Mississippi
Hurricane Evacuation Study

Final Report
April 2012

Transportation Analysis

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Technical Memorandum

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Executive Summary

The Mobile District, U.S. Army Corps of Engineers (USACE) conducted this study to update hurricane evacuation clearance times for the State of Mississippi. The study area included the coastal counties of Hancock, Harrison and Jackson as well as the inland counties of Pearl River, Stone and George. The previous study, completed in February 2001, relied upon 1990 U.S. Census data. This study utilizes 2010 U.S. Census data, where available, and employs similar study methodology used in other recent regional hurricane evacuation study efforts. Recently released 2010 U.S. Census data is available for populations and housing units. Mobile homes and vehicle counts as well as data on the number of tourist and seasonal units were estimated based on available 2000 U.S. Census and 2006 American Community Survey data. The hotel/motel inventory was supplemented by information received from the counties. Demographic changes have occurred in this region as a result of population growth. In addition to population changes, the three coastal study area counties have re-drawn their evacuation zone maps based on updated SLOSH data and high resolution topographic data. The new county evacuation maps incorporate a different configuration of zones that takes into account revisions to the potential storm surge inundation areas. Changes in growth, understanding of risk, and areas that need to be evacuated have resulted in clearance time changes for the region.

The transportation analysis process includes five primary steps; the development of evacuation zones and categories, the establishment of an evacuation roadway network, calculating the number of evacuees and vehicles, determining the specific areas evacuees will come from and where they will go, and then routing evacuees along the evacuation roadway network. The analysis section of the report includes separate sub-sections that address how these steps were undertaken, data and assumptions used in the analysis, and other supporting data. The report also includes a study findings section that discusses the development of hurricane evacuation clearance time estimates as well as recommendations for regional traffic control measures to improve evacuation operations. In support of the report, a user-friendly transportation model was developed.

Hurricane evacuation clearance times are provided for the three coastal counties of Hancock, Harrison and Jackson. Clearance times were also calculated for the area around Hattiesburg as well as for scenarios involving traffic from other states (Louisiana, Alabama and Florida), and the activation of contraflow on I-55 and I-59. The times were calculated based on traffic congestion levels at principle bottlenecks on the evacuation roadway network. The times include a range of scenarios that take into account tourist occupancy levels (low, medium, high, and extreme), storm intensity

scenarios (three different intensity scenarios per county), and response rates (slow, medium, fast and immediate). The potential clearance time benefits associated with the implementation of traffic management measures or roadway improvements at key locations was also reviewed.

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I. Introduction

Coastal Mississippi is at significant risk to impact from hurricanes. Hurricane Katrina (2005) underscored the vulnerability of coastal and inland counties in this region and the need to implement effective and timely evacuations.

The last hurricane evacuation transportation analysis to address the entirety of the Mississippi coast was the *Mississippi Hurricane Evacuation Restudy Transportation Analysis* conducted in February 2001. Other transportation studies and analyses that influence this study include:

- *Louisiana and Mississippi Bi-State Hurricane Evacuation Study (2005)*
- *Southeast Louisiana and Mississippi Clearance Times Updates (2006)*
- *Vulnerability Analysis for Mississippi Hurricane Events (2010)*

This current study builds on recent re-study efforts and incorporates relevant data included in these other studies.

Figure 1 illustrates the Mississippi Hurricane Evacuation Study (HES) area.

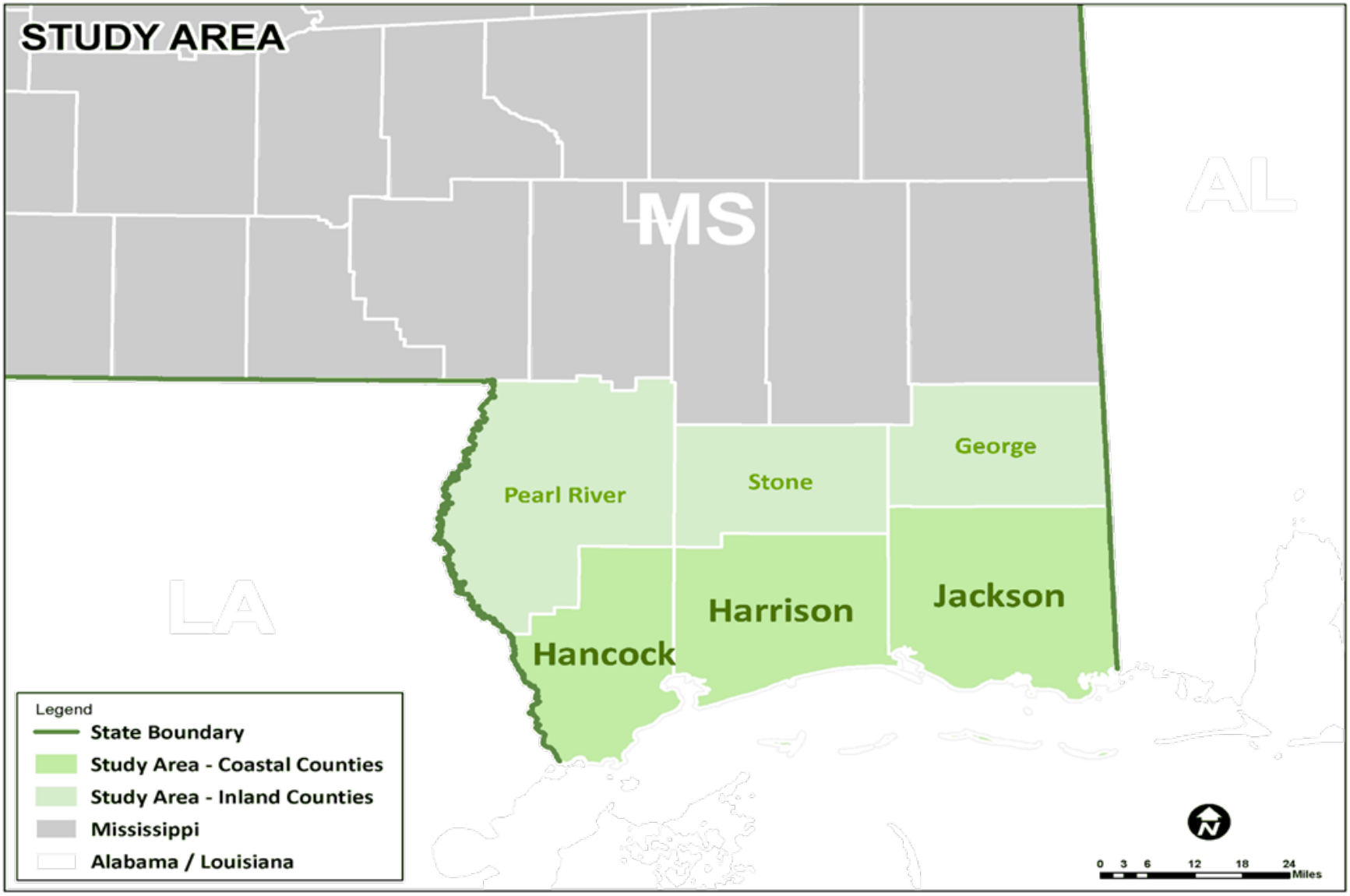

Figure 1: Mississippi Study Area

II. Project Scope

The project was undertaken in two phases. The first phase of the project, completed in August 2011, included a transportation analysis, preparation of evacuation clearance times for inclusion into HURREVAC, and the development of a user-friendly automated transportation model (ATM). The second phase of the project, initiated in December 2011, included the preparation of a HES report and training on the use of the ATM. The primary purpose of the transportation analysis is to calculate the clearance times needed to conduct a safe and timely evacuation for a range of hurricane threats. Other purposes are to define the evacuation roadway network, to evaluate critical traffic links, and assess the potential impacts of interstate traffic.

The transportation analysis addressed five primary steps:

- developing evacuation zones and scenarios,
- establishing an evacuation roadway network,
- calculating the number of evacuees and vehicles,
- conducting evacuee trip generation and assigning destinations
- routing evacuees along the evacuation roadway network.

These steps led to the development of study findings, the most important of which are estimates of hurricane evacuation clearance times for the coastal counties of Hancock, Harrison, and Jackson, as well as for the Hattiesburg area. The study report also assesses the impact of interstate traffic from Louisiana, Alabama and Florida and the benefits of contraflow in I-55 and I-59 on regional clearance times. The report also provides information on other evacuation related issues, such as sheltering and recommendations on traffic control measures designed to improve evacuation operations.

The ATM developed for the Mississippi Study Area generates the clearance time results referenced in this document. It was developed in an accessible, user-friendly format to provide users with a streamlined, spreadsheet-based evacuation model that allows real-time sensitivity analyses through the modification of model inputs. The model is structured similarly to those in use in other USACE HES areas throughout the United States. A column in the ATM allows users in future years to simply plug in an estimated growth factor to quickly update clearance times and evacuation demand statistics.

The model includes three primary data entry modules (socioeconomic, behavioral and out-route assignment) and three primary data results modules (evacuation statistics, evacuating vehicles and clearance time). While the ATM results have been used to determine the hurricane evacuation clearance times for the study area counties, users

have the ability to apply the model to test alternative scenarios as well as adjust data based on changed conditions. Data that may be modified by users include socioeconomic data, behavioral assumptions, roadway segment service volume and traffic routing.

III. Study Analysis

The methodology employed in conducting a hurricane evacuation transportation analysis involves a series of sequential steps. These steps and information related to this study are detailed in this section.

A) Evacuation Zones and Scenarios

The first step in the evacuation planning process involves developing evacuation zones. The fundamental guidelines for developing zones require developing zones that reflect risk, are readily understandable, and are easily communicated to the public. The evacuation zones for this study area were reconfigured as part of the 2010 USACE-led vulnerability analysis process that was undertaken prior to the initiation of the transportation analysis.

Updated county storm surge inundation maps were produced by the USACE using NOAA's most recent Sea, Lake, and Overland Surge from Hurricanes (SLOSH) model simulations for the Mobile Basin (2010) (Figures 2, 3 and 4). For this study, the USACE coordinated with the counties and state to apply this new understanding of storm surge risk to prepare evacuation scenario maps. While the updated storm surge inundation maps identified areas that could be subject to possible flooding during a specific Saffir-Simpson category of hurricane, to make the zones easier to communicate, the evacuation zone boundaries were aligned with key roadway segments or other geographic features where possible. These zones were provided to the transportation analysis contractors at the project kick-off meeting for use in this study.

In the 2001 study, each of the three coastal counties employed three storm scenarios and developed their zones accordingly based on the Saffir-Simpson scale, covering Category 1-2, Category 3, and Category 4-5 hurricane events. In this study the counties decided to move to a lettered zone designation system to allow for more flexibility in decision making and public notification. Hancock and Jackson Counties are using three zones. For these counties Zone A corresponds with storm category 1-2, Zone B corresponds with storm category 3, and Zone C corresponds with storm categories 4-5. Harrison County decided to reduce the number of scenarios and associated zones to two; Zone A corresponds with storm categories 1-3 and Zone B corresponds with storm categories 4-5. These evacuation scenarios are shown in Figures 5, 6 and 7.

Within each scenario for the three counties there are additional factors that can be modeled, including variations in tourist occupancy (low – 20%, medium – 50%, high – 85%, and extreme – 100%) and response rate (immediate, rapid, medium and slow). The impact of out-of-region and out-of-state traffic is also evaluated.

The evacuation scenarios were developed as part of a collaborative process between the local, state and federal government stakeholders and were provided to Atkins for use in the transportation analysis. The State of Mississippi suggested in the interest of public communication that in future studies revisions to the coastal evacuation zones may be explored in order to make them more consistent between the counties.

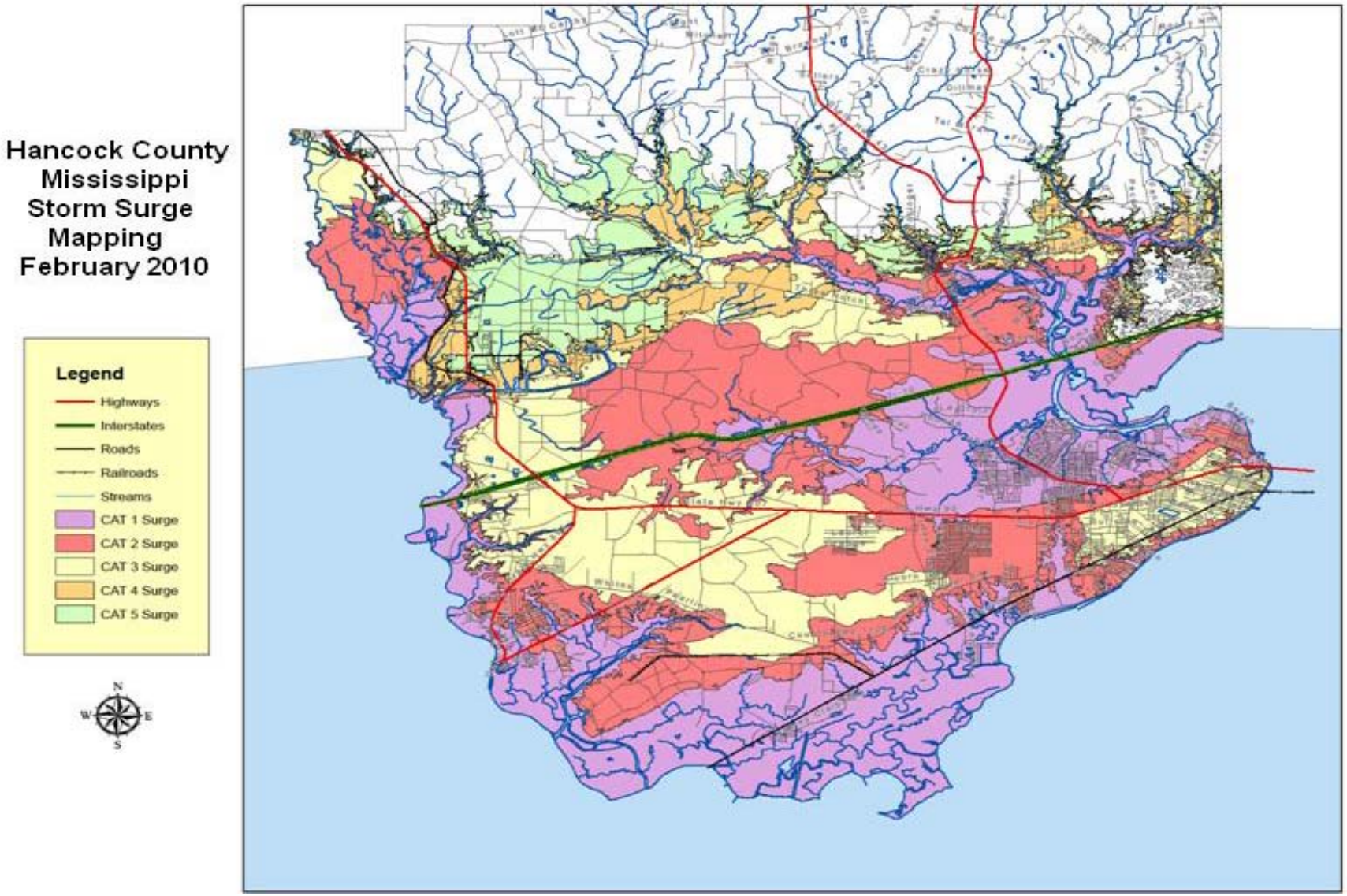

Figure 2: Storm Surge Inundation - Hancock County

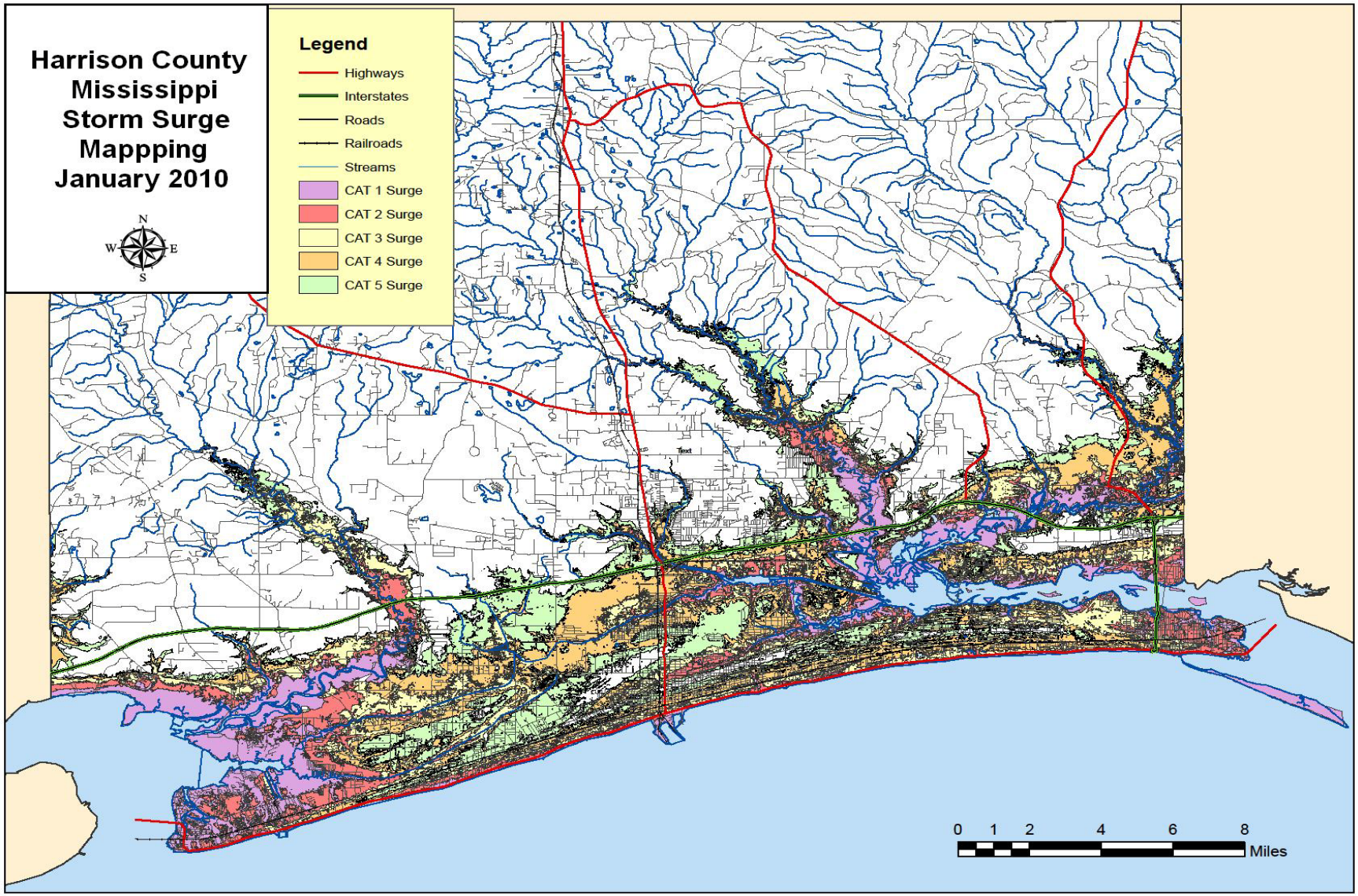

Figure 3: Storm Surge Inundation - Harrison County

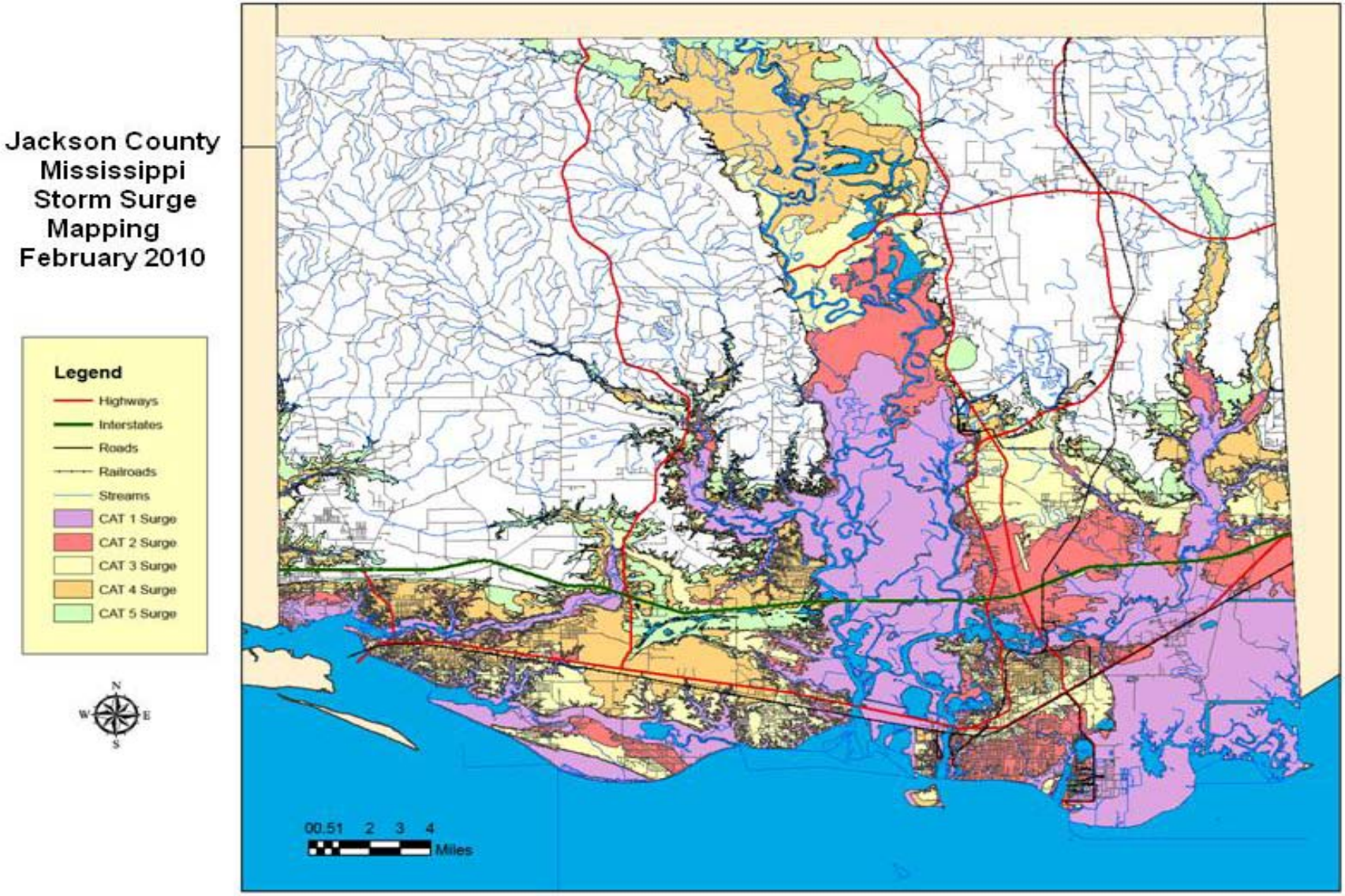

Figure 4: Storm Surge Inundation - Jackson County

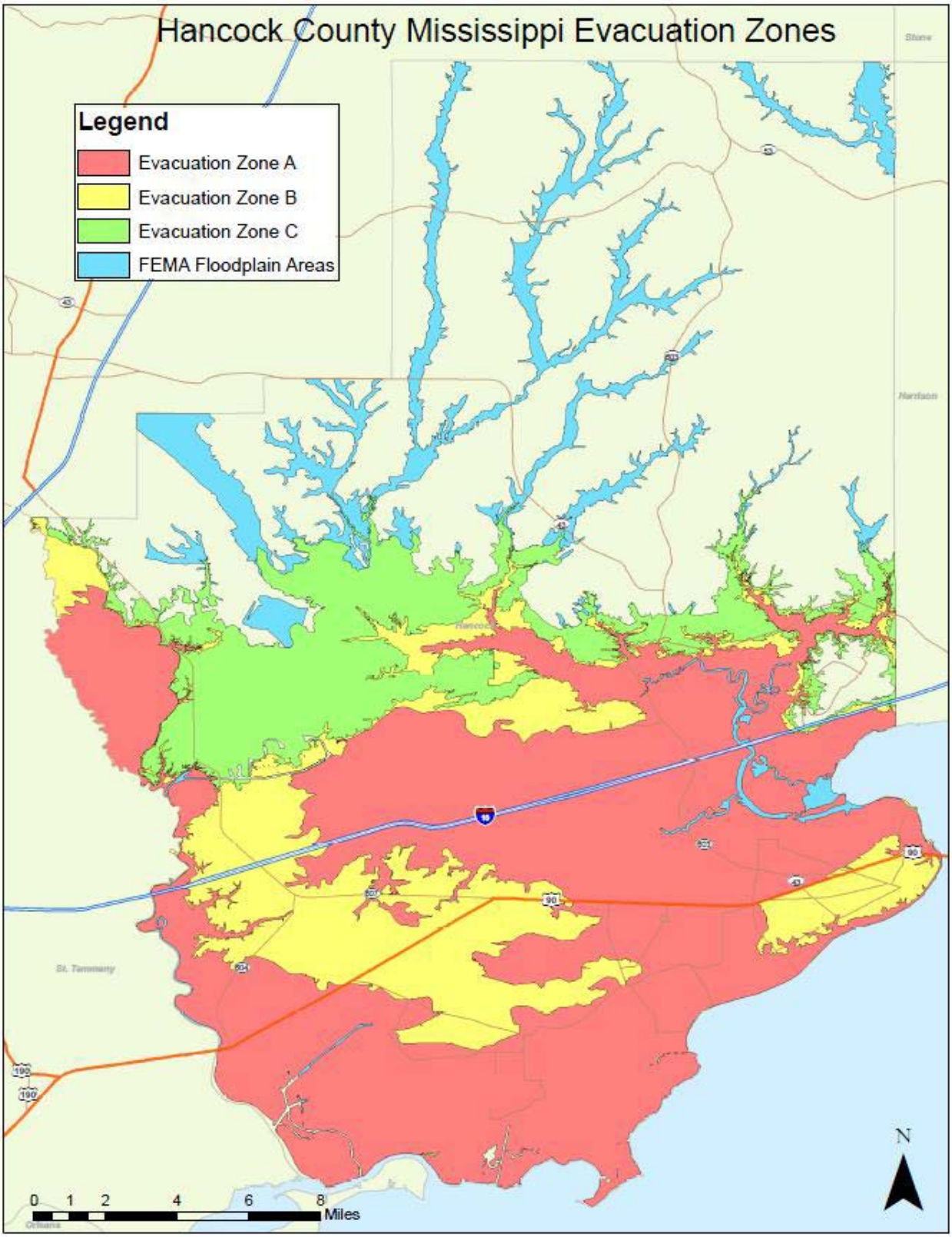

Figure 5: Evacuation Scenarios - Hancock County

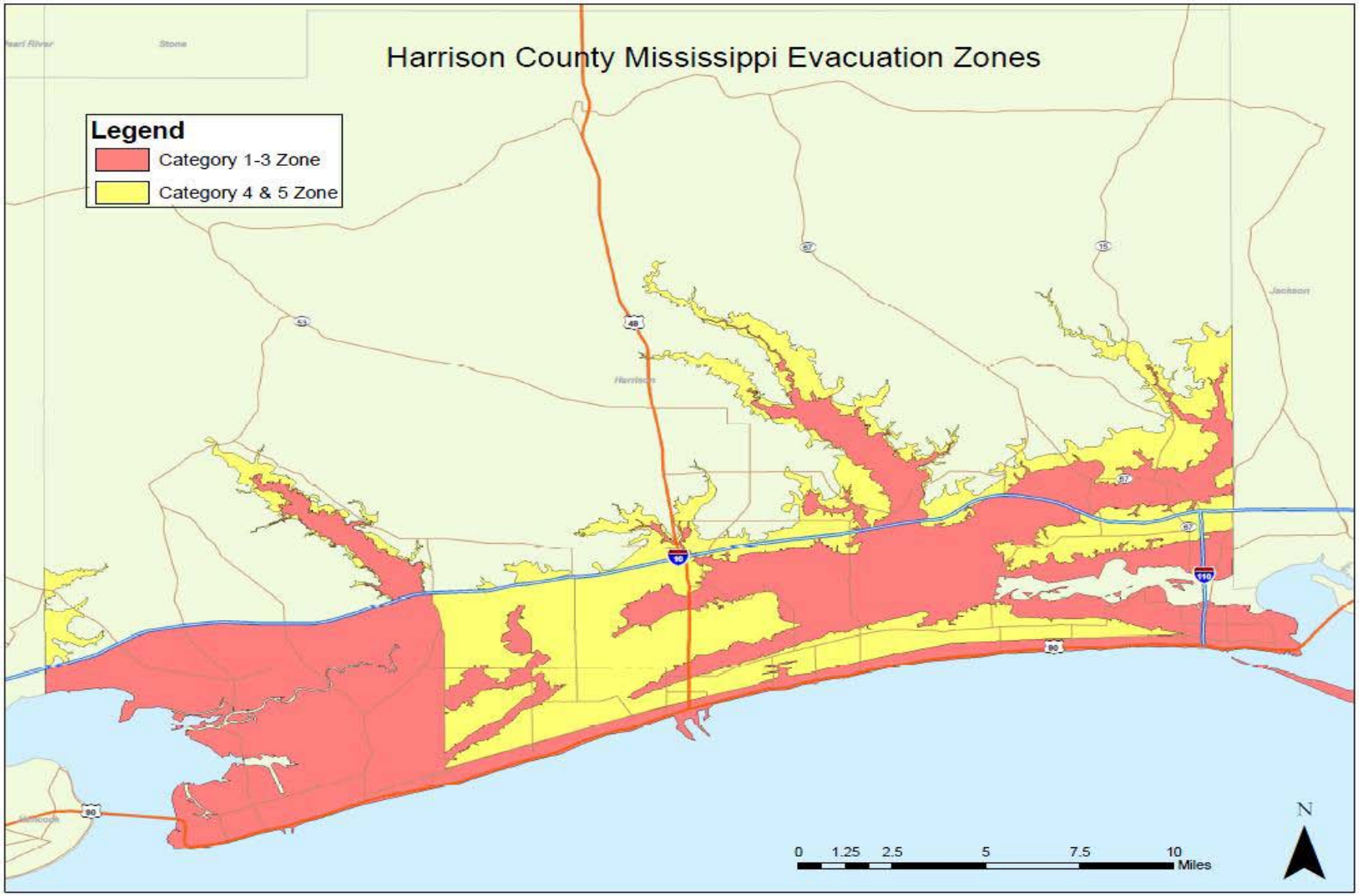

Figure 6: Evacuation Scenarios - Harrison County

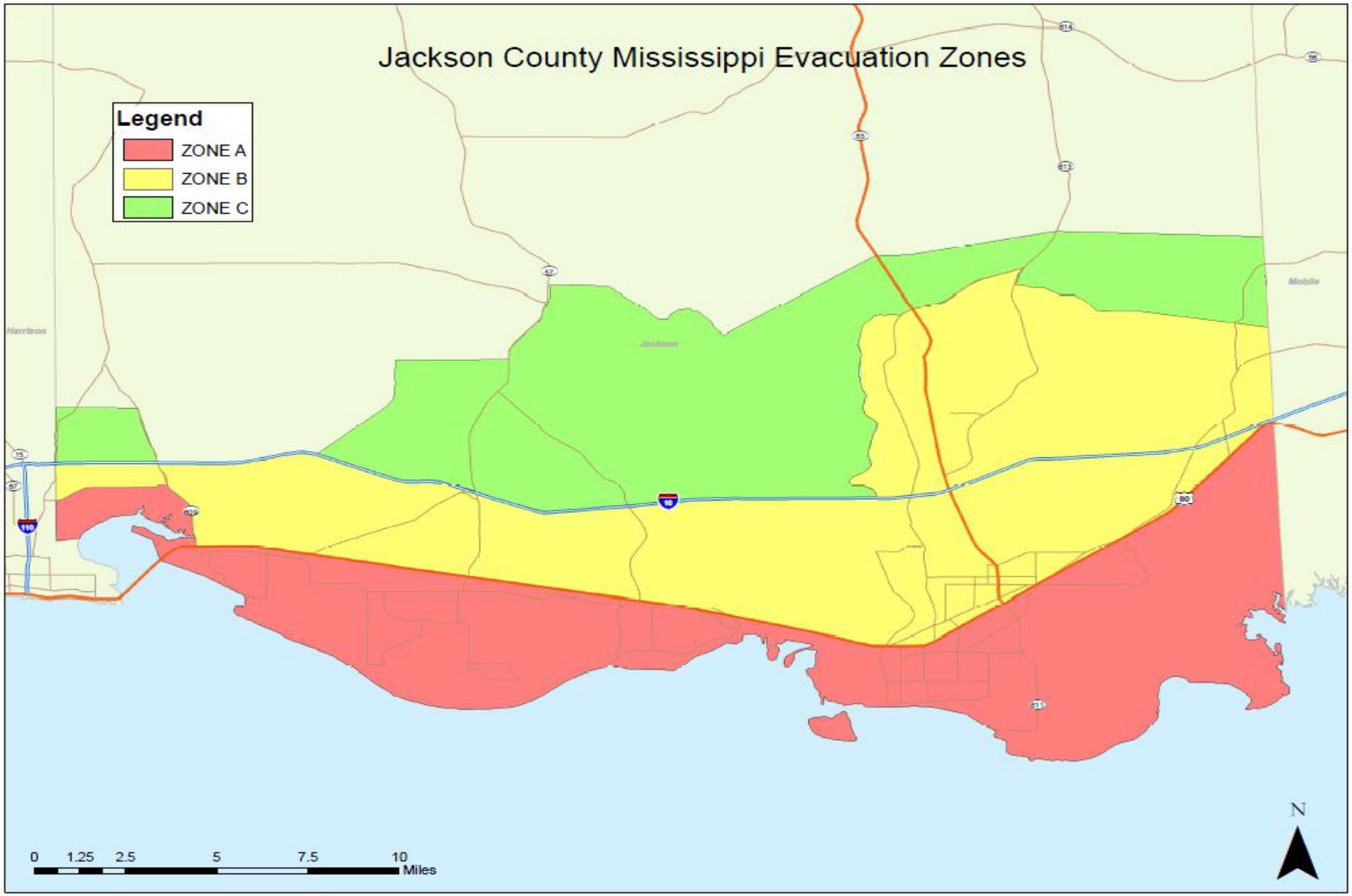

Figure 7: Evacuation Scenarios - Jackson County

After the zones are developed, they are subdivided into a set of numbered traffic evacuation zones, or TEZs. For this study, the TEZs were based on the census blocks that best correspond to the delineated zone boundaries. These subunits allow for socioeconomic data collection within their boundaries and form the building blocks of the modeling process. Because of the rather significant changes to the evacuation scenarios between the 2001 study and the current study, the TEZs used in this study are significantly different than those used in the previous study. In some areas, particularly in coastal Harrison County, the census blocks were aligned to better match geographic regions with primary out routes. Table 1 shows a detail listing of the TEZ's for Hancock, Harrison and Jackson Counties.

The descriptions of the Hancock County evacuation scenarios are listed below and Figure 8 depicts the TEZs developed for Hancock County.

Evacuation Scenario Descriptions – Hancock County:

Evacuation Zone A – Category 1-2: Includes all areas in the Category 1 and 2 surge area as well as all people living in an identified floodplain on the Current Flood Insurance Rate Maps for the County and all residents in mobile homes, FEMA cottages and travel trailers.

Evacuation Zone B – Category 3: Includes all areas in Evacuation Zone A plus all areas in the Category 3 surge area as well as all people living in an identified floodplain on the Current Flood Insurance Rate Maps for the County and all residents in mobile homes, FEMA cottages and travel trailers.

Evacuation Zone C – Category 4-5: Includes all areas in Evacuation Zones A and B plus all areas in the Category 4-5 surge area as well as all people living in an identified floodplain on the Current Flood Insurance Rate Maps for the County and all residents in mobile homes, FEMA cottages and travel trailers.

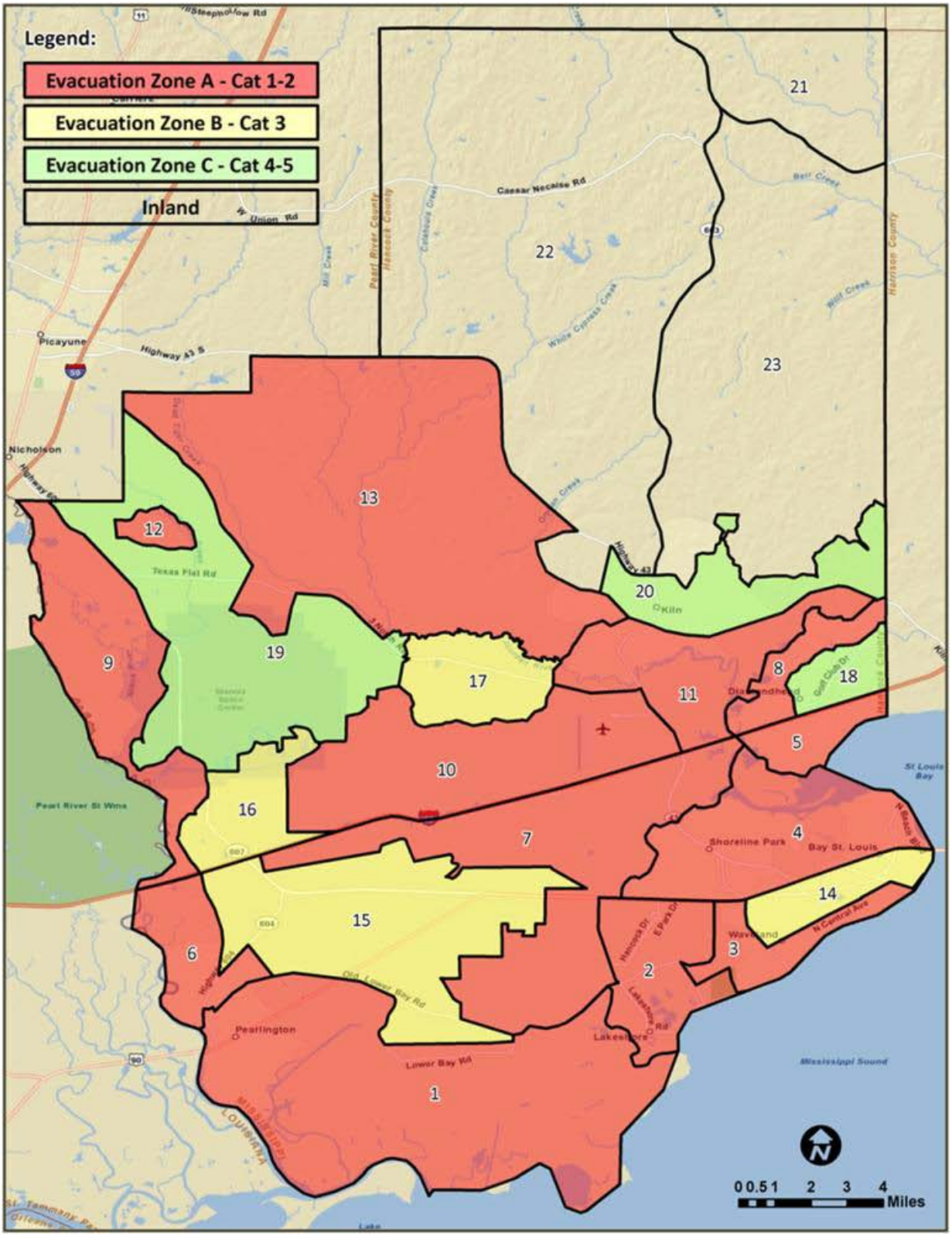

Figure 8: Traffic Evacuation Zones - Hancock County

The descriptions of the Harrison County evacuation scenarios are listed below and Figure 9 depicts the TEZs developed for Harrison County.

Evacuation Scenario Descriptions – Harrison County:

Evacuation Zone A – Category 1-3: The Pass Christian area south of I-10 and west of Beat Line Road, all areas south of the Louisville & Nashville Railroad, all areas on Biloxi peninsula East of I-110, and all flood prone areas along the Back Bay of Biloxi, Tchoutacabouff River, Biloxi River, Bayou Bernard, Brickyard Bayou, Industrial waterway, Turkey Creek, Wolf River and tributaries to these streams.

Evacuation Zone B – Category 4-5: All areas South of I-10 and all flood prone areas along the Back Bay of Biloxi, Tchoutacabouff River, Biloxi River, Bayou Bernard, Brickyard Bayou, Industrial waterway, Turkey Creek, Wolf River and tributaries to these streams.

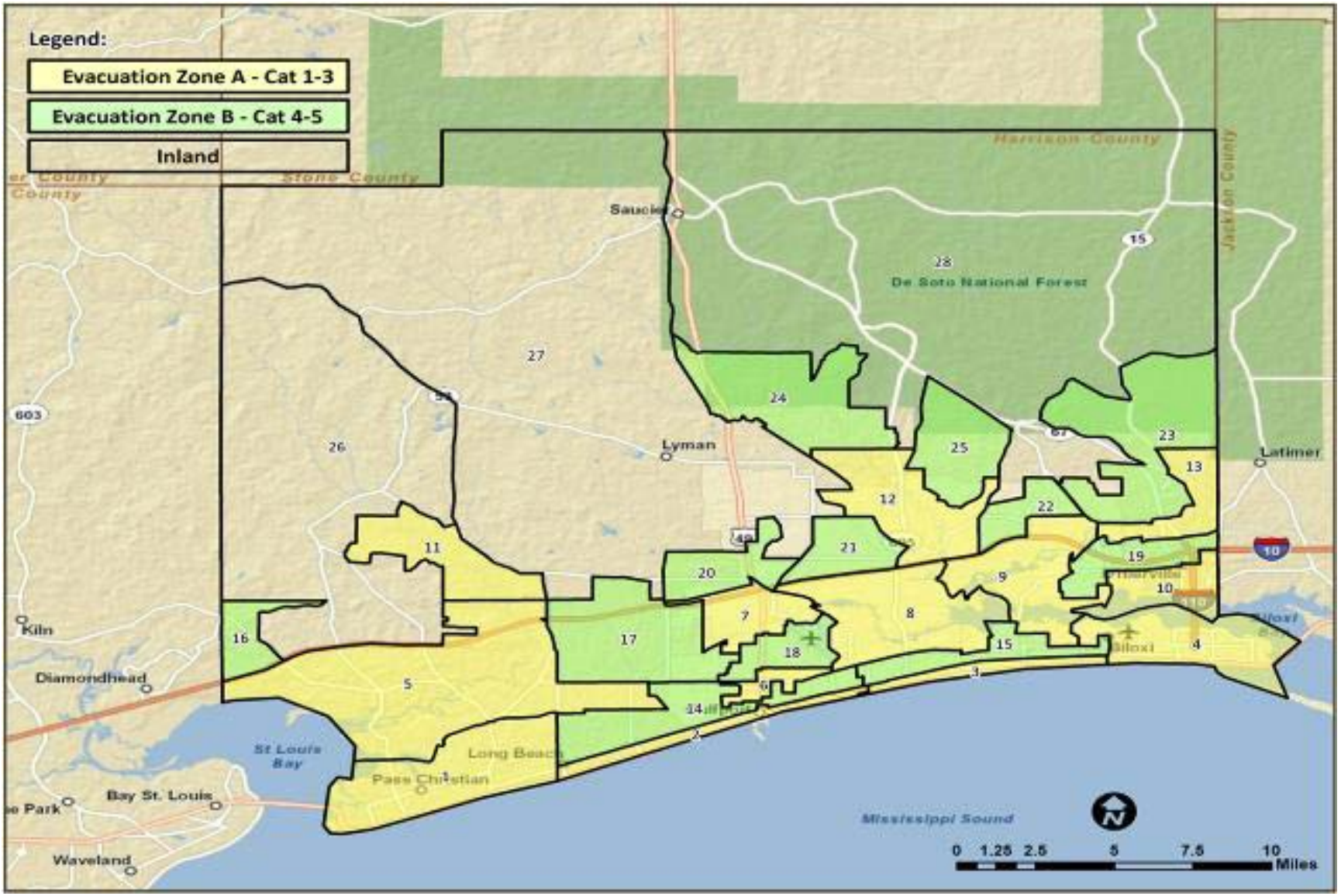

Figure 9: Traffic Evacuation Zones - Harrison County

The descriptions of the Jackson County evacuation scenarios are listed below and Figure 10 depicts the TEZs developed for Jackson County.

Evacuation Scenario Descriptions – Jackson County:

Evacuation Zone A: South of Hwy 90 from the Alabama State line west thru Ocean Springs. North of Ocean Springs up Highway 609/Washington Avenue on the west side up to Lemoyne Boulevard then west to the Harrison County line covering everything south of Lemoyne and west of Highway 609/Washington Avenue.

Evacuation Zone B: South of I-10 from the Harrison County line going east till it gets to the East Pascagoula River then north up to a line where Highway 613 & Highway 63 intersects then continuing north up Highway 613 to Saracennia Road intersection then south approximately 1/2 mile to Nutbank Road then east on Nutbank to Lily Orchard Road. From there the imaginary line extends across the Escatawpa River to the intersection of Forts Lake Road and Maples Lane.

Evacuation Zone C: Starting from the Forts Lake Road / Alabama State Line west across to Highway 613 / Carters Road – west to Highway 63 / Lampkin Road – continuing west across the river to Poticaw Bayou Road to the Highway 57 intersection – South on Highway 57 to Humphrey Road – west on Humphrey to Old Ft. Bayou Road then south to I-10. The western portion of the C Zone is North up Tucker Road to McClellan Road then west to the Harrison County line.

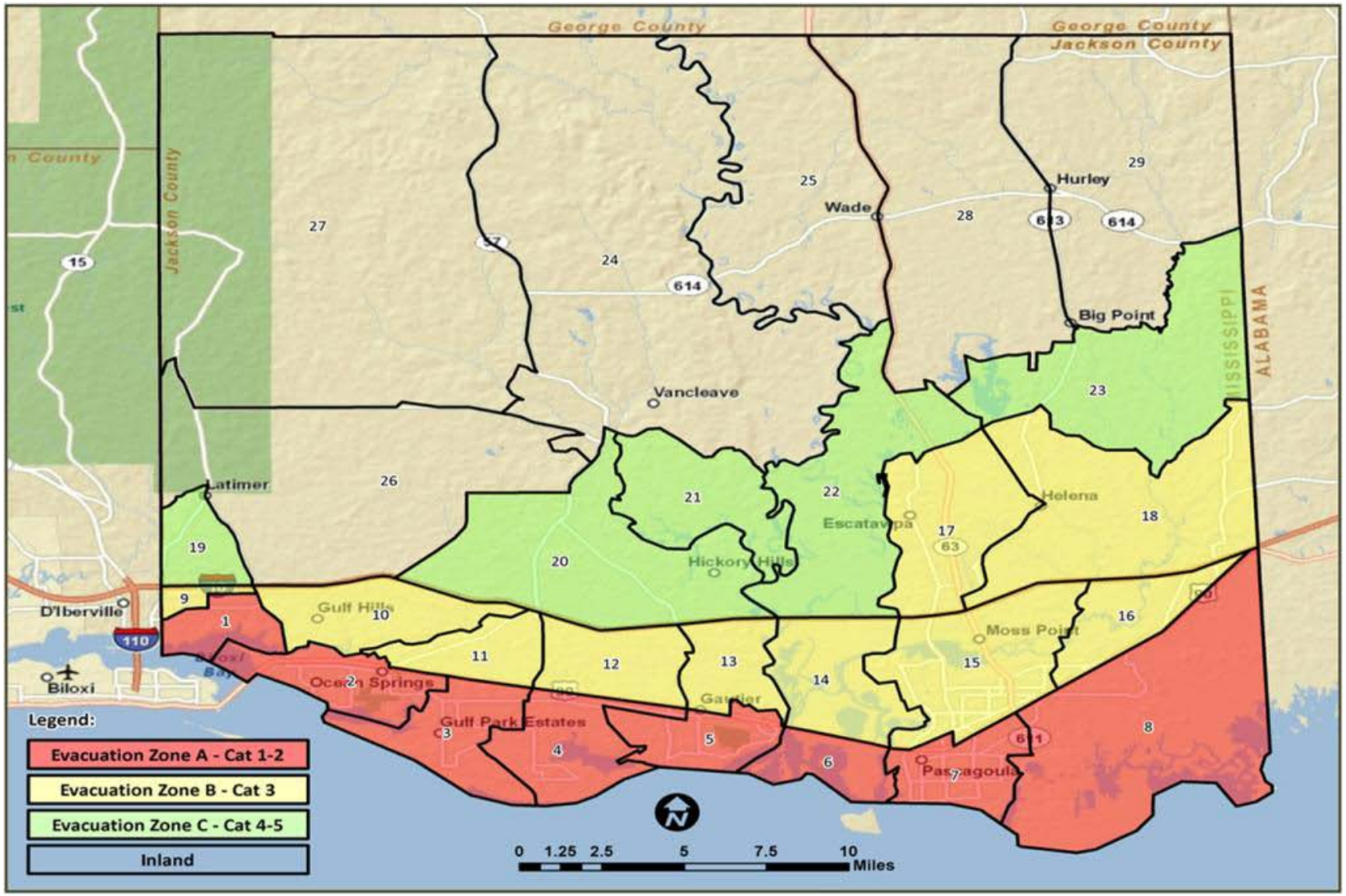

Figure 10: Traffic Evacuation Zones - Jackson County

Table 1: Traffic Evacuation Zones with Generalized Area Name

County	Evacuation Zones	Traffic Evacuation Zone Map ID	Traffic Evacuation Zone Generalized Area Name
Hancock	Evacuation Zone A – Cat 1-2	1	1. Pearlington
		2	2. Lakeshore
		3	3. Beach Boulevard
		4	4. Bay St. Louis
		5	5. Diamondhead Airport
		6	6. Logtown
		7	7. Bayou LaCroix
		8	8. Rotten Bayou
		9	9. Macks Island
		10	10. Stennis Airport
		11	11. Jourdan River
		12	12. Turtleskin Creek
		13	13. Catahoula Creek
	Evacuation Zone B – Cat 3	14	14. Waveland
		15	15. Westonia
		16	16. Pearl River
		17	17. Texas Flat Road
	Evacuation Zone C – Cat 4-5	18	18. Diamondhead
		19	19. Stennis Space Center
		20	20. Kiln
	Inland	21	21. Crane Creek
		22	22. Caesar Necaise Road
		23	23. Rocky Hill Dedeaux Road
Harrison	Evacuation Zone A – Cat 1-3	1	1. Pass Christian
		2	2. Gulfport
		3	3. Edgewater Mall
		4	4. Biloxi
		5	5. De Lisle
		6	6. Evergreen Garden Cemetary
		7	7. US 49 at I-10
		8	8. Big Lake
		9	9. Sunkist Country Club
		10	10. D'Iberville
		11	11. Wolf River
		12	12. Loraine
		13	13. N of Tchoutacabouffa River
	Evacuation Zone B – Cat 4-5	14	14. Naval Construction Battalion Center
		15	15. President Broadwater Golf Club
		16	16. Kiln Delisle Road
		17	17. Turkey Creek
		18	18. Gulfport-Biloxi Airport
		19	19. S of Tchoutacabouffa River
		20	20. Landon
		21	21. Dedeaux Road
		22	22. "old" MS 67
		23	23. "new" MS 67 and MS 15
		24	24. Grandway Boulevard
		25	25. Old Woolmarket Road

Table 1: Traffic Evacuation Zones with Generalized Area Name (continued)

County	Evacuation Zones	Traffic Evacuation Zone Map ID	Traffic Evacuation Zone Generalized Area Name
Harrison (continued)	Inland	26	26. Vidalia and Firetower Roads
		27	27. Lyman
		28	28. De Soto National Forest
Jackson	Evacuation Zone A – Cat 1-2	1	1. Biloxi Bay
		2	2. Ocean Springs
		3	3. Gulf Park Estates
		4	4. Graveline Bay
		5	5. Shepard State Park
		6	6. Pascagoula Bay
		7	7. Pascagoula
		8	8. Bangs Lake
	Evacuation Zone B – Cat 3	9	9. St. Martin
		10	10. Gulf Hills
		11	11. Ocean Springs Road
		12	12. Fire Tower Road
		13	13. West Pascagoula River
		14	14. Big Lake
		15	15. Moss Point
		16	16. Pollock Ferry Road
		17	17. Trent Lott Airport
		18	18. Helena
	Evacuation Zone C – Cat 4-5	19	19. Tucker Road
		20	20. Hickory Hills
		21	21. Paige Bayou Road
		22	22. Pascagoula River WMA
		23	23. Black Creek Cooling Pond
	Inland	24	24. Vancleave
		25	25. Black Creek
		26	26. Latimer
		27	27. Red Creek WMA
		28	28. Wade
		29	29. Hurley

B) Evacuation Roadway Network

The second stage in the evacuation modeling process involves identifying the evacuation roadway network. The network is limited to the primary evacuation routes that evacuees will use to travel from the risk areas. The evacuation roadway network does not include all the local roads in the Mississippi counties, only those roadways which are likely to convey a significant number of evacuating vehicles which have been aggregated from adjoining local roads.

Based on input from the stakeholders, the primary evacuation network covers the three coastal and three inland counties. The secondary network includes roadways that are expected to convey traffic through Hattiesburg on to destinations along the I-20 corridor,

including Jackson. The secondary network also includes those roadways expected to convey out-of-state traffic into or through the region as well as regional connectors. The network, including the additional modeled segments, was reviewed by area stakeholders and revisions and updates were made based on their comments. The regional evacuation network map is shown in Figure 11.

Once established, the network is divided into a series of segments, or road links, which are bounded by nodes represented on the maps by dots. As part of the modeling process, data is collected regarding these links and roadway segments, including directional service volume and average daily trip information.

In anticipation of the heavy traffic demands on a highway's normal capacity during an evacuation, especially in evacuations expected to involve the City of New Orleans metro area, Mississippi emergency managers, law enforcement, and transportation officials should consider methods to enhance the capacity of existing roadways, including contra flowing traffic. In coordination with officials from the State of Louisiana, contraflow plans have been developed for I-59 and I-55 to maximize northbound traffic volume. It is anticipated that these plans will be available to be implemented in the event of a Category 4 or 5 hurricane. The implementations of the contra flow segments are critical to the region for reducing overall clearance times.

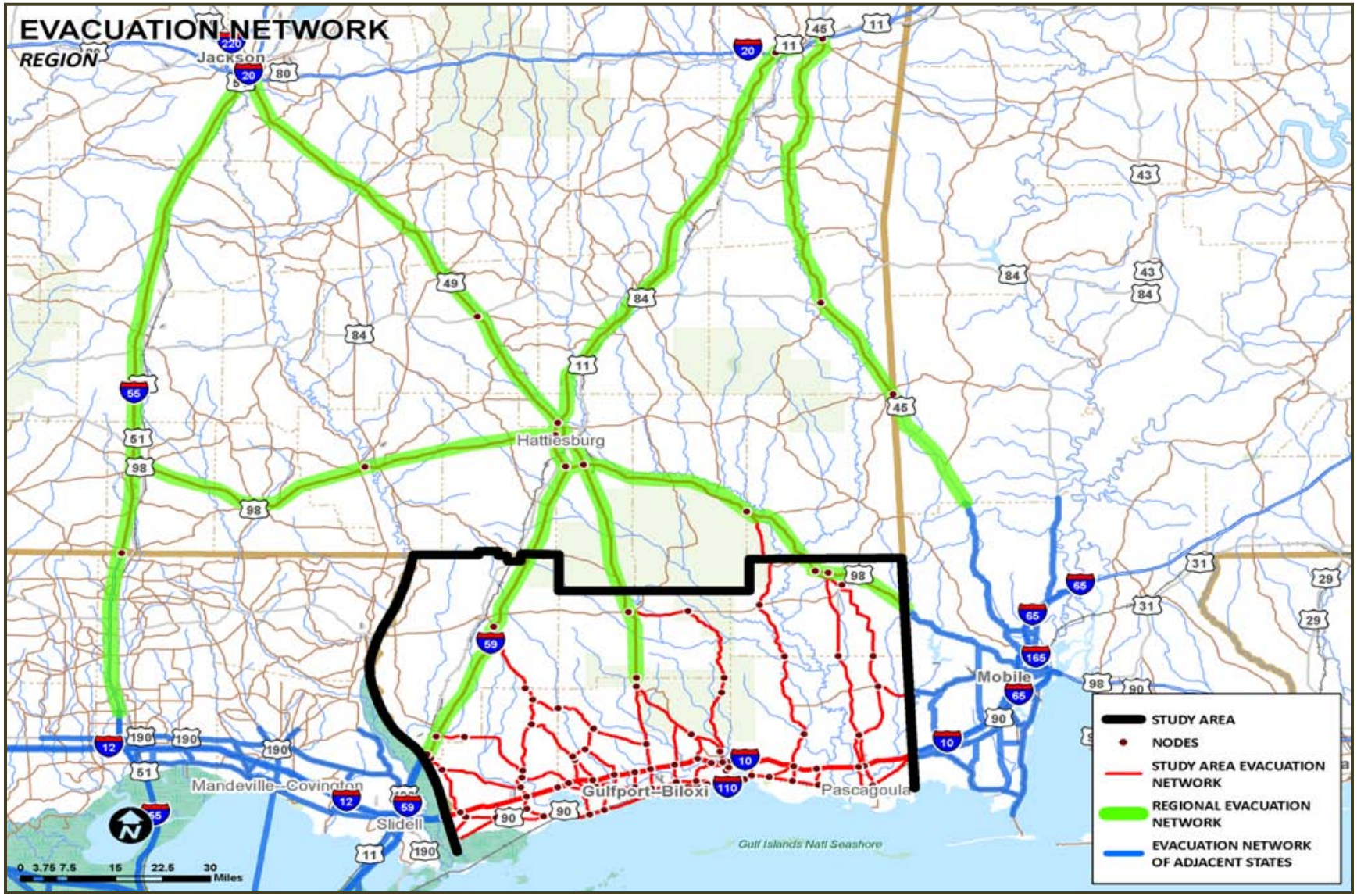

Figure 11: Traffic Evacuation Network - Mississippi Study Area

As noted, the evacuation roadway network was initially developed based on that used in the 2001 study, but was reviewed and updated by the study stakeholders. Key regional connectors were added to the network for the purposes of modeling expected evacuee route choices and traffic movements. The network was developed to allow for determining impacts at key locations outside of the primary study area (including Hattiesburg), and for evaluating the benefits of contraflow.

Table 2 lists the critical roadway segments and the estimated initial service volume at the commencement of the evacuation.

Table 2: Critical Roadway Segments

County	Critical Roadway Segments	Directional Service Volume per hour	Number of Lanes *(Both Directions)*	AADT*
Hancock	US 90 at MS 603 / 43 (out of Waveland)	1,500	4	3,100
	I-10 at MS 603 / 43 (out of Bay St. Louis)	3,00	4	34,000
	603 / 43 at Kiln Delisle Road (at Kiln)	1,100	2	8,900
	I-10 at MS 607	3,000	4	35,000
	MS 43 at Pearl River Co Line	1,100	2	6,400
	MS 53 at Pearl River Co Line	1,100	2	2,300
Harrison	1-10 at Kiln Delisle Road	3,000	4	35,000
	I-10 at Firetower Road	3,000	4	35,000
	Menge Avenue at Red Creek Road (at Cuevas)	850	2	5,700
	1-10 at County Farm Road	3,000	4	35,000
	US 49 at Pass Road / 28th Street (at Gulfport)	1,500	4	39,000
	I-10 at US 49	3,000	4	58,000
	US 49 at MS 53 (at Lyman)	1,500	4	38,000
	US 49 at MS 67 (at Saucier)	1,700	4	15,000
	I-10 at MS 67	3,000	4	58,000
	New MS 67 at old MS 67	1,500	4	3,000
	US 90 at I-110 (at Biloxi)	1,500	4	45,000
	I-10 at I-110 (at D'Iberville)	3,000	4	51,000
Jackson	I-10 at MS 609 (out of Ocean Springs)	3,000	4	34,000
	I-10 at MS 57 (out of Fountainbleau)	3,000	4	50,000
	US 90 at MS 613 / Main Street (at Pascagoula)	1,500	4	38,000
	US 90 at MS 63 (at Moss Point)	1,500	4	31,000
	I-10 at MS 613 (at Escatawpa)	3,000	4	31,000
	I-10 at Hwy 63 (at Escatawpa)	3,000	4	47,000
	MS 57 Jim Ramsay Road (at Vancleave)	1,100	2	9,400
Regional Segments	I-10 westbound at Louisiana State Line (Hancock)	3,000	4	38,000
	I-59 MS at MS 607 (Pearl River Co at Nicholson)	3,000	4	28,000
	US 49 at MS 26 (Stone Co at Wiggins)	1,700	4	16,000
	MS 63 at MS 613 (George Co at Lucedale)	1,500	4	16,000
	I-10 eastbound at Alabama State line (Jackson Co)	3,000	4	47,000
	I-59 at Highway 43 (Pearl River Co at Picayune)	3,000	4	28,000
	I-59 at MS 53 intersection (Pearl River Co at Poplarville)	3,000	4	15,000
	US 98 at MS 198 (George Co at Lucedale)	1,700	4	5,400
	US 98 at MS 57 (at McLain)	1,700	4	6,200
	US 49 at US 98 intersection (Hattiesburg area)	1,700	4	18,000

Table 2: Critical Roadway Segments (continued)

County	Critical Roadway Segments	Directional Service Volume per hour	Number of Lanes *(Both Directions)*	AADT*
	I-59 at US 98 intersection (Hattiesburg area)	3,000	4	19,000
	I-59 at US 49 intersection (Hattiesburg area)	3,000	4	44,000
	I-55 at US 98 intersection (at McComb)	3,000	4	25,000
	US 49 at US 84 (at Collins)	1,700	4	21,000
	I-59 at US 11 (at Laurel)	3,000	4	36,000

*AADT – Annual Average Daily Traffic = total yearly volume divided by the number of days in a year.

C) Socioeconomic Data

The third stage of the planning process involves determining how many people are evacuating. This is achieved by collecting demographic data on permanent residents and tourists from the U.S. Census and other state and local sources. The collection of socioeconomic data for this effort focused largely on collecting best available dwelling unit data for each county from a number of sources. With the U.S. Census having not released some of its 2010 sub county level data at the time the analysis was performed, this part of the study reviewed and incorporated data from multiple sources. Dwelling unit data required for the transportation analysis includes permanent occupied units, mobile homes, and seasonal units. Seasonal units must include hotel/motels, seasonal condo/timeshares, and RV/campground spaces to get an accurate picture of seasonal population that might need to evacuate along with the permanent residents. Population and dwelling unit estimates were made using data collected from the 2010 U.S. Census. Mobile homes and vehicle counts as well as data on the number of tourist and seasonal units were estimated using an annualized growth factor based on available 2000 U.S. Census and 2006 American Community Survey data. The hotel/motel inventory was supplemented by information received from the counties.

Tables 3 and 4 identify the socioeconomic data used for estimating the population and the total number of vehicles for the three coastal counties (Hancock, Harrison and Jackson). Table 5 identifies the vulnerable mobile homes and evacuating vehicles located in the nearby inland counties which were also included in this study (Pearl River, Stone and George). A vehicle usage figure was applied to total evacuating vehicles based on historical behavioral data. Coastal evacuation zones were assigned 75 or 80 percent depending on their proximity to the coast. Inland evacuation zones including the inland counties used 70 percent for their vehicle usage.

Behavioral assumptions are also incorporated to help determine the actual participation rates of individual and vehicle usage. A participation rate was applied to the evacuating population numbers based on the county-specific evacuation scenario. The combination of demographic data interpreted in light of behavioral assumptions allows the modelers to identify the appropriate number of vehicles that will be loading the evacuation roadway network from each numbered zone in each scenario.

Table 3: Socioeconomic Data – Population by Evacuation Zones

County	Evacuation Zone	Permanent Occupied Housing Units*	People per Permanent Occupied Housing Units (avg.)	Population Permanent Occupied Housing Units	Mobile Home Units*	People per Mobile Home Units (avg.)	Population Mobile Home Units	Seasonal / Tourist Units*	People per Seasonal / Tourist Units (avg.)	Population Seasonal / Tourist Units
Hancock	Evacuation Zone A - Cat 1-2	8,518	2.53	21,344	1,842	2.53	4,810	1,855	3.0	5,568
	Evacuation Zone B - Cat 3	3,284	2.53	7,916	253	2.53	620	732	3.0	2,196
	Evacuation Zone C - Cat 4-5	1,875	2.58	4,547	256	2.58	714	123	3.0	368
	Inland	3,703	2.74	10,122	1,970	2.74	5,389	140	3.0	420
	Total	**17,380**		**43,929**	**4,321**		**11,533**	**2,851**		**8,552**
Harrison	Evacuation Zone A - Cat 1-3	30,063	2.59	77,494	3,227	2.59	8,380	9,359	3.0	28,078
	Evacuation Zone B - Cat 4-5	26,150	2.64	67,384	3,479	2.64	9,110	943	3.0	2,828
	Inland	15,262	2.77	42,227	5,393	2.77	14,971	143	3.0	429
	Total	**71,475**		**187,105**	**12,099**		**32,461**	**10,445**		**31,335**
Jackson	Evacuation Zone A - Cat 1-2	21,425	2.62	56,258	1,576	2.62	4,275	771	3.00	2,314
	Evacuation Zone B - Cat 3	17,316	2.35	45,325	1,542	2.35	4,061	1,029	2.70	3,086
	Evacuation Zone C - Cat 4-5	5,060	2.74	13,870	1,406	2.74	3,869	439	3.00	1,318
	Inland	8,403	2.88	24,215	3,648	2.88	10,513	316	3.00	948
	Total	**52,205**		**139,668**	**8,171**		**22,719**	**2,555**		**7,666**

Note: Mobile homes are a sub-set of permanent occupied numbers therefore total population of permanent units includes mobile home population numbers above.

Table 4: Vehicle Ownership Data – Vehicles by Evacuation Zones

County	Evacuation Zone	Permanent Occupied Housing Units	Vehicles per Permanent Occupied Housing Units (avg.)	Vehicles Permanent Occupied Housing Units	Mobile Home Units	Vehicles per Mobile Home Units (avg.)	Vehicles Mobile Home Units	Seasonal / Tourist Units	Vehicles per Seasonal / Tourist Units (avg.)	Vehicles Seasonal / Tourist Units
Hancock	Evacuation Zone A - Cat 1-2	8,518	1.68	21,344	1,842	1.68	3,304	1,855	1.03	1,912
	Evacuation Zone B - Cat 3	3,284	1.51	7,916	253	1.51	388	732	1.03	754
	Evacuation Zone C - Cat 4-5	1,875	1.76	4,547	256	1.76	489	123	1.03	126
	Inland	3,703	2.09	10,122	1,970	2.09	4,025	140	1.03	144
	Total	**17,380**		**43,929**	**4,321**		**8,207**	**2,851**		**2,936**
Harrison	Evacuation Zone A - Cat 1-3	30,063	1.71	51,030	3,227	1.71	5,603	9,359	1.03	9,640
	Evacuation Zone B - Cat 4-5	26,150	1.74	42,397	3,479	1.74	6,073	943	1.03	971
	Inland	15,262	1.95	29,805	5,393	1.95	10,506	143	1.03	147
	Total	**71,475**		**123,231**	**12,099**		**22,181**	**10,445**		**10,758**
Jackson	Evacuation Zone A - Cat 1-2	21,425	1.81	38,401	1,576	1.81	2,924	771	1.03	753
	Evacuation Zone B - Cat 3	17,316	1.63	30,670	1,542	1.63	2,819	1,029	0.92	1,004
	Evacuation Zone C - Cat 4-5	5,060	1.83	9,425	1,406	1.83	2,637	439	1.03	429
	Inland	8,403	2.04	17,018	3,648	2.04	7,382	316	1.03	308
	Total	**52,205**		**95,514**	**8,171**		**15,763**	**2,555**		**2,493**

Note: Mobile homes are a sub-set of permanent occupied numbers therefore total population of permanent units includes mobile home population numbers above.

Table 5: Inland County Data

Inland County	Mobile Home Units	Evacuating Vehicles											
		Cat 1 - 2				Cat 1 - 3				Cat 1 - 5			
		Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
George County	1,862	1,176	1,217	1,265	1,286	1,689	1,747	1,814	1,842	2,423	2,505	2,601	2,642
Pearl River County	4,902	3,015	3,172	3,355	3,433	4,328	4,547	4,803	4,912	6,208	6,521	6,887	7,043
Stone County	1,207	692	730	774	793	999	1,052	1,114	1,140	1,435	1,511	1,599	1,636
Total	**7,971**	**4,884**	**5,119**	**5,394**	**5,511**	**7,017**	**7,346**	**7,730**	**7,895**	**10,066**	**10,537**	**11,086**	**11,322**

Evacuees and Vehicles

The number of evacuees and vehicles in this study was calculated based on best available data. Socioeconomic data was collected from secondary sources by the contractor. A separate, study-specific behavioral analysis was conducted as part of the overall HES study effort.

The primary source of behavioral data used for this transportation analysis came from the results of survey research undertaken by Dr. Betty Hearn Morrow and Dr. Hugh Gladwin of SocResearch Miami. The data collection portion of the survey was conducted by the Institute for Public Opinion Research (IPOR) at Florida International University under the direction of Dr. Gladwin. The behavioral study helped in determining a number of the modeling parameters used in the transportation analysis. Behavioral parameters from other recently completed National Hurricane Program (NHP) Hurricane Evacuation Studies (HES) as well as input from State and local governments helped in finalizing the assumptions used in this analysis.

Tables 6 and 7 identify the behavioral assumptions related to evacuee participation and vehicle usage respectively. As noted, these assumptions are derived from those employed in recent studies and validated in post storm analyses. All assumptions were reviewed in light of the results of the recently completed SocResearch Miami study.

For Table 6, the following assumptions were made:

Hancock and Jackson County (these counties include three Scenarios; A, B and C)

- Scenario A Evacuation Zones are closest to the coast, and therefore 100% evacuee participation is assumed.
- In Scenario B Evacuation Zones, there is lesser participation in lower category storms, but participation rates increase as the storm intensity increases. While there may be less participation in lower category storms, participation rates increase as the storm intensity increases, and may be 100% in the higher category storms.
- Scenario C Evacuation Zones follow a similar pattern as Scenario B evacuees with less participation in lower category storms and increasing participation in higher category storms, and may be 100% in the higher category storms.

Harrison County (this counties includes two Scenarios; A and B)

- Scenario A Evacuation Zones are closest to the coast, and therefore 100% evacuee participation is assumed.
- Scenario B Evacuation Zones exhibit less participation in lower category storms and increasing participation in higher category storms, and may be 100% in the higher category storms.

For Table 7, the following assumptions were made:

- Seasonal and tourist units will utilize 100% of their vehicles for evacuation purposes.
- Permanent and mobile home units use 65% to 75% of the vehicles available to them. Factors may include fear of separation among family members.
- Zones closest to the coast have slightly higher vehicle utilization than those further inland.

Evacuation numbers assume a 100% participation rate for those areas being told to evacuate. It is imperative that any modeling approach ensure the safety of evacuees. As such, all individuals who reside in areas that should evacuate in any given scenario are modeled accordingly. The result is a 100 percent participation rate for surge areas, an approach that is consistent with all previously conducted USACE studies. Modeled participation rates for risk areas outside of the primary surge area decline according to reduction in risk, with inland areas exhibiting the lowest levels of participation. The modeling approach also includes some level of participation from areas outside of the primary evacuation zone to account for shadow evacuees.

Table 8 identifies the total number of evacuees and Table 9 identifies the evacuating vehicles by traffic evacuation zone anticipated in each modeled scenario.

As noted, the 100 percent participation rate was used for the surge evacuation areas with a much lower rate applied to (non mobile home) inland non-surge evacuation areas. Jackson County included some sparsely populated inland areas along the Pascagoula River that could be subject to storm surge. For the purposes of modeling, separate TEZs were established to cover this area to allow for modification in behavioral data or alternative scenario testing through the use of the ATM.

It should be recognized that behavioral research, including the SocResearch Miami study, often indicate a much lower participation rate in areas subject to storm surge,

ranging from 50 percent in low category storms, up to 80 to 90 percent in high category storms. The purpose of a clearance times is to provide emergency managers with the full operational period in which an evacuation must occur if everyone who should evacuate does so. It should be noted that the ATM provided as part of the study provides emergency managers with the ability to quickly modify participation rates for additional behavioral scenarios.

Table 6: Evacuee Participation

County	Evacuation Zone	Zone A / Cat 1 - 2			Zones A and B / Cat 1 - 3			Zones A, B, and C / Cat 1 - 5		
		Perm Occ Units	Mobile Home Units	Tourist Units	Perm Occ Units	Mobile Home Units	Tourist Units	Perm Occ Units	Mobile Home Units	Tourist Units
Hancock	Evacuation Zone A - Cat 1-2	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Evacuation Zone B - Cat 3	2%	60%	70%	100%	100%	100%	100%	100%	100%
	Evacuation Zone C - Cat 4-5	1%	50%	65%	2%	60%	70%	100%	100%	100%
	Inland*	1%	5% 40%	5% 55%	1% 2%	10% 50%	10% 65%	2% 100%	50% 100%	65% 100%
Harrison**	Evacuation Zone A - Cat 1-3	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Evacuation Zone B - Cat 4-5	2%	60%	70%	2%	60%	70%	100%	100%	100%
	Inland*	1%	5%	5%	1%	5%	5%	2% 100%	50% 100%	65% 100%
Jackson	Evacuation Zone A - Cat 1-2	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Evacuation Zone B - Cat 3	2%	60%	70%	100%	100%	100%	100%	100%	100%
	Evacuation Zone C - Cat 4-5	1%	50%	65%	2%	60%	70%	100%	100%	100%
	Inland*	1%	5% 25% 40%	5% 50% 55%	1% 2%	10% 50%	10% 65%	2% 100%	50% 100%	65% 100%

*Multiple participation rates may apply for inland zones. The higher participation rate was applied to inland zones which are subject to riverine flooding.
**Harrison County evacuates their Zone A for Category 1-3 events; therefore data presented for their 'A' and 'B' zones is the same.

Table 7: Evacuee Vehicle Usage Rates

County	Evacuation Zone	Vehicle Usage % for Permanent Units	Vehicle Usage % for Mobile Home Units	Vehicle Usage % for Tourist Units
Hancock	Evacuation Zone A - Cat 1-2	80%	80%	100%
	Evacuation Zone B - Cat 3	75%	75%	100%
	Evacuation Zone C - Cat 4-5	75%	75%	100%
	Inland	70% or 75%	70% or 75%	100%
Harrison	Evacuation Zone A - Cat 1-3	80%	80%	100%
	Evacuation Zone B - Cat 4-5	75%	75%	100%
	Inland	70%	70%	100%
Jackson	Evacuation Zone A - Cat 1-2	80%	80%	100%
	Evacuation Zone B - Cat 3	75%	75%	100%
	Evacuation Zone C - Cat 4-5	75%	75%	100%
	Inland	70%	70%	100%

Table 8: Evacuating People Statistics

County	Evacuation Zone	Zone A / Cat 1 - 2				Zones A and B / Cat 1 - 3				Zones A, B and C / Cat 1 - 5			
		Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Hancock	Evacuation Zone A - Cat 1-2	22,457	24,127	26,076	26,911	22,457	24,127	26,076	26,911	22,457	24,127	26,076	26,911
	Evacuation Zone B - Cat 3	825	1,286	1,824	2,055	8,355	9,014	9,783	10,112	8,355	9,014	9,783	10,112
	Evacuation Zone C - Cat 4-5	443	515	598	634	556	634	724	762	4,620	4,731	4,859	4,915
	Inland	460	470	481	485	757	773	792	800	3,377	3,461	3,559	3,601
	Total	**24,186**	**26,398**	**28,979**	**30,086**	**32,126**	**34,549**	**37,374**	**38,585**	**38,810**	**41,334**	**44,278**	**45,539**
Harrison*	Evacuation Zone A - Cat 1-3	83,110	91,534	101,361	105,573	83,110	91,534	101,361	105,573	83,110	91,534	101,361	105,573
	Evacuation Zone B - Cat 4-5	7,027	7,621	8,314	8,611	7,027	7,621	8,314	8,611	67,949	68,798	69,788	70,212
	Inland	1,023	1,030	1,037	1,040	1,023	1,030	1,037	1,040	12,610	12,699	12,803	12,847
	Total	**91,161**	**100,185**	**110,712**	**115,224**	**91,161**	**100,185**	**110,712**	**115,224**	**163,670**	**173,030**	**183,951**	**188,631**
Jackson	Evacuation Zone A - Cat 1-2	56,720	57,415	58,225	58,572	56,720	57,415	58,225	58,572	56,720	57,415	58,225	58,572
	Evacuation Zone B - Cat 3	3,694	4,342	5,098	5,422	45,942	46,868	47,948	48,411	45,942	46,868	47,948	48,411
	Evacuation Zone C - Cat 4-5	2,206	2,463	2,763	2,891	2,706	2,983	3,306	3,444	14,134	14,529	14,990	15,188
	Inland	1,479	1,514	1,554	1,571	2,265	2,317	2,378	2,404	11,248	11,448	11,681	11,781
	Total	**64,100**	**65,734**	**67,640**	**68,457**	**107,634**	**109,583**	**111,857**	**112,832**	**128,044**	**130,260**	**132,844**	**133,952**

*Harrison County evacuates their Zone A for Category 1-3 events; therefore data presented for their 'A' and 'B' zones is the same.

Table 9: Evacuating Vehicle Statistics

County	Evacuation Zone	Zone A / Cat 1 - 2				Zones A and B / Cat 1 - 3				Zones A, B, and C / Cat 1 - 5			
		Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Hancock	Evacuation Zone A - Cat 1-2	12,589	13,170	13,849	14,140	12,589	13,170	13,849	14,140	12,589	13,170	13,849	14,140
	Evacuation Zone B - Cat 3	347	503	684	762	3,891	4,113	4,373	4,484	3,891	4,113	4,373	4,484
	Evacuation Zone C - Cat 4-5	223	248	277	290	283	310	342	355	2,642	2,681	2,726	2,745
	Inland	251	254	258	260	408	414	420	423	1,804	1,834	1,868	1,883
	Total	**13,410**	**14,175**	**15,069**	**15,451**	**17,171**	**18,008**	**18,984**	**19,402**	**20,927**	**21,799**	**22,816**	**23,252**
Harrison*	Evacuation Zone A - Cat 1-3	42,822	45,644	48,937	50,349	42,822	45,644	48,937	50,349	42,822	45,644	48,937	50,349
	Evacuation Zone B – Cat 4-5	3,417	3,617	3,851	3,951	3,417	3,617	3,851	3,951	32,159	32,444	32,778	32,921
	Inland	504	507	509	510	504	507	509	510	6,241	6,272	6,308	6,323
	Total	**46,743**	**49,768**	**53,297**	**54,810**	**46,743**	**49,768**	**53,297**	**54,810**	**81,222**	**84,361**	**88,023**	**89,593**
Jackson	Evacuation Zone A - Cat 1-2	30,878	31,113	31,388	31,506	30,878	31,113	31,388	31,506	30,878	31,113	31,388	31,506
	Evacuation Zone B - Cat 3	1,831	2,048	2,302	2,411	23,209	23,520	23,882	24,037	23,209	23,520	23,882	24,037
	Evacuation Zone C - Cat 4-5	1,098	1,186	1,288	1,332	1,351	1,446	1,557	1,604	7,265	7,400	7,558	7,626
	Inland	728	740	754	760	1,113	1,131	1,152	1,161	5,529	5,597	5,676	5,710
	Total	**34,535**	**35,087**	**35,732**	**36,009**	**56,551**	**57,210**	**57,978**	**58,308**	**66,881**	**67,630**	**68,504**	**68,878**

*Harrison County evacuates their Zone A for Category 1-3 events; therefore data presented for their 'A' and 'B' zones is the same.

D) Trip Generation and Destinations

The next stage of the process requires an understanding of the destinations that individual evacuees will travel to. Destinations in the transportation modeling are defined as: in county public shelters, in county friends/relatives, in county hotel motels, and out of county. While the behavioral analysis is helpful in discerning destination patterns, it is unreliable for specific percentages. People are twice as likely to say they will go to a public shelter as actually go to one. People assume that hotel motel space will be available locally when most will close or not be available. Churches also play a big role in this area and are part of the friends/relative percentage for modeling purposes. This study relies on both current behavioral and past post storm evacuation parameters in the modeling. It is as much an art as science to correctly gauge and apply behavioral assumptions correctly. Fortunately, many studies have been documented for this exact area and provide a basis for the behavioral tendencies of the populations. The ATM, produced as a part of this study, allows the modification of destination percentages where someone may have a different scenario they would like to test.

Destinations for evacuees from the study area's three counties will depend on the perceived risk from the approaching storm. Larger and/or more intense hurricanes may drive evacuees further inland as they attempt to get out of harm's way. The percentage of individuals heading to each of these specific destinations is applied to the total number of individuals in each numbered TEZ. This allows the total number of vehicles going to each destination to be calculated. Table 10 identifies the anticipated destination percentages of evacuees in each modeled scenario.

The shelter destination included in the model relates to self evacuees (those individuals who can get into a car and evacuate) and represent potential demand, regardless of the available capacity. Tables 11 and 12 identify the number of people and vehicles going to public shelter. Tables 13 through 15 identify the number of vehicles traveling to friends or relatives, hotels or motels, and out of area destinations.

Table 10: Evacuee Destination Percentages

County	Evacuation Zone	Percent to Public Shelters			Percent to Friends / Relatives			Percent to Hotels / Motels			Percent to Out of Area		
		A / Cat 1-2	A+B / Cat 1-3	A,B+C / Cat 1-5	A / Cat 1-2	A+B / Cat 1-3	A,B+C / Cat 1-5	A / Cat 1-2	A+B / Cat 1-3	A,B+C / Cat 1-5	A / Cat 1-2	A+B / Cat 1-3	A,B+C / Cat 1-5
Hancock	Evacuation Zone A - Cat 1-2	5%	5%	5%	50%	40%	30%	5%	5%	5%	40%	50%	60%
	Evacuation Zone B - Cat 3	7%	7%	7%	58%	48%	38%	0%	0%	0%	35%	45%	55%
	Evacuation Zone C - Cat 4-5	12%	12%	12%	58%	48%	38%	0%	0%	0%	30%	40%	50%
	Inland	15%	15%	20%	65%	55%	40%	0%	0%	0%	20%	30%	40%
Harrison*	Evacuation Zone A - Cat 1-3	5%	5%	5%	50%	50%	30%	5%	5%	5%	40%	40%	60%
	Evacuation Zone B - Cat 4-5	7%	7%	7%	58%	58%	38%	0%	0%	0%	35%	35%	55%
	Inland	15%	15%	20%	65%	65%	40%	0%	0%	0%	20%	20%	40%
Jackson	Evacuation Zone A - Cat 1-2	5%	5%	5%	50%	40%	30%	5%	5%	5%	40%	50%	60%
	Evacuation Zone B - Cat 3	7%	7%	7%	58%	48%	38%	0%	0%	0%	35%	45%	55%
	Evacuation Zone C - Cat 4-5	12%	12%	12%	58%	48%	38%	0%	0%	0%	30%	40%	50%
	Inland	15%	15%	20%	65%	55%	40%	0%	0%	0%	20%	30%	40%

*Harrison County evacuates their Zone A for Category 1-3 events; therefore data presented for their ‘A’ and ‘B’ zones is the same.

Table 11: Evacuating People to Public Shelters

County	Evacuation Zone	Zone A / Cat 1 - 2				Zones A and B / Cat 1 - 3				Zones A, B, and C / Cat 1 - 5			
		Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Hancock	Evacuation Zone A - Cat 1-2	1,123	1,206	1,304	1,346	1,123	1,206	1,304	1,346	1,123	1,206	1,304	1,346
	Evacuation Zone B - Cat 3	58	90	128	144	585	631	685	708	585	631	685	708
	Evacuation Zone C - Cat 4-5	53	62	72	76	67	76	87	91	554	568	583	590
	Inland	69	70	72	73	114	116	119	120	675	692	712	720
	Total	**1,303**	**1,428**	**1,576**	**1,639**	**1,889**	**2,029**	**2,195**	**2,265**	**2,937**	**3,097**	**3,284**	**3,364**
Harrison	Evacuation Zone A - Cat 1-3	4,156	4,577	5,068	5,279	4,156	4,577	5,068	5,279	4,156	4,577	5,068	5,279
	Evacuation Zone B - Cat 4-5	492	533	582	603	492	533	582	603	4,756	4,816	4,885	4,915
	Inland	153	154	156	156	153	154	156	156	2,522	2,540	2,561	2,569
	Total	**4,801**	**5,265**	**5,806**	**6,037**	**4,801**	**5,265**	**5,806**	**6,037**	**11,434**	**11,932**	**12,514**	**12,763**
Jackson	Evacuation Zone A - Cat 1-2	2,836	2,871	2,911	2,929	2,836	2,871	2,911	2,929	2,836	2,871	2,911	2,929
	Evacuation Zone B - Cat 3	259	304	357	380	3,216	3,281	3,356	3,389	3,216	3,281	3,356	3,389
	Evacuation Zone C - Cat 4-5	265	296	332	347	325	358	397	413	1,696	1,743	1,799	1,823
	Inland	222	227	233	236	340	348	357	361	2,250	2,290	2,336	2,356
	Total	**3,581**	**3,697**	**3,833**	**3,891**	**6,716**	**6,857**	**7,021**	**7,091**	**9,998**	**10,185**	**10,403**	**10,496**

*Harrison County evacuates their Zone A for Category 1-3 events; therefore data presented for their 'A' and 'B' zones is the same.

Table 12: Evacuating Vehicles to Public Shelters

County	Evacuation Zone	Zone A / Cat 1 - 2				Zones A and B / Cat 1 - 3				Zones A, B, and C / Cat 1 - 5			
		Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Hancock	Evacuation Zone A - Cat 1-2	629	659	692	707	629	659	692	707	629	659	692	707
	Evacuation Zone B - Cat 3	24	35	48	53	272	288	306	314	272	288	306	314
	Evacuation Zone C - Cat 4-5	27	30	33	35	34	37	41	43	317	322	327	329
	Inland	38	38	39	39	61	62	63	63	361	367	374	377
	Total	**718**	**762**	**812**	**834**	**997**	**1,046**	**1,103**	**1,127**	**1,580**	**1,635**	**1,699**	**1,727**
Harrison	Evacuation Zone A - Cat 1-3	2,141	2,282	2,447	2,517	2,141	2,282	2,447	2,517	2,141	2,282	2,447	2,517
	Evacuation Zone B - Cat 4-5	239	253	270	277	239	253	270	277	2,251	2,271	2,294	2,304
	Inland	76	76	76	77	76	76	76	77	1,248	1,254	1,262	1,265
	Total	**2,456**	**2,611**	**2,793**	**2,871**	**2,456**	**2,611**	**2,793**	**2,871**	**5,640**	**5,808**	**6,003**	**6,087**
Jackson	Evacuation Zone A - Cat 1-2	1,544	1,556	1,569	1,575	1,544	1,556	1,569	1,575	1,544	1,556	1,569	1,575
	Evacuation Zone B - Cat 3	128	143	161	169	1,625	1,646	1,672	1,683	1,625	1,646	1,672	1,683
	Evacuation Zone C - Cat 4-5	132	142	155	160	162	174	187	192	872	888	907	915
	Inland	109	111	113	114	167	170	173	174	1,106	1,119	1,135	1,142
	Total	**1,913**	**1,952**	**1,998**	**2,018**	**3,498**	**3,545**	**3,601**	**3,624**	**5,146**	**5,209**	**5,283**	**5,315**

*Harrison County evacuates their Zone A for Category 1-3 events; therefore data presented for their 'A' and 'B' zones is the same.

Table 13: Evacuating Vehicles to Friends / Relatives

County	Evacuation Zone	Zone A / Cat 1 - 2				Zones A and B / Cat 1 - 3				Zones A, B and C / Cat 1 - 5			
		Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Hancock	Evacuation Zone A - Cat 1-2	6,294	6,585	6,925	7,070	5,036	5,268	5,540	5,656	3,777	3,951	4,155	4,242
	Evacuation Zone B - Cat 3	201	292	397	442	1,868	1,974	2,099	2,152	1,479	1,563	1,662	1,704
	Evacuation Zone C - Cat 4-5	129	144	161	168	136	149	164	171	1,004	1,019	1,036	1,043
	Inland	163	165	168	169	224	227	231	233	722	734	747	753
	Total	**6,788**	**7,186**	**7,650**	**7,849**	**7,264**	**7,619**	**8,034**	**8,211**	**6,981**	**7,267**	**7,599**	**7,742**
Harrison	Evacuation Zone A - Cat 1-3	21,411	22,822	24,469	25,174	21,411	22,822	24,469	25,174	12,847	13,693	14,681	15,105
	Evacuation Zone B - Cat 4-5	1,982	2,098	2,233	2,292	1,982	2,098	2,233	2,292	12,220	12,329	12,456	12,510
	Inland	328	329	331	332	328	329	331	332	2,497	2,509	2,523	2,529
	Total	**23,721**	**25,250**	**27,033**	**27,797**	**23,721**	**25,250**	**27,033**	**27,797**	**27,563**	**28,531**	**29,660**	**30,144**
Jackson	Evacuation Zone A - Cat 1-2	15,439	15,557	15,694	15,753	12,351	12,445	12,555	12,602	9,263	9,334	9,416	9,452
	Evacuation Zone B - Cat 3	1,062	1,188	1,335	1,398	11,140	11,289	11,463	11,538	8,819	8,937	9,075	9,134
	Evacuation Zone C - Cat 4-5	637	688	747	773	649	694	747	770	2,761	2,812	2,872	2,898
	Inland	473	481	490	494	612	622	634	639	2,212	2,239	2,270	2,284
	Total	**17,611**	**17,913**	**18,266**	**18,418**	**24,752**	**25,051**	**25,399**	**25,548**	**23,055**	**23,322**	**23,634**	**23,767**

*Harrison County evacuates their Zone A for Category 1-3 events; therefore data presented for their 'A' and 'B' zones is the same.

Table 14: Evacuating Vehicles to Hotels / Motels

County	Evacuation Zone	Zone A / Cat 1 - 2				Zones A and B / Cat 1 - 3				Zones A, B, and C / Cat 1 - 5			
		Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Hancock	Evacuation Zone A - Cat 1-2	629	659	692	707	629	659	692	707	629	659	692	707
	Evacuation Zone B - Cat 3	0	0	0	0	0	0	0	0	0	0	0	0
	Evacuation Zone C - Cat 4-5	0	0	0	0	0	0	0	0	0	0	0	0
	Inland	0	0	0	0	0	0	0	0	0	0	0	0
	Total	**629**	**659**	**692**	**707**	**629**	**659**	**692**	**707**	**629**	**659**	**692**	**707**
Harrison	Evacuation Zone A - Cat 1-3	2,141	2,282	2,447	2,517	2,141	2,282	2,447	2,517	2,141	2,282	2,447	2,517
	Evacuation Zone B - Cat 4-5	0	0	0	0	0	0	0	0	0	0	0	0
	Inland	0	0	0	0	0	0	0	0	0	0	0	0
	Total	**2,141**	**2,282**	**2,447**	**2,517**	**2,141**	**2,282**	**2,447**	**2,517**	**2,141**	**2,282**	**2,447**	**2,517**
Jackson	Evacuation Zone A - Cat 1-2	1,544	1,556	1,569	1,575	1,544	1,556	1,569	1,575	1,544	1,556	1,569	1,575
	Evacuation Zone B - Cat 3	0	0	0	0	0	0	0	0	0	0	0	0
	Evacuation Zone C - Cat 4-5	0	0	0	0	0	0	0	0	0	0	0	0
	Inland	0	0	0	0	0	0	0	0	0	0	0	0
	Total	**1,544**	**1,556**	**1,569**	**1,575**	**1,544**	**1,556**	**1,569**	**1,575**	**1,544**	**1,556**	**1,569**	**1,575**

*Harrison County evacuates their Zone A for Category 1-3 events; therefore data presented for their ‘A’ and ‘B’ zones is the same.

Table 15: Evacuating Vehicles to Out of Area

County	Evacuation Zone	Zone A / Cat 1 - 2				Zones A and B / Cat 1 - 3				Zones A, B, and C / Cat 1 - 5			
		Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Hancock	Evacuation Zone A - Cat 1-2	5,036	5,268	5,540	5,656	6,294	6,585	6,925	7,070	7,553	7,902	8,309	8,484
	Evacuation Zone B - Cat 3	122	176	240	267	1,751	1,851	1,968	2,018	2,140	2,262	2,405	2,466
	Evacuation Zone C - Cat 4-5	67	74	83	87	113	124	137	142	1,321	1,340	1,363	1,373
	Inland	50	51	52	52	122	124	126	127	722	734	747	753
	Total	**5,274**	**5,569**	**5,914**	**6,062**	**8,281**	**8,684**	**9,155**	**9,357**	**11,736**	**12,239**	**12,825**	**13,076**
Harrison	Evacuation Zone A - Cat 1-3	17,129	18,258	19,575	20,139	17,129	18,258	19,575	20,139	25,693	27,387	29,362	30,209
	Evacuation Zone B - Cat 4-5	1,196	1,266	1,348	1,383	1,196	1,266	1,348	1,383	17,687	17,844	18,028	18,107
	Inland	101	101	102	102	101	101	102	102	2,497	2,509	2,523	2,529
	Total	**18,426**	**19,625**	**21,025**	**21,624**	**18,426**	**19,625**	**21,025**	**21,624**	**45,877**	**47,740**	**49,913**	**50,845**
Jackson	Evacuation Zone A - Cat 1-2	12,351	12,445	12,555	12,602	15,439	15,557	15,694	15,753	18,527	18,668	18,833	18,903
	Evacuation Zone B - Cat 3	641	717	806	844	10,444	10,584	10,747	10,817	12,765	12,936	13,135	13,220
	Evacuation Zone C - Cat 4-5	329	356	386	400	541	578	623	642	3,632	3,700	3,779	3,813
	Inland	146	148	151	152	334	339	346	348	2,212	2,239	2,270	2,284
	Total	**13,467**	**13,666**	**13,898**	**13,998**	**26,758**	**27,058**	**27,409**	**27,559**	**37,136**	**37,542**	**38,017**	**38,220**

*Harrison County evacuates their Zone A for Category 1-3 events; therefore data presented for their 'A' and 'B' zones is the same.

A subcomponent of trip distribution involves identifying destinations that evacuees may seek, including public shelter. Behavioral research and actual experience indicates that nationally, some evacuees may indeed seek out public shelter rather than the home of a friend or relative or a hotel motel during an actual evacuation. Destination percentages identified in the SocResearch Miami behavioral survey as well as those employed in other studies conducted throughout the southeast were reviewed and applied in establishing the destination percentages used for this analysis. This data provides officials with an idea of the potential demand they might expect to encounter in an actual evacuation so that they can plan accordingly.

Table 16 lists public shelter data provided by state and local officials, including their location and, where available, their capacity. Table 17 displays public shelter demand, derived from destination selection data in the transportation model.

Table 16: Public Shelters

County	Shelter Name	Address	City	Zip	Type	Capacity	TEZ*
Hancock	Hancock County Stand-alone Shelters/Flat Top-Catahoula	24075 Hwy 43	Picayune	39466	Shelter	300	13
	Hancock County Leetown Shelter	28251 Berry Patch Rd	Picayune	39466	Shelter	300	22
	Hancock County Shelter/Kiln	18324 Hwy 43	Kiln	39556	Shelter	500	22
	Hancock County Shelter/Necaise	30350 Hwy 603	Perkinston	39573	Shelter	300	23
	Hancock County Shelter/Dedeaux	1089 County Rd 350	Kiln	39556	Shelter	500	23
	Total					**1,900**	
Harrison	West Harrison Community Center	4470 Espy Ave	Long Beach	39560	Shelter	Post Storm	1
	Harrison County Schools-West Harrison High	10399 County Farm Rd	Gulfport	39503	Shelter	2,000	11
	Central Elementary Gulfport	1043 Pass Rd	Gulfport	39501	Shelter	400	14
	Biloxi High School	1845 Richard Dr	Biloxi	39532	Shelter	Special Needs	19
	North Bay Elementary	1825 Popps Ferry Rd	Biloxi	39532	Shelter	400	19
	Gulfport Charles Walker Comm. Center	14416 Dedeaux Rd	Gulfport	39503	Shelter	300	20
	North Woolmarket K-8	16320 Old Woolmarket Rd	Biloxi	39532	Shelter	600	25
	Harrison County-Lobouy Road Shelter	9509 Lobouy Rd	Pass Christian	39571	Shelter	800	26
	Harrison County-County Farm Rd Shelter	15001 County Farm Rd	Gulfport	39503	Shelter	800	27
	Harrison County-Saucier-Lizana Rd Shelter	23715 Saucier-Lizana Rd	Gulfport	39503	Shelter	800	27
	Harrison County-D'Iberville High	15625 Lamey Bride Rd	Biloxi	39532	Shelter	2,000	28
	Total					**8,100**	

Table 16: Public Shelters (continued)

County	Shelter Name	Address	City	Zip	Type	Capacity	TEZ*
Jackson	St. Martin Community Center	15008 Lemoyne Blvd	Biloxi	39532	Post	96	1
	Ocean Springs Middle School	3600 Hanshaw Rd	Ocean Springs	39564	Wtr / Ice Dist Ctr		3
	Fontainebleau Community Center	3901 Hwy 57 South	Ocean Springs	39564	Emergency Responder Shelter		3
	New Life Church	9720 Hwy 90	Moss Point	39562	Post	67	8
	St. Martin East Elementary	7508 Rose Farm Rd	Ocean Springs	39564	Primary / overflow	228	10
	St. Martin Middle School (Gold Roof)	10800 Yellow Jacket Rd	Ocean Springs	39564	TS / Cat 1	467	10
	St. Martin High School (new)	11300 Yellow Jacket Blvd	Ocean Springs	39564	Primary - FEMA 361	480	10
	St. Martin Upper Elementary (Blue Roof)	11000 Yellow Jacket Blvd	Ocean Springs	39564	TS / Cat1	495	10
	Gautier Convention Center	2012 Library Ln	Gautier	39553	Post	62	13
	Jackson Co. Fair Grounds	2902 Shortcut Rd	Pascagoula	39567	Post	475	15
	Moss Point High School	4913 Weems St	Moss Point	39563	TS / Cat 1	300	15
	Riverfront Community Center	4400 Denny St	Moss Point	39563	Post	85	15
	Latimer Community Center	10908 Daisy Vestry Rd	Ocean Springs	39564	Primary / overflow	150	19
	Vancleave High School	12412 Hwy 57	Vancleave	39565	Primary	575	20
	Larue Community Center	19400 Larue Rd	Ocean Springs	39564	Post	30	27
	Vestry Community Center	25900 Old Schoolhouse Rd	Biloxi	39532	Post	30	27
	East Central High School	21700 Slider Rd	Moss Point	39562	Primary	432	28
	East Central Community Center	4300 Hwy 614	Moss Point	39563	Special Needs	60	29
	Total					**4,032**	

***TEZ Legend:**

Hancock & Jackson	Evacuation Zone A—Cat 1-2	Evacuation Zone B—Cat 3	Evacuation Zone C—Cat 4-5	Inland
Harrison	Evacuation Zone A—Cat 1-3	Evacuation Zone B—Cat 4-5	Inland	

Table 17: Public Shelter Demand (in People)

County	Shelter	Zone A / Cat 1 - 2				Zones A and B / Cat 1 - 3				Zones A, B, and C / Cat 1 - 5			
		Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Hancock	Shelter Demand	1,303	1,429	1,575	1,638	1,888	2,029	2,194	2,265	2,938	3,097	3,284	3,363
	Shelter Capacity*	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
	Deficit / Surplus	**297**	**171**	**25**	**-38**	**-288**	**-429**	**-594**	**-665**	**-1,338**	**-1,497**	**-1,684**	**-1,763**
Harrison**	Shelter Demand	4,801	5,265	5,806	6,037	4,801	5,265	5,806	6,037	11,434	11,932	12,514	12,763
	Shelter Capacity*	6,100	6,100	6,100	6,100	6,100	6,100	6,100	6,100	4,400	4,400	4,400	4,400
	Deficit / Surplus	**1,299**	**835**	**294**	**63**	**1,299**	**835**	**294**	**63**	**-7,034**	**-7,532**	**-8,114**	**-8,363**
Jackson	Shelter Demand	3,581	3,697	3,833	3,891	6,716	6,857	7,021	7,091	9,998	10,185	10,403	10,496
	Shelter Capacity	3,869	3,869	3,869	3,869	1,277	1,277	1,277	1,277	552	552	552	552
	Deficit / Surplus	**288**	**172**	**36**	**-22**	**-5,439**	**-5,580**	**-5,744**	**-5,814**	**-9,446**	**-9,633**	**-9,851**	**-9,944**

***Shelter capacities not provided by county as of yet.
**Harrison County evacuates their Zone A for Category 1-3 events; therefore data presented for their 'A' and 'B' zones is the same.

Note: Shelter capacity estimates are intended to provide a general overview of potential space surpluses or deficits when projected demand is reviewed in light of available identified spaces. Capacity figures are subject to change.

E) Trip Assignment

Once the total number of vehicles evacuating from each zone in each scenario is established, each individual trip must be routed along the evacuation roadway network. In the modeling process, each trip is meticulously routed through the evacuation roadway appropriate for that trip. For the study area, evacuating traffic was routed along the most accessible out routes from or through each county, paying attention to logical route selections. Trips are attenuated on the network by incorporating evacuation traffic for all destination types on routes close to the storm surge inundation areas and then using only out of county trips on segments leading out of the counties.

In the model, every TEZ is assigned its own unique combination of out routes by percentage of its evacuating vehicles leaving the region. The out-of-region evacuating vehicles from each TEZ are then aggregated on each out route to determine the total vehicle demand for the region on those roadways. In this manner, each key roadway segment on an evacuation corridor is assigned a total number of vehicles by evacuation scenario.

Using data from the recent evacuation studies, knowledge of the study area, and professional judgment, vehicle movements were calculated to determine the estimated number of vehicles from each TEZ that would be utilizing each modeled roadway segment. The specific routing determinations, for each modeled link when viewed in the context of total demand versus capacity, allows for an understanding of congestion by modeled roadway segment. The underlying data, including a GIS map layer of the roadway network by segment, as well as a data table that contains directional service volumes and the total number of vehicles by roadway segment in each modeled scenario, has been provided as part of this report. Figure 12 depicts the relative congestion by roadway segment for the study area counties in a worst case evacuation scenario. Table 18 provides a listing of the worst case evacuation network congestion for each modeled/critical roadway segment as well as directional service volume which indicates the amount of traffic that can be processed per hour at the start of an evacuation.

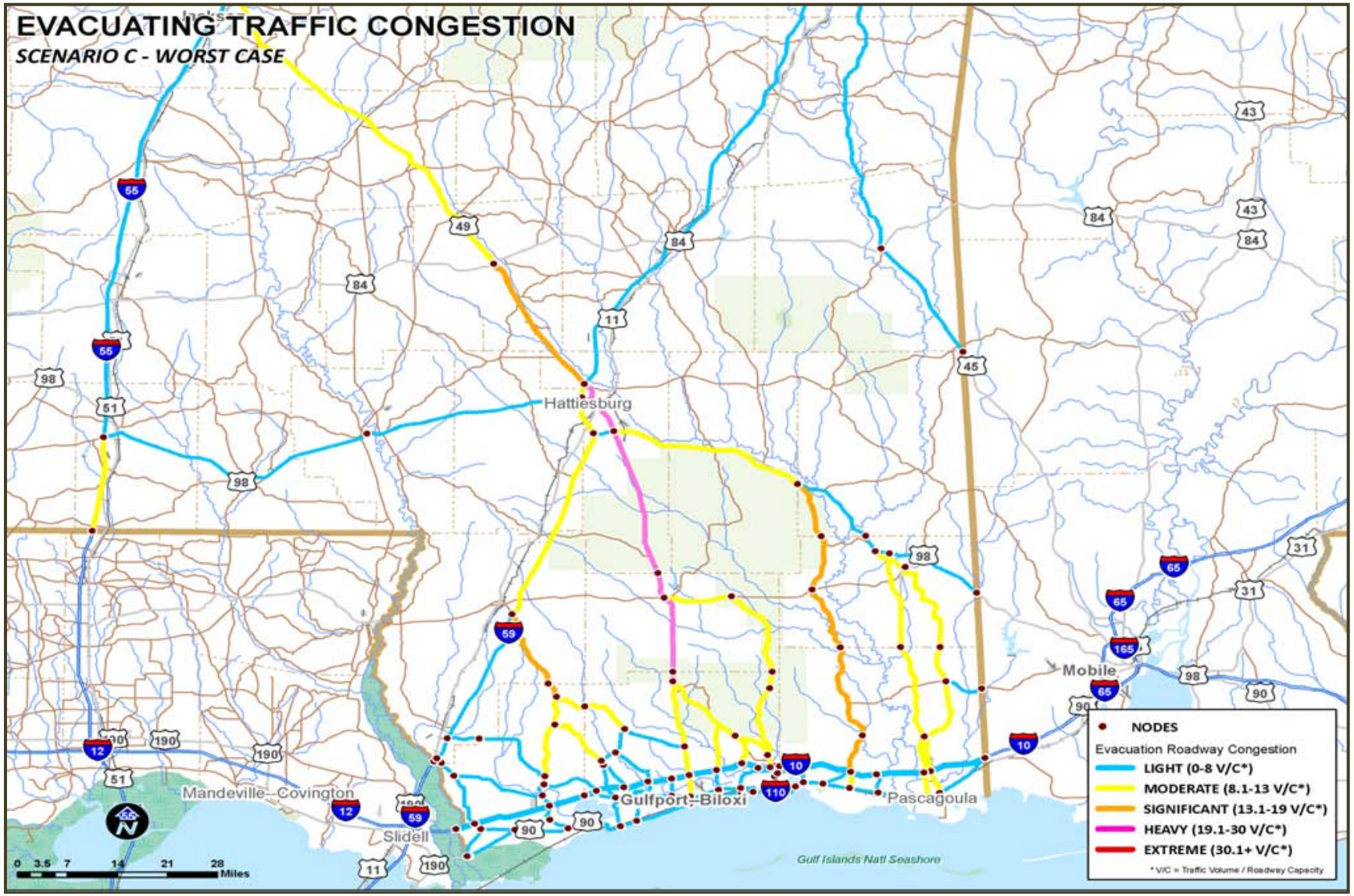

Figure 12: Worst Case Evacuating Traffic Congestion - Mississippi Study Area

Table 18: Worst Case Evacuation Network Congestion (2011 Base Year Evacuating Traffic by Vehicle)

County	Critical Roadway Segments	Directional Service Volume	Zone A / Cat 1 - 2				Zones A and B / Cat 1 - 3				Zones A, B, and C / Cat 1 - 5			
			Evac Veh Low Occ	Evac Veh Med Occ	Evac Veh High Occ	Evac Veh Max Occ	Evac Veh Low Occ	Evac Veh Med Occ	Evac Veh High Occ	Evac Veh Max Occ	Evac Veh Low Occ	Evac Veh Med Occ	Evac Veh High Occ	Evac Veh Max Occ
Hancock	US 90 at MS 603 / 43 (out of Waveland)	1,500	1,416	1,523	1,647	1,701	2,909	3,065	3,248	3,326	3,518	3,707	3,928	4,023
	I-10 at MS 603/43 (out of Bay St. Louis)	3,000	1,686	1,762	1,850	1,888	2,303	2,395	2,503	2,549	4,303	4,446	4,612	4,684
	603 / 43 at Kiln-Delisle Rd (at Kiln)	1,100	1,520	1,598	1,690	1,729	2,109	2,208	2,324	2,373	3,505	3,636	3,790	3,856
	I-10 at MS 607	3,000	2,429	2,535	2,659	2,712	3,313	3,444	3,597	3,663	6,264	6,468	6,706	6,808
	MS 43 at Pearl River Co line	1,100	1,350	1,416	1,493	1,525	1,854	1,940	2,040	2,083	2,450	2,556	2,679	2,732
	MS 53 at Pearl River Co line	1,100	4,731	4,978	5,267	5,390	6,581	6,892	7,254	7,410	11,568	11,989	12,480	12,690
Harrison	I-10 at Kiln-Delisle Rd	3,000	1,771	1,855	1,954	1,996	2,427	2,526	2,642	2,692	4,433	4,586	4,764	4,840
	I-10 at Firetower Rd	3,000	1,874	1,964	2,069	2,113	2,569	2,674	2,797	2,850	4,680	4,842	5,031	5,112
	Menge Ave at Red Creek Rd (at Cuevas)	850	1,211	1,258	1,314	1,338	1,211	1,258	1,314	1,338	1,816	1,887	1,971	2,006
	I-10 at County Farm Rd	3,000	2,028	2,126	2,240	2,289	2,781	2,895	3,029	3,086	5,051	5,226	5,431	5,519
	US 49 at Pass Rd/28th St (at Gulfport)	1,500	1,745	1,917	2,117	2,203	1,745	1,917	2,117	2,203	2,618	2,876	3,176	3,305
	I-10 at US 49	3,000	3,899	4,119	4,375	4,485	4,766	5,003	5,279	5,398	10,062	10,429	10,857	11,040
	US 49 at MS 53 (at Lyman)	1,500	4,149	4,427	4,751	4,890	4,149	4,427	4,751	4,890	10,792	11,225	11,729	11,945
	US 49 at MS 67 (at Saucier)	1,700	5,927	6,324	6,787	6,986	5,927	6,324	6,787	6,986	15,417	16,035	16,756	17,065
	I-10 at MS 67	3,000	3,276	3,455	3,663	3,753	4,104	4,300	4,529	4,627	8,392	8,695	9,048	9,200
	New MS 67 at old MS 67	1,500	4,149	4,427	4,751	4,890	4,149	4,427	4,751	4,890	10,792	11,225	11,729	11,945
	US 90 at I-110 (at Biloxi)	1,500	2,258	2,808	3,449	3,724	2,258	2,808	3,449	3,724	3,388	4,212	5,173	5,586
	I-10 at I-110 (at D'Iberville)	3,000	5,147	5,447	5,798	5,948	6,089	6,408	6,780	6,939	13,403	13,897	14,473	14,720
Jackson	I-10 at MS 609 (out of Ocean Springs)	3,000	2,513	2,639	2,787	2,850	3,454	3,598	3,767	3,839	6,167	6,388	6,644	6,755
	I-10 at MS 57 (out of Fountainbleau)	3,000	2,884	3,031	3,203	3,277	3,967	4,134	4,329	4,412	7,034	7,288	7,585	7,712
	US 90 at MS 613/Main St (at Pascagoula)	1,500	2,890	2,893	2,898	2,899	3,612	3,617	3,622	3,624	4,335	4,340	4,346	4,349
	US 90 at MS 63 (at Moss Point)	1,500	2,985	2,988	2,992	2,994	3,731	3,735	3,740	3,742	4,477	4,482	4,488	4,491
	I-10 at MS 613 (at Escatawpa)	3,000	3,255	3,423	3,620	3,704	4,481	4,670	4,891	4,986	7,902	8,189	8,525	8,669
	I-10 at Hwy 63 (at Escatawpa)	3,000	4,139	4,356	4,609	4,717	5,703	5,945	6,227	6,348	10,005	10,372	10,800	10,984
	MS 57 at Jim Ramsay Road (at Vancleave)	1,100	6,607	6,707	6,824	6,874	11,765	11,903	12,065	12,134	16,540	16,729	16,950	17,044
Regional	I-10 wb at LA state line (Hancock Co)	3,000	2,858	2,983	3,128	3,190	3,898	4,052	4,232	4,309	7,370	7,610	7,890	8,010
	I-59 MS at MS 607 (Pearl River Co at Nicholson)	3,000	1,116	1,180	1,254	1,286	1,475	1,553	1,644	1,684	1,891	1,992	2,109	2,160
	US 49 at MS 26 (Stone Co at Wiggins)	1,700	12,476	13,286	14,230	14,635	13,233	14,050	15,002	15,411	33,409	34,683	36,169	36,806
	MS 63 at MS 613 (George Co at Lucedale)	1,500	3,859	3,916	3,983	4,012	9,319	9,419	9,535	9,585	11,961	12,085	12,231	12,293
	I-10 eb at AL state line (Jackson Co)	3,000	5,138	5,410	5,728	5,864	7,084	7,386	7,739	7,890	12,357	12,815	13,349	13,577
	I-59 at Hwy 43 (Pearl River County at Picayune)	3,000	1,515	1,624	1,751	1,806	2,029	2,158	2,309	2,373	2,682	2,853	3,053	3,139
	I-59 at MS 53 intersection (Pearl River Co at Poplarville)	3,000	7,553	8,092	8,720	8,989	10,315	10,953	11,698	12,017	16,779	17,651	18,667	19,102
	US 98 at MS 198 (George County at Lucedale)	1,700	107	111	116	118	353	360	369	372	765	776	790	796
	US 98 at MS 57 (at McLain)	1,700	721	733	747	753	1,585	1,604	1,626	1,635	2,440	2,466	2,496	2,509
	US 49 at US 98 intersection (Hattiesburg area)	1,700	12,312	13,075	13,966	14,347	13,830	14,609	15,518	15,907	33,181	34,396	35,814	36,422
	I-59 at US 98 intersection (Hattiesburg area)	3,000	10,270	10,931	11,701	12,032	13,012	13,774	14,662	15,043	24,873	25,954	27,215	27,756
	I-59 at US 49 intersection (Hattiesburg area)	3,000	8,167	8,665	9,247	9,496	11,006	11,588	12,268	12,559	20,666	21,498	22,468	22,884

Table 18: Worst Case Evacuation Network Congestion (2011 Base Year Evacuating Traffic by Vehicle) (continued)

County	Critical Roadway Segments	Directional Service Volume	Zone A / Cat 1 - 2				Zones A and B / Cat 1 - 3				Zones A, B, and C / Cat 1 - 5			
			Evac Veh Low Occ	Evac Veh Med Occ	Evac Veh High Occ	Evac Veh Max Occ	Evac Veh Low Occ	Evac Veh Med Occ	Evac Veh High Occ	Evac Veh Max Occ	Evac Veh Low Occ	Evac Veh Med Occ	Evac Veh High Occ	Evac Veh Max Occ
Regional (cont.)	I-55 at US 98 intersection (at McComb)	3,000	30	32	34	34	54	57	60	61	93	98	103	106
	US 49 at US 84 (at Collins)	1,700	6,895	7,337	7,853	8,074	8,110	8,586	9,140	9,378	18,564	19,288	20,132	20,494
	I-59 at US 11 (at Laurel)	3,000	4,933	5,238	5,595	5,748	6,734	7,094	7,514	7,694	12,813	13,331	13,935	14,194
Destinations	US 49 at Jackson, MS	1,500	4,414	4,700	5,034	5,177	5,027	5,331	5,685	5,836	12,152	12,620	13,165	13,399
	I-59 at Meridian, MS	3,000	2,728	2,906	3,114	3,203	3,623	3,828	4,067	4,170	7,296	7,597	7,949	8,100
Additional States	I-59 at MS 43 with LA (Pearl River Co at Picayune)	3,000	28,278	28,387	32,287	32,341	57,742	57,871	62,254	62,319	133,529	133,700	141,289	141,375
	I-55 at US 98 with LA (Hattiesburg area)	3,000	24,353	24,355	28,474	28,475	50,817	50,820	56,088	56,089	131,569	131,573	139,161	139,163
	I-10 eb at MS 607 with LA	3,000	7,720	7,720	9,149	9,149	15,630	15,630	17,237	17,237	33,525	33,525	35,804	35,804
	I-10 wb at MS 63 with AL	3,000	25,780	26,923	27,873	28,442	42,901	44,177	45,240	45,878	48,144	49,428	50,497	51,139
	US 45 at MS 84 with AL (at Waynesboro)	1,700	1,445	1,590	1,713	1,786	7,487	7,759	7,986	8,122	7,625	7,897	8,124	8,260
	US 98 at MS 198 with AL (at Lucedale)	1,700	7,619	8,157	8,608	8,877	24,709	25,478	26,120	26,505	25,853	26,627	27,274	27,661
	I-10 wb at MS 63 with AL & FL	3,000	29,082	30,225	32,125	32,695	46,204	47,480	49,492	50,130	53,156	54,440	56,523	57,165

F) Evacuation Traffic from Other States and Regions

One of the task items required in this study was an examination of impact traffic from other states would have on the study area. Depending on the track of a hurricane, traffic impacts might be expected from the east (including Florida and Alabama evacuees), or the west (to include Louisiana evacuees). Out of state evacuees were modeled on several key roadways, including US 45, US 98 and I-10 from the east, and I-55, I-59 and I-10 from the west.

Table 18 shows the potential of traffic from each jurisdiction on the roadway which will be impacted.

IV. Study Findings

A) Clearance Times

The evacuation modeling process, as with all modeling efforts, transforms complex real world events into a series of numbers. The modeling approach used in this study has been accepted nationally and validated through numerous post storm assessments, but like any modeling process, it involves a simplification of complex real world systems. Evacuation modeling results – including clearance times – are only as good as the available inputs. The model relies on objective data and assumptions related to resident populations, expected evacuation behaviors, roadway characteristics and other inputs. It also includes more subjective components, including traffic routing and destination choices. All of the data is subject to change over time due to changing conditions. Model results that are ten or more years old would be less accurate than more recently estimated results.

For evacuations that have occurred over the last 25 years throughout the coastal United States, real time traffic count data has been reviewed to see how roadway capacity fluctuates during hurricane evacuations. Based on this knowledge and experience in the modeling process, the evacuation has been divided into four quarters. During the first quarter of the evacuation, it is assumed that roadway segments will be able to process vehicles at near maximum directional capacity. As the evacuation progresses, vehicle flows diminish during the second and third quarters as more evacuees try to load the road network and the available capacity is overwhelmed. In the fourth quarter of the evacuation, the modeling assumes a return to near full capacity. This approach has yielded the development of valid clearance times that have been tested favorably by real events. Service volumes are diminished by 15% in the second quarter of the evacuation and reduced another 15% in the third quarter of the evacuation. In the fourth

quarter, service volumes return to the starting value as observed in multiple evacuations.

Once the steps in the modeling process have been undertaken, it is possible to generate estimates of hurricane evacuation clearance times. The roadway network functions like a pipe and the vehicles passing like water through that conduit. In areas where the “pipe” is narrow, where the roadway has a low service volume and evacuation traffic volumes are higher, clearance times will be higher. The worst possible bottleneck that a county’s traffic must pass through before reaching its external destination determines its clearance time. This point may sometimes be in another county.

Clearance time is the period needed from when the first vehicle leaves its zone of origin to the point where the last evacuating vehicles reaches an assumed destination, which in the case of the study area is the I-20 corridor, specifically the cities of Jackson and Meridian. Clearance time estimates include several components, including mobilization time, travel time and queuing delay time. The mobilization time is the time required by evacuees to prepare for evacuation and enter the road network, travel time is the time needed to travel along the road network and queuing delay time is the cumulative time associated with all stops caused by traffic congestion. Clearance time calculations recognize that some evacuees will still be preparing to leave while others have already commenced evacuation.

Background traffic for each critical roadway segment was also incorporated based on the average annual daily trips (AADT) collected for these nodes from data from Mississippi Department of Transportation (MDOT). Following the approaches used in other evacuation studies, the AADT was multiplied by a peak hour travel and directional factor to calculate levels of background traffic that might be present at the start of an evacuation. For example, if a roadway in the study area carries 30,000 vehicles on a daily basis, that figure would be multiplied by 55% directional factor and a 12% peak hour percentage to come up with a starting background traffic number of 1,980 vehicles. These vehicles have to be processed through the network in addition to the expected numbers of evacuating vehicles.

Clearance time estimates are also influenced by the rapidity of evacuation response by the evacuating population, or how quickly the vulnerable population will respond to an evacuation order or advisory. This factor directly impacts how quickly evacuees try to load the road network. Behavioral data from past hurricane evacuation research demonstrates that mobilization and actual departures of the evacuating population can occur over a very brief time, or over a period of many hours. The evacuation response curves presented in Figure 13 reflect slow, medium, and fast or responses which are

designed to include the range of mobilization times that may be experienced in a hurricane evacuation scenario.

The behavioral response curves shown in Figure 13 are generalized scenarios that have been used in past HES efforts and were originally based on work done by Dr. Jay Baker of Hazards Management Group. Every evacuation has a different response curve/footprint.

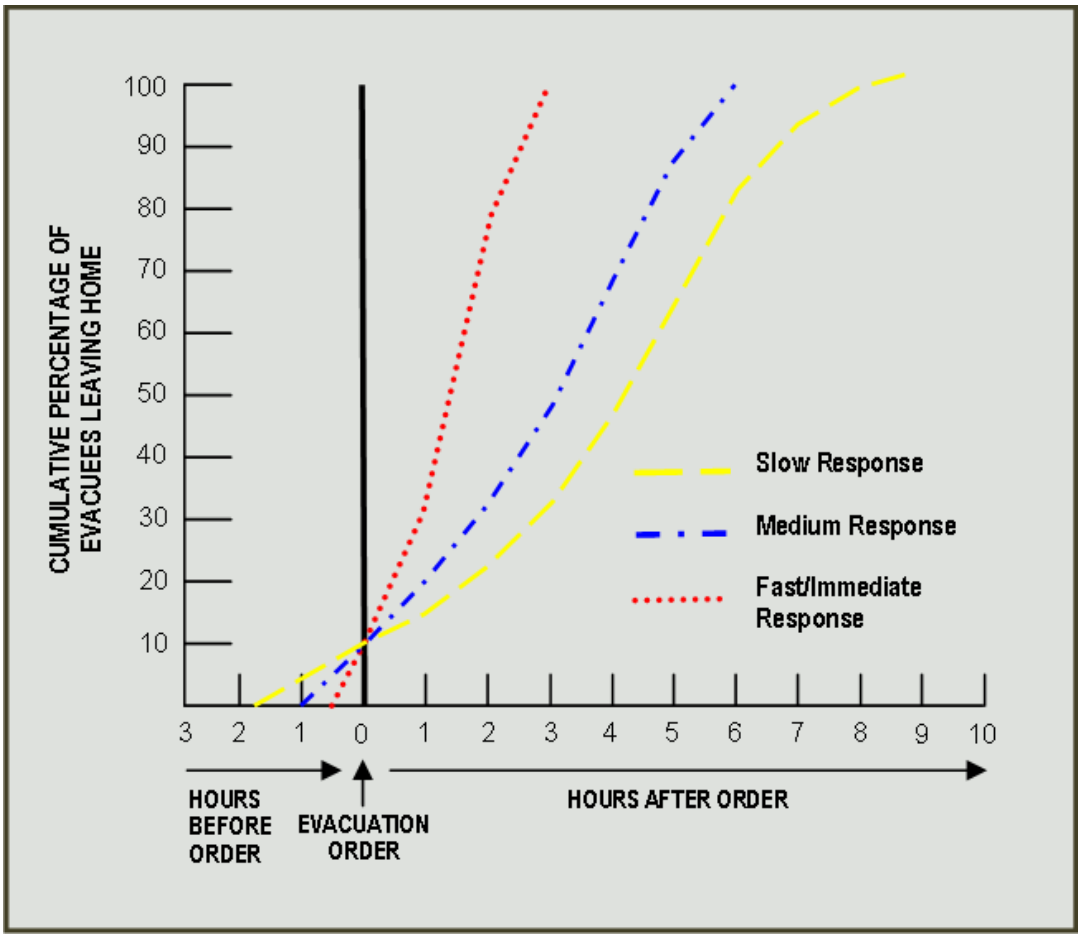

Figure 13: Generalized Evacuation Response Curve for Clearance Time Testing

While these basic assumptions were used in this study, other factors may affect evacuation response rates, including the timing of a hurricane evacuation order and the urgency of messages communicated by The Weather Channel® and local news media. Communicating evacuation instructions to people when they can be reached is an important factor. Hurricanes are by nature unpredictable. Storms can rapidly intensify or increase their forward motion. Windows of opportunity exist for enhanced or more rapid evacuation responses from the public. During weekdays, evacuation orders issued in

the early morning (5 am – 7 am) or during dinner hours (5 pm – 7 pm) may reach a broader audience and result in more rapid responses although during the weekend when less people are at work there may be less of a difference. On any day of the week, the issuance of an evacuation order at 3 am when people are generally asleep may also result in a slower evacuation response rate than one issued at 7 am as people are beginning to start their day.

A wide range of clearance times are provided for each storm scenario. These times are designed to guide emergency managers in making the critical decision of when to call for an evacuation. While the model can produce times that include 6 minute variations (tenths of hours), this level of differentiation is not particularly relevant to decision makers who will be basing their actions on 6 hour National Hurricane Center advisory periods.

Clearance times have been developed based on maximum (85%), high (70%), medium (50%) and low (20%) tourist occupancy rates. Seasonal/hotel occupancies were varied between the lowest occupancy that might be present at the start of an evacuation (November weekday) and the most extreme scenario where 85% of the units are still occupied at the start of an evacuation of the general population. This assumes at least 15% of the tourists will flee or cancel their trip before an evacuation begins. The seasonal unit numbers in the ATM also account for RV sites/campgrounds. The occupancy rates were developed based on hotel / motel occupancy rates that are typical throughout the hurricane season.

Transportation analyses often include only two variables; a high season tourist level, representing the average occupancy rate during the height of tourist season (which would be in the summer months in coastal Mississippi), as well as a low season tourist level, which represents the average occupancy during the winter months. The variation in tourism is moderated slightly in this region of the country compared to other areas along the Gulf Coast due to the presence of casino destinations, which draw tourist year round. Even on special holidays such as July 4, the occupancy rates will not be 100% <u>at the start of an evacuation.</u> The ATM developed for the project actually allows the user to incorporate the actual tourist occupancy at the start of an evacuation.

Clearance times were provided for a slow (9 hour), medium (7 hour), fast (4 hour), and immediate (4 hour) mobilization response time. Clearance time runs are generated based on a range of variables; different hurricane intensities, levels of background traffic, different tourist occupancy levels, and the rapidity of response by evacuees.

As a result of planning and operational decisions made by each coastal county, Hancock and Jackson developed three evacuation scenarios, while Harrison County

limited their local evacuation scenarios to two. Despite the fact that Harrison has two scenarios, there will be slight variations within their Scenario A times depending on whether their neighboring counties are evacuating at their A or B levels.

Based on the three storm intensity scenarios (*de jure* for Hancock and Jackson and *de facto* for Harrison), four response rates and four tourist occupancy levels, contraflow on I-55 and I-59, and the impact of traffic from neighboring states (both eastbound and westbound into MS), 192 different scenarios were tested and reported for the study area. Table 19 shows the clearance times for each scenario by county.

Recent hurricane history demonstrates that the coastal region of Mississippi has the potential to be a crossroads for evacuating traffic from other states, both to the east (from Florida and Alabama) and, more significantly from the west (from Louisiana, including the New Orleans Metro Area). A storm making landfall in the Pensacola, FL or Mobile, AL area (such as Ivan in 2004) is a good example of an event that could drive evacuating traffic west into Mississippi. A storm making landfall anywhere in Southeast Louisiana or otherwise threatening New Orleans, LA (such as Gustav in 2008) has the potential to drive a significant number of evacuees into Mississippi.

As would be expected, the impacts from evacuating traffic from the west have the potential to be much more significant than those from the east. While Louisiana traffic will add congestion on a large number of evacuation routes, the greatest increases in clearance times are anticipated to occur at I-59 and MS 43 in Pearl River County. A regional evacuation involving traffic from Florida and Alabama would increase clearance times for both Hancock and Harrison Counties.

The interstate impacts from the East will be most significant along the I-10 corridor. Since a large percentage of the coastal evacuating traffic originates south of I-10, this increase in through traffic has the potential to increase congestion and clearance times. The greatest increase in congestion from background conditions would be expected at MS 63 in Jackson County. A regional evacuation involving traffic from Florida and Alabama would increase Jackson County clearance times.

These increases in clearance times underscore the importance of the contraflow plan for I-55 and I-59, as well as the traffic management plans around Hattiesburg. An evaluation of clearance times with contraflow implemented show marked benefits when compared to the times that would be expected with unmanaged additional traffic from Louisiana, with greater benefits realized in higher category storm events.

A listing of the clearance times by critical roadway segment for each response (slow, medium, fast, and immediate) is located in Tables 20, 21, and 22.

Critical segments along the roadway network will control the flow of evacuation traffic. While many roads are expected to be congested and there are obviously key roadways that will carry the largest number of evacuees to their destination of choice out of the region, specific bottleneck help determine the worst case clearance times for counties.

The following roadways are the most critical roadway segments in the study area:

Hancock County

- US 49 at US 84 (at Collins)
- I-59 and MS 43 (in Pearl River County at Picayune, from LA in a multi-state evacuation)

Harrison County

- US 49 at MS 26 (in Stone County at Wiggins)
- US 49 at US 98 (around Hattiesburg)
- I-59 and MS 43 (in Pearl River County at Picayune, from LA in a multi-state evacuation)

Jackson County

- I-10 (from FL/AL in a multi-state evacuation)
- MS 57 at Jim Ramsay Road (at Vancleave)

Hattiesburg Area

- US 49 at US 98

Figure 14 depicts the focal points and contraflow for the Mississippi study area.

As seen in Figure 15, the potential evacuation traffic congestion by roadway segment for the worst case scenario is illustrated for the region. Estimated congestion levels were compared to the roadway network service volume. The highest segments, in red, are assumed to have higher levels of congestion and therefore are considered the “critical links” for a particular scenario. These segments may vary depending on storm intensity; therefore officials should not concentrate on any one particular location but rather ensure the most extreme locations are monitored for each event.

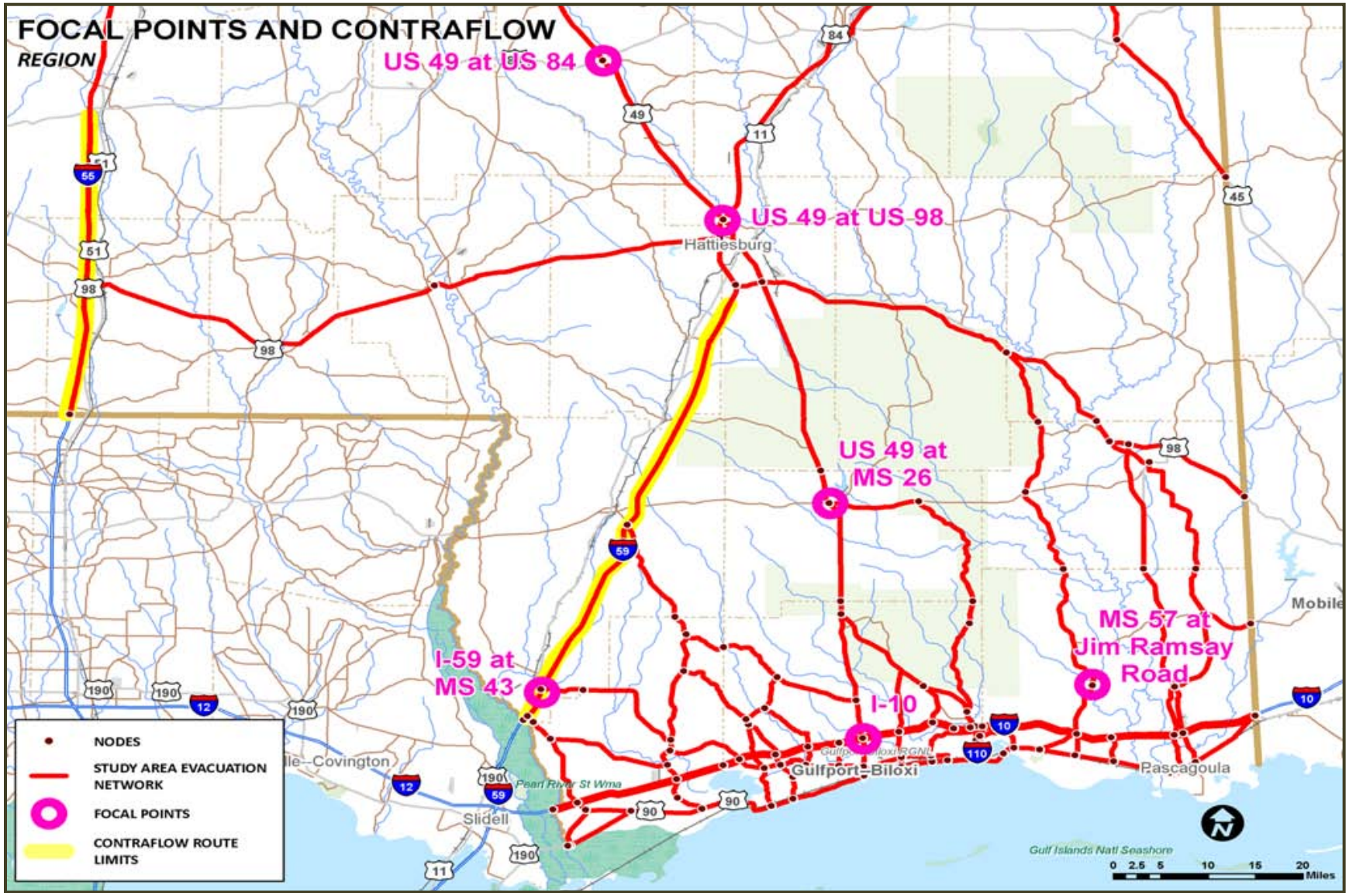

Figure 14: Focal Points and Contraflow

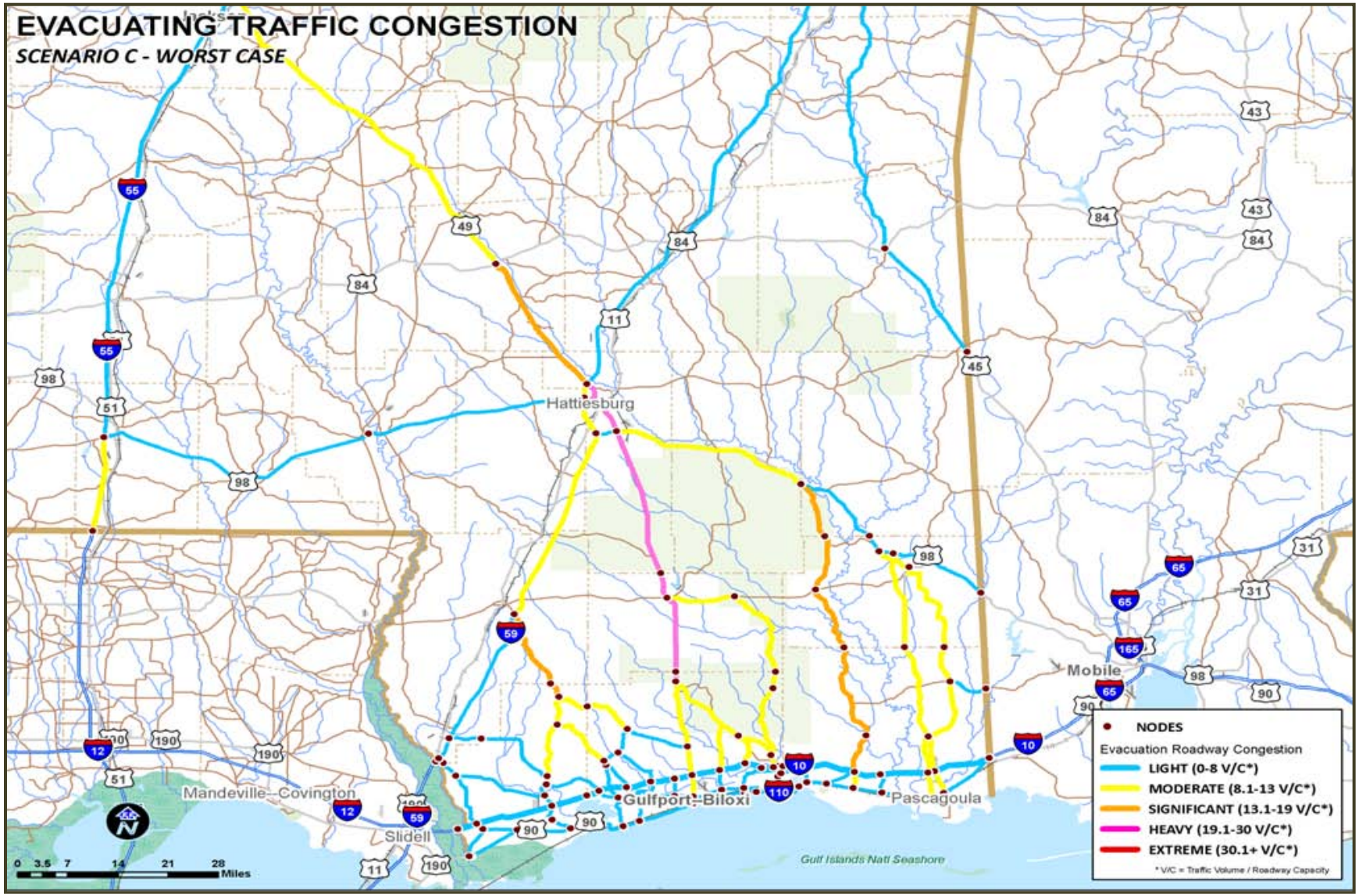

Figure 15: Worst Case Evacuating Traffic Congestion - Mississippi Study Area

Table 19: County Clearance Times

County		Response	Evacuation Clearance Times Zone A / Cat 1 - 2				Evacuation Clearance Times Zones A and B / Cat 1 - 3				Evacuation Clearance Times Zones A, B, and C / Cat 1 - 5			
			Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Hancock	US 49 at US 84 (at Collins)	Slow	10	10	11	11	11	11	11	12	17	18	18	19
		Medium	8	8	8	8	8	9	9	9	15	16	16	16
		Fast	5	5	6	6	6	6	6	7	12	13	13	14
		Immediate	5	5	6	6	6	6	6	7	12	13	13	14
Harrison	US 49 at MS 26 (Stone County at Wiggins)	Slow	13	14	15	15	13	14	15	15	27	27	28	29
		Medium	11	12	12	12	11	12	12	12	24	25	26	27
		Fast	8	9	10	10	8	9	10	10	22	22	23	24
		Immediate	8	9	10	10	8	9	10	10	22	22	23	24
Jackson	MS 57 at Jim Ramsay Road (at Vancleave)	Slow	12	12	12	12	17	17	17	17	22	22	22	22
		Medium	10	10	10	10	15	15	15	15	19	20	20	20
		Fast	7	7	7	7	12	12	12	12	17	17	17	17
		Immediate	7	7	7	7	12	12	12	12	17	17	17	17

Note: All roadway segments reflected in this table are critical locations to monitor and control for traffic movements. The selection and listing of each is not meant to be a complete list of every traffic control point or problem location that could be expected during an evacuation.

These times do not reflect possible interstate impacts or benefits associated with contraflow.

Table 20: Additional Clearance Times by Critical Roadway Segment – Hattiesburg Area

Area	Critical Roadway Segment	Response	Evacuation Clearance Times Zone A / Cat 1 - 2				Evacuation Clearance Times Zones A and B / Cat 1 - 3				Evacuation Clearance Times Zones A, B, and C / Cat 1 - 5			
			Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Hattiesburg Area	US 49 at US 98 intersection	Slow	13	14	14	15	14	15	15	16	27	27	28	29
		Medium	11	12	12	12	12	13	13	13	24	25	26	26
		Fast	8	9	9	10	9	10	10	11	22	22	23	24
		Immediate	8	9	9	10	9	10	10	11	22	22	23	24

Note: The roadway segment reflected in this table is a critical location to monitor and control for traffic movements. The selection and listing is not meant to be a complete list of every traffic control point or problem location that could be expected during an evacuation.

Segment specific clearance times for the Hattiesburg area. These times were developed at the request of the State of Mississippi and the local government stakeholders.

Table 21: Additional Clearance Times by Critical Roadway Segment – Additional States

Area	Critical Roadway Segment	Response	Evacuation Clearance Times Zone A / Cat 1 - 2				Evacuation Clearance Times Zones A and B / Cat 1 - 3				Evacuation Clearance Times Zones A, B, and C / Cat 1 - 5			
			Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Additional States (LA)	I-59 at MS 43 (Pearl River County at Picayune)	Slow	16	16	17	17	26	26	28	28	53	54	56	56
		Medium	13	13	15	15	24	24	26	26	51	51	54	54
		Fast	11	11	12	12	21	21	23	23	48	49	51	51
		Immediate	11	11	12	12	21	21	23	23	48	49	51	51
Additional States (AL and FL)	I-10 Westbound at MS 63 with AL & FL	Slow	16	17	17	17	22	23	24	24	25	25	26	26
		Medium	14	14	15	15	20	21	21	22	23	23	24	24
		Fast	11	12	12	12	17	18	19	19	20	20	21	21
		Immediate	11	12	12	12	17	18	19	19	20	20	21	21

Note: All roadway segments reflected in this table are critical locations to monitor and control for traffic movements. The selection and listing of each is not meant to be a complete list of every traffic control point or problem location that could be expected during an evacuation.

Segment specific clearance times reflecting the impact of interstate traffic from the west (Louisiana) and east (Alabama and Florida).

Table 22: Additional Clearance Times by Critical Roadway Segment – Contraflow

Area	Critical Roadway Segment	Response	Evacuation Clearance Times Zone A / Cat 1 - 2				Evacuation Clearance Times Zones A and B / Cat 1 - 3				Evacuation Clearance Times Zones A, B, and C / Cat 1 - 5			
			Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ	Low Occ	Med Occ	High Occ	Max Occ
Contraflow	I-59 Northbound with LA	Slow	15	15	16	16	17	17	18	18	32	32	33	33
		Medium	12	12	13	13	15	15	15	15	29	30	31	31
		Fast	10	10	11	11	12	12	13	13	27	27	28	28
		Immediate	10	10	11	11	12	12	13	13	27	27	28	28
Contraflow	I-55 Northbound with LA	Slow	14	14	15	15	16	16	17	17	32	32	33	33
		Medium	12	12	13	13	14	14	15	15	30	30	31	31
		Fast	9	9	10	10	11	11	12	12	27	27	28	28
		Immediate	9	9	10	10	11	11	12	12	27	27	28	28

Note: All roadway segments reflected in this table are critical locations to monitor and control for traffic movements. The selection and listing of each is not meant to be a complete list of every traffic control point or problem location that could be expected during an evacuation.

Segment specific clearance times reflecting the benefit of contraflow. Mississippi contraflow plans assume Louisiana traffic impacts.

It is critical to recognize that clearance times are predicated upon all evacuation movements occurring before the advent of sustained tropical storm force winds. Typically storm surge effects which cut off roadways occur well after the arrival of sustained tropical storm winds. Based on this modeling assumption, evacuation movements occurring within the prescribed clearance times would not be impacted by surge related roadway flooding.

While the model for the Mississippi Study Area transportation analysis is based on a typical storm scenario, as illustrated in Figure 16, it is critical that emergency managers monitor storm conditions and National Weather Service advisories to determine if information regarding a higher than expected or more rapid rise of storm surge is predicted.

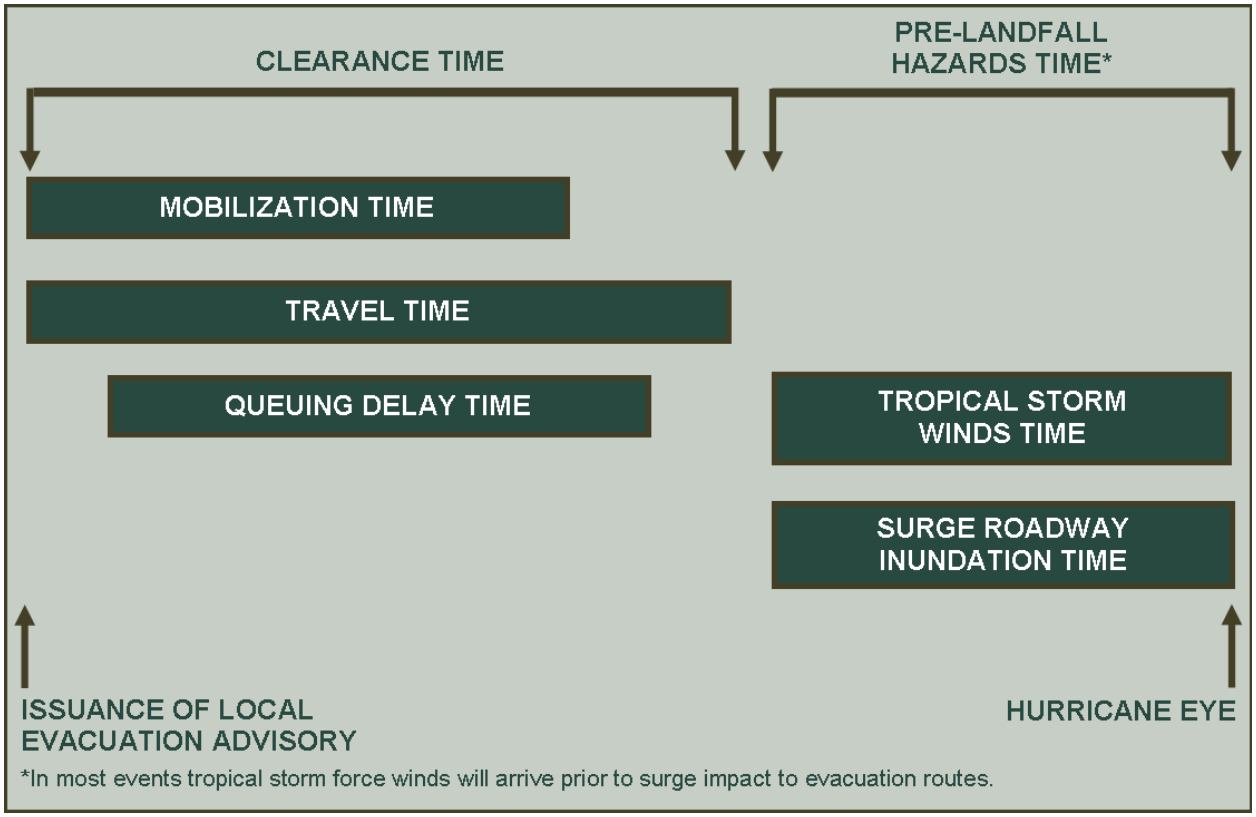

Figure 16: Components of Clearance Time

Table 23 abbreviates the more expansive data provided in Tables 19 through 22 by showing only the best and worst clearance time for each evacuation scenario as a range regardless of response rate or tourist occupancy.

Table 23: Clearance Times Ranges

County / Area	Critical Roadway Segment	Cat 1 Range	Cat 2 Range	Cat 3 Range	Cat 4 Range	Cat 5 Range
Hancock	US 49 at US 84 (at Collins)	5 to 11 hours	5 to 11 hours	6 to 12 hours	12 to 19 hours	12 to 19 hours
Harrison	US 49 at MS 26 (Stone County at Wiggins)	8 to 15 hours	9 to 15 hours	9 to 16* hours	22 to 29 hours	22 to 29 hours
Jackson	MS 57 at Jim Ramsay Road (at Vancleave)	7 to 12 hours	7 to 12 hours	12 to 17 hours	17 to 22 hours	17 to 22 hours
Hattiesburg Area	US 49 at US 98 Intersection	8 to 15 hours	8 to 15 hours	9 to 16 hours	22 to 29 hours	22 to 29 hours
Additional States**	I-59 at MS 43 (Pearl River County at Picayune) (West impact – worst case) Includes LA traffic	11 to 17 hours	11 to 17 hours	21 to 28 hours	48 to 56 hours	48 to 56 hours
	I-10 at MS 63 (East impact) Includes AL and FL traffic	11 to 17 hours	11 to 17 hours	17 to 24 hours	20 to 26 hours	20 to 26 hours
Contraflow**	I-59 Northbound with LA	10 to 16 hours	10 to 16 hours	12 to 18 hours	27 to 33 hours	27 to 33 hours
	I-55 Northbound with LA	9 to 15 hours	9 to 15 hours	11 to 17 hours	27 to 33 hours	27 to 33 hours

***** Clearance time for Harrison County in a Cat 3 based on the Hattiesburg area bottleneck.
****** Contraflow on I-59 and I-55 are not projected to be impacted in Cat 1 to 3 scenarios.
Worst case clearance times based on I-10 for Cat 1 to 2 events.

Variable Accuracy and Confidence Limits

The evacuation modeling process, as with all modeling efforts, transforms complex real world events into a series of numbers. The modeling approach used in this study has been accepted for decades and validated through numerous post storm assessments, but, like any modeling process, it involves a radical simplification of complex real world systems and as such may include an inherent margin of error. The transportation model employed in this study relies on sets of objective data on populations, behaviors, roadway characteristics and other elements. It also includes subjective components, including routing and destination choices. All of the data is subject to change over time due to changing conditions. Model results that are ten or more years old would be less accurate than more recently estimated results.

Efforts have been made to obtain the most current and best available input data, with sources properly identified in the report. These data have been compared, where possible, to data obtained or derived from other sources. In instances where two sets of data were available, the contractor relied on their 30+ years of experience in evacuation modeling to assure the data used in the analysis was appropriate for use in the modeling process and appeared to be in the correct range. Reasonable variations in

demographic inputs will have relatively minor impact on clearance times, although some changes should be expected. While the clearance time estimates provided in the study are fully supported by the contractor, a margin of error may exist due to the range of different modeled inputs as well as actual conditions leading up to an evacuation.

Evacuation modeling results – including clearance times – are only as good as the available inputs. The modeling approach used in this study relies upon the most current SLOSH model surge results in developing risk-based evacuation zones. According to NOAA, the SLOSH model is accurate to +/- 20 percent. As an example, if the model calculates a peak 10 foot storm surge, the observed peak could range from 8 to 12 feet. The modeling approach also relies heavily on U.S. Census data. While touted as being more accurate than the 1990 Census, the U.S. Census Bureau acknowledges variations in the accuracy of its published data by as much as 10 percent for some variables. A range of behavioral data was used in this study, including the recently completed U.S. Census survey, as well as data from past analyses. Behavioral studies commonly provide results that are accurate to within 10% of actual values depending on sample size and response rates. Finally, roadway service volumes fluctuate greatly during an evacuation, sometimes varying by as much as 30 percent less than the theoretical maximum. The transportation analysis contractor is 95 percent confident that the clearance times fall within the accuracy limits of the key inputs stated above.

B) Traffic Control Measures

Based on feedback from State and local government stakeholders, there do not appear to be any major scheduled roadway projects that will have a direct impact on improving clearance times for the 2012 season. Counties and cities, however, are engaged in routine maintenance, resurfacing and bridge improvement projects. These actions are critical in meeting or exceeding LOS standards which are a factor in the estimation of clearance times. In addition, MDOT's website (www.gomdot.com) can be viewed as needed for a listing of scheduled improvements which may impact the study area.

The movement of evacuating vehicles during a hurricane evacuation requires extensive traffic control efforts to make maximum use of the roadway capacity and to expedite a safe escape from hurricane hazards. Directing resources to areas that have been identified as potential congestion "hot spots" may help alleviate congestion. Capital improvement to these segments, as well as to the critical bottlenecks that influence the regional clearance time estimates, may reduce overall evacuation clearance times.

Some additional recommendations concerning traffic control are as follows:

- Where the State and counties have sufficient personnel resources, officers should be stationed at critical intersections to facilitate traffic flow; where

intersections will continue to have signalized control, signal patterns providing the most "green time" for westbound evacuation travel should be activated.

- If possible, arrangements should be made with tow truck operators so that they are pre-positioned along key travel corridors and critical roadway facilities such as bridges.

- The state and counties should continue to develop their GIS based dashboard for statewide evacuation and sheltering including a monitoring system which would monitor travel flow at key locations, report traffic tie-ups and shelter and hotel availability to the general public as they evacuate.

- High level bridges must be monitored for early wind vulnerability as sustained tropical storm winds will arrive earlier on these structures than at ground level; trucks, RV's and other high profile vehicles will be especially vulnerable to these conditions.

Roadway measures can be classified into three groups:

- Structural Improvements. Including lane widening, designed to increase roadway capacity.

- Maintenance of Traffic. Including signage, designed to improve the maximum Level of Service D hourly service volume.

- Operational Interventions. Including implementing traffic diversions or executing a contra flow plan, which will improve service volumes on specific facilities or route traffic along less utilized facilities.

Specific traffic control measures and roadway modifications at the critical roadway segments identified may help alleviate anticipated congestion in these areas and subsequently improve overall local and / or regional clearance times.

Interstate impacts are of critical concern to this region. Recommendations related to reducing these effects include a combination of structural improvements, Maintenance of Traffic and operational interventions.

To the West, there is not much that can be done structurally to alleviate the potential maximum impact. Some general recommendations include the continued interstate coordination on the use of the I-55 / I-59 contraflow plans and the installation of

automated signage and switchback lanes on the contraflow routes, which MDOT already addresses.

To the East, improving traffic along I-65 in Alabama would have the double benefit of potentially reducing the impact of traffic from Florida and Alabama crossing into Mississippi and providing evacuees from Mississippi heading into Alabama with a less congested out route. The State of Alabama maintains plans for contraflow along I-65.

The State of Mississippi is encouraged to coordinate with neighboring states for contraflow and sheltering needs.