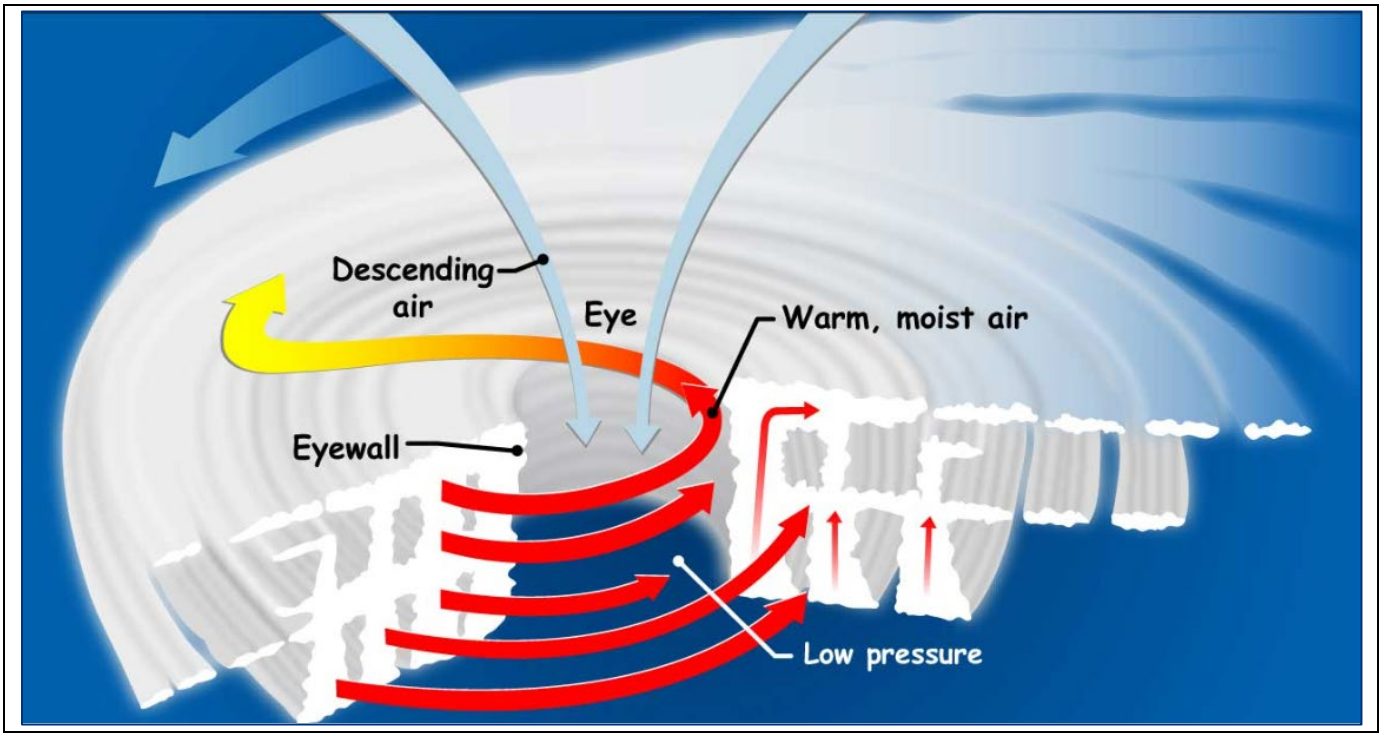
13. HURRICANE

13.1 HAZARD PROFILE

13.1.1 Hazard Description

A tropical cyclone is an organized system of clouds and thunderstorms around a warm-air core that originates in tropical or subtropical waters (between about 35 degrees latitude north and south). Tropical cyclones include hurricanes, tropical storms, and tropical depressions. They are fueled by a different heat mechanism than other cyclonic windstorms such as nor'easters and polar lows. Figure 13-1 illustrates the formation of a tropical cyclone. The characteristic that separates a tropical cyclone from another cyclonic system is that at any height in the atmosphere, the center of a tropical cyclone will be warmer than its surroundings, a phenomenon called "warm core" storm systems (NWS n.d.). Tropical cyclones strengthen when water evaporated from the ocean is released as the saturated air rises.

Figure 13-1. Formation of a Tropical Cyclone



Source: NASA 2019

Tropical cyclones can develop in the Atlantic between the Lesser Antilles and the African coast or in the warm tropical waters of the Caribbean Sea and Gulf of Mexico. These storms can move up the Atlantic coast of the United States, impacting the eastern seaboard, or move into the United States through the states along the Gulf Coast, bringing wind and rain as far north as New England before moving eastward offshore (NOAA 2020).

As storm systems strengthen into hurricanes (maximum sustained winds of at least 74 mph), the surface winds move continuously in a circular motion. Meteorologists refer to this pattern as "closed circulation." The direction of

circulation is different depending on where the storm is located: it is counterclockwise in the Northern hemisphere and clockwise in the Southern hemisphere. These rotating winds lead to the development of the characteristic "eye" of the hurricane: the calm, clear center of the storm. The eye is surrounded by the eyewall, where winds are strongest.

The National Weather Service (NWS) issues hurricane and tropical storm watches and warnings, which remain in effect as long as the event poses a significant threat to life and property (NOAA NHC 2010):

- **Tropical Storm Watch** is issued when tropical storm conditions (sustained winds of 39 to 73 mph) are possible within the specified area within 48 hours.
- **Tropical Storm Warning** is issued when tropical storm conditions (sustained winds of 39 to 73 mph) are expected somewhere within the specified area within 36 hours.
- **Hurricane Watch** is issued when hurricane conditions (sustained winds of 74 mph or higher) are possible within the specified area. The watch is issued 48 hours prior to the anticipated onset of tropical storm-force winds.
- **Hurricane/Typhoon Warning** is issued when hurricane conditions (sustained winds of 74 mph or higher) are expected somewhere within the specified area. The warning is issued 36 hours in advance of the anticipated onset of tropical storm-force winds. The warning can remain in effect when dangerously high water or combination of dangerously high water and waves continue, even though winds may be less than hurricane force.

13.1.2 Location

Sussex County is not located along the Atlantic Coast, but hurricanes and tropical storms can track inland, bringing heavy rainfall, strong winds, and flooding. These storms are regional events that can impact very large areas hundreds to thousands of miles across over the life the storm. Therefore, all communities within Sussex County are equally subject to the impacts of hurricanes and tropical storms. Areas in Sussex County that are subject to flooding and wind damage are particularly vulnerable.

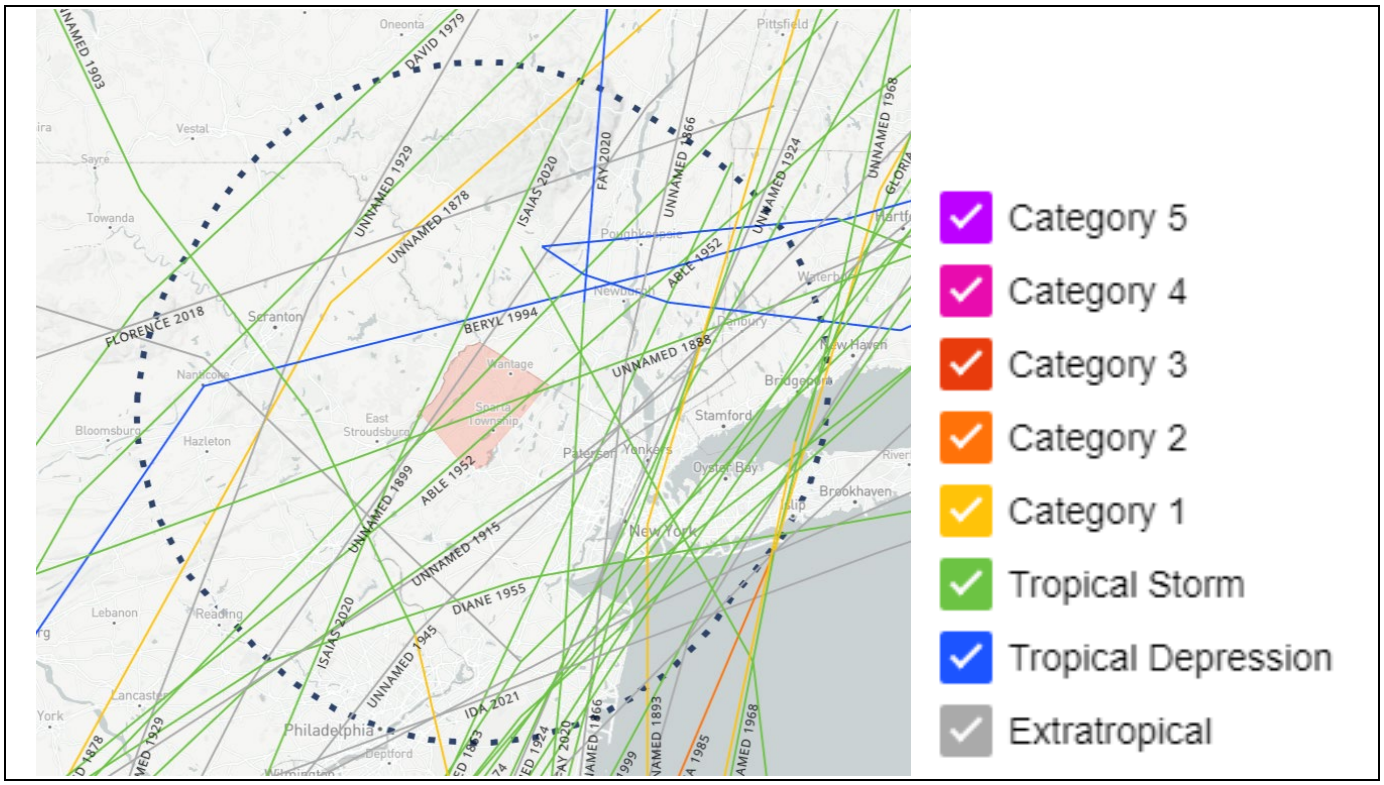
Figure 13-2 shows the paths of the centers of previous hurricanes and tropical storms that tracked within 60 nautical miles of Sussex County, a distance within which significant impacts are typically felt. Since 1861, the County has been impacted by three tropical depressions, 23 tropical storms, five hurricanes, and 13 extratropical cyclones (cyclones with that draw energy from the contrast between warm and cold air masses) (NOAA NHC 2024).

13.1.3 Extent

Hurricane Risk Index

Figure 13-3 shows a relatively low Hurricane Risk Index for Sussex County from FEMA's National Risk Index (FEMA 2019).

Figure 13-2. Historical Tropical Storm and Hurricane Tracks 1861 to 2023



Source: NOAA NHC 2023

Figure 13-3. National Risk Index, Hurricane Risk Index Score

Source: FEMA 2019
Note: Sussex County is outlined in a blue border.

Wind-Based Scale

The extent of a tropical cyclone is measured using the Saffir-Simpson Hurricane Wind Scale. This scale is used to estimate the potential property damage and flooding expected when a tropical cyclone makes landfall. Based on a storm's sustained wind speed, it designates a tropical depression, tropical storm, or hurricane category 1 to 5, as shown in Table 13-1. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Tropical storms and Category 1 and 2 storms are still dangerous and require preventative measures (NOAA 2020).

Table 13-1. Saffir-Simpson Wind Scale

Category	Wind Speed
Tropical Depression	38 mph or less
Tropical Storm	39 to 73 mph
Hurricane Category 1	74 to 95 mph
Hurricane Category 2	96 to 110 mph
Hurricane Category 3	111 to 129 mph
Hurricane Category 4	130 to 156 mph
Hurricane Category 5	157 mph or higher

Source: NOAA 2020

Mean Return Period

In evaluating the potential for hazard events of a given magnitude, a mean return period (MRP) is often used. The MRP provides an estimate of the frequency of an event that may occur within any given year based on past recorded events. Figure 13-5 and Figure 13-6 show the estimated maximum three-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP events. These peak wind speed projections were generated using FEMA's Hazus v6 wind model. The estimated hurricane track for the 100- and 500-year event is also shown. The maximum three-second gust wind speeds for Sussex County for both the 100- and 500-year MRP events are 74 to 95 mph (Category 1 hurricane).

13.1.4 Previous Occurrences

FEMA Major Disaster and Emergency Declarations

Sussex County has been included in eight major disaster (DR) or emergency (EM) declarations for hurricane-related events, as listed in Table 13-2.

Table 13-2. FEMA Declarations for Hurricane Events in Sussex County

Event Date	Declaration Date	Declaration Number	Description
September 16 – 18, 1999	September 17, 1999	EM-3148	New Jersey Hurricane Floyd
August 26 – September 5, 2011	August 27, 2011	EM-3332	Hurricane Irene in New Jersey

Event Date	Declaration Date	Declaration Number	Description
August 26 – September 5, 2011	August 27, 2011	DR-4021	Hurricane Irene in New Jersey
October 26 – November 8, 2012	October 28, 2012	EM-3354	New Jersey Hurricane Sandy
October 26 – November 8, 2012	October 30, 2012	DR-4086	New Jersey Hurricane Sandy
August 4, 2020	December 11, 2020	DR-4574	Tropical Storm Isaias
September 1 - 3, 2021	September 2, 2021	EM-3573	Remnants of Hurricane Ida
September 1 - 3, 2021	September 5, 2021	DR-4614	Remnants of Hurricane Ida

Sources: FEMA 2024

USDA Declarations

The U.S. Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans from the U.S. Department of Agriculture (USDA) to producers suffering losses in those counties and in contiguous counties. Since the previous Sussex County HMP, the County has not been included in any USDA hurricane-related agricultural disaster declarations (USDA 2024).

Previous Events

Known hurricane events that impacted Sussex County between January 2020 and June 2024 are listed in Table 13-3. For events prior to 2020, refer to the 2021 Sussex County HMP.

Figure 13-4. Wind Speeds for the 100-Year Mean Return Period Event

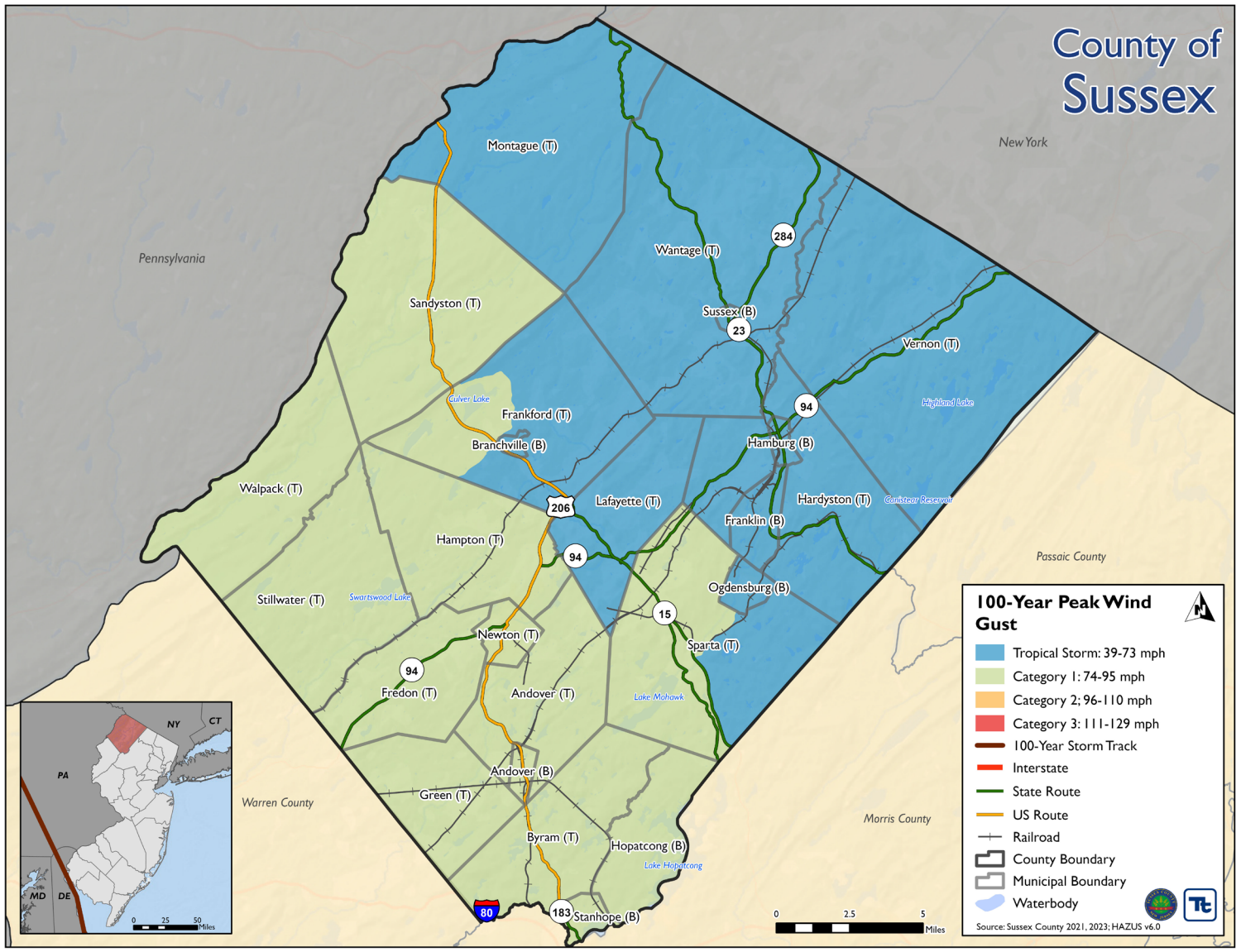


Figure 13-5. Wind Speeds for the 500-Year Mean Return Period Event

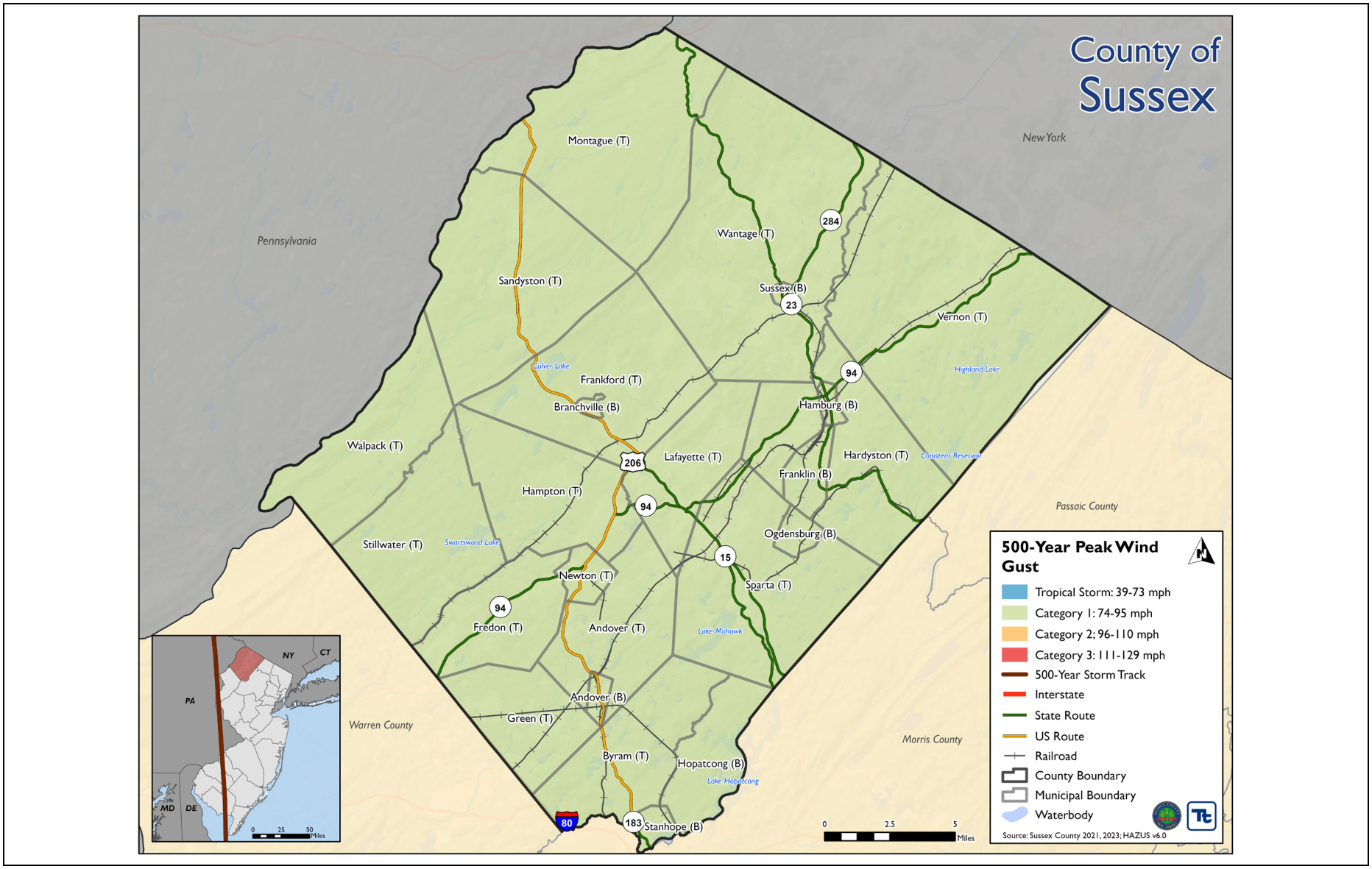


Table 13-3. Hurricane Events in Sussex County (2020 to 2024)

Event Date	FEMA Declaration or State Proclamation Number	Sussex County included in declaration?	Location Impacted	Description
July 10, 2020	N/A	N/A	Sussex County	Tropical Storm Fay moved northward along the coasts of Delaware and New Jersey. The storm produced rainfall up to 6 inches in New Jersey, with the highest totals in the southern part of the state. Some areas also experienced a period of tropical storm force winds, especially near the coast. Overall impacts from wind were limited.
August 4, 2020	EM-3573-NJ, DR-4614-NJ	Yes	Sussex County	Tropical Storm Isaias brought high winds, heavy rain, tornadoes, and coastal flooding to the mid-Atlantic region, becoming the most impactful tropical cyclone to impact most of the region since Sandy in 2012. Several reports of downed trees and power lines were made.
September 1 - 3, 2021	EM-3573-NJ, DR-4614-NJ	Yes	Sussex County	Post-Tropical Cyclone Ida brought heavy rain to New Jersey on September 1. Rainfall totals were as high as 10 inches. The heavy rain caused significant flash flooding, mainly in the northern half of the state. It resulted in widespread property damage and several fatalities.

Source: FEMA 2024; National Oceanic and Atmospheric Administration 2024

13.1.5 Probability of Future Occurrences

Probability Based on Previous Occurrences

Information on previous hurricane occurrences in the County was used to calculate the probability of future occurrence of such events, as summarized in Table 13-4. Based on historical records and input from the Steering Committee, the probability of occurrence for hurricane in the County is considered “occasional.” It is estimated that Sussex County will continue to experience direct and indirect impacts of hurricanes and tropical storms such as flooding, extreme wind, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays.

Table 13-4. Probability of Future Hurricane Events in Sussex County

Hazard Type	Number of Occurrences Between 1842 and 2024	Percent Chance of Occurring in Any Given Year
Tropical Depression	3	1.6%
Tropical Storm	23	12.6%
Hurricanes (all categories)	5	2.7%
Total	**31**	**16.9%**

Sources: FEMA 2024; NOAA NHC 2024

Effect of Climate Change on Future Probability

Climate change may result in changes to the frequency of coastal storms. In the past decade, warmer ocean temperatures have resulted in many tropical systems taking place outside of the typical hurricane season. Eight of

the last nine years have featured a tropical system occurring before the official start of the season (Sullivan 2023). In 2016, a rare winter hurricane named Alex developed in the middle of January (BBC 2019). According to NOAA's database, 39 storms formed in the Atlantic Basin before June 1 from 1851 through 2020, a long-term average of one such early storm every four to five years. The 2010s had the most such storms, and there has been a steady increase since the 1990s. However, the 1950s had six such storms, the 1930s had four and there was another four preseason storm streak from 1887 through 1890. It is possible there were other such storms in the era before satellites – before the mid-1960s – that were missed by ship observations or reports from areas impacted. It remains to be seen if expansion of the traditional hurricane season is a long-term trend or a common occurrence (Erdman 2020).

13.1.6 Cascading Impacts on Other Hazards

Hurricanes can interact with the following hazards of concern identified for this HMP:

- **Flood**—Hurricane rainfall can contribute to severe flooding
- **Geological Hazards—**Hurricane rainfall can lead to unstable ground, causing landslides. The oversaturation of the ground can also increase the likelihood of sinkhole events, depending on the soil composition.
- **Health—**Impacts of flooding associated with hurricanes may include exposure to pathogens such as mold. Floodwaters can be contaminated by pollutants such as sewage, human and animal feces, pesticides, fertilizers, oil, asbestos, and rusting building materials.

13.2 VULNERABILITY AND IMPACT ASSESSMENT

A probabilistic assessment was conducted for the 100- and 500-year MRPs through a Level 2 analysis in HAZUS v6 to estimate potential losses associated with these high-wind events. The Hazus methodology for hurricanes is described in Section 4.3.2. The impacts on population, existing structures, critical facilities, and the economy are presented below.

13.2.1 Life, Health, and Safety

Overall Population

The impact of a hurricane on life, health, and safety is dependent upon the severity of the event and whether adequate warning time is provided to residents. For the purposes of this HMP, the entire population of Sussex County (144,221 people) is exposed to hurricanes.

For the 100-year MRP event, Hazus estimates no households in Sussex County will be displaced and temporary shelter will not be required. However, as shown in Table 13-5, the 500-year MRP event may result in 3 displaced households and 1 person seeking temporary shelter. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

Table 13-5. Displaced Households and Persons Seeking Shelter Caused by the 500-Year MRP Hurricane Event

	500-Year Mean Return Period Hurricane	
	Displaced Households	Persons Seeking Short-Term Sheltering
Andover (B)	0	0
Andover (T)	0	0
Branchville (B)	0	0
Byram (T)	0	0
Frankford (T)	0	0
Franklin (B)	0	0
Fredon (T)	0	0
Green (T)	0	0
Hamburg (B)	0	0
Hampton (T)	0	0
Hardyston (T)	0	0
Hopatcong (B)	1	1
Lafayette (T)	0	0
Montague (T)	0	0
Newton (T)	0	0
Ogdensburg (B)	0	0
Sandyston (T)	0	0
Sparta (T)	1	0
Stanhope (B)	0	0
Stillwater (T)	0	0
Sussex (B)	0	0
Vernon (T)	1	0
Walpack (T)	0	0
Wantage (T)	0	0
Sussex County (Total)	**3**	**1**

Source: Hazus v6.0
Note: Results for population are rounded down.

Socially Vulnerable Population

Socially vulnerable populations are most susceptible to the hurricane hazard, based on factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Economically disadvantaged populations are more vulnerable because they are likely to lack funds to evacuate. The population over the age of 65 is also more vulnerable and might physically have more difficulty evacuating. The older population generally requires extra time or outside assistance during evacuations and is more likely to need medical attention that might not be available due to isolation during a hurricane event.

Without a quantitative assessment of potential impacts of a hurricane on socially vulnerable populations, the Planning Partners can best assess mitigation options through an understanding of the general numbers and locations of such populations across Sussex County. Section 3.5.3 provides detailed data on socially vulnerable populations within the planning area. Table 13-6 summarizes highlights of this information. For planning purposes, it is reasonable to assume that percentages and distribution of socially vulnerable populations affected by a hurricane will be similar to the countywide numbers.

Table 13-6. Distribution of Socially Vulnerable Populations by Municipality

Category	Sussex County Total		Municipality Highest in Category		Municipality Lowest in Category	
	Number	Percent	Number	Percent	Number	Percent
			Vernon (T)	Walpack (T)	Walpack (T)	Sparta (T)
Population Over 65	**25,451**	**17.65%**	**3,687**	**100.00%**	**7**	**13.38%**
			Sparta (T)	Lafayette (T)	Walpack (T)	Walpack (T)
Population Under 5	**6,500**	**4.51%**	**1,160**	**7.21%**	**0**	**0.00%**
Non-English-Speaking Population	**1,922**	**1.33%**	Hopatcong (B) **339**	Hamburg (B) **10.17%**	Andover, Frankford, Sandyston, Stanhope, Stillwater, Walpack **0**	Andover, Frankford, Sandyston, Stanhope, Stillwater, Walpack **0.00%**
Population With Disability	**15,697**	**10.88%**	Vernon (T) **2,318**	Franklin (B) **17.32%**	Walpack (T) **0**	Walpack (T) **0.00%**
Population Below Poverty Level	**7,320**	**5.08%**	Vernon (T) **877**	Sussex (B) **18.03%**	Walpack (T) **0**	Walpack (T) **0.00%**
Households Below ALICE Threshold	**14,428**	**21%**	Vernon (T) 1,833	Sussex (B0 **48%**	Branchville (B) 90	Green (T) **14%**

13.2.2 General Building Stock

Building construction plays a major role in the extent of damage resulting from a hurricane event. Due to differences in construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings, in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. High-rise buildings are also very vulnerable structures. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

The Hazus wind model was run to estimate potential losses to buildings. Damage to buildings is a direct result of wind speed, direction, and duration, which is dependent upon the storm's intensity and track. Expected building damage was evaluated across the wind damage categories described in Table 13-7. Building damage as a result of the 100-year and 500-year MRP hurricane wind events was estimated using Hazus, as summarized in Table 13-8. The analysis found that no buildings will be severely or completely destroyed by the 100-year MRP event, 1 will be moderately damaged, and 293 will have minor damage. For the 500-year MRP event, the analysis estimates that 2 buildings will be completely destroyed, 2 will experience severe damage, 219 will be moderately damaged, and 4,028 will have minor damage. The majority of the losses are estimated to the residential occupancy class for both MRP events.

Table 13-9 summarizes the damage estimated for the 100- and 500-year MRP events. The total estimated damage to buildings for all occupancy types across Sussex County is $25.5 million for the 100- MRP event and $130.6 million for the 500- MRP event. Most of these losses are to residential buildings. The damage counts include buildings damaged at all severity levels from minor damage to destruction. Total dollar damage reflects the overall impact on buildings at an aggregate level. The Township of Vernon is estimated to experience the greatest damage in a 100-year and 500-year MRP event: $4.2 million and $25.3 million, respectively.

Table 13-7. Description of Damage Categories

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
No Damage or Very Minor Damage Little or no visible damage from the outside. No broken windows, or failed roof deck. Minimal loss of roof cover, with no or very limited water penetration.	≤2%	No	No	No	No	No
Minor Damage Maximum of one broken window, door or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for repair.	>2% and ≤15%	One window, door, or garage door failure	No	<5 impacts	No	No
Moderate Damage Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.	>15% and ≤50%	> one and ≤ the larger of 20% & 3	1 to 3 panels	Typically 5 to 10 impacts	No	No
Severe Damage Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	>50%	> the larger of 20% & 3 and ≤50%	>3 and ≤25%	Typically 10 to 20 impacts	No	No
Destruction Complete roof failure and/or, failure of wall frame. Loss of more than 50% of roof sheathing.	Typically >50%	>50%	>25%	Typically >20 impacts	Yes	Yes

Source: FEMA 2022

Table 13-8. Expected Damages from 100 and 500-Year MRP Events

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	100-year		500-year	
			Building Count	Percent Buildings in Occupancy Class	Building Count	Percent Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)	62,412	None	62,137	99.6%	58,295	93.4%
		Minor	274	0.4%	3,905	6.3%
		Moderate	1	<0.1%	210	0.3%
		Severe	0	0.0%	1	<0.1%
		Complete Destruction	0	0.0%	2	<0.1%
Commercial Buildings	3,345	None	3,328	99.5%	3,223	96.4%
		Minor	17	0.5%	114	3.4%
		Moderate	0	0.0%	8	0.2%
		Severe	0	0.0%	1	0.0%
		Complete Destruction	0	0.0%	0	0.0%
Industrial Buildings	227	None	225	99.1%	217	95.6%
		Minor	2	0.9%	9	4.1%
		Moderate	0	0.0%	1	0.3%
		Severe	0	0.0%	0	0.0%
		Complete Destruction	0	0.0%	0	0.0%
Other[a]	5,953	None	5,942	99.8%	5,768	96.9%
		Minor	11	0.2%	182	3.0%
		Moderate	0	0.0%	4	0.1%
		Severe	0	0.0%	0	0.0%
		Complete Destruction	0	0.0%	0	0.0%

Source: Hazus v6.0; NJGIN 2023; Sussex County 2023

a. Other = Government, Religion, Agricultural, and Education

Table 13-9. Estimated Building Damage by General Occupancy for the 100-Year and 500-Year MRP Events

	Estimated Building Losses (Residential)		Estimated Building Losses (Commercial)		Estimated Building Losses (Industrial)		Estimated Building Losses (All Other Occupancies)		Estimated Building Losses (All Occupancies)	
	100-Year MRP Event	500-Year MRP Event	100-Year MRP Event	500-Year MRP Event	100-Year MRP Event	500-Year MRP Event	100-Year MRP Event	500-Year MRP Event	100-Year MRP Event	500-Year MRP Event
Andover (B)	$124,213	$505,254	$11,610	$135,227	$149	$903	$1,157	$12,608	$137,129	$653,992
Andover (Twp)	$947,670	$3,640,348	$111,633	$1,129,615	$2,792	$17,039	$9,760	$158,804	$1,071,855	$4,945,806
Branchville (B)	$136,160	$576,475	$17,205	$101,787	$603	$1,631	$2,349	$50,555	$156,317	$730,447
Byram (Twp)	$1,198,237	$4,959,633	$65,130	$798,412	$178	$1,084	$9,253	$87,833	$1,272,798	$5,846,961
Frankford (Twp)	$981,262	$4,107,485	$86,212	$494,144	$3,367	$10,085	$11,009	$234,434	$1,081,851	$4,846,148
Franklin (B)	$705,506	$3,763,067	$48,707	$1,056,578	$3,301	$40,162	$7,310	$143,381	$764,825	$5,003,189
Fredon (Twp)	$531,232	$1,864,558	$2,701	$18,277	$1,840	$7,459	$2,116	$69,601	$537,890	$1,959,895
Green (Twp)	$781,875	$2,647,775	$6,760	$31,105	$3,861	$15,678	$4,659	$93,451	$797,156	$2,788,008
Hamburg (B)	$561,875	$2,856,840	$45,782	$1,165,287	$4,128	$64,695	$9,334	$111,528	$621,120	$4,198,350
Hampton (Twp)	$707,823	$2,928,374	$60,618	$281,735	$653	$2,002	$11,805	$133,482	$780,899	$3,345,592
Hardyston (Twp)	$1,628,732	$7,771,379	$52,075	$902,341	$4,666	$55,942	$9,625	$236,371	$1,695,099	$8,966,034
Hopatcong (B)	$2,559,577	$10,692,852	$48,121	$696,361	$0	$0	$16,104	$184,881	$2,623,802	$11,574,094
Lafayette (Twp)	$559,534	$2,402,518	$47,297	$332,742	$5,883	$27,712	$10,334	$342,041	$623,048	$3,105,013
Montague (Twp)	$303,156	$1,685,416	$14,864	$80,543	$641	$1,943	$7,765	$48,403	$326,426	$1,816,305
Newton (T)	$968,964	$3,810,773	$149,651	$926,359	$11,363	$56,628	$31,053	$167,910	$1,161,030	$4,961,670
Ogdensburg (B)	$328,245	$1,772,158	$19,572	$446,084	$0	$0	$6,019	$48,544	$353,836	$2,266,786
Sandyston (Twp)	$182,137	$761,697	$11,481	$33,744	$1,582	$4,564	$11,328	$41,462	$206,529	$841,467
Sparta (Twp)	$3,380,932	$15,065,780	$249,699	$3,726,895	$9,398	$74,552	$28,365	$404,374	$3,668,394	$19,271,601
Stanhope (B)	$672,875	$2,593,770	$12,302	$178,920	$6,050	$45,394	$6,204	$50,968	$697,431	$2,869,052
Stillwater (Twp)	$397,330	$1,484,059	$4,599	$29,307	$0	$0	$3,597	$30,471	$405,527	$1,543,838
Sussex (B)	$276,243	$1,690,860	$139,523	$1,056,064	$3,866	$23,131	$11,983	$100,953	$431,615	$2,871,007
Vernon (Twp)	$4,113,941	$23,410,648	$49,571	$1,220,367	$5,159	$91,640	$26,746	$658,889	$4,195,417	$25,381,543
Walpack (Twp)	$6,087	$25,456	$384	$1,128	$53	$153	$379	$1,386	$6,902	$28,122
Wantage (Twp)	$1,857,475	$9,298,375	$73,026	$671,401	$1,027	$5,448	$32,128	$817,157	$1,963,657	$10,792,382
Sussex County (Total)	$23,911,084	$110,315,549	$1,328,522	$15,514,424	$70,562	$547,845	$270,383	$4,229,486	$25,580,551	$130,607,303

Source: Hazus v6.0; Sussex County 2023; RS Means 2022; NJOGIS, Civil Solutions, Spatial Data Logic

13.2.3 Community Lifelines and Other Critical Facilities

Utility infrastructure could suffer damage from hurricane high winds associated with falling tree limbs or other debris, resulting in the loss of power. Loss of service can impact residents and business operations alike. Interruptions in heating or cooling utilities can affect populations such as the young and elderly, who are particularly vulnerable to temperature-related health impacts. Loss of power can impact other public utilities, including potable water, wastewater treatment, and communications. In addition to public water services, property owners with private wells might not have access to potable water due to pump failure until power is restored. Lack of power to emergency facilities, including police, fire, EMS, and hospitals, will inhibit a community's ability to effectively respond to an event and maintain the safety of its citizens.

Table 13-10 and Table 13-11 summarize the damage state probabilities for critical facilities during the 100-year and 500-year MRP events, respectively. For both events, there are no days predicted for loss of function of any lifeline.

Table 13-10. Estimated Impacts on Critical Facilities for the 100-Year MRP Hurricane Event

	Loss of Days	Average Percent Probability of Sustaining Damage 100-Year Mean Return Period Hurricane			
		Minor	Moderate	Severe	Complete
Communications	0	0.3%	<0.1%	0.0%	0.0%
Energy	0	0.7%	<0.1%	0.0%	0.0%
Food, Hydration, Shelter	0	1.0%	0.1%	0.0%	0.0%
Hazardous Materials	0	0.8%	<0.1%	<0.1%	0.0%
Health and Medical	0	0.3%	<0.1%	0.0%	0.0%
Safety and Security	0	0.7%	<0.1%	0.0%	0.0%
Transportation	0	0.1%	0.0%	0.0%	0.0%
Water Systems	0	0.6%	<0.1%	0.0%	0.0%

Source: Hazus v6.0; NJGIN 2023; Sussex County 2021, 2023

Table 13-11. Estimated Impacts on Critical Facilities for the 500-Year MRP Hurricane Event

	Loss of Days	Average Percent Probability of Sustaining Damage 500-Year Mean Return Period Hurricane			
		Minor	Moderate	Severe	Complete
Communications	0	4.4%	0.7%	0.1%	0.0%
Energy	0	3.7%	0.4%	<0.1%	0.0%
Food, Hydration, Shelter	0	5.6%	0.9%	<0.1%	0.0%
Hazardous Materials	0	3.6%	0.6%	0.2%	<0.1%
Health and Medical	0	2.2%	0.3%	0.0%	0.0%
Safety and Security	0	3.0%	0.3%	<0.1%	0.0%
Transportation	0	4.2%	0.1%	0.0%	0.0%
Water Systems	0	3.1%	0.3%	<0.1%	0.0%

Source: Hazus v6.0; NJGIN 2023; Sussex County 2021, 2023

As a result of a 100-year MRP event, Hazus estimates that the Food, Hydration, Shelter lifeline has the greatest chance of sustaining minor damage (1 percent probability), followed by the Energy and Safety and Security lifelines (both at 0.7 percent probability). Food, Hydration, Shelter lifelines also have the greatest chance of moderate damage, at an approximate 0.1 percent probability. Severe damage to lifelines is negligible, and no complete damage is predicted.

As a result of a 500-year MRP event, Hazus estimates that Food, Hydration, Shelter lifelines have the greatest chance of sustaining minor damage (5.6 percent) and moderate damage (0.9 percent). Severe damage to all lifelines is negligible, with the greatest chance for Hazardous Materials lifelines (0.2 percent probability). Similarly, complete damage is negligible, with potential only for Hazardous Materials lifelines (<0.1 percent).

13.2.4 Economy

Damage to structures from hurricane flooding and wind can have long-lasting impacts on the economy. When a business is closed during storm recovery, there is lost economic activity in the form of day-to-day business and wages to employees. Economic impacts include loss of business function (e.g., tourism, recreation), damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. During Hurricane Sandy, the State of New Jersey, including Sussex County, lost millions of dollars in wages and economic activity.

Long-term impacts on transportation lifelines affect day-to-day commuting and goods transport. Utility infrastructure (power lines, gas lines, electrical systems) damage can result in the loss of power, which can impact business operations.

Debris management can be costly and impact the local economy. Hazus estimates the amount of debris that might be produced as result of the 100- and 500-year MRP wind events. Table 13-12 summarizes the estimated debris by municipality. Because the estimated debris production does not include debris generated by flooding, this is likely a conservative estimate. For both MRP events, debris production from trees is the greatest, with the 100-year MRP creating an estimated 4,230 tons of debris, and the 500-year MRP event creating 169,744 tons.

13.2.5 Natural, Historic and Cultural Resources

Natural

The impacts of hurricane related winds on the environment typically take place over a larger area. Widespread, severe damage to tree and plant species is likely. This includes uprooting or destruction of trees and an increased threat of wildfire in areas where dead trees are not removed. Hurricanes can also destroy terrestrial species habitats and the aquatic species that relied on a waterbody, such as the Delaware River, for a habitat.

Historic

Winds associated with hurricanes can cause damage or destruction to the County's historical infrastructure. Many historical buildings may not be built to withstand high winds. Historic buildings also face structural damage during flood events caused by the rains from a hurricane. Historic resources and structures were often built close to waterways, increasing their flood risk. Hurricane-induced flooding could bring devastating loss of life and property to the area in and around historical landmarks.

Table 13-12. Debris Production for 100- and 500-Year Mean Return Period Event Winds

	Brick and Wood (tons)		Concrete and Steel (tons)		Tree (tons)		Eligible Tree Volume (cubic yards)	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Andover (B)	11	60	0	0	64	763	178	2,136
Andover (Twp)	103	527	0	0	234	6,504	656	13,782
Branchville (B)	18	81	0	0	0	1,248	0	1,872
Byram (Twp)	88	513	0	0	724	8,952	1,713	21,083
Frankford (Twp)	97	483	0	0	0	8,550	0	15,611
Franklin (B)	66	516	0	0	0	1,475	0	7,931
Fredon (Twp)	41	182	0	0	0	3,435	0	4,810
Green (Twp)	52	230	0	0	0	4,167	0	6,251
Hamburg (B)	52	435	0	0	0	336	0	2,958
Hampton (Twp)	55	286	0	0	0	7,528	0	12,305
Hardyston (Twp)	115	862	0	0	770	14,012	1,232	23,157
Hopatcong (B)	154	1,077	0	0	223	4,388	380	18,264
Lafayette (Twp)	73	365	0	0	0	5,169	0	6,203
Montague (Twp)	15	138	0	0	0	14,909	0	11,927
Newton (T)	123	554	0	0	0	649	0	4,677
Ogdensburg (B)	25	215	0	0	0	862	0	4,568
Sandyston (Twp)	11	76	0	0	0	12,437	0	9,950
Sparta (Twp)	272	1,878	0	0	549	14,999	1,189	41,526
Stanhope (B)	42	254	0	0	0	602	0	4,456
Stillwater (Twp)	11	126	0	0	0	4,514	0	7,223
Sussex (B)	56	326	0	0	0	120	0	1,029
Vernon (Twp)	237	2,353	0	0	1,666	33,630	3,083	67,509
Walpack (Twp)	0	3	0	0	0	416	0	333
Wantage (Twp)	185	1,138	0	0	0	20,079	0	24,648
Sussex County (Total)	**1,902**	**12,678**	**0**	**0**	**4,230**	**169,744**	**8,431**	**314,209**

Source: Hazus v6.0; Sussex County 2023; NJOGIS, Civil Solutions, Spatial Data Logic

Cultural

Winds associated with hurricanes can cause damage or destruction to the County's cultural resources. Cultural resources may be located inside historical buildings, which may not be built to withstand high winds. Outdoor events are likely to be postponed or cancelled as the result of hurricane conditions.

13.3 CHANGE OF VULNERABILITY SINCE 2021 HMP

Overall, the County's vulnerability to the earthquake hazard has not changed, and the entire County will continue to be vulnerable to this hazard. Any change in vulnerability since the previous HMP would be attributed to changes in population density and new development. The risk assessment for hurricane winds was performed in Hazus v6 for Sussex County and was based on the most current and best available data, including building and critical facility

inventories. The building inventory was updated using RSMeans 2022 values, which are more current and reflect replacement cost rather than the building stock improvement values reported in the 2021 HMP. Further, the 2021 5-year population estimates from the American Community Survey were used to evaluate the population exposed to the hazard areas.

13.4 FUTURE CHANGES THAT MAY AFFECT RISK

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

13.4.1 Potential or Planned Development

As discussed in Chapter 3, areas targeted for future growth have been identified across the County. It is anticipated that any new development will be exposed to the hurricane hazard. However, due to increased standards and codes, new development might be less vulnerable to wind and flood-related hazards compared to the aging building stock.

13.4.2 Projected Changes in Population

Changes in the density of population can impact the number of persons exposed to the hurricane hazard. Persons that move into older buildings may increase their overall vulnerability. Those moving into newer construction may decrease their vulnerability.

The New Jersey Department of Labor and Workforce Development produced population projections by County from 2014 to 2019, 2024, 2029, and 2034. According to these projections, Sussex County is projected to have a decrease in population in the upcoming years. These projection totals include a population of 140,400 by 2024, 137,300 by 2029, and 136,600 by 2034 (State of New Jersey 2017).

13.4.3 Climate Change

Since the 1970s, there has been a global increase in tropical cyclone intensity and duration, correlated with increased sea surface temperature. This suggests that future increases of tropical sea surface temperature might lead to future increases in tropical cyclone intensity and duration. However, there is a high level of uncertainty regarding the relationship between climate change and storm events (Emanuel, Kerry 2005). Future improvements in modeling smaller scale climatic processes can be expected and will lead to improved understanding of how the changing climate will alter temperature, precipitation, and storm events in New Jersey. It remains to be seen if factors such as steering currents (the winds directing or pushing the storm), atmospheric shear (change in direction and speed of winds at increasing heights), and the presence of Saharan dust (the dust suppresses cloud formation by inhibiting convection) will increase or decrease the risk of hurricanes (NJDEP 2020).