	941,650	403,671
NC-90			X		X				X		X			X		X	32	1,724,059	716,634
NC-91	X					X			X		X			X	X		21	962,078	399,837
NC-92		X				X			X		X			X	X		23	1,269,910	523,478
NC-93			X			X			X		X			X	X		39	2,575,011	1,045,519
NC-94	X						X		X		X			X	X		21	1,192,567	471,937
NC-95		X					X		X		X			X	X		26	1,500,104	595,504
NC-96			X				X		X		X			X	X		41	2,750,550	1,095,668

* All clearance times were rounded to the nearest hour in the table above. Note: When RtePM did not evacuate all vehicles, an assumption of an additional hour was added to the clearance time for conservatism.

Scenario Title	Participation Rate			Hurricane Intensity				Response Curve			New York City		Contraflow Operations		Background Traffic		Clearance Time (hr.) *	Evacuating Population	Evacuating Vehicles
	Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
NC-97	■			■						■		■	■			■	19	319,317	177,204
NC-98		■		■						■		■	■			■	19	464,322	235,225
NC-99			■	■						■		■	■			■	26	1,026,247	459,977
NC-100	■				■					■		■	■			■	19	528,008	253,203
NC-101		■			■					■		■	■			■	22	717,700	329,066
NC-102			■		■					■		■	■			■	31	1,500,109	642,029
NC-103	■					■				■		■	■		■		21	637,197	296,375
NC-104		■				■				■		■	■		■		25	945,029	420,016
NC-105			■			■				■		■	■		■		38	2,250,130	942,057
NC-106	■						■			■		■	■		■		22	767,399	343,386
NC-107		■					■			■		■	■		■		26	1,074,936	466,953
NC-108			■				■			■		■	■		■		38	2,325,382	967,117
NC-109	■			■						■		■		■		■	19	319,317	177,204
NC-110		■		■						■		■		■		■	19	464,322	235,225
NC-111			■	■						■		■		■		■	26	1,026,247	459,977
NC-112	■				■					■		■		■		■	20	528,008	253,203
NC-113		■			■					■		■		■		■	22	717,700	329,066
NC-114			■		■					■		■		■		■	32	1,500,109	642,029
NC-115	■					■				■		■		■	■		21	637,197	296,375
NC-116		■				■				■		■		■	■		24	945,029	420,016
NC-117			■			■				■		■		■	■		38	2,250,130	942,057
NC-118	■						■			■		■		■	■		22	767,399	343,386
NC-119		■					■			■		■		■	■		26	1,074,936	466,953
NC-120			■				■			■		■		■	■		39	2,325,382	967,117
NC-121	■			■						■	■		■			■	19	428,342	213,484
NC-122		■		■						■	■		■			■	19	573,347	271,505
NC-123			■	■						■	■		■			■	25	1,135,272	496,257
NC-124	■				■					■	■		■			■	20	751,958	327,808
NC-125		■			■					■	■		■			■	22	941,650	403,671
NC-126			■		■					■	■		■			■	32	1,724,059	716,634
NC-127	■					■				■	■		■		■		21	962,078	399,837
NC-128		■				■				■	■		■		■		26	1,269,910	523,478
NC-129			■			■				■	■		■		■		40	2,575,011	1,045,519
NC-130	■						■			■	■		■		■		24	1,192,567	471,937
NC-131		■					■			■	■		■		■		27	1,500,104	595,504
NC-132			■				■			■	■		■		■		42	2,750,550	1,095,668
NC-133	■			■						■	■			■		■	19	428,342	213,484
NC-134		■		■						■	■			■		■	19	573,347	271,505
NC-135			■	■						■	■			■		■	25	1,135,272	496,257
NC-136	■				■					■	■			■		■	19	751,958	327,808
NC-137		■			■					■	■			■		■	22	941,650	403,671
NC-138			■		■					■	■			■		■	32	1,724,059	716,634
NC-139	■					■				■	■			■	■		21	962,078	399,837
NC-140		■				■				■	■			■	■		26	1,269,910	523,478
NC-141			■			■				■	■			■	■		40	2,575,011	1,045,519
NC-142	■						■			■	■			■	■		23	1,192,567	471,937
NC-143		■					■			■	■			■	■		27	1,500,104	595,504
NC-144			■				■			■	■			■	■		42	2,750,550	1,095,668

* All clearance times were rounded to the nearest hour in the table above. Note: When RtePM did not evacuate all vehicles, an assumption of an additional hour was added to the clearance time for conservatism.

The range in clearance times was 19 to 42 hours for the NC evacuation scenarios. For scenarios with over 1 million people evacuating, RtePM reported an evacuation clearance time of at least 24 hours. For a Category 1 hurricane, the evacuation clearance time ranged from 19 to 27 hours. For a Category 2 hurricane, the evacuation clearance time ranged from 19 to 32 hours. For a Category 3 hurricane, the evacuation clearance time ranged from 21 to 40 hours. For a Category 4 hurricane, the evacuation clearance time ranged from 21 to 42 hours.

Congestion Summary

Visual inspection of the hour-by-hour RtePM results was conducted for each NC scenario. Congestion was observed at the following locations:

- Route 17 and Interstate 287 (I-287) intersection near state boundary at Mahwah Township, NJ,
- Garden State Parkway from I-80 at Saddle Brook, NJ to the state boundary at Montvale, NJ,
- I-280 and I-80 intersection near Troy Hills, NJ,
- I-78 from Liberty Corner Road at Liberty Corner, NJ to West Main Street at Clinton Town, NJ,
- I-287 from I-78 at Pluckemin, NJ to US-22 near Bridgewater, NJ,
- I-95 from Route 33 near Hightstown, NJ to Garden State Parkway,
- I-195 from Bordentown Road (US-206) at White Horse, NJ to US-9 near Winston Park, NJ,
- I -295 in Ewing Township, NJ, from Scotch Road to River Road,
- I -95 and NJ Turnpike intersection around Sharp at Mansfield Township, NJ,

During scenarios with higher hurricane intensities, congestion was observed at the NJ Turnpike from Burlington-Mount Holly Road to Route 73 near Ramblewood, NJ, and near I-280 at the intersection with Eisenhower Parkway at Roseland Borough, NJ. **Figure 6-3** shows roads with the most frequent congestion in the NC scenarios. In scenarios with NYC evacuees, some congestion was identified on I-87 and I-95 near the endpoints close to NYC. For the NC scenarios, contraflow activation was only applied on I-195. Some congestion was observed even when contraflow was activated, however it was reduced. However, minimal overall improvement (one hour) in evacuation clearance time was observed was contraflow was applied.

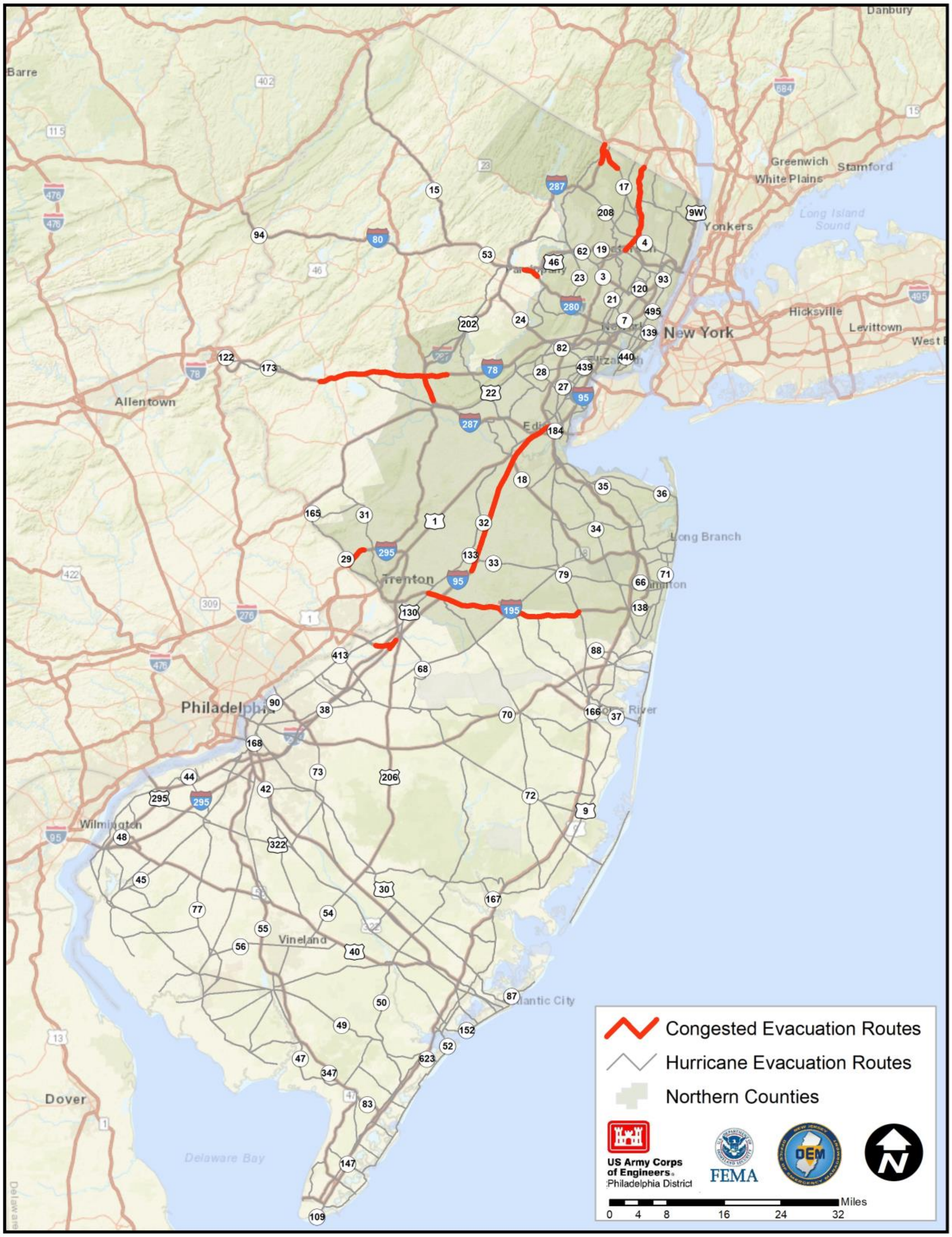

Figure 6-3 Northern Counties Scenarios - Congested Routes

6.4 Southern Counties Scenarios

In total, 72 scenarios were simulated in RtePM for the southern counties. Southern county (SC) scenarios are regional scenarios—where each evacuation scenario includes the eight southern counties (Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Ocean, and Salem counties). **Table 6-3** provides a graphical crosswalk that shows scenario assumptions, clearance times, and a summary of the regional evacuating population. Several scenarios included contraflow operations (for the Atlantic City Expressway, Garden State Parkway, State Route 47/347, State Route 72, and I-195).

Appendix D includes a summary of the evacuation scenarios and clearance time results, including for the SC simulations. Section 6.5 is a summary of scenarios and discusses the general trends of the evacuation scenarios with supporting graphs. **A companion MS Excel workbook with the evacuation scenarios and clearance time results is also included for ease of reference, sorting, and filtering of clearance time results. The workbook was also used to help integrate evacuation scenarios and clearances times in HURREVAC.**

The assumptions (and column header descriptions) used for the CS evacuation scenarios included:

- Scenario ID: southern counties scenarios (SC)
- Southern NJ counties (Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Ocean, Salem)
- Medium surge zone (Med SZ), medium evacuation zone (Med EZ), and high evacuation zone (High EZ) participation rates
- Hurricane intensity (i.e., Category 1,2, 3, or 4 storms)
  - Evacuation zones corresponding to the hurricane intensity storm surge inundation areas (Table 2-2) are ordered to evacuate. Inland shadow evacuees are included for NJ.
- Low or medium background traffic as described in Section 5.3.2
- Slow (24 hours), medium (18 hours), or fast (12 hours) response curves[32]
- No NYC evacuees
- Contraflow operations (Yes/No)
  - All five contraflow plans were applied for these scenarios.

[32] Atlantic County Zone A has modified response curves due to the need to evacuate the barrier island population before the other evacuation zones. The team conducted a sensitivity analysis on response curve timing for Atlantic County Zone A as described in Appendix E.

Table 6-3 Southern Counties Scenarios Input Parameters and Clearance Times

Scenario Title	Participation Rate			Hurricane Intensity				Response Curve			New York City		Contraflow Operations		Background Traffic		Clearance Time (hr.)	Evacuating Population	Evacuating Vehicles
	Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
SC-1	■			■				■				■	■			■	28	398,604	276,243
SC-2		■		■				■				■	■			■	31	636,719	371,495
SC-3			■	■				■				■	■			■	38	1,084,737	550,691
SC-4	■				■			■				■	■			■	29	526,460	325,038
SC-5		■			■			■				■	■			■	33	807,704	437,545
SC-6			■		■			■				■	■			■	42*	1,425,731	684,756
SC-7	■					■		■				■	■		■		30	624,912	364,199
SC-8		■				■		■				■	■		■		34	997,820	513,588
SC-9			■			■		■				■	■		■		42	1,694,489	792,247
SC-10	■						■	■				■	■		■		31	702,141	392,977
SC-11		■					■	■				■	■		■		38*	1,087,152	546,970
SC-12			■				■	■				■	■		■		42	1,729,578	803,944
SC-13	■			■				■				■		■		■	35	398,604	276,243
SC-14		■		■				■				■		■		■	38	636,719	371,495
SC-15			■	■				■				■		■		■	49	1,084,737	550,691
SC-16	■				■			■				■		■		■	37	526,460	325,038
SC-17		■			■			■				■		■		■	40	807,704	437,545
SC-18			■		■			■				■		■		■	52*	1,425,731	684,756
SC-19	■					■		■				■		■	■		39	624,912	364,199
SC-20		■				■		■				■		■	■		43	997,820	513,588
SC-21			■			■		■				■		■	■		51	1,694,489	792,247
SC-22	■						■	■				■		■	■		40	702,141	392,977
SC-23		■					■	■				■		■	■		46*	1,087,152	546,970
SC-24			■				■	■				■		■	■		52	1,729,578	803,944
SC-25	■			■					■			■	■			■	26	398,604	276,243
SC-26		■		■					■			■	■			■	29	636,719	371,495
SC-27			■	■					■			■	■			■	37	1,084,737	550,691
SC-28	■				■				■			■	■			■	28	526,460	325,038
SC-29		■			■				■			■	■			■	32	807,704	437,545
SC-30			■		■				■			■	■			■	40*	1,425,731	684,756
SC-31	■					■			■			■	■		■		29	624,912	364,199
SC-32		■				■			■			■	■		■		33	997,820	513,588
SC-33			■			■			■			■	■		■		40	1,694,489	792,247
SC-34	■						■		■			■	■		■		30	702,141	392,977
SC-35		■					■		■			■	■		■		36*	1,087,152	546,970
SC-36			■				■		■			■	■		■		41	1,729,578	803,944
SC-37	■			■					■			■		■		■	36	398,604	276,243
SC-38		■		■					■			■		■		■	39	636,719	371,495
SC-39			■	■					■			■		■		■	47	1,084,737	550,691
SC-40	■				■				■			■		■		■	38	526,460	325,038
SC-41		■			■				■			■		■		■	42	807,704	437,545
SC-42			■		■				■			■		■		■	50*	1,425,731	684,756
SC-43	■					■			■			■		■	■		40	624,912	364,199
SC-44		■				■			■			■		■	■		43	997,820	513,588
SC-45			■			■			■			■		■	■		50	1,694,489	792,247
SC-46	■						■		■			■		■	■		41	702,141	392,977
SC-47		■					■		■			■		■	■		45*	1,087,152	546,970
SC-48			■				■		■			■		■	■		50	1,729,578	803,944
SC-49	■			■						■		■	■			■	25	398,604	276,243
SC-50		■		■						■		■	■			■	28	636,719	371,495
SC-51			■	■						■		■	■			■	35	1,084,737	550,691
SC-52	■				■					■		■	■			■	27	526,460	325,038
SC-53		■			■					■		■	■			■	30	807,704	437,545

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Scenario Title	Participation Rate			Hurricane Intensity				Response Curve			New York City		Contraflow Operations		Background Traffic		Clearance Time (hr.)	Evacuating Population	Evacuating Vehicles
	Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
SC-54			X		X					X		X	X			X	40*	1,425,731	684,756
SC-55	X					X				X		X	X		X		28	624,912	364,199
SC-56		X				X				X		X	X		X		33*	997,820	513,588
SC-57			X			X				X		X	X		X		40	1,694,489	792,247
SC-58	X						X			X		X	X		X		28	702,141	392,977
SC-59		X					X			X		X	X		X		34*	1,087,152	546,970
SC-60			X				X			X		X	X		X		40	1,729,578	803,944
SC-61	X			X						X		X		X		X	36	398,604	276,243
SC-62		X		X						X		X		X		X	39	636,719	371,495
SC-63			X	X						X		X		X		X	46	1,084,737	550,691
SC-64	X				X					X		X		X		X	37	526,460	325,038
SC-65		X			X					X		X		X		X	40	807,704	437,545
SC-66			X		X					X		X		X		X	49*	1,425,731	684,756
SC-67	X					X				X		X		X	X		39	624,912	364,199
SC-68		X				X				X		X		X	X		43*	997,820	513,588
SC-69			X			X				X		X		X	X		49	1,694,489	792,247
SC-70	X						X			X		X		X	X		39	702,141	392,977
SC-71		X					X			X		X		X	X		43*	1,087,152	546,970
SC-72			X				X			X		X		X	X		50	1,729,578	803,944

* All clearance times were rounded to the nearest hour in the table above. Note: When RtePM did not evacuate all vehicles, an assumption of an additional hour was added to the clearance time for conservatism.

The range in clearance times was 25 to 52 hours for the SC scenarios. For scenarios with over 1 million people evacuating, RtePM reported an evacuation clearance time of at least 35 hours.

For a Category 1 hurricane, the evacuation clearance time ranged from 25.1 to 48.6 hours. For a Category 2 hurricane, the evacuation clearance time ranged from 27.1 to 52 hours. For a Category 3 hurricane, the evacuation clearance time ranged from 27.8 to 50.8 hours. For a Category 4 hurricane, the evacuation clearance time ranged from 28.1 to 51.7 hours. The clearance time range remains similar for each of the hurricane intensities because of the availability of the entire NJ transportation network, which allowed the population to evacuate to designated endpoints. A comparison of the scenarios with contraflow operations revealed an improvement of approximately 7-11 hours in evacuation clearance time when contraflow operations where applied. This was a significant improvement for instances where activation was warranted. Additional discussion and comparisons of contraflow scenarios are discussed in Section 6.7.

Congestion Summary

Visual inspection of the hour-by-hour RtePM results for each SC scenario was conducted. Congestion was observed at the following locations:

- Garden State Parkway at Tinton Falls Borough, NJ, from West Park Avenue to Corlies Avenue (Route 33),
- I-195 from US-9 near Winston Park, NJ to I-95,
- Garden State Parkway from Cedar Bridge Avenue at Lakewood Township, NJ to Lacy Road at Lacy Township, NJ,

- I -95 and NJ Turnpike intersection around Sharp at Mansfield Township, NJ,
- North-South Freeway (Route 42) from Route 55 at Deptford Township to I-76 at Fairview, NJ,
- Route 55 at Deptford Township, NJ from North-South Freeway (Route 42) to Delsea Drive (Route 47),
- Atlantic City Expressway from Wrangleboro Road near McKee City, NJ to Laurel Dale (Route 50) near West Egg Harbor, NJ,
- Congestion was observed on the Garden State Parkway from West Laurel Drive at Somers Point to the Atlantic City Expressway when there was no contraflow. Once contraflow was activated, congestion was no longer observed in RtePM.
- NJ Turnpike exit and I-295 at Carneys Point Township, NJ.

For scenarios using higher participation rates, additional congestion was identified through visual inspection at the following locations:

- Garden State Parkway from RT-208 at Arcola, NJ to state boundary at Mahwah Township, NJ, as evacuees also use this endpoint in North of NJ to evacuate.
- I -295 in Ewing Township, NJ from Scotch Road to River Road.
- Atlantic City Expressway from Berlin Gross Keys Road to East Black Horse Pike (Route 42) near Turnersville, NJ. Once contraflow was active, congestion shifted to Mays Landing Road (Route 73) near Winslow Township, NJ to Route 42.
- Garden State Parkway from Route 50 at Seaville, NJ to Sea Island Boulevard at Ocean View, NJ.

Figure 6-4 shows roads with the most frequent congestion (from visual inspection) in the southern counties scenarios.

Figure 6-4 Southern Counties Scenarios - Congested Routes

6.5 Summary of Evacuation Scenarios

The 252 regional and statewide evacuation scenarios captured a spectrum of behavioral, traffic, and operational conditions that may impact the region. Countywide (CW) and county-step were completed as sensitivity runs and included simulations for every evacuation zone in each of the 17 counties **(Appendix E).**

It is unlikely that individual counties would evacuate. Therefore, it is recommended that NJ emergency managers primarily use statewide and regional (CS, NC, and SC) scenarios when supporting evacuation planning and operations, as these evacuation scenarios simulate the impacts of evacuating traffic from adjacent counties.

Based on the inputs provided by the user, RtePM completed simulations for each evacuation scenario, reported an evacuation clearance time, and created a time series graphic showing evacuation flow. This section summarizes the results of the scenarios completed as part of the NJHES Re-Study. The following graphs represent different groupings of variables so that the general trends can be distinguished and visualized. Note when the y-axis changes between 2 million to 5 million people, depending on the grouping of scenarios. These are based on the results described in Sections 6.2 to Section 6.4.

Based on the results from RtePM, there was a relatively linear relationship given the evacuating population and the final clearance times. **Figure 6-5** and **Figure 6-6** show the evacuation clearance time by hurricane intensity for the NC and SC scenarios, respectively. The figures capture the range of clearance times for different hurricane intensities. As observed, at lower evacuating populations (1 million or less), clearance times results were closely grouped (blue box on Figure 6-5), showing a cluster at 19, 21, and 27 hours. This cluster provides a comparison of similar scenarios with variable slow, medium, and fast response curves (i.e., how quickly the population responds to and then evacuates from the region). Selected NC scenarios with similar parameters (except for hurricane intensity) are also highlighted.

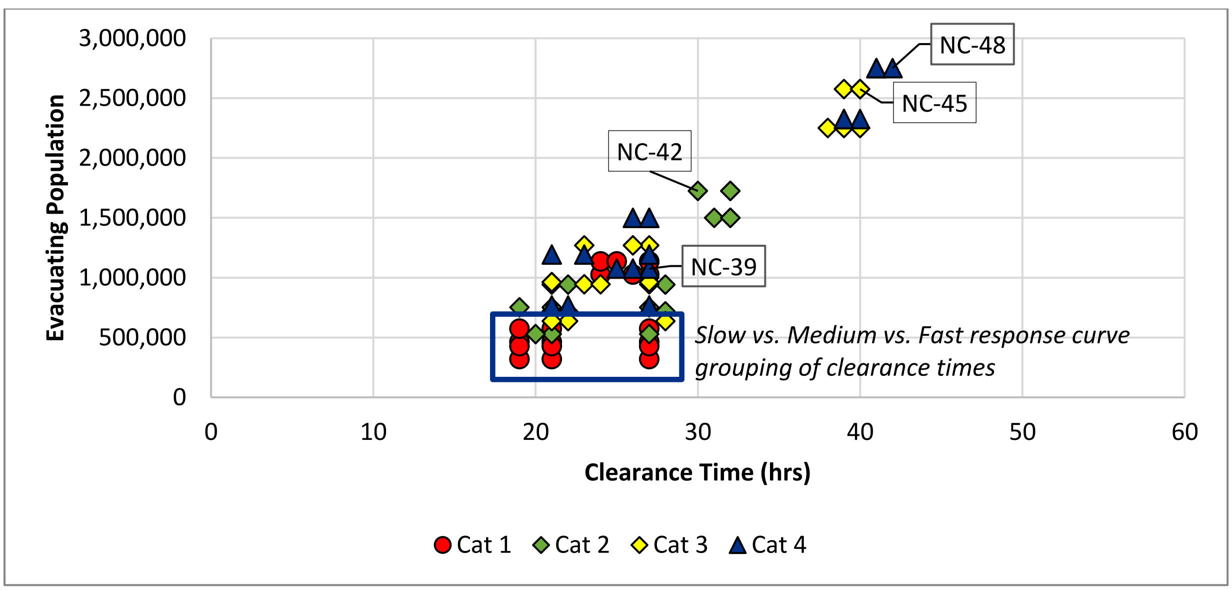

Figure 6-5 Evacuation Clearance Times for Northern Counties Scenarios by Hurricane Intensity

Figure 6-6 shows the range of clearance times for different hurricane intensities in the southern counties. A distinct grouping, shown by the blue box, is a graphical representation of the improvement in clearance times from implementing contraflow and was most prominent in southern counties scenarios. SC-12 and SC-24 had the same input parameters (except for contraflow). Section 6.7 summarizes contraflow scenarios.

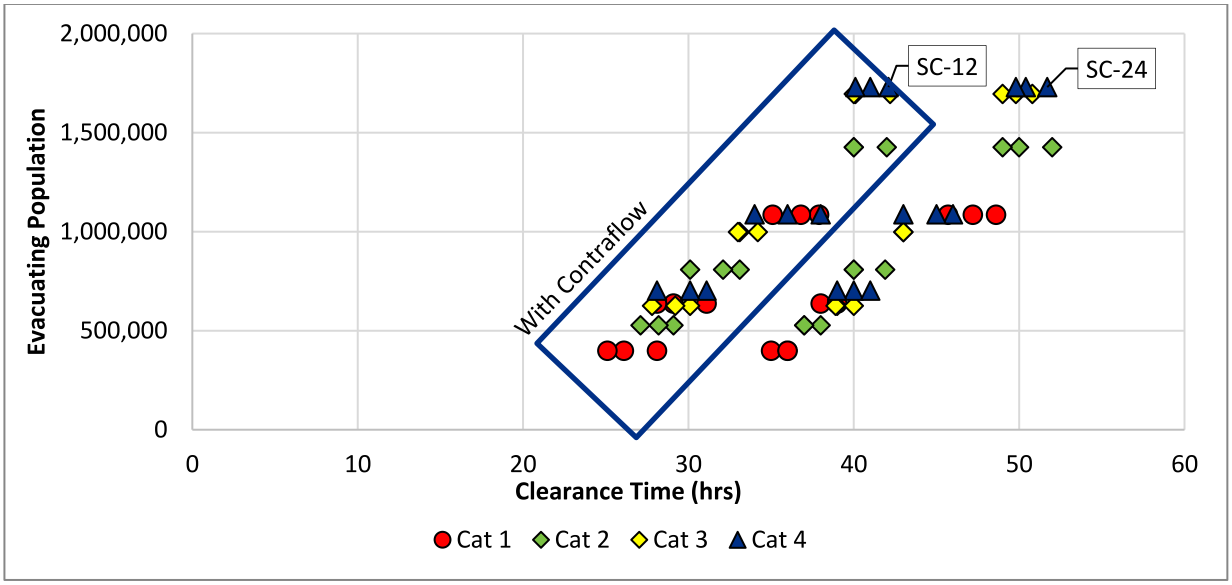

Figure 6-6 Evacuation Clearance Times for Southern Counties Scenarios by Hurricane Intensity

Next, the scenarios were summarized by the response curve. **Figure 6-7** through **Figure 6-9** show the evacuation clearance time by response curve for the CS, NC, and SC scenarios, respectively. Generally, the fast response curve (12 hours) had a lower clearance time than evacuation scenarios with similar inputs and settings compared to the medium (18 hours) or slow (24 hours) response curves. The difference in clearance time was up to 3 hours for CS (Figure 6-7) and SC (Figure 6-9) scenarios and up to 8 hours for NC scenarios (Figure 6-8). However, there are instances where a change in response curve results in a clearance time that is the same or within an hour of a similar scenario and may be attributed to evacuating population size. A blue box highlights the impact of contraflow in the SC scenarios (Figure 6-9). Selected scenarios with similar parameters (except for response curve) are highlighted for context.

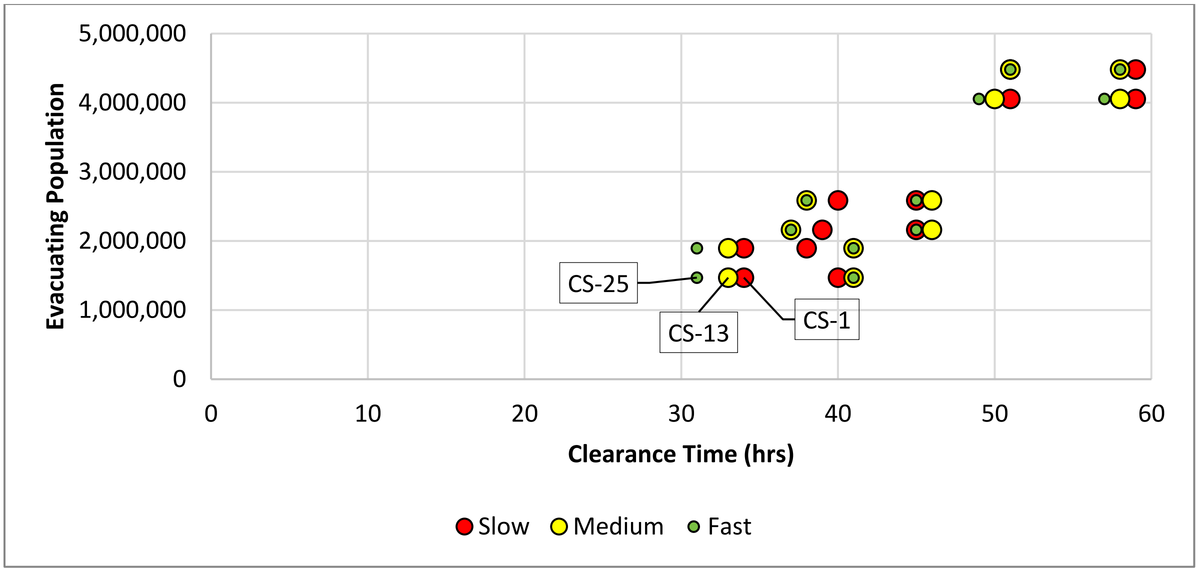

Figure 6-7 Evacuation Clearance Times for Catastrophic Scenarios by Response Curve

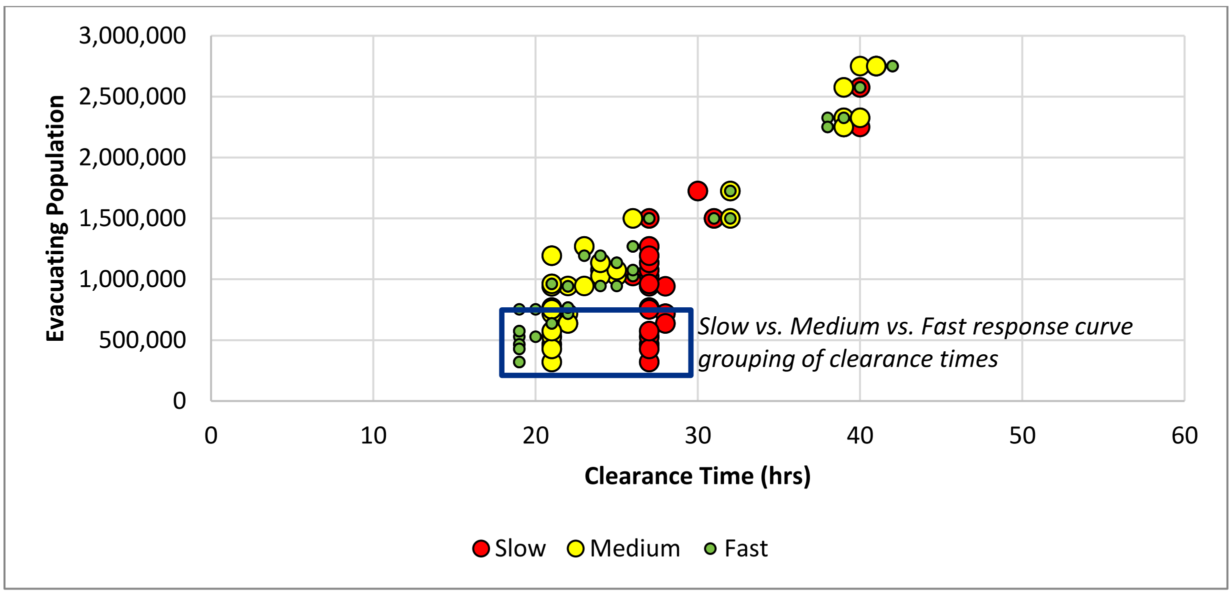

Figure 6-8 Evacuation Clearance Times for Northern Counties Scenarios by Response Curve

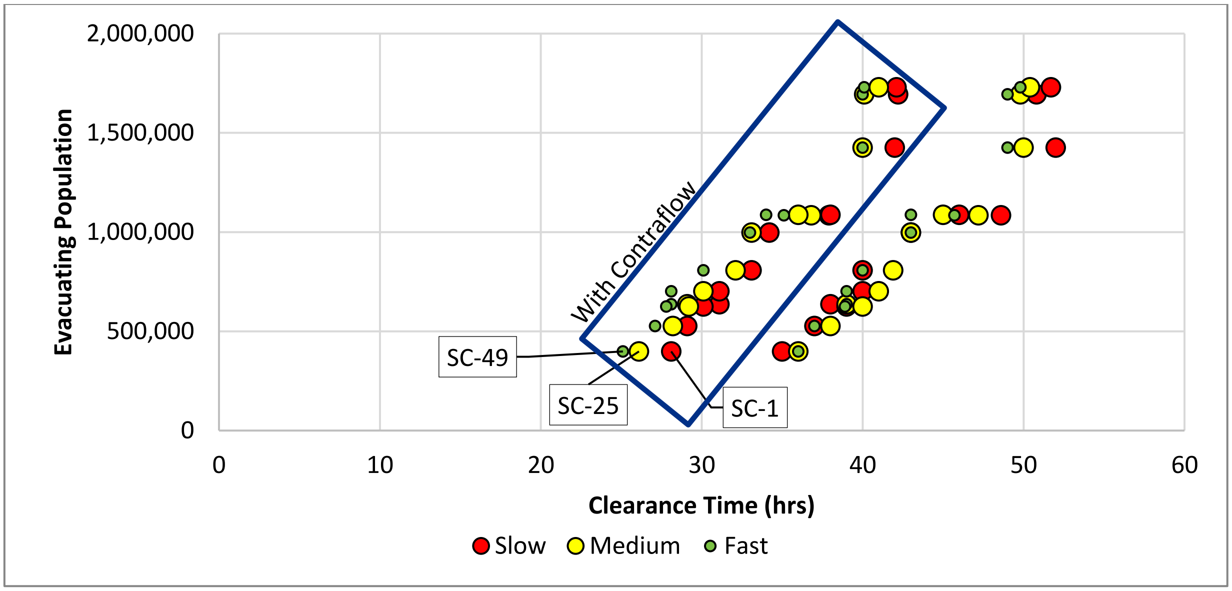

Figure 6-9 Evacuation Clearance Times for Southern Counties Scenarios by Response Curve

Finally, the evacuations scenarios were summarized by evacuation participation rate for evacuation zones by comparing the number of people who are evacuating. **Figure 6-10** through **Figure 6-12** show the clearance time by evacuation participation rates for CS, NC, and SC, respectively. Generally, there was a linear relationship between the number of people evacuating to the final clearance times. When less than 1 million people are evacuating during the NC scenarios, the clustering was related to the minimum response time needed for an evacuation. In general, increasing the evacuation participation rates or total population increased the clearance time. Evacuation participation rates are discussed in greater detail in Section 3.2, and are summarized below for additional reference:

- High evacuation participation rates of 100% (Table 3-6) were applied to the entire population within the ordered evacuation zones. This is a typical evacuation planning approach and has been applied in other recent HESs. These were the maximum evacuation rates (considered worst-case) and were referred to as **High Evacuation Zone (EZ)** participation rates.

- Evacuation participation rates from the NJ HEBS Report (Table 3-5) were applied to the entire population within the ordered evacuation zones. These were referred to as **Medium Evacuation Zone (EZ)** participation rates.

- Lastly, to specifically address the portion of the population at risk of storm surge flooding within evacuation zones, evacuation participation rates from the NJ HEBS Report (Table 3-5) were applied to only the population at risk of flooding from storm surge within the evacuation zones. This method leveraged the RtePM US Census block group data and storm surge inundation areas developed during the Hazard Analysis. These rates were referred to as **Medium Surge Zone (SZ)** participation rates.

The difference in clearance times between the Medium SZ to Medium EZ participation rates ranged between 4 to 7 hours in the CS scenarios, 0 to 5 hours in NC scenarios, and 3 to 7 hours in SC scenarios. As observed in these graphs, the higher the evacuation participation rate, the greater the population, and thus the greater the evacuation clearance time. Selected scenarios with similar parameters (except for participation rate) are highlighted for context.

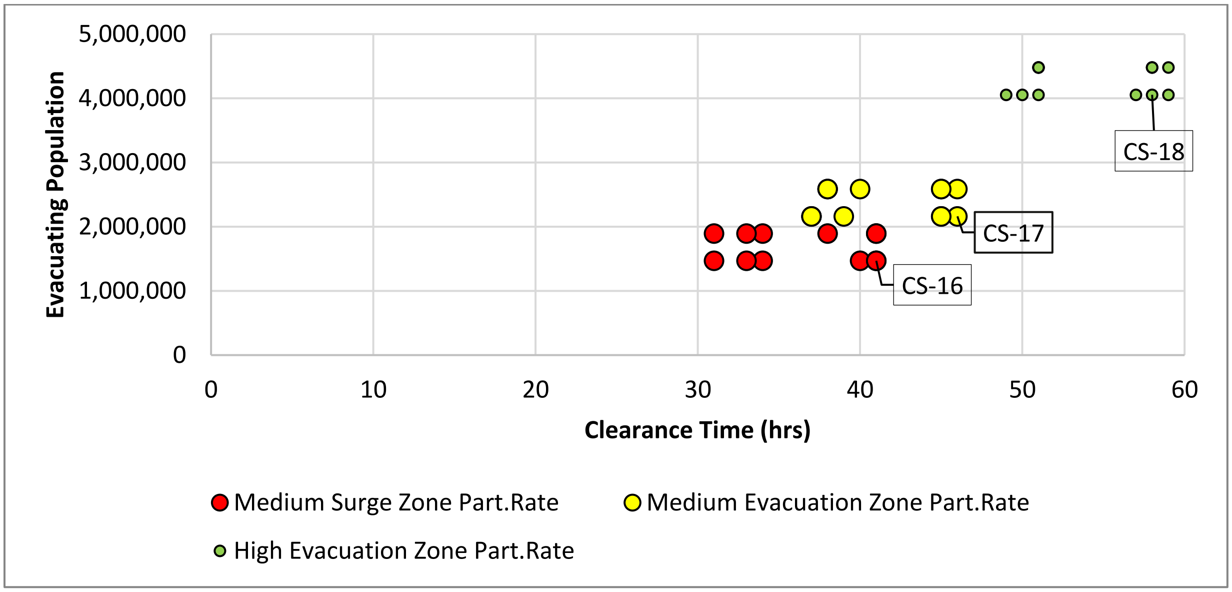

Figure 6-10 Evacuation Clearance Times for Catastrophic Scenarios by Participation Rates

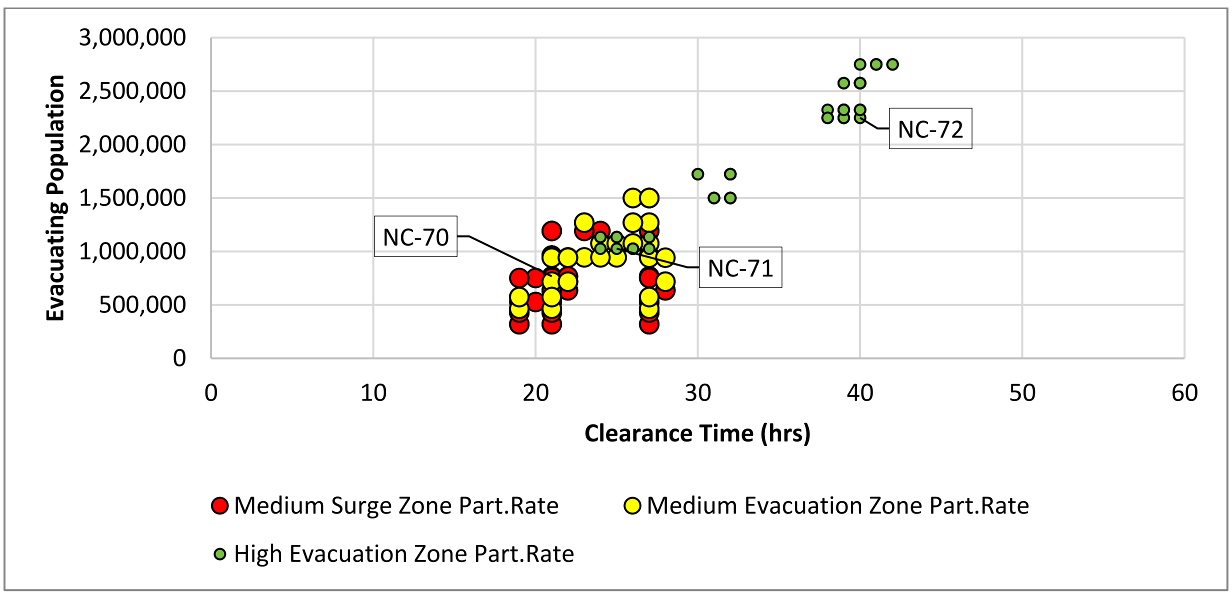

Figure 6-11 Evacuation Clearance Times for Northern Counties Scenarios by Participation Rates

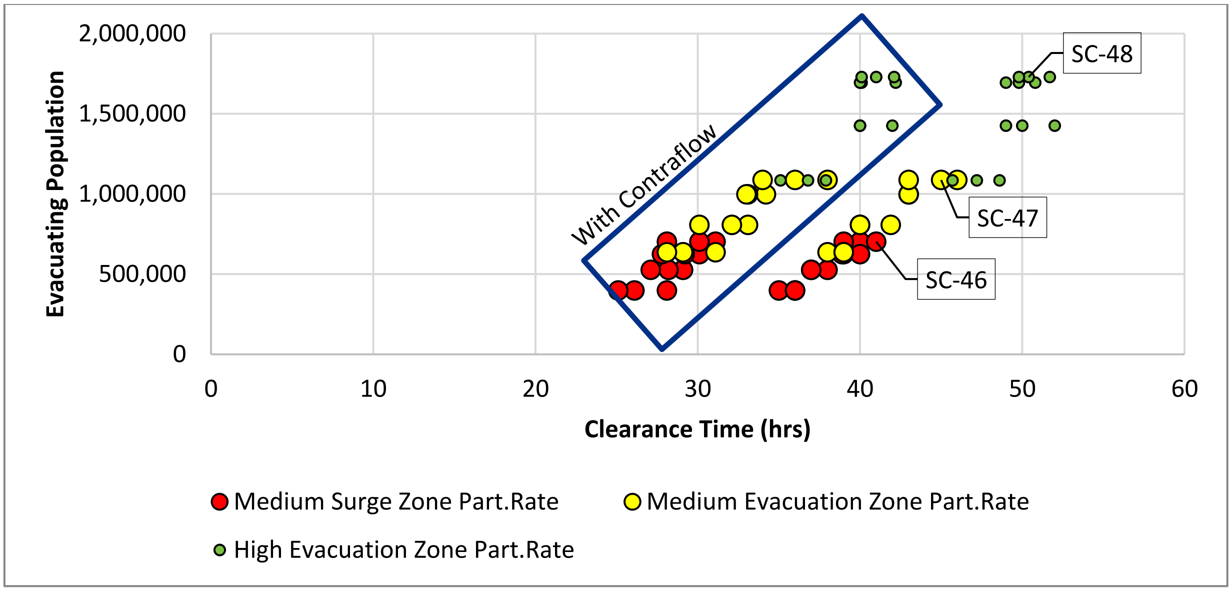

Figure 6-12 Evacuation Clearance Times for Southern Counties Scenarios by Participation Rates

6.6 Impacts from New York City Evacuees

CS and NC scenarios include NYC evacuation zones and evacuating populations (a total of 90 scenarios). **Figure 6-13** shows the CS scenarios for the with and without NYC evacuees. Selected scenarios with similar parameters (except for the NYC population) are highlighted for context.

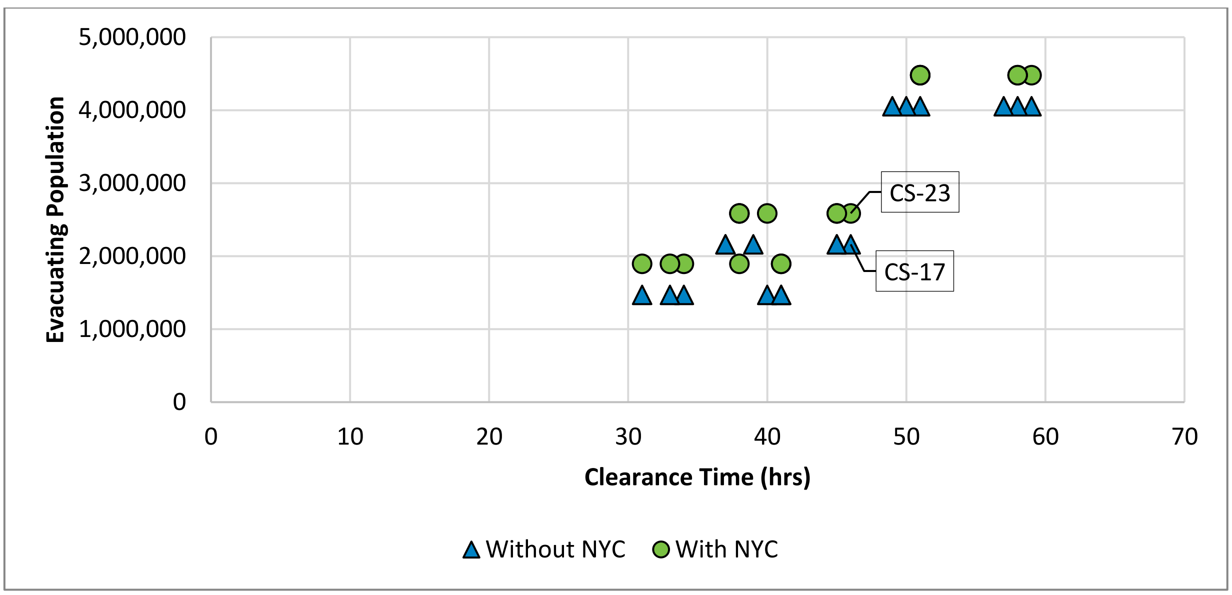

Figure 6-13 Evacuation Clearance Times for Catastrophic Scenarios with NYC Evacuees

From the results, it appeared the inclusion of NYC evacuees had a minimal (0 to 2 hours) impact on the NJHES Re-Study clearance times compared to scenarios with similar response curves and participation rate settings. The NYC behavioral assumptions are listed in Section 5.4. This minimal impact is likely due to several reasons:

1. The participation rate in NYC represented only the population that would evacuate to NJ (i.e., the majority of NYC evacuees leave and go to other locations such as inland, other counties in NY and CT),
2. The percent of people using public transit is much higher than in areas of NJ (i.e., fewer private vehicles on the roadway network),
3. The response curves for NYC evacuees, based on the 2015 NYSNYCHES, showed that NYC evacuees respond faster than the NJ evacuees, based on the 2017 NJ HEBS Report response curves,
4. The NJHES Re-Study have several endpoints at the northern border of NY and NJ, which are open as a point of safety for NYC evacuees, and
5. The evacuation zone shapes representing NYC were combined to represent all five boroughs, so assumptions were made to represent the NYC evacuees. Participation rates were assigned to the overall population even though boroughs closer to NJ may have higher evacuation participation rates.

NYC Response Sensitivity Runs

Several dozen sensitivity runs were simulated to test each of the parameters to determine which controls the clearance time. Only when applying a high participation rate for NYC and NJ (for a total of 5,664,433 people evacuating in the scenario), a slow response curve (24 hours), and de-activating all of the RtePM endpoints in NY to force traffic to NJ, did RtePM yield a clearance time result of 66 hours. This result was considered a sensitivity test, and not a result that was documented in the scenario summary as part of the NJHES Re-Study.

The participation rate was the most sensitive parameter for the Transportation Analysis in RtePM. This was tested by de-activating the RtePM endpoints in NY and changing the evacuation participation rate of the NYC evacuation zones. The baseline scenario (CS-12) used for this sensitivity run yielded an evacuation clearance time result of 58 hours (this was the raw output from RtePM and did not include the additional hour assumption applied when simulations do not fully clear the roadways in the model). When a 22% participation rate was applied to the NYC evacuees, the evacuation clearance time increased by 2 hours. When the evacuation participation rate was changed to 28%, the evacuation clearance time increased by 3 hours compared to the baseline. For a 45% participation rate and 83% participation rate, the clearance time increased by 4 and 8 hours compared to the baseline, respectively.

Figure 6-14 shows the NC scenarios that included NYC evacuees. The changes in clearance time comparison in these instances were also minimal when comparing evacuation scenarios with similar scenario parameters and settings. The greatest evacuation clearance time increases were observed in scenarios that included NYC evacuees when participation rates were set to high, when a Category 4 impacted the area, and when fast response curves for NJ were selected (which would cause the majority of NY evacuees to enter the roadway network at a similar time as the NJ evacuees). The clearance times for these scenarios increased by 3 to 4 hours. Selected scenarios with similar parameters (except for the NYC population) are highlighted for context.

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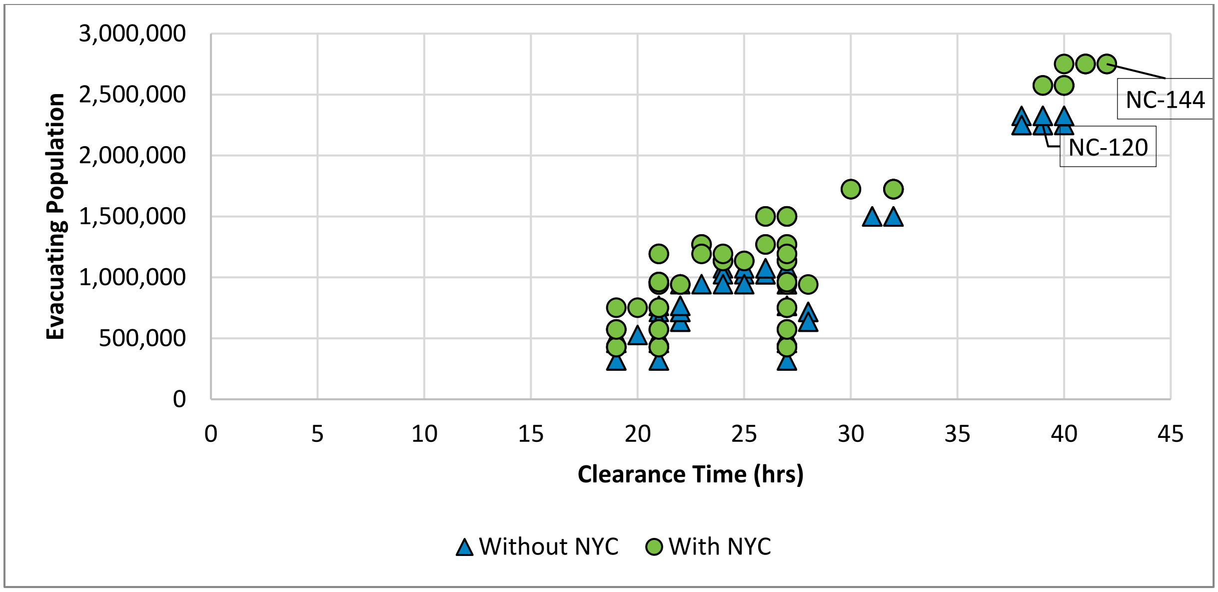

Figure 6-14 Evacuation Clearance Times for Northern Counties Scenarios with NYC Evacuees

6.7 Contraflow Scenarios

The state, county, and local officials can use the following results to consider when a contraflow plan can be activated. Ultimately, the decision to implement a contraflow strategy is made by the Governor of NJ based on recommendations by the NJOEM State Director. Contraflow operations were applied to the transportation modeling based on existing plans provided by NJOEM, NJSP, and NJDOT. The review of the contraflow decision matrix (Section 5.6) signified that contraflow could occur for any of the hurricane intensities or storm surge inundation areas listed. However, a decision to activate contraflow depends on other factors (storm track, population density, and background conditions [tides/incipient flooding]). Local and state operational plans have and will continue to consider the impact of contraflow operations on available state resources. Contraflow plans detail the timing and resources required, as well as the decision actions needed before implementation. RtePM simulations assume an instantaneous implementation of the contraflow plan as soon as an evacuation is ordered. In practice, emergency managers will require additional time establish contraflow actions prior to the start of the evacuation.

In total, 126 evacuation scenarios (18 CS scenarios, 72 NC scenarios, and 36 SC scenarios) were simulated to determine the impact of contraflow operations on evacuation clearance times. These 126 evacuation scenarios illustrated the potential time savings due to contraflow implementation. In general, the improvement in evacuation clearance times increased as the evacuating traffic volumes increased. There was improvement across the network when contraflow was used, but congestion was still observed on some routes. The contraflow methodology in RtePM relies on a decreased efficiency rate for when lanes were reversed. This accounts for the concept that some congestion may occur when individuals travel in the opposite-than-normal direction. **Figure 6-15** shows the evacuation clearance times for CS scenarios with all five contraflow plans applied. The clearance time improved between 4 to 10 hours after applying contraflow. Selected scenarios with similar parameters (except for the NYC population) are highlighted for context.

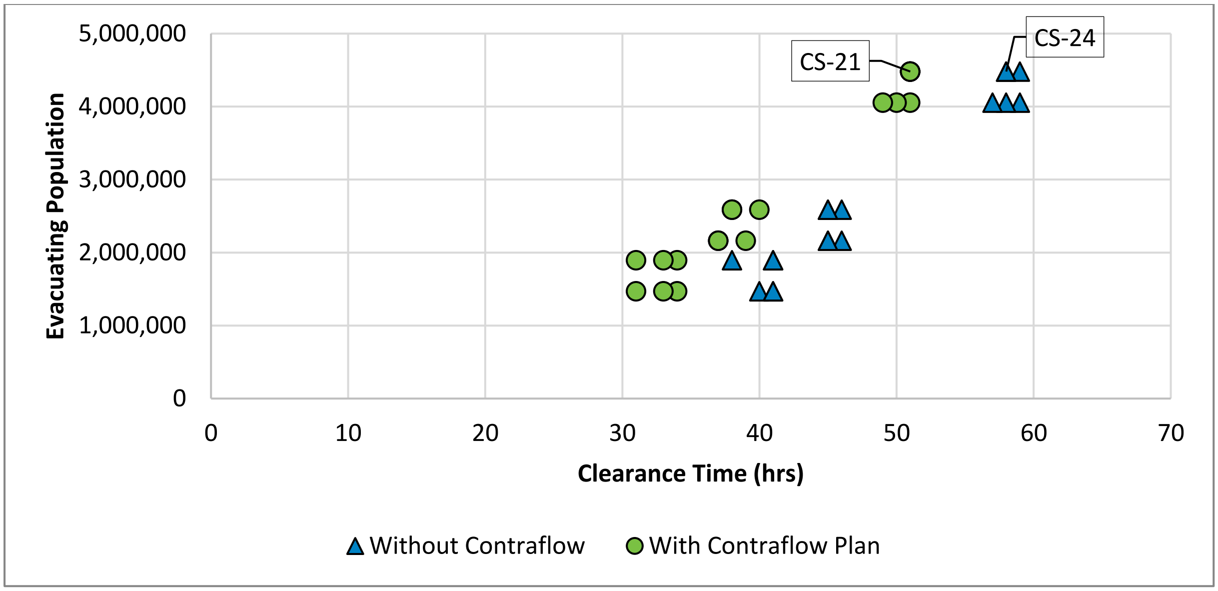

Figure 6-15 Evacuation Clearance Times for Catastrophic Scenarios with Contraflow

For NC scenarios, the I-195 contraflow plan was implemented based on proximity to Monmouth County. Based on the review of results, minimal impacts were observed on evacuation clearance time results for northern counties. **Figure 6-16** shows the evacuation clearance times for the SC scenarios with contraflow. As discussed in Section 5.6, all five contraflow plans were applied for these scenarios. In comparison, the range of improvement for the clearance times was between 7 to 11 hours. These improvements were most significant when the participation rate was high. SC-12 and SC-24 had the same input parameters (except for contraflow).

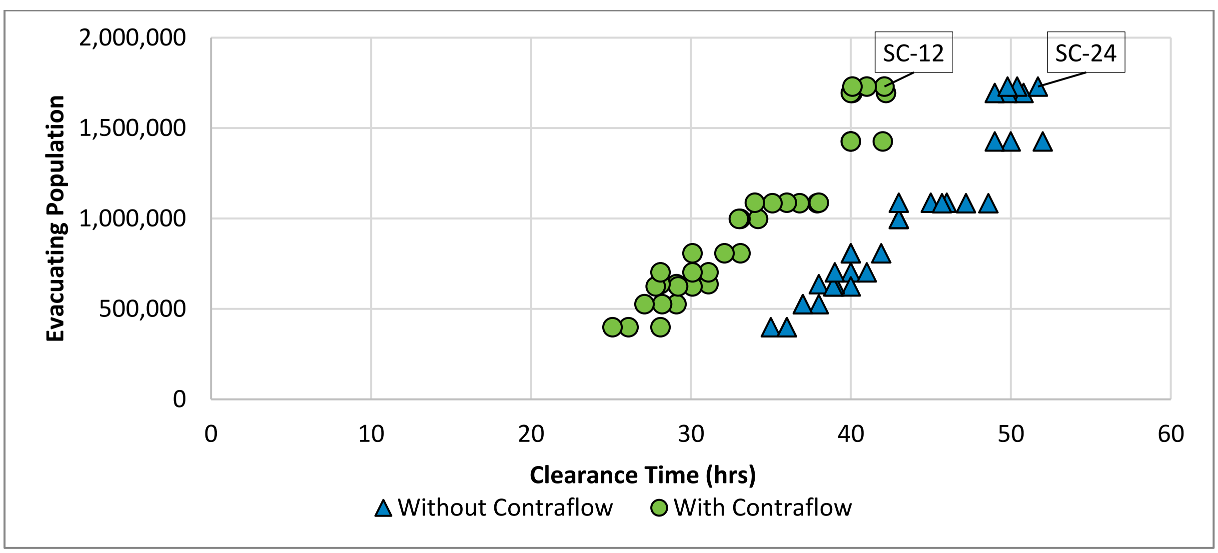

Figure 6-16 Evacuation Clearance Times for Southern Counties Scenarios with Contraflow

6.8 Summary of Transportation Analysis

6.8.1 Summary of New Features

Under the National Hurricane Program, USACE conducts HESs in partnership with the FEMA and NOAA-NHC. These studies include different analyses: Hazard, Vulnerability, Behavioral, Shelter, and Transportation. The overall goal of HES is to support local, state, and federal governments with ongoing hurricane evacuation planning efforts by leveraging the latest available data and technologies. The ultimate outputs of these studies are evacuation scenarios and their calculated evacuation *clearance times*, which represent the time it takes to clear the roadway of all evacuating vehicles, measured from the moment an evacuation order is issued until the time when the final evacuating vehicle reaches its point of safety.

Several improvements were made as part of the NJHES Re-Study effort, including:

- Updated storm surge inundation mapping using the latest (SLOSH) model data available at the time of the Hazards Analysis. In 2016, the USACE Philadelphia District created storm surge inundation area maps which depicted the worst-case scenario storm surge inundation areas associated with Category 1, 2, 3, and 4 hurricanes. Section 2.0 summarizes the final outputs generated during this analysis.

- Updated evacuation zones for each county impacted by coastal storm surge through close coordination between the USACE Philadelphia District, FEMA Region II, NJOEM, NJDOT, and NJ county emergency managers in 2017. Overall, 132 evacuation zones were developed throughout the state, which included up to 7 letter zones (Zone A to Zone G) and between 3 to 17 evacuation shapes (A, A1, A2, B, B1, B2, etc.) for each county. Section 2.0 summarizes the final outputs generated during this analysis.

- Updated evacuation behavioral data and assumptions using a 2017 behavioral survey conducted in NJ, which leveraged a telephone survey to gather input for coastal county populations based on recent storm experience. There were four primary behavioral parameters needed to inform additional analyses in the NJHES Re-Study: *evacuation participation rates*, *response curves*, *vehicle usage rates*, and *destination rates*. Section 3.0 summarizes how the study team leveraged the results of the behavioral survey to develop behavioral assumptions used as inputs to the Shelter and Transportation Analyses.

- Updated shelter location, capacity, and demand data, including a shelter vulnerability assessment to determine which shelters may be impacted under certain storm conditions. Section 4.0 provides tables showing how many shelters are impacted by storm surge for different hurricane intensities. It also provides tables showing which counties would have potential shelter capacity deficits based on different evacuation participation rates and hurricane intensities.

- Development of new evacuation scenarios and use of a new transportation model, RtePM, to complete the Transportation Analysis. Section 5.0 describes the various modeling inputs needed to calculate clearance times in RtePM. It also includes the process for developing the final roadway network in the model, which represents 2020 transportation projects and includes contraflow procedures. Section 6.0 details the development of regional and statewide evacuation scenarios, clearance times, and provides a series of regionwide and general evacuation recommendations.

The use of RtePM was a significant change from the last HES. RtePM is a web-based transportation modeling tool with updated population and transportation network data sources. RtePM allows a user to change various parameters and conditions to analyze, store, and share results for a large number of evacuation scenarios. In addition, it allows users to perform visual analysis of overall evacuation traffic flow on an hourly timestep. The NJHES Re-Study was one of the first studies conducted by the National Hurricane Program to utilize RtePM. It contributed to improvements in the development of the software and continued progress in evacuation modeling and disaster planning.

6.8.2 Summary of Results from the Transportation Analysis

The NJHES Re-Study resulted in the development of 252 different evacuation scenarios to provide emergency managers with an array of parameters and a range of clearance times to better plan for hurricane evacuations. The Transportation Analysis sections of this report (Section 5.0 and Section 6.0) detail the assumptions used to develop evacuation scenarios and calculate evacuation clearance time results, including for scenarios with NYC evacuees and with contraflow operations. It is important to note that the results from the NJHES Re-Study do not supersede nor dictate any changes to the existing NYS and NYC HESs.

There were 17 counties affected by coastal storm surge that were a part of the NJHES Re-Study, which were divided into northern and southern regions. A series of catastrophic evacuation scenarios (36 in total) were developed, which represented statewide evacuations for worst-case scenario storm surge from hurricanes (i.e., Category 4 hurricane intensity). Various evacuation participation rates were applied to the populations in the study area to determine who would participate in an evacuation. **Table 6-4** summarizes the ranges in clearance times for the NJHES Re-Study. Appendix D summarizes the inputs and results for the evacuation scenarios. It is recommended that local, state, and federal emergency managers leverage the statewide and evacuation clearance times for operational planning and decision-making.

Table 6-4 Range of Clearance Times by Evacuation Participation Rate

	Evacuation Participation Rate Applied to Population within Surge Zone (Least Conservative)	Evacuation Participation Rate Applied to Population within Evacuation Zone	100% Evacuation Participation Rate Applied to Population within Evacuation Zone (Most Conservative)
All Coastal Counties	31-41 hours	37-46 hours	49-59 hours
Northern Counties	19-28 hours	19-28 hours	24-42 hours
Southern Counties	25-41 hours	28-46 hours	35-52 hours

6.8.3 Overall Trends from Evacuation Clearance Times Results

Logically, higher participation rates resulted in longer evacuation clearance times as an increase in population and more vehicles on the roadway network cause congestion. More population participating in an evacuation was also driven by the hurricane intensity (and the potential for storm surge inundation) and which evacuation zones were being ordered to evacuate. In a comparison of scenarios with different response curves, the changes in clearance times appear to be minimal. The most conservative scenario used a High EZ participation rate, impacted all counties and NYC, and assumed a Category 4 hurricane (with a clearance time of 59 hours). The least conservative, used the Medium SZ participation rate applied to only the population that is impacted by a Category 1 storm surge inundation and quickly responds to an evacuation order (with a clearance time of 19 hours).

To evaluate the impact of contraflow operations, 126 evacuation scenarios were evaluated. Improvements to evacuation clearance times when contraflow was employed were moderate based on transportation modeling results (up to 11 hours of clearance time improvement for some scenarios). Thus, given the planning and operational efforts to date, the detailed plans in place completed by NJDOT, and the time and cost related to contraflow operations, it is recommended that the State continue to study and refine contraflow options and implementation.

The statewide and northern counties evacuation scenarios also included NYC evacuees. For these evacuation scenarios, it was assumed that only a portion of the NYC evacuees traveled to NJ. The behavioral assumptions from the NYS and NYC HES were used and several approximations were made to account for this additional influx of evacuees into NJ. Overall, the transportation modeling showed minimal impact (0 to 2 hours) on the clearance times for the NJHES Re-Study, due to how quickly the NYC population was set to respond to an evacuation order. The clearance times only increased significantly when very conservative behavioral and transportation assumptions were applied in sensitivity scenarios (such as increasing the NYC participation rate nearly four-fold, implementing a slow response time of 24 hours, and closing off evacuation routes north of NYC).

Sensitivity scenarios included county-specific scenarios (113 in total) to demonstrate clearance times for evacuating individual counties and to determine the impacts associated with evacuating a progression of zones (Zone A, Zone A+B, etc.) within each county. The results of these county-specific scenarios were included in Appendix E and provided primarily as a reference.

Although this report and the figures, appendices, and charts related to this report are static, the results from the newly updated SLOSH model and RtePM are best leveraged in a dynamic mapping environment and are intended to be integrated into HURREVAC, the National Hurricane Program's web-based hurricane evacuation decision support software. Using HURREVAC, NJHES Re-Study results, including evacuation scenarios and clearances can be easily accessed by local, state, and federal emergency managers to support informed decision making.

6.8.4 Regionwide and General Evacuation Recommendations

For future regional and state planning efforts, the following statewide and general evacuation considerations were recommended after reviewing the suite of transportation scenarios and clearance times:

- The movement of evacuating vehicles during a hurricane evacuation requires extensive traffic control efforts to maximize the use of the roadway capacity and expedite a safe evacuation from hurricane hazards. Directing resources to areas identified as potential congestion bottlenecks may help alleviate congestion.
- Where the State and counties have sufficient personnel resources, officers should be stationed at critical intersections to facilitate traffic flow; intersections should continue to have signalized control, signal patterns providing the most “green” time at traffic lights along the evacuation route should an evacuation be activated.

- If possible, arrangements should be made with tow truck operators to be pre-positioned along key travel corridors and critical roadway facilities, such as bridges.
- State and counties should consider developing a GIS-based dashboard for statewide evacuation and sheltering, including a system to monitor travel flow at key locations, reports of traffic tie-ups, and shelter and hotel availability to the general public as they evacuate.
- High-level bridges must be monitored for early wind vulnerability because sustained tropical-storm-force winds arrive earlier on these structures than at ground level; trucks, RVs, and other high-profile vehicles are especially vulnerable to these conditions.
- Coordination should occur with hotels, motels, and campgrounds regarding evacuating the seasonal visitor population earlier. Accounting for the information identified and summarized in this study, state and local emergency management officials should consider potential pre-evacuation policies for these populations.

Appendix A

Percent of Storm Surge Inundation Areas in Evacuation Zones

Region	County	Evacuation Zone	Percent of Storm Surge Inundation Areas in Evacuation Zones			
			Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Northern Counties	Bergen	A	2.14%	9.28%	14.30%	20.92%
		B1	38.56%	71.65%	81.88%	89.07%
		B2	0.00%	0.00%	0.00%	0.00%
		C	63.97%	85.73%	87.33%	89.12%
		D	0.00%	0.00%	0.00%	0.00%
		E1	0.08%	0.23%	1.06%	6.09%
		E2	0.01%	0.10%	0.22%	0.54%
		F	0.00%	0.00%	0.00%	0.00%
	Essex	A	44.99%	77.47%	89.02%	94.09%
		B	8.76%	28.41%	45.57%	53.87%
		C	0.00%	0.00%	0.00%	0.00%
		D	0.00%	0.00%	0.00%	0.00%
		E	0.00%	0.00%	0.00%	0.00%
		F	0.00%	0.09%	0.62%	1.77%
		G	0.00%	0.00%	0.00%	0.00%
	Hudson	A	74.88%	88.74%	93.06%	96.13%
		B	54.93%	83.28%	89.72%	94.04%
		C	26.66%	70.11%	83.83%	89.19%
		D	7.78%	39.26%	63.36%	77.80%
		E	18.75%	20.01%	36.03%	63.49%
		F	0.87%	1.40%	2.25%	4.28%
		G	2.12%	2.45%	2.83%	3.92%
	Mercer	A	0.00%	0.00%	0.00%	3.28%
		B	0.30%	1.74%	3.95%	9.78%
		C	0.00%	0.00%	0.00%	0.00%
		D	0.06%	0.25%	0.47%	0.71%
		E	0.00%	0.00%	0.00%	0.00%
		F	0.00%	0.00%	0.00%	0.00%
		G	0.00%	0.00%	0.00%	0.00%

Region	County	Evacuation Zone	Percent of Storm Surge Inundation Areas in Evacuation Zones			
			Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Northern Counties	Middlesex	A	25.98%	50.37%	73.59%	98.01%
		B1	20.49%	43.07%	61.25%	70.44%
		B2	11.63%	23.24%	31.89%	41.35%
		C1	17.83%	33.62%	43.46%	50.82%
		C2	1.71%	3.46%	5.93%	10.88%
		D1	9.18%	16.28%	23.60%	46.31%
		D2	0.00%	0.00%	0.00%	0.02%
		E	1.01%	3.98%	9.30%	18.20%
		F1	0.00%	0.01%	0.07%	0.20%
		F2	0.00%	0.30%	0.89%	2.38%
		G1	2.39%	5.69%	8.17%	11.60%
		G2	0.05%	0.21%	1.03%	3.87%
		G3	0.00%	0.00%	0.00%	0.00%
	Monmouth	A	87.91%	99.02%	99.90%	99.98%
		B	0.51%	92.45%	98.78%	100.00%
		C	0.00%	0.11%	95.77%	100.00%
		D	0.00%	0.00%	0.00%	93.11%
		E	0.00%	0.00%	0.00%	0.00%
		F	0.00%	0.00%	0.00%	0.00%
	Passaic	A1	0.49%	23.39%	46.55%	63.09%
		A2	1.35%	9.73%	21.37%	35.61%
		B	0.00%	0.00%	0.00%	0.00%
		C	0.00%	0.00%	0.00%	0.00%
		D	0.00%	0.00%	0.00%	0.00%
		E1	0.00%	0.00%	0.00%	0.00%
		E2	0.00%	0.00%	0.36%	0.83%
		F	0.00%	0.00%	0.00%	0.00%
		G	0.00%	0.00%	0.00%	0.00%
	Somerset	A1	0.09%	0.46%	4.06%	11.16%
		A2	0.00%	0.00%	0.00%	0.00%
		B1	0.00%	0.09%	0.26%	0.70%
		B2	0.00%	0.00%	0.00%	0.18%
		C	0.00%	0.00%	0.00%	0.00%
		D	0.00%	0.00%	0.00%	0.00%

Region	County	Evacuation Zone	Percent of Storm Surge Inundation Areas in Evacuation Zones			
			Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Northern Counties	Union	A	52.64%	84.06%	94.43%	97.16%
		B	31.98%	65.36%	87.25%	97.35%
		C	0.03%	1.16%	9.09%	22.57%
		D1	0.00%	0.00%	0.00%	0.00%
		D2	0.00%	0.00%	0.00%	0.00%
		D3	0.00%	0.00%	0.00%	0.00%
		E	0.00%	0.00%	0.00%	0.00%
		F1	0.00%	0.00%	0.00%	0.00%
		F2	0.00%	0.00%	0.00%	0.00%
		G1	0.00%	0.00%	0.00%	0.00%
		G2	0.00%	0.00%	0.00%	0.00%
Southern Counties	Atlantic	A	67.43%	98.60%	99.66%	99.66%
		B	43.95%	66.79%	81.62%	93.81%
		C1	0.32%	1.44%	3.57%	8.83%
		C2	9.93%	22.11%	32.82%	43.27%
		D	1.77%	5.92%	12.04%	18.92%
		E	0.30%	0.72%	3.25%	8.81%
		F	0.33%	0.64%	2.04%	4.16%
	Burlington	A	1.86%	5.86%	10.10%	15.25%
		B	1.17%	10.70%	20.15%	45.24%
		C	0.06%	0.66%	8.40%	27.94%
		D	0.00%	0.00%	4.53%	17.60%
		E	0.08%	0.99%	3.24%	6.01%
		F	0.00%	0.11%	0.27%	1.98%
		G	0.00%	0.02%	0.06%	0.25%

Region	County	Evacuation Zone	Percent of Storm Surge Inundation Areas in Evacuation Zones			
			Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Southern Counties	Camden	A	10.33%	34.28%	63.43%	80.94%
		B1	10.01%	61.05%	89.36%	98.03%
		B2	2.57%	55.31%	76.15%	91.53%
		C1	3.02%	8.30%	41.99%	84.85%
		C2	2.71%	35.36%	64.44%	84.49%
		C3	2.29%	37.28%	55.85%	76.40%
		D1	0.00%	1.52%	3.53%	16.64%
		D2	0.00%	37.97%	87.37%	100.00%
		D3	1.77%	6.14%	14.44%	31.13%
		D4	0.59%	4.44%	8.60%	16.37%
		D5	0.77%	4.75%	10.55%	20.06%
		E	0.00%	0.00%	0.01%	1.14%
		F	0.00%	0.00%	0.00%	0.00%
	Cape May	A	68.94%	94.52%	98.70%	99.57%
		B	6.29%	24.98%	55.79%	77.59%
		C	0.45%	5.66%	16.50%	22.66%
	Cumberland	A	57.65%	67.65%	82.65%	92.65%
		B	0.00%	0.00%	0.00%	0.00%
		C	0.00%	0.00%	0.00%	0.00%
	Gloucester	A	20.94%	49.69%	71.15%	86.07%
		B	4.40%	28.41%	59.31%	77.21%
		C	0.17%	0.61%	1.28%	2.53%
		D	0.25%	1.18%	3.66%	7.03%
		E	0.00%	0.00%	0.00%	0.00%

Region	County	Evacuation Zone	Percent of Storm Surge Inundation Areas in Evacuation Zones			
			Category 1 Hurricane	Category 2 Hurricane	Category 3 Hurricane	Category 4 Hurricane
Southern Counties	**Ocean**	A1	43.94%	69.69%	86.96%	93.76%
		A2	29.22%	77.48%	99.87%	99.87%
		A3	31.80%	98.34%	99.45%	99.45%
		A4	38.92%	96.22%	99.78%	99.78%
		A5	47.94%	85.09%	93.76%	98.77%
		A6	21.18%	69.04%	99.08%	99.08%
		A7	16.68%	71.51%	99.79%	99.79%
		B1	4.25%	8.45%	16.18%	30.34%
		B2	0.44%	2.83%	8.47%	21.23%
		B3	0.04%	0.97%	7.69%	17.57%
		C1	1.67%	26.43%	74.92%	97.03%
		C2	1.26%	8.55%	24.90%	43.39%
		C3	1.86%	10.21%	17.28%	25.63%
		C4	13.94%	31.04%	49.44%	63.51%
		C5	2.52%	17.42%	59.80%	76.08%
		D	0.00%	0.00%	0.19%	0.71%
		E	0.00%	0.00%	0.02%	0.50%
	Salem	A	24.94%	44.25%	58.83%	71.62%
		B	1.20%	3.66%	6.47%	11.26%
		C	0.00%	0.00%	0.00%	0.00%

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Appendix B

Medium Evacuation Participation Rate Calculation by Hurricane Intensity

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Bergen	Cat 2	A	Inland	34,805	13%	4,351	3%	870	25%	8,701	5%	1,740	33%	11,312	5%	1,740	38%	13,052	8%	2,610
		A	Cat 1	1,223	13%	153	25%	303	25%	306	30%	370	33%	398	39%	471	38%	459	44%	538
		A	Cat 2	6,677	13%	835	13%	835	25%	1,669	25%	1,669	33%	2,170	33%	2,170	38%	2,504	38%	2,504
		A	Cat 3	4,837	13%	605	8%	363	25%	1,209	15%	726	33%	1,572	30%	1,451	38%	1,814	30%	1,451
		A	Cat 4	6,052	13%	757	8%	454	25%	1,513	15%	908	33%	1,967	30%	1,816	38%	2,270	30%	1,816
				53,596	13%	6,699	5%	2,824	25%	13,399	10%	5,413	33%	17,419	14%	7,648	38%	20,098	17%	8,920
	Cat 1	B1,C	Inland	10,889	25%	2,695	3%	272	30%	3,294	5%	544	39%	4,192	5%	544	44%	4,791	8%	817
		B1,C	Cat 1	26,070	25%	6,452	25%	6,452	30%	7,886	30%	7,886	39%	10,037	39%	10,037	44%	11,471	44%	11,471
		B1,C	Cat 2	31,879	25%	7,890	13%	3,985	30%	9,643	25%	7,970	39%	12,273	33%	10,361	44%	14,027	38%	11,955
		B1,C	Cat 3	12,481	25%	3,089	8%	936	30%	3,776	15%	1,872	39%	4,805	30%	3,744	44%	5,492	30%	3,744
		B1,C	Cat 4	6,523	25%	1,614	8%	489	30%	1,973	15%	978	39%	2,511	30%	1,957	44%	2,870	30%	1,957
				87,842	25%	21,741	14%	12,135	30%	26,572	22%	19,251	39%	33,819	30%	26,643	44%	38,650	34%	29,943
	Inland	B2,D,E1,E2,F	Inland	760,210	3%	19,005	3%	19,005	5%	38,011	5%	38,011	5%	38,011	5%	38,011	8%	57,016	8%	57,016
		B2,D,E1,E2,F	Cat 1	570	3%	14	25%	141	5%	29	30%	173	5%	29	39%	220	8%	43	44%	251
		B2,D,E1,E2,F	Cat 2	931	3%	23	13%	116	5%	47	25%	233	5%	47	33%	303	8%	70	38%	349
		B2,D,E1,E2,F	Cat 3	6,390	3%	160	8%	479	5%	320	15%	959	5%	320	30%	1,917	8%	479	30%	1,917
		B2,D,E1,E2,F	Cat 4	30,045	3%	751	8%	2,253	5%	1,502	15%	4,507	5%	1,502	30%	9,013	8%	2,253	30%	9,013
				798,147	3%	19,954	3%	21,995	5%	39,907	5%	43,881	5%	39,907	6%	49,463	8%	59,861	9%	68,547

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Essex	Cat 1	A,B	Inland	10,314	25%	2,553	3%	258	30%	3,120	5%	516	39%	3,971	5%	516	44%	4,538	8%	774
		A,B	Cat 1	14,731	25%	3,646	25%	3,646	30%	4,456	30%	4,456	39%	5,671	39%	5,671	44%	6,482	44%	6,482
		A,B	Cat 2	30,264	25%	7,490	13%	3,783	30%	9,155	25%	7,566	39%	11,652	33%	9,836	44%	13,316	38%	11,349
		A,B	Cat 3	16,905	25%	4,184	8%	1,268	30%	5,114	15%	2,536	39%	6,509	30%	5,072	44%	7,438	30%	5,072
		A,B	Cat 4	6,038	25%	1,494	8%	453	30%	1,827	15%	906	39%	2,325	30%	1,811	44%	2,657	30%	1,811
				78,253	25%	19,368	12%	9,408	30%	23,671	20%	15,979	39%	30,127	29%	22,906	44%	34,431	33%	25,487
	Inland	C,D,E,F,G	Inland	719,869	3%	17,997	3%	17,997	5%	35,993	5%	35,993	5%	35,993	5%	35,993	8%	53,990	8%	53,990
		C,D,E,F,G	Cat 1	0	3%	0	25%	0	5%	0	30%	0	5%	0	39%	0	8%	0	44%	0
		C,D,E,F,G	Cat 2	154	3%	4	13%	19	5%	8	25%	38	5%	8	33%	50	8%	12	38%	58
		C,D,E,F,G	Cat 3	1,360	3%	34	8%	102	5%	68	15%	204	5%	68	30%	408	8%	102	30%	408
		C,D,E,F,G	Cat 4	3,262	3%	82	8%	245	5%	163	15%	489	5%	163	30%	979	8%	245	30%	979
				724,645	3%	18,116	3%	18,363	5%	36,232	5%	36,725	5%	36,232	5%	37,430	8%	54,348	8%	55,434

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Hudson	Cat 1	A,B,C	Inland	12,428	25%	3,076	3%	311	30%	3,759	5%	621	39%	4,785	5%	621	44%	5,468	8%	932
		A,B,C	Cat 1	134,775	25%	33,357	25%	33,357	30%	40,769	30%	40,769	39%	51,888	39%	51,888	44%	59,301	44%	59,301
		A,B,C	Cat 2	42,267	25%	10,461	13%	5,283	30%	12,786	25%	10,567	39%	16,273	33%	13,737	44%	18,597	38%	15,850
		A,B,C	Cat 3	13,931	25%	3,448	8%	1,045	30%	4,214	15%	2,090	39%	5,363	30%	4,179	44%	6,130	30%	4,179
		A,B,C	Cat 4	7,111	25%	1,760	8%	533	30%	2,151	15%	1,067	39%	2,738	30%	2,133	44%	3,129	30%	2,133
				210,512	25%	52,102	19%	40,529	30%	63,680	26%	55,114	39%	81,047	34%	72,559	44%	92,625	39%	82,396
	Cat 2	D	Inland	7,890	13%	986	3%	197	25%	1,972	5%	394	33%	2,564	5%	394	38%	2,959	8%	592
		D	Cat 1	2,580	13%	322	25%	638	25%	645	30%	780	33%	838	39%	993	38%	967	44%	1,135
		D	Cat 2	10,067	13%	1,258	13%	1,258	25%	2,517	25%	2,517	33%	3,272	33%	3,272	38%	3,775	38%	3,775
		D	Cat 3	8,743	13%	1,093	8%	656	25%	2,186	15%	1,311	33%	2,841	30%	2,623	38%	3,278	30%	2,623
		D	Cat 4	5,519	13%	690	8%	414	25%	1,380	15%	828	33%	1,794	30%	1,656	38%	2,070	30%	1,656
				34,798	13%	4,350	9%	3,164	25%	8,699	17%	5,831	33%	11,309	26%	8,938	38%	13,049	28%	9,780
	Cat 3	E	Inland	8,932	8%	670	3%	223	15%	1,340	5%	447	30%	2,680	5%	447	30%	2,680	8%	670
		E	Cat 1	4,775	8%	358	25%	1,182	15%	716	30%	1,444	30%	1,433	39%	1,838	30%	1,433	44%	2,101
		E	Cat 2	418	8%	31	13%	52	15%	63	25%	104	30%	125	33%	136	30%	125	38%	157
		E	Cat 3	4,163	8%	312	8%	312	15%	624	15%	624	30%	1,249	30%	1,249	30%	1,249	30%	1,249
		E	Cat 4	7,517	8%	564	8%	564	15%	1,128	15%	1,128	30%	2,255	30%	2,255	30%	2,255	30%	2,255
				25,806	8%	1,935	9%	2,333	15%	3,871	15%	3,748	30%	7,742	23%	5,925	30%	7,742	25%	6,432
	Cat 4	F,G	Inland	400,818	8%	30,061	3%	10,020	15%	60,123	5%	20,041	30%	120,245	5%	20,041	30%	120,245	8%	30,061
		F,G	Cat 1	4,529	8%	340	25%	1,121	15%	679	30%	1,370	30%	1,359	39%	1,744	30%	1,359	44%	1,993
		F,G	Cat 2	1,093	8%	82	13%	137	15%	164	25%	273	30%	328	33%	355	30%	328	38%	410
		F,G	Cat 3	1,342	8%	101	8%	101	15%	201	15%	201	30%	403	30%	403	30%	403	30%	403
		F,G	Cat 4	3,333	8%	250	8%	250	15%	500	15%	500	30%	1,000	30%	1,000	30%	1,000	30%	1,000
				411,114	8%	30,834	3%	11,629	15%	61,667	5%	22,385	30%	123,334	6%	23,542	30%	123,334	8%	33,866

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Mercer	Cat 4	A	Inland	1,003	8%	75	3%	25	15%	150	5%	50	30%	301	5%	50	30%	301	8%	75
		A	Cat 1	0	8%	0	25%	0	15%	0	30%	0	30%	0	39%	0	30%	0	44%	0
		A	Cat 2	0	8%	0	13%	0	15%	0	25%	0	30%	0	33%	0	30%	0	38%	0
		A	Cat 3	0	8%	0	8%	0	15%	0	15%	0	30%	0	30%	0	30%	0	30%	0
		A	Cat 4	31	8%	2	8%	2	15%	5	15%	5	30%	9	30%	9	30%	9	30%	9
				1,034	8%	78	3%	27	15%	155	5%	55	30%	310	6%	59	30%	310	8%	84
	Cat 2	B	Inland	17,130	13%	2,141	3%	428	25%	4,282	5%	856	33%	5,567	5%	856	38%	6,424	8%	1,285
		B	Cat 1	10	13%	1	25%	2	25%	2	30%	3	33%	3	39%	4	38%	4	44%	4
		B	Cat 2	47	13%	6	13%	6	25%	12	25%	12	33%	15	33%	15	38%	18	38%	18
		B	Cat 3	101	13%	13	8%	8	25%	25	15%	15	33%	33	30%	30	38%	38	30%	30
		B	Cat 4	318	13%	40	8%	24	25%	80	15%	48	33%	103	30%	95	38%	119	30%	95
				17,605	13%	2,201	3%	468	25%	4,401	5%	934	33%	5,722	6%	1,001	38%	6,602	8%	1,432
	Inland	C,D,E,F,G	Inland	359,617	3%	8,990	3%	8,990	5%	17,981	5%	17,981	5%	17,981	5%	17,981	8%	26,971	8%	26,971
		C,D,E,F,G	Cat 1	48	3%	1	25%	12	5%	2	30%	15	5%	2	39%	18	8%	4	44%	21
		C,D,E,F,G	Cat 2	192	3%	5	13%	24	5%	10	25%	48	5%	10	33%	62	8%	14	38%	72
		C,D,E,F,G	Cat 3	273	3%	7	8%	21	5%	14	15%	41	5%	14	30%	82	8%	21	30%	82
		C,D,E,F,G	Cat 4	319	3%	8	8%	24	5%	16	15%	48	5%	16	30%	96	8%	24	30%	96
				360,449	3%	9,011	3%	9,071	5%	18,022	5%	18,132	5%	18,022	5%	18,239	8%	27,034	8%	27,242

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Middlesex	Cat 1	A,B,C1,D1	Inland	84,214	25%	20,843	3%	2,105	30%	25,475	5%	4,211	39%	32,422	5%	4,211	44%	37,054	8%	6,316
		A,B,C1,D1	Cat 1	22,631	25%	5,601	25%	5,601	30%	6,846	30%	6,846	39%	8,713	39%	8,713	44%	9,958	44%	9,958
		A,B,C1,D1	Cat 2	26,815	25%	6,637	13%	3,352	30%	8,112	25%	6,704	39%	10,324	33%	8,715	44%	11,799	38%	10,056
		A,B,C1,D1	Cat 3	24,173	25%	5,983	8%	1,813	30%	7,312	15%	3,626	39%	9,306	30%	7,252	44%	10,636	30%	7,252
		A,B,C1,D1	Cat 4	25,757	25%	6,375	8%	1,932	30%	7,792	15%	3,864	39%	9,917	30%	7,727	44%	11,333	30%	7,727
				183,591	25%	45,439	8%	14,803	30%	55,536	14%	25,250	39%	70,682	20%	36,618	44%	80,780	23%	41,309
	Cat 2	C2,G1	Inland	87,637	13%	10,955	3%	2,191	25%	21,909	5%	4,382	33%	28,482	5%	4,382	38%	32,864	8%	6,573
		C2,G1	Cat 1	1,572	13%	196	25%	389	25%	393	30%	476	33%	511	39%	605	38%	589	44%	692
		C2,G1	Cat 2	1,962	13%	245	13%	245	25%	490	25%	490	33%	638	33%	638	38%	736	38%	736
		C2,G1	Cat 3	1,920	13%	240	8%	144	25%	480	15%	288	33%	624	30%	576	38%	720	30%	576
		C2,G1	Cat 4	3,406	13%	426	8%	255	25%	852	15%	511	33%	1,107	30%	1,022	38%	1,277	30%	1,022
				96,497	13%	12,062	3%	3,225	25%	24,124	6%	6,147	33%	31,361	7%	7,222	38%	36,186	10%	9,598
	Inland	D2,F1,F2,G2,G3	Inland	478,620	3%	11,965	3%	11,965	5%	23,931	5%	23,931	5%	23,931	5%	23,931	8%	35,896	8%	35,896
		D2,F1,F2,G2,G3	Cat 1	18	3%	0	25%	4	5%	1	30%	5	5%	1	39%	7	8%	1	44%	8
		D2,F1,F2,G2,G3	Cat 2	460	3%	11	13%	57	5%	23	25%	115	5%	23	33%	149	8%	34	38%	172
		D2,F1,F2,G2,G3	Cat 3	1,188	3%	30	8%	89	5%	59	15%	178	5%	59	30%	356	8%	89	30%	356
		D2,F1,F2,G2,G3	Cat 4	4,472	3%	112	8%	335	5%	224	15%	671	5%	224	30%	1,342	8%	335	30%	1,342
				484,757	3%	12,119	3%	12,452	5%	24,238	5%	24,900	5%	24,238	5%	25,785	8%	36,357	8%	37,774
	Cat 2	E	Inland	69,924	13%	8,741	3%	1,748	25%	17,481	5%	3,496	33%	22,725	5%	3,496	38%	26,222	8%	5,244
		E	Cat 1	1,071	13%	134	25%	265	25%	268	30%	324	33%	348	39%	412	38%	401	44%	471
		E	Cat 2	1,762	13%	220	13%	220	25%	441	25%	441	33%	573	33%	573	38%	661	38%	661
		E	Cat 3	3,779	13%	472	8%	283	25%	945	15%	567	33%	1,228	30%	1,134	38%	1,417	30%	1,134
		E	Cat 4	6,688	13%	836	8%	502	25%	1,672	15%	1,003	33%	2,174	30%	2,006	38%	2,508	30%	2,006
				83,224	13%	10,403	4%	3,018	25%	20,806	7%	5,831	33%	27,048	9%	7,621	38%	31,209	11%	9,516

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Monmouth	Cat 1	A	Inland	1	25%	0	3%	0	30%	0	5%	0	39%	1	5%	0	44%	1	8%	0
		A	Cat 1	48,917	25%	12,107	25%	12,107	30%	14,797	30%	14,797	39%	18,833	39%	18,833	44%	21,524	44%	21,524
		A	Cat 2	4,589	25%	1,136	13%	574	30%	1,388	25%	1,147	39%	1,767	33%	1,491	44%	2,019	38%	1,721
		A	Cat 3	402	25%	100	8%	30	30%	122	15%	60	39%	155	30%	121	44%	177	30%	121
		A	Cat 4	3	25%	1	8%	0	30%	1	15%	0	39%	1	30%	1	44%	1	30%	1
				53,912	25%	13,343	24%	12,711	30%	16,309	30%	16,005	39%	20,756	38%	20,446	44%	23,721	43%	23,366
	Cat 2	B	Inland	0	13%	0	3%	0	25%	0	5%	0	33%	0	5%	0	38%	0	8%	0
		B	Cat 1	115	13%	14	25%	29	25%	29	30%	35	33%	37	39%	44	38%	43	44%	51
		B	Cat 2	37,800	13%	4,725	13%	4,725	25%	9,450	25%	9,450	33%	12,285	33%	12,285	38%	14,175	38%	14,175
		B	Cat 3	3,505	13%	438	8%	263	25%	876	15%	526	33%	1,139	30%	1,051	38%	1,314	30%	1,051
		B	Cat 4	331	13%	41	8%	25	25%	83	15%	50	33%	108	30%	99	38%	124	30%	99
				41,751	13%	5,219	12%	5,041	25%	10,438	24%	10,060	33%	13,569	32%	13,480	38%	15,657	37%	15,376
	Cat 3	C	Inland	0	8%	0	3%	0	15%	0	5%	0	30%	0	5%	0	30%	0	8%	0
		C	Cat 1	0	8%	0	25%	0	15%	0	30%	0	30%	0	39%	0	30%	0	44%	0
		C	Cat 2	25	8%	2	13%	3	15%	4	25%	6	30%	7	33%	8	30%	7	38%	9
		C	Cat 3	38,927	8%	2,920	8%	2,920	15%	5,839	15%	5,839	30%	11,678	30%	11,678	30%	11,678	30%	11,678
		C	Cat 4	1,630	8%	122	8%	122	15%	245	15%	245	30%	489	30%	489	30%	489	30%	489
				40,582	8%	3,044	8%	3,045	15%	6,087	15%	6,090	30%	12,175	30%	12,175	30%	12,175	30%	12,176
	Cat 4	D	Inland	4,620	8%	346	3%	115	15%	693	5%	231	30%	1,386	5%	231	30%	1,386	8%	346
		D	Cat 1	0	8%	0	25%	0	15%	0	30%	0	30%	0	39%	0	30%	0	44%	0
		D	Cat 2	7	8%	1	13%	1	15%	1	25%	2	30%	2	33%	2	30%	2	38%	3
		D	Cat 3	183	8%	14	8%	14	15%	27	15%	27	30%	55	30%	55	30%	55	30%	55
		D	Cat 4	37,324	8%	2,799	8%	2,799	15%	5,599	15%	5,599	30%	11,197	30%	11,197	30%	11,197	30%	11,197
				42,134	8%	3,160	7%	2,929	15%	6,320	14%	5,859	30%	12,640	27%	11,485	30%	12,640	28%	11,601
	Inland	E,F	Inland	475,037	3%	11,876	3%	11,876	5%	23,752	5%	23,752	5%	23,752	5%	23,752	8%	35,628	8%	35,628
		E,F	Cat 1	0	3%	0	25%	0	5%	0	30%	0	5%	0	39%	0	8%	0	44%	0
		E,F	Cat 2	0	3%	0	13%	0	5%	0	25%	0	5%	0	33%	0	8%	0	38%	0
		E,F	Cat 3	1	3%	0	8%	0	5%	0	15%	0	5%	0	30%	0	8%	0	30%	0
		E,F	Cat 4	13	3%	0	8%	1	5%	1	15%	2	5%	1	30%	4	8%	1	30%	4
				475,050	3%	11,876	3%	11,877	5%	23,753	5%	23,754	5%	23,753	5%	23,756	8%	35,629	8%	35,632

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Passaic	Cat 1	A	Inland	6,696	25%	1,657	3%	167	30%	2,026	5%	335	39%	2,578	5%	335	44%	2,946	8%	502
		A	Cat 1	90	25%	22	25%	22	30%	27	30%	27	39%	34	39%	34	44%	39	44%	39
		A	Cat 2	2,329	25%	576	13%	291	30%	704	25%	582	39%	897	33%	757	44%	1,025	38%	873
		A	Cat 3	2,623	25%	649	8%	197	30%	794	15%	394	39%	1,010	30%	787	44%	1,154	30%	787
		A	Cat 4	2,612	25%	646	8%	196	30%	790	15%	392	39%	1,006	30%	784	44%	1,149	30%	784
				14,350	25%	3,552	6%	873	30%	4,341	12%	1,729	39%	5,525	19%	2,697	44%	6,314	21%	2,986
	Inland	B,C,D,E,F,G	Inland	500,692	3%	12,517	3%	12,517	5%	25,035	5%	25,035	5%	25,035	5%	25,035	8%	37,552	8%	37,552
		B,C,D,E,F,G	Cat 1	0	3%	0	25%	0	5%	0	30%	0	5%	0	39%	0	8%	0	44%	0
		B,C,D,E,F,G	Cat 2	2	3%	0	13%	0	5%	0	25%	0	5%	0	33%	1	8%	0	38%	1
		B,C,D,E,F,G	Cat 3	397	3%	10	8%	30	5%	20	15%	60	5%	20	30%	119	8%	30	30%	119
		B,C,D,E,F,G	Cat 4	1,233	3%	31	8%	92	5%	62	15%	185	5%	62	30%	370	8%	92	30%	370
				502,324	3%	12,558	3%	12,640	5%	25,116	5%	25,280	5%	25,116	5%	25,524	8%	37,674	8%	38,042

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Somerset	Cat 3	A1	Inland	68,883	8%	5,166	3%	1,722	15%	10,332	5%	3,444	30%	20,665	5%	3,444	30%	20,665	8%	5,166
		A1	Cat 1	85	8%	6	25%	21	15%	13	30%	26	30%	25	39%	33	30%	25	44%	37
		A1	Cat 2	345	8%	26	13%	43	15%	52	25%	86	30%	104	33%	112	30%	104	38%	130
		A1	Cat 3	2,986	8%	224	8%	224	15%	448	15%	448	30%	896	30%	896	30%	896	30%	896
		A1	Cat 4	5,319	8%	399	8%	399	15%	798	15%	798	30%	1,596	30%	1,596	30%	1,596	30%	1,596
				77,619	8%	5,821	3%	2,409	15%	11,643	6%	4,802	30%	23,286	8%	6,081	30%	23,286	10%	7,825
	Inland	A2,B,C,D	Inland	257,542	3%	6,439	3%	6,439	5%	12,877	5%	12,877	5%	12,877	5%	12,877	8%	19,316	8%	19,316
		A2,B,C,D	Cat 1	0	3%	0	25%	0	5%	0	30%	0	5%	0	39%	0	8%	0	44%	0
		A2,B,C,D	Cat 2	59	3%	1	13%	7	5%	3	25%	15	5%	3	33%	19	8%	4	38%	22
		A2,B,C,D	Cat 3	227	3%	6	8%	17	5%	11	15%	34	5%	11	30%	68	8%	17	30%	68
		A2,B,C,D	Cat 4	702	3%	18	8%	53	5%	35	15%	105	5%	35	30%	211	8%	53	30%	211
				258,530	3%	6,463	3%	6,516	5%	12,926	5%	13,031	5%	12,926	5%	13,175	8%	19,390	8%	19,616

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Union	Cat 1	A,B	Inland	6,972	25%	1,726	3%	174	30%	2,109	5%	349	39%	2,684	5%	349	44%	3,068	8%	523
		A,B	Cat 1	10,635	25%	2,632	25%	2,632	30%	3,217	30%	3,217	39%	4,095	39%	4,095	44%	4,679	44%	4,679
		A,B	Cat 2	19,891	25%	4,923	13%	2,486	30%	6,017	25%	4,973	39%	7,658	33%	6,465	44%	8,752	38%	7,459
		A,B	Cat 3	21,503	25%	5,322	8%	1,613	30%	6,505	15%	3,225	39%	8,278	30%	6,451	44%	9,461	30%	6,451
		A,B	Cat 4	19,057	25%	4,717	8%	1,429	30%	5,765	15%	2,859	39%	7,337	30%	5,717	44%	8,385	30%	5,717
				78,058	25%	19,319	11%	8,335	30%	23,612	19%	14,622	39%	30,052	30%	23,076	44%	34,345	32%	24,829
	Cat 3	C	Inland	161,242	8%	12,093	3%	4,031	15%	24,186	5%	8,062	30%	48,373	5%	8,062	30%	48,373	8%	12,093
		C	Cat 1	14	8%	1	25%	3	15%	2	30%	4	30%	4	39%	5	30%	4	44%	6
		C	Cat 2	1,802	8%	135	13%	225	15%	270	25%	450	30%	541	33%	586	30%	541	38%	676
		C	Cat 3	15,563	8%	1,167	8%	1,167	15%	2,335	15%	2,335	30%	4,669	30%	4,669	30%	4,669	30%	4,669
		C	Cat 4	33,410	8%	2,506	8%	2,506	15%	5,011	15%	5,011	30%	10,023	30%	10,023	30%	10,023	30%	10,023
				212,030	8%	15,902	4%	7,933	15%	31,805	7%	15,863	30%	63,609	11%	23,345	30%	63,609	13%	27,467
	Inland	D,E,F,G	Inland	268,748	3%	6,719	3%	6,719	5%	13,437	5%	13,437	5%	13,437	5%	13,437	8%	20,156	8%	20,156
		D,E,F,G	Cat 1	0	3%	0	25%	0	5%	0	30%	0	5%	0	39%	0	8%	0	44%	0
		D,E,F,G	Cat 2	0	3%	0	13%	0	5%	0	25%	0	5%	0	33%	0	8%	0	38%	0
		D,E,F,G	Cat 3	0	3%	0	8%	0	5%	0	15%	0	5%	0	30%	0	8%	0	30%	0
		D,E,F,G	Cat 4	0	3%	0	8%	0	5%	0	15%	0	5%	0	30%	0	8%	0	30%	0
				268,748	3%	6,719	3%	6,719	5%	13,437	5%	13,437	5%	13,437	5%	13,437	8%	20,156	8%	20,156

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Atlantic	Cat 1	A	Inland	56	40%	22	3%	2	48%	27	6%	3	60%	33	6%	3	64%	36	8%	5
		A	Cat 1	8,822	40%	3,529	40%	3,529	48%	4,235	48%	4,235	60%	5,293	60%	5,293	64%	5,646	64%	5,646
		A	Cat 2	4,644	40%	1,858	25%	1,138	48%	2,229	35%	1,625	60%	2,786	49%	2,276	64%	2,972	53%	2,438
		A	Cat 3	133	40%	53	9%	12	48%	64	21%	28	60%	80	36%	48	64%	85	39%	52
		A	Cat 4	0	40%	0	9%	0	48%	0	21%	0	60%	0	36%	0	64%	0	39%	0
				13,655	40%	5,462	34%	4,680	48%	6,554	43%	5,891	60%	8,193	56%	7,620	64%	8,739	60%	8,141
	Cat 1	B,C2	Inland	5,536	40%	2,214	3%	152	48%	2,657	6%	304	60%	3,322	6%	304	64%	3,543	8%	457
		B,C2	Cat 1	58,129	40%	23,252	40%	23,252	48%	27,902	48%	27,902	60%	34,878	60%	34,878	64%	37,203	64%	37,203
		B,C2	Cat 2	18,991	40%	7,596	25%	4,653	48%	9,116	35%	6,647	60%	11,395	49%	9,306	64%	12,154	53%	9,970
		B,C2	Cat 3	3,685	40%	1,474	9%	332	48%	1,769	21%	774	60%	2,211	36%	1,327	64%	2,358	39%	1,437
		B,C2	Cat 4	3,173	40%	1,269	9%	286	48%	1,523	21%	666	60%	1,904	36%	1,142	64%	2,031	39%	1,238
				89,515	40%	35,806	32%	28,674	48%	42,967	41%	36,294	60%	53,709	52%	46,957	64%	57,289	56%	50,304
	Cat 3	C1	Inland	2,318	9%	209	3%	64	21%	487	6%	128	36%	835	6%	128	39%	904	8%	191
		C1	Cat 1	8	9%	1	40%	3	21%	2	48%	4	36%	3	60%	5	39%	3	64%	5
		C1	Cat 2	29	9%	3	25%	7	21%	6	35%	10	36%	11	49%	14	39%	11	53%	15
		C1	Cat 3	56	9%	5	9%	5	21%	12	21%	12	36%	20	36%	20	39%	22	39%	22
		C1	Cat 4	136	9%	12	9%	12	21%	29	21%	29	36%	49	36%	49	39%	53	39%	53
				2,548	9%	229	4%	92	21%	535	7%	182	36%	917	8%	216	39%	994	11%	287
	Cat 1	D	Inland	89,494	40%	35,798	3%	2,461	48%	42,957	6%	4,922	60%	53,696	6%	4,922	64%	57,276	8%	7,383
		D	Cat 1	4,752	40%	1,901	40%	1,901	48%	2,281	48%	2,281	60%	2,851	60%	2,851	64%	3,041	64%	3,041
		D	Cat 2	9,565	40%	3,826	25%	2,344	48%	4,591	35%	3,348	60%	5,739	49%	4,687	64%	6,122	53%	5,022
		D	Cat 3	11,561	40%	4,624	9%	1,040	48%	5,549	21%	2,428	60%	6,936	36%	4,162	64%	7,399	39%	4,509
		D	Cat 4	12,106	40%	4,842	9%	1,090	48%	5,811	21%	2,542	60%	7,263	36%	4,358	64%	7,748	39%	4,721
				127,478	40%	50,991	7%	8,835	48%	61,190	12%	15,521	60%	76,487	16%	20,981	64%	81,586	19%	24,676
	Cat 3	E	Inland	28,802	9%	2,592	3%	792	21%	6,048	6%	1,584	36%	10,369	6%	1,584	39%	11,233	8%	2,376
		E	Cat 1	96	9%	9	40%	38	21%	20	48%	46	36%	34	60%	57	39%	37	64%	61
		E	Cat 2	248	9%	22	25%	61	21%	52	35%	87	36%	89	49%	121	39%	97	53%	130
		E	Cat 3	2,012	9%	181	9%	181	21%	423	21%	423	36%	724	36%	724	39%	785	39%	785
		E	Cat 4	3,198	9%	288	9%	288	21%	672	21%	672	36%	1,151	36%	1,151	39%	1,247	39%	1,247
				34,355	9%	3,092	4%	1,360	21%	7,215	8%	2,811	36%	12,368	11%	3,638	39%	13,399	13%	4,599
	Cat 3	F	Inland	36,207	9%	3,259	3%	996	21%	7,603	6%	1,991	36%	13,034	6%	1,991	39%	14,121	8%	2,987
		F	Cat 1	61	9%	5	40%	24	21%	13	48%	29	36%	22	60%	36	39%	24	64%	39
		F	Cat 2	54	9%	5	25%	13	21%	11	35%	19	36%	20	49%	27	39%	21	53%	29
		F	Cat 3	216	9%	19	9%	19	21%	45	21%	45	36%	78	36%	78	39%	84	39%	84
		F	Cat 4	355	9%	32	9%	32	21%	75	21%	75	36%	128	36%	128	39%	139	39%	139
				36,893	9%	3,320	3%	1,085	21%	7,748	6%	2,159	36%	13,281	6%	2,260	39%	14,388	9%	3,277

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Burlington	Cat 1	A	Inland	1,927	40%	771	3%	53	48%	925	6%	106	60%	1,156	6%	106	64%	1,233	8%	159
		A	Cat 1	42	40%	17	40%	17	48%	20	48%	20	60%	25	60%	25	64%	27	64%	27
		A	Cat 2	91	40%	36	25%	22	48%	44	35%	32	60%	54	49%	44	64%	58	53%	48
		A	Cat 3	96	40%	38	9%	9	48%	46	21%	20	60%	58	36%	35	64%	61	39%	37
		A	Cat 4	117	40%	47	9%	11	48%	56	21%	25	60%	70	36%	42	64%	75	39%	46
				2,272	40%	909	5%	111	48%	1,091	9%	203	60%	1,363	11%	252	64%	1,454	14%	317
	Cat 1	B	Inland	16,220	40%	6,488	3%	446	48%	7,786	6%	892	60%	9,732	6%	892	64%	10,381	8%	1,338
		B	Cat 1	387	40%	155	40%	155	48%	186	48%	186	60%	232	60%	232	64%	247	64%	247
		B	Cat 2	3,913	40%	1,565	25%	959	48%	1,878	35%	1,370	60%	2,348	49%	1,917	64%	2,504	53%	2,054
		B	Cat 3	5,246	40%	2,098	9%	472	48%	2,518	21%	1,102	60%	3,147	36%	1,888	64%	3,357	39%	2,046
		B	Cat 4	11,706	40%	4,682	9%	1,054	48%	5,619	21%	2,458	60%	7,024	36%	4,214	64%	7,492	39%	4,565
				37,472	40%	14,989	8%	3,085	48%	17,986	16%	6,007	60%	22,483	24%	9,144	64%	23,982	27%	10,251
	Cat 3	C,D,E	Inland	32,418	9%	2,918	3%	891	21%	6,808	6%	1,783	36%	11,670	6%	1,783	39%	12,643	8%	2,674
		C,D,E	Cat 1	14	9%	1	40%	6	21%	3	48%	7	36%	5	60%	8	39%	5	64%	9
		C,D,E	Cat 2	184	9%	17	25%	45	21%	39	35%	64	36%	66	49%	90	39%	72	53%	96
		C,D,E	Cat 3	4,642	9%	418	9%	418	21%	975	21%	975	36%	1,671	36%	1,671	39%	1,810	39%	1,810
		C,D,E	Cat 4	9,335	9%	840	9%	840	21%	1,960	21%	1,960	36%	3,361	36%	3,361	39%	3,641	39%	3,641
				46,592	9%	4,193	5%	2,200	21%	9,784	10%	4,789	36%	16,773	15%	6,913	39%	18,171	18%	8,231
	Inland	G,F	Inland	366,408	3%	10,076	3%	10,076	6%	20,152	6%	20,152	6%	20,152	6%	20,152	8%	30,229	8%	30,229
		G,F	Cat 1	51	3%	1	40%	20	6%	3	48%	24	6%	3	60%	30	8%	4	64%	32
		G,F	Cat 2	470	3%	13	25%	115	6%	26	35%	165	6%	26	49%	230	8%	39	53%	247
		G,F	Cat 3	911	3%	25	9%	82	6%	50	21%	191	6%	50	36%	328	8%	75	39%	355
		G,F	Cat 4	6,092	3%	168	9%	548	6%	335	21%	1,279	6%	335	36%	2,193	8%	503	39%	2,376
				373,933	3%	10,283	3%	10,842		20,566		21,812		20,566		22,935		30,849		33,239

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Camden	Cat 1	A,B,C	Inland	10,132	40%	4,053	3%	279	48%	4,863	6%	557	60%	6,079	6%	557	64%	6,484	8%	836
		A,B,C	Cat 1	1,654	40%	661	40%	661	48%	794	48%	794	60%	992	60%	992	64%	1,058	64%	1,058
		A,B,C	Cat 2	18,207	40%	7,283	25%	4,461	48%	8,739	35%	6,373	60%	10,924	49%	8,922	64%	11,653	53%	9,559
		A,B,C	Cat 3	19,389	40%	7,756	9%	1,745	48%	9,307	21%	4,072	60%	11,633	36%	6,980	64%	12,409	39%	7,562
		A,B,C	Cat 4	14,520	40%	5,808	9%	1,307	48%	6,970	21%	3,049	60%	8,712	36%	5,227	64%	9,293	39%	5,663
				63,902	40%	25,561	13%	8,453	48%	30,673	23%	14,845	60%	38,341	35%	22,678	64%	40,897	39%	24,678
	Cat 2	D	Inland	140,744	25%	34,482	3%	3,870	35%	49,261	6%	7,741	49%	68,965	6%	7,741	53%	73,891	8%	11,611
		D	Cat 1	928	25%	227	40%	371	35%	325	48%	446	49%	455	60%	557	53%	487	64%	594
		D	Cat 2	6,587	25%	1,614	25%	1,614	35%	2,306	35%	2,306	49%	3,228	49%	3,228	53%	3,458	53%	3,458
		D	Cat 3	8,801	25%	2,156	9%	792	35%	3,080	21%	1,848	49%	4,313	36%	3,168	53%	4,621	39%	3,432
		D	Cat 4	15,429	25%	3,780	9%	1,389	35%	5,400	21%	3,240	49%	7,560	36%	5,555	53%	8,100	39%	6,017
				172,490	25%	42,260	5%	8,036	35%	60,372	9%	15,580	49%	84,520	12%	20,249	53%	90,557	15%	25,114
	Inland	E,F	Inland	275,901	3%	7,587	3%	7,587	6%	15,175	6%	15,175	6%	15,175	6%	15,175	8%	22,762	8%	22,762
		E,F	Cat 1	7	3%	0	40%	3	6%	0	48%	4	6%	0	60%	4	8%	1	64%	5
		E,F	Cat 2	12	3%	0	25%	3	6%	1	35%	4	6%	1	49%	6	8%	1	53%	6
		E,F	Cat 3	17	3%	0	9%	2	6%	1	21%	4	6%	1	36%	6	8%	1	39%	7
		E,F	Cat 4	2,997	3%	82	9%	270	6%	165	21%	629	6%	165	36%	1,079	8%	247	39%	1,169
				278,934	3%	7,671	3%	7,864	6%	15,341	6%	15,815	6%	15,341	6%	16,270	8%	23,012	9%	23,948

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Cape May	Cat 1	A	Inland	229	40%	91	3%	6	48%	110	6%	13	60%	137	6%	13	64%	146	8%	19
		A	Cat 1	45,387	40%	18,155	40%	18,155	48%	21,786	48%	21,786	60%	27,232	60%	27,232	64%	29,048	64%	29,048
		A	Cat 2	9,472	40%	3,789	25%	2,321	48%	4,546	35%	3,315	60%	5,683	49%	4,641	64%	6,062	53%	4,973
		A	Cat 3	767	40%	307	9%	69	48%	368	21%	161	60%	460	36%	276	64%	491	39%	299
		A	Cat 4	108	40%	43	9%	10	48%	52	21%	23	60%	65	36%	39	64%	69	39%	42
				55,963	40%	22,385	37%	20,560	48%	26,862	45%	25,297	60%	33,578	58%	32,201	64%	35,816	61%	34,381
	Cat 1	B	Inland	7,830	40%	3,132	3%	215	48%	3,759	6%	431	60%	4,698	6%	431	64%	5,011	8%	646
		B	Cat 1	4,802	40%	1,921	40%	1,921	48%	2,305	48%	2,305	60%	2,881	60%	2,881	64%	3,073	64%	3,073
		B	Cat 2	14,593	40%	5,837	25%	3,575	48%	7,005	35%	5,108	60%	8,756	49%	7,151	64%	9,340	53%	7,661
		B	Cat 3	21,757	40%	8,703	9%	1,958	48%	10,443	21%	4,569	60%	13,054	36%	7,832	64%	13,924	39%	8,485
		B	Cat 4	13,866	40%	5,546	9%	1,248	48%	6,656	21%	2,912	60%	8,320	36%	4,992	64%	8,874	39%	5,408
				62,848	40%	25,139	14%	8,917	48%	30,167	24%	15,324	60%	37,709	37%	23,287	64%	40,223	40%	25,273
	Cat 2	C	Inland	1,614	25%	395	3%	44	35%	565	6%	89	49%	791	6%	89	53%	847	8%	133
		C	Cat 1	7	25%	2	40%	3	35%	2	48%	3	49%	3	60%	4	53%	4	64%	5
		C	Cat 2	82	25%	20	25%	20	35%	29	35%	29	49%	40	49%	40	53%	43	53%	43
		C	Cat 3	172	25%	42	9%	16	35%	60	21%	36	49%	85	36%	62	53%	91	39%	67
		C	Cat 4	111	25%	27	9%	10	35%	39	21%	23	49%	54	36%	40	53%	58	39%	43
				1,986	25%	487	5%	93	35%	695	9%	180	49%	973	12%	235	53%	1,043	15%	291

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Cumberland	Cat 1	A	Inland	92	40%	37	3%	3	48%	44	6%	5	60%	55	6%	5	64%	59	8%	8
		A	Cat 1	4,817	40%	1,927	40%	1,927	48%	2,312	48%	2,312	60%	2,890	60%	2,890	64%	3,083	64%	3,083
		A	Cat 2	6,524	40%	2,610	25%	1,598	48%	3,131	35%	2,283	60%	3,914	49%	3,197	64%	4,175	53%	3,425
		A	Cat 3	4,374	40%	1,750	9%	394	48%	2,099	21%	918	60%	2,624	36%	1,575	64%	2,799	39%	1,706
		A	Cat 4	4,985	40%	1,994	9%	449	48%	2,393	21%	1,047	60%	2,991	36%	1,795	64%	3,190	39%	1,944
				20,792	40%	8,317	21%	4,370	48%	9,980	32%	6,566	60%	12,475	46%	9,461	64%	13,307	49%	10,165
	Inland	B,C	Inland	142,467	3%	3,918	3%	3,918	6%	7,836	6%	7,836	6%	7,836	6%	7,836	8%	11,754	8%	11,754
		B,C	Cat 1	0	3%	0	40%	0	6%	0	48%	0	6%	0	60%	0	8%	0	64%	0
		B,C	Cat 2	0	3%	0	25%	0	6%	0	35%	0	6%	0	49%	0	8%	0	53%	0
		B,C	Cat 3	0	3%	0	9%	0	6%	0	21%	0	6%	0	36%	0	8%	0	39%	0
		B,C	Cat 4	3	3%	0	9%	0	6%	0	21%	1	6%	0	36%	1	8%	0	39%	1
				142,470	3%	3,918	3%	3,918	6%	7,836	6%	7,836	6%	7,836	6%	7,837	8%	11,754	8%	11,755

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Gloucester	Cat 1	A,B	Inland	9,976	40%	3,990	3%	274	48%	4,789	6%	549	60%	5,986	6%	549	64%	6,385	8%	823
		A,B	Cat 1	2,388	40%	955	40%	955	48%	1,146	48%	1,146	60%	1,433	60%	1,433	64%	1,528	64%	1,528
		A,B	Cat 2	7,935	40%	3,174	25%	1,944	48%	3,809	35%	2,777	60%	4,761	49%	3,888	64%	5,079	53%	4,166
		A,B	Cat 3	9,072	40%	3,629	9%	816	48%	4,355	21%	1,905	60%	5,443	36%	3,266	64%	5,806	39%	3,538
		A,B	Cat 4	6,439	40%	2,576	9%	580	48%	3,091	21%	1,352	60%	3,863	36%	2,318	64%	4,121	39%	2,511
				35,810	40%	14,324	13%	4,570	48%	17,189	22%	7,729	60%	21,486	32%	11,454	64%	22,918	35%	12,566
	Cat 3	C,D	Inland	185,083	9%	16,657	3%	5,090	21%	38,867	6%	10,180	36%	66,630	6%	10,180	39%	72,182	8%	15,269
		C,D	Cat 1	424	9%	38	40%	170	21%	89	48%	204	36%	153	60%	255	39%	166	64%	272
		C,D	Cat 2	1,776	9%	160	25%	435	21%	373	35%	621	36%	639	49%	870	39%	693	53%	932
		C,D	Cat 3	3,615	9%	325	9%	325	21%	759	21%	759	36%	1,302	36%	1,302	39%	1,410	39%	1,410
		C,D	Cat 4	5,679	9%	511	9%	511	21%	1,193	21%	1,193	36%	2,045	36%	2,045	39%	2,215	39%	2,215
				196,578	9%	17,692	3%	6,531	21%	41,281	7%	12,957	36%	70,768	7%	14,650	39%	76,665	10%	20,098
	Inland	E	Inland	75,624	3%	2,080	3%	2,080	6%	4,159	6%	4,159	6%	4,159	6%	4,159	8%	6,239	8%	6,239
		E	Cat 1	0	3%	0	40%	0	6%	0	48%	0	6%	0	60%	0	8%	0	64%	0
		E	Cat 2	0	3%	0	25%	0	6%	0	35%	0	6%	0	49%	0	8%	0	53%	0
		E	Cat 3	0	3%	0	9%	0	6%	0	21%	0	6%	0	36%	0	8%	0	39%	0
		E	Cat 4	0	3%	0	9%	0	6%	0	21%	0	6%	0	36%	0	8%	0	39%	0
				75,624	3%	2,080	3%	2,080	6%	4,159	6%	4,159	6%	4,159	6%	4,159	8%	6,239	8%	6,239

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Ocean	**Cat 1**	A	Inland	5,307	40%	2,123	3%	146	48%	2,547	6%	292	60%	3,184	6%	292	64%	3,396	8%	438
		A	Cat 1	62,142	40%	24,857	40%	24,857	48%	29,828	48%	29,828	60%	37,285	60%	37,285	64%	39,771	64%	39,771
		A	Cat 2	41,615	40%	16,646	25%	10,196	48%	19,975	35%	14,565	60%	24,969	49%	20,392	64%	26,634	53%	21,848
		A	Cat 3	19,197	40%	7,679	9%	1,728	48%	9,215	21%	4,031	60%	11,518	36%	6,911	64%	12,286	39%	7,487
		A	Cat 4	5,468	40%	2,187	9%	492	48%	2,625	21%	1,148	60%	3,281	36%	1,968	64%	3,500	39%	2,133
				133,730	40%	53,492	28%	37,419	48%	64,190	37%	49,865	60%	80,238	50%	66,848	64%	85,587	54%	71,676
	Cat 1	B,C	Inland	10,652	40%	4,261	3%	293	48%	5,113	6%	586	60%	6,391	6%	586	64%	6,818	8%	879
		B,C	Cat 1	873	40%	349	40%	349	48%	419	48%	419	60%	524	60%	524	64%	558	64%	558
		B,C	Cat 2	4,499	40%	1,800	25%	1,102	48%	2,160	35%	1,575	60%	2,699	49%	2,205	64%	2,879	53%	2,362
		B,C	Cat 3	8,951	40%	3,580	9%	806	48%	4,297	21%	1,880	60%	5,371	36%	3,222	64%	5,729	39%	3,491
		B,C	Cat 4	4,821	40%	1,929	9%	434	48%	2,314	21%	1,012	60%	2,893	36%	1,736	64%	3,086	39%	1,880
				29,797	40%	11,919	10%	2,984	48%	14,302	18%	5,472	60%	17,878	28%	8,272	64%	19,070	31%	9,171
	Cat 2	B,C	Inland	104,219	25%	25,534	3%	2,866	35%	36,477	6%	5,732	49%	51,067	6%	5,732	53%	54,715	8%	8,598
		B,C	Cat 1	2,302	25%	564	40%	921	35%	806	48%	1,105	49%	1,128	60%	1,381	53%	1,209	64%	1,473
		B,C	Cat 2	12,569	25%	3,079	25%	3,079	35%	4,399	35%	4,399	49%	6,159	49%	6,159	53%	6,599	53%	6,599
		B,C	Cat 3	19,681	25%	4,822	9%	1,771	35%	6,888	21%	4,133	49%	9,644	36%	7,085	53%	10,333	39%	7,676
		B,C	Cat 4	23,290	25%	5,706	9%	2,096	35%	8,151	21%	4,891	49%	11,412	36%	8,384	53%	12,227	39%	9,083
				162,061	25%	39,705	7%	10,734	35%	56,721	13%	20,260	49%	79,410	18%	28,742	53%	85,082	21%	33,429
	Inland	D,E	Inland	304,771	3%	8,381	3%	8,381	6%	16,762	6%	16,762	6%	16,762	6%	16,762	8%	25,144	8%	25,144
		D,E	Cat 1	0	3%	0	40%	0	6%	0	48%	0	6%	0	60%	0	8%	0	64%	0
		D,E	Cat 2	17	3%	0	25%	4	6%	1	35%	6	6%	1	49%	8	8%	1	53%	9
		D,E	Cat 3	769	3%	21	9%	69	6%	42	21%	162	6%	42	36%	277	8%	63	39%	300
		D,E	Cat 4	3,837	3%	106	9%	345	6%	211	21%	806	6%	211	36%	1,381	8%	317	39%	1,496
				309,394	3%	8,508	3%	8,800	6%	17,017	6%	17,736	6%	17,017	6%	18,429	8%	25,525	9%	26,949

County	Hurricane Intensity	Evacuation Zones	Surge Zones	2020 Population	Cat 1				Cat 2				Cat 3				Cat 4			
					EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation		EZ Evacuation		SZ Evacuation	
Salem	Cat 1	A	Inland	2,729	40%	1,091	3%	75	48%	1,310	6%	150	60%	1,637	6%	150	64%	1,746	8%	225
		A	Cat 1	13,016	40%	5,206	40%	5,206	48%	6,248	48%	6,248	60%	7,810	60%	7,810	64%	8,330	64%	8,330
		A	Cat 2	13,558	40%	5,423	25%	3,322	48%	6,508	35%	4,745	60%	8,135	49%	6,643	64%	8,677	53%	7,118
		A	Cat 3	6,021	40%	2,408	9%	542	48%	2,890	21%	1,264	60%	3,613	36%	2,168	64%	3,853	39%	2,348
		A	Cat 4	2,558	40%	1,023	9%	230	48%	1,228	21%	537	60%	1,535	36%	921	64%	1,637	39%	998
				37,881	40%	15,152	25%	9,375	48%	18,183	34%	12,944	60%	22,729	47%	17,691	64%	24,244	50%	19,019
	Cat 1	B	Inland	12,284	40%	4,914	3%	338	48%	5,896	6%	676	60%	7,370	6%	676	64%	7,862	8%	1,013
		B	Cat 1	180	40%	72	40%	72	48%	87	48%	87	60%	108	60%	108	64%	115	64%	115
		B	Cat 2	356	40%	142	25%	87	48%	171	35%	124	60%	213	49%	174	64%	228	53%	187
		B	Cat 3	363	40%	145	9%	33	48%	174	21%	76	60%	218	36%	131	64%	232	39%	142
		B	Cat 4	623	40%	249	9%	56	48%	299	21%	131	60%	374	36%	224	64%	399	39%	243
				13,806	40%	5,522	4%	586	48%	6,627	8%	1,094	60%	8,284	10%	1,313	64%	8,836	12%	1,700
	Inland	C	Inland	14,037	3%	386	3%	386	6%	772	6%	772	6%	772	6%	772	8%	1,158	8%	1,158
		C	Cat 1	0	3%	0	40%	0	6%	0	48%	0	6%	0	60%	0	8%	0	64%	0
		C	Cat 2	0	3%	0	25%	0	6%	0	35%	0	6%	0	49%	0	8%	0	53%	0
		C	Cat 3	0	3%	0	9%	0	6%	0	21%	0	6%	0	36%	0	8%	0	39%	0
		C	Cat 4	0	3%	0	9%	0	6%	0	21%	0	6%	0	36%	0	8%	0	39%	0
				14,037	3%	386	3%	386	6%	772	6%	772	6%	772	6%	772	8%	1,158	8%	1,158

Appendix C
Shelter Inventory and Capacity

County	Region	Shelter Name	Address	City	Capacity	Post-Impact Capacity
Hunterdon	Central	Riegel Ridge Comm Ctr	910 Milford Warren Glen	Holland Township	650	325
Hunterdon	Central	So Hunterdon Reg HS	301 Mt. Airy Harbourton Rd	Lambertville	1600	800
Hunterdon	Central	Southridge Comm Chc	7 Pittstown Road	Clinton	452	226
Hunterdon	Central	No Hunterdon Reg HS	1445 State Route 31 S	Annandale	750	325
Mercer	Central	The College of New Jersey	2000 Pennington Rd	Ewing	1237	618
Mercer	Central	Joyce Kilmer Sch	1300 Stuyvesant Ave	Trenton	300	150
Mercer	Central	W. Trenton Fire House	40 West Upper Ferry Road	Ewing	345	0
Mercer	Central	Ewing Sr & Comm Ctr	999 Lower Ferry Road	Ewing	350	175
Mercer	Central	Stokes Elem Sch	915 Parkside Ave	Trenton	270	135
Middlesex	Central	Rutgers Athletic Ctr	83 Rockafeller Drive	Piscataway	500	250
Middlesex	Central	Woodbridge Comm Ctr	600 Main Street	Woodbridge	800	800
Middlesex	Central	Old Bridge (Sandburg) S	363 Rt 516	Old Bridge	400	400
Middlesex	Central	Spotswood HS	105 Summerville Rd	Spotswood	500	250
Middlesex	Central	South Plainfield HS	200 Lake Street	South Plainfield	300	150
Middlesex	Central	Monroe Community Center	120 Monmouth Road	Monroe Township	800	400
Middlesex	Central	Middlesex County College	2600 Woodbridge Avenue	Edison	100	50
Monmouth	Central	Brookdale Comm Col, Collins Arena	765 Newman Springs Road	Lincroft	3000	2000
Monmouth	Central	Brookdale Comm Col, Student Life Ctr	766 Newman Springs Road	Lincroft	1000	700
Monmouth	Central	Monmouth Park Race Tr	175 Ocean Port Ave	Oceanport	0	500

County	Region	Shelter Name	Address	City	Capacity	Post-Impact Capacity
Monmouth	Central	MC Parks, Recreation Center	2566 Guam Lane	Tinton Falls	500	300
Monmouth	Central	Monmouth Co BioTech HS	5000 Kozloski Road	Freehold	500	300
Ocean	Central	RWJ Barnabus Health Arena	1245 Old Freehold Road	Toms River	1100	500
Ocean	Central	Southern Regional HS	90 Cedar Bridge Road	Manahawkin	1000	500
Ocean	Central	Pinelands Reg Jr HS	365 Nugentown Road	Tuckerton	1000	500
Ocean	Central	Jackson Liberty Middle	125 N. Hope Chapel Road	Jackson	3529	1764
Ocean	Central	Toms River East HS	1225 Raider Way	Toms River	600	300
Somerset	Central	Raritan Valley College	118 Lamington Road	Branchburg	540	270
Somerset	Central	Manville VFW	600 Washington Ave	Manville	390	195
Somerset	Central	Bernardville High Sch	25 Olcott Avenue	Bernardsville	497	248
Somerset	Central	Bound Brook High Sch	111 W Union Ave	Boundbrook	500	250
Union	Central	Summit HS	125 Kent Place	Summit	520	260
Union	Central	Westfield HS	550 Dorian Road	Westfield	436	216
Union	Central	Cranford Comm Ctr	220 Walnut Ave	Cranford	325	161
Bergen	North	Bergen Co Comm Col	400 Parmus Road	Parmus	630	315
Bergen	North	FDU- Rothman Ctr	100 University Plaza Drive	Hackensack	1950	975
Bergen	North	Lyndhurst Sr Ctr	250 Cleveland Ave	Lyndhurst	207	103
Bergen	North	Northern Valley Reg HS	162 Knickerbocker Road	Demarest	427	212
Bergen	North	Ramapo College	505 Ramapo Valley Road	Mahwah	882	746
Essex	North	JFK Recreational Ctr	211 West Kinney Ave	Newark	857	426
Essex	North	Livingston HS	30 Robert Harp Drive	Livingston	945	472
Essex	North	East Orange Civic Ctr	1 Fellowship Circle	East Orange	270	135

County	Region	Shelter Name	Address	City	Capacity	Post-Impact Capacity
Essex	North	Lincoln Ave Elem Sch	216 Lincoln Ave	Orange	1117	558
Hudson	North	Jose Marti Sch	1800 Summit Ave	Union City	240	120
Hudson	North	PS #7	222 Laidlaw Street	Jersey City	954	477
Hudson	North	North Bergen HS	7417 Kennedy Blvd	North Bergen	813	406
Hudson	North	Anna L. Klein Sch	301 69th Street	Guttenberg	1839	919
Morris	North	Mennan Sports Arena	161 East Hanover Ave	Morristown	300	150
Morris	North	Morristown HS	50 Early Street	Morristown	950	475
Morris	North	Pequannock Township HS	85 Sunset Road	Pompton Plains	745	372
Morris	North	Parsippany PAL	33 Baldwin Road	Parsippany	800	400
Morris	North	Morris Co PS Training Academy	500 West Hanover Ave	Morristown	100	50
Passaic	North	Lakeland Reg HS	205 Conklintown Road	Wanaque	480	240
Passaic	North	Passaic Co Comm Col	204 Ellison Street	Patterson	472	236
Sussex	North	Kittatinny Reg HS	77 Halsey Road	Newton	1000	500
Sussex	North	Lafayette Fed Chur	180 Route 15	Lafayette	200	100
Sussex	North	Hopatcong HS	2A Windsor Ave	Hopatcong	2380	1190
Sussex	North	Sussex Co. Tech	105 N Church Road	Sparta	1600	800
Sussex	North	High Point Reg HS	299 Pidgeon Hill Road	Sussex	1600	800
Sussex	North	Wallkill Valley Reg HS	10 Grumm Road	Hamburg	1600	800
Warren	North	Phillipsburg HS	500 Hillcrest Blvd	Phillipsburg	659	329
Warren	North	N Warren Reg HS	11 Noe Road	Blairstown	615	307
Warren	North	Warren Co Tech Sch	1500 Route 57	Washington	200	100
Atlantic	South	Buena Reg Middle Sch	175 Weymouth Ave	Buena	374	237
Atlantic	South	Egg Harbor Township HS	24 High School Drive	Egg Harbor Township	1600	800
Atlantic	South	Galloway Township Mid Sc	100 S Reeds Road	Galloway	250	231

County	Region	Shelter Name	Address	City	Capacity	Post-Impact Capacity
Atlantic	South	Hammonton HS	566 Old Forks Road	Hammonton	1611	805
Atlantic	South	Buena Reg HS	125 Weymouth Road	Buena	450	225
Atlantic	South	Atlantic Christian	391 Zion Road	Egg Harbor Township	235	117
Atlantic	South	Reeds Road School	103 S Reeds Road	Galloway	720	320
Atlantic	South	Roland Rogers	105 S Reeds Road	Galloway	1500	814
Atlantic	South	Oakcrest HS	1824 Dennis Foreman Drive	Mays Landing	626	313
Atlantic	South	Pleasantville HS	701 Mill Road	Pleasantville	550	338
Atlantic	South	Pleasantville Mid Sch	801 Mill Road	Pleasantville	542	381
Atlantic	South	Mullica Township Mid Sch	500 Elwood Road	Elwood	250	124
Atlantic	South	Galloway Comm Chart	112 S New York Road	Absecon	243	117
Atlantic	South	Northfield Comm Sch	2000 New Road	Northfield	1037	515
Atlantic	South	St. Augustine Prep (MNS Only)	611 Cedar Avenue	Richland	80	80
Burlington	South	Fountain of Life	2035 Columbus Road	Burlington	900	450
Burlington	South	Chairville Elem Sch	36 Chairville Road	Medford	400	200
Burlington	South	Rowan Col @ Burl Co	601 Pemberton Browns Mills Pemberton	Pemberton	400	200
Burlington	South	Palmyra Community Center	20 W Broad St	Palmyra	300	150
Burlington	South	Rancocas Valley High School	520 Hedding Jacksonville Rd	Mt Holly	300	150
Camden	South	Camden Co College	200 College Drive	Blackwood	400	200
Camden	South	Cherry Hill HS East	1750 Creson Road	Cherry Hill	260	130
Camden	South	Pennsauken HS	800 Hylton Road	Pennsauken	1620	810
Camden	South	Eastern Reg HS	1401 Laurel Oak Road	Voorhees	599	398
Camden	South	Gloucester City HS	1300 Market Street	Gloucester City	260	130

County	Region	Shelter Name	Address	City	Capacity	Post-Impact Capacity
Cape May	South	Woodbine Devel Ctr	1175 Dehirsh Ave	Woodbine	500	300
Cape May	South	Upper Township Middle Sch	525 Perry Road	Petersburg	250	250
Cape May	South	Middle Township HS	300 E. Atlantic Ave	Cape May Crt Hse	49	24
Cape May	South	Upper Township Prim Sch	100 Old Tuckahoe Road	Marmora	200	200
Cape May	South	Middle Township Ele Sch	215 Eldredge Road	Cape May Crt Hse	150	150
Cumberland	South	Cumberland Co College	3322 College Drive	Vineland	607	400
Cumberland	South	Vineland HS	3010 E. Chestnut Ave	Vineland	300	300
Cumberland	South	Buckshutem Mid Sch	550 Buckshutem Road	Bridgeton	350	350
Cumberland	South	Bridgeton HS	111 N. West Avenue	Bridgeton	270	135
Gloucester	South	Rowan University	201 Mullica Hill Road	Glassboro	500	250
Gloucester	South	Gloucester Co VoTech	1360 Tanyard Road	Barnsboro	1000	500
Gloucester	South	West Deptford HS	1600 Crown Point Road	Westville	500	250
Gloucester	South	Williamstown Mid Sch	561 Clayton Road	Williamstown	500	250
Gloucester	South	Rowan Col at Glouc	1400 Tanyard Road	Sewell	1000	500
Salem	South	Salem Community College	460 Hollywood Ave	Carneys Point	800	200
Salem	South	Pennsville Mem HS	1105 South Broadway	Pennsville	1800	250
Salem	South	Woodstown HS	140 East Avenue	Woodstown	1800	450
Warren	North	Hackettstown HS	701 Warren Street	Hackettstown	500	250
Salem	South	Author Schalick High Sch	718 Centerton Rd	Pittsgrove Township	425	212
Hunterdon	Central	Hunterdon Ctrl HS	84 State Route 31	Flemmington	1000	500
Atlantic	South	Stockton Un- Big Blue	101 Vera King Farris Drive	Galloway	800	400
Burlington	South	New Lisbon Dev Ctr	104 NJ-72	Vincetown	250	125
Cumberland	South	Vineland Dev Ctr	1676 East Landis Ave	Vineland	500	250

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Appendix D
Evacuation Scenarios, Clearance Times, and Input Parameters

A companion MS Excel workbook with the evacuation scenarios and clearance time results is also included for ease of reference, sorting, and filtering of clearance time results.

Scenario Title	Participation Rate			Hurricane intensity				Response Curve			New York		Contraflow		Background Traffic		Clearance Time (hr.)*	Evacuating Population	Evacuating Vehicles
	Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
CS-1																	34.0	1,469,540	736,363
CS-2																	39.0	2,162,088	1,013,923
CS-3																	51.0	4,054,960	1,771,061
CS-4																	40.0	1,469,540	736,363
CS-5																	45.0	2,162,088	1,013,923
CS-6																	59.0	4,054,960	1,771,061
CS-7																	34.0	1,894,708	864,914
CS-8																	40.0	2,587,256	1,142,474
CS-9																	51.0	4,480,128	1,899,612
CS-10																	38.0	1,894,708	864,914
CS-11																	45.0	2,587,256	1,142,474
CS-12																	59.0	4,480,128	1,899,612
CS-13																	33.0	1,469,540	736,363
CS-14																	37.0	2,162,088	1,013,923
CS-15																	50.0	4,054,960	1,771,061
CS-16																	41.0	1,469,540	736,363
CS-17																	46.0	2,162,088	1,013,923
CS-18																	58.0	4,054,960	1,771,061
CS-19																	33.0	1,894,708	864,914
CS-20																	38.0	2,587,256	1,142,474
CS-21																	51.0	4,480,128	1,899,612
CS-22																	41.0	1,894,708	864,914
CS-23																	46.0	2,587,256	1,142,474
CS-24																	58.0	4,480,128	1,899,612
CS-25																	31.0	1,469,540	736,363
CS-26																	37.0	2,162,088	1,013,923
CS-27																	49.0	4,054,960	1,771,061
CS-28																	41.0	1,469,540	736,363
CS-29																	45.0	2,162,088	1,013,923
CS-30																	57.0	4,054,960	1,771,061
CS-31																	31.0	1,894,708	864,914
CS-32																	38.0	2,587,256	1,142,474
CS-33																	51.0	4,480,128	1,899,612
CS-34																	41.0	1,894,708	864,914
CS-35																	45.0	2,587,256	1,142,474
CS-36																	58.0	4,480,128	1,899,612
SC-1																	28.0	398,604	276,243
SC-2																	31.0	636,719	371,495
SC-3																	38.0	1,084,737	550,691
SC-4																	29.0	526,460	325,038
SC-5																	33.0	807,704	437,545
SC-6																	42.0	1,425,731	684,756
SC-7																	30.0	624,912	364,199
SC-8																	34.0	997,820	513,588
SC-9																	42.0	1,694,489	792,247
SC-10																	31.0	702,141	392,977
SC-11																	38.0	1,087,152	546,970
SC-12																	42.0	1,729,578	803,944
SC-13																	35.0	398,604	276,243
SC-14																	38.0	636,719	371,495
SC-15																	49.0	1,084,737	550,691
SC-16																	37.0	526,460	325,038

Scenario Title	Participation Rate			Hurricane intensity				Response Curve			New York		Contraflow		Background Traffic		Clearance Time (hr.)*	Evacuating Population	Evacuating Vehicles
	Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
SC-17		■			■			■				■		■		■	40.0	807,704	437,545
SC-18			■		■			■				■		■		■	52.0	1,425,731	684,756
SC-19	■					■		■				■		■	■		39.0	624,912	364,199
SC-20		■				■		■				■		■	■		43.0	997,820	513,588
SC-21			■			■		■				■		■	■		51.0	1,694,489	792,247
SC-22	■						■	■				■		■	■		40.0	702,141	392,977
SC-23		■					■	■				■		■	■		46.0	1,087,152	546,970
SC-24			■				■	■				■		■	■		52.0	1,729,578	803,944
SC-25	■			■					■			■	■			■	26.0	398,604	276,243
SC-26		■		■					■			■	■			■	29.0	636,719	371,495
SC-27			■	■					■			■	■			■	37.0	1,084,737	550,691
SC-28	■				■				■			■	■			■	28.0	526,460	325,038
SC-29		■			■				■			■	■			■	32.0	807,704	437,545
SC-30			■		■				■			■	■			■	40.0	1,425,731	684,756
SC-31	■					■			■			■	■		■		29.0	624,912	364,199
SC-32		■				■			■			■	■		■		33.0	997,820	513,588
SC-33			■			■			■			■	■		■		40.0	1,694,489	792,247
SC-34	■						■		■			■	■		■		30.0	702,141	392,977
SC-35		■					■		■			■	■		■		36.0	1,087,152	546,970
SC-36			■				■		■			■	■		■		41.0	1,729,578	803,944
SC-37	■			■					■			■		■		■	36.0	398,604	276,243
SC-38		■		■					■			■		■		■	39.0	636,719	371,495
SC-39			■	■					■			■		■		■	47.0	1,084,737	550,691
SC-40	■				■				■			■		■		■	38.0	526,460	325,038
SC-41		■			■				■			■		■		■	42.0	807,704	437,545
SC-42			■		■				■			■		■		■	50.0	1,425,731	684,756
SC-43	■					■			■			■		■	■		40.0	624,912	364,199
SC-44		■				■			■			■		■	■		43.0	997,820	513,588
SC-45			■			■			■			■		■	■		50.0	1,694,489	792,247
SC-46	■						■		■			■		■	■		41.0	702,141	392,977
SC-47		■					■		■			■		■	■		45.0	1,087,152	546,970
SC-48			■				■		■			■		■	■		50.0	1,729,578	803,944
SC-49	■			■						■		■	■			■	25.0	398,604	276,243
SC-50		■		■						■		■	■			■	28.0	636,719	371,495
SC-51			■	■						■		■	■			■	35.0	1,084,737	550,691
SC-52	■				■					■		■	■			■	27.0	526,460	325,038
SC-53		■			■					■		■	■			■	30.0	807,704	437,545
SC-54			■		■					■		■	■			■	40.0	1,425,731	684,756
SC-55	■					■				■		■	■		■		28.0	624,912	364,199
SC-56		■				■				■		■	■		■		33.0	997,820	513,588
SC-57			■			■				■		■	■		■		40.0	1,694,489	792,247
SC-58	■						■			■		■	■		■		28.0	702,141	392,977
SC-59		■					■			■		■	■		■		34.0	1,087,152	546,970
SC-60			■				■			■		■	■		■		40.0	1,729,578	803,944
SC-61	■			■						■		■		■		■	36.0	398,604	276,243
SC-62		■		■						■		■		■		■	39.0	636,719	371,495
SC-63			■	■						■		■		■		■	46.0	1,084,737	550,691
SC-64	■				■					■		■		■		■	37.0	526,460	325,038
SC-65		■			■					■		■		■		■	40.0	807,704	437,545
SC-66			■		■					■		■		■		■	49.0	1,425,731	684,756
SC-67	■					■				■		■		■	■		39.0	624,912	364,199
SC-68		■				■				■		■		■	■		43.0	997,820	513,588
SC-69			■			■				■		■		■	■		49.0	1,694,489	792,247
SC-70	■						■			■		■		■	■		39.0	702,141	392,977
SC-71		■					■			■		■		■	■		43.0	1,087,152	546,970
SC-72			■				■			■		■		■	■		50.0	1,729,578	803,944
NC-1	■			■				■				■	■			■	27.0	319,317	177,204
NC-2		■		■				■				■	■			■	27.0	464,322	235,225
NC-3			■	■				■				■	■			■	26.0	1,026,247	459,977
NC-4	■				■			■				■	■			■	27.0	528,008	253,203
NC-5		■			■			■				■	■			■	28.0	717,700	329,066
NC-6			■		■			■				■	■			■	31.0	1,500,109	642,029
NC-7	■					■		■				■	■		■		28.0	637,197	296,375
NC-8		■				■		■				■	■		■		27.0	945,029	420,016
NC-9			■			■		■				■	■		■		39.0	2,250,130	942,057
NC-10	■						■	■				■	■		■		27.0	767,399	343,386
NC-11		■					■	■				■	■		■		27.0	1,074,936	466,953

Scenario Title	Participation Rate			Hurricane intensity				Response Curve			New York		Contraflow		Background Traffic		Clearance Time (hr.)*	Evacuating Population	Evacuating Vehicles
	Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
NC-12			■				■	■				■	■		■		40.0	2,325,382	967,117
NC-13	■			■				■				■		■		■	27.0	319,317	177,204
NC-14		■		■				■				■		■		■	27.0	464,322	235,225
NC-15			■	■				■				■		■		■	27.0	1,026,247	459,977
NC-16	■				■			■				■		■		■	27.0	528,008	253,203
NC-17		■			■			■				■		■		■	28.0	717,700	329,066
NC-18			■		■			■				■		■		■	31.0	1,500,109	642,029
NC-19	■					■		■				■		■	■		28.0	637,197	296,375
NC-20		■				■		■				■		■	■		27.0	945,029	420,016
NC-21			■			■		■				■		■	■		40.0	2,250,130	942,057
NC-22	■						■	■				■		■	■		27.0	767,399	343,386
NC-23		■					■	■				■		■	■		27.0	1,074,936	466,953
NC-24			■				■	■				■		■	■		39.0	2,325,382	967,117
NC-25	■			■				■			■		■			■	27.0	428,342	213,484
NC-26		■		■				■			■		■			■	27.0	573,347	271,505
NC-27			■	■				■			■		■			■	27.0	1,135,272	496,257
NC-28	■				■			■			■		■			■	27.0	751,958	327,808
NC-29		■			■			■			■		■			■	27.0	941,650	403,671
NC-30			■		■			■			■		■			■	30.0	1,724,059	716,634
NC-31	■					■		■			■		■		■		27.0	962,078	399,837
NC-32		■				■		■			■		■		■		27.0	1,269,910	523,478
NC-33			■			■		■			■		■		■		40.0	2,575,011	1,045,519
NC-34	■						■	■			■		■		■		27.0	1,192,567	471,937
NC-35		■					■	■			■		■		■		27.0	1,500,104	595,504
NC-36			■				■	■			■		■		■		41.0	2,750,550	1,095,668
NC-37	■			■				■			■			■		■	27.0	428,342	213,484
NC-38		■		■				■			■			■		■	27.0	573,347	271,505
NC-39			■	■				■			■			■		■	27.0	1,135,272	496,257
NC-40	■				■			■			■			■		■	27.0	751,958	327,808
NC-41		■			■			■			■			■		■	28.0	941,650	403,671
NC-42			■		■			■			■			■		■	30.0	1,724,059	716,634
NC-43	■					■		■			■			■	■		27.0	962,078	399,837
NC-44		■				■		■			■			■	■		27.0	1,269,910	523,478
NC-45			■			■		■			■			■	■		40.0	2,575,011	1,045,519
NC-46	■						■	■			■			■	■		27.0	1,192,567	471,937
NC-47		■					■	■			■			■	■		27.0	1,500,104	595,504
NC-48			■				■	■			■			■	■		41.0	2,750,550	1,095,668
NC-49	■			■					■			■	■			■	21.0	319,317	177,204
NC-50		■		■					■			■	■			■	21.0	464,322	235,225
NC-51			■	■					■			■	■			■	25.0	1,026,247	459,977
NC-52	■				■				■			■	■			■	21.0	528,008	253,203
NC-53		■			■				■			■	■			■	22.0	717,700	329,066
NC-54			■		■				■			■	■			■	32.0	1,500,109	642,029
NC-55	■					■			■			■	■		■		22.0	637,197	296,375
NC-56		■				■			■			■	■		■		22.0	945,029	420,016
NC-57			■			■			■			■	■		■		39.0	2,250,130	942,057
NC-58	■						■		■			■	■		■		21.0	767,399	343,386
NC-59		■					■		■			■	■		■		24.0	1,074,936	466,953
NC-60			■				■		■			■	■		■		39.0	2,325,382	967,117
NC-61	■			■					■			■		■		■	21.0	319,317	177,204
NC-62		■		■					■			■		■		■	21.0	464,322	235,225
NC-63			■	■					■			■		■		■	24.0	1,026,247	459,977
NC-64	■				■				■			■		■		■	21.0	528,008	253,203
NC-65		■			■				■			■		■		■	21.0	717,700	329,066
NC-66			■		■				■			■		■		■	32.0	1,500,109	642,029
NC-67	■					■			■			■		■	■		22.0	637,197	296,375
NC-68		■				■			■			■		■	■		23.0	945,029	420,016
NC-69			■			■			■			■		■	■		39.0	2,250,130	942,057
NC-70	■						■		■			■		■	■		21.0	767,399	343,386
NC-71		■					■		■			■		■	■		25.0	1,074,936	466,953
NC-72			■				■		■			■		■	■		40.0	2,325,382	967,117
NC-73	■			■					■		■		■			■	21.0	428,342	213,484
NC-74		■		■					■		■		■			■	21.0	573,347	271,505
NC-75			■	■					■		■		■			■	24.0	1,135,272	496,257
NC-76	■				■				■		■		■			■	21.0	751,958	327,808
NC-77		■			■				■		■		■			■	21.0	941,650	403,671
NC-78			■		■				■		■		■			■	32.0	1,724,059	716,634

Scenario Title	Participation Rate			Hurricane intensity				Response Curve			New York		Contraflow		Background Traffic		Clearance Time (hr.)*	Evacuating Population	Evacuating Vehicles
	Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
NC-79	X					X			X		X		X		X		21.0	962,078	399,837
NC-80		X				X			X		X		X		X		23.0	1,269,910	523,478
NC-81			X			X			X		X		X		X		39.0	2,575,011	1,045,519
NC-82	X						X		X		X		X		X		21.0	1,192,567	471,937
NC-83		X					X		X		X		X		X		26.0	1,500,104	595,504
NC-84			X				X		X		X		X		X		40.0	2,750,550	1,095,668
NC-85	X			X					X		X			X		X	21.0	428,342	213,484
NC-86		X		X					X		X			X		X	21.0	573,347	271,505
NC-87			X	X					X		X			X		X	24.0	1,135,272	496,257
NC-88	X				X				X		X			X		X	21.0	751,958	327,808
NC-89		X			X				X		X			X		X	21.0	941,650	403,671
NC-90			X		X				X		X			X		X	32.0	1,724,059	716,634
NC-91	X					X			X		X			X	X		21.0	962,078	399,837
NC-92		X				X			X		X			X	X		23.0	1,269,910	523,478
NC-93			X			X			X		X			X	X		39.0	2,575,011	1,045,519
NC-94	X						X		X		X			X	X		21.0	1,192,567	471,937
NC-95		X					X		X		X			X	X		26.0	1,500,104	595,504
NC-96			X				X		X		X			X	X		41.0	2,750,550	1,095,668
NC-97	X			X						X		X	X			X	19.0	319,317	177,204
NC-98		X		X						X		X	X			X	19.0	464,322	235,225
NC-99			X	X						X		X	X			X	26.0	1,026,247	459,977
NC-100	X				X					X		X	X			X	19.0	528,008	253,203
NC-101		X			X					X		X	X			X	22.0	717,700	329,066
NC-102			X		X					X		X	X			X	31.0	1,500,109	642,029
NC-103	X					X				X		X	X		X		21.0	637,197	296,375
NC-104		X				X				X		X	X		X		25.0	945,029	420,016
NC-105			X			X				X		X	X		X		38.0	2,250,130	942,057
NC-106	X						X			X		X	X		X		22.0	767,399	343,386
NC-107		X					X			X		X	X		X		26.0	1,074,936	466,953
NC-108			X				X			X		X	X		X		38.0	2,325,382	967,117
NC-109	X			X						X		X		X		X	19.0	319,317	177,204
NC-110		X		X						X		X		X		X	19.0	464,322	235,225
NC-111			X	X						X		X		X		X	26.0	1,026,247	459,977
NC-112	X				X					X		X		X		X	20.0	528,008	253,203
NC-113		X			X					X		X		X		X	22.0	717,700	329,066
NC-114			X		X					X		X		X		X	32.0	1,500,109	642,029
NC-115	X					X				X		X		X	X		21.0	637,197	296,375
NC-116		X				X				X		X		X	X		24.0	945,029	420,016
NC-117			X			X				X		X		X	X		38.0	2,250,130	942,057
NC-118	X						X			X		X		X	X		22.0	767,399	343,386
NC-119		X					X			X		X		X	X		26.0	1,074,936	466,953
NC-120			X				X			X		X		X	X		39.0	2,325,382	967,117
NC-121	X			X						X	X		X			X	19.0	428,342	213,484
NC-122		X		X						X	X		X			X	19.0	573,347	271,505
NC-123			X	X						X	X		X			X	25.0	1,135,272	496,257
NC-124	X				X					X	X		X			X	20.0	751,958	327,808
NC-125		X			X					X	X		X			X	22.0	941,650	403,671
NC-126			X		X					X	X		X			X	32.0	1,724,059	716,634
NC-127	X					X				X	X		X		X		21.0	962,078	399,837
NC-128		X				X				X	X		X		X		26.0	1,269,910	523,478
NC-129			X			X				X	X		X		X		40.0	2,575,011	1,045,519
NC-130	X						X			X	X		X		X		24.0	1,192,567	471,937
NC-131		X					X			X	X		X		X		27.0	1,500,104	595,504
NC-132			X				X			X	X		X		X		42.0	2,750,550	1,095,668
NC-133	X			X						X	X			X		X	19.0	428,342	213,484
NC-134		X		X						X	X			X		X	19.0	573,347	271,505
NC-135			X	X						X	X			X		X	25.0	1,135,272	496,257
NC-136	X				X					X	X			X		X	19.0	751,958	327,808
NC-137		X			X					X	X			X		X	22.0	941,650	403,671
NC-138			X		X					X	X			X		X	32.0	1,724,059	716,634
NC-139	X					X				X	X			X	X		21.0	962,078	399,837
NC-140		X				X				X	X			X	X		26.0	1,269,910	523,478
NC-141			X			X				X	X			X	X		40.0	2,575,011	1,045,519
NC-142	X						X			X	X			X	X		23.0	1,192,567	471,937
NC-143		X					X			X	X			X	X		27.0	1,500,104	595,504
NC-144			X				X			X	X			X	X		42.0	2,750,550	1,095,668

* All clearance times were rounded to the nearest hour in the table above. Note: When RtePM did not evacuate all vehicles, an assumption of an additional hour was added to the clearance time for conservatism.

Appendix E

Countywide and County-Step Sensitivity Scenarios

This appendix summarizes scenarios that were completed on a county-specific basis and for sensitivity comparison. **However, it is unlikely that individual counties would evacuate. Therefore, it is recommended that NJ emergency managers primarily use statewide and regional (CS, NC, and SC) scenarios when supporting evacuation planning and operations, as these evacuation scenarios simulate the impacts of evacuating traffic from adjacent counties.**

E.1 Countywide Sensitivity Scenarios

The purpose of the county scenarios was to provide a sensitivity comparison if a countywide (CW) evacuation was ordered (although it was unrealistic for only one county to evacuate, instead of several counties or an entire region). Consistent parameters were chosen to induce an evacuation of enough of the population. The assumptions for these scenarios included:

- Evacuation zones that were impacted by storm surge inundation from a Category 2 hurricane[33] included those impacted by a Category 1 hurricane and shadow evacuees from other zones. Section 3.2.4 and Section 3.2.5 show detailed maps of the evacuation zones and participation rates applied to each county.
- In addition, all CW scenarios utilized a medium response curve (18 hours), medium background traffic, and Medium EZ participation rates (see Section 3.2.2 for information on participation rate development). The results of the CW scenarios are summarized in **Table E-1**.

Table E-1 Countywide Scenario Clearance Time

Scenario Title	County	Participation Rate			Hurricane Intensity				Response Curve			New York City		Contraflow		Background Traffic		Clearance Time (hr.)*	Evacuating Population	Evacuating Vehicles
		Med SZ	Med EZ	High EZ	Cat 1	Cat 2	Cat 3	Cat 4	Slow	Med	Fast	With	W/O	Yes	No	Low	Med			
CW-1	Bergen																	18	83,558	32,952
CW-2	Essex																	20*	61,494	23,819
CW-3	Hudson																	20*	150,193	62,159
CW-4	Mercer																	18	22,107	7,739
CW-5	Middlesex																	19	131,140	52,172
CW-6	Monmouth																	19	140,472	100,701
CW-7	Passaic																	19	29,004	10,130
CW-8	Somerset																	19	25,384	9,500
CW-9	Union																	19	73,893	29,894
CW-10	Atlantic																	35	172,635	94,476
CW-11	Burlington																	19	48,473	18,370
CW-12	Camden																	19	109,871	43,915
CW-13	Cape May																	30	131,014	95,300
CW-14	Cumberland																	19	23,009	12,240

[33] Category 2 was selected for modeling CW scenarios because a Category 1 storm does not impact all counties in the study area.

CW-15	Gloucester																	19	66,360	26,704
CW-16	Ocean																	20	227,689	133,682
CW-17	Salem																	19	28,653	12,858

*All clearance times in the table above were rounded to the nearest hour. Note: When RtePM did not evacuate all vehicles, an assumption of an additional hour was added to the clearance time for conservatism.

In general, for the CW scenarios modeled for the sensitivity analysis, **the clearance times ranged from 18 hours to 20 hours for most counties, except for Atlantic County (35 hours) and Cape May County (30 hours), which had a high density of seasonal tourists located on barrier island communities with a limited number of roadways to the mainland.**

As described in Section 5.3.4, tourist units (hotels, motels, and campgrounds) were inputted in RtePM for Atlantic County (42,294 units) and Cape May County (71,463 units), in addition to other counties that also had tourist units. **If seasonal tourists were removed, the Atlantic County clearance times decreased from 35 hours to 19.1 hours, while the Cape May County clearance times decreased from 29.6 to 19.5 hours. These two counties have among the highest seasonal population and also have limited evacuation roadways and road capacity.**

In the review of graphical output in RtePM for the countywide scenarios, congestion was observed in the following areas:

- Garden State Parkway (in Hudson, Monmouth, Ocean, and Cape May Counties)
- I-195 (in Monmouth and Ocean Counties)
- Atlantic City Expressway (in Atlantic County)

For the CW scenarios, congestion was not observed in Bergen, Essex, Middlesex, Passaic, Union, Mercer, Somerset, Cumberland, Gloucester, Salem, Camden, or Burlington Counties.

E.2 Atlantic County Zone A Sensitivity Scenarios

Based on coordination with stakeholders and written descriptions of the evacuation zones, Atlantic County Zone A was noted to evacuate before other evacuation zones since there was one bridge connecting Atlantic City to Brigantine. Several test scenarios had to be run to determine an appropriate response curve and initial starting hour to allow Atlantic County Zone A to evacuate before other evacuation zones. For the sensitivity scenarios, the other evacuation zones were set to a medium response curve of 18 hours with a starting hour of 8 (after the evacuation order-hour 0). **Table E-2** shows a summary of several test scenarios to evaluate the Atlantic County clearance time for different response curves and starting hours. It also shows the time in hours during the RtePM simulation when 100% of the evacuees were able to leave Atlantic County Zone A.

Table E-2 Sensitivity Scenario Results for Atlantic Zone A

Response Curve	Starting Hour	Atlantic County Clearance Time (hrs.)	Time (hrs.) that Atlantic Zone A reaches 100% Evacuation
Medium (18 Hours)	4	39	20
Medium (18 Hours)	8	35.9	20
Medium (18 Hours)	12	35.9	24
Fast (12 Hours)	4	38	15

Response Curve	Starting Hour	Atlantic County Clearance Time (hrs.)	Time (hrs.) that Atlantic Zone A reaches 100% Evacuation
Fast (12 Hours)	8	35.9	14
Fast (12 Hours)	12	35.9	18
Very Fast (6 Hours)	8	35	9

To allow for faster evacuation of Atlantic Zone A, the response curve was changed from Medium (18 hours) to Very Fast (6 hours). As a result of the sensitivity analysis to target the initial evacuation of Atlantic County Zone A, the 2017 NJ HEBS Report response curve durations were divided by a factor of three (3) to calculate the slow, medium, and fast response curves for Atlantic County Zone A only. This allowed the population to initiate evacuation and clear out before other zones. **Table E-3** summarizes the response curves used for Atlantic County Zone A and compares them to the response curves used for other evacuation zones.

Table E-3 Response Curves for NJ Evacuation Zones and Atlantic Zone A

Response Curve	NJ Evacuation Zones	Atlantic Zone A
Slow	24 hrs.	8 hrs.
Medium	18 hrs.	6 hrs.
Fast	12 hrs.	4 hrs.

E.3 County-step Sensitivity Scenarios

As described in Sections 2.0 and 3.0, the regional and spatial differences in the development of the evacuation zones required additional unique analysis so that the county-specific results were aligned with the evacuation zones as they have been identified and accepted.

To complete this, county-step scenarios were simulated in RtePM. These scenarios represented a stepwise increase in population by using evacuation zone shapes and letters (Zone A, Zone A + Zone B, Zone A + Zone B + Zone C, etc.). The assumptions for the county-step sensitivity scenarios included:

- Vehicle usage rates:
  - 2.5 people per vehicle
  - Vehicle towing: 0%
  - Private vehicle usage: 100%
- Participation rates:
  - High participation rate (100% of the population in the evacuation zone participates)
  - Evacuees to shelters: 0%
  - No seasonal tourist population

- Medium background traffic
- Medium response curve (18 hours)

For the county-step scenarios, the evacuation zones (grouped by letter) were used in RtePM to calculate the clearance times. When all of the RtePM roadway network endpoints were active (the yellow circles in Figure 5-4) and the above parameters were used, the evacuation clearance times did not change because populations from the county-step scenarios were able to disperse to any of the active endpoints resulting in nearly the same clearance time for those scenarios.

Therefore, to show the impact of the increase in population, the county-step scenarios were restricted to evacuate each county to a single endpoint. The single endpoint differed for each county and was selected based on where the county would normally evacuate to in a regional scenario. The selected endpoint is shown in **Figure E-1** through **Figure E-9** for the northern counties and **Figure E-10** through **Figure E-17** for the southern counties**. Table E-4** summarizes the results organized by region, alphabetical order, and by evacuation zone.

These scenarios provided a county-specific perspective for the defined evacuation zones within one county. The clearance time results were relatively high and considered conservative but respected the defined evacuation zones for each county. Similar to the CW sensitivity scenarios, it is unrealistic for only one county to evacuate versus several counties or a region. Therefore, these scenarios were developed for sensitivity analysis purposes only. Given the spatial variability and unique qualities of the evacuation zones (including the zones that covered areas impacted by riverine flooding or inland areas), the county-step scenarios demonstrated the impact on clearance times as each of the zones was ordered to evacuate.

The minimum clearance time was 18 hours since the medium response curve (the time it takes for evacuees to respond) was 18 hours. Overall, the population was the primary driver in dictating the end result of the evacuation clearance time. The high clearance times shown for whole-county evacuations (which include inland areas not vulnerable to storm surge and freshwater flooding) may inform all-hazards evacuation planning but are not recommended for operational use during hurricane evacuations. Population density was not calculated for this exercise.

Table E-4 County-step Scenario Clearance Time

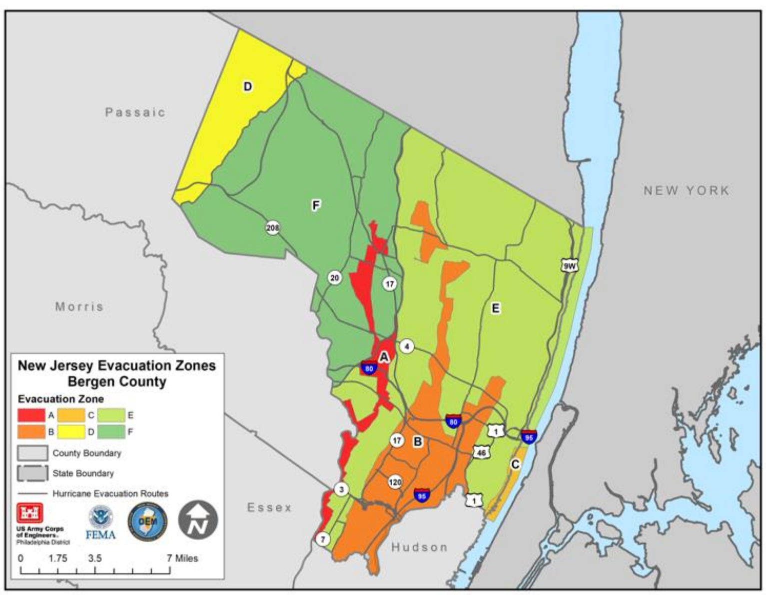
Region	County	Evacuation Zones							Clearance Time (hr.) *	Evacuating Population
		A	B	C	D	E	F	G		
Northern	Bergen								19	53,776
Northern	Bergen								20	144,422
Northern	Bergen								20	150,451
Northern	Bergen								21	159,519
Northern	Bergen								74	727,498
Northern	Bergen								89	939,321
Northern	Essex								19	70,074
Northern	Essex								19	77,882
Northern	Essex								19	82,806
Northern	Essex								19	85,483
Northern	Essex								19	89,830
Northern	Essex								34	393,361
Northern	Essex								65	800,725
Northern	Hudson								20	77,356

Region	County	Evacuation Zones							Clearance Time (hr.) *	Evacuating Population
		A	B	C	D	E	F	G		
Northern	Hudson								25	166,628
Northern	Hudson								31	210,585
Northern	Hudson								35	245,493
Northern	Hudson								37	271,213
Northern	Hudson								56	479,037
Northern	Hudson								82	682,062
Northern	Mercer								18	1,032
Northern	Mercer								18	18,675
Northern	Mercer								18	40,472
Northern	Mercer								26	199,500
Northern	Mercer								30	234,315
Northern	Mercer								42	348,320
Northern	Mercer								45	378,661
Northern	Middlesex								19	23,424
Northern	Middlesex								19	108,562
Northern	Middlesex								20	174,999
Northern	Middlesex								25	239,240
Northern	Middlesex								32	322,726
Northern	Middlesex								54	598,964
Northern	Middlesex								72	849,764
Northern	Monmouth								19	53,813
Northern	Monmouth								19	95,395
Northern	Monmouth								22	136,163
Northern	Monmouth								25	178,483
Northern	Monmouth								37	393,974
Northern	Monmouth								56	654,706
Northern	Passaic								18	14,412
Northern	Passaic								18	54,656
Northern	Passaic								19	63,488
Northern	Passaic								19	79,796
Northern	Passaic								41	346,199
Northern	Passaic								55	469,262
Northern	Passaic								65	515,336
Northern	Somerset								19	77,813
Northern	Somerset								24	257,456
Northern	Somerset								28	306,781
Northern	Somerset								31	335,954
Northern	Union								19	17,631
Northern	Union								19	77,844
Northern	Union								26	289,243
Northern	Union								27	305,583
Northern	Union								38	457,868
Northern	Union								41	495,737
Northern	Union								46	558,138
Southern	Atlantic								8	13,706
Southern	Atlantic								19	98,364
Southern	Atlantic								19	105,886
Southern	Atlantic								26	233,682
Southern	Atlantic								27	267,974
Southern	Atlantic								29	304,894
Southern	Burlington								19	2,277
Southern	Burlington								19	39,766
Southern	Burlington								19	72,823
Southern	Burlington								19	82,458
Southern	Burlington								19	86,404
Southern	Burlington								27	281,779
Southern	Burlington								42	460,865
Southern	Camden								18	1,942
Southern	Camden								18	21,550

Region	County	Evacuation Zones							Clearance Time (hr.) *	Evacuating Population
		A	B	C	D	E	F	G		
Southern	Camden	■	■	■					18	63,903
Southern	Camden	■	■	■	■				22	235,552
Southern	Camden	■	■	■	■	■			40	461,463
Southern	Camden	■	■	■	■	■	■		44	514,067
Southern	Cape May	■							19	56,145
Southern	Cape May	■	■						20	118,981
Southern	Cape May	■	■	■					20	120,959
Southern	Cumberland	■							19	20,838
Southern	Cumberland	■	■						19	21,981
Southern	Cumberland	■	■	■					19	163,512
Southern	Gloucester	■							18	11,405
Southern	Gloucester	■	■						18	35,956
Southern	Gloucester	■	■	■					18	70,163
Southern	Gloucester	■	■	■	■				23	233,061
Southern	Gloucester	■	■	■	■	■			28	308,530
Southern	Ocean	■							20	134,070
Southern	Ocean	■	■						22	188,413
Southern	Ocean	■	■	■					32	325,235
Southern	Ocean	■	■	■	■				37	393,634
Southern	Ocean	■	■	■	■	■			60	635,451
Southern	Salem	■							18	38,014
Southern	Salem	■	■						18	51,820
Southern	Salem	■	■	■					19	65,837

*Note: Clearance times are based on only one endpoint as shown in subsequent figures. This should be used for information purposes only. All clearance times were rounded to the nearest hour in the table above.

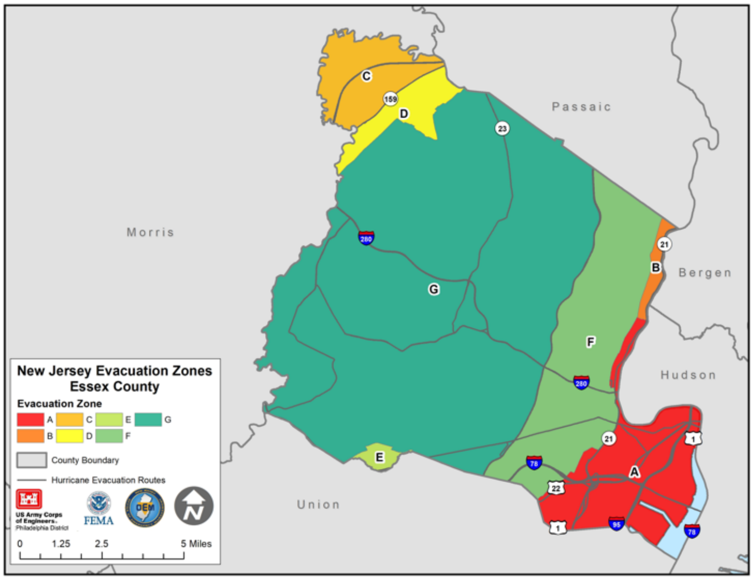
Northern Counties



- One endpoint on I-78

Evacuation Zones	Evacuating Population	Clearance Time
A	53,776	19.2
A+B	144,422	19.6
A+B+C	150,451	20.2
A+B+C+D	159,519	21.1
A+B+C+D+E	727,498	73.4
A+B+C+D+E+F	939,321	88.5

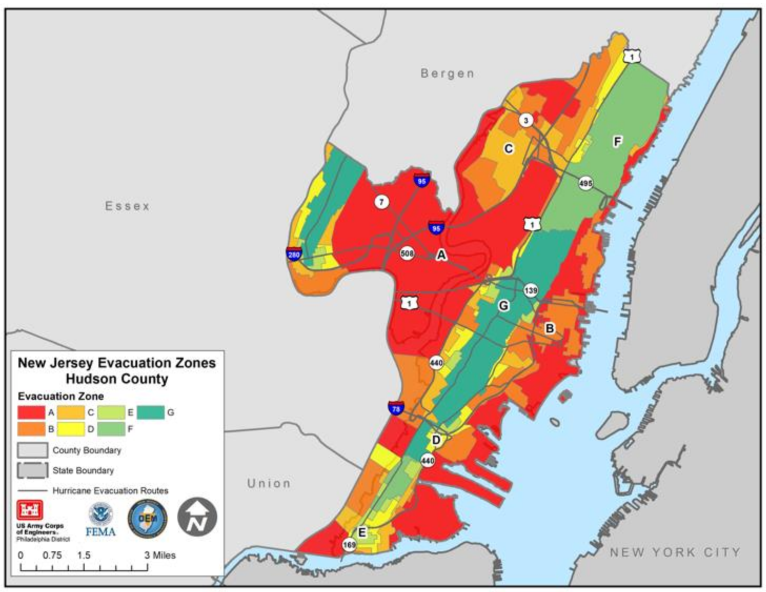
Figure E-1 Bergen County Evacuation Zones and County-step Clearance Times



- One endpoint on I-78

Evacuation Zones	Evacuating Population	Clearance Time
A	70,074	19.0
A+B	77,882	19.0
A+B+C	82,806	19.0
A+B+C+D	85,483	19.0
A+B+C+D+E	89,830	19.0
A+B+C+D+E+F	393,361	34.0
A+B+C+D+E+F+G	800,725	65.0

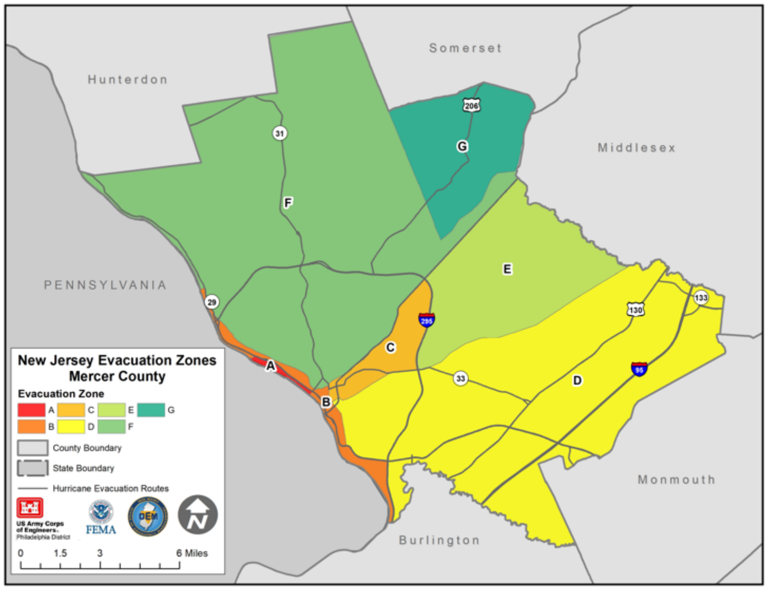
Figure E-2 Essex County Evacuation Zones and County-step Clearance Times



- One endpoint on I-78

Evacuation Zones	Evacuating Population	Clearance Time
A	77,356	19.2
A+B	166,628	25.0
A+B+C	210,585	31.0
A+B+C+D	245,493	35.0
A+B+C+D+E	271,213	37.0
A+B+C+D+E+F	479,037	56.0
A+B+C+D+E+F+G	682,062	82.0

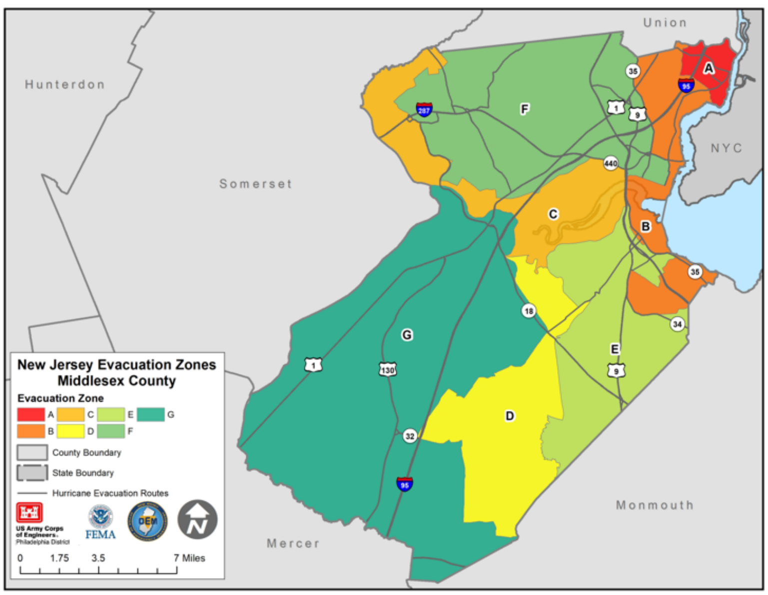
Figure E-3 Hudson County Evacuation Zones and County-step Clearance Times



- One endpoint on I-295

Evacuation Zones	Evacuating Population	Clearance Time
A	1,032	18.1
A+B	18,675	18.2
A+B+C	40,472	18.2
A+B+C+D	199,500	25.7
A+B+C+D+E	234,315	29.5
A+B+C+D+E+F	348,320	41.7
A+B+C+D+E+F+G	378,661	45.2

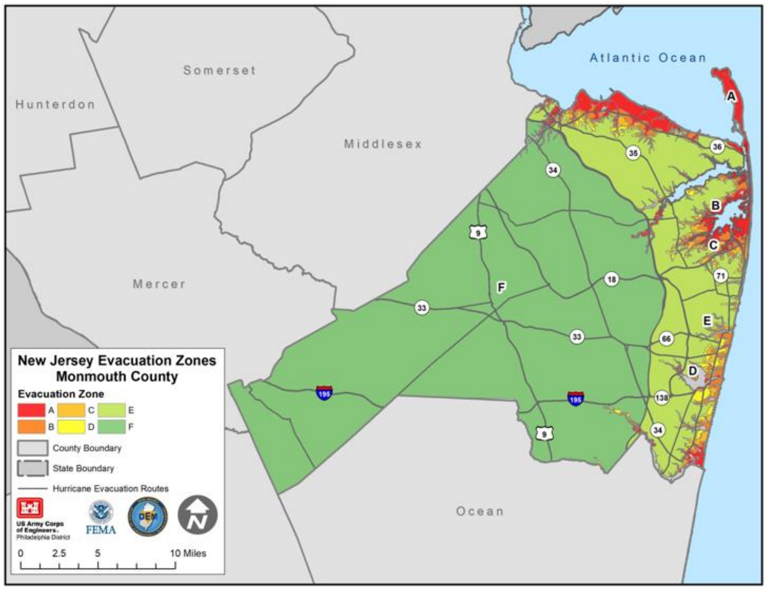
Figure E-4 Mercer County Evacuation Zones and County-step Clearance Times



- One endpoint on I-78

Evacuation Zones	Evacuating Population	Clearance Time
A	23,424	19
A+B	108,562	19.2
A+B+C	174,999	20.2
A+B+C+D	239,240	25
A+B+C+D+E	322,726	32.2
A+B+C+D+E+F	598,964	54.2
A+B+C+D+E+F+G	849,764	72

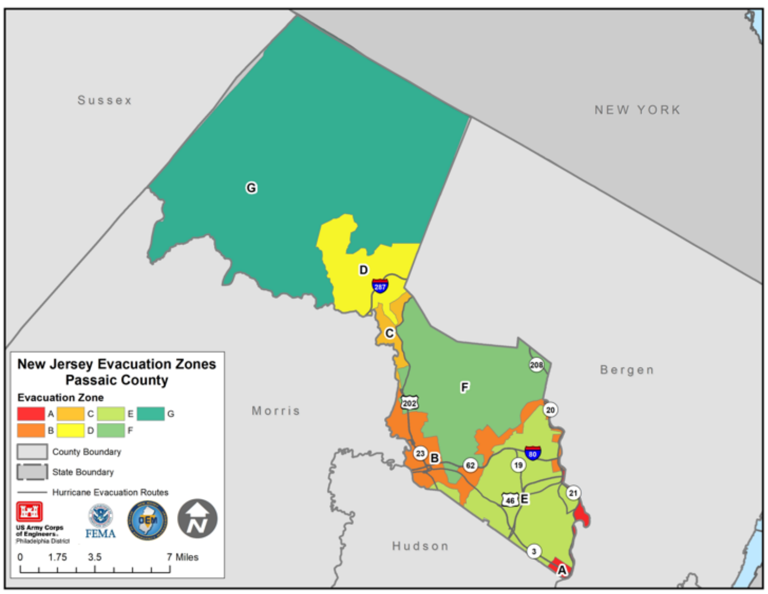
Figure E-5 Middlesex County Evacuation Zones and County-step Clearance Times



- One endpoint on I-78

Evacuation Zones	Evacuating Population	Clearance Time
A	53,813	19.3
A+B	95,395	19.3
A+B+C	136,163	22.3
A+B+C+D	178,483	25.4
A+B+C+D+E	393,974	37.2
A+B+C+D+E+F	654,706	56.2

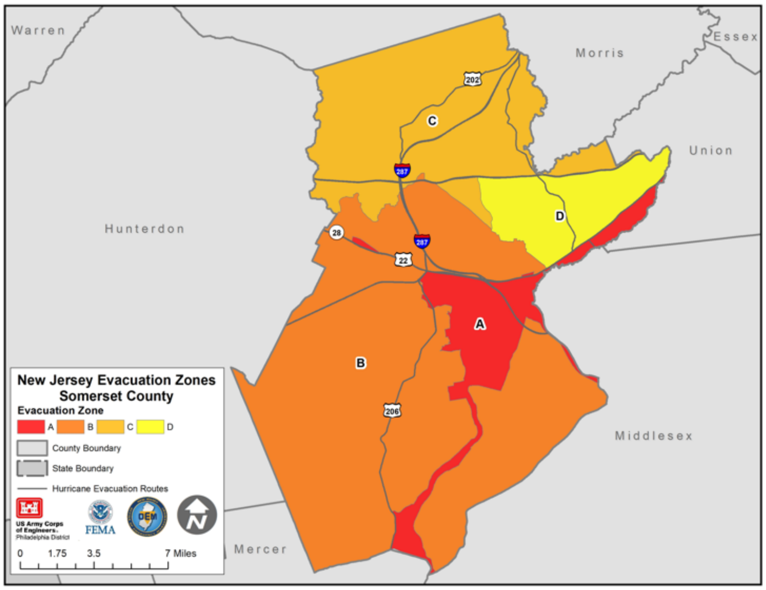
Figure E-6 Monmouth County Evacuation Zones and County-step Clearance Times



- One endpoint on Garden State PKWY

Evacuation Zones	Evacuating Population	Clearance Time
A	14,412	18.3
A+B	54,656	18.4
A+B+C	63,488	18.6
A+B+C+D	79,796	18.6
A+B+C+D+E	346,199	41.3
A+B+C+D+E+F	469,262	54.6
A+B+C+D+E+F+G	515,336	65.4

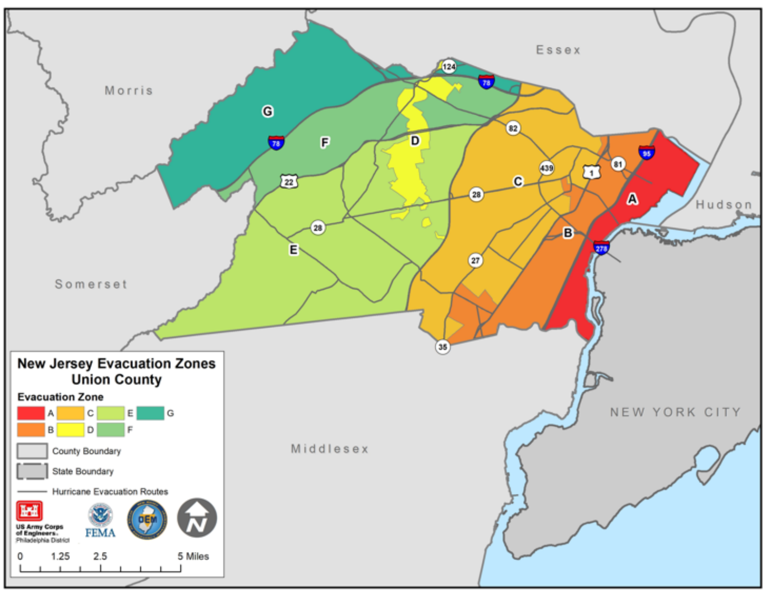
Figure E-7 Passaic County Evacuation Zones and County-step Clearance Times



- One endpoint on I-78

Evacuation Zones	Evacuating Population	Clearance Time
A	77,813	18.8
A+B	257,456	24.2
A+B+C	306,781	27.7
A+B+C+D	335,954	30.6

Figure E-8 Somerset County Evacuation Zones and County-step Clearance Times

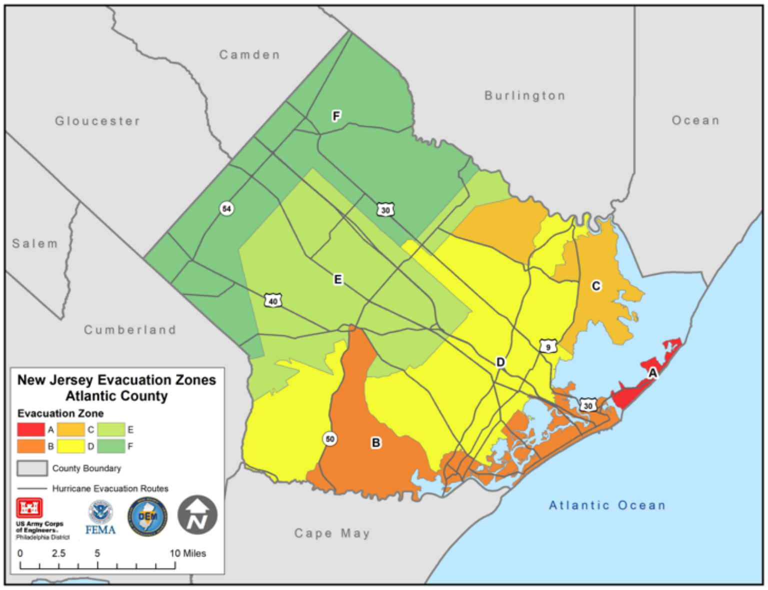


- One endpoint on I-78

Evacuation Zones	Evacuating Population	Clearance Time
A	17,631	19.0
A+B	77,844	19.0
A+B+C	289,243	26.1
A+B+C+D	305,583	27.2
A+B+C+D+E	457,868	38.1
A+B+C+D+E+F	495,737	40.8
A+B+C+D+E+F+G	558,138	45.5

Figure E-9 Union County Evacuation Zones and County-step Clearance Times

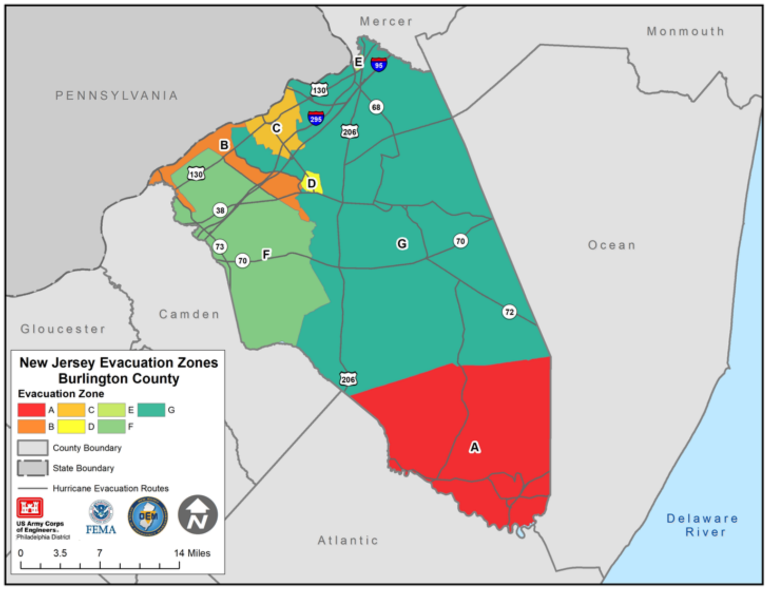
Southern Counties



- One endpoint on I-76

Evacuation Zones	Evacuating Population	Clearance Time
A	13,706	8.1
A+B	98,364	19.1
A+B+C	105,886	19.1
A+B+C+D	233,682	25.8
A+B+C+D+E	267,974	27.2
A+B+C+D+E+F	304,894	29.4

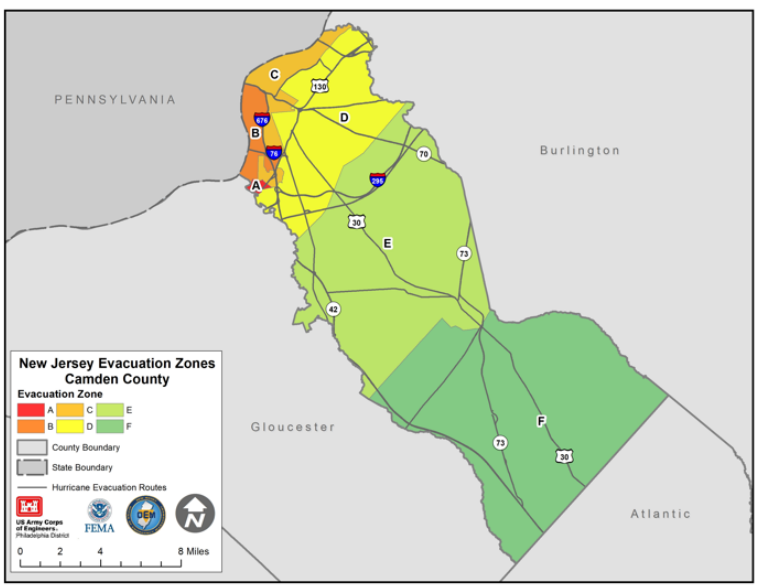
Figure E-10 Atlantic County Evacuation Zones and County-step Clearance Times



- One endpoint on I-76

Evacuation Zones	Evacuating Population	Clearance Time
A	2,277	19.1
A+B	39,766	19.1
A+B+C	72,823	19.1
A+B+C+D	82,458	19.1
A+B+C+D+E	86,404	19.1
A+B+C+D+E+F	281,779	27.3
A+B+C+D+E+F+G	460,865	41.7

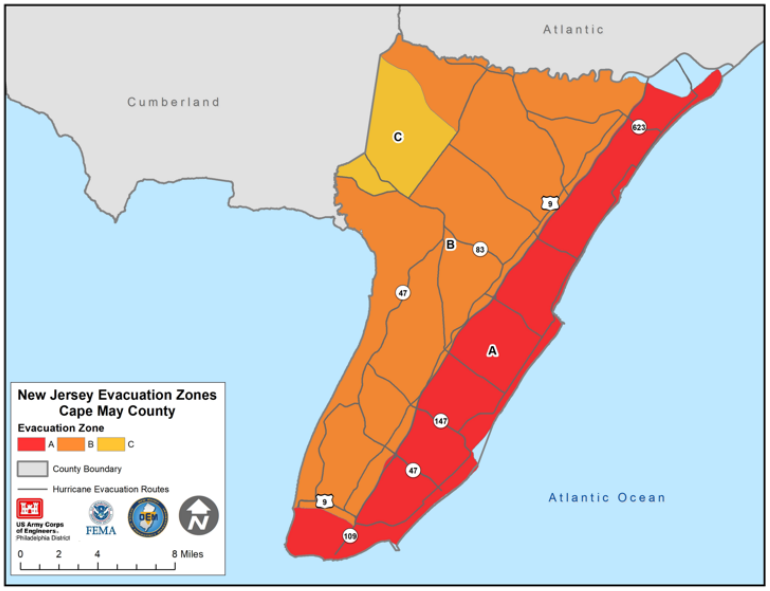
Figure E-11 Burlington County Evacuation Zones and County-step Clearance Times



- One endpoint on Benjamin Franklin Bridge

Evacuation Zones	Evacuating Population	Clearance Time
A	1,942	18.2
A+B	21,550	18.2
A+B+C	63,903	18.2
A+B+C+D	235,552	22.2
A+B+C+D+E	461,463	39.4
A+B+C+D+E+F	514,067	44.3

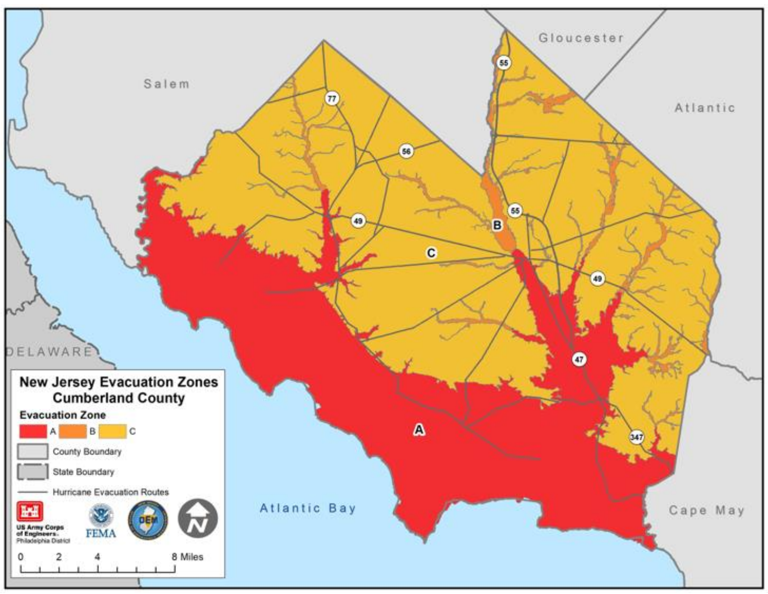
Figure E-12 Camden County Evacuation Zones and County-step Clearance Times



- One endpoint on I-76

Evacuation Zones	Evacuating Population	Clearance Time
A	56,145	19.4
A+B	118,981	20.4
A+B+C	120,959	20.4

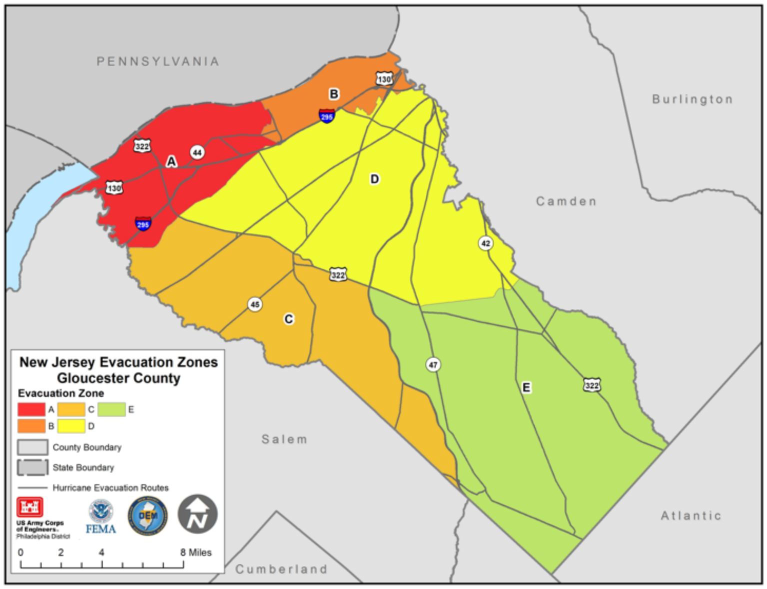
Figure E-13 Cape May County Evacuation Zones and County-step Clearance Times



- One endpoint on I-76

Evacuation Zones	Evacuating Population	Clearance Time
A	20,838	18.9
A+B	21,981	18.9
A+B+C	163,512	19.2

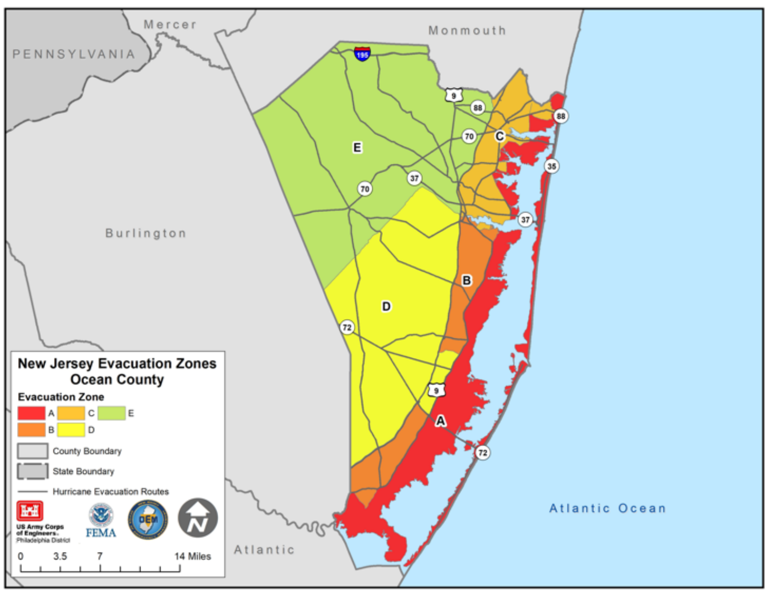
Figure E-14 Cumberland County Evacuation Zones and County-step Clearance Times



- One endpoint on I-76

Evacuation Zones	Evacuating Population	Clearance Time
A	11,405	18.3
A+B	35,956	18.3
A+B+C	70,163	18.4
A+B+C+D	233,061	22.5
A+B+C+D+E	308,530	28.4

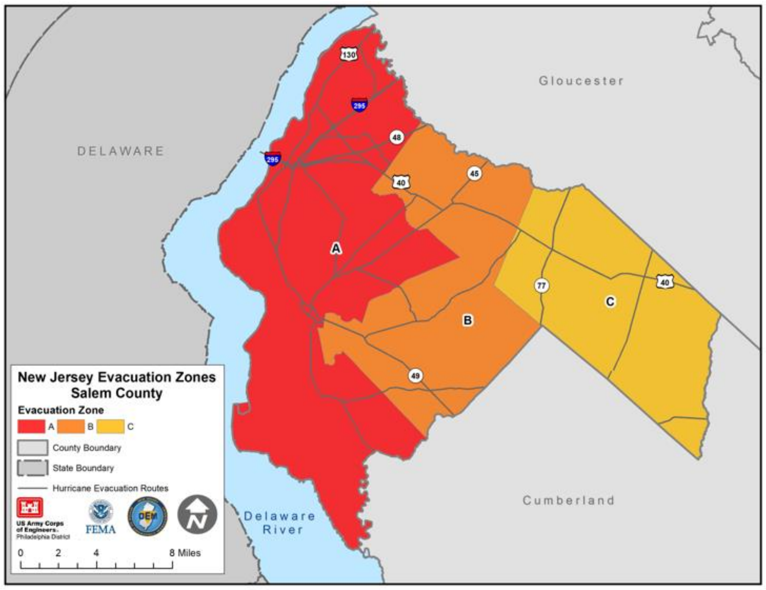
Figure E-15 Gloucester County Evacuation Zones and County-step Clearance Times



- One endpoint on I-76

Evacuation Zones	Evacuating Population	Clearance Time
A	134,070	19.5
A+B	188,413	21.5
A+B+C	325,235	31.5
A+B+C+D	393,634	36.5
A+B+C+D+E	635,451	60.2

Figure E-16 Ocean County Evacuation Zones and County-step Clearance Times



- One endpoint on I-295

Evacuation Zones	Evacuating Population	Clearance Time
A	38,014	18.3
A+B	51,820	18.3
A+B+C	65,837	18.7

Figure E-17 Salem County Evacuation Zones and County-step Clearance Times