



**FEMA**

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**Vulnerability Analysis for South Carolina Hurricane Events  
Northern Conglomerate Counties- Final Report  
January 2012**

# VULNERABILITY ANALYSIS FOR SOUTH CAROLINA HURRICANE EVENTS

NORTHERN CONGLOMERATE COUNTIES

## National Hurricane Program

### FINAL REPORT

*Prepared for:*

Federal Emergency Management Agency  
National Hurricane Program



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## 1 PURPOSE

The purpose of the South Carolina Vulnerability Analysis is to identify the areas, populations, and facilities in the Northern Conglomerate counties that are potentially vulnerable to hurricane-induced flooding and wind damages under a variety of hurricane scenarios. The vulnerable population determined as part of this study is comprised of all persons residing within the area subject to storm surge inundation and the residents of mobile homes within the study area but located above the expected storm surge inundation levels. This includes tourists (both within and outside the storm surge inundation areas) that would need to evacuate during a hurricane threat. Because of their greater vulnerability to the strong winds associated with hurricanes, all mobile and manufactured home residents are considered in the vulnerability analysis regardless of their location within the study area. The best available GIS population data was used to assist with the identification of vulnerable populations.

The evacuation zones, which were developed by the coastal counties, were used to locate and quantify the vulnerable population in each county. GIS software and data was used to map the locations of the evacuation zones within the county and estimate the number of people living in those areas. Vulnerable population data was collected for each of the county's evacuation scenarios. Estimates of total vehicles that would be used to evacuate each zone were also included in the database.

The Vulnerability Analysis also identifies populations and their characteristics, institutions, medical facilities and other points of interest (i.e., critical facilities, hazardous material storage facilities, major points of interest, etc.) potentially vulnerable to hurricane hazards. The institutions selected for analysis were determined in coordination with State and local emergency management. Local tax assessor data were utilized to estimate the number of vulnerable properties (residential, commercial and industrial). GIS data were created to illustrate the location of each facility or point of interest in relation to surge-inundation areas, wave impact areas and freshwater flooding from rainfall runoff.

The Northern Conglomerate counties included in the Vulnerability Analysis study area are shown in Figure 1-1. The Northern Conglomerate study area includes the following counties: Horry, Georgetown, Williamsburg, Marion, Florence, Dillon, Clarendon, Sumter, Darlington, Lee and Marlboro. The analysis will focus primarily on the coastal counties of Horry and Georgetown. These two counties are the most vulnerable to hurricane storm surge and wind damage, and are currently the only counties in the Northern Conglomerate where evacuation scenarios have been developed.

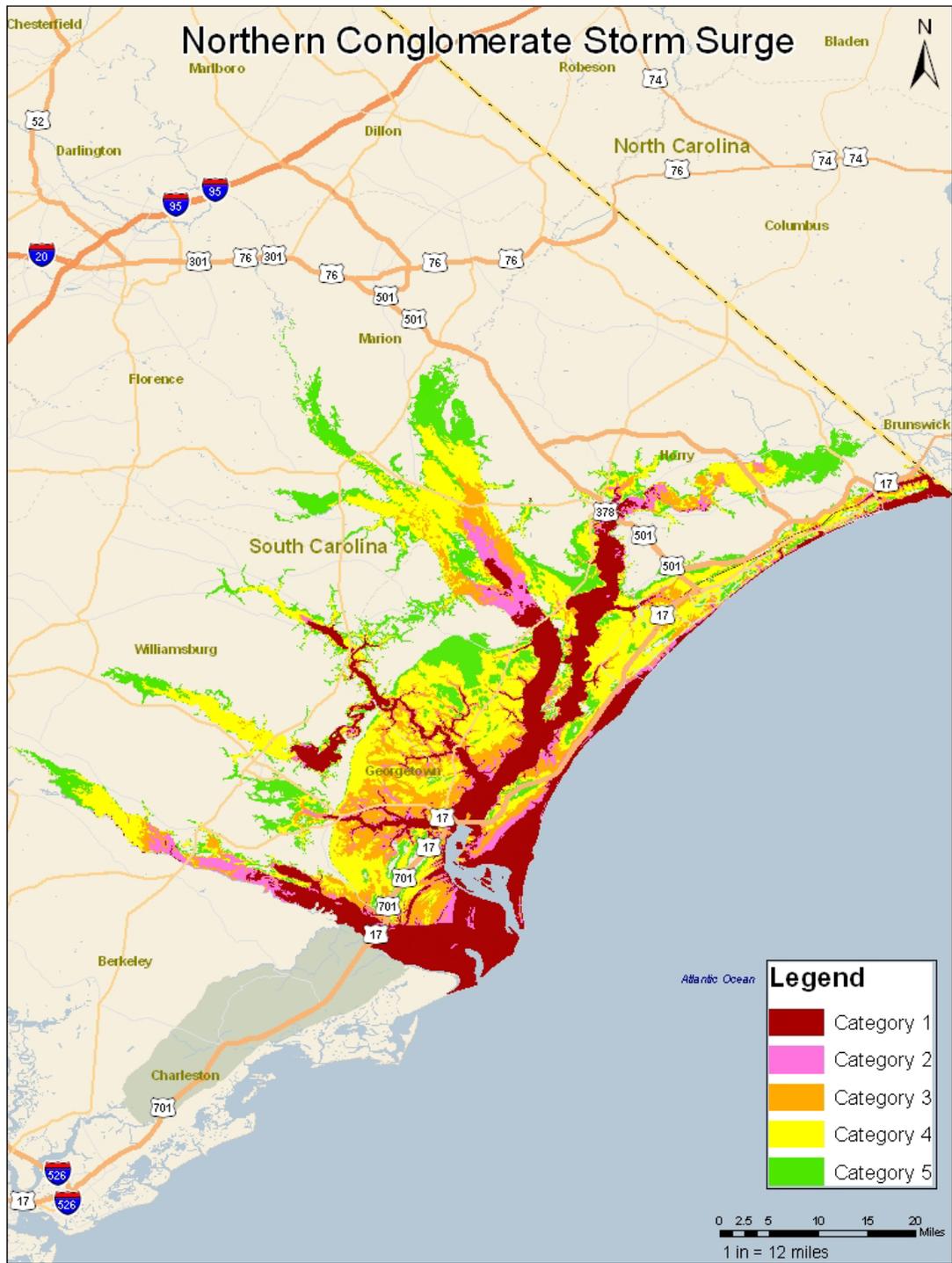


**Figure 1-1: Northern Coastal Conglomerate Study Area**

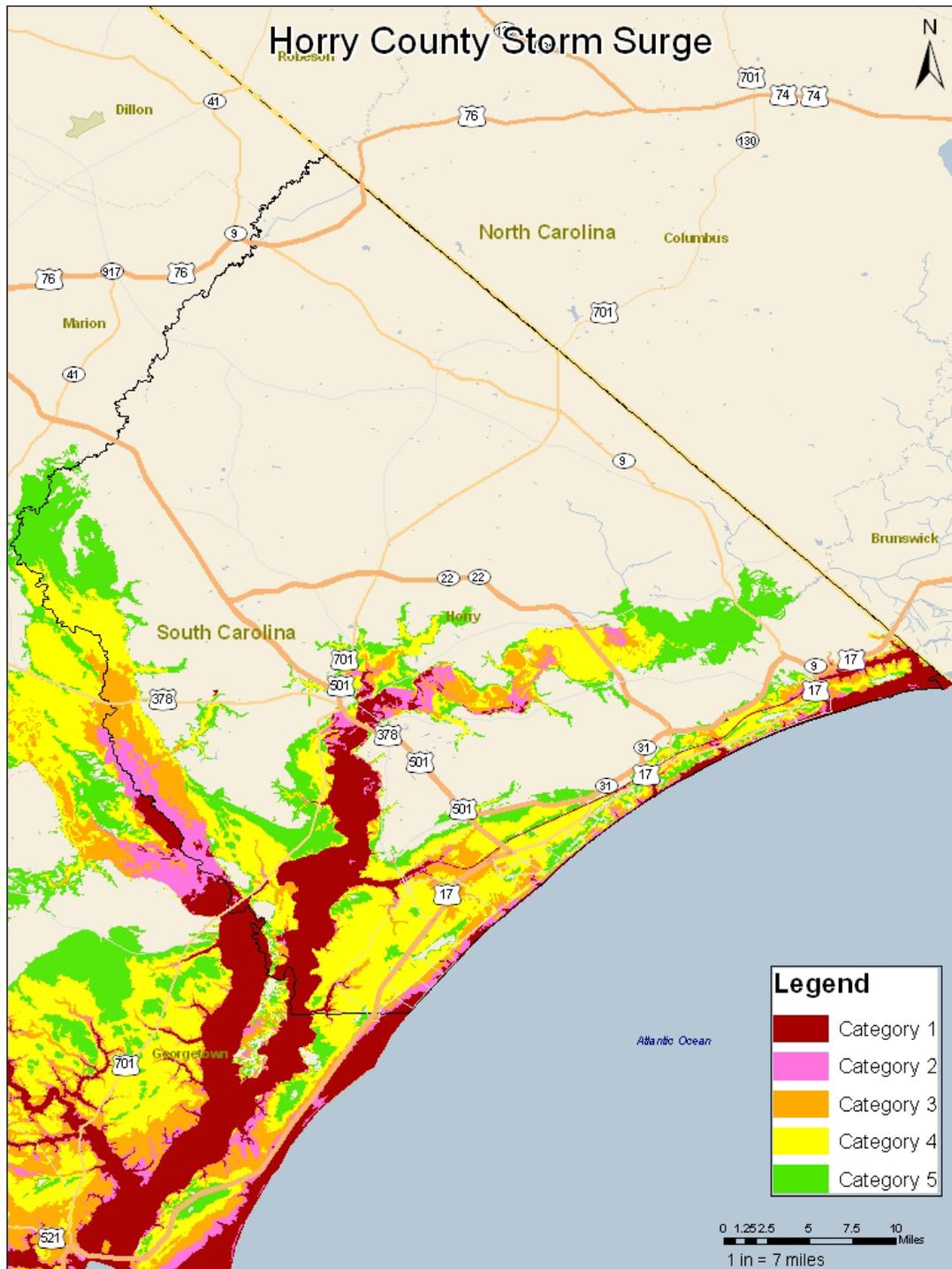
## 2 STORM SURGE INUNDATION AND MAPPING

Because of uncertainties in hurricane forecasting, storm surge mapping takes a variety of scenarios into account due to the sensitivity of surge values to the track, direction, intensity, forward speed, size, and landfall location. Within a few hours, a hurricane can change its forward speed, intensity and direction, which can create quite different flooding scenarios prior to and at landfall. The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model is the computer model utilized by the National Oceanic and Atmospheric Administration (NOAA), and is used by the National Hurricane Center (NHC) for coastal inundation risk assessment and the operational prediction of storm surge. For Horry and Georgetown Counties, storm surge inundation maps based on the Maximum of Maximum (MOMs) SLOSH output have been produced for each Saffir-Simpson (SS) Hurricane Wind Scale Category. The maps depict the areas of possible storm surge inundation that could be generated by the five categories of hurricane intensity.

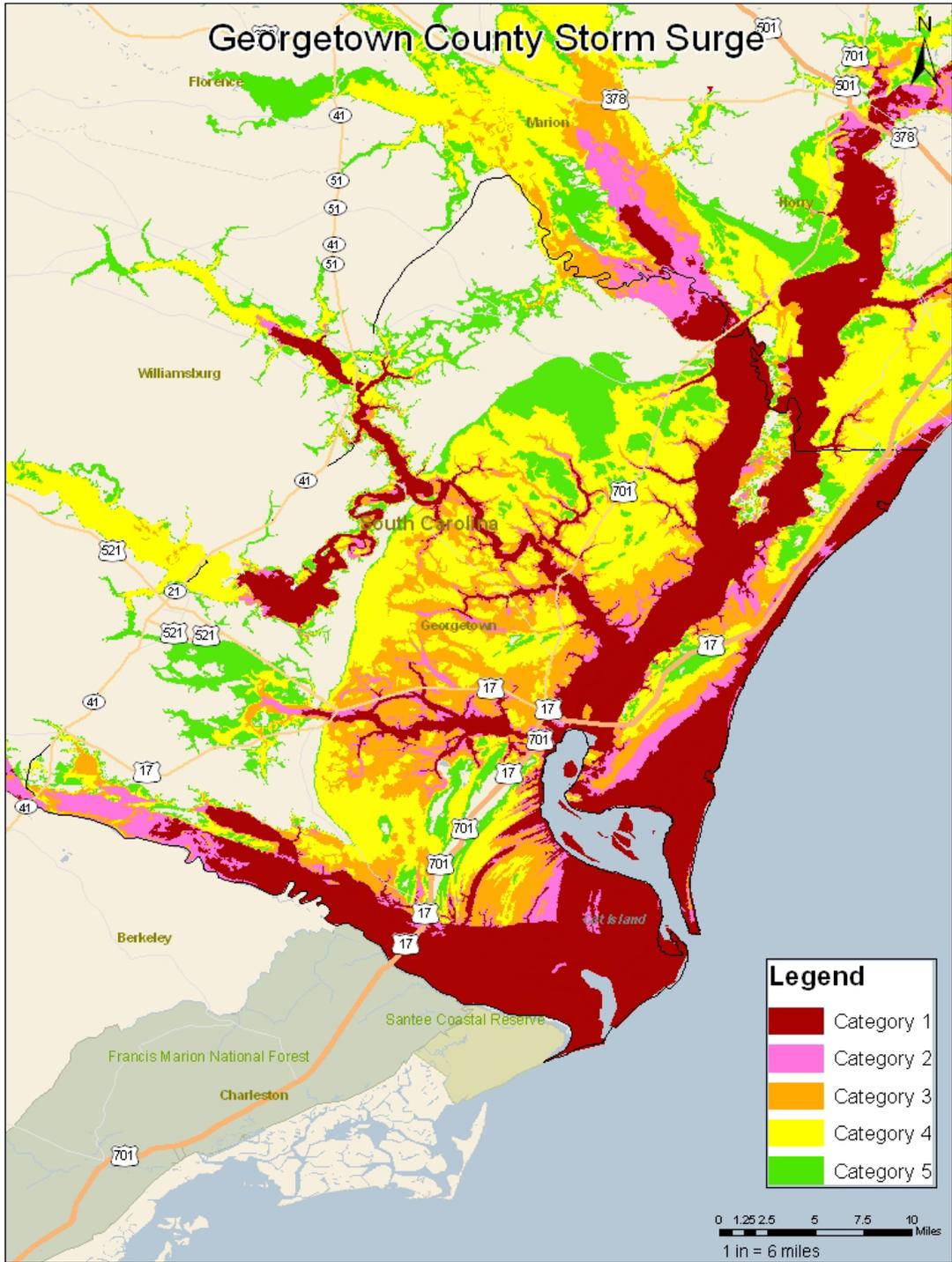
GIS mapping of storm surge inundation was completed by the Baltimore District U.S. Army Corps of Engineers (USACE) to support the Hazards, Transportation, Behavioral and Vulnerability Analyses of the Hurricane Evacuation Study (HES). Figure 2-1 illustrates the extent of possible storm surge inundation in the Northern Conglomerate. The potential for storm surge is evident in the coastal counties of Horry and Georgetown as well as the inland counties of Williamsburg, Florence and Marion. Figures 2-2 and 2-3 show the extent of storm surge inundation in the coastal counties of Horry and Georgetown. It should be noted that the maps do not show the areas of potential inundation from one particular hurricane with an SS Category; they show the overall area of possible inundation from all types of hurricanes (different tracks, directions, and forward speeds) within an SS Category that were simulated in the SLOSH model. The identification of all areas of possible flooding from different types of hurricanes within a SS Category allows for long-range planning and the establishment of evacuation zones when the exact characteristics of the actual hurricane threat are not known. The colored areas of the map correspond to the additional possible surge inundation for a particular storm category beyond that of all lower storm categories. It should be noted that the total surge inundation for each category includes the area labeled for that category as well as all areas in lower storm categories.



**Figure 2-1: Northern Conglomerate Storm Surge Inundation Areas**



**Figure 2-2: Horry County Storm Surge Inundation Areas**



**Figure 2-3: Georgetown County Storm Surge Inundation Areas**

### 3 HURRICANE EVACUATION SCENARIOS AND ZONES

Evacuation zones are developed to depict areas where threatened populations should be moved away from hazards caused by natural or manmade disasters. Zones are established to simplify notification to the public and foster an efficient and timely response to evacuation orders given by elected officials. Hurricane evacuation zones are the areas that need to be evacuated for a particular hurricane scenario to protect residents at risk from flooding or high winds. Evacuation zones include all areas having a serious risk of storm surge flooding. Evacuation zones sometimes include non-flood areas if they would potentially be cut off or surrounded by flooded areas or need to be included in the evacuation zone to allow the public to better understand the locations being asked to evacuate. When evacuation orders are given, residents and visitors in these areas are expected to move out of the respective zones to a site further inland or move to higher ground.

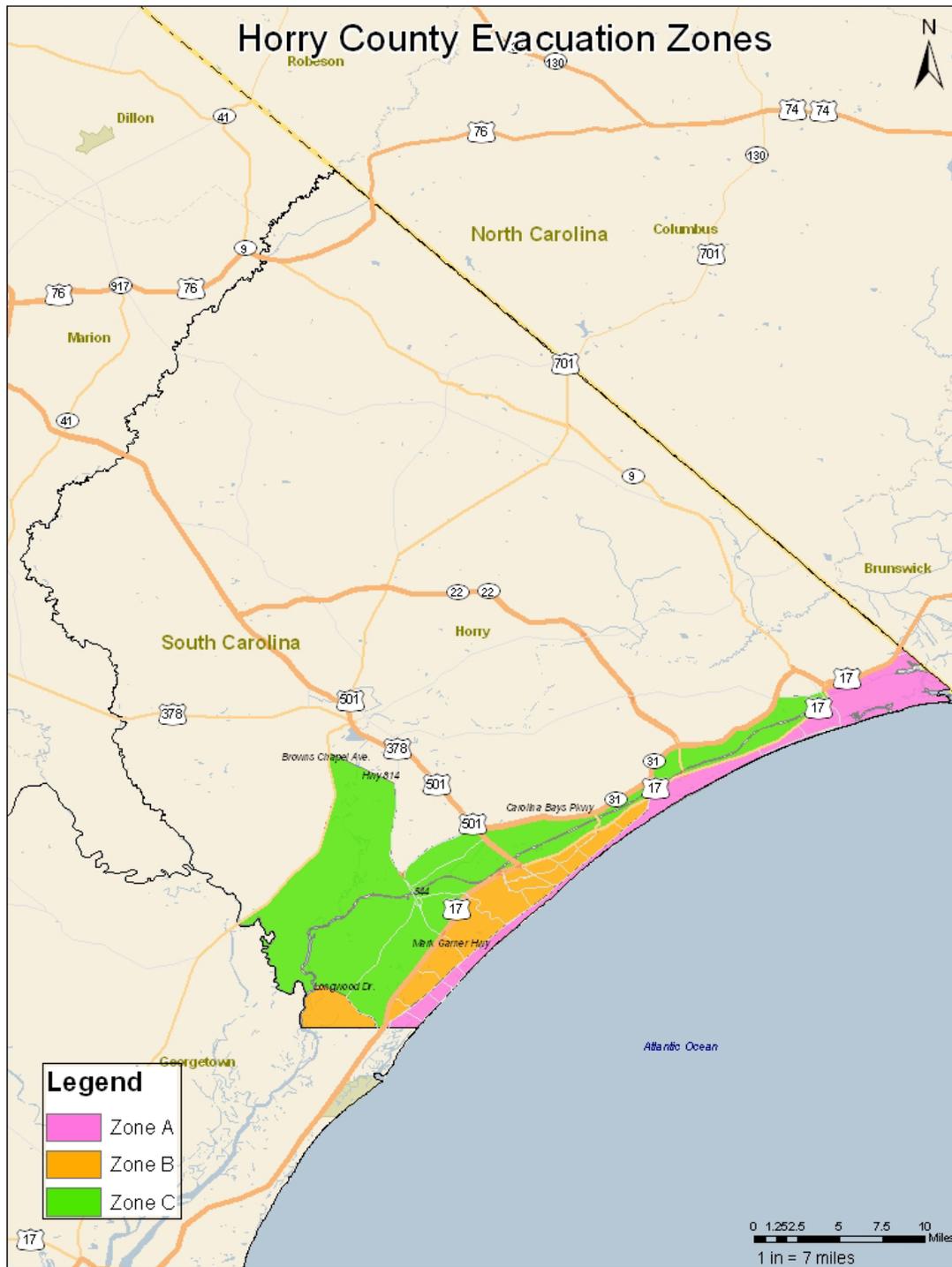
Evacuation scenarios are developed to simplify evacuation decision-making by comparing areas of potential storm surge for each hurricane category. The development of approved evacuation zones is crucial for the completion of the Transportation Analysis portion of the HES. Individual zones were developed for the coastal counties through coordination of the Charleston District USACE with Horry and Georgetown county emergency management agencies. The evacuation zones were provided to the contractor for use in the vulnerability analysis process where they were used to estimate the evacuating population and number of evacuating vehicles.

Evacuation zones in Horry and Georgetown counties are based primarily on prominent community features (i.e., streams, rivers, major highways, etc.) and correspond generally to the storm surge flooding risk. Horry and Georgetown counties each have three evacuation scenarios. Evacuation Scenario A would be ordered for a Category 1 or a Category 2 hurricane. Evacuation Scenario B would be ordered for a Category 3 hurricane and Evacuation Scenario C would be ordered for a Category 4 or a Category 5 hurricane.

Tables 3-1 and 3-2 identify the evacuation scenarios that were established by the local jurisdictions in March 2011. These scenarios have been developed for Horry and Georgetown counties in South Carolina. Figures 3-1 and 3-2 illustrate the evacuation zones for each county.

**Table 3-1: Horry County Evacuation Scenarios**

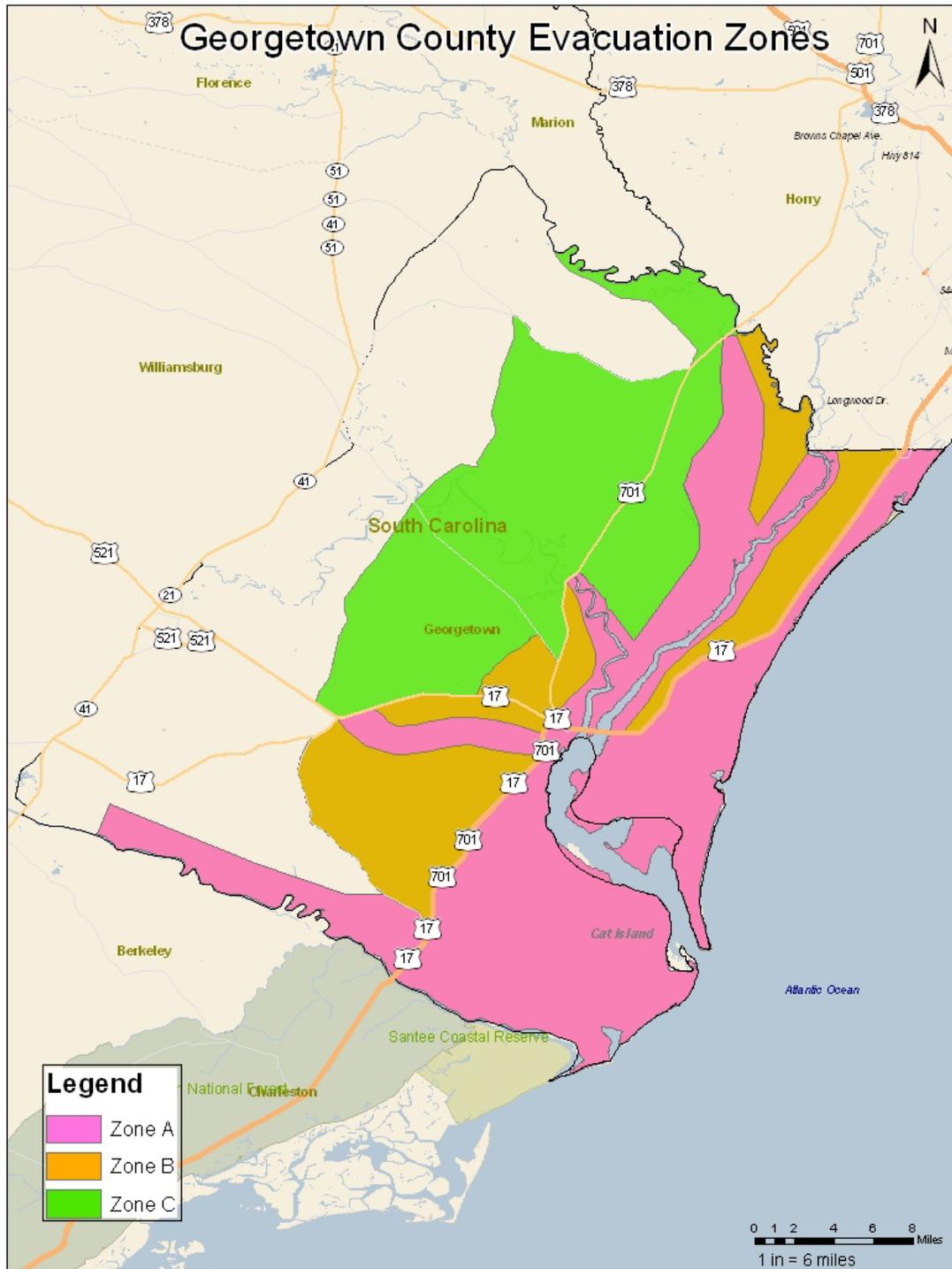
Evacuation Scenario	Storm	Description
A	Category 1 & 2	Includes all areas east of US Business 17 (Kings Hwy) up to intersection with US 17 (Kings Hwy) and then all areas east of US 17 (Kings Hwy) to the northern county line. Also all flood prone areas along the Waccamaw River and the Great and Little Pee Dee Rivers and all mobile homes residents in the county.
B	Category 3	Includes all areas south of Hwy 707 and Longwood Drive including all areas in Longwood Plantation (Blackmoor) to the Waccamaw River and all areas east of US 17 By-Pass (Mark Garner Hwy) to US 17 (N. Kings Hwy) and all areas east of US 17 (N. Kings Hwy) to the Northern county line. Also all flood prone areas along the Waccamaw River and the Great and Little Pee Dee Rivers and all mobile homes residents in the county.
C	Category 4 & 5	Includes all areas between Hwy 701 and Hwy 544, south of Brown's Chapel Avenue and Hwy 814 plus all areas East of Highway 31 (Carolina Bays Pkwy) to Highway 90; and all areas East of Highway 90 to Highway 17 and all areas east of US 17 to the northern county Line. Also all flood prone areas along the Waccamaw River and the Great and Little Pee Dee Rivers and all mobile homes residents in the county.



**Figure 3-1: Horry County Evacuation Zones**

**Table 3-2: Georgetown County Evacuation Scenarios**

Evacuation Scenario	Storm	Description
A	Category 1 & 2	Areas East of Highway 17 to the Atlantic Ocean from the South Santee River and North to the Horry County line, including Sandy Island; areas East of Dawhoo Lake and South of Walker Road and Powell Road to the South Santee River; all low-lying areas along the Waccamaw River, Great Pee Dee River, Black River, and Sampit River South of Highway 521 (17A), including Maryville; and all mobile home residents in the County.
B	Category 3	Areas East of Dawhoo Lake and South of Walker Road to Powell Road to the South Santee River; all areas on the Atlantic Ocean side of Powell Road to Alt US 17 to Hwy 521 to Brick Chimney Road to State Hwy 51 to Black River Road ending at the Black River; all low-lying areas along the Waccamaw River, Great Pee Dee River, and Black River, and all areas East of them to the coast; and all mobile home residents in the County.
C	Category 4 & 5	Areas East of Dawhoo Lake and South of Walker Road to Powell Road to the South Santee River; all areas on the Atlantic Ocean side of Powell Road to Alt US 17 to Hwy 521 to Sawmill Road to Indian Hut Road to Carvers Bay Road (State Hwy S-22-4) to Plantation Hill Road (State Hwy 261) to Old Pee Dee Road to the Northern County Line; and all mobile home residents in the County.



**Figure 3-2: Georgetown County Evacuation Zones**

## 4 VULNERABLE POPULATION

The identification of vulnerable populations is a critical component of any vulnerability analysis. For the purpose of the study, the vulnerable population is defined as persons residing within the evacuation zones subject to storm surge and the residents of all mobile homes within the coastal counties. Mobile home residents countywide and all tourists are advised to evacuate for any storm scenario when an evacuation has been ordered.

Storm surge and evacuation zone maps were provided to the contractor by Charleston District USACE for use in the vulnerability analysis process. South Carolina population figures were obtained from the U.S. Census Bureau's 2010 Census (by Census block) through American FactFinder<sup>1</sup> ([factfinder2.census.gov](http://factfinder2.census.gov)). The vulnerable population was determined from an overlay of the 2010 population at the block level with storm surge and evacuation zone shapefiles. A spatial analysis was performed to calculate the percentage of the population in each block group that was located in each storm surge area and evacuation zone. Parcel data from the County tax assessors were provided by Horry and Georgetown Emergency Management Agencies to determine the number of mobile homes and their location within the county. The 2010 American Community Survey (ACS) 1-year estimates (for areas with a population of 65,000 or more) and the 2005-2009 5-year estimates ([factfinder.census.gov](http://factfinder.census.gov)) were referenced to obtain the total number of mobile homes in the inland counties of the Northern Conglomerate. The mobile home population in each evacuation zone and storm surge area was calculated by multiplying the number of mobile homes by the average household size for that county. The average household size for all counties in the Northern Conglomerate is illustrated in Table 4-3.

Tourist data was gathered from a database of hotel/motel, timeshares and campground locations provided by the Myrtle Beach Area Chamber of Commerce and from the Statistical Abstract for the Myrtle Beach Area of South Carolina<sup>2</sup> prepared by the Chamber's Marketing Research Department. Additional accommodations providers in Georgetown County were provided by the Tourism Manager at the Georgetown County Chamber of Commerce. These data sources were used to identify and locate the vulnerable populations within the coastal counties. The tourist population was calculated based on available room counts<sup>3</sup> and occupancy rates of the tourist units. High and low occupancy rates assumptions<sup>4</sup> were based on research conducted by the Clay Brittain Jr. Center for Resort Tourism at Coastal Carolina University and presented in the 2011 Statistical Abstract.

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<sup>1</sup> Data from the 2010 Census and the 2010 ACS were obtained through the New American FactFinder at [factfinder2.census.gov](http://factfinder2.census.gov). Data from the 2005-2009 ACS were obtained through the legacy American FactFinder at [factfinder.census.gov](http://factfinder.census.gov). The Legacy American FactFinder will be discontinued in the fall of 2011.

<sup>2</sup> Statistical Abstract for the Myrtle Beach Area of South Carolina, 20<sup>th</sup> Edition. Marketing Research Department, Myrtle Beach Chamber of Commerce, January 2011. (<http://www.myrtlebeachareachamber.com/research/docs/20statabstract.pdf>)

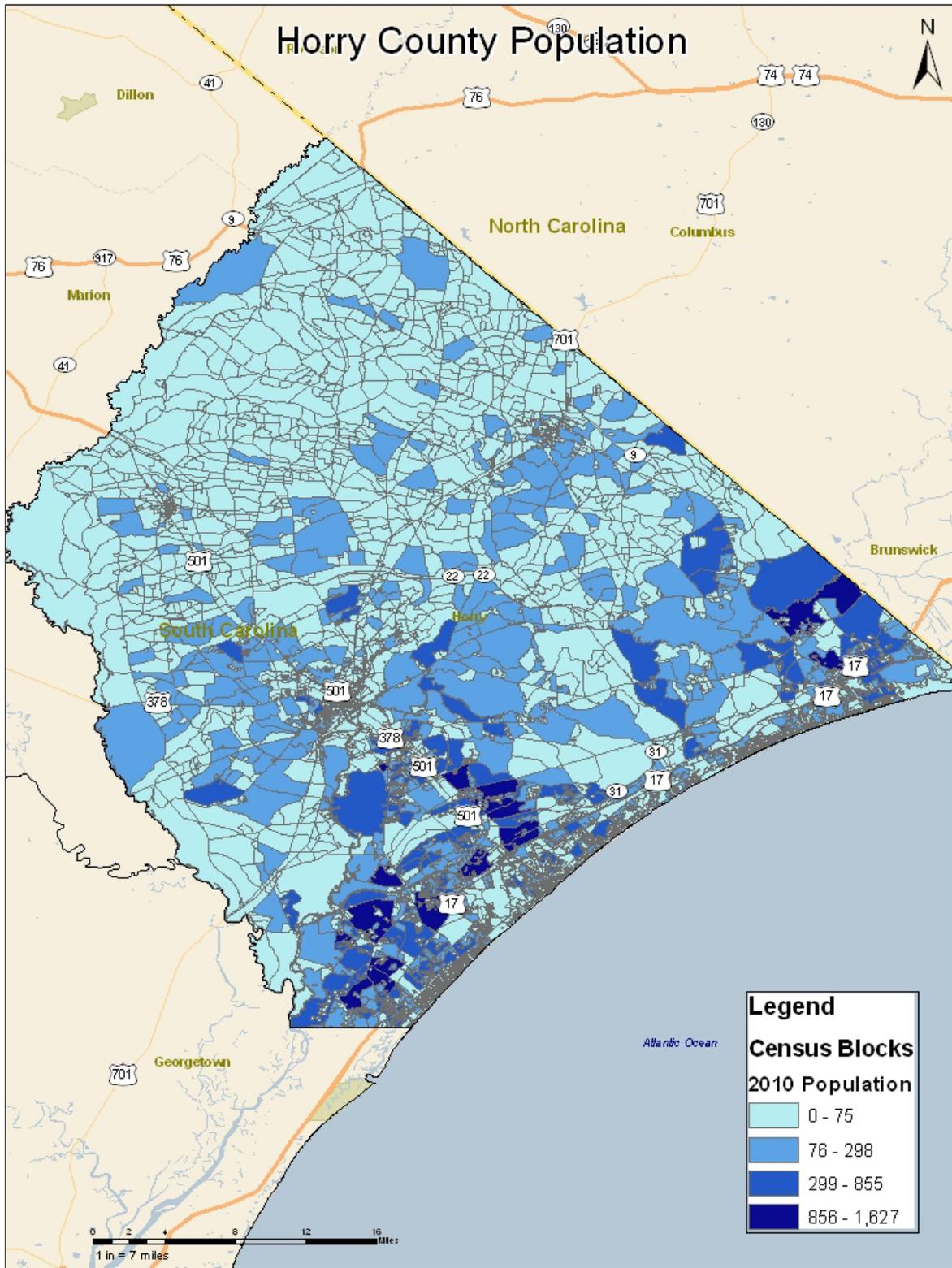
<sup>3</sup> The primary resources for the number of rooms/units at each property were the Myrtle Beach and Georgetown County Chambers of Commerce. Additional research was conducted online and through phone calls with properties to collect room counts for accommodations that were unknown.

<sup>4</sup> Low tourist occupancy for Grand Strand lodging properties is 23.4% (December); High tourist occupancy is 83.6% (July). The average tourist party to the Grand Strand consists of five people, three adults and two children.

Tables 4-1 and 4-2 provide estimates of the vulnerable population in Horry and Georgetown counties by storm surge areas and evacuation zone. The total population, mobile home population and the tourist population (at low, high, and 100 percent occupancy) are calculated for each surge area, evacuation zone and for areas outside of these regions. The mobile home database in Horry County did not have a parcel designation for every mobile home within the county. Mobile homes that were not attributed to a specific parcel number could not be spatially classified. The population residing in these mobile homes is listed as “undetermined” in the table. The values listed are cumulative and not independent by storm category and evacuation zone. Figures 4-1 and 4-2 depict the spatial distribution of the population at the Census block level for Horry and Georgetown counties.

**Table 4-1: Vulnerable Population in Horry County**

HORRY COUNTY			
	TOTAL POPULATION	MOBILE HOME POPULATION	TOURIST POPULATION
EVAC ZONE			100% OCC
A	28,169	1,773	195,430
A-B	68,178	2,254	210,720
A-B-C	137,687	4,494	233,865
OUT	131,604	9,636	8,060
Undetermined		43,037	
TOTAL	269,291	57,167	241,925
SURGE AREA			
1	7,994	462	40,260
1-2	16,434	1,346	99,935
1-3	45,826	2,673	169,610
1-4	120,777	4,460	213,695
1-5	145,483	5,299	227,740
OUT	123,808	8,831	14,185
Undetermined		43,037	
TOTAL	269,291	57,167	241,925



**Figure 4-1: Horry County Population by Census Block**

**Table 4-2: Vulnerable Population in Georgetown County**

GEORGETOWN COUNTY			
	TOTAL POPULATION	MOBILE HOME POPULATION	TOURIST POPULATION
EVAC ZONE			100% OCC
A	14,862	2,260	22,205
A & B	41,406	7,803	23,435
A, B & C	47,247	11,300	23,435
OUT	12,911	5,266	1,085
TOTAL	60,158	16,565	24,520
SURGE AREA			
1	6,010	1,456	17,200
1-2	12,941	3,609	22,290
1-3	31,792	8,189	23,075
1-4	44,312	10,673	23,435
1-5	48,503	11,863	23,435
OUT	11,655	4,702	1,085
TOTAL	60,158	16,565	24,520



The vulnerable population in Horry and Georgetown counties consists of all those residing in a potential storm surge area, residents of mobile homes and all tourists. In Horry County, approximately half of the permanent population resides in an area that could experience storm surge. The largest percent increase in vulnerable population occurs between the Category 2 and Category 3 surge areas. This increase represents a transition from the predominately tourist region at the beaches to the communities where the majority of Horry County's permanent population is located. The largest population within a surge area is located in the Category 4 storm surge area (~75,000 people). From the population distribution map, it is evident that many population centers in Horry County (Myrtle Beach, Little River, Garden City, Surfside Beach, Red Hill and Socastee) are located near the coast. Depending on the season, Horry County's tourist population can potentially equal that of its permanent population, nearly doubling the number of people in the County that could be impacted if a hurricane were to threaten the area. Nearly six percent of Horry County residents live in mobile homes (~16,000 people). As the mobile home population is extremely vulnerable to tropical storm or hurricane force winds, all tourists and mobile home residents would be ordered to evacuate regardless of their location relative to the surge area.

In Georgetown County, nearly 80% of the population is located within a surge area (~48,000 people). The largest percent increase in the vulnerable population occurs between the Category 2 and Category 3 surge areas. The largest population is located in the Category 3 surge area (~19,000). The Waccamaw Neck communities (Murrells Inlet, Litchfield, Pawleys Island and DeBordieu) have exploded with development in recent years. Above the Category 3 surge area, the percent increase in the vulnerable population declines. The inland areas of Georgetown County are relatively rural, and consequently much less densely populated than the coastal areas. However, the inland communities located outside of an evacuation zone contain 30% of the mobile home population in the County and will need to be evacuated for high wind hazards, regardless of storm category. Tourist locations in Georgetown County are primarily located in the Category 1 surge area. So, although the tourist population is smaller in Georgetown County relative to Horry County, a larger percentage of tourists would be impacted by smaller Category storms.

In terms of evacuation zones, significant variability in the vulnerable population is evident from one evacuation zone to the next. The vulnerable population nearly triples from Zone A to Zone B in Georgetown County (a 179% increase from 14,862 to 41,406), and more than doubles in Horry County (a 142% increase from 28,169 to 68,178). In Georgetown County, there is less than a 15% increase in vulnerable population when Zone C is added to the evacuation order. However, in Horry County, the percent increase in the vulnerable population from Zone B to Zone C is over 100%, nearly doubling the number of evacuees who would be ordered to evacuate (from 68,178 to 137,687). Calling for the evacuation of Zone B in both Horry and Georgetown counties will significantly increase the number of evacuees. When Zone C is added to the evacuation order, the evacuating population will only increase slightly in Georgetown County, but would double in Horry County. Evacuation Zone C in Horry County includes a much larger portion of the County's permanent population than the same zone in Georgetown County, due to the higher population density in Horry County relative to Georgetown.

From the vulnerable population tables, it is evident that the tourist population in each county is primarily located along the coast and declines significantly as you move inland. The Grand Strand Region is the major tourist attraction and popular beach vacation destination along the Northern South Carolina coast and Horry and Georgetown counties have the majority of their tourist population located in a hurricane surge area. The tourist population in Georgetown County is primarily located within a Category 1 surge area. As the coastal elevation is slightly higher in Horry County, the surge areas, and the potential for storm surge inundation, does not extend as far inland as in Georgetown County. As such, the tourist population in Horry County is more likely to be located in a higher Category storm surge area. The percent increase in the tourist population in Horry County builds up to the Category 3 surge area, where the tourist population is the largest, before it begins to taper off.

Table 4-3 shows the total population and the mobile home population for the Northern Conglomerate counties. For the purpose of this analysis, the vulnerable population of the inland counties in the Northern Conglomerate is considered to be all mobile home residents. Residents living in manufactured housing have the potential to be severely impacted by the winds of a tropical system. The vulnerable population located in a storm surge area was not determined for the inland counties of the Northern Conglomerate that had storm surge areas depicted. It was determined that these areas are well represented by the FEMA flood zone areas, and therefore, are not considered in this phase of the vulnerability analysis. No evacuation zones were determined for these inland county surge areas.

**Table 4-3: Mobile Home Populations in the Northern Conglomerate**

<b>COUNTY</b>	<b>TOTAL POPULATION</b>	<b>AVERAGE HOUSEHOLD SIZE</b>	<b># OF MOBILE HOMES</b>	<b>MOBILE HOME POPULATION</b>
CLARENDON	34,971	2.54	6,529	16,584
DARLINGTON	68,681	2.54	8,553	21,725
DILLON	32,062	2.65	4,547	12,050
FLORENCE	136,885	2.54	12,205	31,001
GEORGETOWN	60,158	2.43	6,817	16,565
HORRY	269,291	2.37	24,121	57,167
LEE	19,220	2.54	3,047	7,739
MARION	33,062	2.52	4,698	11,839
MARLBORO	28,933	2.47	3,152	7,785
SUMTER	107,456	2.59	11,807	30,580
WILLIAMSBURG	34,423	2.53	5,483	13,872
<b>TOTAL</b>	<b>825,142</b>		<b>90,959</b>	<b>226,907</b>

## 5 VULNERABLE STRUCTURES AND EVACUATING VEHICLES

Along with the vulnerable population, the number of structures within the community that are vulnerable to storm surge is imperative information for emergency management and a crucial piece of knowledge from the evacuation, response and recovery standpoint. Another crucial piece of knowledge is the number of vehicles that may be utilized in the evacuation process. These two components of the Vulnerability Analysis have been developed to assist emergency managers in determining the number and characteristics of vulnerable properties within their communities.

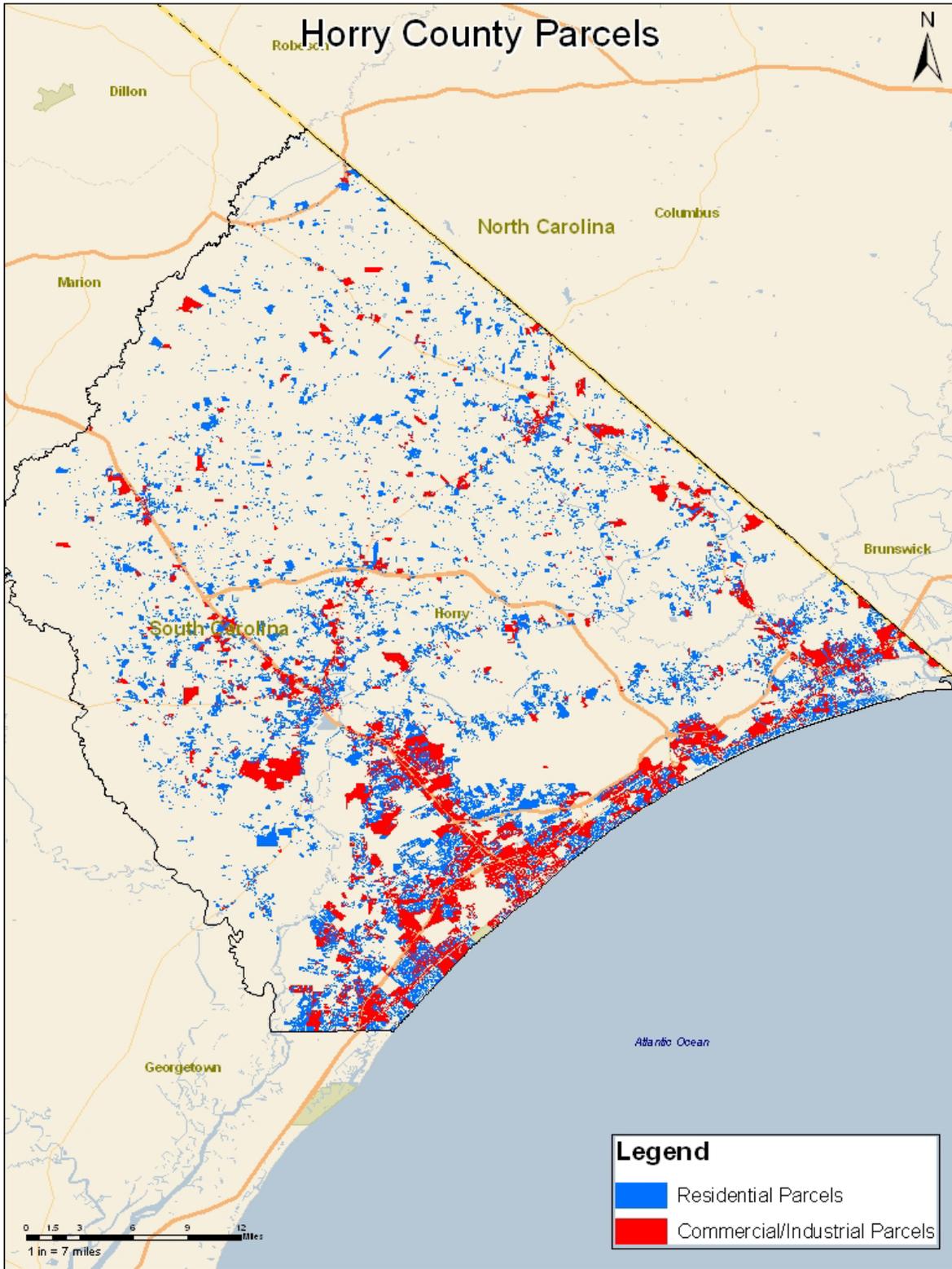
### VULNERABLE STRUCTURES

Parcel data from Horry and Georgetown county tax assessors were utilized in a spatial analysis to classify and select the residential, commercial and industrial structures and mobile homes in the county that are vulnerable to the five hurricane storm surge categories. From the tourist databases provided by the Myrtle Beach and Georgetown County Chambers of Commerce, the location of hotels, motels, Bed and Breakfasts (B&B's) and campgrounds were mapped and classified by storm surge area and evacuation zone.

Tables 5-1 and 5-2 show the number and type of vulnerable structures in each surge area and evacuation zone as well as those that are located outside of these areas. The values listed are cumulative and not independent by storm category. Mobile homes in Horry County that were not attributed to a specific parcel number could not be spatially classified and their location is listed as "undetermined." Georgetown County parcel designations did not include an independent use code for industrial sites. As such, commercial and industrial structures are shown in the same category for Georgetown County. Figures 5-1 and 5-2 illustrate the distribution of residential, commercial and industrial parcels in Horry and Georgetown counties.

**Table 5-1: Vulnerable Structures in Horry County**

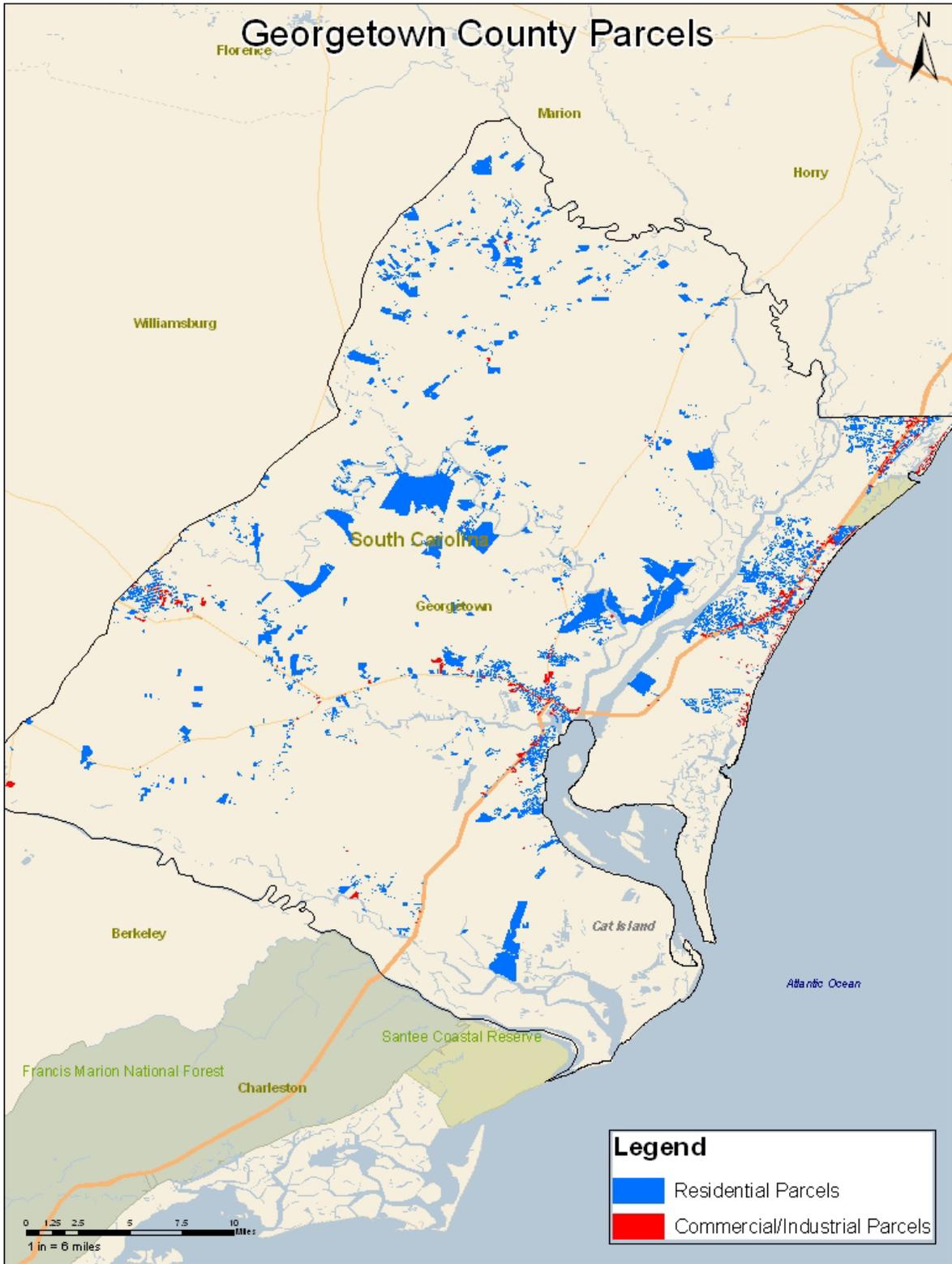
HORRY COUNTY					
	MOBILE HOMES	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TOURIST
<b>SURGE AREA</b>					
1	195	25,285	652	1	8,052
1-2	568	44,702	1,306	1	19,987
1-3	1,128	63,822	3,016	2	33,922
1-4	1,882	108,882	6,493	15	42,739
1-5	2,236	121,698	7,733	25	45,548
NA	3,726	52,781	3,319	49	2,837
Undetermined	18,159				
<b>TOTAL</b>	<b>24,121</b>	<b>174,479</b>	<b>11,052</b>	<b>74</b>	<b>48,385</b>
<b>EVAC ZONE</b>					
A	748	57,170	2,661	0	39,086
A & B	951	78,212	5,358	6	42,144
A, B & C	1,896	119,193	7,329	17	46,773
NA	4,066	55,286	3,723	57	1,612
Undetermined	18,159				
<b>TOTAL</b>	<b>24,121</b>	<b>174,479</b>	<b>11,052</b>	<b>74</b>	<b>48,385</b>



**Figure 5-1: Horry County Parcels**

**Table 5-2: Vulnerable Structures in Georgetown County**

GEORGETOWN				
	MOBILE HOMES	RESIDENTIAL	COMMERCIAL/ INDUSTRIAL	TOURIST
SURGE AREA				
1	599	3,722	1,591	3,440
1-2	1,485	7,678	2,129	4,458
1-3	3,370	15,179	2,689	4,615
1-4	4,392	19,409	2,841	4,687
1-5	4,882	20,883	2,918	4,687
NA	1,935	3,444	324	217
TOTAL	6,817	24,327	3,242	4,904
EVAC ZONE				
A	930	8,667	2,299	4,441
A & B	3,211	19,569	2,889	4,687
A, B & C	4,650	20,541	2,917	4,687
NA	2,167	3,786	325	217
TOTAL	6,817	24,327	3,242	4,904



**Figure 5-2: Georgetown County Parcels**

### **Residential Properties**

An assessment of vulnerable structures reveals that both Horry and Georgetown counties have a higher percentage of their residential structures in a surge area than outside of the surge area. Georgetown County has a larger percentage of residences located in surge areas (86%) compared to Horry County (70%). A higher percentage of Horry County residents live in communities closer to the coast. A large portion of residential structures are located in the Category 1 surge area along the immediate coast, but the largest concentration of residential structures in Horry County is located slightly inland from the beach in the Category 4 surge area (~45,000). In Georgetown County, the highest amount of residential structures is located in the Category 3 surge area (~7,500). Due to the nature of the topography along the immediate coast, land elevations are generally higher in Horry County than in Georgetown County. As such, smaller category storms are likely to have a greater impact on residential structures in Georgetown County as storm surge has the potential to reach further inland.

### **Commercial/Industrial Properties**

A large number of commercial structures in both counties would be affected by storm surge. In general, the distribution of commercial properties mirrors the distribution of residential properties in both counties. Horry County has approximately 70% of its commercial properties located in surge areas. As many businesses in Horry County cater to the tourist population, there are a large number of restaurants, entertainment venues, and shopping districts along the beach. A large portion of commercial structures are located in Category 1 to Category 3 surge areas, and decrease with increasing distance from the coast. In Georgetown County, 90% of commercial and industrial structures are located in a surge area. Georgetown County has a greater percentage of its commercial structures in lower category surge areas compared to Horry County. Of the commercial properties that are vulnerable to storm surge, the highest percent are located in a Category 1 storm surge area (50%).

Industry in Horry County is primarily located inland where it is less likely to experience impacts from hurricane storm surge. A few industrial structures are located in Category 4 and Category 5 surge zones which could be inundated in a major hurricane. However, inland winds and freshwater flooding may be of greater concern to industrial properties in Horry County.

### **Tourist Properties**

The economy of these two counties relies heavily on the tourism industry whose livelihood depends on the occupancy of its tourist structures and the operation of its businesses along the coast. Horry and Georgetown counties have over 95% of their tourist properties in a surge area, with almost all located in Category 1 to Category 3 surge areas. A significant portion of commercial activity is located along the beaches of the Grand Strand making these areas extremely vulnerable to storm surge and increasing their potential for serious economic losses in the aftermath of a hurricane. Clearly, the potential exists for significant impacts on commercial activities in both Horry and Georgetown counties from any hurricane.

### **Mobile Homes**

In Georgetown County, 70% of mobile homes are located in a surge area. A higher percentage of mobile homes are located in the inland communities within the County which are only likely to experience storm surge in a major hurricane. As previously noted, not all mobile homes in Horry County could be spatially classified due to limitations in the tax assessor records. However, all mobile homes in Horry and Georgetown counties should be ordered to evacuate regardless of their location relative to storm surge. Due to their extreme vulnerability to high winds and the potential for structural damage, mobile home residents in both counties would be advised to seek shelter for a hurricane of any size.

Mobile home and tourist data from the Census estimates compared to the best available data from the Northern Conglomerate coastal counties are presented in Table 5-3. Census estimates slightly overestimate the number of mobile homes and tourist units in Horry and Georgetown counties but generally provide a good estimate of these populations. The number of mobile homes and tourist units for the remaining counties in the Northern Conglomerate were estimated from Census estimates and are shown in Table 5-4. Outside of Horry and Georgetown counties along the coast, the next largest tourist population exists in Clarendon County. This is likely due to high volume of seasonal and second homes located along the popular Lake Marion, the largest lake in South Carolina.

**Table 5-3: Vulnerable Structure Comparison**

<b>VULNERABLE STRUCTURE COMPARISON</b>				
<b>COUNTY</b>	<b>MOBILE HOMES</b>		<b>TOURIST/SEASONAL UNITS</b>	
	<b>COUNTY</b>	<b>CENSUS</b>	<b>COUNTY</b>	<b>CENSUS</b>
GEORGETOWN	6,817	6,932	4,904	5,112
HORRY	24,121	29,055	48,385	49,862

**Table 5-4: Mobile Homes and Tourist Units in the Northern Conglomerate**

<b>COUNTY</b>	<b>MOBILE HOMES</b>	<b>TOURIST UNITS</b>
CLARENDON	6,529	2,261
DARLINGTON	8,553	345
DILLON	4,547	153
FLORENCE	12,205	416
GEORGETOWN	6,817	4,904
HORRY	24,121	48,385
LEE	3,047	123
MARION	4,698	320
MARLBORO	3,152	176
SUMTER	11,807	352
WILLIAMSBURG	5,483	458
<b>TOTAL</b>	<b>90,959</b>	<b>57,893</b>

## EVACUATING VEHICLES

Based on the vulnerable population, the number of evacuating vehicles in each evacuation zone was calculated by first dividing the total number of evacuees by the county's average household size, resulting in the number of evacuating households. For planning purposes, a 100% evacuation participation rate of the vulnerable population is assumed. The number of evacuating households was multiplied by the average number of vehicles each household will take to evacuate<sup>5</sup>. Similarly, the number of evacuating tourist vehicles was calculated by dividing the tourist population by the size of the average tourist party<sup>6</sup>, assuming that the tourist population takes one vehicle per party during an evacuation. Table 5-5 illustrates the potential number of evacuating vehicles in each evacuation zone and potential shadow evacuees outside of an evacuation zone.

**Table 5-5: Evacuating Vehicles in Horry County**

HORRY COUNTY EVACUATING VEHICLES		
	PERMANENT POPULATION	AT 100% TOURIST OCCUPANCY
EVAC ZONE		
A	15,451	54,537
A & B	37,397	79,541
A, B & C	75,525	122,298
OUT	72,188	73,800
COUNTYWIDE TOTAL	147,712	196,097

<sup>5</sup> Assumes the average household takes 1.3 vehicles during evacuation (2010 South Carolina Hurricane Evacuation Behavioral Study Report).

<sup>6</sup> The average tourist party to the Grand Strand is assumed to be five people, three adults and two children. Statistical Abstract for the Myrtle Beach Area of South Carolina, 20<sup>th</sup> Edition. Marketing Research Department, Myrtle Beach Chamber of Commerce, January 2011. (<http://www.myrtlebeachareachamber.com/research/docs/20statabstract.pdf>)

**Table 5-6: Evacuating Vehicles in Georgetown County**

GEORGETOWN COUNTY EVACUATING VEHICLES		
	PERMANENT POPULATION	AT 100% TOURIST OCCUPANCY
EVAC ZONE		
A	7,951	12,392
A & B	22,151	26,838
A, B & C	25,276	29,963
OUT	6,907	7,124
COUNTYWIDE TOTAL	32,183	37,087

Horry County will see a 50% increase in the number of evacuating vehicles between Zone A and Zone B and between Zone B and Zone C. The largest number of evacuating vehicles would come from Zone A. A significant portion of the population in Horry County is located outside of an evacuation zone, which could potentially lead to shadow evacuees and higher evacuation clearance times. In Georgetown County, the number of evacuating vehicles doubles from Zone A to Zone B (from 12,392 to 26,838). The order to evacuate the second evacuation zone targets more of the county's permanent population. Evacuation Zone C in Georgetown County does not include a significantly greater portion of the vulnerable population. Furthermore, there is a smaller portion of the population outside of the evacuation zones, so there is less potential for impacts from shadow evacuations in Georgetown County.

As previously noted in the vulnerable population tables, tourist populations generally decline above a Category 3 surge area. Applied to evacuating vehicles, there is not a significant increase in evacuating vehicles with the addition of evacuation Zone C to an evacuation order. The largest increase in the number of vehicles on evacuation roadways lies in the decision to evacuate Zone B.

## 6 SOCIETAL ANALYSIS

Vulnerable populations may also be defined by the social characteristics of a community. Having in-depth knowledge of the local population and its social characteristics, such as demographics, age, income, housing tenancy, language, etc., can greatly enhance the effectiveness of evacuation planning and management. Census data can provide useful information to identify societal features of the counties. The U.S. Census Bureau 2010 Demographic Profile Data, 2010 Summary File (SF1) 100% Data and the 2005-2009 5-year ACS estimates were used to examine and locate socially vulnerable populations in Horry and Georgetown counties. Results are shown in Table 6-1. Two key vulnerability factors, mobile home residents and households without vehicles, are illustrated in Figures 6-1 and 6-2. The racial breakdown of Horry and Georgetown populations are displayed in Figures 6-3 and 6-4.

**Table 6-1: Demographic Information of the Northern Conglomerate Coastal Counties Compared to the State and National Average**

<b>Demographics</b>	<b>National Average</b>	<b>South Carolina</b>	<b>Horry County</b>	<b>Georgetown County</b>
	%	%	%	%
<b>Population</b>	<b>308,745,538</b>	<b>4,625,364</b>	<b>269,291</b>	<b>60,158</b>
Median Age	37.2	37.9	41.1	45.4
Persons under 18 years old	24.0	23.4	20.1	21.6
Persons over 65 years old	13.0	13.7	17.1	19.8
<b>Race</b>				
White	72.4	66.2	79.9	63.2
African American	12.6	27.9	13.4	33.6
Asian	4.8	1.3	1.0	0.5
AIAN	0.9	0.4	0.5	0.2
NHPI	0.2	0.1	0.1	0.02
Other	6.2	2.5	3.1	1.6
Two or more races	2.9	1.7	2.0	0.9
<b>Ethnicity</b>				
Hispanic	16.3	5.1	6.2	3.1
Non Hispanic	83.7	94.9	93.8	96.9
<b>Housing Status</b>				
Occupied	88.6	84.3	60.3	72.8
Owner- Occupied	65.1	69.3	68.6	77.8
Renter-Occupied	34.9	30.7	31.4	22.2
Vacant	11.4	15.7	39.7	27.2
<b>Income</b>				
Median Household Income	\$50,046	\$42,018	\$41,568	\$42,283
Persons below poverty level	15.3	18.2	20.1	19.3
<b>Other</b>				
High school education or higher	85.6	84.1	87.3	83.2
Language other than English spoken in home	20.6	6.8	7.7	4.2
Persons per square mile	88.4	153.9	237.5	73.9
No vehicle available	9.1	7.3	5.5	8.9
Disabled	11.9	13.9	13.9	na
Unemployed	10.8	12.8	12.6	9.6
Mobile homes	6.6	17.6	15.6	21.0

## DEMOGRAPHICS

### **Horry County**

Compared to National averages, the population of Horry County has: more elderly residents (17.1% compared to 13.0%), fewer children (20.1% compared to 24.0%), higher poverty level (20.1% compared to 15.3%), more mobile home residents (15.6% compared to 6.6%) and fewer households without vehicles (5.5% compared to 9.1%). Horry County residents have higher education levels than the National average (87.3% with high school education compared to 85.6%). Horry County has a very high population density at 237.5 people per square mile, a figure that is more than 2.5 times the National average (88.4). Horry County also has more vacant housing units (39.7% compared to 11.4%), supported by the large amount of second homes and vacation rental units along the Grand Strand. The racial profile of Horry County is less diverse than both the Nation and the State with 80% of the population of Caucasian descent.

### **Georgetown County**

Compared to National averages, the population of Georgetown County has: a higher poverty level (19.3% compared to 15.3%) and more elderly residents (19.8% compared to 13.0%). There are far fewer renters (22.2% compared to 34.9%), and a lower population density (73.9 people per square mile compared to 88.4). About 17% of Georgetown County residents have less than a high school education, higher than the National and State average, and neighboring Horry County. There are far more mobile homes than the National average (21.0% compared to 6.6%), all which would be ordered to evacuate, regardless of storm category. Nearly 9% of Georgetown County households report having no vehicles. Although this figure is similar to the National average of 9.1%, it should be considered a major factor in the County's evacuation planning considering its vulnerability to hurricane hazards. Given the number of elderly and mobile home residents, as well as those living below the poverty level, Georgetown County may have more transportation-dependent residents than the average community. The racial profile of Georgetown County is more diverse than that of Horry County and the State, with a larger percentage of African American residents.

## Percent of Mobile Home Residents

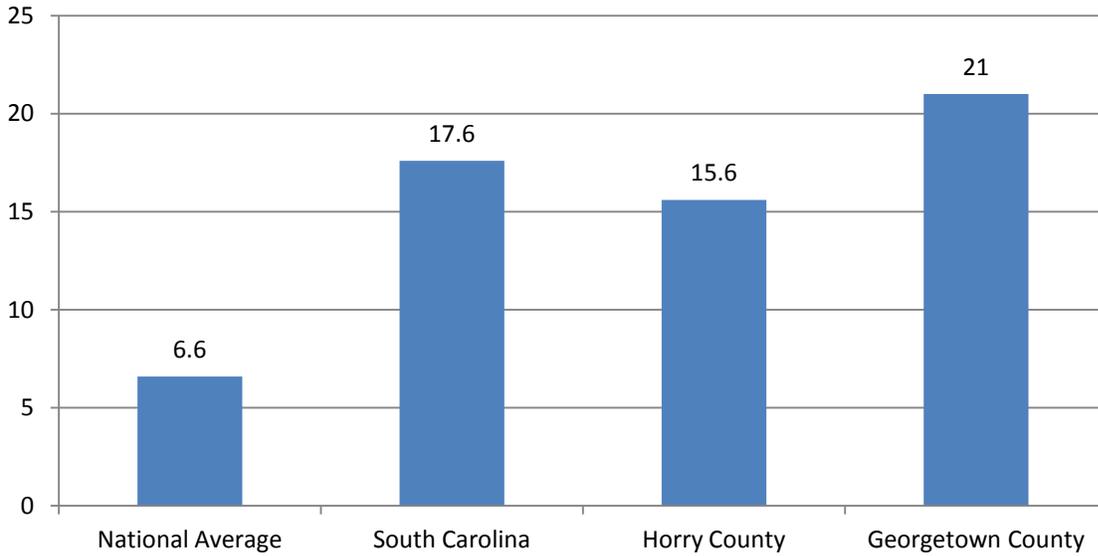


Figure 6-1: Percent of Residents who live in Mobile Homes

## Percent of Households without Vehicles

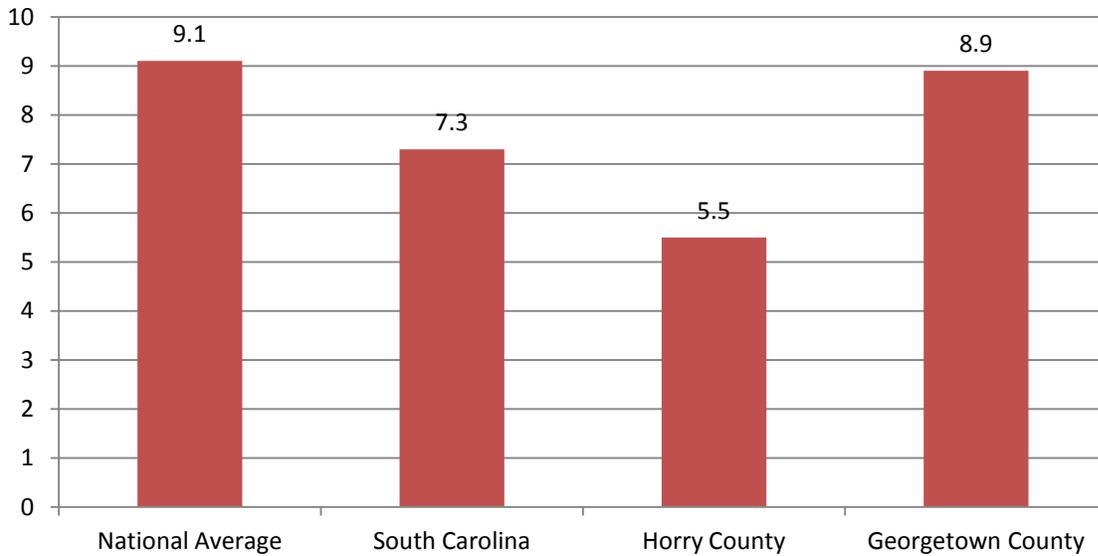


Figure 6-2: Percent of Households without Vehicles

### Horry County Race Breakdown

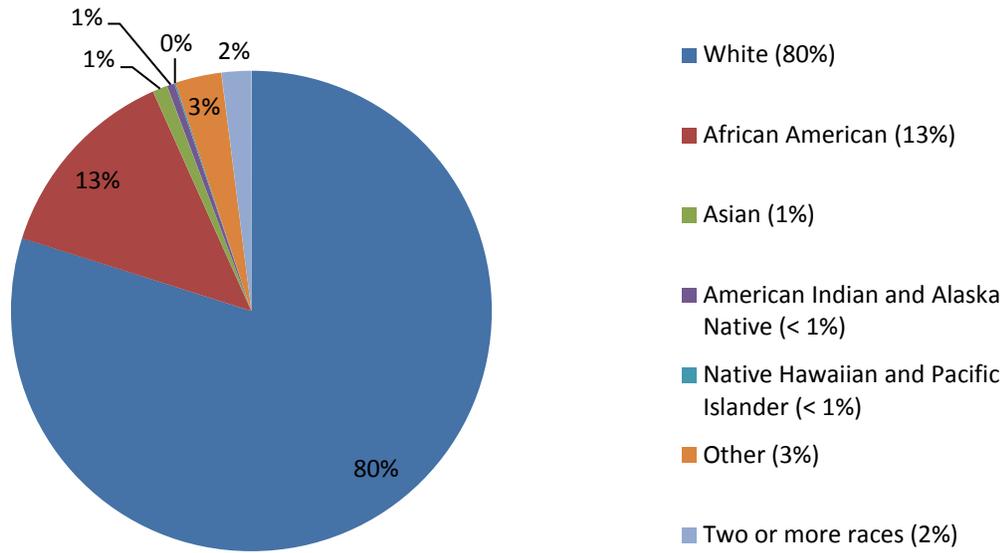


Figure 6-3: Horry County Racial Profile

### Georgetown County Race Breakdown

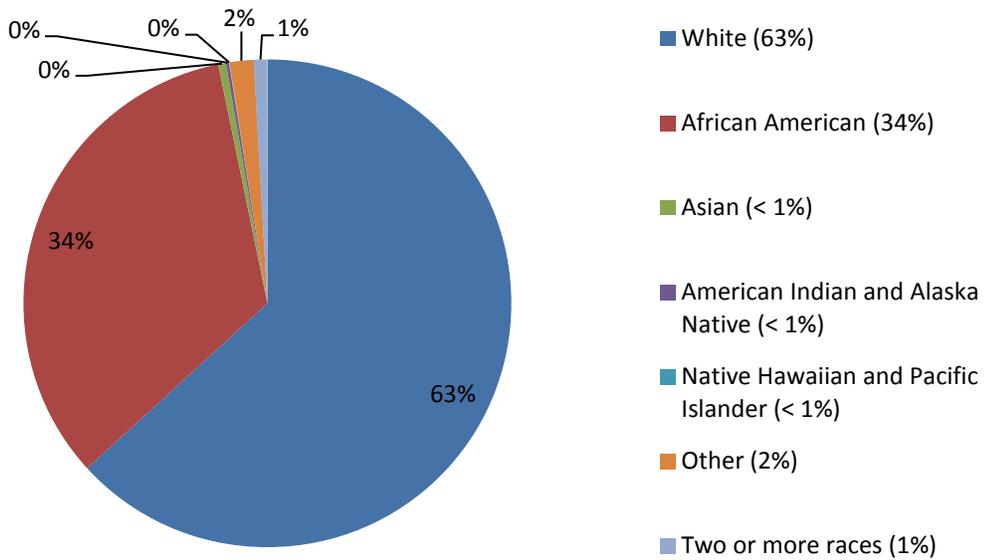


Figure 6-4: Georgetown County Racial Profile

### **Evacuation Implications**

The population of Horry and Georgetown counties is generally older than the State and National average. The age breakdown of the population reflects a larger number of retired and elderly populations in the Grand Strand. With age comes the potential for prior hurricane experience, depending on the length of residence in the area. This experience could positively or negatively impact their evacuation decision making and behavior. A negative or particularly traumatic past hurricane experience may encourage evacuation for a future event. However, a negative evacuation experience or heavy traffic on the evacuation roadway network may have the opposite effect, especially if the storm did not end up having a major impact, leading many to stay behind or ignore an evacuation order. Past behavioral studies have shown that the older populations are sometimes more reluctant to evacuate than younger populations.

Of particular concern to evacuation planning are the relatively high poverty levels and the number of mobile home residents. The low income segment of the population may not have access to resources, whether physical or fiscal, necessary to facilitate an evacuation. Both Horry and Georgetown counties have a relatively high percentage of households living in mobile homes. These residents may need assistance in locating and securing safe shelter for themselves and their families in the event of a hurricane. Additionally, the median income of the general population is below the National average and a significant portion of the population in Horry and Georgetown counties are living below the poverty level. In Georgetown County, a significant portion of the population (9%) does not own a vehicle. These critical transportation needs residents may need transportation assistance from the Government in order to evacuate. Transportation assistance may also be necessary for the relatively high percentage of the population living below poverty level. Adequate planning should be conducted to evaluate the availability of transportation resources to assist in this effort.

The spatial distribution of these vulnerability factors, along with other pertinent social features of Horry and Georgetown counties, are shown in Appendix A.

## 7 CRITICAL FACILITIES

Critical facilities are community entities that are critical to the operation of the community and need special consideration for hurricane preparedness. They may need assistance, special consideration, or attention prior to an ordered evacuation or immediately after the storm has passed as they have been deemed “critical” to the livelihood of the community. Critical facilities, as viewed by the SC Emergency Management Division (SCEMD) and local emergency management, include: hospitals, medical facilities, police stations, fire stations, shelters and emergency operations centers (EOCs) that are needed for community support functions and/or emergency response activities before, during and after an emergency. Other critical facilities considered in the vulnerability analysis include schools, airports, bridges, water/sewer treatment plants and State facilities, each representing an asset of the community that is vital to maintaining and restoring normal operations within the County in the post-storm environment. Data for the critical facilities assessment was obtained from Horry and Georgetown emergency management and SCEMD. Neither first-floor elevation nor potential storm surge heights were provided with the data.

The critical facilities from the various data sources were compiled by the county and any multiple facilities were eliminated and gaps in the data (address, city, state, zip, and latitude/longitude) were addressed. A spatial analysis (select by location) was performed to associate the facilities’ location with respect to surge area, evacuation zone and flood hazard area. Flood hazard areas were defined as areas with a 1% annual chance of flooding (100-year floodplain) designated as Zone A on FEMA Flood Insurance Rate Maps (FIRMs). Potential wave impact was also assessed by examining the location of each facility in respect to the coastal high hazard area, identified as Zone V. This area represents the 1% annual chance of wave heights of 3 feet or greater. Any facilities outside of the surge areas or evacuation zones were labeled as NA. Yes (Y) or No (N) classifications were assigned to each critical facility based upon whether or not it was located in the 100-year floodplain or wave impact area. Once the geodatabase was complete, the list of critical facilities was sent to local emergency management for approval and modified based on the responses received. It should be noted that there is no correlation between the 1% annual chance flood level and any particular category of hurricane. The SLOSH model used to calculate the storm surge inundation areas is not probability based, and multiple categories of hurricanes may be capable of producing the 1% annual chance water level.

The complete list of critical facilities designated by each county can be found in Appendix B. The tables show the facility name, type, address, and in which hurricane surge area and evacuation zone it is located. The location relative to the 1% annual chance floodplain and the potential for wave impacts are also included. It should be noted that the surge area, evacuation zone, floodplain and wave impact designations were assigned based on the GIS data and/or latitude and longitude provided by the counties. Verification and/or updates of street addresses or geographic coordinates were not completed as part of the assessment. Data obtained from local emergency management is up-to-date and accurate.

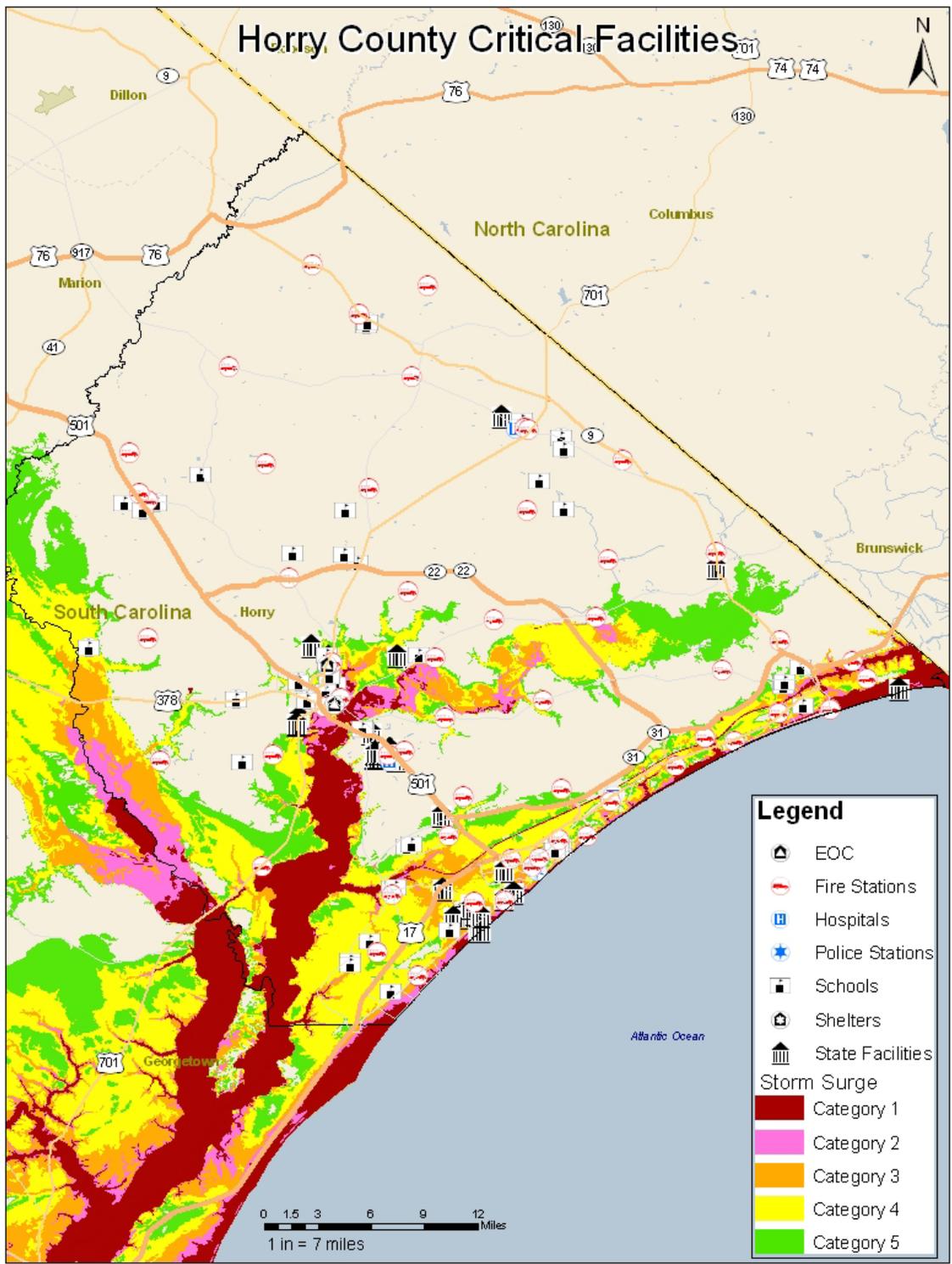
Table 7-1 provides a summary of critical facility types in each of the five storm surge areas. Table 7-2 provides a summary of critical facility types in each evacuation zone. The number of facilities is cumulative; it includes the facilities within that surge area and any facilities located in a lower category surge area. Figures 7-1 through 7-4 show the location of some primary critical facilities, such as the EOC, police and fire stations, medical facilities and shelters in relation to storm surge areas and flood zones.

**Table 7-1: Critical Facilities Summary Table by Surge Inundation Area**

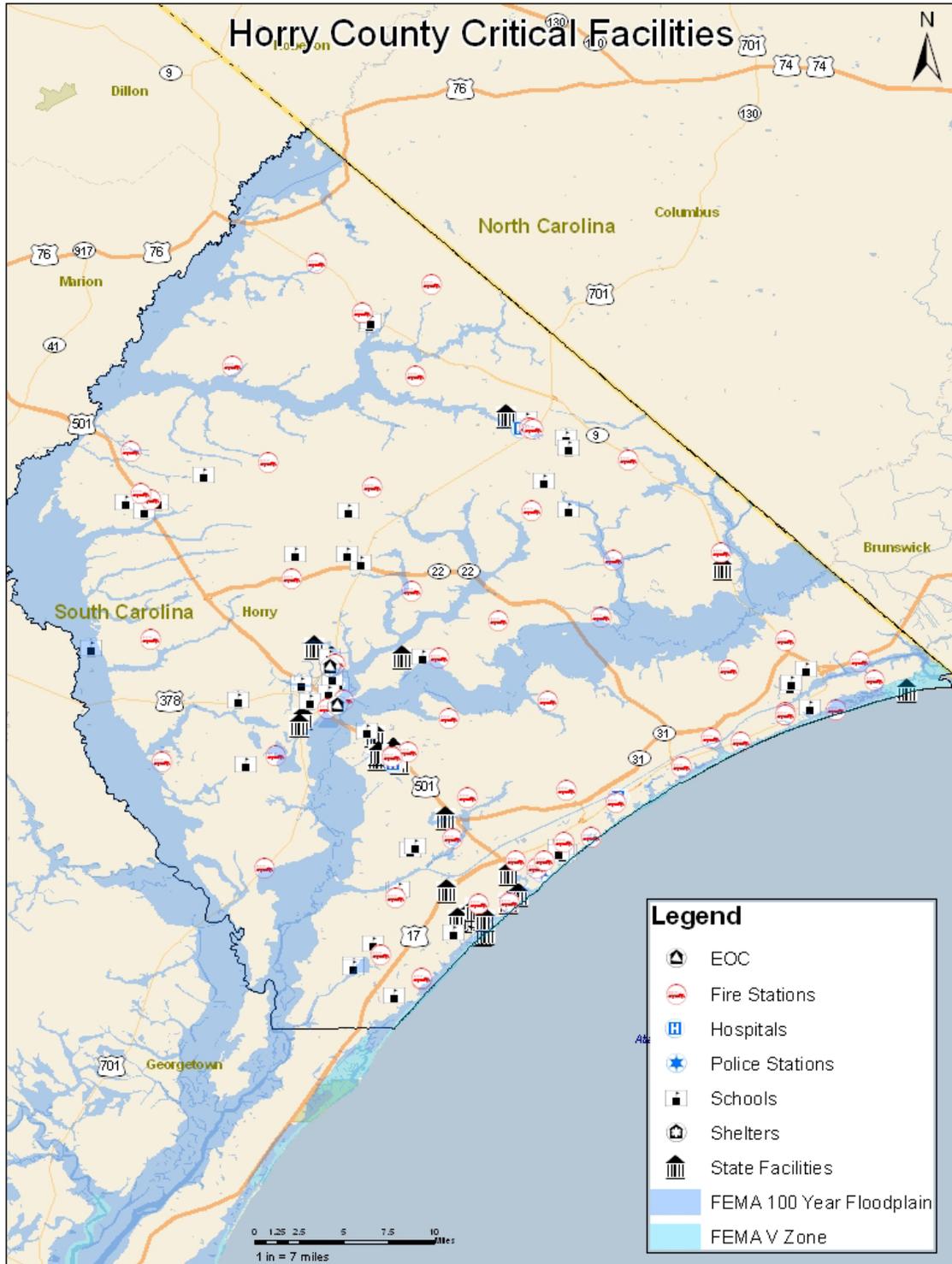
Facility Type	Total	Cat 1	Cat 1-2	Cat 1-3	Cat 1-4	Cat 1-5	Out of Surge Area	Zone A	Zone V
<b>Georgetown County</b>									
Bridges	24	17	20	21	22	24	0	17	2
Critical Points	14	0	3	10	12	13	1	0	0
EOC Facilities	2	0	0	1	1	1	1	0	0
Fire Stations	21	0	3	7	14	16	5	1	0
Hardware-Lumber Yards	5	0	1	1	2	3	2	0	0
Hospitals	2	0	0	1	2	2	0	0	0
Marinas	6	6	6	6	6	6	0	3	1
Medical Facilities	2	0	0	1	1	2	0	0	0
Nursing Homes	8	0	1	6	7	8	0	0	0
Police Stations	4	1	1	3	3	3	1	1	0
Post Offices	3	0	0	3	3	3	0	0	0
Recycling Centers	14	0	0	3	7	9	5	2	0
Schools	25	0	1	9	18	18	7	0	0
Shelters	2	0	0	0	0	0	2	0	0
State Facilities	22	5	7	14	15	15	7	4	1
Voting Locations	36	0	4	14	22	26	10	0	0
<b>TOTAL</b>	<b>190</b>	<b>29</b>	<b>47</b>	<b>100</b>	<b>118</b>	<b>149</b>	<b>41</b>	<b>28</b>	<b>4</b>
<b>Horry County</b>									
Airports	4	0	0	0	2	2	2	0	0
Bridges	15	6	8	8	8	9	6	15	0
EOC and Data Centers	2	0	0	0	1	2	0	0	0
Fire Stations	64	1	1	3	21	27	37	4	0
Hospitals	4	0	0	0	0	1	3	0	0
Police Stations	2	0	0	0	1	2	0	0	0
Schools	49	0	0	0	10	15	34	1	0
Shelters	11	0	0	0	2	2	9	1	0
State Facilities	79	3	4	6	16	22	57	0	4
Water/Sewer Treatment Facilities	10	0	1	1	7	8	2	3	0
<b>TOTAL</b>	<b>239</b>	<b>10</b>	<b>14</b>	<b>17</b>	<b>68</b>	<b>89</b>	<b>150</b>	<b>24</b>	<b>4</b>

**Table 7-2: Critical Facilities Summary Table by Evacuation Zone**

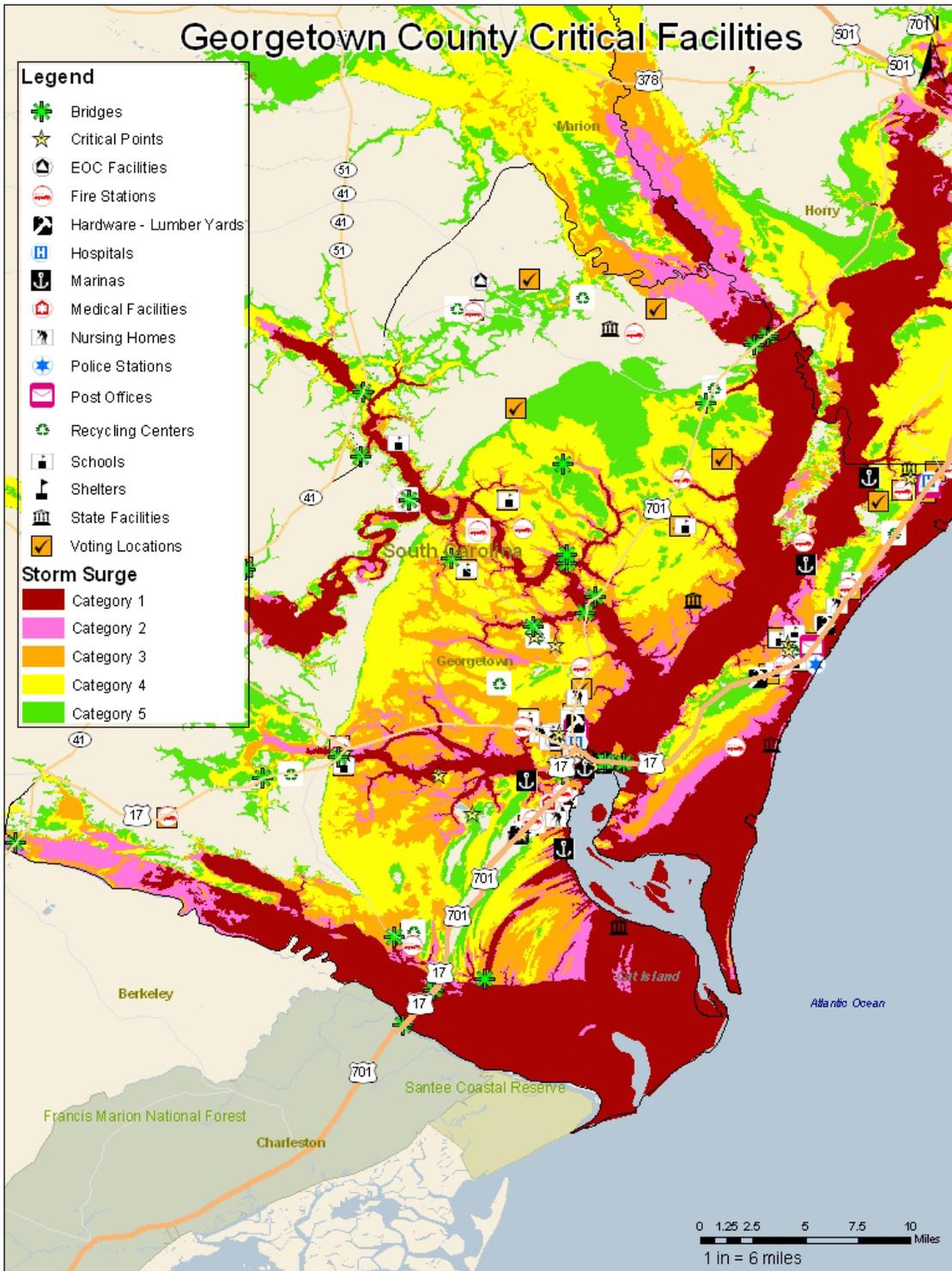
Facility Type	Total	Zone A	Zone A & B	Zone A, B & C	Out of Evacuation Zone
<b>Georgetown County</b>					
Bridges	24	5	7	14	10
Critical Points	14	6	12	14	0
EOC Facilities	2	0	1	1	1
Fire Stations	21	6	11	15	6
Hardware-Lumber Yards	5	0	4	4	1
Hospitals	2	1	2	2	0
Marinas	6	6	6	6	0
Medical Facilities	2	1	2	2	0
Nursing Homes	8	3	8	8	0
Police Stations	4	2	3	3	1
Post Offices	3	1	3	3	0
Recycling Centers	14	1	4	9	5
Schools	25	2	15	19	6
Shelters	2	0	0	0	2
State Facilities	22	11	15	18	4
Voting Locations	36	10	23	28	8
<b>TOTAL</b>	<b>190</b>	<b>45</b>	<b>116</b>	<b>146</b>	<b>44</b>
<b>Horry County</b>					
Airports	4	0	1	2	2
Bridges	15	0	0	0	15
EOC and Data Centers	2	0	0	0	2
Fire Stations	64	9	18	26	38
Hospitals	4	0	1	1	3
Police Stations	2	0	1	1	1
Schools	49	2	8	18	31
Shelters	11	0	0	0	11
State Facilities	79	4	16	16	63
Water/Sewer Treatment Facilities	10	0	0	6	4
<b>TOTAL</b>	<b>239</b>	<b>15</b>	<b>44</b>	<b>69</b>	<b>170</b>



**Figure 7-1: Horry County Critical Facilities in Surge Inundation Areas**



**Figure 7-2: Horry County Critical Facilities in Flood Zones**



**Figure 7-3: Georgetown County Critical Facilities in Surge Inundation Areas**



**Figure 7-4: Georgetown County Critical Facilities in Flood Zones**

From the summary table and maps, it is evident that a larger percentage of Georgetown County critical facilities are located in the surge area (78%) compared to Horry County (37%). 149 of the 190 critical facilities in Georgetown County are located in surge prone areas. Horry County has 89 of its 239 critical facilities in a surge area. In both counties, the majority of hospitals and medical institutions are located outside of the Category 1 and Category 2 surge areas. All hospitals in Horry County are completely outside of the surge area. In Georgetown County, all medical facilities could potentially be inundated in a major hurricane (Category 3 and above). Additionally, the County's eight nursing homes are all located in a surge prone area. All shelters in Georgetown County are located outside of the surge area. Two shelters, Conway Elementary School and South Conway Elementary School, were identified in Horry County which could be susceptible to storm surge in a Category 4 or Category 5 hurricane.

Police and fire stations in Horry County are generally located in areas outside of the Category 3 storm surge. Fewer than half (43%) of first response facilities have the potential to flood in a major hurricane in Horry County. In Georgetown County, on the other hand, over 75% of first response facilities are located in a surge area. State facilities located in Horry and Georgetown counties are potentially vulnerable to storm surge. Those in Georgetown County are more likely to be inundated than in Horry County. State facilities in Georgetown County are primarily located in Category 1 and Category 2 surge areas. The State facilities that are located in Horry County are either outside of the surge area completely (50%) or are located in a Category 4 or Category 5 surge area.

Over half of the schools in Horry County are located outside of the surge area. The remaining schools could potentially be flooded in a Category 4 or Category 5 storm. Georgetown County has a greater percentage of its schools located within a surge area (72% vs. 31% in Horry County). Half of the bridges that were identified as critical infrastructure in Horry County have the potential to be flooded in a Category 1 storm. In Georgetown County that percentage increases to 70%. Only a small percentage of critical facilities in both counties are located in the FEMA 1% annual chance floodplain. An even smaller portion of these facilities are located in a V-Zone. It should be noted that the FEMA flood maps are in the process of being updated and 1% annual chance floodplains and the V-Zones could change when these maps are finalized.

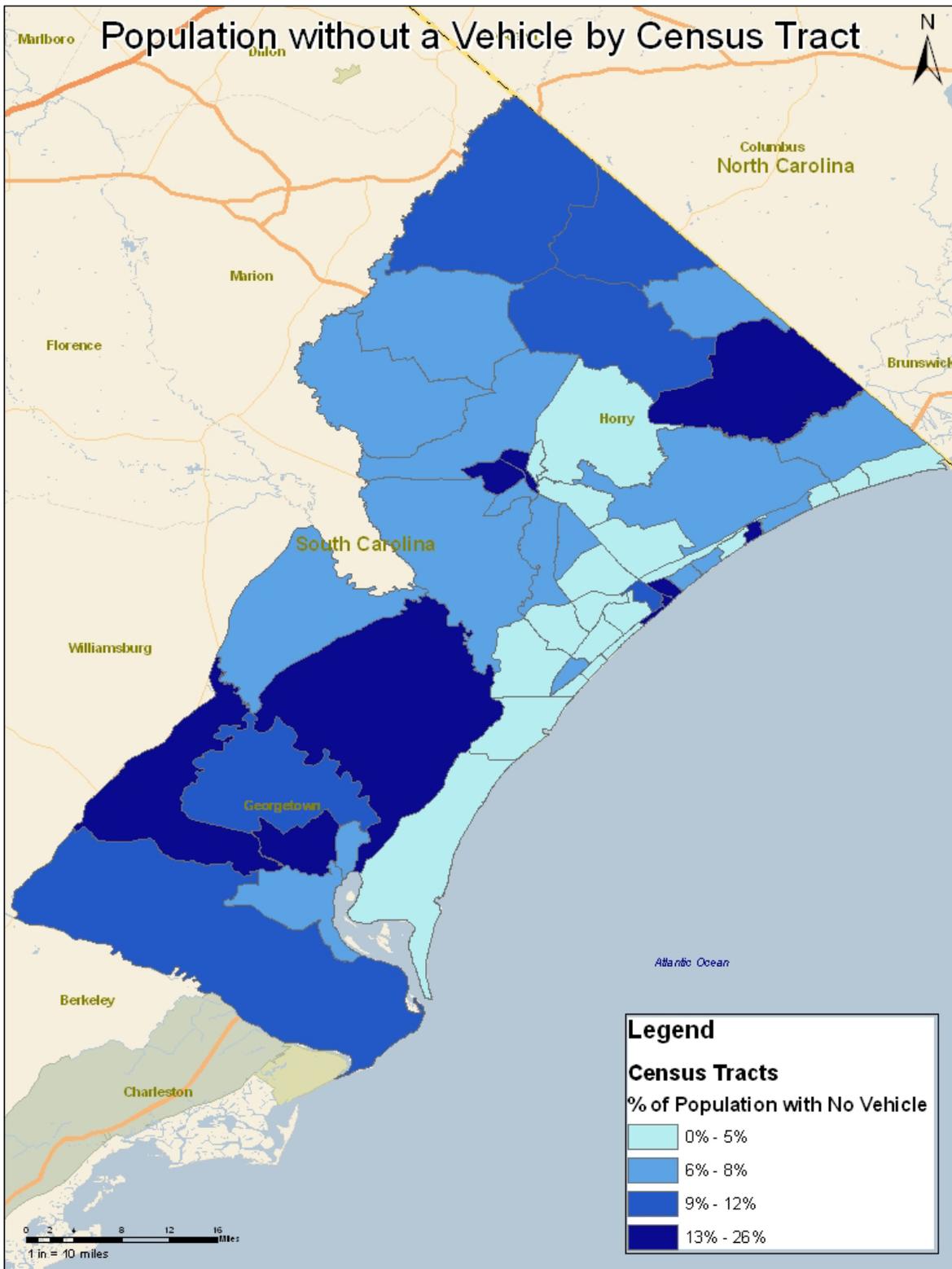
In addition to storm surge hazards, emergency management officials should be aware of the potential for wind damage to upper floors of multi-story buildings. Post-hurricane surveys in other areas show that extreme winds can inflict major damage to multi-story structures, exposing occupants to life-threatening danger. Agencies responsible for hurricane preparedness of special needs facilities (hospitals, nursing homes, adult homes, and correctional facilities) should ensure that proper attention is given to the complex task of planning and coordinating emergency response. A GeoPDF displaying the critical facilities and all additional Vulnerability Analysis datasets will be created for Horry and Georgetown counties and provided to the local emergency managers as an additional visualization and decision-making tool to assist in emergency operations.

## 8 CRITICAL TRANSPORTATION NEEDS (CTN)

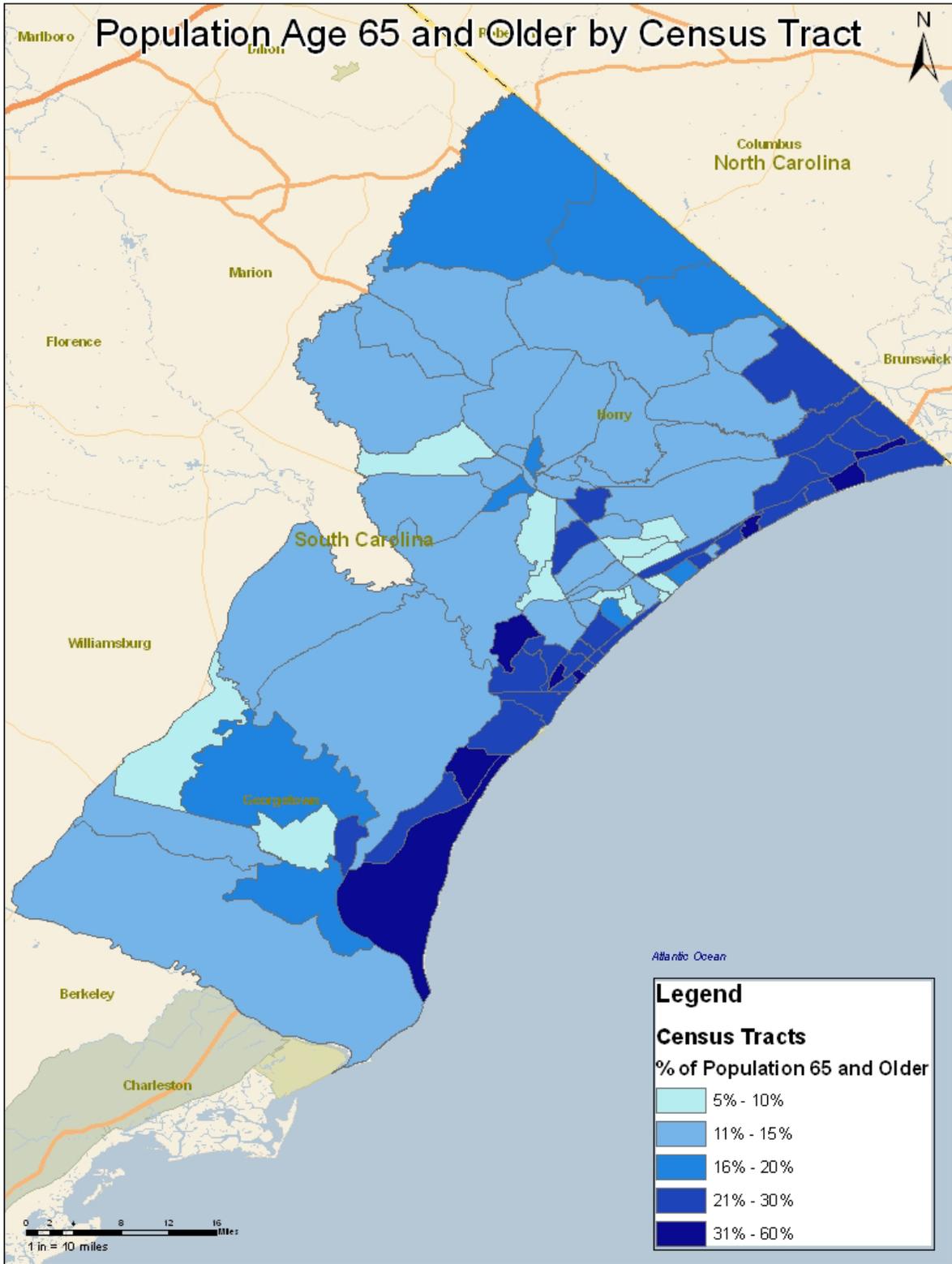
This section of the analysis tests the feasibility of a Critical Transportation Needs (CTN) model for determining the evacuation transportation needs of segments of the populations of Horry and Georgetown counties based on information about the social and economic characteristics of their respective populations. Relevant data were collected from Census 2005-2009 5-year American Community Survey (ACS) Estimates. The 2011 South Carolina Hurricane Evacuation Behavioral Study was consulted for data on residents' evacuation decision-making process.

The logical beginning of the CTN analysis involved the collection of information about where persons with relevant characteristics tend to live within each county. Data were collected by Census tract and the information was put into a geographical database. A geographical analysis was performed to help locate and identify potential areas of CTN populations which are likely to have high percentages of people needing transportation assistance from the County or State to evacuate.

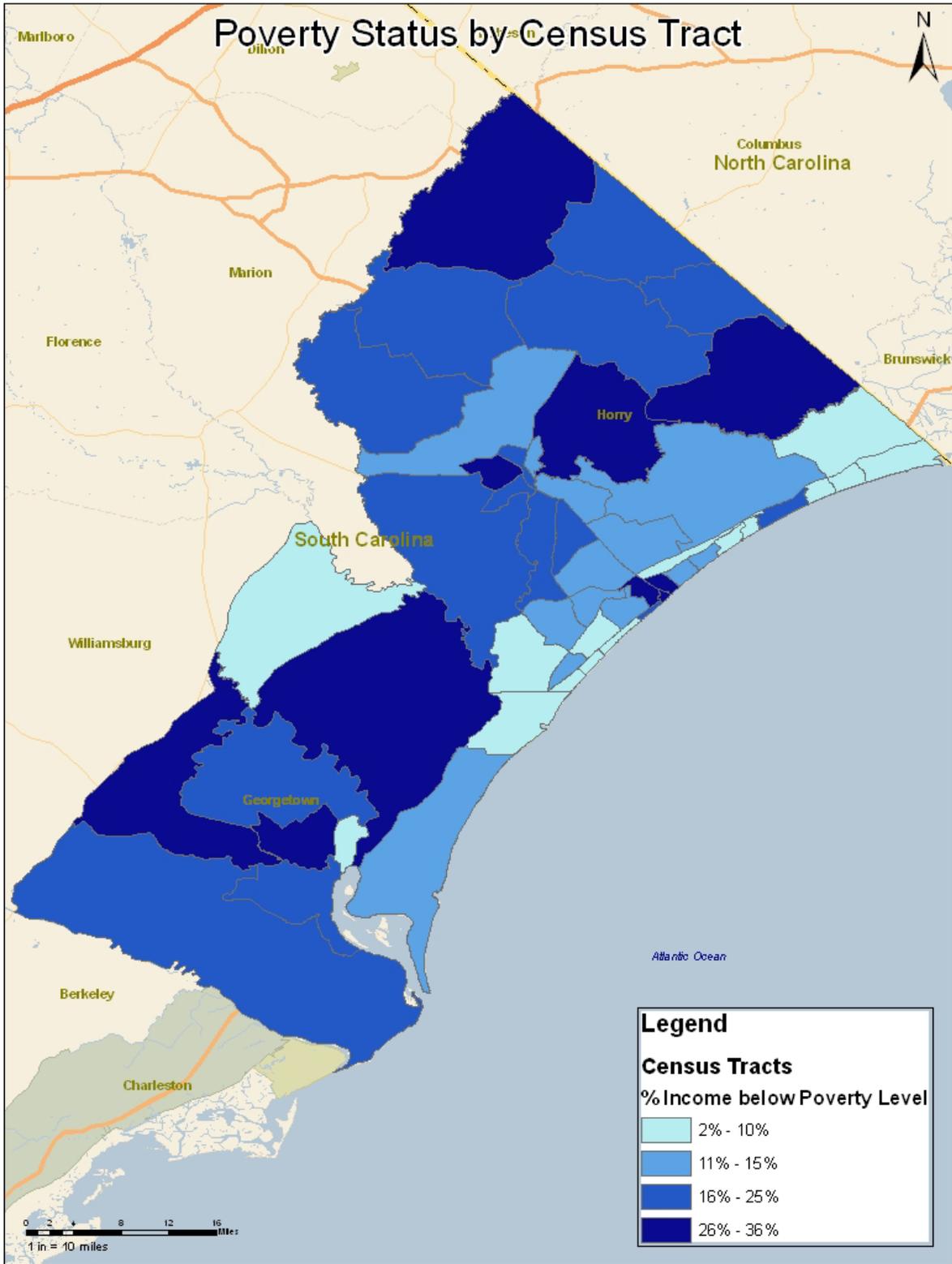
Figures 8-1 to 8-3 illustrate how three of the most relevant vulnerability factors – households without vehicles, persons over 65, and population below poverty level – are distributed by Census tract in the two coastal counties in the Northern Conglomerate. The following three maps illustrate the geographical dispersion of these vulnerability factors (Figures 7-1 to 7-3) in Horry and Georgetown counties.



**Figure 8-1: Horry and Georgetown County Populations without a Vehicle by Census Tract**



**Figure 8-2: Horry and Georgetown County Population Age 65 and Older by Census Tract**



**Figure 8-3: Horry and Georgetown County Poverty Status by Census Tract**

## DETERMINING TRANSPORTATION RESOURCES

The following section of the vulnerability analysis outlines the use of a CTN model spreadsheet<sup>7</sup> for estimating the type and number of transportation and manpower resources that will be required to respond to the CTNs of the counties.

The Excel spreadsheet provided with the analysis represents a possible process for estimating these transportation resources. The model incorporates the results of the 2011 South Carolina Hurricane Evacuation Behavioral Study and the assumptions listed below as model inputs. The population in each evacuation zone was determined by a spatial overlay of 2010 population estimates by Census block with current hurricane evacuation zones.

It should be noted that the inputs in the spreadsheet are only sample values. These inputs represent the behavioral responses of a particular survey population; responses that are constantly changing with the nature of the population surveyed and their perceived notions. As such, they should not be accepted as universal truth. Ultimately, State and local emergency management have the responsibility to decide on the type and source of data to include into the model.

## MODEL INPUTS/ASSUMPTIONS

The outline that follows describes the step-by-step process for utilizing the model. The model is provided in Excel spreadsheet format along with the Vulnerability Analysis report.

Planning for adequate special needs emergency transportation for residents in private homes is often the responsibility of local emergency management officials, while transportation for those in health-related facilities should be the responsibility of the individual facilities. Although detailed information concerning residents of private homes may be difficult to obtain, each local government should develop procedures for maintaining an up-to-date roster of persons likely to need special assistance. Non-ambulatory patients will require transportation that can easily accommodate wheelchairs, stretchers, and possibly, life-sustaining equipment. Lack of resources for these needs could result in critical evacuation delays and increased hazards for the evacuees. The CTN population for each county changes from year to year, and requires public cooperation and assistance to maintain an up-to-date listing.

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<sup>7</sup> Alabama Hurricane Evacuation Project Critical Transportation Needs, September 2009

- i. Estimating the Number of CTN Individuals that Would Evacuate
  - a. Inputs-
    - i. Known data (Green)
      - 1. Population of Horry and Georgetown counties (Countywide and in each evacuation zone)
    - ii. Behavioral Survey Results (Yellow)
      - 1. Percent of the population that would evacuate
        - a. Category 1& Category 2 Storms-
          - i. 28% in Evacuation Zone A, 31% in Evacuation Zone B, 17% in Evacuation Zone C.
        - b. Category 3, 4 & 5 Storms-
          - i. 83% in Evacuation Zone A, 85% in Evacuation Zone B, 75% in Evacuation Zone C.
      - 2. Percent of the population needing transportation
        - a. 3.6% of the population will require transportation assistance by an outside agency
          - i. 10% of households (HH) (from 2011 South Carolina Hurricane Evacuation Behavioral Study) said someone would need additional help to evacuate their homes. Of those that require assistance, 43% reported special care needs and 36% reported needing transportation.
  - b. Outputs- (Blue)
    - i. Number of CTNs
      - 1. By Storm Category
        - a. Countywide
        - b. Each Evacuation Zone
        - c. Cumulative (i.e., by increasing number of zones issued to evacuate)

- ii. Estimating the Transportation Resources to Evacuate CTN Individuals
  - a. Inputs-
    - i. Behavioral Survey Results (Yellow)
      - 1. Percent of people requiring regular transportation
        - a. Half of evacuating and non-evacuating households would require basic transportation
      - 2. Percent of people requiring special transportation
        - a. Half of evacuating and non-evacuating households would require transportation for special care needs
    - ii. Assumptions (Pink)
      - 1. Percent of people requiring each type of special transportation
        - a. 5% of CTN individuals identified as having special transportation needs will require either a wheelchair van or ambulance and the remainder may be transported on a bus that is wheelchair capable.
      - 2. Capacity of each vehicle type
        - a. Buses (Normal and Wheelchair-Accessible)
          - i. 32 and 25 respectively
        - b. Special (Wheelchair Van or Ambulance)
          - i. The capacity of special transport vehicles is assumed to be five, the average of the capacities of wheelchair vans (eight) and ambulances (two)<sup>8</sup>.
      - 3. Manpower
        - a. Driver and Medical Staff/Personnel
          - i. One driver for traditional buses
          - ii. One driver and one aide for wheelchair-accessible buses
          - iii. One driver and two medical staff for special transport vehicles (ambulance)

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<sup>8</sup> Mass Evacuation Transportation Planning Model, Agency for Healthcare Research and Quality, New York City Pilot Test, <http://massevacmodel.ahrq.gov>

## 9 SURVEY OF VULNERABILITY ASSESSMENT NEEDS

The purpose of this section is to present the summary results of a brief survey of the emergency management directors of the Northern Conglomerate counties asking for their input and recommendations for new tools and analyses that could assist them in making vulnerability determinations and help in their planning process. Task # 3 of the Scope of Work (SOW) for the SC HES Vulnerability Analysis, sub-task K states, “Survey all Coastal Counties to determine the need of other tools that would assist them in making vulnerability determinations. Use this survey to prepare a report for SCEMD and FEMA to use in developing future planning endeavors.” It was determined that a separate survey of the inland counties would also be accomplished in order to fully cover the scope of Comprehensive Hurricane Emergency Management Strategies (CHEMS) activities. Completed survey questionnaires from the Northern Conglomerate counties are presented in Appendix C.

The Central and Southern counties will be surveyed in the next phase of the project, and the results will be incorporated into the overall final report.

### METHODOLOGY

The following description outlines the study process and deliverables of this activity. The contractor developed a brief survey questionnaire for the coastal counties requesting comments and suggestions concerning the need for tools and other analyses for making vulnerability determinations. Even though only the coastal counties were mentioned in the SOW, it was decided to include the inland counties as well. A separate survey was developed and provided to the inland counties. The questionnaire was reviewed and approved by the USACE Study Manager and the SCEMD Plans Manager prior to the submittal to the counties. The contractor contacted each county emergency management director individually, explained the purpose of the survey and provided a digital copy of the survey document to each of the directors along with some background information on the CHEMS process.

Table 3-1 below contains a listing of several potential CHEMS Study Items and components that have previously been identified as possible new activities and areas to provide assistance and analyses to emergency managers.

**Figure 9-1: Current CHEMS Study Items and Components**

<b>COMPREHENSIVE HURRICANE EMERGENCY MANAGEMENT STRATEGIES</b>	
<b>Study Item</b>	<b>Components</b>
<b>Re-Entry Analysis</b>	Decision Making
	Communication Process
	Storm Damage Impact Analysis
	Roadway Network Considerations/Alternatives
	Post-Storm Security Needs Assessment
<b>Business Mitigation &amp; Recovery Analysis</b>	Impact Assessment
	Mitigation Assessment
	Economic Impact Study
	Recovery Analysis
	Post-Storm Redevelopment Planning
	Business Training and Education
<b>Community Storm Impact Analysis</b>	Coastal Erosion Mapping/Analysis
	Economic Impact Study
	Inland Flood Analysis
	Utility Damage Analysis (Pre)
	Critical Facility Analysis (Pre)
	Post Storm Security Needs Assessment
	Societal Analysis
	Special Needs/Populations Analysis
	Critical Facility Structure Analysis
Transportation Resource Impact	
<b>Recovery Analysis</b>	Debris Management Planning
	Mutual Aid Planning
	Long-Term Sheltering
	Post-Storm Redevelopment Planning
	Public Health Issues
	Catastrophic Impact Planning
	Temporary Housing Assessment
	Review/Update Response/Evacuation Plans
<b>Communication Assessment</b>	Real-time Lines of Communication Assessment
	Public Information Process Analysis
	Interoperability Communications Planning Analysis
<b>Technology Analysis</b>	GIS Applications and Capability Assessment
	Enhanced Decision Tool Updates/Creation
	Enhanced GIS Storm Surge Mapping
	Evacuation Zone Creation GIS Tool
<b>Disaster Mitigation Analysis</b>	Building Code Impact Analysis
	Zoning Analysis
	Community Rating System Assessment
	Facility Performance Analysis
	HAZUS Implementation
Public Education	
<b>Training</b>	HURREVAC
	HAZUS MH
	SLOSH
	Hurricane Planning/Preparedness Field Course
	Incident Command and Management Training
	New EM Training

## SURVEY RESULTS – COASTAL COUNTIES

A summary of the responses from the counties who provided a completed survey form is shown here. Each question is presented followed by a summary of the survey responses from local emergency management. As this portion of the analyses is a “work in progress” and some counties have yet to provide their completed survey, additional responses will be included when they are received. This section will also be updated accordingly as the Vulnerability Analyses for the Central and Southern Conglomerates are completed.

### **(Q1) Do you have any ideas for GIS related tools that could help you do your job better?**

Responses:

1. A program that will allow users to see and interact with data and information on a basic level without having a working knowledge of GIS
2. A system that will allow the end user the ability to incorporate basic data without the need for GIS software
3. A tool where information and data can be viewed added and printed in a simple map

### **(Q2) Do you have any recommendations for improvements to HURREVAC?**

Responses:

1. An overlay of real time data: wind speeds, rain gauges maybe radar

### **(Q3) Please list three CHEMS Study Items by priority that you would like to see developed in your county.**

Responses:

1. Business Mitigation and Recovery Analysis
2. Recovery Analysis
3. Communications Assessment
4. Pets and development of a plan including locations and funding sources to implement the plan
5. Special Needs Population needs and issues

### **(Q4) What types of training would you most like to receive? Please list at least three types.**

Responses:

1. Management of donated goods post disaster
2. Special Needs Population and how to handle
3. People and Pets during an evacuation

**(Q5) Would a Re-Entry Analysis benefit you and your county? What should it include?**

Responses:

1. Yes, a regional plan set up for each conglomerate with pre-determined control points
2. Yes, a tiered re-entry plan

**SURVEY RESULTS - INLAND COUNTIES**

**(Q1) Do you have any ideas for GIS related tools that could help you do your job better?**

Responses:

1. None at this time

**(Q2) Do you have any recommendations for improvements to HURREVAC?**

Responses:

1. Develop an application for HURREVAC for iPads and “smartphones” devices which will allow emergency managers access via these devices.
2. Continue to enhance the program in future years.

**(Q3) Please list three CHEMS Study Items by priority you would like to see developed in your county.**

Responses:

1. Economic Impact Analysis
2. Storm Damage Impact
3. Inland Flooding Analysis
4. Recovery Analysis
5. Disaster Mitigation Analysis
6. Community Storm Impact Analysis
7. Re-Entry Analysis
8. Business Mitigation and Recovery Analysis
9. Disaster Mitigation Analysis
10. Communication Assessment

**(Q4) Are there any specific “Inland Issues” that you would like to see addressed?**

Responses:

1. Inland storm surge mapping with water depths
2. Interagency communication capability among the counties and the State during specific incidents and periods of re-entry from major evacuations
3. Planning on traffic control and evacuation and re-entry routing must be more fully planned.

4. Planning for emergency shelters in Marlboro County to be opened and used for evacuees from the coast
5. Retrofit all designated evacuation shelters for generator hook ups.

**(Q5) Do you have major issues with evacuating or notifying mobile home residents? How can this best be resolved?**

Responses:

1. Clarendon County has to rely on the television stations for public awareness. This is the primary method for notification.
2. Procedures for notifying special needs and special medical needs population (many in mobile homes with cell phones only).

**(Q6) Are there evacuation traffic related issues that you need assistance with?**

Responses:

1. Analysis of impact of coastal evacuation on Marlboro County (i.e., traffic flow and control, etc.)
2. Extension of designated evacuation routes beyond Interstate 95

## 10 SUMMARY

The vulnerability analysis portion of the South Carolina Hurricane Evacuation Study presented here depicts the areas, populations, facilities, critical facilities, institutions and community areas subject to a storm's hazards in the Northern Conglomerate coastal counties of Horry and Georgetown. Storm surge inundation zone maps and evacuation zone maps were developed for the HES and these were used extensively in this analysis. The location of properties, facilities and populations were compared and analyzed to the areas depicted on these maps.

As evidenced in the results depicted in this analysis, the vulnerability of property, critical facilities and population in South Carolina's two northern coastal counties is not evenly distributed between cities or along transportation routes. Some areas are more susceptible to the impacts of hazards than others based on the characteristics of development and landscape. The land immediately inland of the beach front areas in Horry County is generally at a higher elevation than the areas immediately inland of the beach front areas in Georgetown County. This results in a much greater potential for inland inundation of storm surge in Georgetown County. As witnessed extensively in previous storms, when community growth is coupled with residences in high-risk surge areas, differential vulnerabilities can lead to catastrophic results. The geographic distribution of vulnerability also necessitates different mitigation, post-response, and recovery actions. Given temporal and spatial changes in vulnerability in the future, there is no one-size-fits-all approach to preparedness, response, recovery, and mitigation.

A brief summary of the results of the analysis are presented here:

In Horry County, 54% of the permanent population resides in areas susceptible to storm surge flooding and 51% of the permanent population resides in the county's evacuation zones. The largest population increase within a surge area is located between the Category 3 and Category 4 storm surge area. From the population distribution map, it is evident that many population centers in Horry County (Myrtle Beach, Little River, Garden City, Surfside Beach, Red Hill and Socastee) are located near the coast. Depending on the season, Horry County's tourist population can potentially equal that of its permanent population, nearly doubling the number of people in the County that could be impacted if a hurricane were to threaten the area. The areas inland of the storm surge zones are densely populated. Nearly six percent of Horry County residents live in mobile homes.

In Georgetown County, 80% of the population is located within a surge area and more than 78% reside in one of the County's evacuation zones. The largest population is located in the Category 3 surge area. The Waccamaw Neck communities of Murrells Inlet, Litchfield, Pawleys Island and DeBordieu have exploded with development in recent years. Above the Category 3 surge area, the percent increase in the vulnerable population declines. The inland areas of Georgetown County are relatively rural, and consequently much less densely populated than the coastal areas. However, inland areas outside of an evacuation zone have a significant mobile home population (30% of all mobile home residents) that will need to be evacuated for any evacuation scenario. Tourist locations in Georgetown County are primarily located in the Category 1 surge area. Although the tourist population is smaller in Georgetown County relative to Horry County, a larger percentage of tourists would be impacted by smaller category storms.

In the evacuation zones of each county, a significant variability in the vulnerable population exists from one evacuation zone to the next. The vulnerable population nearly triples from Zone A to Zone B in Georgetown County (a 179% increase from 14,862 to 41,406) and more than doubles in Horry County (a 142% increase from 28,169 to 68,178). In Georgetown County, there is less than a 15% increase in vulnerable population when Zone C is added to the evacuation order but in Horry County, the percent increase in the vulnerable population from Zone B to Zone C is over 100%, nearly doubling the number

of evacuees who would be ordered to evacuate (from 68,178 to 137,687). When Zone C is added to the evacuation order, the evacuating population will only increase slightly in Georgetown County, but would double in Horry County.

Knowing where properties, critical facilities and infrastructure are concentrated within communities and their relationship to potential hurricane hazards and surge inundation is critical to an emergency manager in making better informed decisions and developing local plans and procedures to protect the threatened population from these events. Utilizing the geospatial identification of important community features performed in the vulnerability analysis and the tools provided may be the most effective method to reduce the risk and improve local resilience to hurricane hazards.