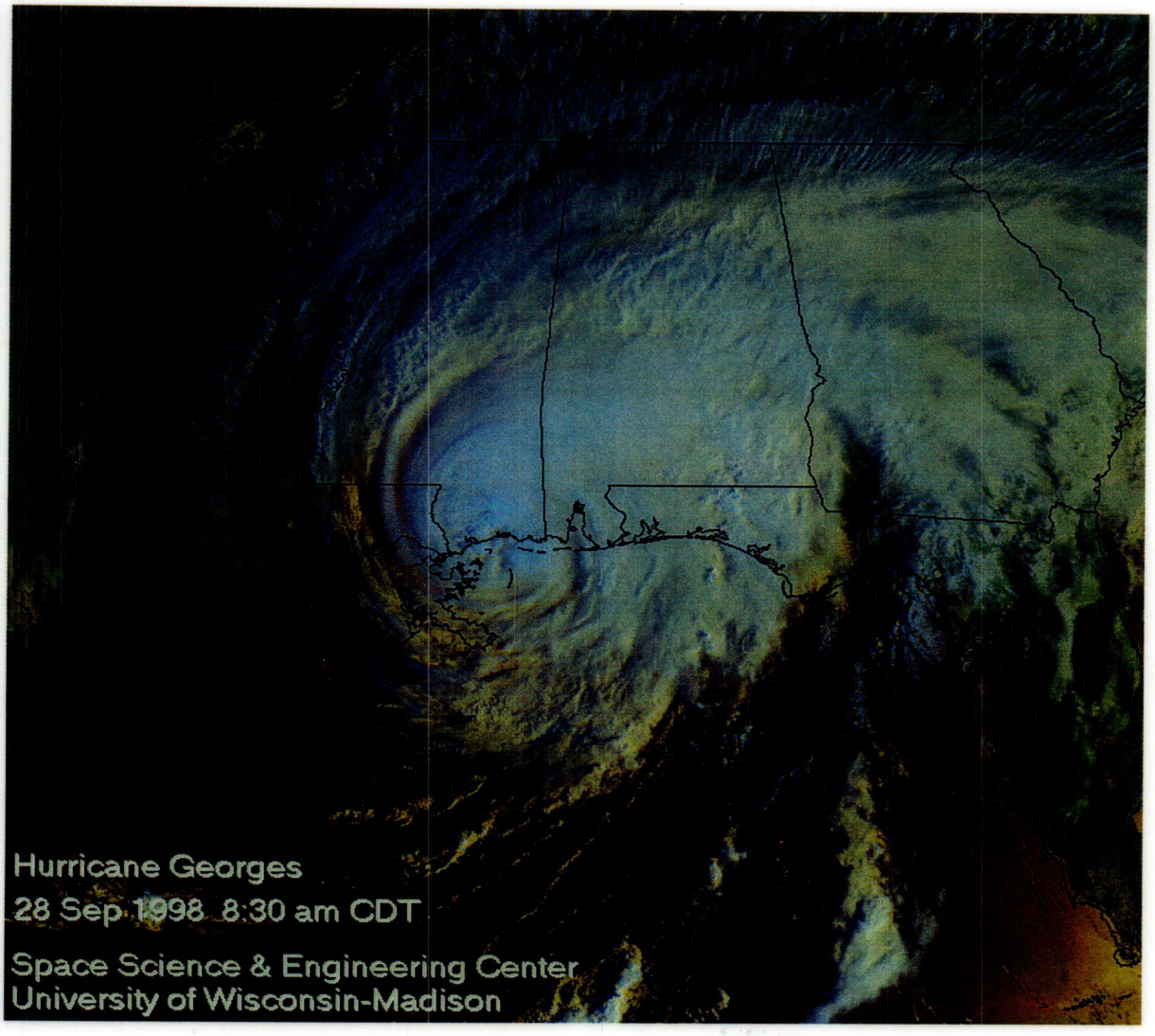
Mississippi Hurricane Evacuation Restudy

Hurricane Evacuation Transportation Analysis



Prepared For

US Army Corps of Engineers Mobile District

Prepared By

Post, Buckley, Schuh & Jernigan, Inc.

MISSISSIPPI TRANSPORTATION ANALYSIS

FINAL REPORT

Prepared for:

U.S. Army Corps of Engineers
Mobile District

Prepared by:

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1.0 INTRODUCTION

1.1 OVERVIEW

With each new hurricane season, the counties along the Mississippi coast remain extremely vulnerable to the threat of an intense hurricane strike. Recently, the region has sustained direct impacts from storms such as Hurricane Georges in 1998 and Tropical Storm Danny in 1997. In response to this vulnerability, Mississippi's coastal counties continue to work diligently on every aspect of the hurricane preparedness process.

The study area faces distinct challenges due to the variety of vulnerable populations which must be considered in the evacuation process. For example, coastal areas in the region face significant storm surge inundation potential, and many residents are located in low-lying inland areas which are vulnerable to freshwater flooding. Each of the gulf-coast counties has a significant mobile home population, with homes that are highly susceptible to hurricane force winds. This area also has an abundance of hotel/motels and casinos which generate high tourism all year round.

The coastal counties must be prepared to evacuate highly vulnerable populations on critical routes, often concurrently with westbound and eastbound evacuees from adjacent states. In this particular region, evacuees will find evacuation difficult as there are limited route choices to leave the region and local public shelter and inland hotel/motel space is limited.

During a hurricane evacuation, a significant number of vehicles will have to be moved across the local and regional road network. The quantity of evacuating vehicles will vary depending upon the magnitude of the hurricane, publicity and warnings provided about the storm, and particular behavioral response characteristics of the vulnerable population. In the event of an evacuation, the entry of vehicles onto the road network typically depends on the response of evacuees to an evacuation order or storm advisory. Conversely, vehicles exit the roadway network depending on both the planned destinations of evacuees and the availability of acceptable destinations such as public shelters, hotel/motel units and the homes of friends or relatives in non-surge prone areas.

The speed at which vehicles on the road network can travel from origin to destination is dependent on the rate of traffic loadings on specific roadway segments and the ability of those segments to handle a particular volume of vehicles each hour. In order to produce accurate clearance times, the analysis of the study area must account for the impacts of evacuation traffic generated by neighboring counties using roadways within the study area.

This report documents the basic inputs and findings of the study analysis. A separately bound appendix entitled Transportation Model Support Document provides modeling information and data files too extensive for this report.

1.2 ANALYSIS OBJECTIVES AND SCOPE

Recognizing the importance of accurate clearance times, the U.S. Army Corps of Engineers, Mobile District (USCOE) hired Post, Buckley, Schuh and Jernigan, Inc. to perform the tasks necessary to update the area's hurricane evacuation clearance times. The major objectives of the study were as follows:

(1) Use evacuation zones and scenarios developed by each county along the coast for transportation modeling and clearance time calculations.

(2) Quantify the potential evacuation population for each scenario using socioeconomic and behavioral data developed by PBS&J in conjunction with the Gulf Coast Regional Planning Council.

(3) Identify the existing evacuation roadway network, recognizing recent improvements that have been constructed.

(4) Develop hurricane evacuation clearance times for each county and storm scenario for a Year 2000 base year.

(5) Determine regional evacuation traffic that is expected to cross county lines and move inland in order to increase the accuracy of operational planning.

(6) Identify local and regional bottlenecks/critical roadway segments and where applicable, recommend general traffic control strategies.

(7) Develop zone and road network graphics in an ArcInfo/ArcView usable format.

(8) Using the evacuation zone graphic for each county, develop GIS graphics displaying:

permanent occupied dwelling units by evacuation zone
mobile home units by evacuation zone
seasonal dwelling units by evacuation zone
evacuating people by evacuation zone by scenario
public shelter demand by evacuation zone by scenario

(9) Using the evacuation road network graphic for each county, develop GIS graphics displaying:

directional service volume per roadway segment
evacuation traffic congestion by roadway segment by scenario

(10) Use evacuation zones and scenarios developed by the counties for transportation modeling and clearance time calculations for each county. Develop a simplistic abbreviated "model" in a spreadsheet format that can be used by the counties to modify clearance times based on dwelling unit/population data and roadway capacity changes.

1.3 COORDINATION AND REVIEW ACTIVITIES

This study came to fruition through extensive cooperation by the USCOE with local emergency management (EM) staff, the State of Mississippi and PBS&J. The effort included the collection of essential socioeconomic and behavioral data and the development of hurricane evacuation zones, as well as coordination of the various technical inputs. Zones, input assumptions and evacuation statistics used to form the foundation of the analysis were established through a study organization and kickoff meeting held in the spring of 2000 and subsequent phone coordination. The draft of this report was provided for review in October 2000. Comments were provided in November 2000, and the final report was prepared and printed in December 2000.

2.0 TRANSPORTATION ANALYSIS AND INPUT ASSUMPTIONS

The hurricane evacuation transportation modeling performed for the study area required a number of important data inputs and assumptions regarding anticipated evacuation behavior. All hurricanes differ from one another in some respect. Therefore, it became necessary to set forth clear assumptions about storm characteristics and an evacuee's expected response before this type of transportation modeling could begin. Not only does a storm vary in its track, intensity and size, but also in the way it is perceived by residents in potentially vulnerable areas. These factors can cause a wide variance in the behavior of the vulnerable population. Even the time of day at which a storm makes landfall influences the parameters of an evacuation response.

The hurricane evacuation transportation analysis results in clearance times based on a set of assumed conditions and behavioral responses. It is likely that an actual storm will differ from a simulated storm for which clearance times are calculated in this report. Therefore, a sensitivity analysis was performed during the transportation modeling. Those variables having the greatest influence on clearance time were identified and then varied to establish the logical range within which the actual input assumption values might fall.

Key input assumptions guiding the transportation analysis include the following:

1. Traffic Evacuation Zones
2. Housing and Population Data
3. Behavioral Characteristics of the Evacuating Population
4. Roadway Network Assumptions

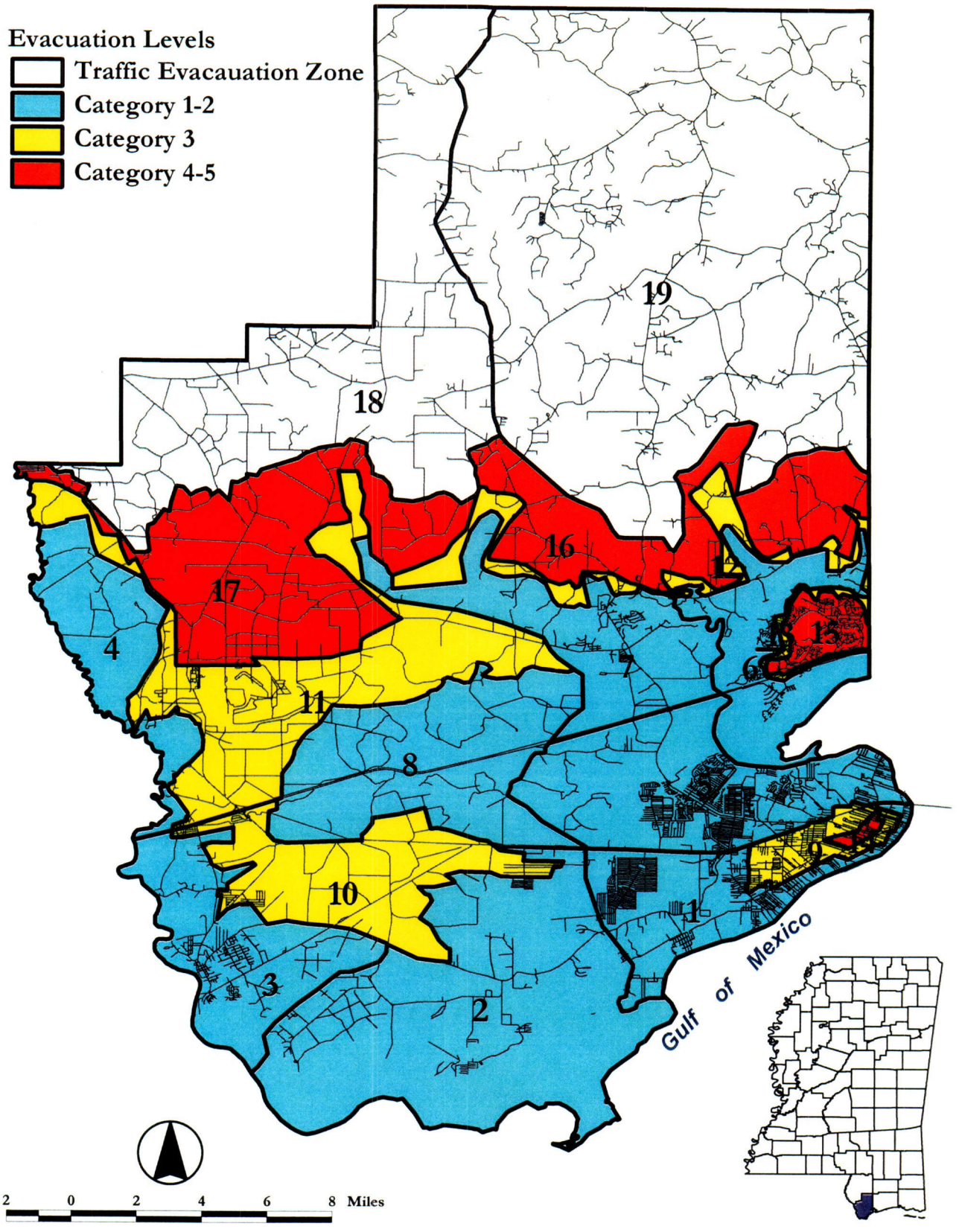
2.1 TRAFFIC EVACUATION ZONES

The foundation of the analysis is a system of evacuation zones developed by each county. The counties, in conjunction with the Corps and PBS&J, developed the boundaries of each zone in relation to well known man-made or natural features, census boundaries, roadways and SLOSH

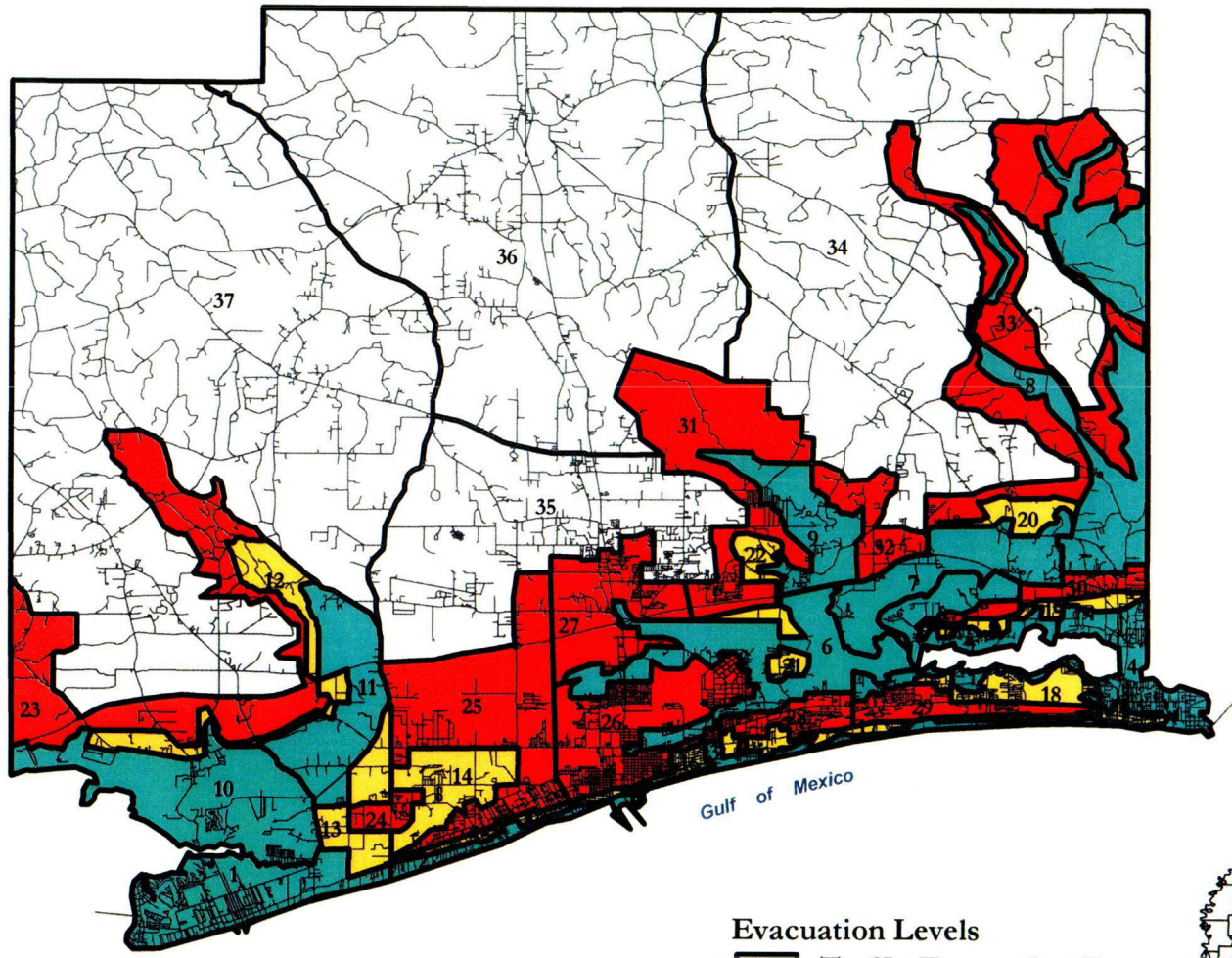
storm surge areas. The primary purpose of the evacuation zones is to target areas that will be asked to evacuate by local emergency management for storm Category 1-2, Category 3, and Category 4-5 storms. Each county put considerable effort into reviewing new storm surge inundation mapping (developed by the Corps of Engineers Mobile District) and delineating areas they would evacuate for various intensities of hurricanes. PBS&J divided the evacuation areas into zones that could then be used for traffic clearance time modeling. The traffic evacuation zones are illustrated in Figures 2-1 through 2-3. In addition, Table 2-1 contains a breakdown of each counties number of evacuation zones and general vulnerability.

Traffic Evacuation Zones

Figure 2-1



Traffic Evacuation Zones



Evacuation Levels
- Traffic Evacuation Zones
- Category 1-2
- Category 3
- Category 4-5

2 0 2 4 6 8 Miles

Figure 2-2

Traffic Evacuation Zones

Figure 2-3

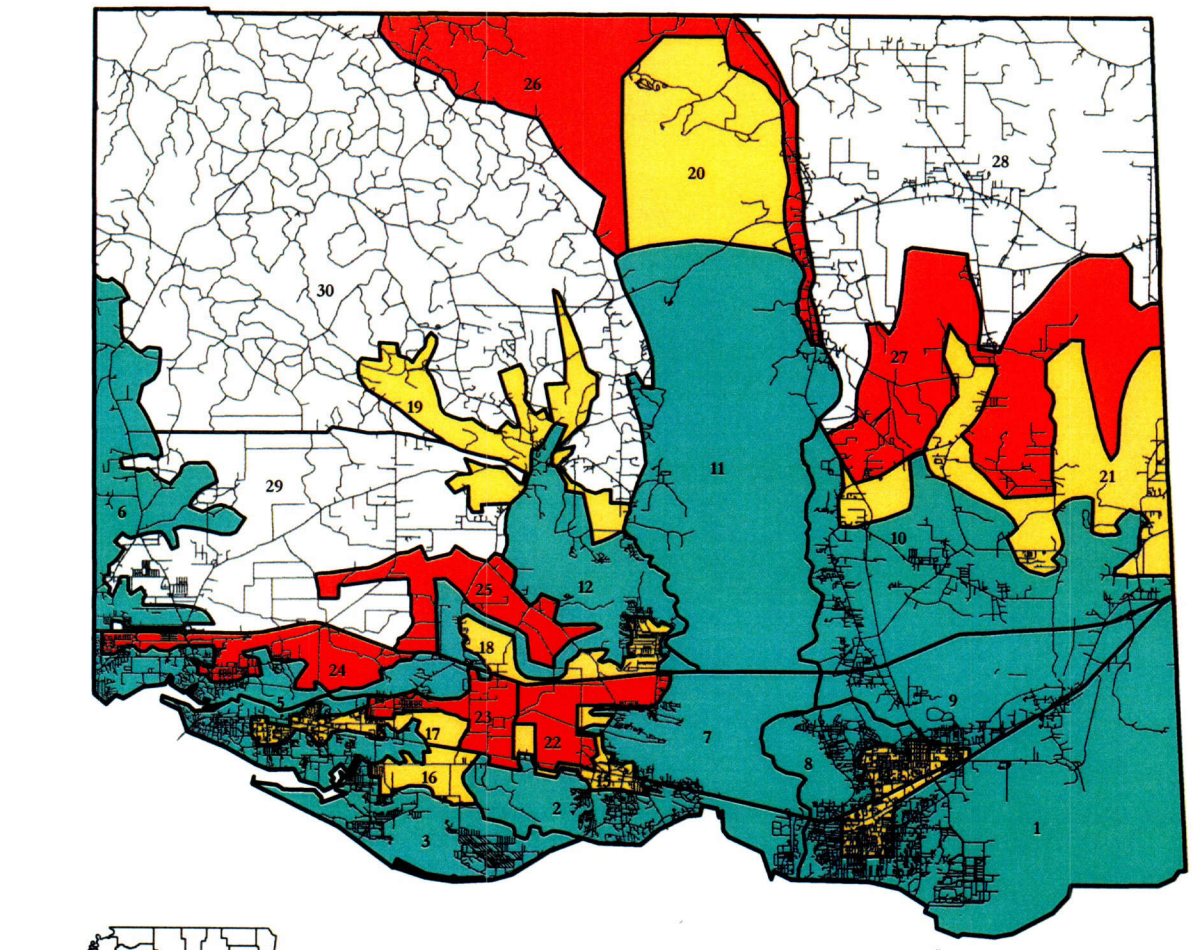


Table 2-1
TRAFFIC EVACUATION ZONES
ASSUMED VULNERABILITY BY STORM SCENARIO BY COUNTY
Mississippi Transportation Analysis

County	Number of Traffic Evacuation Zones	General Zone Vulnerability
Hancock County	19	1-8 storm Category 1 or 2
		9-13 storm Category 3
		14-17 storm Category 4 or 5
		18-19 inland/mobile home only vulnerable
Harrison County	37	1-11 storm Category 1or 2
		12-22 storm Category 3
		23-33 storm Category 4 or 5
		34-37 inland/mobile home only vulnerable
Jackson County	30	1-12 storm Category 1 or 2
		13-21 storm Category 3
		22-27 storm Category 4 or 5

2.2 HOUSING AND POPULATION DATA

Socioeconomic parameters for each traffic evacuation zone, such as dwelling unit totals and persons per dwelling unit were developed using 1995 data obtained from the Gulf Coast Regional Planning Council (GCRPC). This data was supplemented and factored upward by current year population data provided by the counties. Mobile home data was not available from the RPC, and was developed using 1990 information from the U.S. Bureau of the Census. These data were also factored to reflect year 2000 by using control totals from the counties. Seasonal Tourist dwelling units (including hotel/motel units) were developed using 1995 data from the GCRPC. These data were also supplemented and factored upward using data provided by the counties. The key socioeconomic data for each county is summarized in Table 2-2, and this data is provided by traffic evacuation zone in the Transportation Model Support Document.

Table 2-2

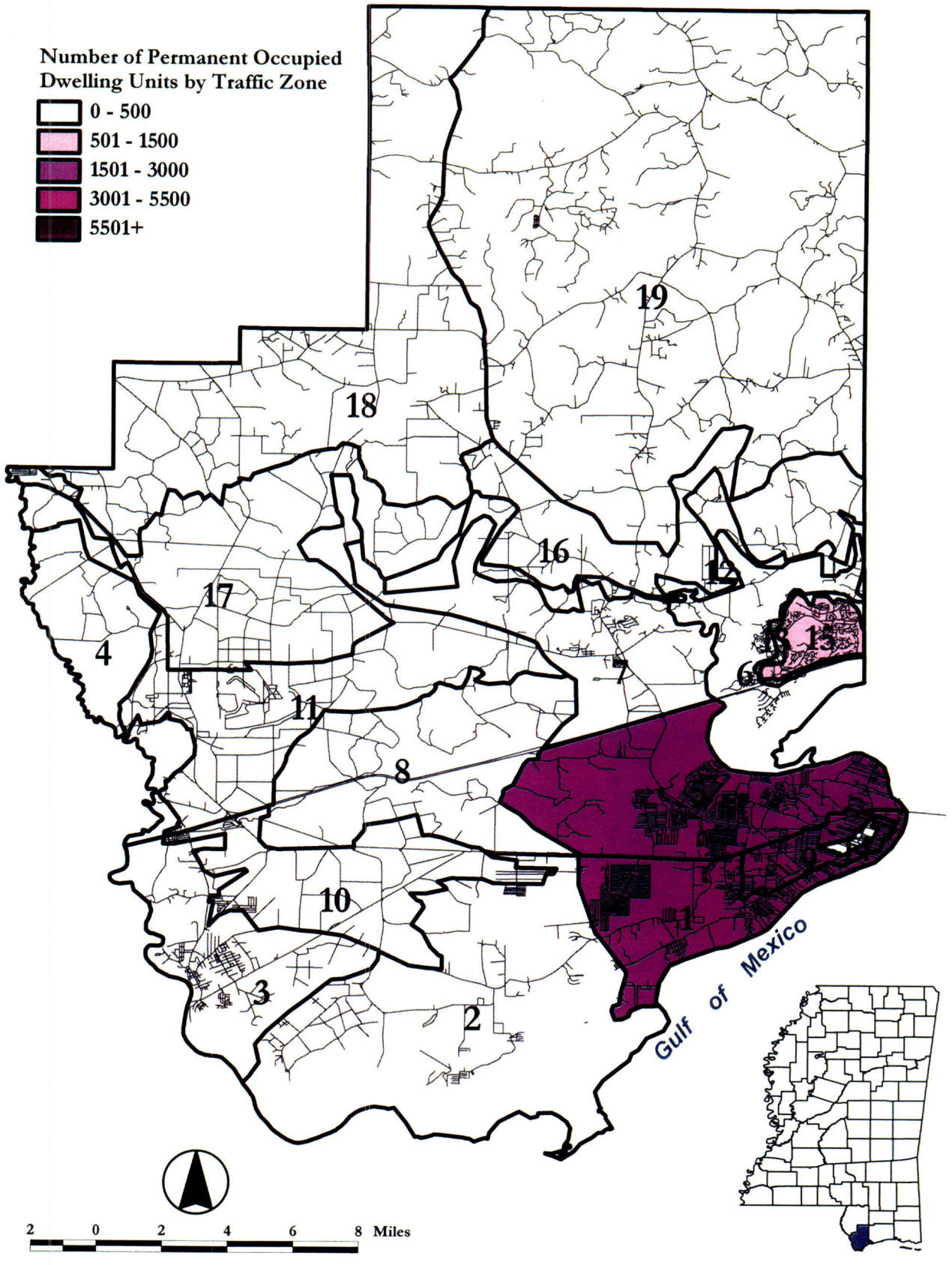
KEY POPULATION/DWELLING UNIT SUMMARY
By County
Mississippi Transportation Analysis

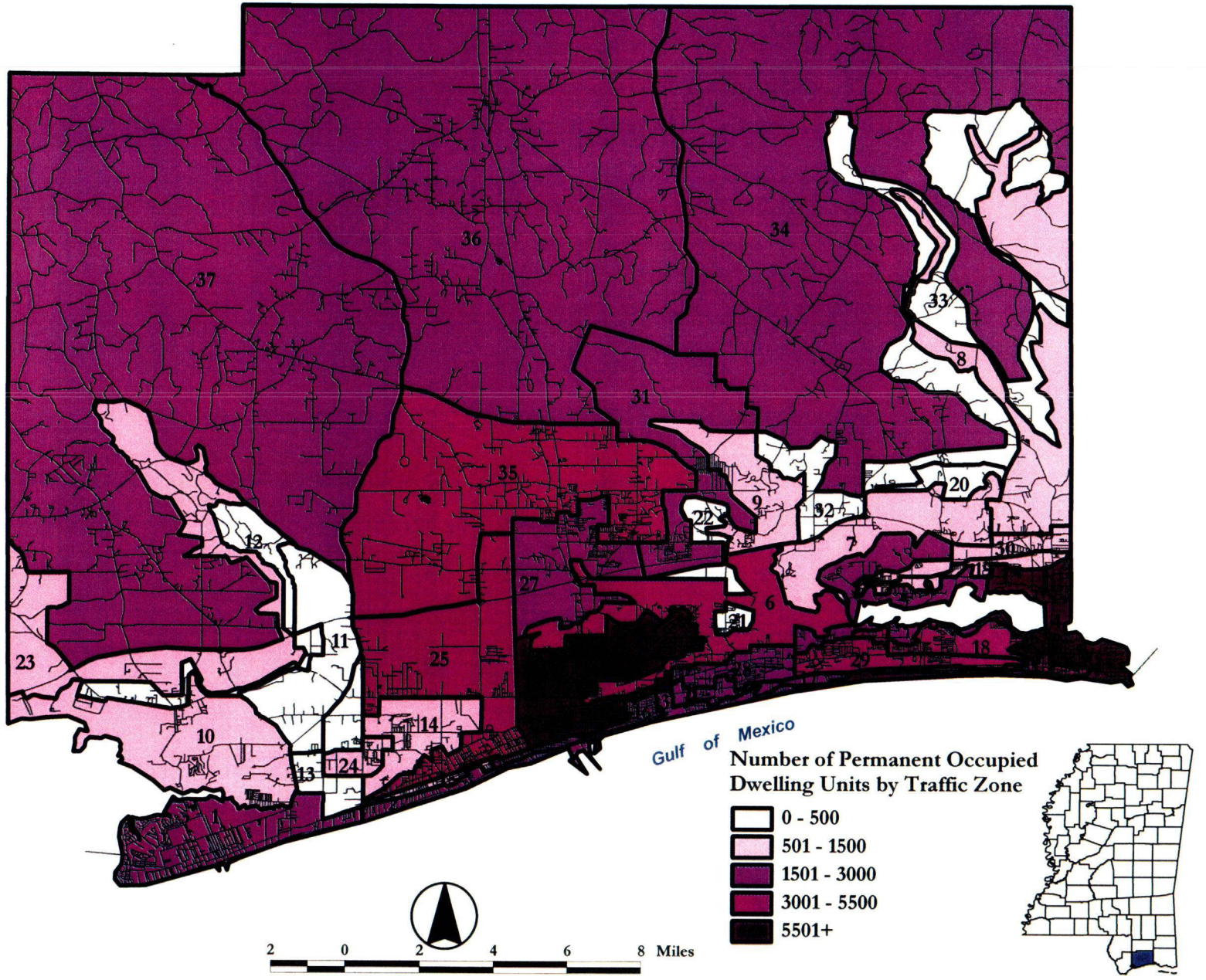
Data Description	Hancock	Harrison	Jackson	Total MS Coastal Area
Year 2000 Permanent Population	40,341	187,097	138,626	366,064
Permanent Occupied Dwelling Units	13,447	71,411	49,158	134,016
Mobile Homes	2,044	7,098	4,845	13,987
Tourist/Seasonal Units	6,544	16,657	8,445	31,646
People per Permanent Unit	3.0	2.62	2.82	2.81
Vehicles per Permanent Unit	1.77	1.77	1.77	1.77

The use of GIS technology (ArcInfo, ArcView) facilitated the production of study graphics, and was used for quality control and display of study inputs. Year 2000 permanent dwelling units by traffic evacuation zone and county are illustrated in Figures 2-4 through 2-6. Year 2000 mobile home units by traffic evacuation zone and county are shown in Figure 2-7 through 2-9. Figures 2-10 through 2-12 display seasonal units by traffic evacuation zone by county.

Permanent Occupied Dwelling Units

Figure 2-4



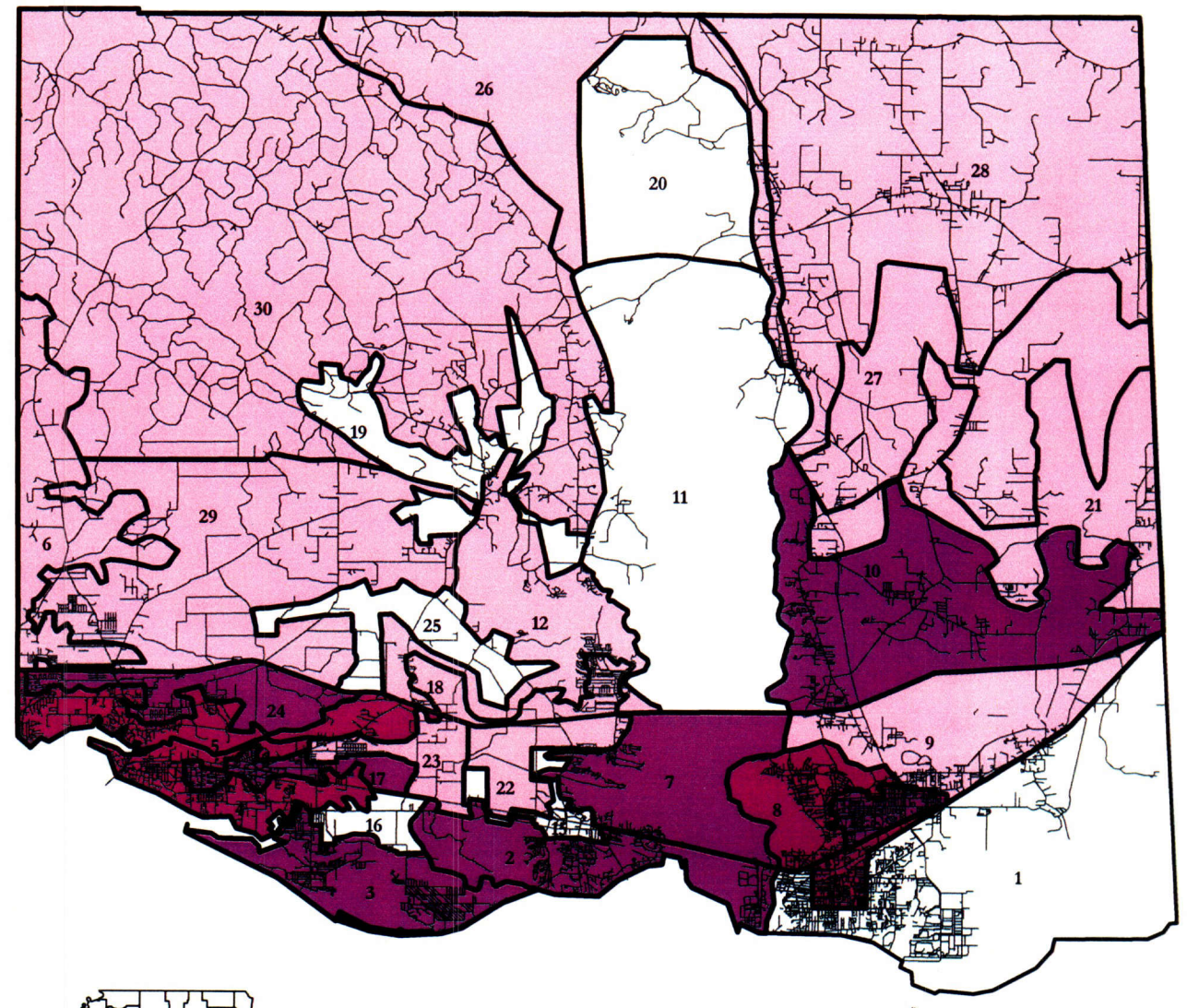


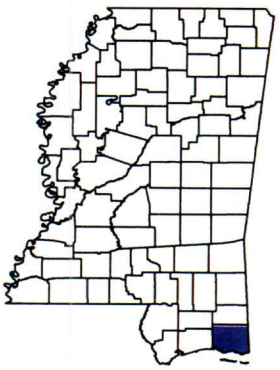
Permanent Occupied Dwelling Units

Figure 2-5

Permanent Occupied Dwelling Units

Figure 2-6





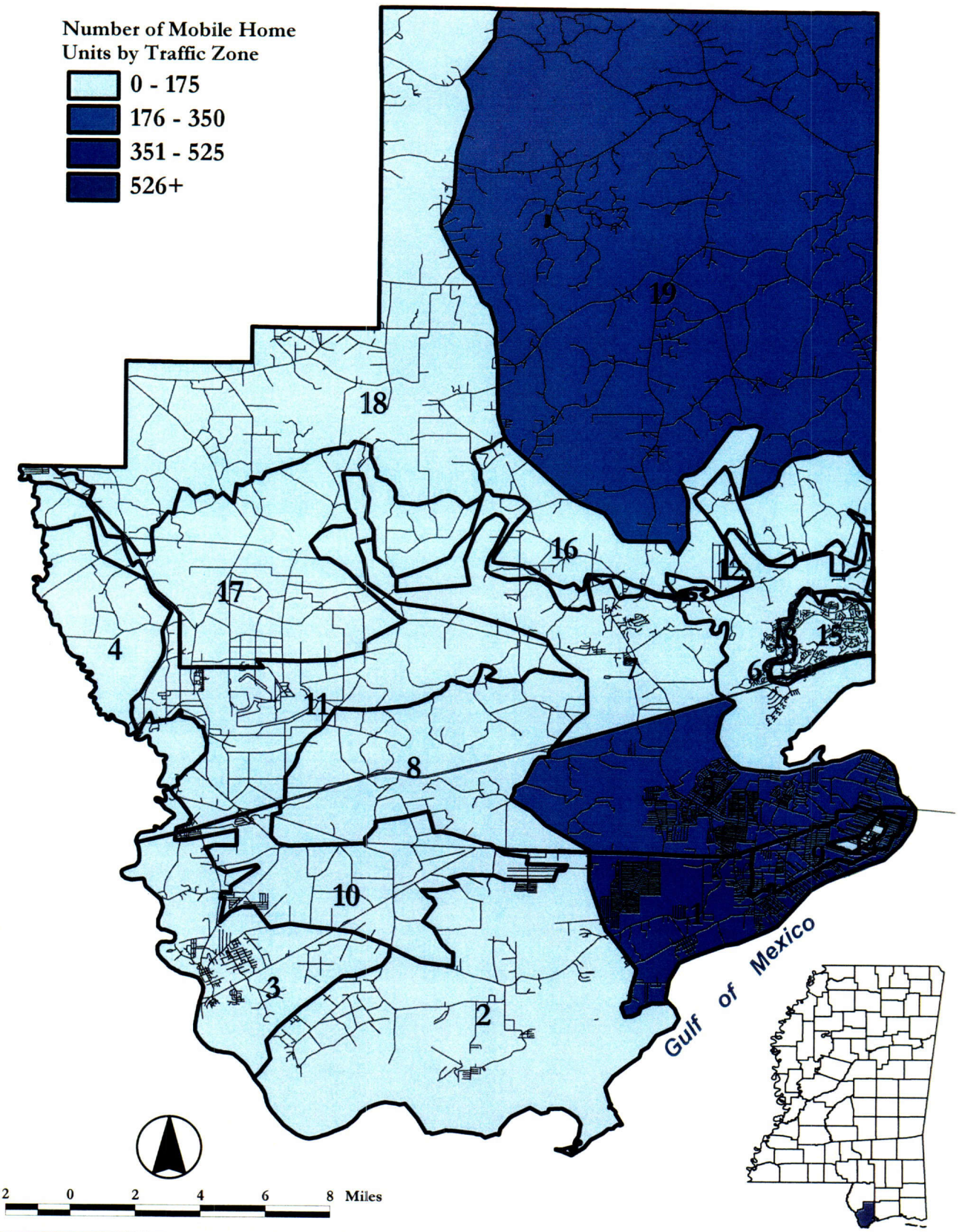
Number of Permanent Occupied Dwelling Units by Traffic Zone

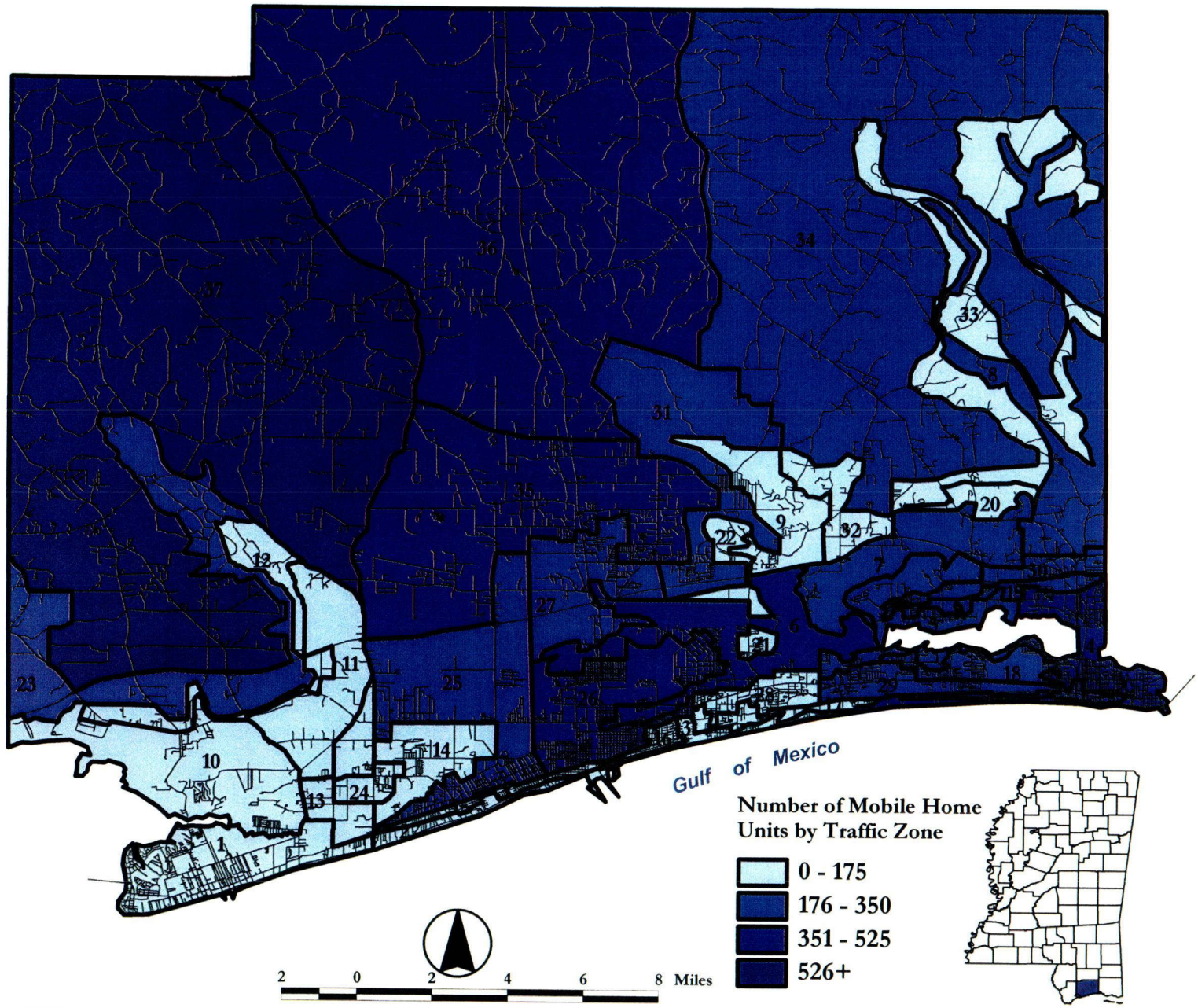
- 0 - 500
- 501 - 1500
- 1501 - 3000
- 3001 - 5500
- 5501+

2 0 2 4 6 8 Miles

Mobile Home Units

Figure 2-7



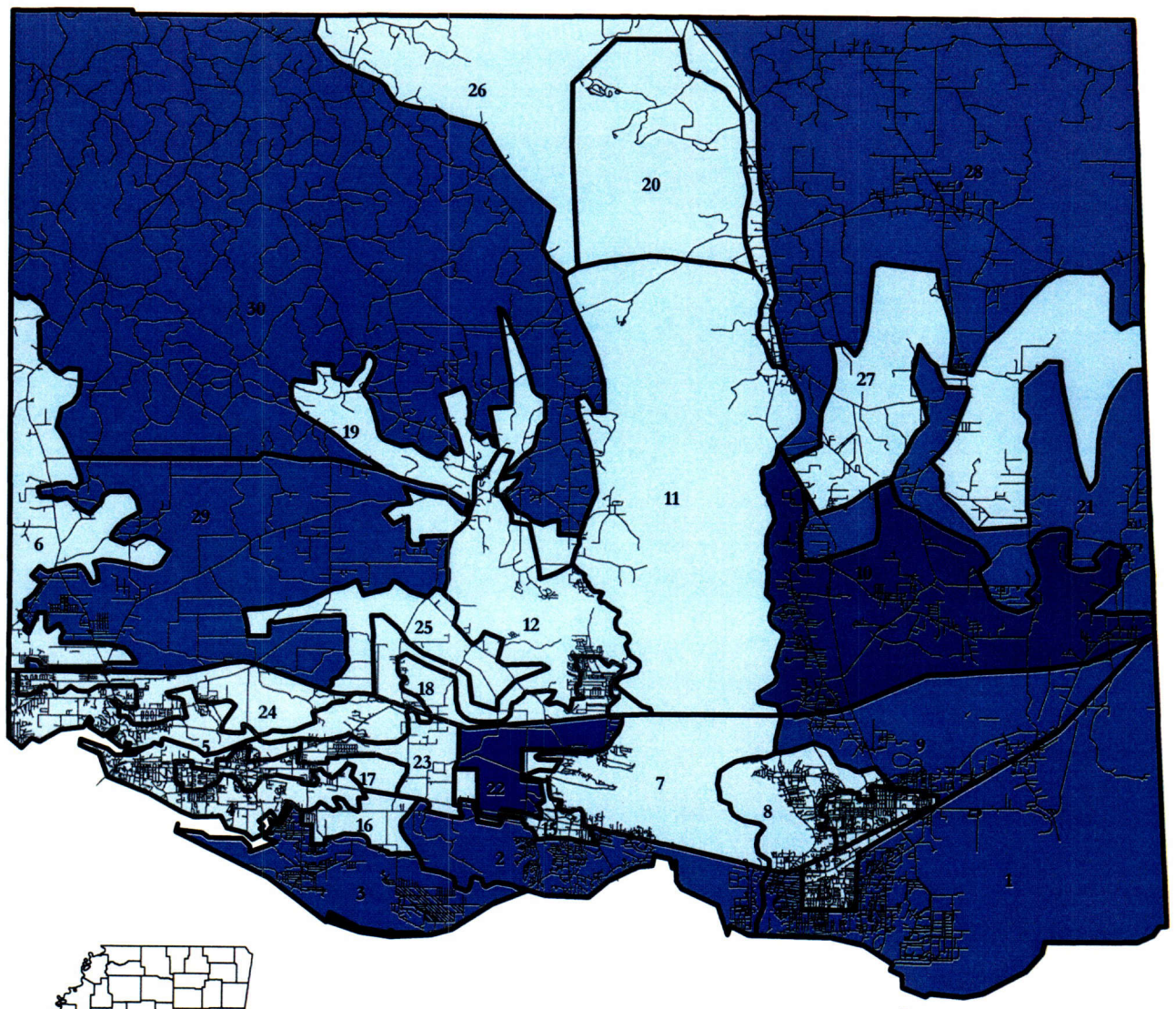


Mobile Home Units

Figure 2-8

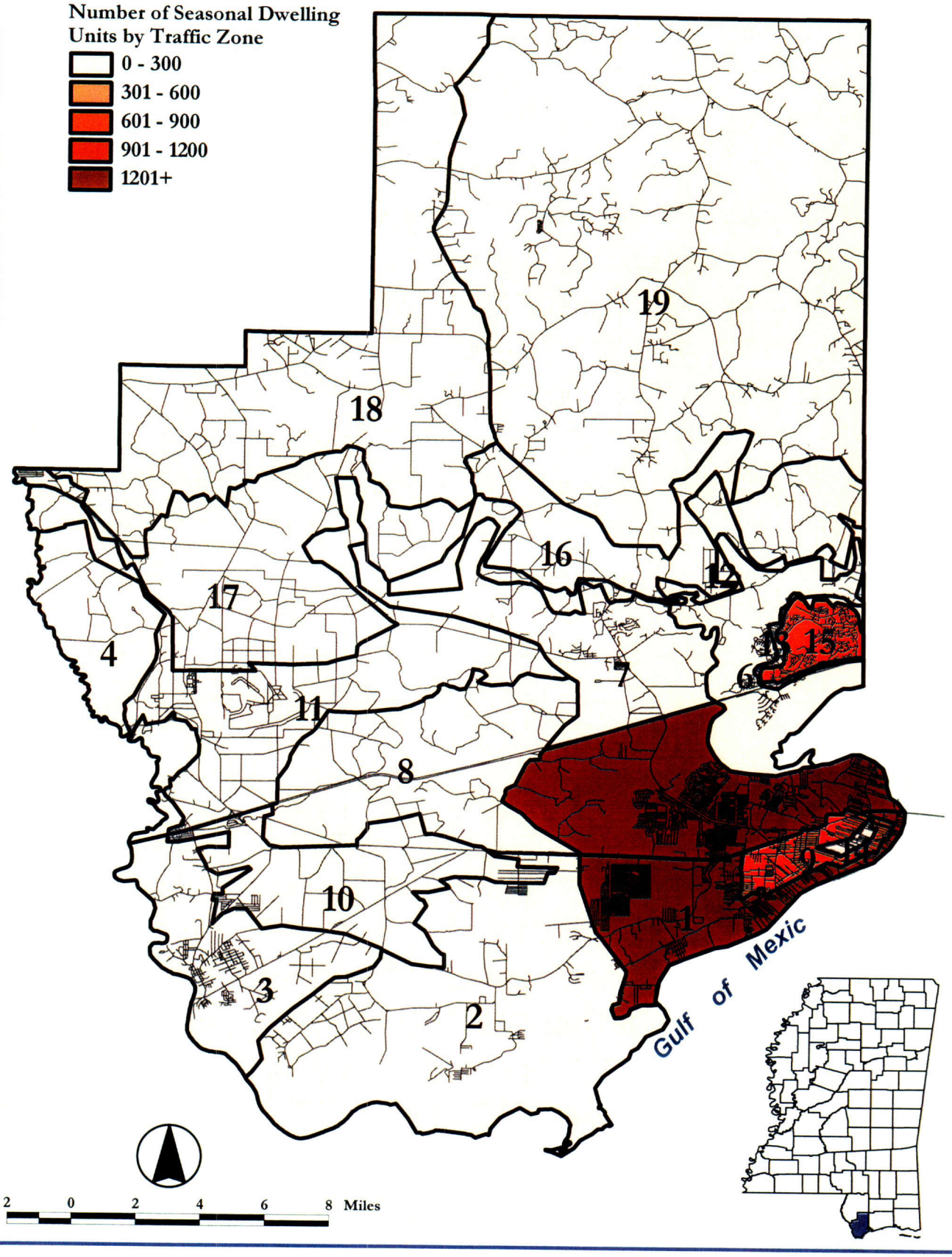
Mobile Home Units

Figure 2-9



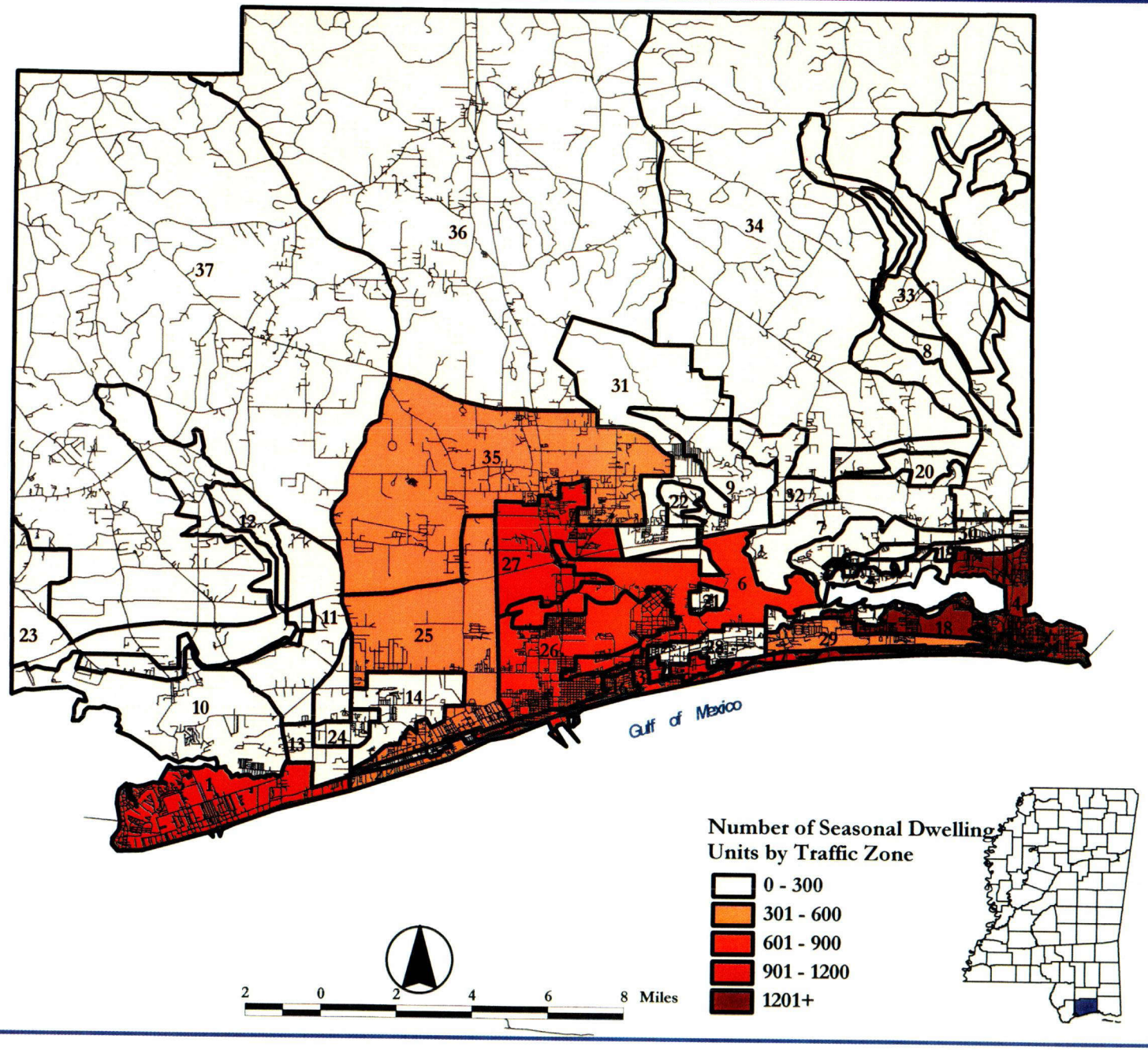
Seasonal Dwelling Units

Figure 2-10



Mississippi Hurricane Evacuation Restudy

Harrison County

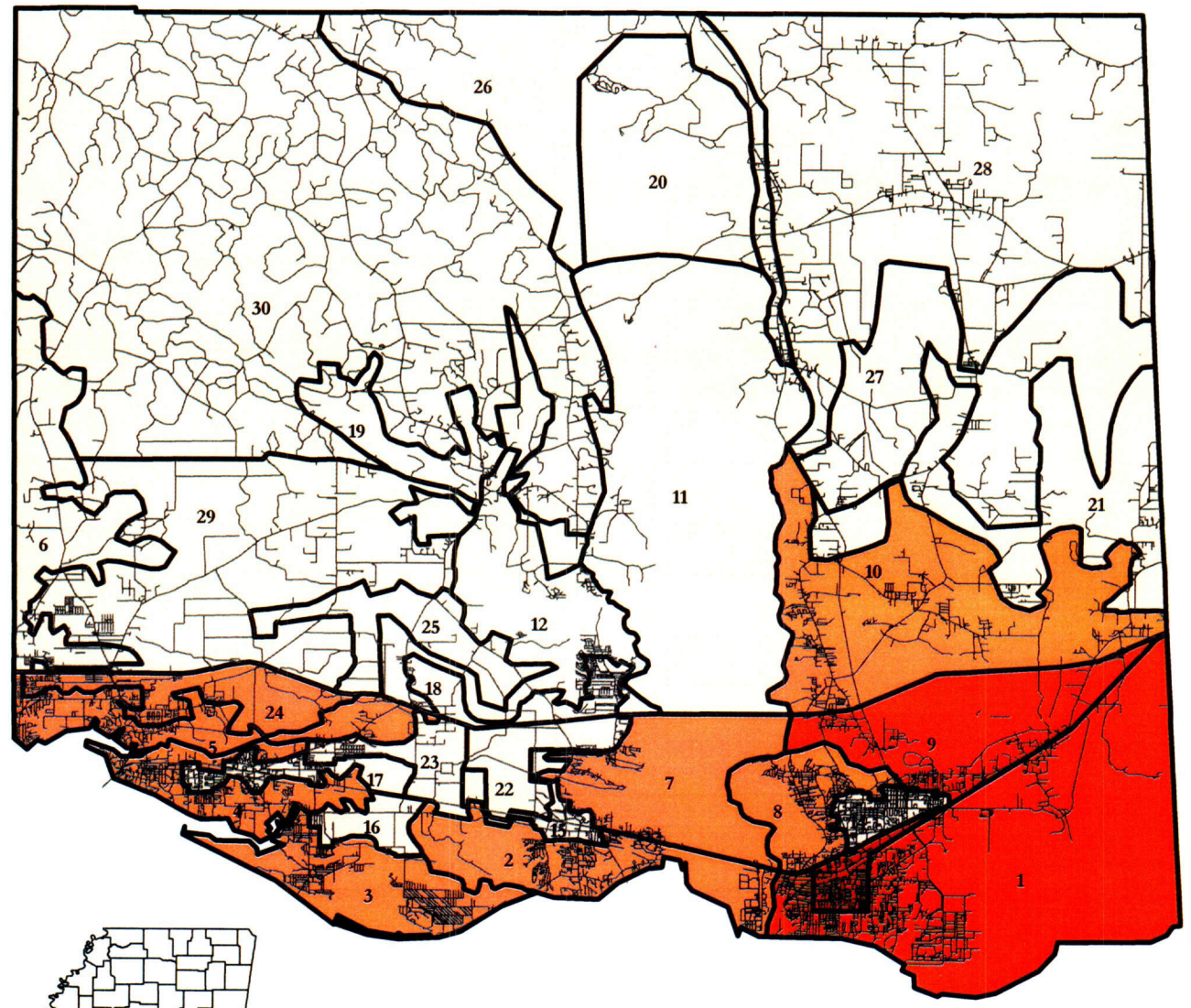


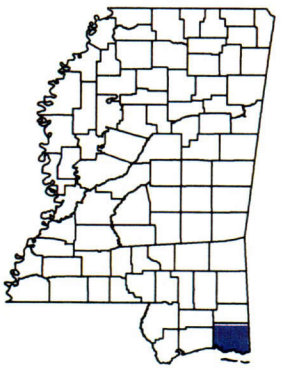
Seasonal Dwelling Units

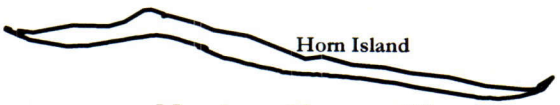
Figure 2-11

Seasonal Dwelling Units

Figure 2-12



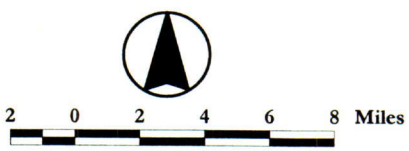




Gulf of Mexico

Number of Seasonal Tourist Units by Traffic Zone

- 0 - 300
- 301 - 600
- 601 - 900
- 901 - 1200
- 1201+



2.3 BEHAVIORAL ASSUMPTIONS

A future evacuation in Mississippi will involve evacuation decision-making by thousands of individuals and households. In order to develop meaningful behavioral assumptions which account for the variations in decision-making, PBS&J reviewed previous and current behavioral analyses conducted by Hazards Management Group (HMG). The PBS&J team used this data source and nationwide experience to focus the transportation analysis on the following behavioral aspects:

- Participation rates - what percent of the population in different areas will evacuate their dwelling units for future hurricane threats?
- Evacuation response rates - how quickly will evacuees respond to what local officials are telling them to do?
- Refuge type percentages - what percent of the population by county sub-area will evacuate to local public shelters, local hotel/motels, local friends' and relatives' homes, or out of the county entirely?
- Vehicle usage - of the vehicles available to the households, what percent of those vehicles will be used in an evacuation?
- Destination percentages - what percent of evacuees will go to what destinations?

PBS&J relied on the following sources of input to develop behavioral assumptions by evacuation zone:

- Initial discussions concerning expected behavioral response with emergency management staff in each county.
- Post storm evacuation assessment for Hurricane Georges in which HMG did an extensive behavioral analysis.
- Behavioral analysis (by HMG for the Mobile District Corps) in conjunction with the Mississippi restudy. This analysis included a tourist component.
- National hurricane behavioral trends ascertained by PBS&J and Hazards Management Group in recent studies.

A great deal of judgement was needed in order to develop the necessary parameters on a zone by zone basis. PBS&J has accumulated a wealth of experience both in Mississippi and around the country developing and applying behavioral parameters for evacuation analysis. This experience aided significantly in the process of generating assumptions.

Behavioral assumptions by zone are provided in the evacuating people and vehicle/trip generation portion of summary sheets located in the Transportation Model Support Document. In addition, the assumed participation rates developed by evacuation zones in each county and for each scenario are provided in the model document as well. The primary participation assumptions are as follows:

- Zones that will be evacuated for storm surge were assumed to have a 100% participation rate. Even though in actuality these rates will be lower (probably much lower in a Category 1 event), as a matter of public safety the clearance times calculated in this study should allow those who are vulnerable to storm surge the opportunity to evacuate whether they choose to or not.

- All mobile homes in inland zones are assumed to evacuate, although in the Category 1/2 scenario slightly less than 100% were assumed to evacuate to make the analysis more realistic.

- A portion of the theoretically non-vulnerable population (shadow evacuees) was also assumed to evacuate in the modeling. In an actual evacuation, the percentages could be higher than the figures used for modeling purposes (1% - 5%), particularly for more intense hurricanes. However, this difference will balance out with the less than 100% of surge residents participating in an actual event.

The abbreviated version of the model being provided to the state and counties allows behavioral parameters to be adjusted where emergency management officials feel it is appropriate.

One set of critical behavioral assumptions included in the transportation analysis involves the response rate of the evacuating population, or how quickly the vulnerable population responds to an evacuation order. 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. To account for this

variation, clearance times were tested for three evacuation response rates represented by different behavioral response curves.

The three response curves, shown in Figure 2-13, illustrate rapid response, medium response and long response and were designed to include a range of possible mobilization times that might be experienced in a future hurricane evacuation situation. For sensitivity analysis, the mobilization/traffic loading time was varied between five hours and ten hours.

A second essential input into the transportation analysis involved the percentage of evacuees assumed to travel to one of four general refuge types by scenario. These assumptions include the expected percent of evacuees from each zone and county traveling to local public shelters, hotel/motel units, the home of a friend or relative, or out of the region entirely. Refuge type percentages were varied for each traffic evacuation zone in the county depending on the category of risk (distance from the coastline) or special characteristics of a zone such as a high number of mobile home units. Assumptions were also varied for permanent residents versus tourists.

It should be noted that refuge percentages refer to refuge desires. In cases where the local hotel/motel demand outweighed the in-county capacities, the transportation analysis assumed that these evacuees would need to go out of county to find acceptable refuge. One important behavioral aspect built into the refuge rates is that the percentage of evacuees going out of county gets larger as the hurricane category increases. Table 2-3 lists destination percentages by state, and Table 2-4 shows destination percentages by cities within Mississippi. Also, in the lower intensity scenarios in the non-surge area, most of the evacuees are mobile home residents who have a higher propensity to use public shelters and this was reflected in the assumptions as well.

The final set of behavioral assumptions concerns vehicle usage rates during an evacuation. Vehicle usage rates pertain to the percentage of vehicles available at the home origin, assumed to be used in the evacuation. Vehicle usage percentages were 70-80% (depending on distance from the coastline) for this transportation analysis.

The key behavioral concepts and assumptions used for the study are summarized in Table 2-5. The precise parameters used for each county and zone for all scenarios are included in Annex C of the Transportation Model Support Document.

Behavioral Response Curves

Figure 2-13

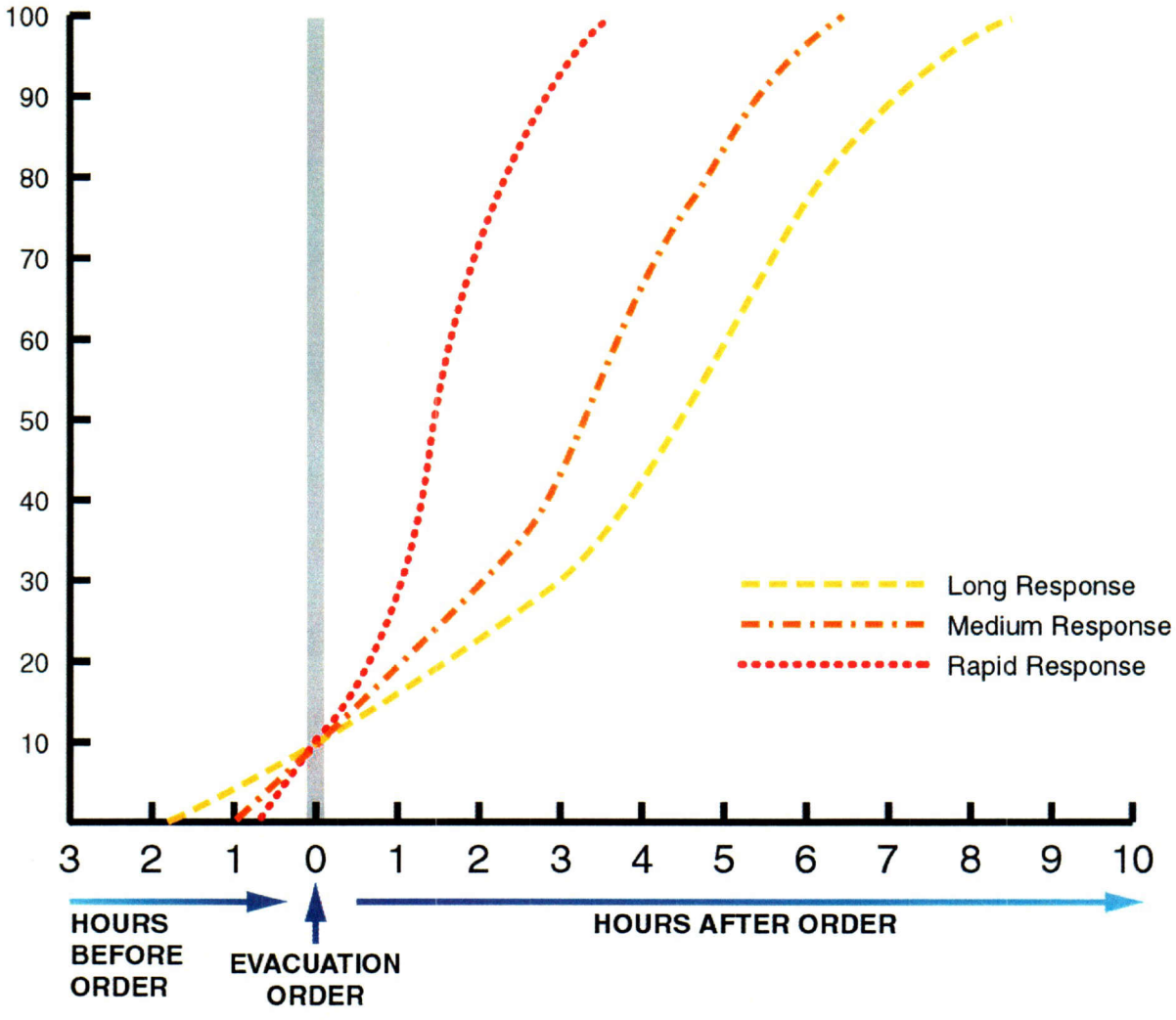


Table 2-3
DESTINATION PERCENTAGES BY STATE*
Mississippi Transportation Analysis

Florida	Georgia	Alabama	Mississippi	Louisiana	Texas	Arkansas
1.6%	1.6%	9.5%	66.7%	14.3%	3.2%	3.2%

Source: Data obtained from behavioral analysis conducted by Hazards Management Group (HMG) for this study.

Table 2-4
DESTINATION PERCENTAGES WITHIN MISSISSIPPI*
Mississippi Transportation Analysis

Destinations Within Mississippi	Percent
Jackson	11.1%
Gulf Port	6.4%
Meridian	6.3%
Hattiesburg	4.8%
Wiggins	3.2%
Diamond Head	3.2%
Other Cities within Mississippi	31.7%

Source: Data obtained from behavioral analysis conducted by Hazards Management Group (HMG) for this study.

Table 2-5
SUMMARY OF BEHAVIORAL ASSUMPTIONS
Mississippi Transportation Analysis

Participation Rates

Even in a scenario involving an intense, Category 4-5 hurricane, it is unlikely that the evacuation participation rate will be as high as 100%. However, conservative assumptions had to be made regarding the percentage of the population that would evacuate with the threat of a storm in each Category 1-5 scenario. In general, the following was assumed for each scenario: a participation rate of 100% for people in storm surge evacuation areas, all mobile home residents, and also a small portion of the theoretically non-vulnerable population. The exception to this is in a Category 1-2 situation where only 70% of the inland mobile homes were assumed to participate.

Under this assumption, clearance times calculated in this transportation analysis will provide residents located in vulnerable areas the opportunity to evacuate, whether or not they choose to evacuate.

Refuge Percentages

Refuge percentages include estimates of the percentage of evacuees traveling to each refuge type. These estimates include the number of evacuees traveling to in-county shelters, in-county homes of friends/relatives (including churches, masonic lodges), in-county hotels/motels, or out of the county destinations. Evacuation zones containing similar characteristics, such as gulf front or inland areas were grouped together by assumptions that were developed using data gathered from current and past observations of Mississippi and other coastal areas around the country.

Of those evacuating:

Percent to Local Public Shelter - 5% of high risk areas (gulf front)
15% of moderate risk areas (Category 3-5 zones)
20% of low risk areas (dry for all scenarios) depending on income

Percent to Out-of-County - 30-60% in a strong storm depending upon risk area and income
20-40% in a weak storm depending upon risk area and income
Of those going out-of-county, 10% were assumed to go west, 10% east and 80% north (this may vary by direction of oncoming storm).

In-County Friends and Relatives Homes - 25-50% in a strong storm depending upon risk area and income
35-60% in a weak storm depending upon risk area and income

Vehicle Utilization

Depending on the risk area, evacuees will use 70-80% of the vehicles available at the household level. This is generally a constant from one evacuation to another.

2.4 ROADWAY NETWORK CHARACTERISTICS

A final group of assumptions used for input to the transportation analysis is related to the roadway system chosen for the evacuation network and traffic control measures considered for traffic movement. Although the assumptions developed for the transportation analysis are general, the efforts at county and municipal levels regarding traffic control and roadway selection must be quite detailed. In urbanized areas like Gulfport and Biloxi, most intersections will be controlled by existing traffic signals. However, as resources permit, traffic control officers will be stationed at bottlenecks identified in this study as well as other local locations of concern. Detailed law enforcement assignments to major bottlenecks involves extensive coordination among local and state officials. This study does not presume to replace those efforts, but seeks to quantify the time elements within which such personnel would operate.

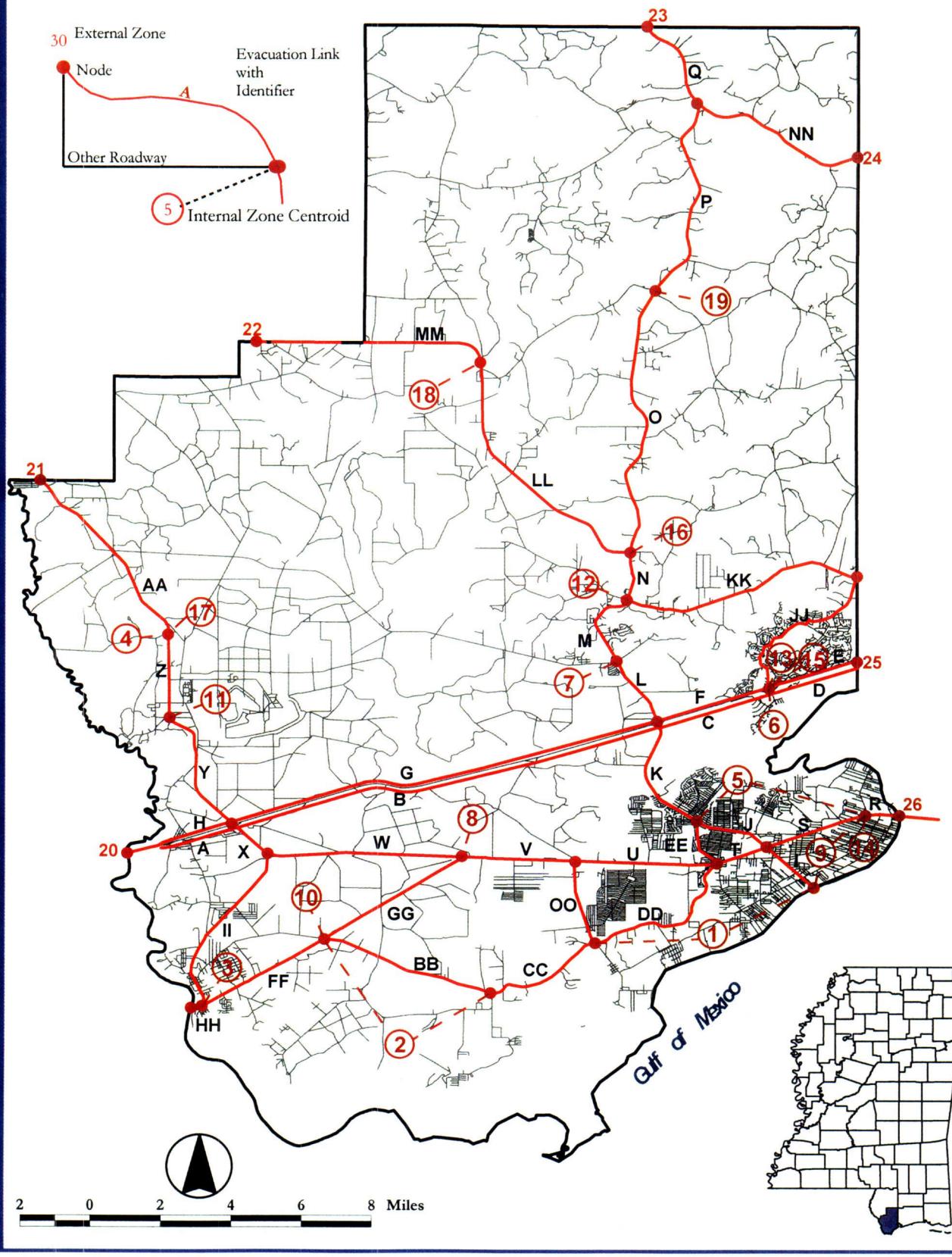
Draft evacuation network maps were reviewed by the counties and roadways were added to the analysis where appropriate. In choosing roadways to be used for the evacuation network, an effort was made to include street facilities with sufficient elevations, substantial shoulder width and surface, and roadways already contained in existing hurricane evacuation plans. In an area such as Mississippi, where there are urban and rural low lying streets that flood in heavy rainfall events, these criteria were difficult to meet.

In order to determine the routing of evacuation, a representation of the roadway system was developed. A "link-node" system was developed to identify roadway sections. Nodes are used to identify the intersection of two roadways or changes in roadway characteristics. Links are the roadway segments between nodes. Each link is identified by a letter designation. Figures 2-14 through 2-16 illustrate the coded evacuation network with link letters and zone connections to the links shown by open circles and dashed lines.

Once the links and nodes were established for the evacuation routes, directional traffic service volumes at Level of Service D were established for each link for the Year 2000. This was accomplished by ascertaining number of lanes, facility type, and area type information from highway

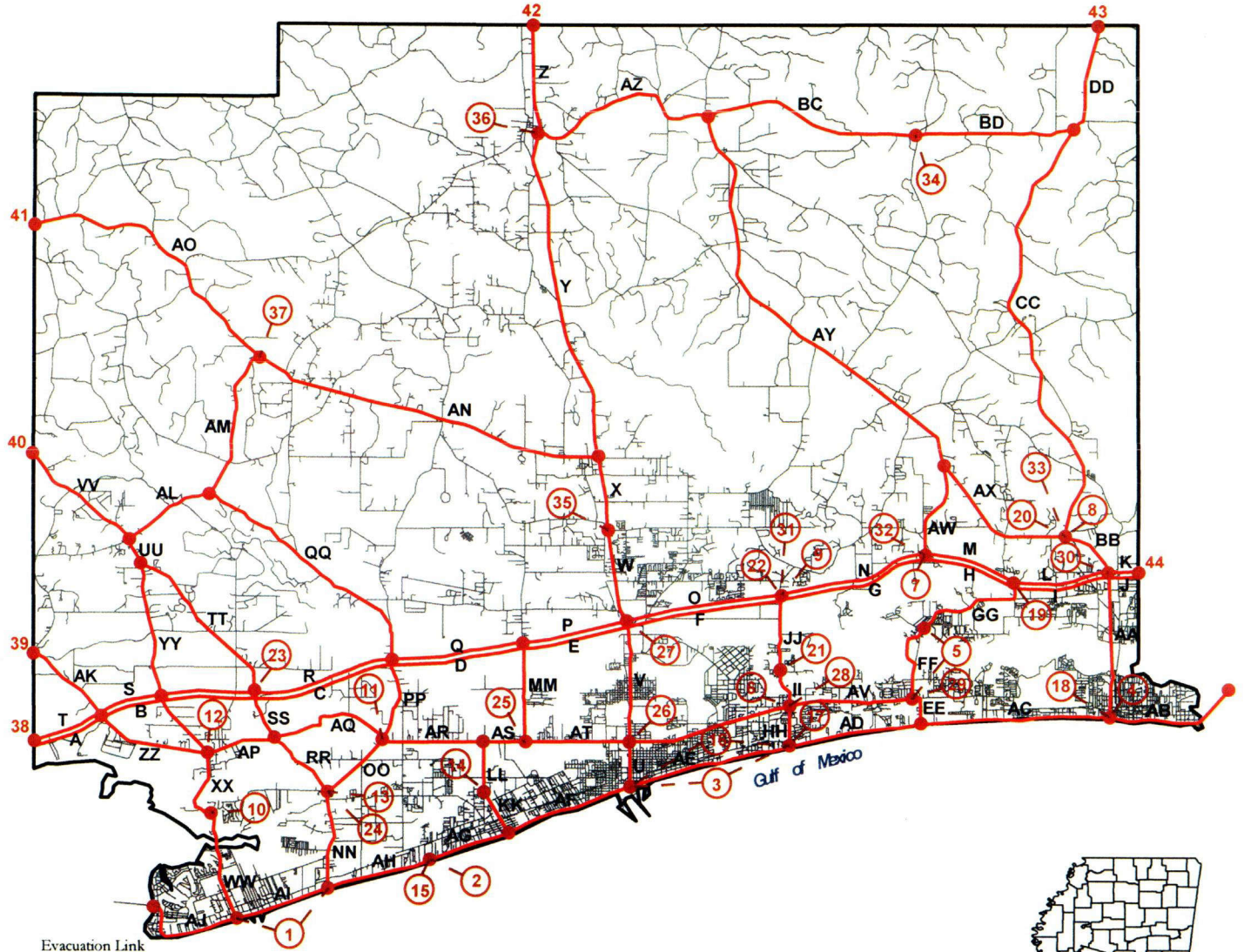
Evacuation Road Network

Figure 2-14



Mississippi Hurricane Evacuation Restudy

Harrison County

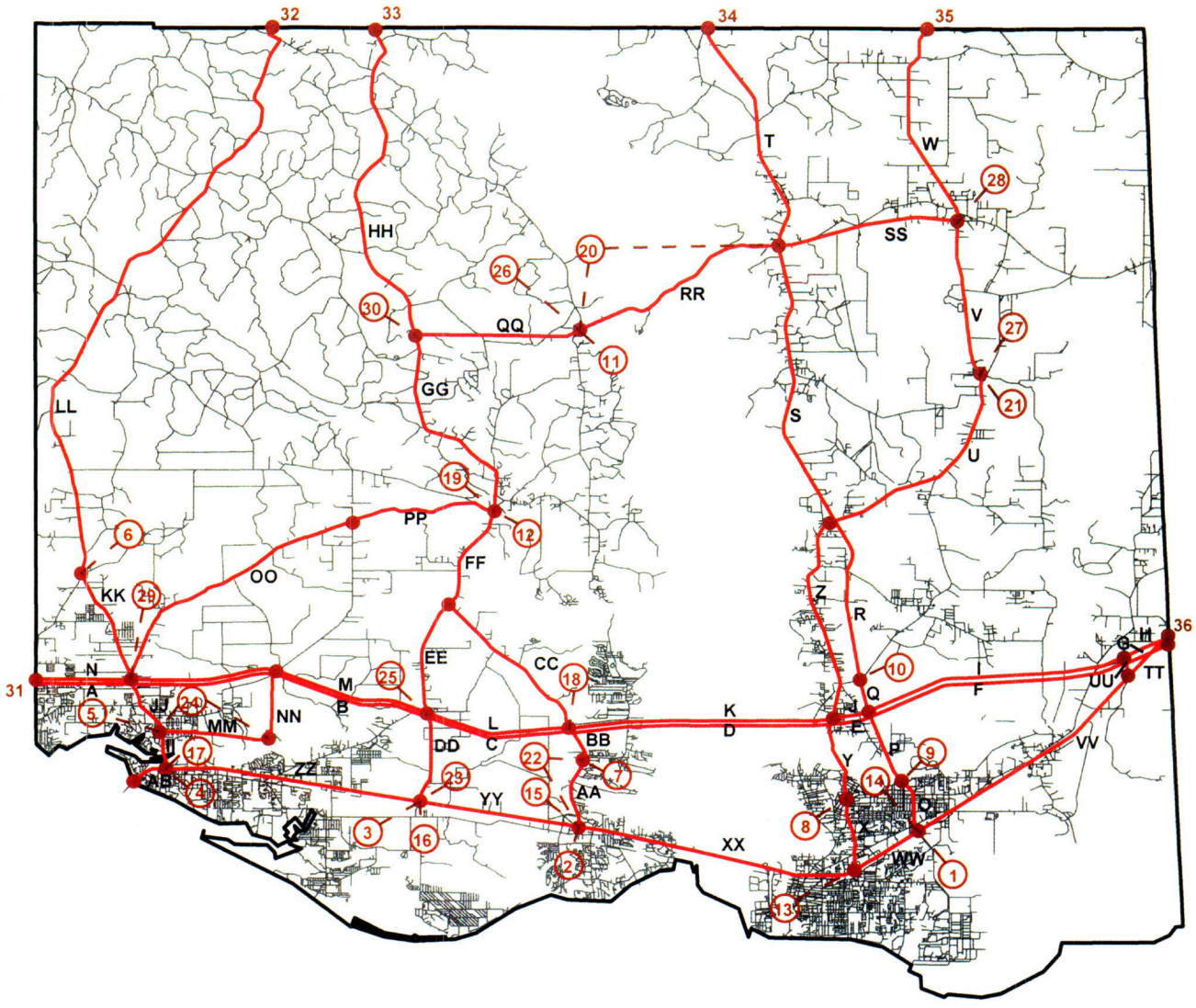


Evacuation Road Network

Figure 2-15

Evacuation Road Network

Figure 2-16



Horn Island

Gulf of Mexico

Petit Bois Island

30 External Zone

Node

Evacuation Link with Identifier

A

Other Roadway

5 Internal Zone Centroid

2 0 2 4 6 8 Miles

maps available from the counties and "field checks"/updating accomplished by PBS&J. Tables were then used to specify a directional, level of service D service volume based on link characteristics. The level of service is the anticipated operating standard of the roadway segment and is determined based on the roadways number of lanes. The number of lanes determines the service volume of a roadway because each lane has an established maximum capacity. Figures 2-17 through 2-19 show the Year 2000 directional service volumes and number of lanes for the evacuation clearance time analysis.

Important assumptions concerning the evacuation road network for the analysis which must be mentioned are:

- The evacuation of all vehicles will occur prior to the arrival of sustained gale storm winds (39 mph) and storm inundation of evacuation routes

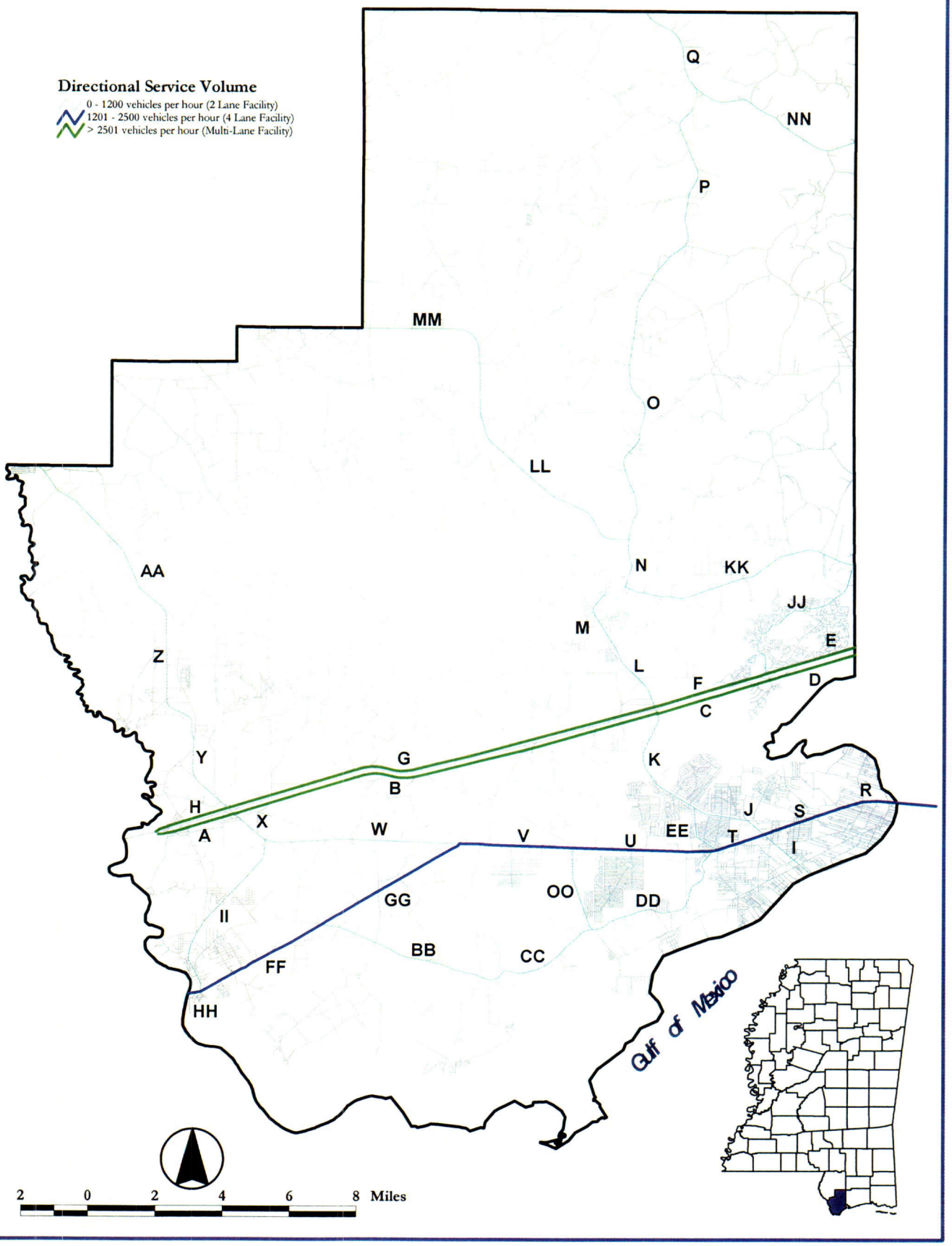
- Provisions will be made for the removal of vehicles in distress on the network through aggressive incident management and agreements worked out with tow truck operators

- Signal timings will be "actuated" to provide the most green time for northbound movements away from the coast

- The U.S. Coast Guard will be contacted to "lock down" drawbridges at least 12 hours before the arrival of hazardous conditions.

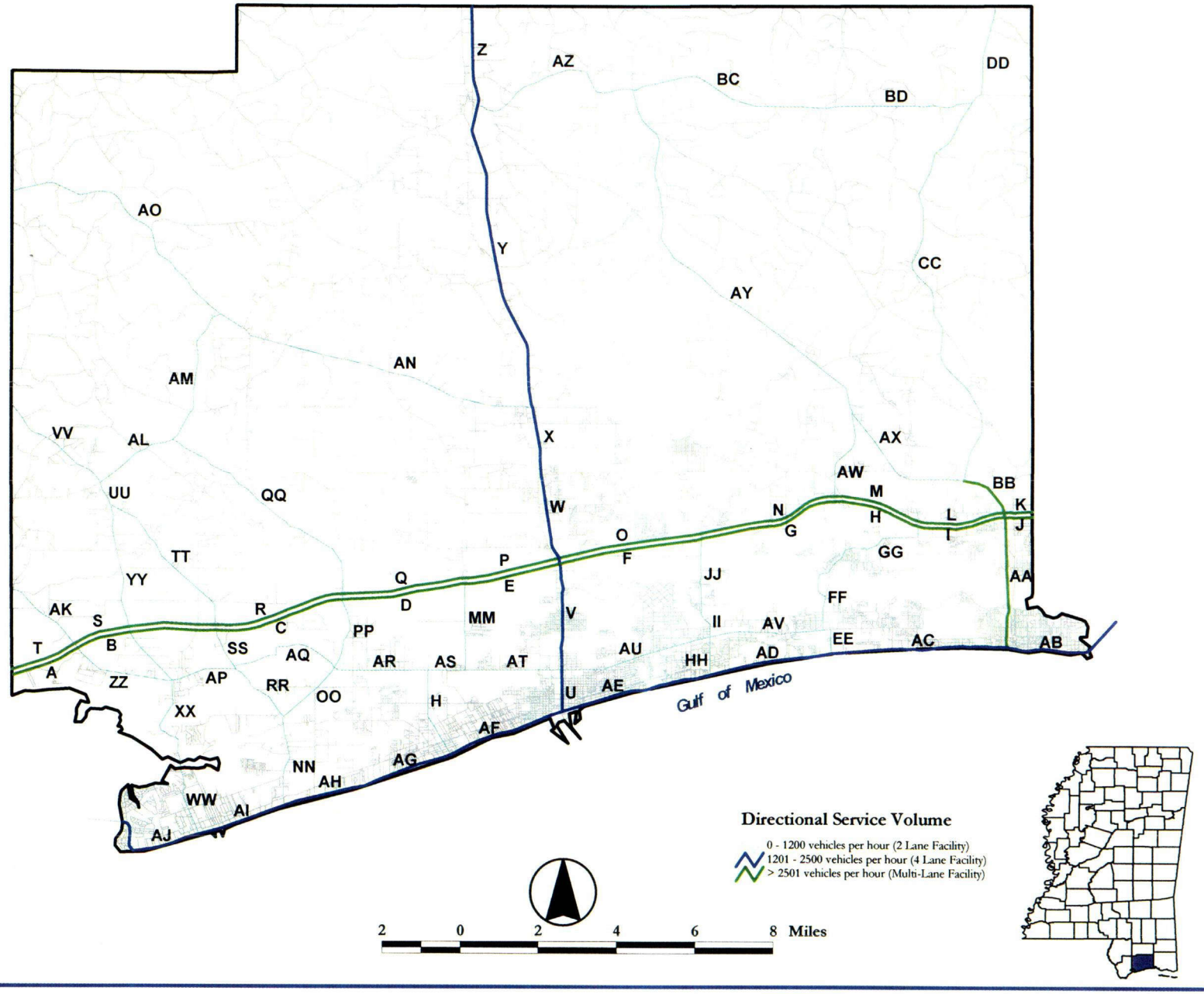
Directional Service Volumes

Figure 2-17



Mississippi Hurricane Evacuation Restudy

Harrison County

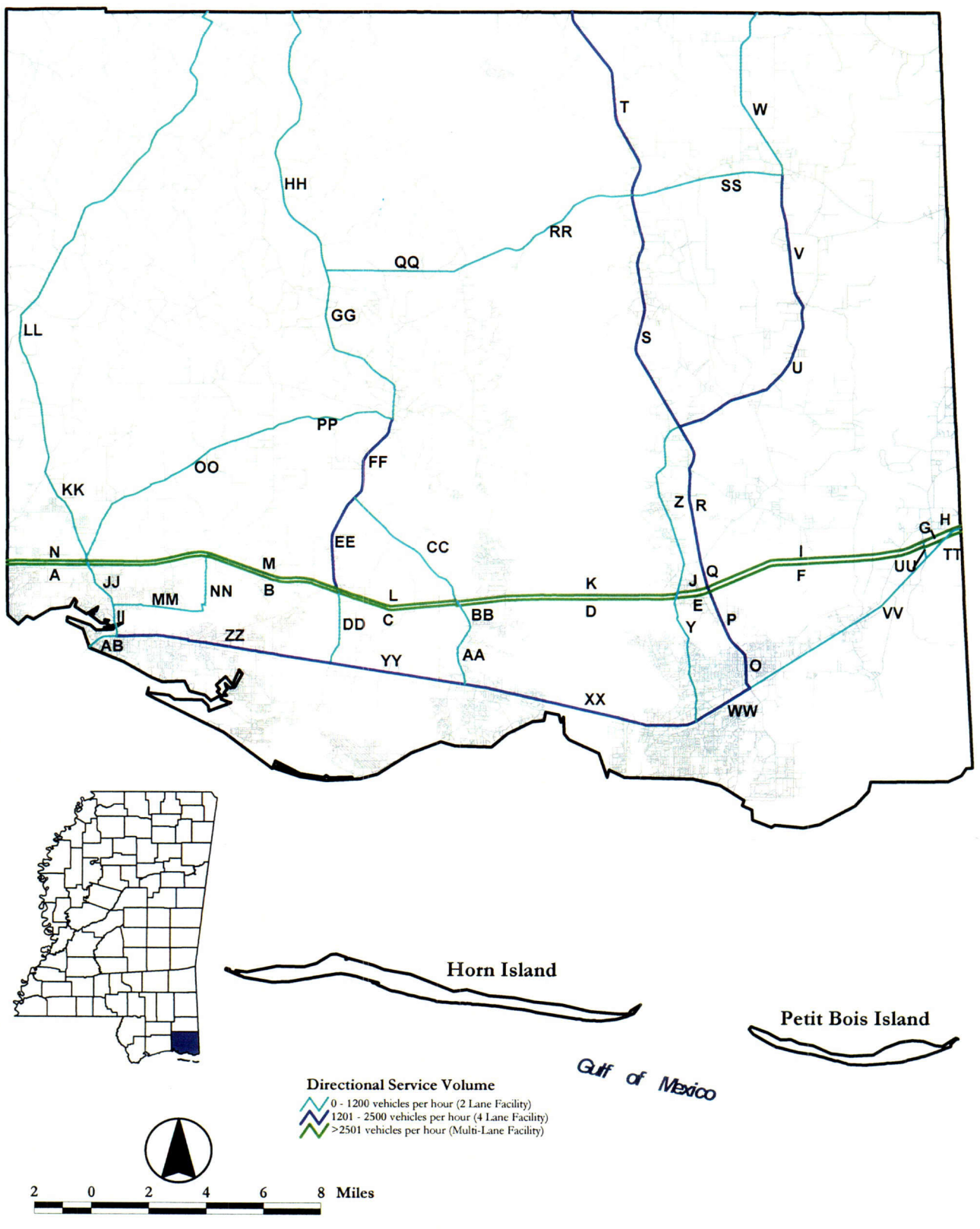


Directional Service Volumes

Figure 2-18

Directional Service Volumes

Figure 2-19



3.0 EVACUATION CLEARANCE TIME MODEL APPLICATION/SYSTEM FORECASTS

Application of PBS&J's transportation modeling methodology for hurricane evacuations, using inputs and assumptions discussed in Chapter 2, produced several key data items and forecasts for hurricane evacuation planning and preparedness. Completion of the transportation modeling process for the Year 2000 base year produced the following:

- Evacuating people and vehicle statistics by evacuation zone by storm scenario
- Shelter demand and capacity considerations by scenario
- Traffic volumes and critical roadway segments by scenario
- Estimated clearance times by scenario

Although an extensive amount of data is generated through the transportation analysis (as provided in the Transportation Model Support Document), the items listed above constitute the most critical outputs for planning for shelter needs, anticipating bottlenecks and defining the timing constraints of an evacuation.

3.1 CLEARANCE TIME MODEL DESCRIPTION

The general philosophy supporting all of PBS&J's hurricane evacuation clearance time work around the country is that the analysis must be technically complex enough to produce reliable estimates of hurricane evacuation clearance times, yet clear enough for the emergency management community to be able to review key modeling assumptions and products. A brief overview of the steps in the modeling process and a description of the computer program framework used in the modeling steps are discussed in this section.

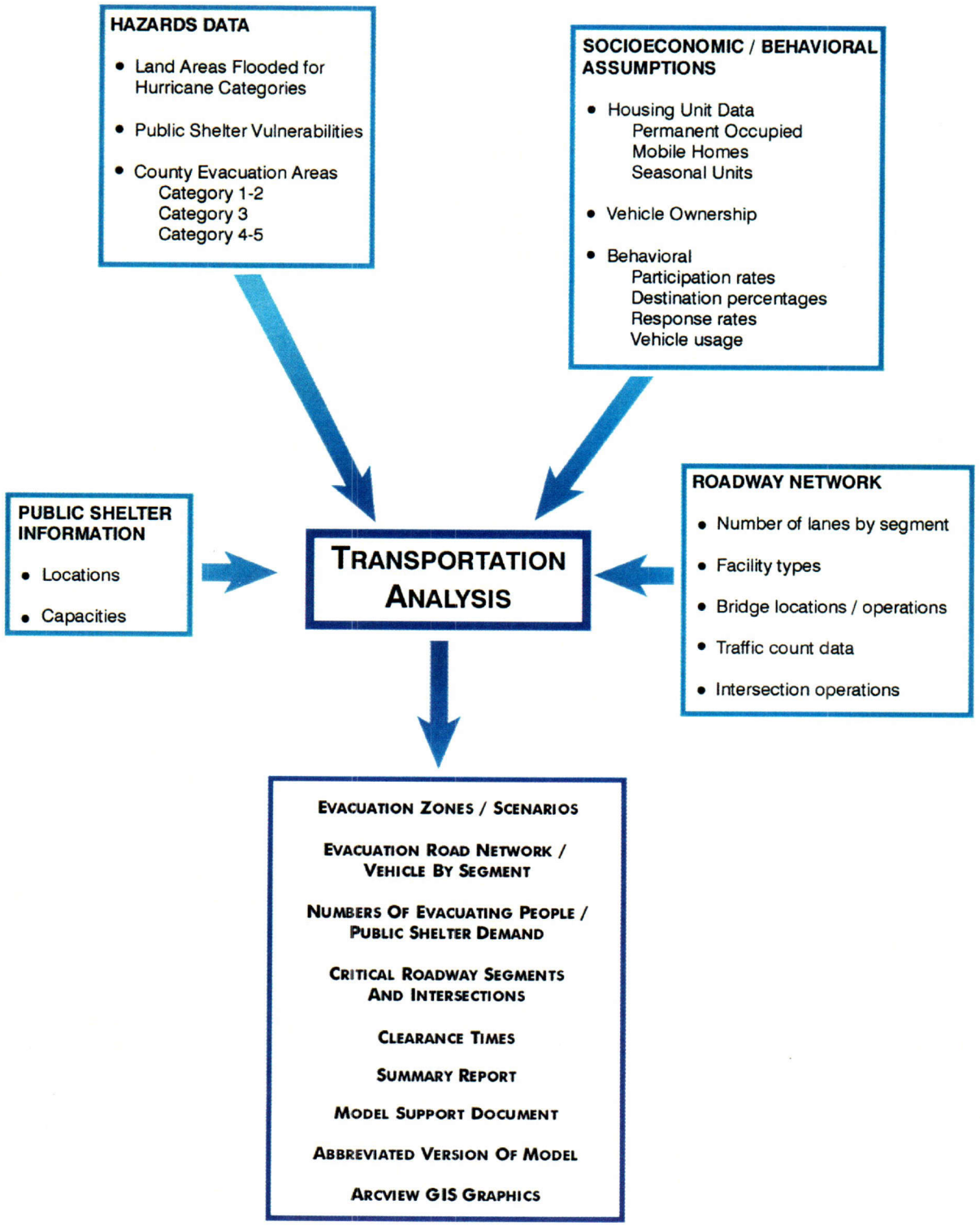
The key modeling steps used in the analysis are as follows:

- Development of Evacuation Zones and Data - identifies who is vulnerable and evacuating
- Trip Generation - calculates how many evacuees will move by county for a particular scenario
- Trip Distribution - determines where evacuees will go
- Development of Evacuation Road Network - addresses the questions, (1) which roads can be used for evacuation and (2) what is the carrying capacity of each road
- Trip Assignment - determines what route(s) evacuees will take to get from their origin to their destination.
- Calculation of Clearance Time - determines how much time it will take for all evacuees to clear the evacuation network

The major inputs and outputs of the overall process are illustrated in Figure 3-1. PBS&J developed an in-house set of computer programs to facilitate the transportation modeling steps described above. Programs are in a Lotus for Windows environment and were originally developed in late 1993/early 1994 by PBS&J for use in all of the firm's ongoing hurricane work. The model was updated dramatically in 1999 and the Mississippi Study is one of the earliest beneficiaries of that update. At the conclusion of the study, PBS&J is providing the USCOE, state and counties with a spreadsheet which will allow state and county officials to make changes additional dwelling units are constructed or when road construction restricts normal flow. This abbreviated model was developed in order to facilitate the ability of the Corps and each county in the study to update their clearance times by accounting for new development and roadway changes.

Clearance Time Model Process

Figure 3-1



The Transportation Model Support Document Appendix to this report provides details about components of the model, file nomenclature and management and model application. One important aspect of operating in the Lotus environment for this study was the ability to import data files directly into the initial programs. In addition, the outputs of other programs were easily captured and exported to ArcView GIS for displays and mapping. Overall, the use of GIS by PBS&J significantly enhanced the process of technical data development and documentation in the study.

3.2 EVACUATING PEOPLE AND VEHICLES BY SCENARIO

Using the trip generation module of PBS&J's battery of hurricane programs, total evacuating people and vehicles produced by each evacuation zone were calculated and split by general destination type (trip purpose). The four general destination types are in-county public shelter, in-county hotel/motels, in-county home of a friend or relative, and out-of-county. This was accomplished for the Year 2000 base year, for each storm intensity and for two levels of assumed tourist occupancy. Low tourist occupancy was assumed to be 35% and high tourist occupancy was assumed to be 95%. The zone by zone statistics resulting from this process can be found in the Transportation Model Support Document in Annex C.

Table 3-1 shows the number of residents and tourists estimated to leave dwelling units for each county and scenario. **The number of people involved in an actual evacuation could total less than these figures** due to the assumed 100 percent participation rate of people from units in storm surge vulnerable areas and mobile homes assumed for each scenario. Even with door-to-door evacuation notification, it will be difficult to convince all to leave who should leave even for the most intense storm threats. Participation rates in tropical storm/weak Category 1-2 hurricanes can be quite low even in potential surge areas. Conversely, for Category 4 and 5 hurricanes, media hype and continual coverage on The Weather Channel tend to produce high participation rates from residents that local officials would rather have stay put.

Table 3-1
EVACUATING PEOPLE STATISTICS
Mississippi Transportation Analysis

County/Scenario	Year 2000 Permanent Population*	Maximum People/ Vehicles Evacuating Dwelling Units People/Vehicles	Maximum Public Shelter Demand	Local Public Shelter Capacity
Hancock County	40,341 People			
Low Tourist Occupancy				
Category 1-2		28,845/12,832	1,982 People	1,750 People
Category 3		38,588/17,162	3,335 People	600 People
Category 4-5		50,589/22,111	5,352 People	450 People
High Tourist Occupancy				
Category 1-2		38,721/16,285	2,079 People	1,750 People
Category 3		50,134/21,204	3,452 People	600 People
Category 4-5		62,367/26,233	5,352 People	450 People
	includes 6,132 mobile home residents countywide	includes up to 19,632 seasonal people countywide		
Harrison County	187,097 People			
Low Tourist Occupancy				
Category 1-2		78,247/39,503	5,185 People	10,590 People
Category 3		120,487/58,963	10,852 People	9,090 People
Category 4-5		203,540/98,177	20,577 People	3,850 People
High Tourist Occupancy				
Category 1-2		98,403/46,554	5,293 People	10,590 People
Category 3		147,820/68,528	11,001 People	9,090 People
Category 4-5		231,728/108,038	20,577 People	3,850 People
	includes 18,597 mobile home residents countywide	includes up to 49,971 seasonal people countywide		
Jackson County	138,626 People			
Low Tourist Occupancy				
Category 1-2		98,684/48,194	6,726 People	3,050 People
Category 3		130,631/62/078	11,336 People	900 People
Category 4-5		141.375/66.784	12,877 People	200 People
High Tourist Occupancy				
Category 1-2		110,726/52,408	6,849 People	3,050 People
Category 3		145,590/67,313	11,488 People	900 People
Category 4-5		156,580/72,107	12,877 People	200 People
	includes 13,663 mobile home residents countywide	includes up to 25,335 seasonal people countywide		

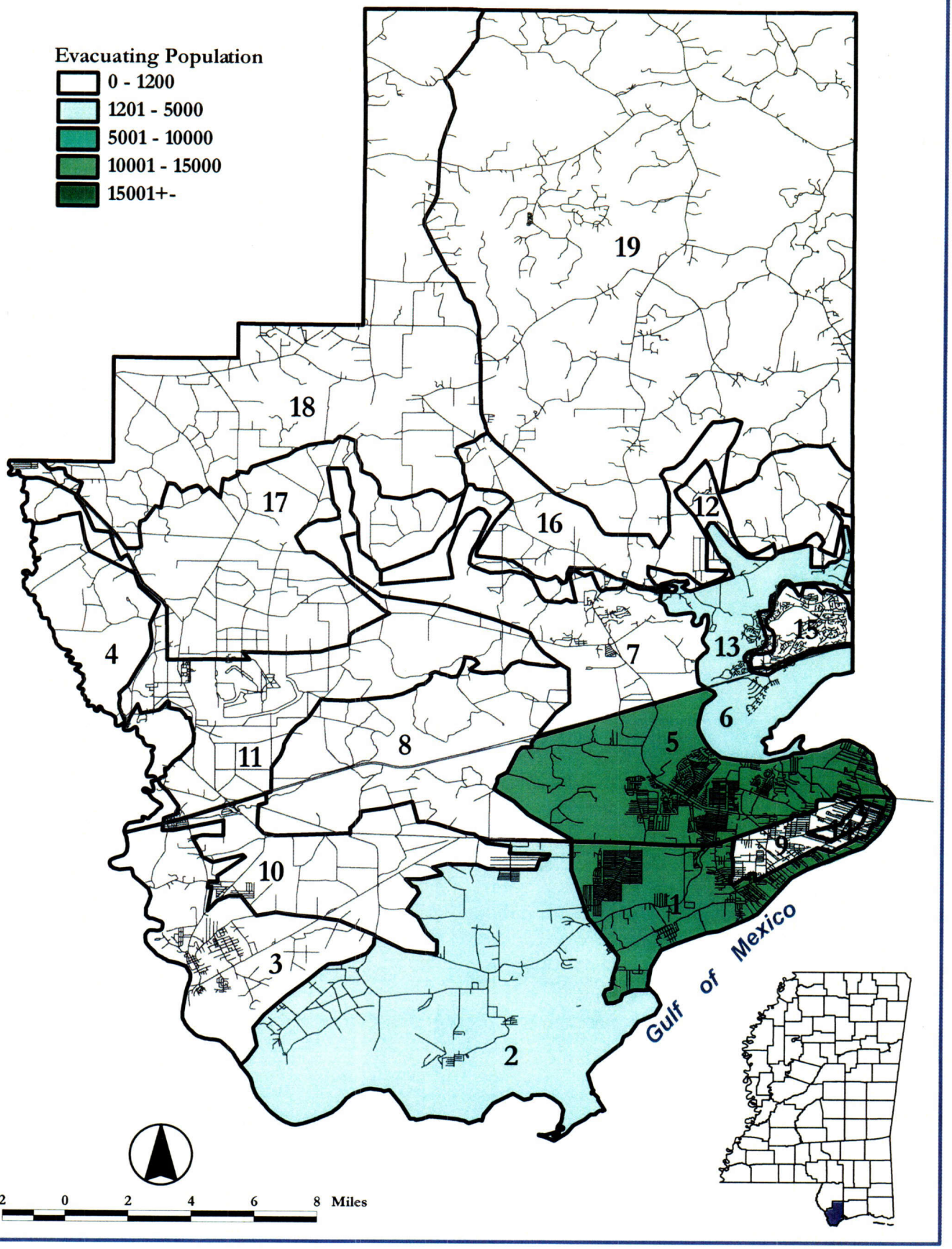
*All socioeconomic data developed by PBS&J using Gulf Regional Planning Government data for input into the transportation analysis effort.

The possible range of evacuating population is represented by a Category 1-2 storm with low tourist occupancy (lowest evacuating population) and a Category 4-5 with high tourist occupancy (highest evacuating population). Figures 3-2 through 3-7 graphically show ranges of evacuating population by county and by evacuation zone for the storm and tourist occupancy scenarios.

Evacuating Population

Category 1/2 Hurricane — Low Tourist Occupancy

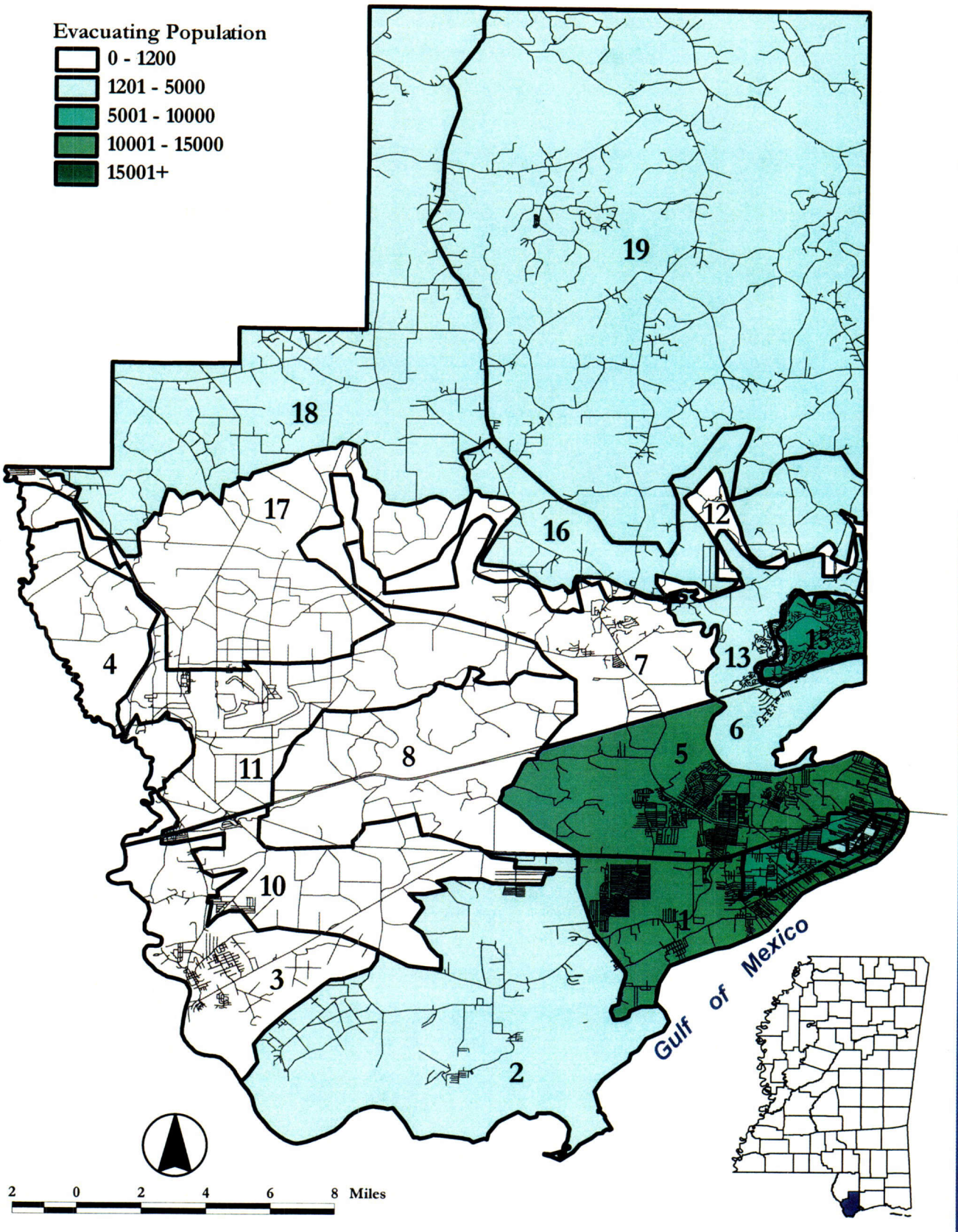
Figure 3 - 2



Evacuating Population

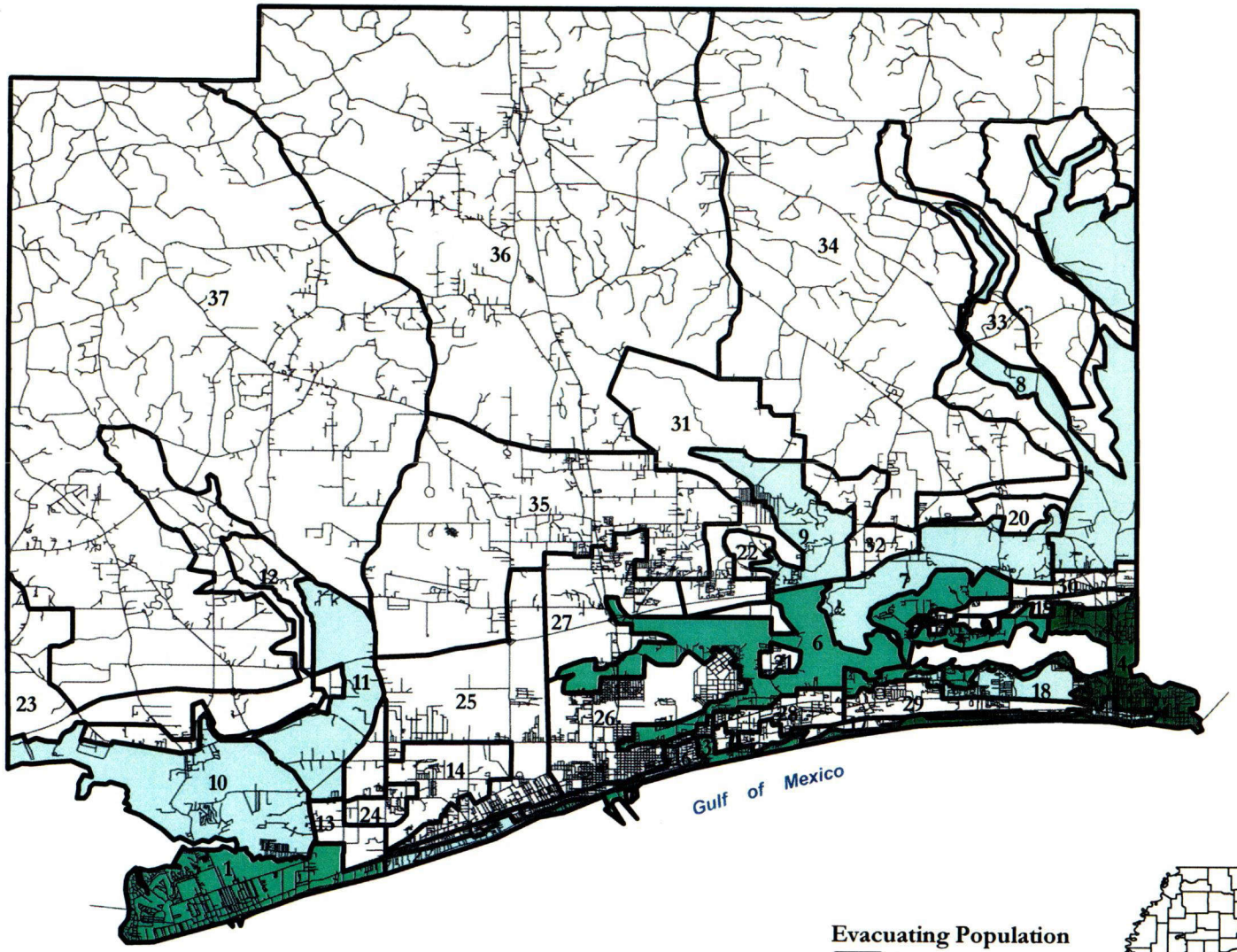
Category 4/5 Hurricane — High Tourist Occupancy

Figure 3-3



Mississippi Hurricane Evacuation Restudy

Harrison County



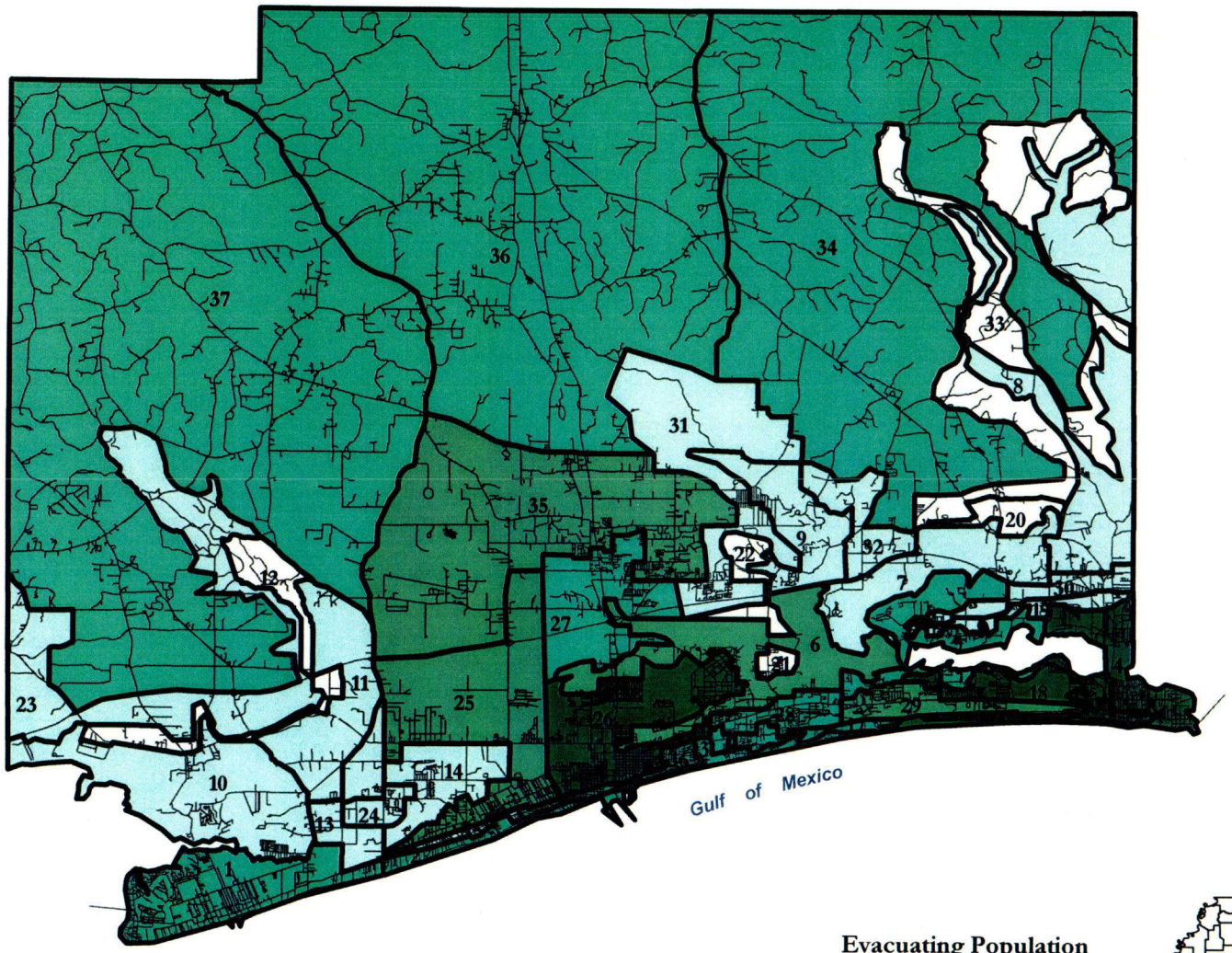
Evacuating Population
- 0 - 1200
- 1201 - 5000
- 5001 - 10000
- 10001 - 15000
- 15001+

2 0 2 4 6 8 Miles

Evacuating Population

Category 1-2 Hurricaine
Low Tourist Occupancy

Figure 3-4



Evacuating Population
- 0 - 1200
- 1201 - 5000
- 5001 - 10000
- 10001 - 15000
- 15001+

2 0 2 4 6 8 Miles

Evacuating Population

Category 4/5 Hurricaine

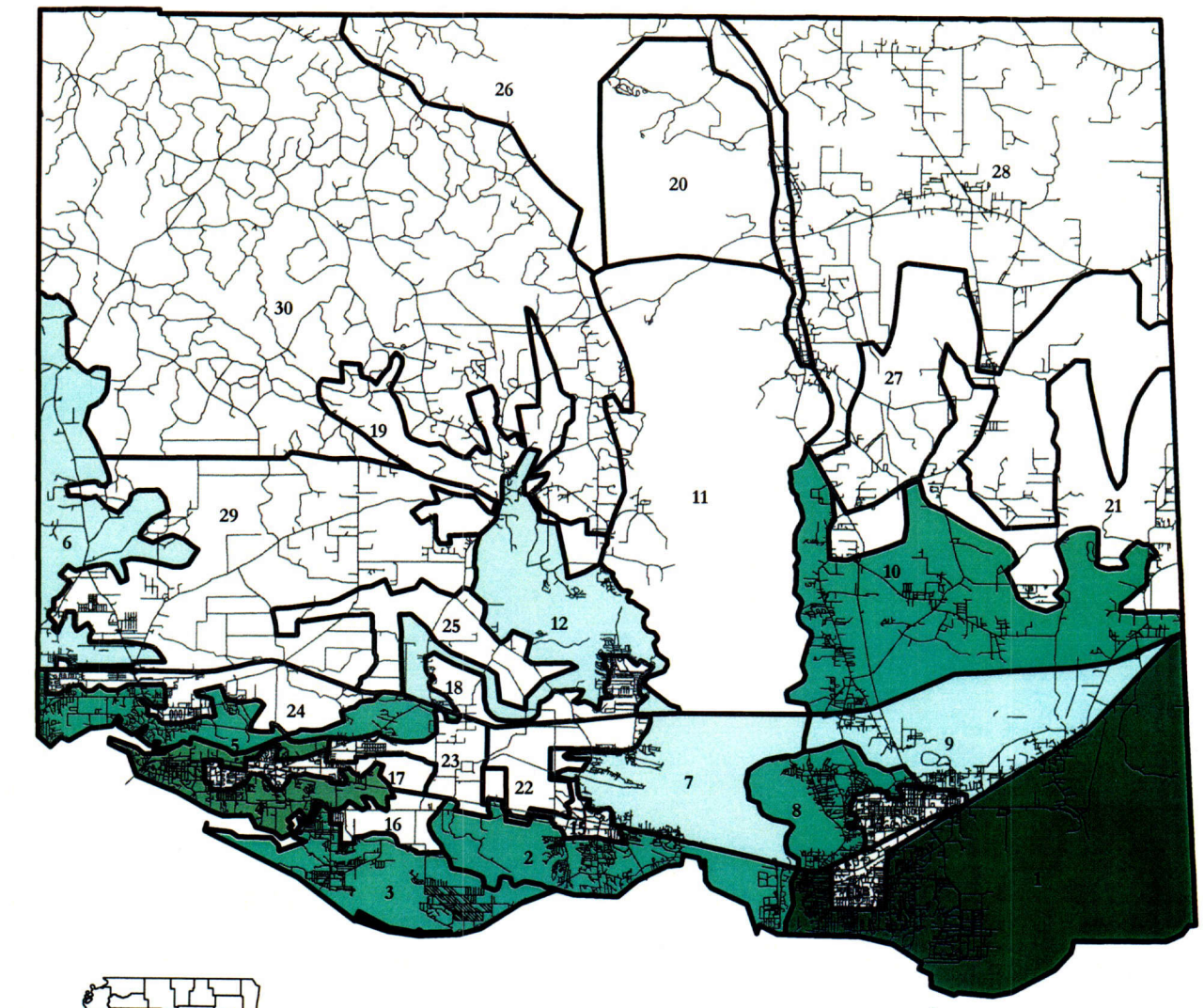
High Tourist Occupancy

Figure 3-5

Evacuating Population

Category 1-2 Hurricane Low Tourist Occupancy

Figure 3-6



Horn Island

Petit Bois Island

Gulf of Mexico

Evacuating Population

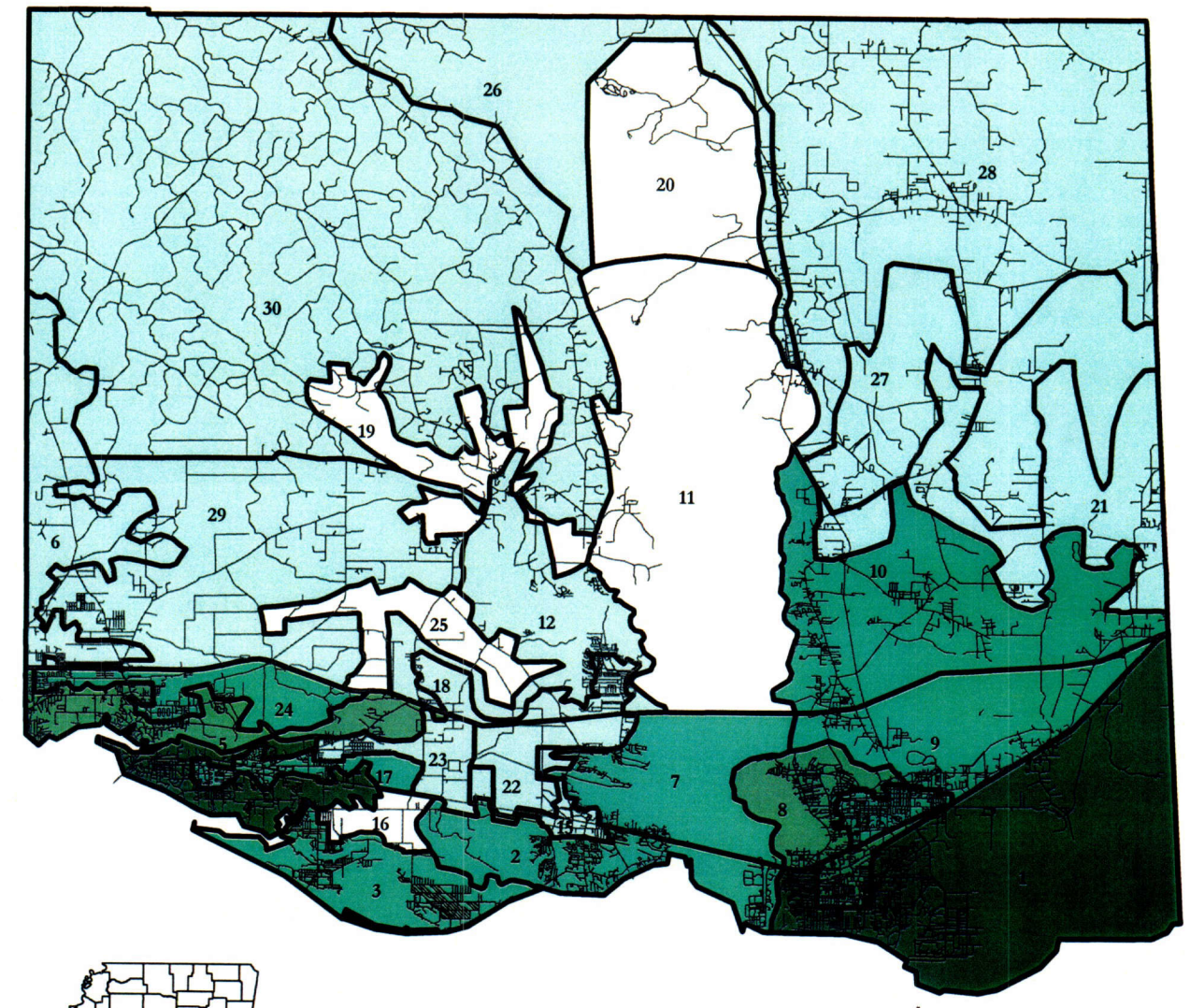
- 0 - 1200
- 1201 - 5000
- 5001 - 10000
- 10001 - 15000
- 15001+

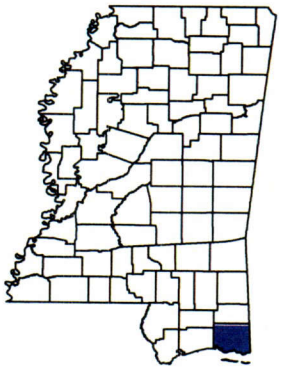
2 0 2 4 6 8 Miles

Evacuating Population

Category 4/5 Hurricane High Tourist Occupancy

Figure 3-7





Horn Island

Petit Bois Island

Gulf of Mexico

Evacuating Population

- 0 - 1200
- 1201 - 5000
- 5001-10000
- 10001 - 15000
- 15001+

2 0 2 4 6 8 Miles

3.3 PUBLIC SHELTER DEMAND/CAPACITY CONSIDERATIONS

One crucial aspect of hurricane evacuation planning involves the coordination of shelter location and capacity to meet the shelter demand of evacuees in any given storm scenario. The counties shelter demand, generally exceeds their theoretical capacities for the higher categories of hurricanes. However, this may be offset in some cases by reducing the square footage per person required, if necessary or by using public shelters in inland non-coastal counties. It should also be noted that in the event that shelter demand exceeds theoretical capacities, local churches and other civic groups may assist with public sheltering needs.

Public shelter locations and capacities were provided to PBS&J for each county by the USCOE. Table 3-1(shown previously) shows potential public shelter demand and reported capacities in each county. Shelter capacities were assigned based on storm scenario. Shelters located within a particular scenario surge area were assumed to have a capacity of zero for that scenario.

One of the aspects of evacuations that PBS&J and HMG have observed nationally over the last five to ten years, is the extremely low public shelter demand that communities are experiencing relative to expected demand from the study processes. In that regard, shelter demand numbers shown in Table 3-1 should be considered high estimates of people seeking shelters.

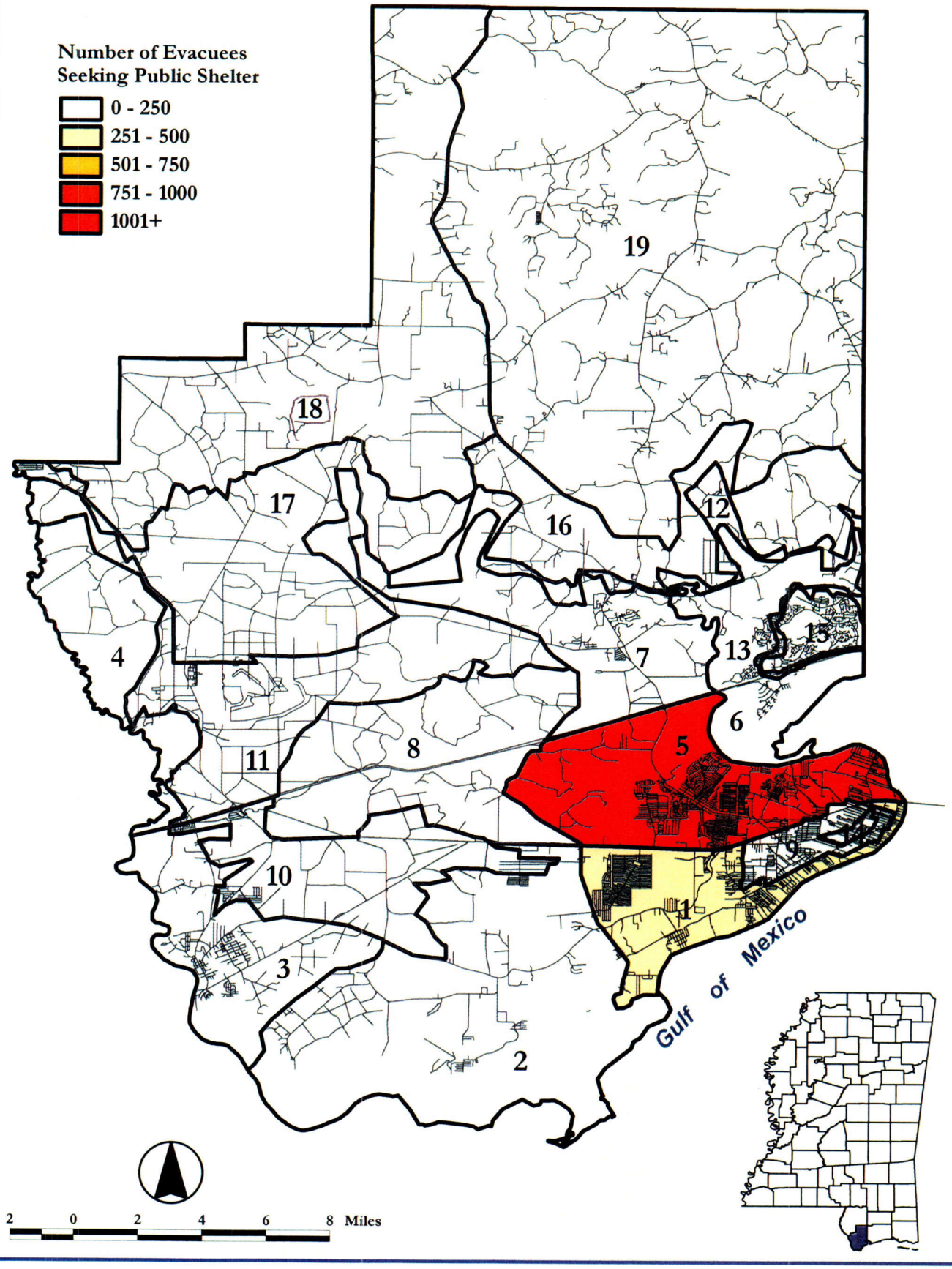
As seen in Table 3-1, public shelter demand generally increases slightly within a county from low to high tourist occupancy for Category 1-3 storms. This demand between low and high tourist occupancy usually remains the same for Category 4-5 storms. A small portion of tourist population generally seeks local public shelters only in lower category storms. There is a tendency for tourists to leave an area during a Category 4-5 storm and return home.

Figures 3-8 through 3-13 illustrate the range of Year 2000 public shelter demand by evacuation zone for each storm scenario. As the counties grow, the need for in-county public shelter space will become greater, particularly if the growth of the mobile home population continues. Since mobile home residents typically have a higher propensity to use local public shelter space than other residents, the high mobile home population in each of the counties may increase the shelter demand. Growth in special needs and elderly populations could also add to the increased demand in this region.

Public Shelter Demand

Category 1/2 Hurricane Low Tourist Occupancy

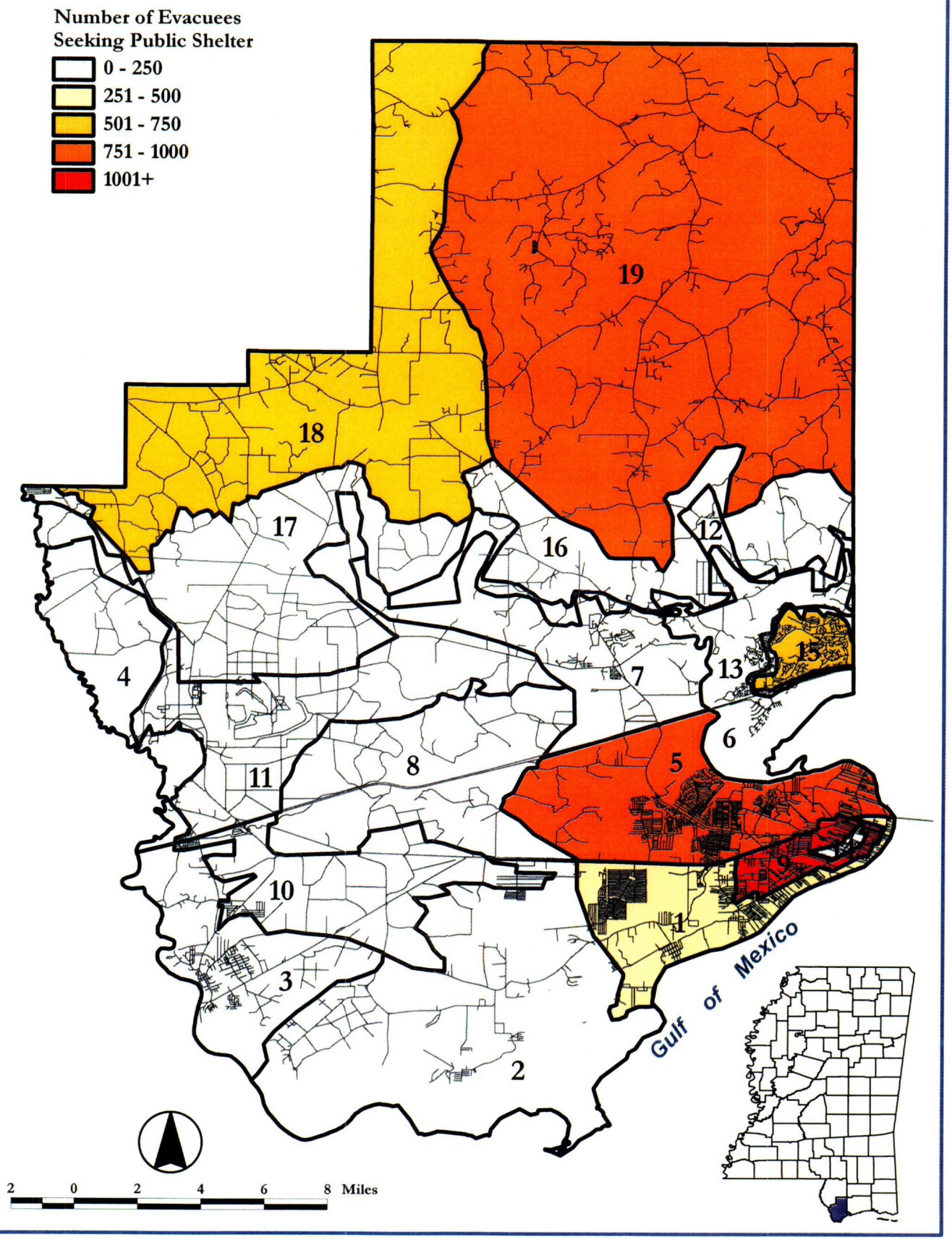
Figure 3-8

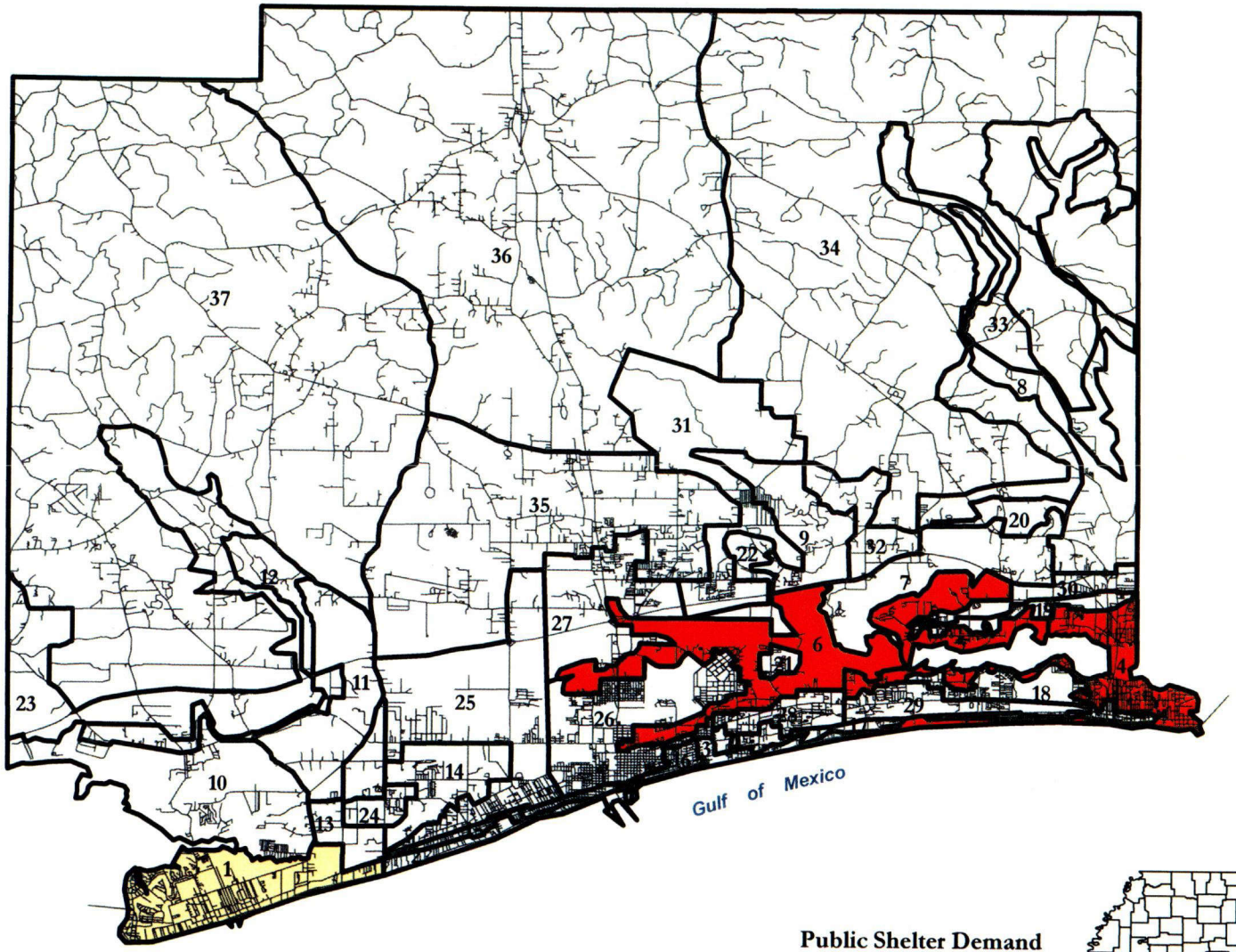


Public Shelter Demand

Category 4/5 Hurricane High Tourist Occupancy

Figure 3-9





Public Shelter Demand

Category 1/2 Hurricaine
Low Tourist Occupancy

Figure 3-10

Public Shelter Demand

Category 4-5 Hurricaine
High Tourist Occupancy

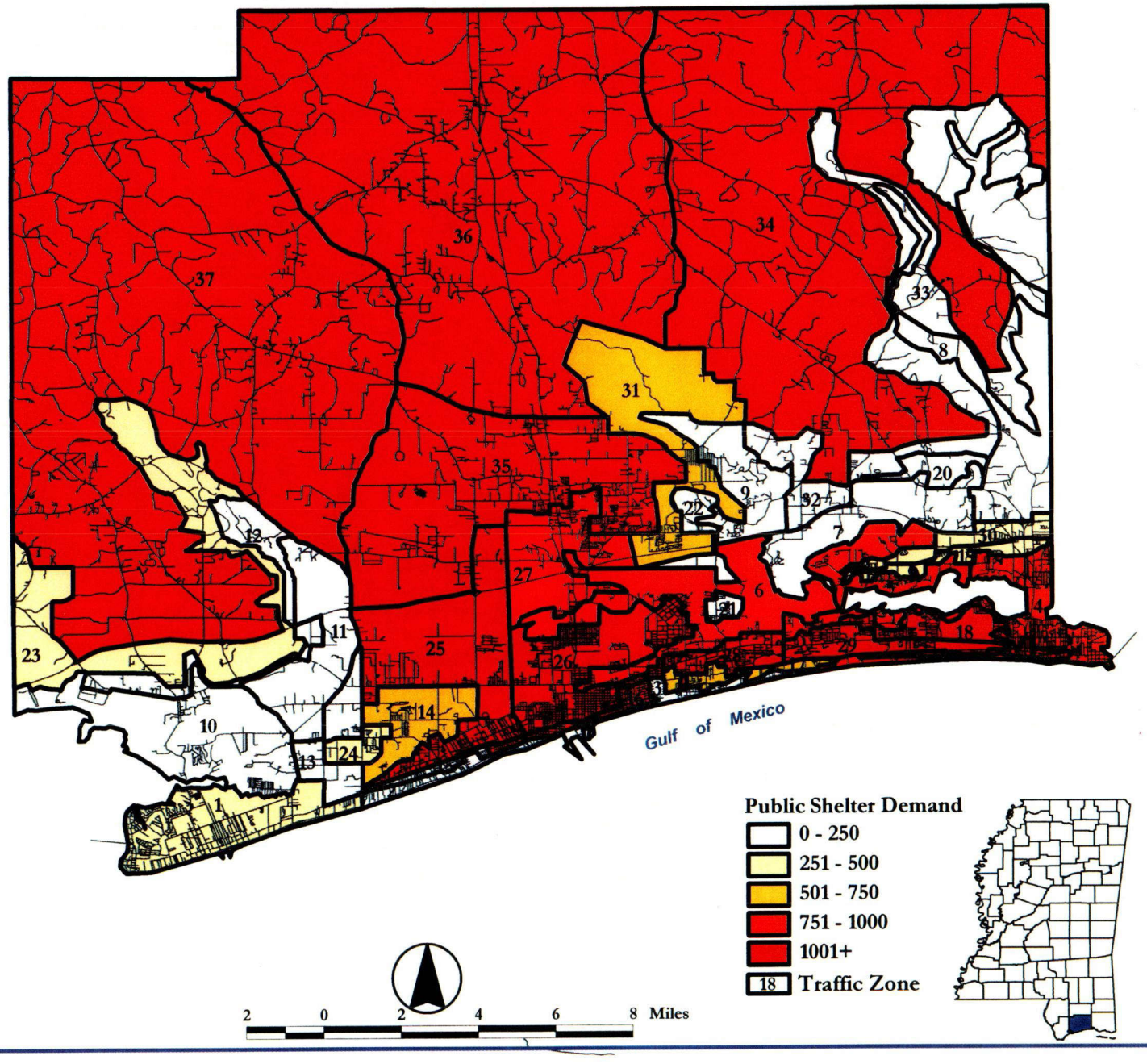
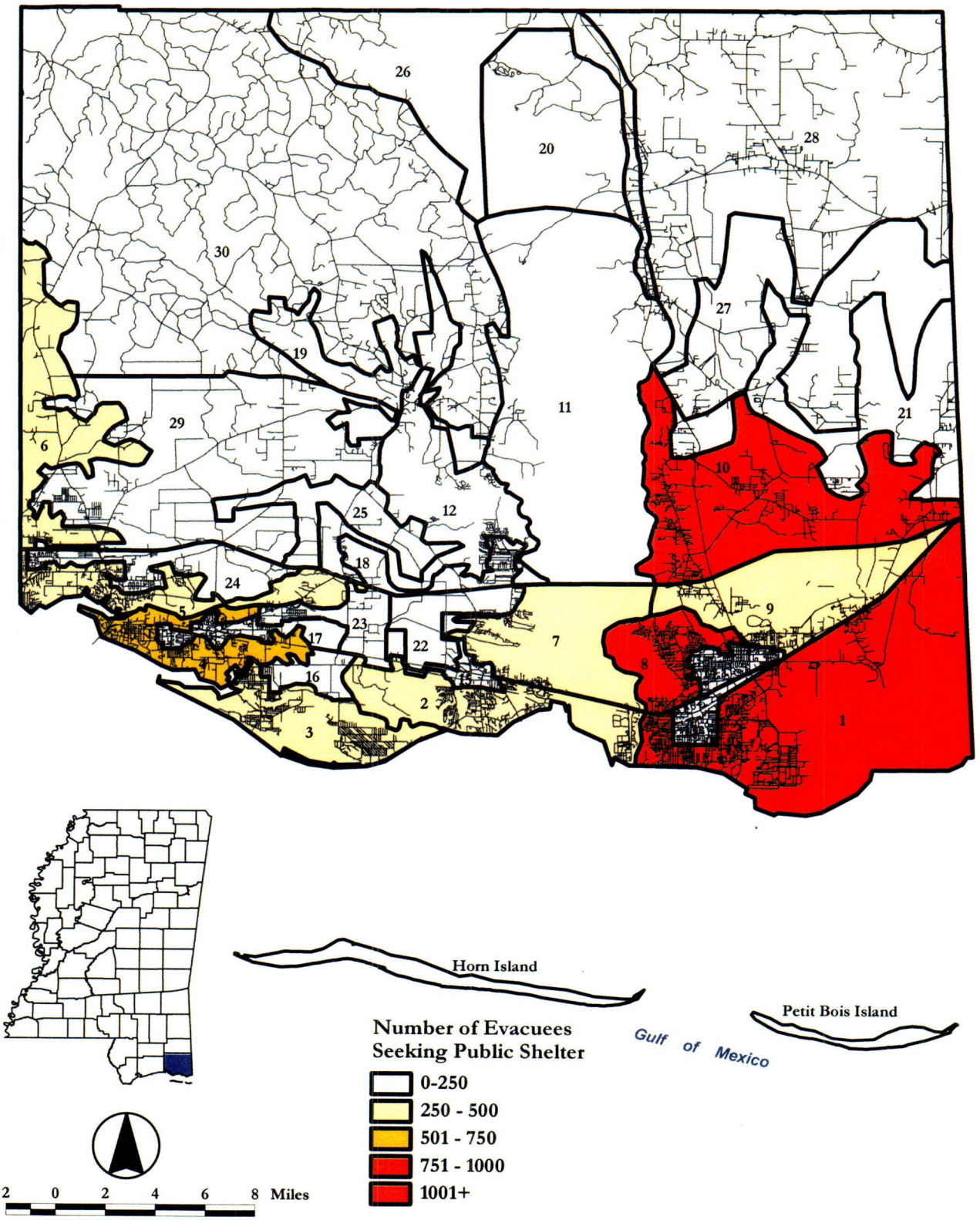


Figure 3-11

Public Shelter Demand

Category 1/2 Hurricane Low Tourist Occupancy

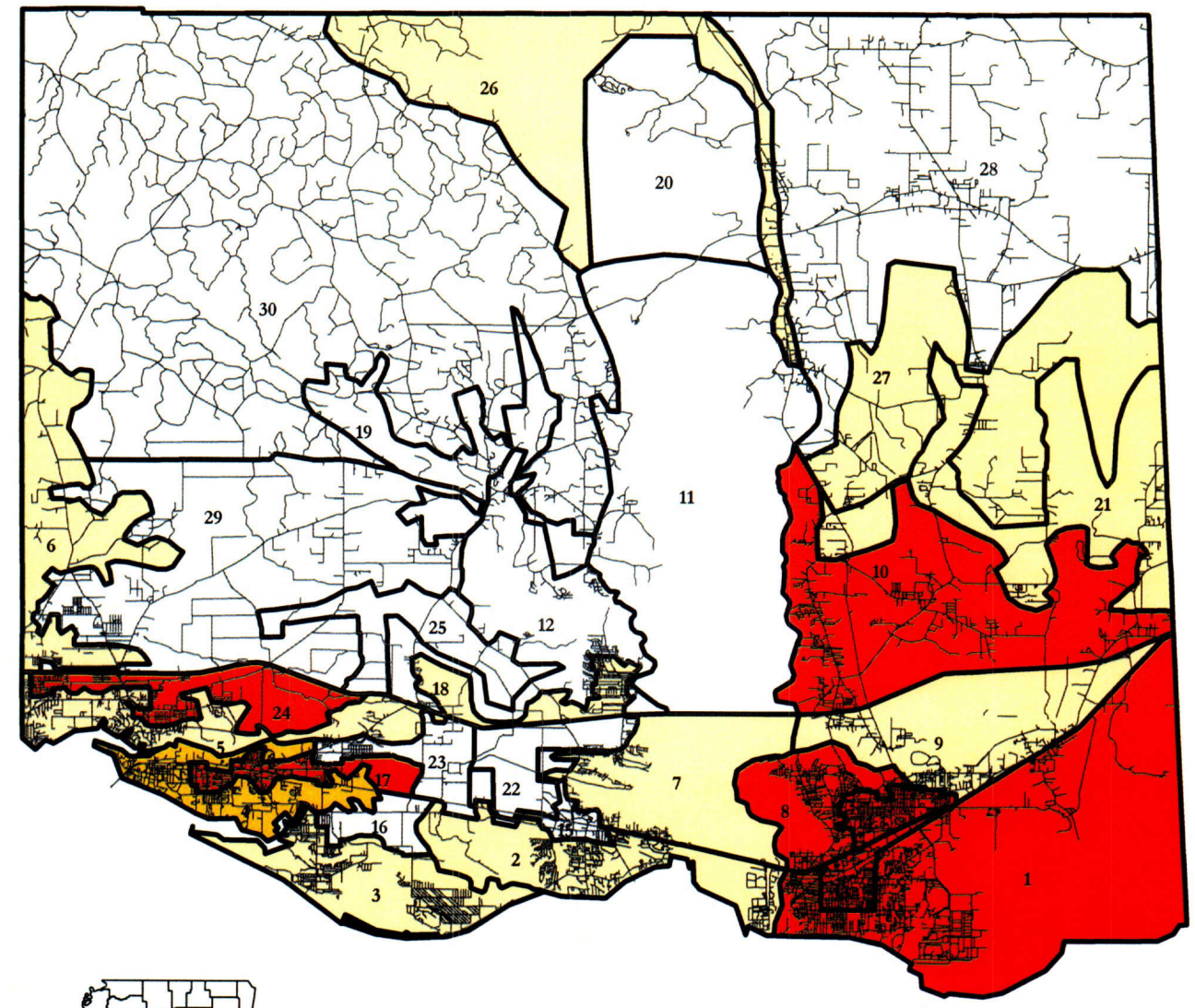
Figure 3-12



Public Shelter Demand

Category 4/5 Hurricane High Tourist Occupancy

Figure 3-13



3.4 EVACUATION TRAFFIC VOLUMES AND CRITICAL ROADWAY SEGMENTS

The assigned evacuating vehicle figures by roadway segment for each Year 2000 storm category by county can be found in the Transportation Model Support Document Appendix. In addition, the Appendix contains the evacuating vehicles to service volume ratio calculated for each roadway segment by storm category. Segments with the highest evacuation vehicles to service volume ratio are considered critical links under a particular scenario. These congested areas control the flow of evacuation traffic during a hurricane evacuation and are key areas for traffic control and monitoring. Many of these same roadways will be supporting not only the evacuating public but also the non-evacuating public attempting to gather supplies and fuel for homes and vehicles. In some cases, depending on the time of the evacuation, residents may also have to travel from work to home before beginning their evacuation movement.

In an urban area such as Gulfport and Biloxi, many locations could be listed, as congestion will be widespread. Table 3-2 lists the most critical roadway segments in each county that will control the flow of evacuation traffic. Table 3-3 lists the routes leaving each county, and the number of vehicles exiting by storm scenario. Figures 3-14 through 3-19 illustrate potential evacuation traffic congestion by roadway segment by storm category and county.

Table 3-2
CRITICAL ROADWAY LOCATIONS/SEGMENTS
Mississippi Transportation Analysis

Hancock County

SR 43 from I-10 to SR 603

Harrison County

US 49 northbound (SR 53 intersection)

SR 15 northbound from I-110 to out of county

Lorraine Road from Pass Road to I-10

Old Pass Road and US 49 intersection

I-110 and US 90 interchange

US 90 (East Beach Blvd) and US 49 intersection

Jackson County

SR 63/SR 613 intersection at Lucedale in George County

SR 57 North of Ramsay Road

SR 609 from US 90 to I-10

Tucker Road from I-10 to Daisy Vestry Road

SR 63 bridge (high level bridge subject to early winds)

Inland Counties

US 49 interchanges with US 98 and I-59

US 49 intersection with US 11 in Hattiesburg

SR 63 and SR 613 intersection at Lucedale

SR 607 interchange with I-59 (northbound on ramp)

SR 53 interchange with I-59 (northbound on ramp)

TABLE 3-3
OUT-OF-COUNTY TRAFFIC VOLUMES BY ROADWAY SEGMENT
Mississippi Transportation Analysis

County	Road Description	Roadway Volume Low Tourist Occupancy			Roadway Volume High Tourist Occupancy		
		Category 1-2	Category3	Category 4-5	Category 1-2	Category 3	Category 4-5
Hancock							
	SR 607 from Santa Rosa to County Line	1,256	2,109	4,462	1,762	2,772	5,035
	SR 43 from Lee Town Road to County Line	2,076	3,272	4,574	3,108	4,493	5,826
	SR 53 from SR 603 to County Line	2,595	4,224	6,731	3,838	5,747	8,439
	SR 53 from SR 603 Eastbound to County Line	100	207	572	167	311	640
	I-10 from SR 607 to County Line	862	1,424	2,194	1,273	1,922	2,729
Harrison	SR 15 North from Bethel Road	9,130	14,841	23,290	12,511	19,109	27,659
	US 49 North of SR 67	7,808	14,169	30,463	10,403	18,003	34,488
	SR 53 from Northrup-Cuevas Road to County Line	1,204	2,357	6,861	1,682	3,089	7,649
	Kiln-Delisle Road from I-10 to County Line	845	1,183	1,784	1,142	1,495	2,101

TABLE 3-3 (continued)
OUT-OF-COUNTY TRAFFIC VOLUMES BY ROADWAY SEGMENT
Mississippi Transportation Analysis

County	Road Description	Roadway Volume Low Tourist Occupancy			Roadway Volume High Tourist Occupancy		
		Category 1-2	Category3	Category 4-5	Category 1-2	Category 3	Category 4-5
Harrison							
	Vadalia Road from JP Lander Road to County Line	845	1,183	1,784	1,142	1,495	2,101
	I-10 Eastbound from I-110 to County Line	2,588	4,323	7,821	3,628	5,658	9,218
	US 90 from I-110 to County Road	1,706	2,922	5,814	2,335	377/	6,703
	US 90 from County Line to Henderson Avenue	1,249	1,916	2,441	1,831	2,568	3,185
	I-10 Westbound from Kiln-Deslisle Road to County Line	2,127	3,614	6,944	2,864	4,612	7,979
Jackson							
	Daisy Vestry Road from Tucker Road	5,185	7,845	10,176	5,925	8,692	11,040
	SR 57 North of Wade Vancleave Road	5,370	8,197	11,523	6,560	9,664	13,030
	SR 63 North of SR 614	5,162	8,671	10,899	6,300	10,077	12,326

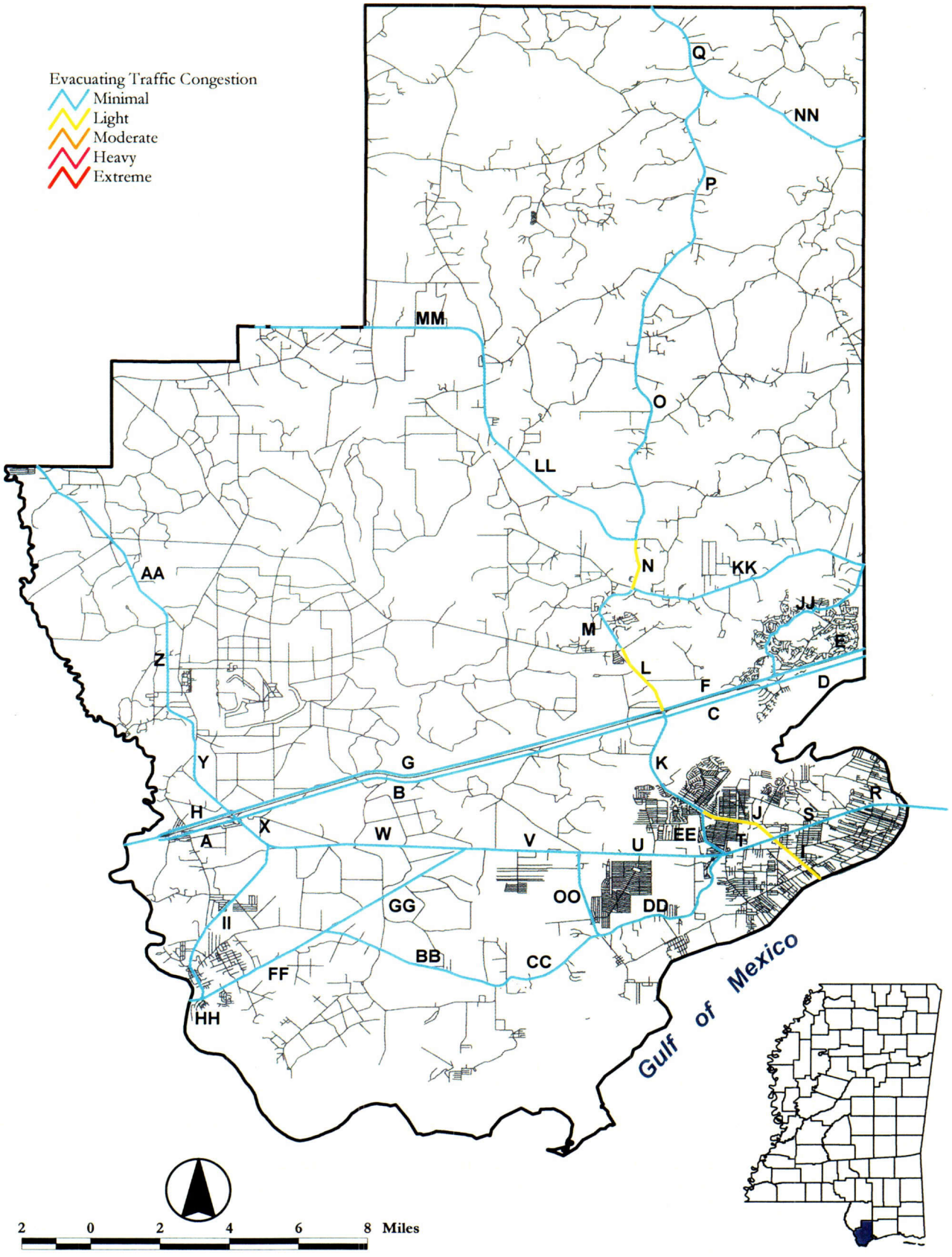
TABLE 3-3 (continued)
OUT-OF-COUNTY TRAFFIC VOLUMES BY ROADWAY SEGMENT
Mississippi Transportation Analysis

County	Road Description	Roadway Volume Low Tourist Occupancy			Roadway Volume High Tourist Occupancy		
		Category 1-2	Category3	Category 4-5	Category 1-2	Category 3	Category 4-5
Jackson	SR 613 North of SR 614	4,546	8,142	9,932	5,489	9,354	11,153
	I-10 Eastbound from Exit 75 to County Line	2,675	4,259	5,292	3,221	4,923	5,970
	US 90 Exit 75 to County Line	2,312	3,665	4,827	2,703	4,183	5,305

Evacuation Traffic Congestion

Category 1-2 Hurricane Low Tourist Occupancy

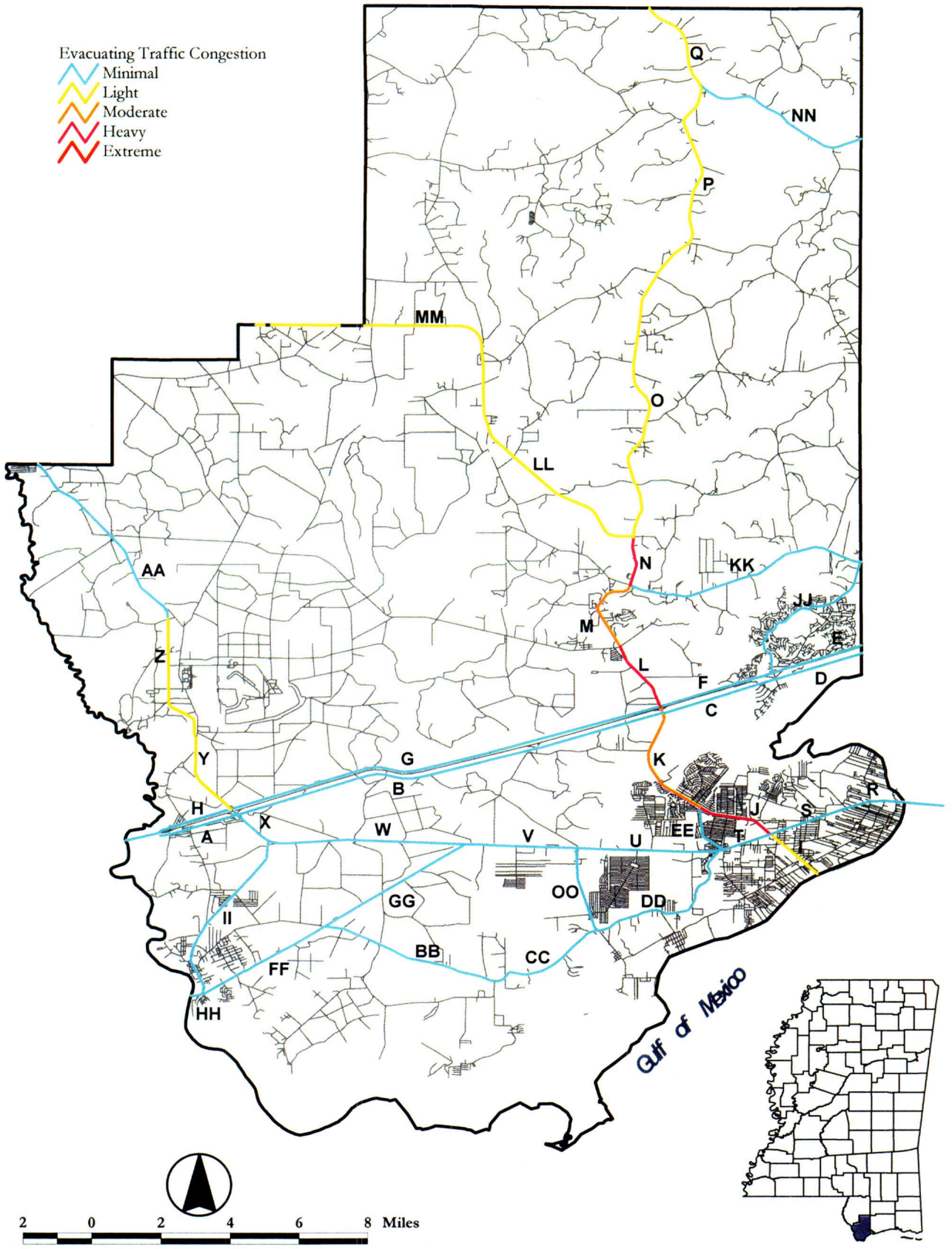
Figure 3-14

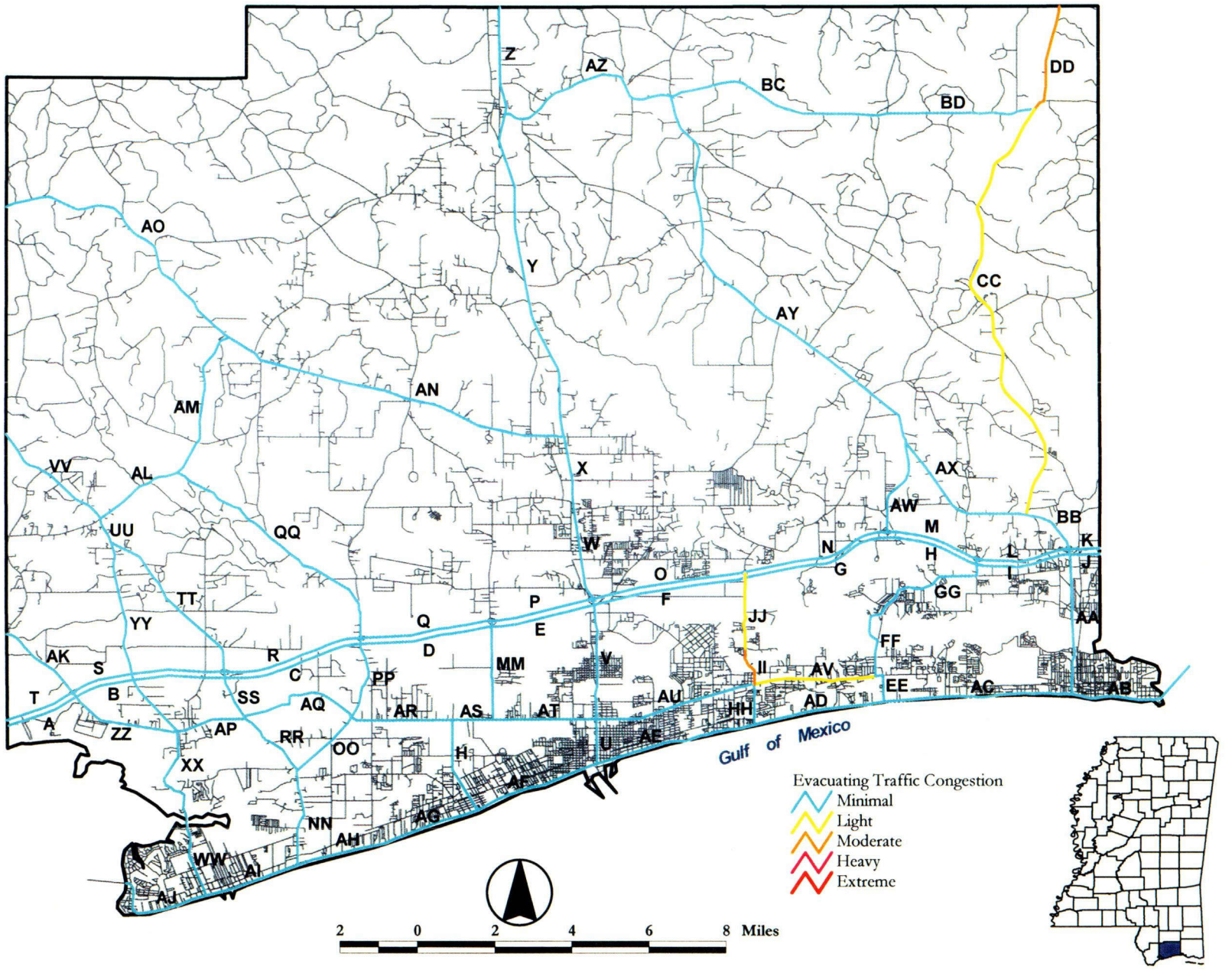


Evacuation Traffic Congestion

Category 4-5 Hurricane High Tourist Occupancy

Figure 3-15

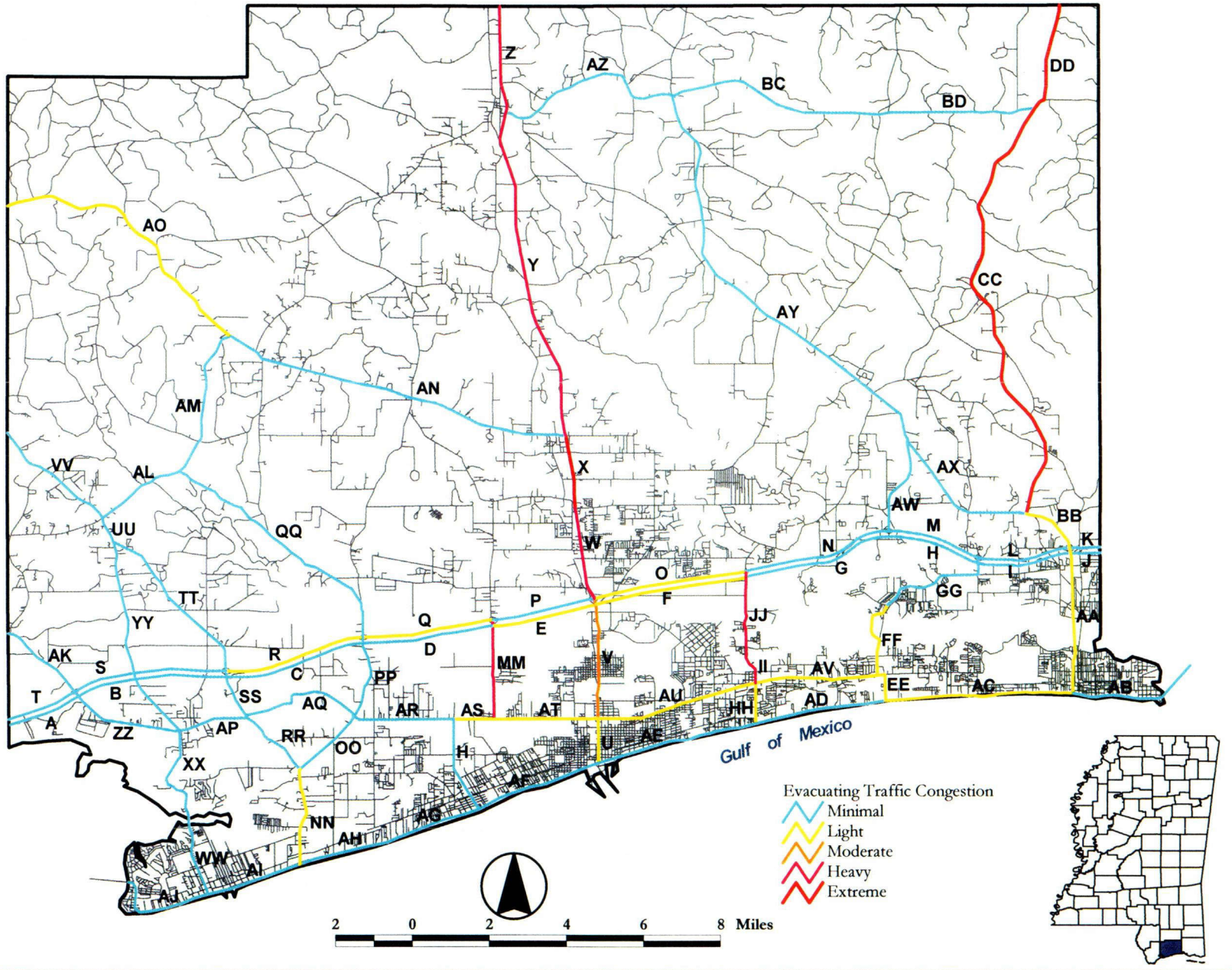




Evacuation Traffic Congestion

Category 1-2 Hurricane Low Tourist Occupancy

Figure 3-16



Evacuation Traffic Congestion

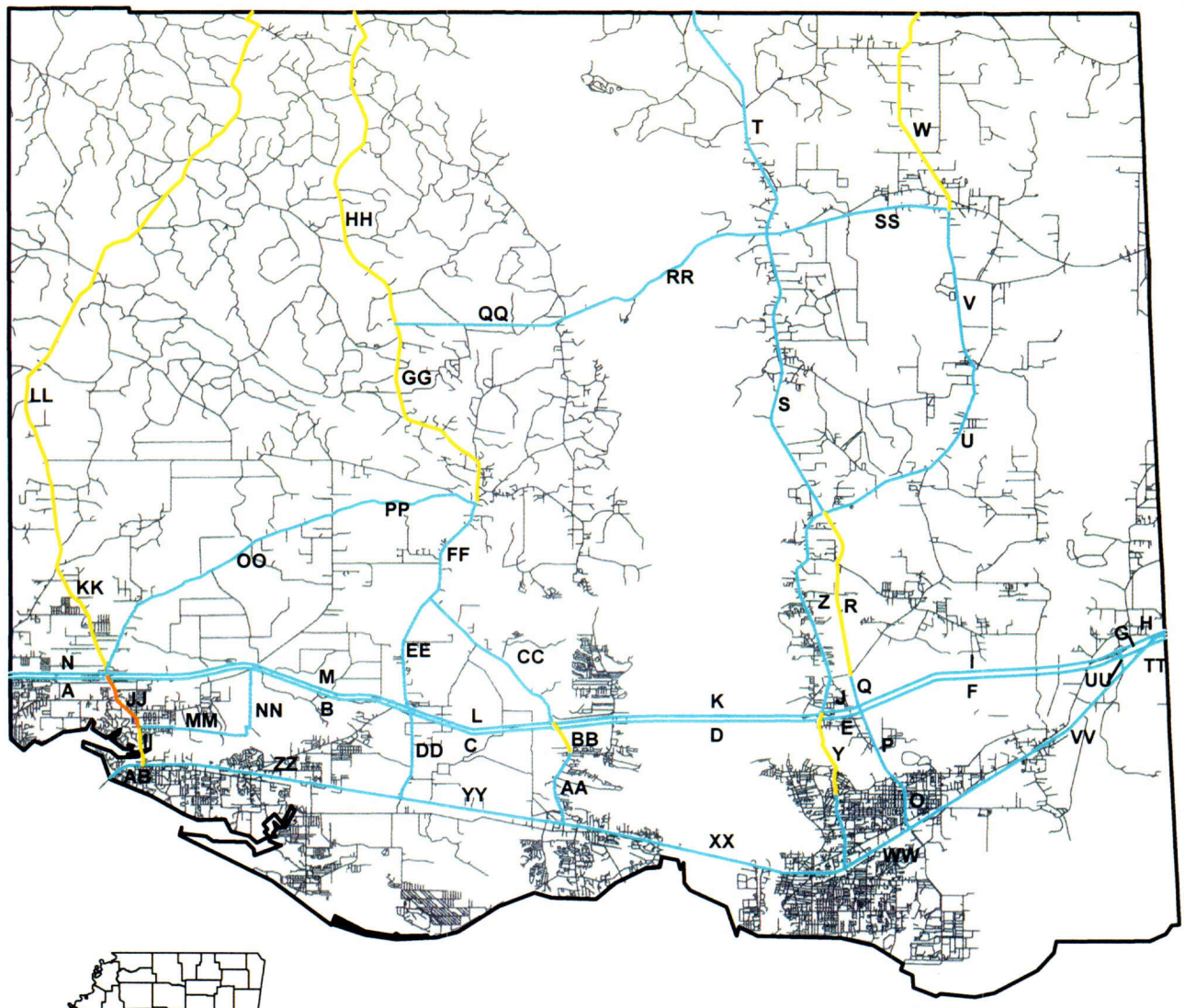
Category 4-5 Hurricane High Tourist Occupancy

Figure 3-17

Evacuation Traffic Congestion

Category 1/2 Hurricane Low Tourist Occupancy

Figure 3-18

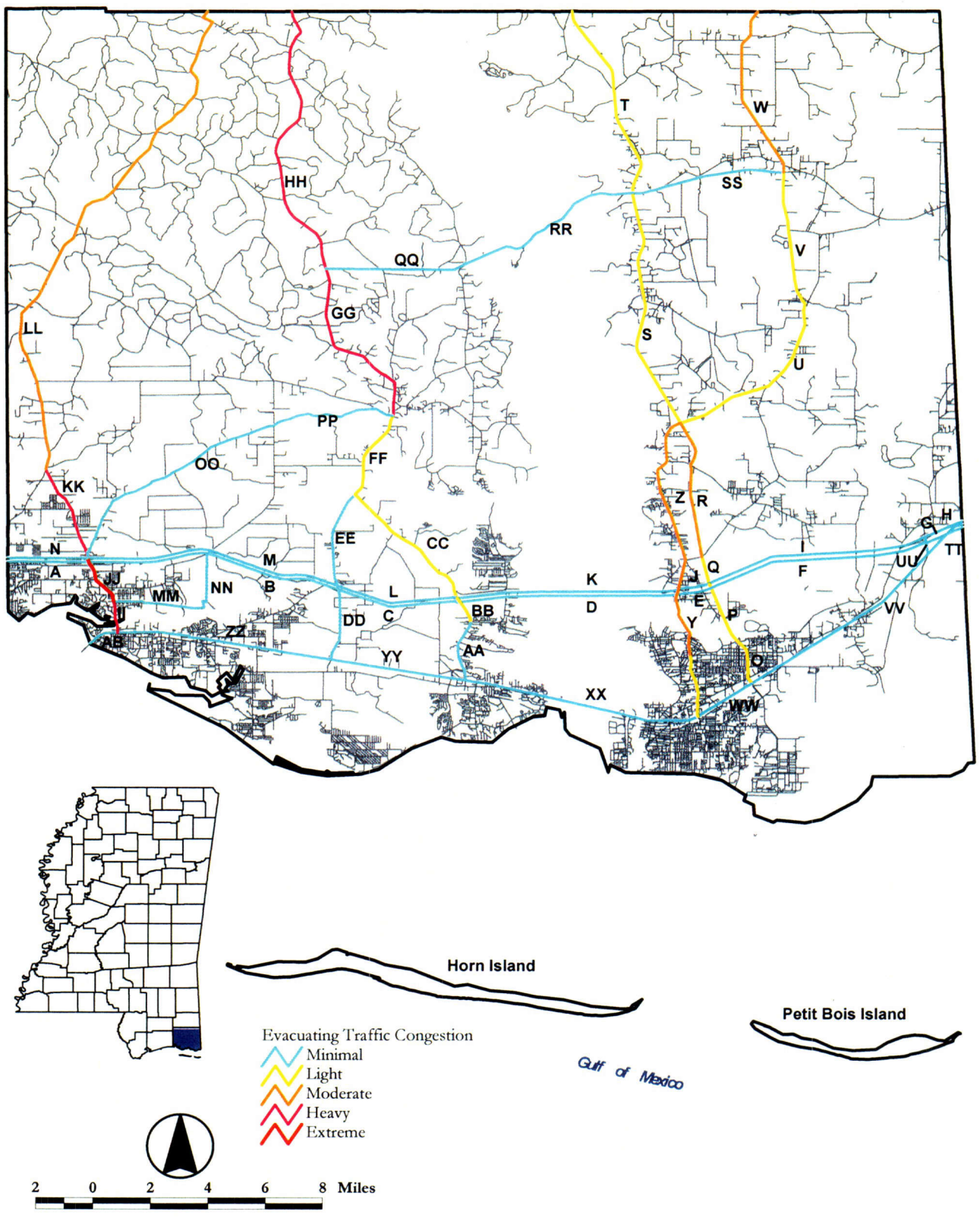


Evacuating Traffic Congestion
- Minimal
- Light
- Moderate
- Heavy
- Extreme

Evacuation Traffic Congestion

Category 4-5 Hurricane High Tourist Occupancy

Figure 3-19



3.5 ESTIMATED EVACUATION CLEARANCE TIMES

An important product of the transportation analysis is the clearance times developed by storm category and by behavioral characteristic for each county. Clearance time is one of two major considerations involved in issuing an evacuation order or advisory. The other time aspect which must be weighed is the arrival of sustained tropical storm winds. Figure 3-20 illustrates these two timing issues of evacuation and their relation.

Clearance time is the time required to clear the roadway of all vehicles evacuating in response to a hurricane situation. **(For study purposes, clearance times were stopped once vehicles reached Hattiesburg or an equivalent northbound distance.)** Clearance time begins when the first evacuating vehicle enters the road network (as defined by a hurricane evacuation behavioral response curve) and ends when the last evacuating vehicle reaches an assumed point of safety. Clearance time includes the time required by evacuees to enter the road network (referred to as mobilization time), the time spent by evacuees traveling along the road network (travel time) and stoppage due to traffic congestion (referred to as queuing delay time). Clearance time does not relate to the time any one vehicle spends traveling on the road network and does not include time needed for local officials to assemble and make a decision to evacuate.

Table 3-3 presents the hurricane evacuation clearance times developed for each county for the Year 2000 storm scenarios. Clearance time runs were accomplished based on differing intensity of hurricanes, levels of background traffic, rapidity of evacuees' response, and differing tourist seasons.

Clearance times fell between 6 and 27 hours for all of the Year 2000 evacuation movement scenarios. Clearance times reflect the effects of adjacent county traffic impacts, and in that regard assume that consistent evacuation decisions will be made and coordinated between adjacent jurisdictions and the State of Mississippi EOC.

The high times for the Category 4/5 scenarios reflect most of the study area's population responding to evacuation and storm information and the funneling of multi-county traffic to only a few available northbound escape routes. Category 4/5 hurricanes will also push a large amount of southeast Louisiana traffic into some of the same destination areas. Table 3-4 shows the maximum potential evacuation traffic entering Mississippi from other states.

TABLE 3-4

MAXIMUM POTENTIAL EVACUATION TRAFFIC ENTERING MISSISSIPPI FROM OTHER STATES

Mississippi Transportation Analysis

Storm Scenario	Louisiana* I-59	Louisiana* I-10	Alabama + Florida I-10	Alabama + Florida US 98	Alabama + Florida US 45
Category 1-2 Medium Tourist Occupancy	12,850	3,395	5,720	720	430
Category 3 Medium Tourist Occupancy	63,250	7,630	18,950	3,100	2,270
Category 4-5 Medium Tourist Occupancy	91,310	16,760	18,950	3,100	2,270

Please Note: Data from Southeast Louisiana is ten years old and is currently being updated by PBS&J under a contract with the US Army Corps of Engineers, New Orleans District.

Components of Evacuation Time

Figure 3-20

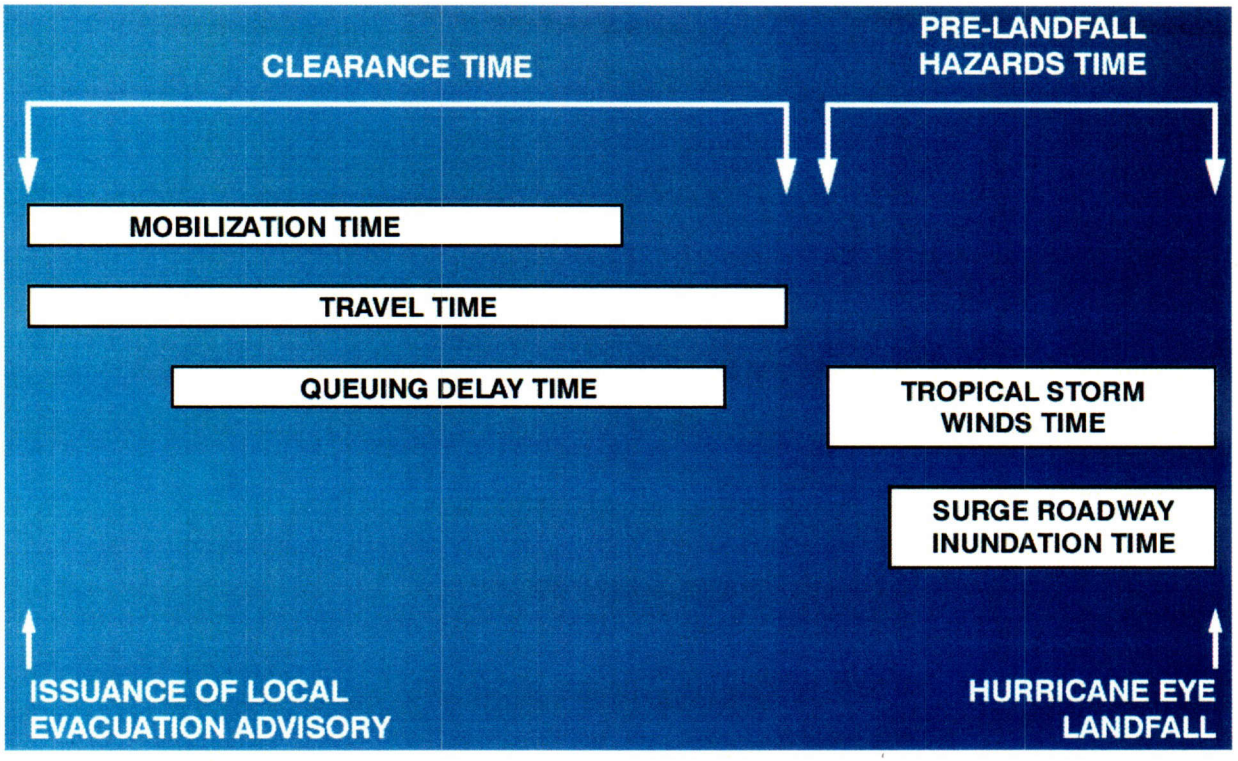


Table 3-5*
YEAR 2000
CLEARANCE TIMES (in hours)
Mississippi Transportation Analysis

Scenario	Response Rate	Hancock		Harrison				Jackson	
		Low Seasonal Occupancy	High Seasonal Occupancy	Low Seasonal Occupancy light background	Low Seasonal Occupancy heavy background	High Seasonal Occupancy light background	High Seasonal Occupancy heavy background	Low Seasonal Occupancy	High Seasonal Occupancy
Category 1-2									
	Rapid Response	8 ¼	11 ¼	6 ¾	7 ¾	8 ½	9 ¾	13 ½	16
	Medium Response	9	11 ¼	9	9	9	10 ½	13 ½	16
	Long Response	12	12	12	12	12	12	13 ¾	16 ¼
worst individual household commute time			6				4 ½		10 ¾
Category 3									
	Rapid Response	12 ¾	16 ½	11	12	13 ¾	14 ¾	22 ½	25 ¾
	Medium Response	12 ¾	16 ½	11 ¼	13	13 ¾	15 ¾	22 ½	25 ¾
	Long Response	13	16 ¾	12	14	14 ¼	16 ¾	22 ½	25 ¾
worst individual household commute time			11				9 ¼		20 ½
Category 4-5									
	Rapid Response	20 ¼	24 ¼	23 ¾	24 ¾	26 ½	27 ½	27 ½	30 ¾
	Medium Response	20 ¼	24 ¼	23 ¾	25 ¼	26 ½	28	27 ½	30 ¾
	Long Response	20 ½	24 ¾	23 ¾	26 ¼	26 ¾	29 ¼	27 ½	30 ¾
worst individual household commute time			19				22		25 ¾

*Socioeconomic data used to develop clearance times were obtained from the Gulf Coast Regional Commission and the 1990 U.S. Census. These data should be checked against the 2000 Census when available. Seasonal data should also be revisited once new data is available.

3.6 GENERAL TRAFFIC CONTROL CONSIDERATION

Some general recommendations concerning traffic control are as follows:

- Where the state and local 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 the northbound 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.

- All draw/swing bridges needed for evacuation should be locked in the "down" position during a hurricane warning, if possible. Boat owners must be made aware of flotilla plans and time requirements for securing vessels.

- The state and counties should jointly work on a statewide evacuation and shelter 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.

- Coordination with the State of Louisiana regarding traffic flow and sheltering requirements will be critical. As this report is being published both states DOTs have undertaken a joint study effort to address these critical concerns.

- 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.