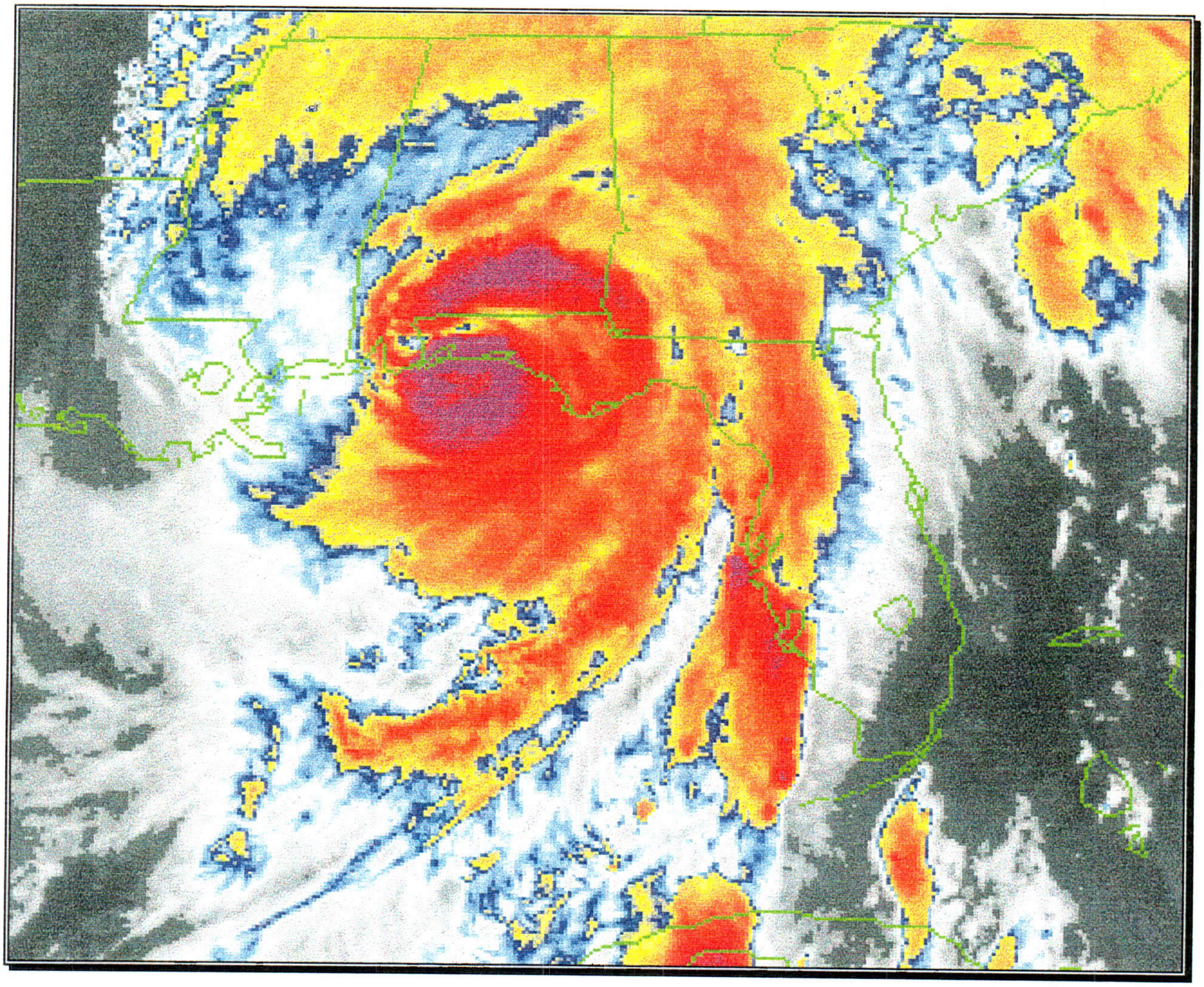
APALACHEE BAY REGION
HURRICANE EVACUATION STUDY
TECHNICAL DATA REPORT
For Gulf, Franklin, Wakulla and Jefferson Counties
Florida
March 1997



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PREFACE

The Apalachee Bay region is lightly populated but most of the population is located along the coastline within the hurricane hazard area. The infrequent occurrence of major hurricanes in the region can contribute to a false sense of security for some public officials and a portion of the citizenry. To further complicate hurricane preparedness, potential storm surges in this area are some of the highest that can be expected along the entire Florida coast. These factors present emergency management officials with a difficult task of developing hurricane evacuation plans that will be reasonably safe and effective.

Government officials and citizens alike must understand that the Apalachee Bay Region will be struck by a catastrophic hurricane some time in the future and that preparedness is of utmost importance. Obtaining information critical to good hurricane evacuation planning requires comprehensive and specialized analyses. The fiscal and staffing limitations of state and local emergency management agencies usually preclude the development of this data. In order to provide the needed technical information, the Federal Emergency Management Agency, the U.S. Army Corps of Engineers, and the National Oceanic and Atmospheric Administration have joined the Florida State Emergency Management Office and local emergency management agencies in conducting the Apalachee Bay Region Hurricane Evacuation Study.

Mobile District

APALACHEE BAY REGION
HURRICANE EVACUATION STUDY

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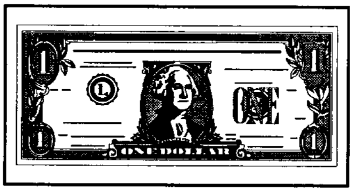
CHAPTER ONE - INTRODUCTION

STUDY PURPOSE

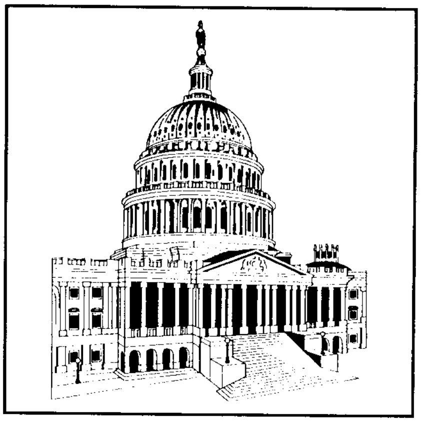
The purpose of this Hurricane Evacuation Study is to provide emergency management officials with realistic data by quantifying the major factors involved in hurricane evacuation decision-making. The technical data presented in this report is not intended to replace any detailed operations plans developed by any of the counties within the study area. Rather, this data is provided as a framework of information that each county can use to update and revise their hurricane evacuation plans and operational procedures to improve their response to future hurricane threats.

FUNDING



The Apalachee Bay Regional Hurricane Evacuation Study was funded by the Federal Emergency Management Agency, the U.S. Army Corps of Engineers and the State of Florida Department of Community Affairs, Division of Emergency Management. Local community officials and agencies provided valuable data and coordination throughout the study at their own expense.

AUTHORITY



The authority for the U.S. Army Corps of Engineers' participation in this study is Section 206 of the Flood Control Act of 1960 (Public Law 86-645). The Federal Emergency Management Agency's participation is authorized by the Disaster Relief Act of 1974 (Public Law 93-288). These laws authorize the allocation of resources for planning activities related to hurricane preparedness.

This study was conducted by the Mobile District, U.S. Army Corps of Engineers, which provided the project management and technical assistance in accordance with U.S. Army Corps of Engineers' publication, Technical Guidelines For Hurricane Evacuation Studies, 1992, and Federal Emergency Management Agency publication CPG 2-16, A Guide To Hurricane Preparedness Planning For State and Local Officials, December 1984.

DESCRIPTION OF STUDY AREA

a. Geography

The Apalachee Bay Region Study area is shown in Figure 1-1. The study area includes the coastal counties of Gulf, Franklin, Wakulla, and Jefferson. The inland counties are Calhoun, Jackson, Liberty, Gadsden and Leon.

There are several large barrier islands and a peninsula along the Gulf and Franklin County coastlines including St. Joseph Peninsula, St. Vincent Island, Little St. George Island, St George Island and Dog Island. Wakulla County has a number of small islands along its coastline with Pine Island being the largest. Jefferson County has by far the smallest coastline of all four Counties with no barrier islands and has the highest hurricane surge heights in the region.

The coastal islands and peninsula separate the bays and sounds from the Gulf of Mexico. All four counties have streams and rivers that empty into the bays and sounds of the Gulf of Mexico.

The orientation of the coastline generally faces west and south in Gulf County and the other three counties face south and south east. Franklin, Wakulla and Jefferson Counties form a large pocket of water called Apalachee Bay. The Apalachicola River flows along the border of Gulf and Franklin Counties and has a drainage basin that extends north of Atlanta, Georgia. The Ochlockonee and Wacissa River basins cover all of Jefferson and Wakulla Counties and the eastern portion of Franklin County.

b. Topography and Geology

The topography of the study area is relatively flat and gradually sloping upward as one moves inland. Jefferson County has the highest ground elevations of all four counties and the smallest area effected by hurricane surges. More than half of Gulf, Franklin and Wakulla Counties are comprised of swamps and wetlands which results in large portions of the counties being inundated by hurricane surge waters.

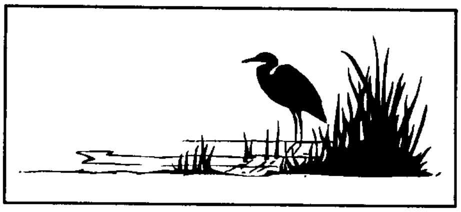
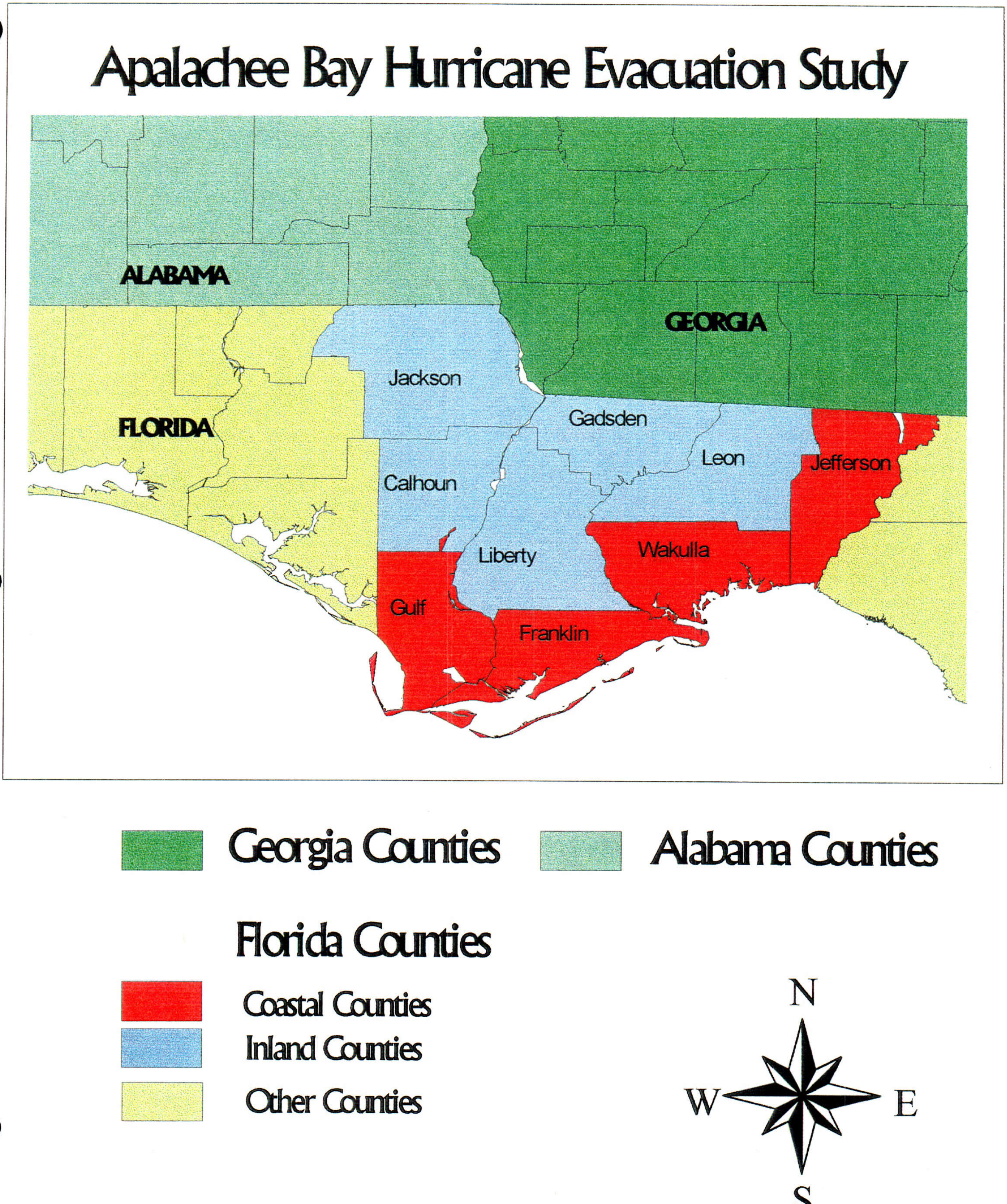


Figure 1-1 General Map of Study Area



In the coastal plains of the Apalachicola River Basin, relatively recent marine sediments, about 4,000 feet thick, rest on a base of older crystalline rock. These sediments consist of gravels, sands, silts, and clays, marls and soft limestone. No major faults are known. The coastal plains soils are sandy and tend to be dry or excessively wet, depending on topography and internal drainage. The flat topography and the dense character of the sediments retard runoff and movement of water through the soils in most of this area. In addition many of the swamps are filled with organic matter which also slows runoff.

The surface soils and bedrock in the Ochlockonee basin are derived entirely from sediments. Bedrock formations in the upper coastal plain are consolidated sands, sands cemented into sandstone, and stratified sandy limestone. In some areas the limestone contain appreciable amounts of clay. In the eastern two-thirds of the lower coastal plains, soluble limestones are at the surface or under a shallow mantle of marine sands. Steeper slopes in this section are generally the result of depressions in the form of sink holes or lake basins made by the solution of limestone and, less often, the result of recent stream action. Few areas in this part of the basin are without sinkholes, but they are irregularly distributed.

The western part of the lower coastal plain area is a region of sands, flat woods, and swamps. Although limestone is near the surface, a high and relatively static ground water has inhibited solution of the limestones. Water stands most of the year in many minor depressions. Jefferson County is underlain with Suwannee limestone. This formation is generally near the surface and outcrops in numerous places. Tampa limestone is prevalent in the eastern portion of Wakulla County. The calcium carbonate in this limestone varies from about 15 to 74 percent or more.

c. Bathymetry

Since shallow water close to shore, tends to increase the magnitude of hurricane-induced storm surge, the slope of the ocean bottom (bathymetry) offshore is extremely important. Apalachee Bay extends along the coastline of Jefferson and Wakulla Counties. The bay is relatively shallow with depths of 2 to 6 feet extending out about 2 miles. The 30 foot depth of water lies about 10 to 12 miles off the coastline of Jefferson and Wakulla Counties. The coastline of Franklin and Gulf Counties are banded with barrier islands which divide a number of sounds and bays from the Gulf of Mexico. The sounds and bays are also relatively shallow with depths ranging from 2 to 20 feet deep. The Gulf of Mexico bathymetry gradually slopes away from the barrier islands with depths reaching 30 feet about 3 miles off shore.

d. Population

The four county study area is generally rural and sparsely populated. Several small towns and cities have a few thousand people with the remaining inhabitants scattered throughout the counties. The following table lists the total population for each of the study area counties for the years 1980 and 1990 along with some other demographic characteristics. The percentage of population change from 1980 to 1990 is also shown.

Table 1-1 Population Characteristics *

ITEM	GULF	FRANKLIN	WAKULLA	JEFFERSON
1980 Population	10,658	7,661	10,887	10,703
1990 Population	11,504	8,967	14,202	11,296
Percent Increase	7.94%	17.05%	30.45%	5.54%
1994 Estimated Pop.	13,808	8,835	15,985	12,700
Households in 1990	4,324	3,628	5,210	3,982
Housing Units in 1990	6,339	5,891	6,587	4,395

* 1980 and 1990 data are from the U.S. Bureau of the Census.
1994 estimates are courtesy of the National Planning Data Corporation.

HISTORICAL HURRICANE ACTIVITY

a. General

Hurricanes are a classification of tropical cyclones which are defined by the National Weather Service as nonfrontal, low pressure synoptic scale (large scale) systems that develop over tropical or subtropical waters and have a definite organized circulation. The classification of tropical cyclones into tropical depressions, tropical storms, or hurricanes depends upon the speed of the sustained (1-minute average) surface winds near the center of the system. Tropical depressions are $\leq$ 33 knots (38 mph), tropical storms are 34 to 63 knots (37-74 mph) inclusive, and hurricanes are $\geq$ 64 knots (75 mph).

The geographical areas affected by tropical cyclones are referred to as tropical cyclone basins. The Atlantic tropical cyclone basin is one of six in the world and includes much of the North Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. The official Atlantic hurricane season begins on June 1 and extends through November 30 of each year; however, occasional tropical cyclones can occur outside of this period.

Early season tropical cyclones are almost exclusively confined to the western Caribbean and the Gulf of Mexico. However, by the end of June or early July, the area of formation gradually shifts eastward, with a slight decline in the overall frequency of storms. By late July, the frequency begins to slowly increase, and the area of formation shifts still farther eastward. By late August, tropical cyclones form over a broad area which extends eastward to near the Cape Verde Islands off the coast of Africa. The period from about August 20 through September 15 produces the most severe hurricanes, many of which travel across the entire Atlantic Ocean. After mid-September, the frequency begins to decline and the formative area retreats westward. By early October, the area of maximum occurrence returns to the western Caribbean. In November, the frequency of tropical cyclone occurrence further declines.

b. Atlantic Tropical Cyclone Basin

Through the research efforts of the National Climate Center in cooperation with the National Hurricane Center, records of tropical cyclone occurrences within the Atlantic tropical cyclone basin have been compiled dating back to 1871. Although other researchers have compiled fragmentary data concerning tropical cyclones within this basin back to the late fifteenth century, the years from 1871 to the present represent the complete period of the development of meteorology and organized weather services in the United States. For the 124-year period from 1871 through 1990, about 1000 tropical cyclones have occurred within the Atlantic tropical cyclone basin data for the years 1871 through 1885 do not allow accurate determinations of the intensities of the storms occurring during those years. The National Hurricane Center maintains detailed computer files of the Atlantic tropical cyclone tracks back to 1886. Of the 889 known Atlantic tropical cyclones of at least tropical storm intensity occurring during the period 1886 through 1990, 519 (58%) are known to have reached hurricane intensity.

Figure 1-2 below illustrates the total number of tropical storms and hurricanes observed on each day, May 1 through December 31, 1886 through 1990.

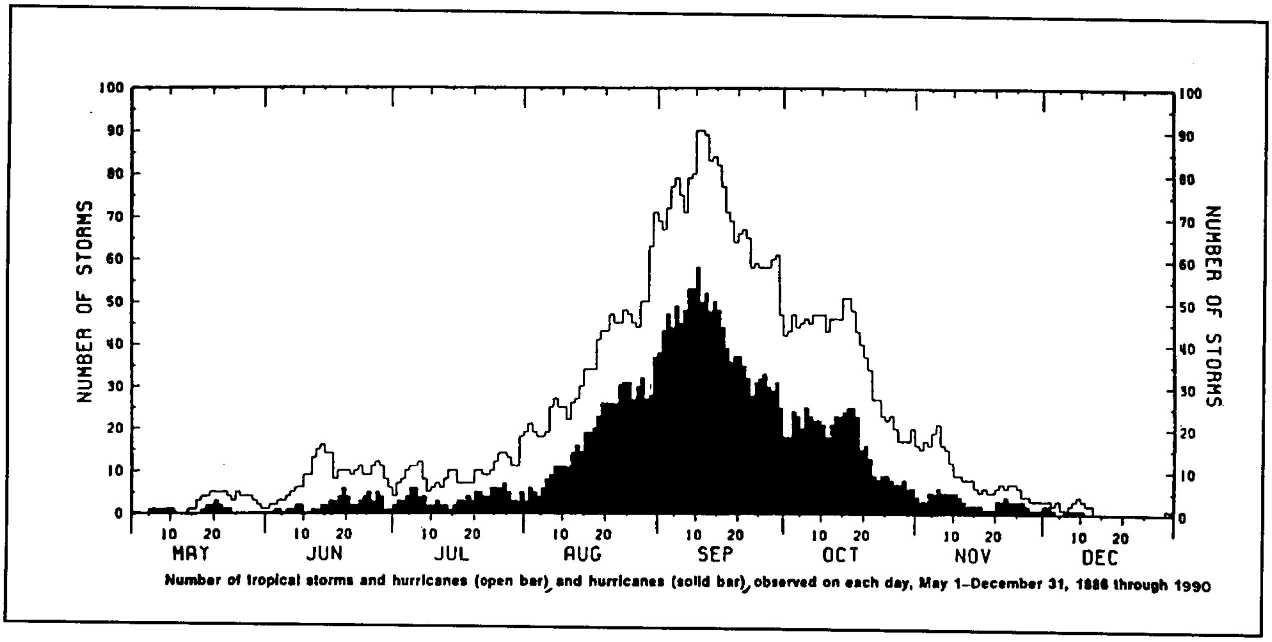


Figure 1-2 Tropical Storms and Hurricanes, 1 May 1886 - 31 Dec 1990

c. Apalachee Bay Region

Between 1886 and 1990, 33 tropical cyclones of hurricane intensity passed within 125 statute miles of Apalachicola, Florida, for an average of one hurricane every 3.2 years. For the period 1871-1885, insufficient data exist to accurately determine which of the tropical cyclones that occurred might have reached hurricane intensity; therefore, for the period of record, 33 hurricane occurrences for the Apalachee Bay Region is probably a conservative estimate.

The tracks of these 33 storms with hurricane force winds are displayed in Figures 1-3 thru 1-9 as follows: storms heading southwest or west-northwestward are in figure 1-3; northwestward moving storm in figure 1-4; north- northwest moving storms in figure 1-5; northbound storms in figure 1-6; north-northeast moving storms in figure 1-7; northeast moving storms in figure 1-8; and east-northeastward moving storm in figure 1-9. In all these figures the track of each hurricane is shown.

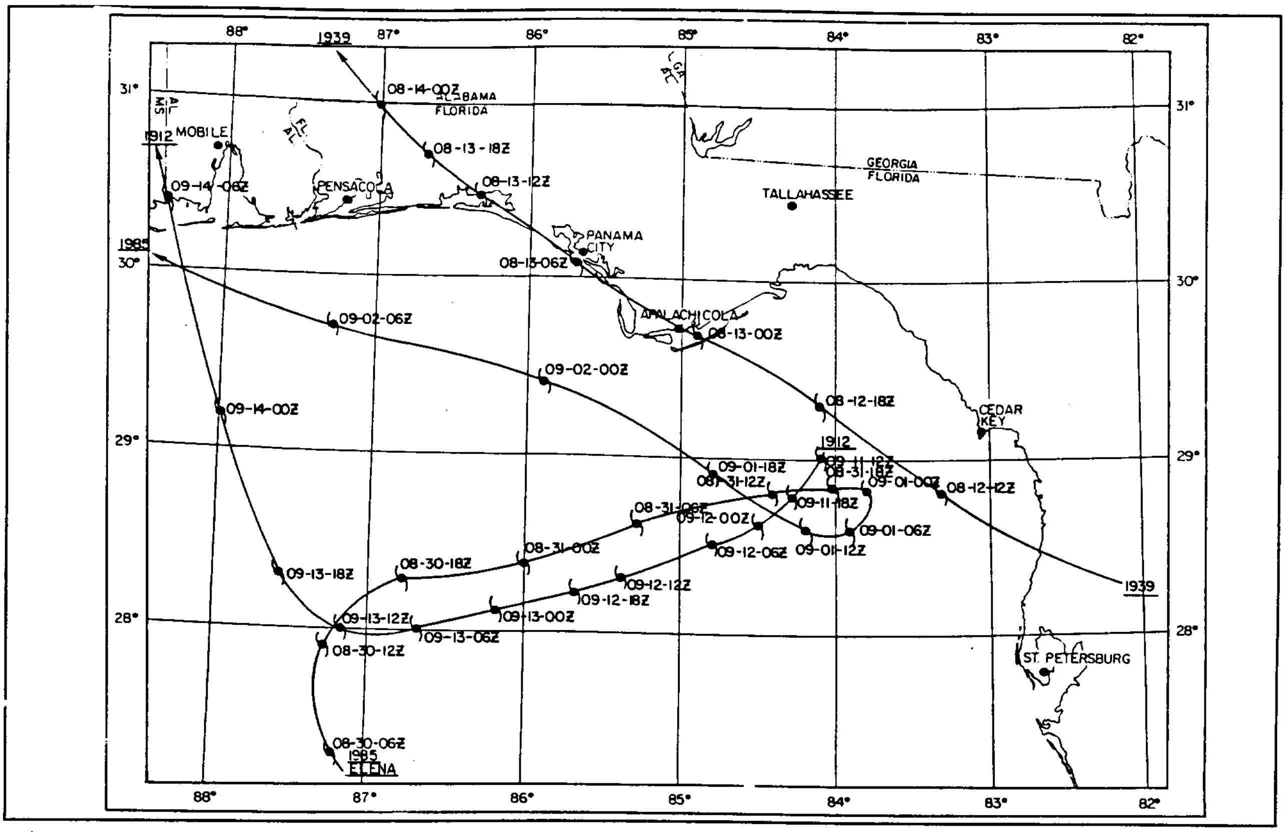


Figure 1-3 Storms moving Southwest or West Northwest.

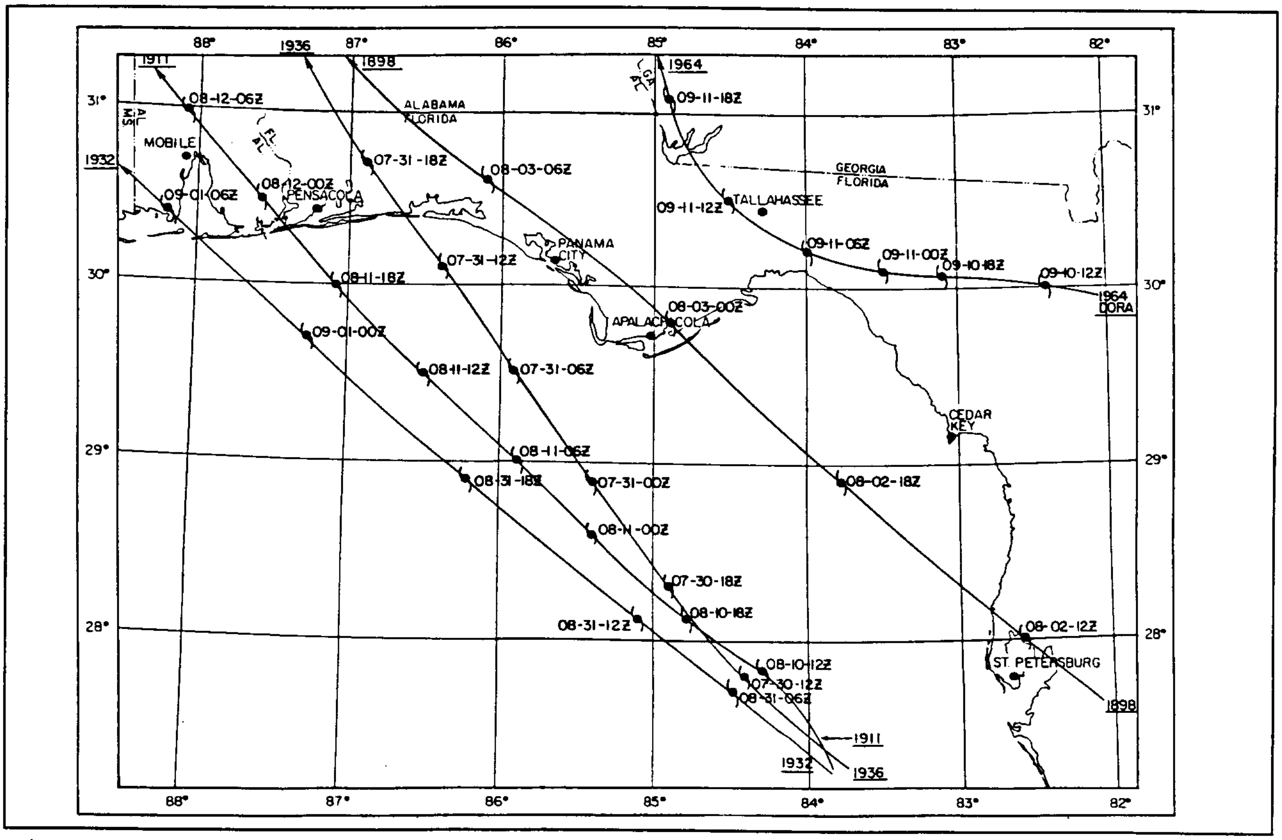


Figure 1-4 Storms moving Northwest.

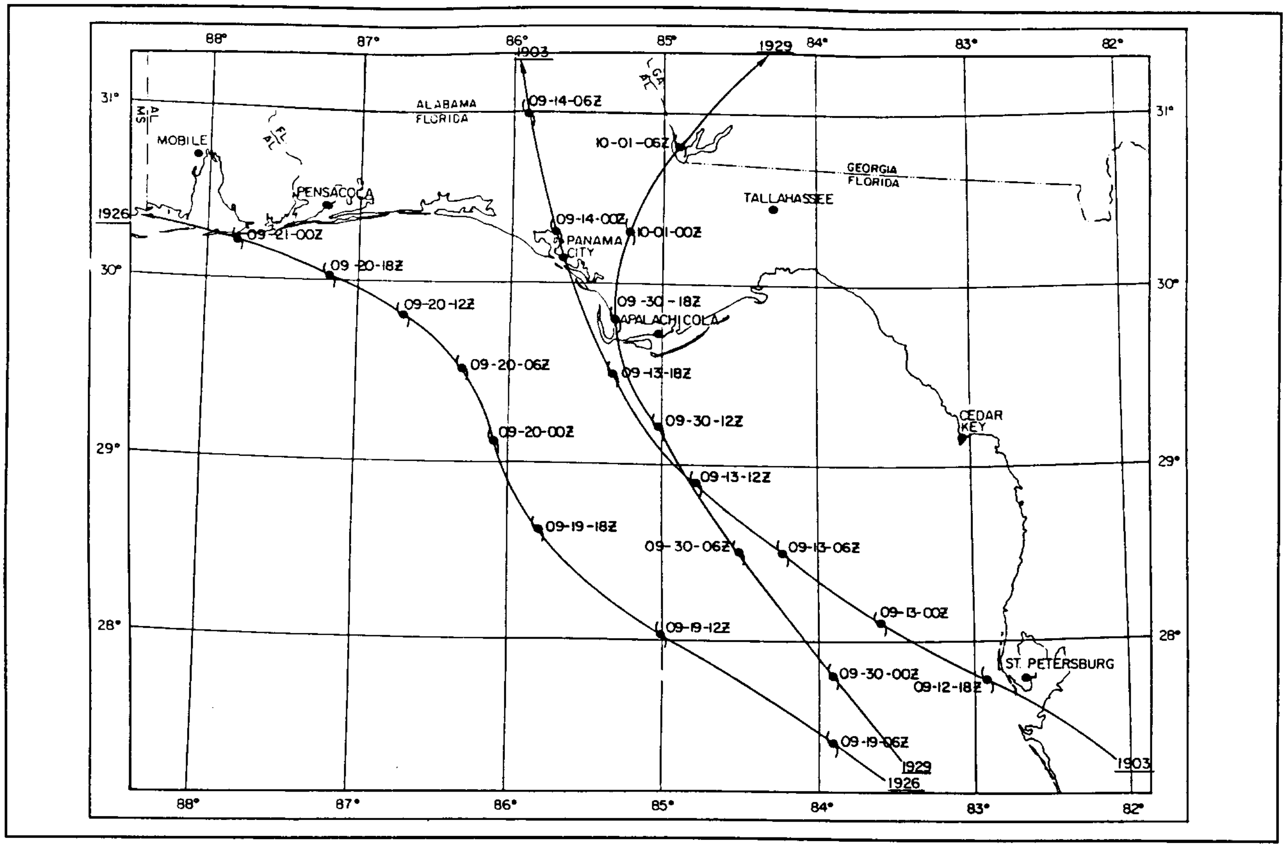


Figure 1-5 Storms moving North Northwest.

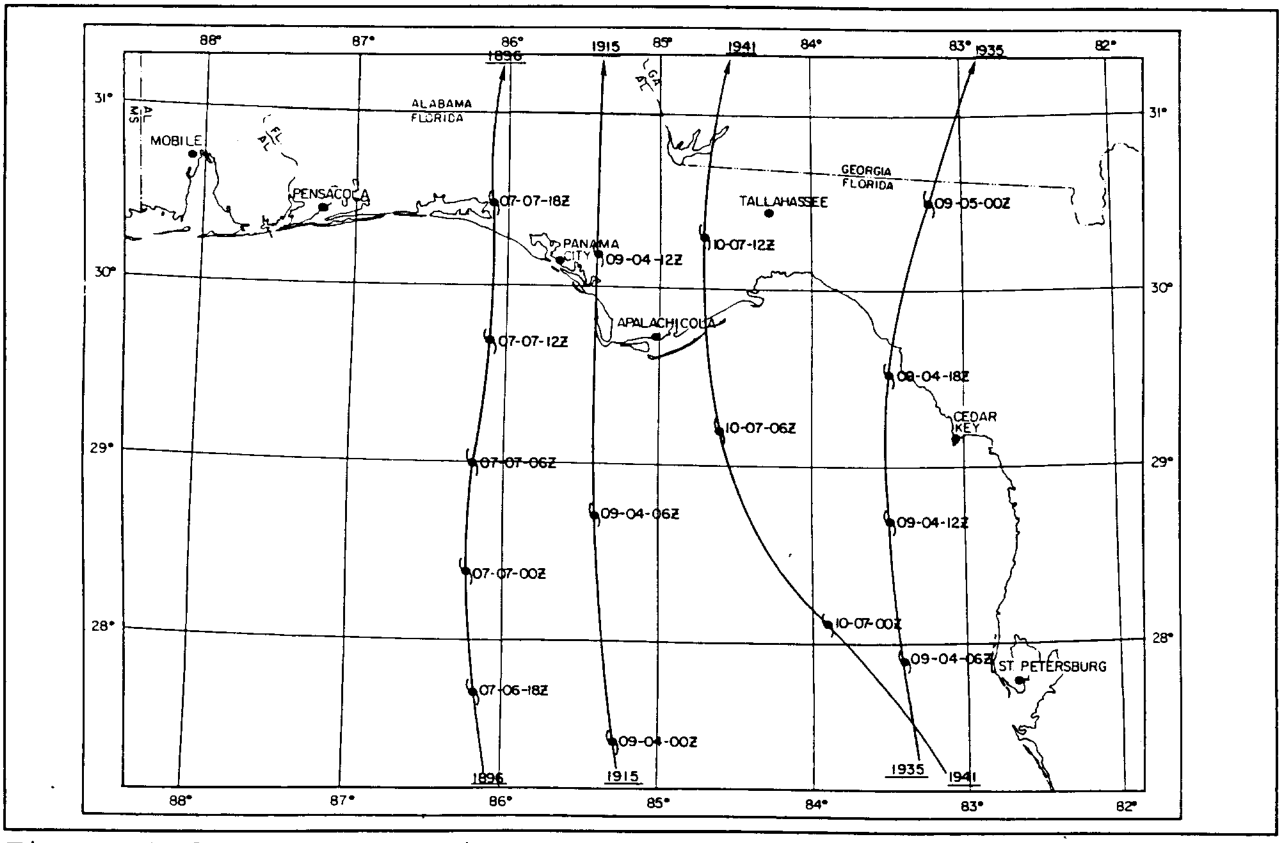


Figure 1-6 Storms moving North.

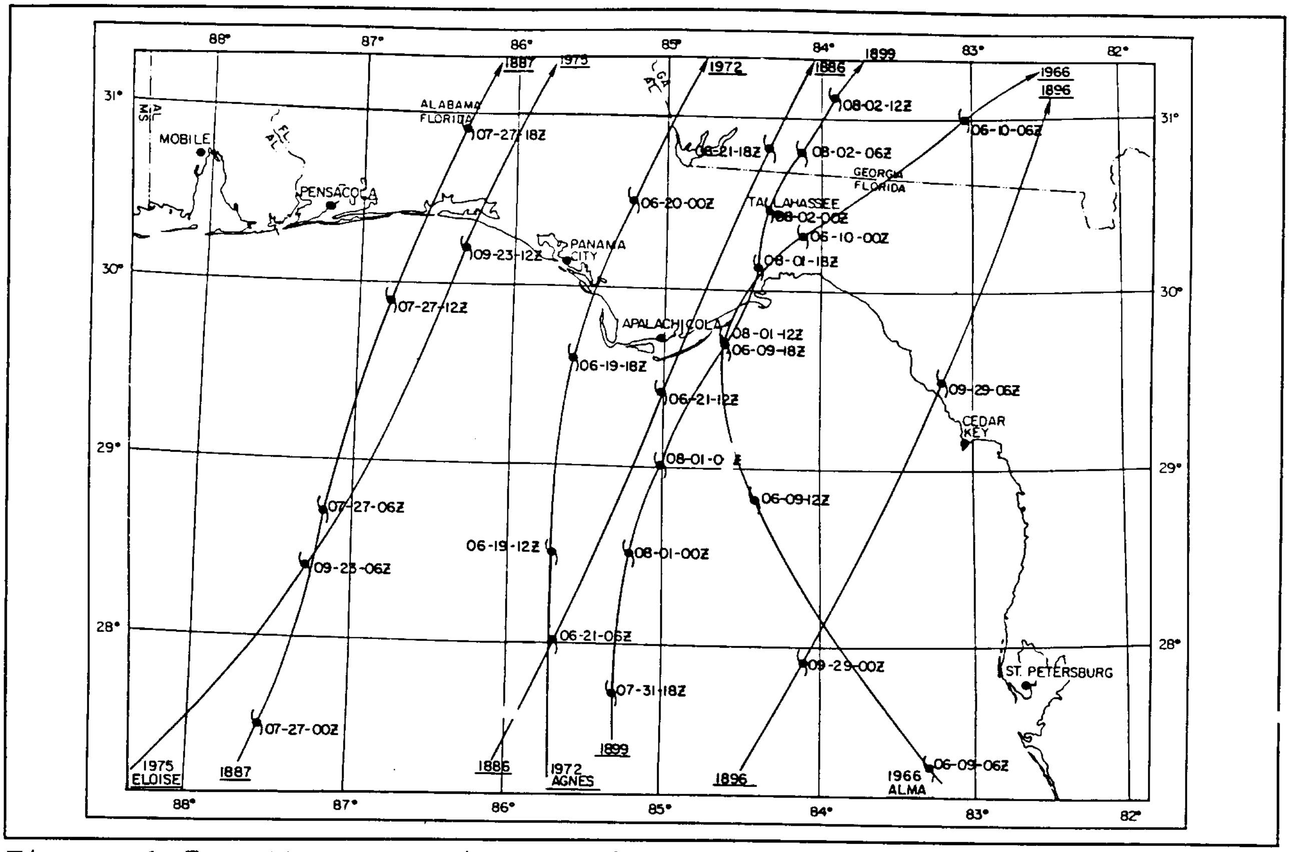


Figure 1-7   Storms moving North Northeast.

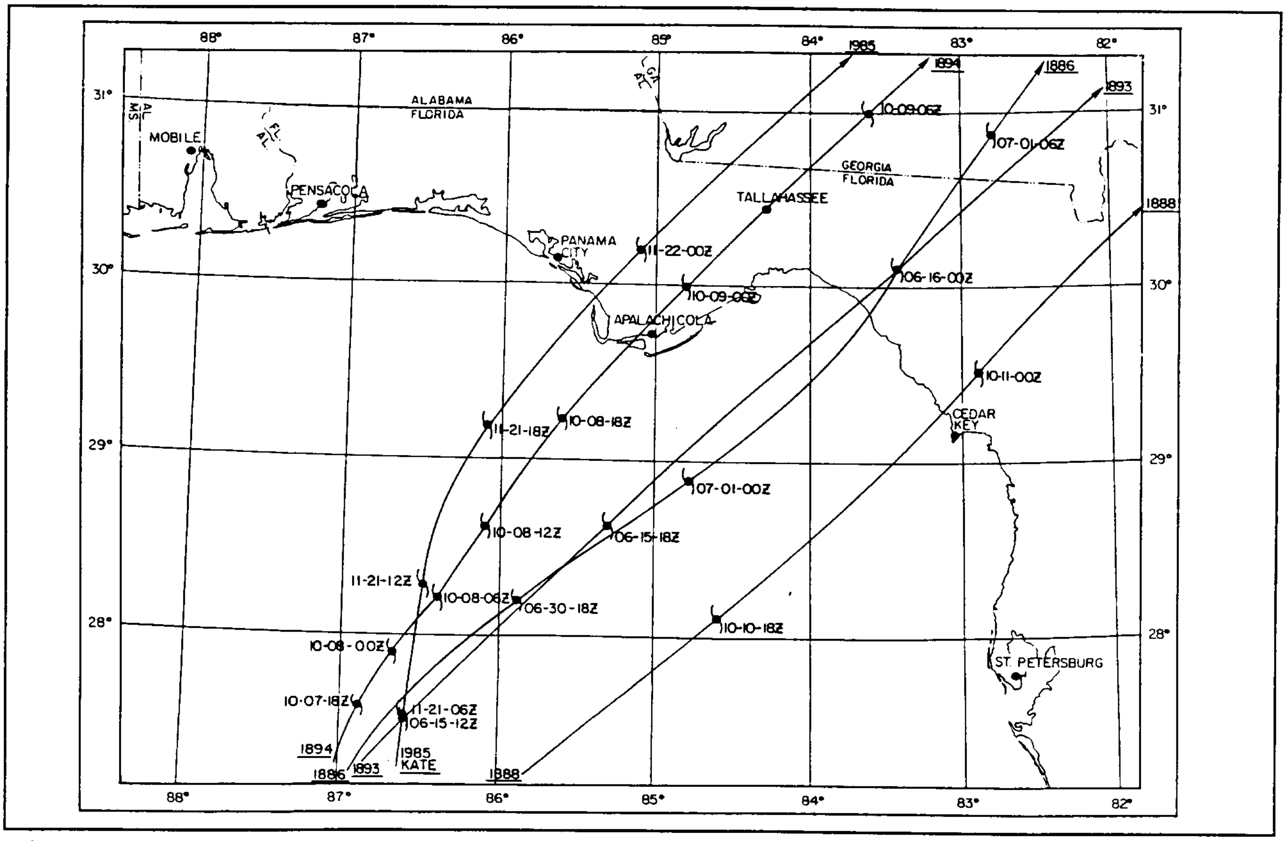


Figure 1-8   Storms moving Northeast.

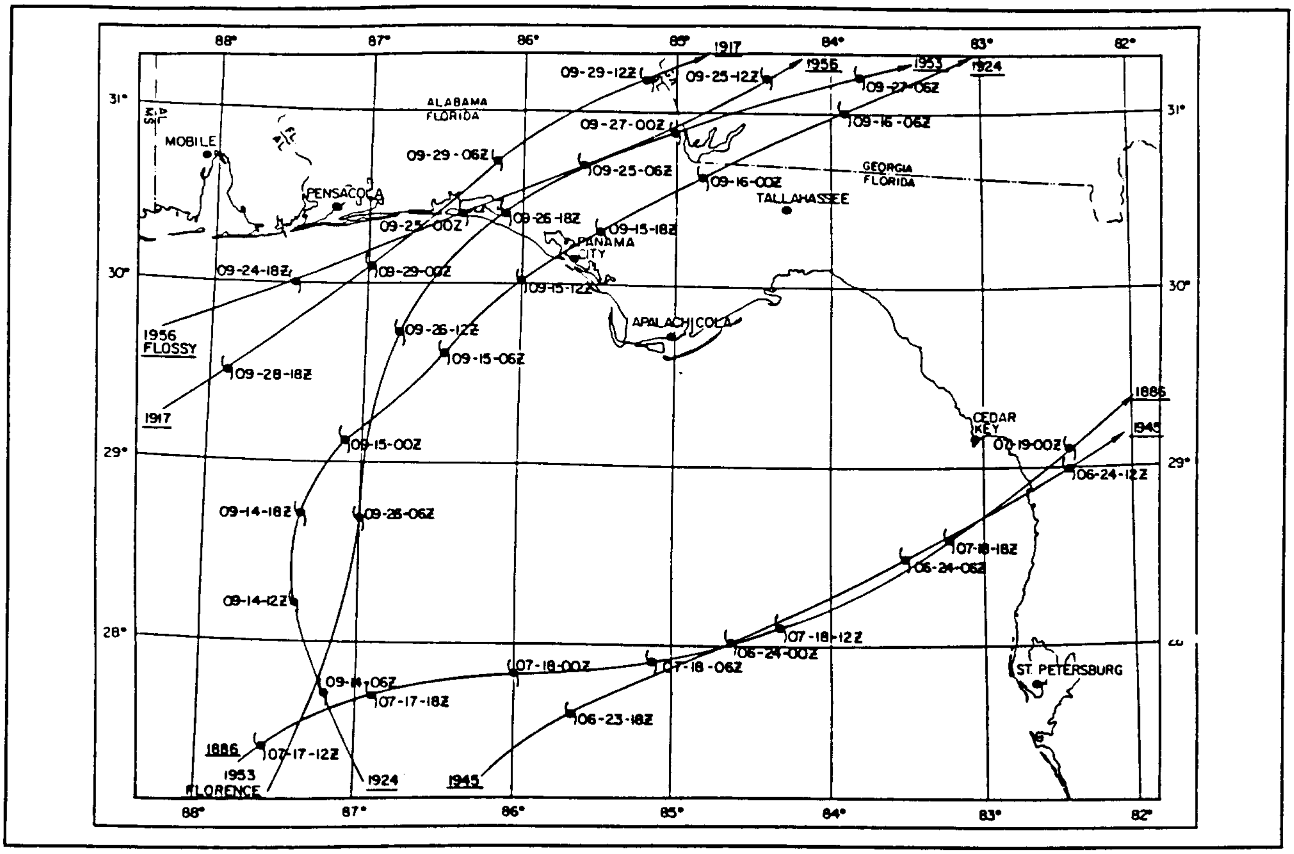


Figure 1-9 Storms moving East Northeast

MAJOR ANALYSES

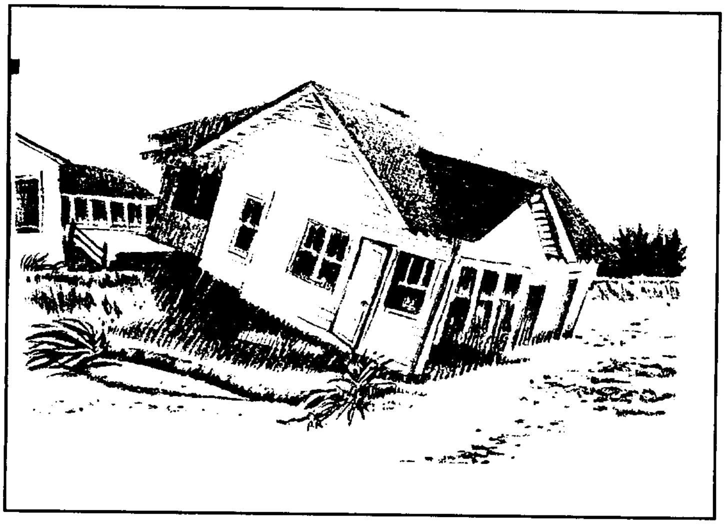
The Apalachicola Bay Region Hurricane Evacuation Study consists of several related analyses that develop technical data concerning hurricane hazards, vulnerability of the population, public response to evacuation advisories, timing of evacuations, and sheltering needs for various hurricane threat situations. The major analyses comprising the Hurricane Evacuation Study are discussed in the following paragraphs with a description of the methodologies for each.

a. Hazards Analysis

The hazards analysis determines the timing, magnitude, and sequence of wind and storm surge hazards that can be expected from hurricanes of various categories, tracks, and forward speeds striking the study area. The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) numerical model was used by the National Hurricane Center to compute surge heights. The potential for freshwater flooding is shown on National Flood Insurance Program maps for each of the counties and must also be considered due to the potential flooding from intense hurricane rainfalls. The Hazards Analysis is presented in more detail in Chapter Two.

b. Vulnerability Analysis

Utilizing the results of the hazards analysis, the vulnerability analysis identifies those areas, populations, and facilities that are vulnerable to specific hazards under a variety of hurricane threats. Inundation maps were produced and evacuation scenarios were developed. Hurricane evacuation zones were delineated for the each of the four counties in the study area. Population data were used to determine the vulnerable population within each evacuation zone. In areas of potential inundation, critical facilities were identified, such as family care homes, nursing homes, and hospitals. Inland wind vulnerability has been evaluated in this study. Further discussion on all aspects of the Vulnerability Analysis is provided in Chapter Three.

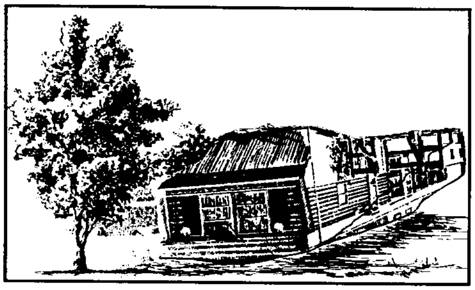


c. **Behavioral Analysis**

This analysis determines the expected response of the population threatened by various hurricane events in terms of the percentage expected to evacuate, probable destinations of evacuees, public shelter use, and utilization of available vehicles. The methodology employed to develop the behavioral data relied on telephone sample surveys and personal interviews within the study area, information from other Hurricane Evacuation Studies, and post-hurricane behavioral studies in other areas. A thorough presentation of the Behavioral Studies can be found in Chapter Four.

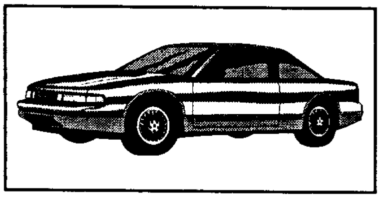
d. **Shelter Analysis**

The shelter analysis presents an inventory of predesignated public shelter facilities, capacities of the shelters, vulnerability of shelters to storm surge flooding, and identifies the range of potential shelter demand for each county. Inventories of predesignated shelters were furnished by the various emergency management offices in each county. Not all the predesignated shelters within the study area are located above expected surge inundation elevations. Potential shelter demands for ranges of hurricane threats were developed using data from the behavioral analysis. Chapter Five contains additional information on the Shelter Analysis for the Apalachee Bay Region.



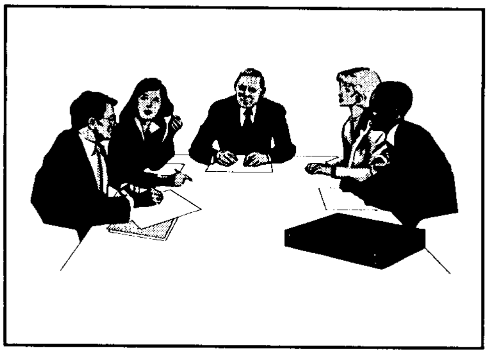
e. **Transportation Analysis**

The principal purpose of the transportation analysis is to determine the time required to evacuate the threatened population (clearance times) under a variety of hurricane situations and to evaluate traffic control measures that could improve the flow of evacuating traffic. Transportation computer modeling techniques developed to simulate hurricane evacuation traffic patterns were used to conduct this analysis. Since three of the four coastal counties are extensively flooded by hurricane surges and have few or no safe evacuation shelters, they will be evacuating most of their population out of the county. To provide a better estimate of where these people will go. Behavioral studies were made to estimate what portion of the evacuees will go to other inland counties or seek safe haven in Georgia or Alabama. Complete details on the Transportation Analysis is presented in Chapter Six.



COORDINATION

A comprehensive coordination program was established for the Apalachee Bay Region Hurricane Evacuation Study that included state and local emergency management officials and representatives from other organizations having direct responsibilities in hurricane emergencies. A description of the coordination of the Apalachee Bay Region Hurricane Evacuation Study follows:



a. Interagency

The Florida State Emergency Management Office has an established channel of communication and coordination from the central State offices through Regional Directors to the county Directors of Emergency Management. From the outset, the U.S. Army Corps of Engineers and Federal Emergency Management Agency relied on this established system to coordinate the study effort. All meetings with the counties were coordinated with the State Emergency Management Office. The Mobile District, U.S. Army Corps of Engineers, provided quarterly status reports to the U.S. Army Corps of Engineers' South Atlantic Division office; Federal Emergency Management Agency, Region IV and the Florida State Emergency Management Office.

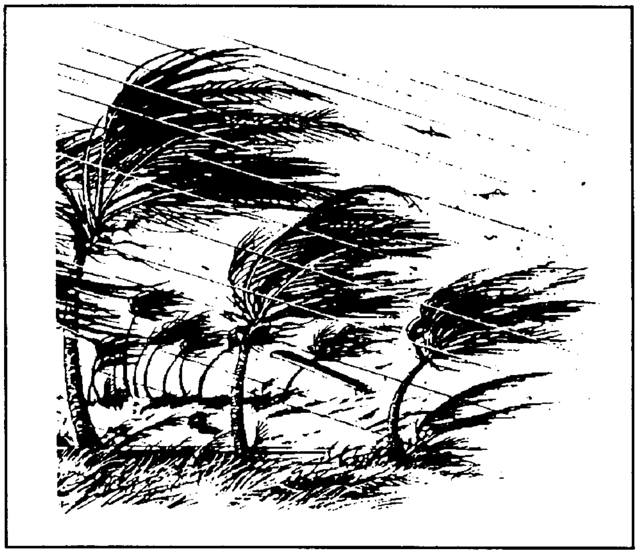
b. Disaster Preparedness Committees

The Disaster Preparedness Committees consisted of Florida State Emergency Management Office officials and county Directors of Emergency Management, and officials of other agencies and organizations, primarily at the county level, who have direct responsibility and authority in some aspect of hurricane emergency operations or planning. These officials represented agencies and organizations that included state and county law enforcement, fire departments, school boards, departments of social services, American Red Cross, and the National Weather Service. The primary purpose of the Disaster Preparedness Committees was to provide important data for the study and to review study products. Since the committee members will be the "users" of the information generated by the evacuation study, committee meetings provided the forum needed to explain the methodologies and products of the various study analyses and the opportunity to receive comments on the study process. Meetings were held at major milestones in the study to gather essential information, to present the results of analyses accomplished to date, to describe the relationships of the major analyses, and to review the progress of the study.

HAZARDS ANALYSIS

CHAPTER TWO - HAZARDS ANALYSIS

PURPOSE



The purpose of the hazards analysis is to quantify the wind speeds and still-water surge heights for various intensities, approach speeds, approach directions, and tracks of hurricanes considered to have a reasonable meteorological probability of occurrence within a particular coastal basin. Due to the wide variation in amounts and times of occurrence from one storm event to another, potential freshwater flooding from rainfall accompanying hurricanes is addressed only in general terms.

The primary objective of the hazards analysis is to determine the probable worst-case effects from hurricanes of various intensities that could strike the region. For the purposes of this study, the term worst-case is used to describe the peak surges and wind speeds that can be expected at all locations within the study area without regard to hurricane track.

FORECASTING INACCURACIES

The worst-case approach is used in the hazards analysis because of inaccuracies in forecasting the precise tracks and other parameters of approaching hurricanes. The National Hurricane Center has made an analysis of hurricane forecasts to determine the normal magnitude of error. From 1976 to 1990, the average error in the official 24-hour hurricane track forecast was 140 statute miles left or right of the forecast track. The average error in the 12-hour official forecast was 70 miles.

During the same time period, the average error in the official 24-hour wind speed forecast was 15 miles per hour (mph), and the average error in the 12-hour official forecast was 10 mph Hurricane evacuation decision-makers should note that an increase of 10 to 15 mph can easily raise the intensity value of the approaching hurricane one category on the Saffir/Simpson Hurricane Scale, which is discussed in the following paragraph. Other factors may work to increase apparent hurricane surge heights above the potential heights calculated by the SLOSH model. Because of these forecast and modeling inaccuracies, public officials who are faced with an imminent evacuation should consider preparing for a hurricane at landfall that may be one category above the forecast strength.

SAFFIR/SIMPSON HURRICANE SCALE

One of the earlier guides developed to describe the potential storm surge generated by hurricanes is the Saffir/Simpson Hurricane Scale. It was developed by Herbert Saffir, Dade County, Florida, Consulting Engineer, and Dr. Robert H. Simpson, former Director of the National Hurricane Center. The National Hurricane Center has added a range of central barometric pressures associated with each category of hurricane described by the Saffir/Simpson Hurricane Scale. A condensed version of the Saffir/Simpson Hurricane Scale with the barometric pressure ranges by category is shown in Table 2-1. The related damage potential of each hurricane category is described in Table 2-2.

Table 2-1 Saffir/Simpson Hurricane Scale

	Central Pressure		Winds	Winds	
Category	Millibars	Inches	(mph)	(kts)	Damage
1	> 980	> 28.9	74-95	64-83	Minimal
2	965-979	28.5 - 28.9	96-110	84-96	Moderate
3	945-964	27.9 - 28.5	111-130	97-113	Extensive
4	920-944	27.2 - 27.9	131-155	114-135	Extreme
5	< 920	< 27.2	> 155	> 135	Catastrophic

Table 2-2 Saffir/Simpson Hurricane Category Damage Scale

Category 1. Winds of 74 to 95 miles per hour. Damage primarily to shrubbery, trees, foliage, and mobile homes. No real wind damage to other structures. Some damage to poorly constructed signs. Low-lying coastal roads inundated, minor pier damage, some small craft in exposed anchorage torn from moorings.

Category 2. Winds of 96 to 110 miles per hour. Considerable damage to shrubbery and tree foliage; some trees blown down. Major damage to exposed mobile homes. Extensive damage to poorly constructed signs. Some damage to roofing materials of buildings; some window and door damage. No major wind damage to buildings. Considerable damage to piers. Marinas flooded. Small craft in unprotected anchorages torn from moorings.

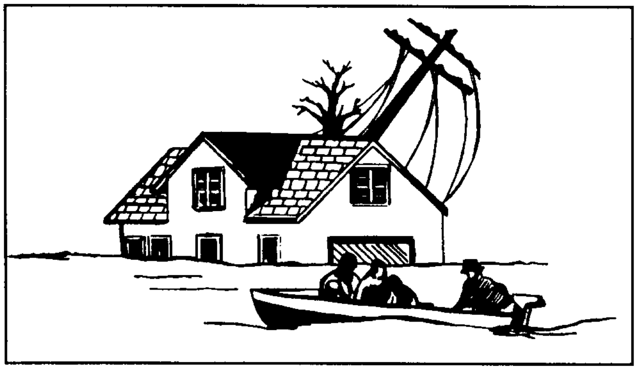
Category 3. Winds of 111 to 130 miles per hour. Foliage torn from trees; large trees blown down. Practically all poorly constructed signs blown down. Some damage to roofing materials of buildings; some window and door damage. Some structural damage to small buildings. Mobile homes destroyed. Serious flooding at coast and many smaller structures near coast destroyed; larger structures near coast damaged by battering waves and floating debris.

Category 4. Winds of 131 to 155 miles per hour. Shrubs and trees blown down; all signs down. Extensive damage to roofing materials, windows, and doors. Complete failure of roofs on many small residences. Complete destruction of mobile homes. Major damage to lower floors of structures near shore due to flooding and battering by waves and floating debris. Major erosion of beaches.

Category 5. Winds greater than 155 miles per hour. Shrubs and trees blown down; considerable damage to roofs of buildings; all signs down. Very severe and extensive damage to windows and doors. Complete failure of roofs on many residences and industrial buildings. Extensive shattering of glass in windows and doors. Some complete building failures. Small buildings overturned or blown away. Complete destruction of mobile homes.

STORM SURGE

a. Introduction



Various storm events can cause abnormally high water levels along ocean coasts and interior shorelines. These higher than expected water levels, known as storm surges, are generally the result of a synoptic scale meteorological disturbance. Storm surges can affect a shoreline over distances of more than 100 miles; however, there may be significant spatial variations in the magnitude of the surge due to local bathymetric and topographic features. Wind is the primary cause of storm surge. Wind blowing over the surface of the water exerts a horizontal force that induces a surface current in the general direction of the wind. The surface current, in turn, forms currents in subsurface water. In the case of a hurricane, the depth affected by this process of current creation depends upon the intensity and forward motion of the storm. For example, a fast-moving hurricane of moderate intensity may only induce currents to a depth of a hundred feet, whereas a slow moving hurricane of the same intensity might induce currents to several hundred feet. As the hurricane approaches the coastline, these horizontal currents are impeded by a sloping continental shelf, thereby causing the water level to rise. The amount of rise increases shoreward to a maximum level that is often inland from the usual coastline.

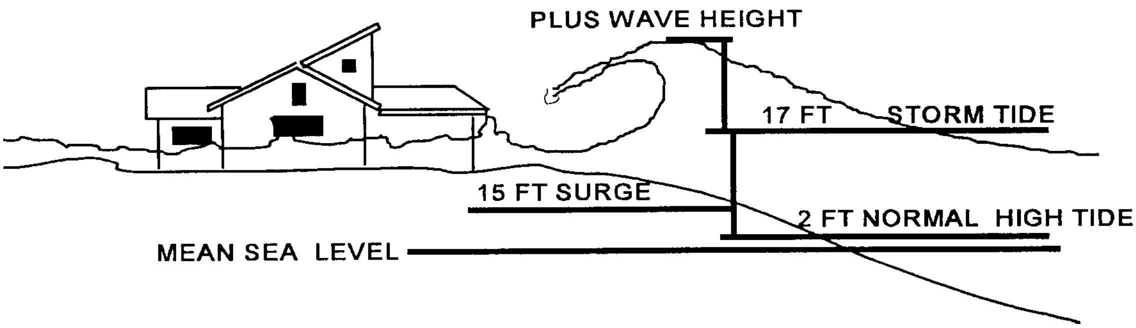
b. Factors Affecting Surge Height

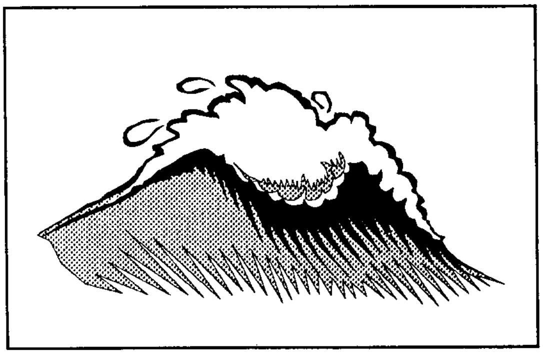
The elevation reached by the storm surge within a coastal basin depends upon the meteorological parameters of the hurricane and the physical characteristics existing within the basin. The meteorological parameters affecting the height of the storm surge include the intensity of the hurricane, measured by the storm-center sea-level pressure, track (path) of the storm, forward speed, and radius of maximum winds. Due to the complementary effects of forward motion and the counterclockwise rotation of the wind field , highest surges from a hurricane usually occur on the northeast quadrant of the storm's track in the region of the radius of maximum winds. This radius, which is measured from the center of the hurricane eye to the location of the highest wind speeds within the storm, can vary from as little as 4 miles to as much as 50 miles or greater. Peak storm surge may vary drastically within a relatively short distance along the coastline depending on the radius of maximum winds and the point of hurricane eye landfall.

The physical characteristics of a basin that influence the surge heights include the basin bathymetry (water depths), roughness of the continental shelf, configuration of the coastline, and natural or man-made barriers. A wide, gently sloping continental shelf or a large bay may produce particularly large storm surges.

c. Total Flood Elevation

Other factors that contribute to the total water height are the initial water level within the basin at the time the hurricane strikes and wave effects. Storm surge is defined as the difference between the observed water level and the normal astronomical tide. Any astronomical tide level above the mean is additive to the storm surge. The timing of the arrival of storm surge is important in that the difference in total flood elevation can be as much as 1 to 2 feet in the study area.



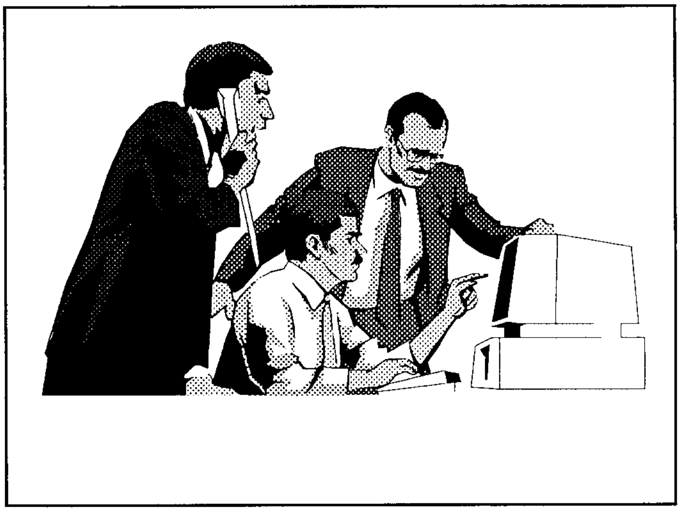


Waves and swells breaking at or near the shore cause a transport of water shoreward. During storms when there is an increase in wave height and wave steepness, water cannot flow back to the sea as rapidly as it was brought shoreward. This results in the phenomenon known as "wave setup" and causes a further increase of water level along the beachfront solely from wave action, in addition to any surge associated with the wind setup. Waves are directly affected by the water depth and will break and dissipate their energy in shallow water. Therefore, a relatively steep offshore beachslope is particularly conducive to this process because large ocean waves can approach very near the shore before breaking. Wave setup is primarily a concern near the beachfront because large waves are generally not transmitted inland of the coastline even if the beach has been overtopped.

THE SLOSH COMPUTER MODEL

a. General

The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model is the latest and most sophisticated mathematical model yet developed by the National Weather Service to calculate potential surge heights from hurricanes. The SLOSH model was developed for real-time forecasting of surges from approaching hurricanes within selected Gulf and Atlantic coastal basins. In addition to furnishing surge heights for the open coast, the SLOSH model has the added capability to simulate the routing of storm surge into sounds, bays, estuaries, and coastal river basins, as well as calculating surge heights for overland locations. Significant natural and manmade barriers are represented in the model, and their effects simulated in the calculations of surge heights within a basin.



The SLOSH model is designed for use in an operational mode; that is, for forecast/hindcast runs without controlled, local calibration, or observed winds. This design was selected so that the user would not be forced to estimate unavailable input data. The SLOSH model contains a storm model into which simple, time-dependent meteorological data are input and from which the driving forces of a simulated storm are calculated. These data are as follows:

(1) Central barometric pressure at 6-hour intervals.

(2) Latitude and longitude of storm positions at 6-hour intervals for a 72-hour tract.

(3) The storm size measured from the center (eye) to the region of maximum winds, commonly referred to as the radius of maximum winds. Wind speed is not an input parameter, since the model calculates a windfield for the modeled storm by balancing forces according to meteorological input parameters.

Also required is the height of the water surface well before the storm directly affects the area of interest. This initial height is the observed, quiescent, water surface height occurring about 2 days before storm arrival, including any existing anomalous rise in the water surface. Astronomical high tide was not set in the model.

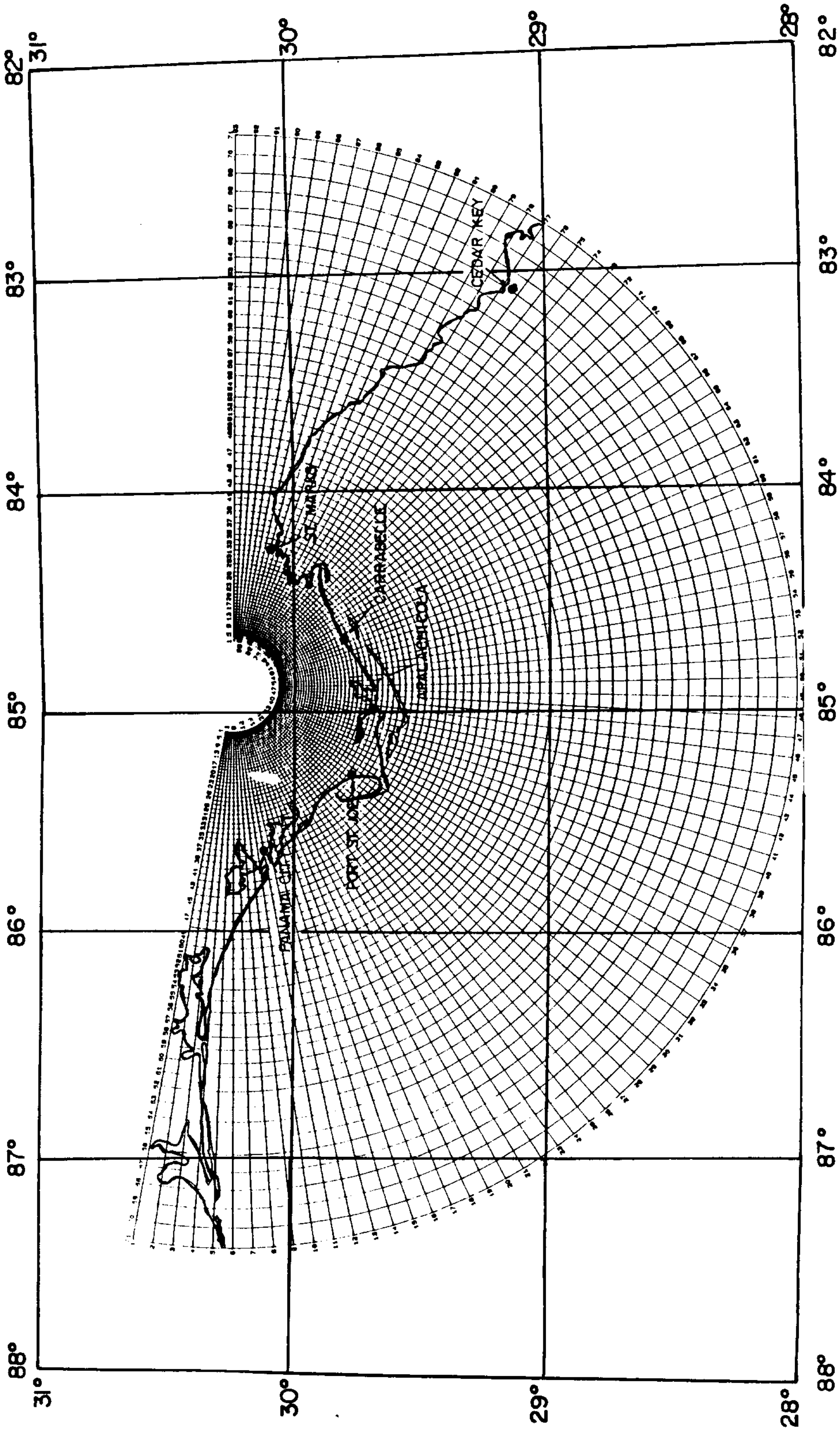
The values or functions for the coefficients within the SLOSH model are generalized to serve for modeling all storms within all basins and are set empirically through comparisons of computed and observed meteorological and surge height data from numerous historical hurricanes. The coefficients are a function of differing storm parameters and basin characteristics. Calibration of the model based on a single storm event within a basin is avoided since there is no guarantee that the same coefficient values will serve as well for other storms.

b. SLOSH Grid Configuration

The SLOSH model utilizes a telescoping polar coordinate (fan-shaped) grid system within which a particular coastal basin is represented. The grid configuration of a SLOSH model is illustrated in figure 2-1. The resolution of the Apalachee Bay model for inland locations near the focus is approximately .1 square mile per grid square and increases to approximately 29.3 square miles at the outer fringe. As shown in figure 2-1, the grid squares constantly expand in size and become progressively larger farther from the coastline. Storm surge heights in the ocean remote to the coastline are of secondary interest in evacuation planning. The advantage of this grid system is that it offers good resolution in areas of primary interest, while conserving computer resources by minimizing the number of calculations.

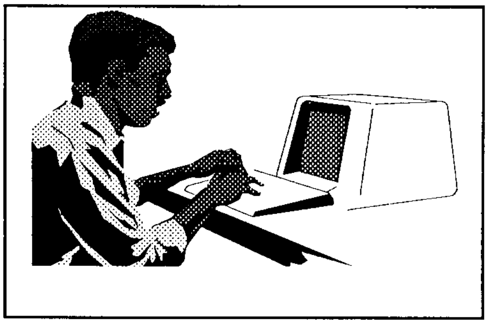
The characteristics of a particular basin are constructed as input data within the model. These characteristics include the topography of inland areas; river basins and waterways; bathymetry of nearshore areas, sounds, bays, and large inland waterbodies; significant natural and manmade barriers such as barrier islands, dunes, roads, levees, etc.; and a segment of the continental shelf. The SLOSH model simulates inland flooding from storm surge and permits the overtopping of barriers and flow through barrier gaps.

Figure 2-1 Apalachee Bay SLOSH Model Polar Grid.



c. Verification of the Model

After a SLOSH model has been constructed for a coastal basin, verification experiments are conducted. These experiments are performed as real-time operational runs in which available meteorological data from historical storms are input in the model. These input data consist solely of observed or hindcast storm parameters and an initial observed sea surface height occurring approximately 48 hours before the storm makes landfall or affects the basin. The computed surge heights are compared with those measured from historical storms and, if necessary, adjustments are made to the input or basin data. These adjustments are not made to force agreements between computed and measured surge heights from historical storms but to more accurately represent the basin characteristics or historical storm parameters. In instances where the model has given realistic results in one area of a basin, but not in another, closer examination has often revealed inaccuracies in the representation of barrier heights or missing values in bathymetric or topographic charts. In the case of historical storms, much of the data are often coarse, with parameters prescribed invariant with time and with an unrealistically smoothed storm track. When necessary, further analysis and subjective decisions are employed to amend the track or other parameters of the historical storms used in the verification process. The hurricanes used to verify the Apalachee Bay SLOSH model were Hurricanes Elena (1985) and Allison (1995).



d. Model Output

The SLOSH model output for a modeled storm consists of a tabulated storm history containing hourly values of storm position, speed, direction of motion, pressure drop, and radius of maximum winds; a surface envelope of highest surges; and for preselected grid points, time-history tabulations of values for surge heights, wind speeds and wind directions. Values in the time-history tabulations are 10-minute averages, given every 30 minutes.

The highest water level reached at each location along the coastline during the passage of a hurricane is called the maximum surge. Maximum surges along the coastline do not necessarily occur at the same time. The time of the maximum surge for one location may differ by several hours from the maximum surge that occurs at another location. The SLOSH model determines the highest surge height values calculated for each grid in the model irrespective of the time of occurrence. The datum used in the model is NGVD, formerly known as mean sea level of 1929 (m.s.l.).

THE APALACHEE BAY MODELING PROCESS

a. Simulated Hurricanes

The Apalachee Bay Region SLOSH model was used to determine the surge heights in Gulf, Franklin, Wakulla and Jefferson counties in Florida. A total of 1,290 hypothetical hurricanes were modeled for the Apalachee Bay Hurricane Evacuation Study. The characteristics of the simulated hurricanes were determined from an analysis of historical hurricanes. The parameters selected for the modeled storms were the intensities, forward speeds, approach directions, and radii of maximum winds that are considered to have the highest meteorological probability of occurrence within the region. They are summarized in Table 2-3 and graphically presented on figures 2-3 through 2-11. The simulated hurricanes had combinations of parameters representing a tropical storm through a category 5 hurricane intensity, nine approach directions . Forward speeds of 5, 15 and 25 miles per hour were used. The radius of maximum winds specified for all the simulated hurricanes at landfall was 20 miles, and the tropical storm was 50 miles.

Table 2-3 Apalachee Bay hypothetical storm scenarios

Direction	Speed (mph)	Intensities	Tracks	Runs
W	5, 15	TS-Cat5	6	72
WNW	5, 15	TS-Cat5	8	96
NW	5, 15	TS-Cat5	10	120
NNW	5, 15	TS-Cat5	10	120
N	5, 15, 25	TS-Cat5	11	198
NNE	5, 15, 25	TS-Cat5	12	216
NE	5, 15, 25	TS-Cat5	10	180
ENE	5, 15, 25	TS-Cat5	9	162
E	5, 15, 25	TS-Cat5	7	126
			Total =	1,290

After making landfall, most hurricanes weaken because the central pressure and radius of maximum winds increase. This was taken into account in modeling each of the storm tracks. The initial sea surface height set in the Apalachee Bay SLOSH model was 1.0 foot. This initial height, known as tide anomaly, represents the height of the water surface above m.s.l. existing several days in advance of approaching hurricanes. Furthermore, to simulate conditions at high tide, an additional 1.5 feet was included. Thus all SLOSH runs of hypothetical hurricanes were supplied with initial datums of 2.5 feet MSL, and the resulting calculations of storm surge represent conditions at time of high tide.

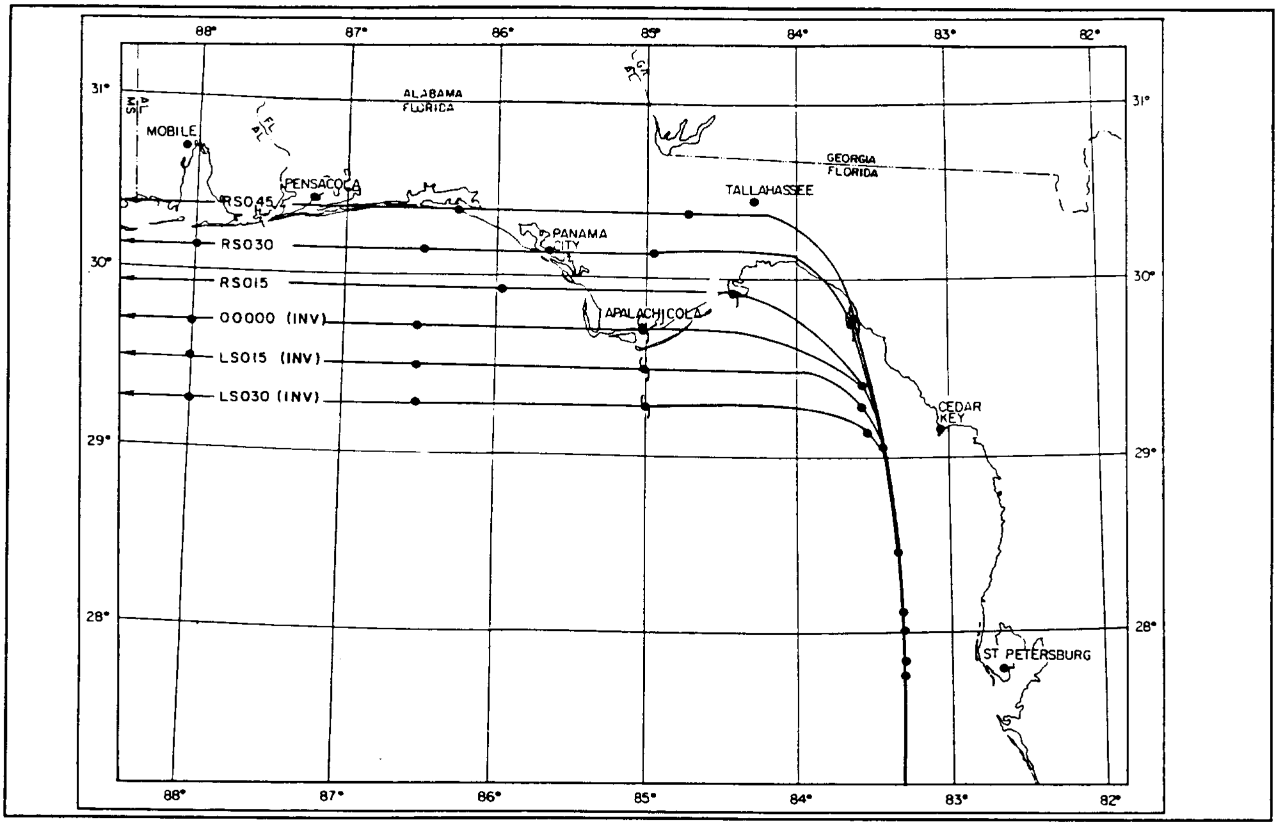


Figure 2-3 Simulated storms moving West.

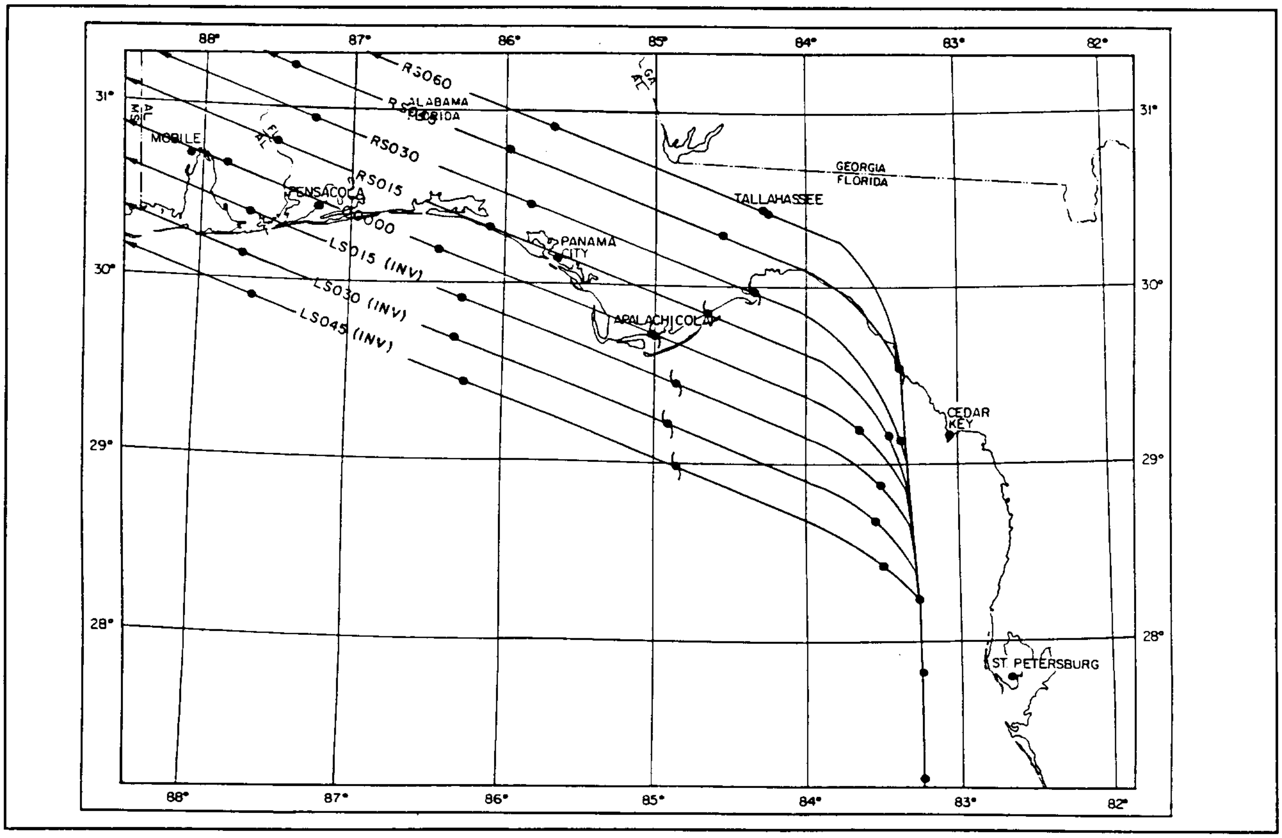


Figure 2-4 Simulated storms moving West Northwest.

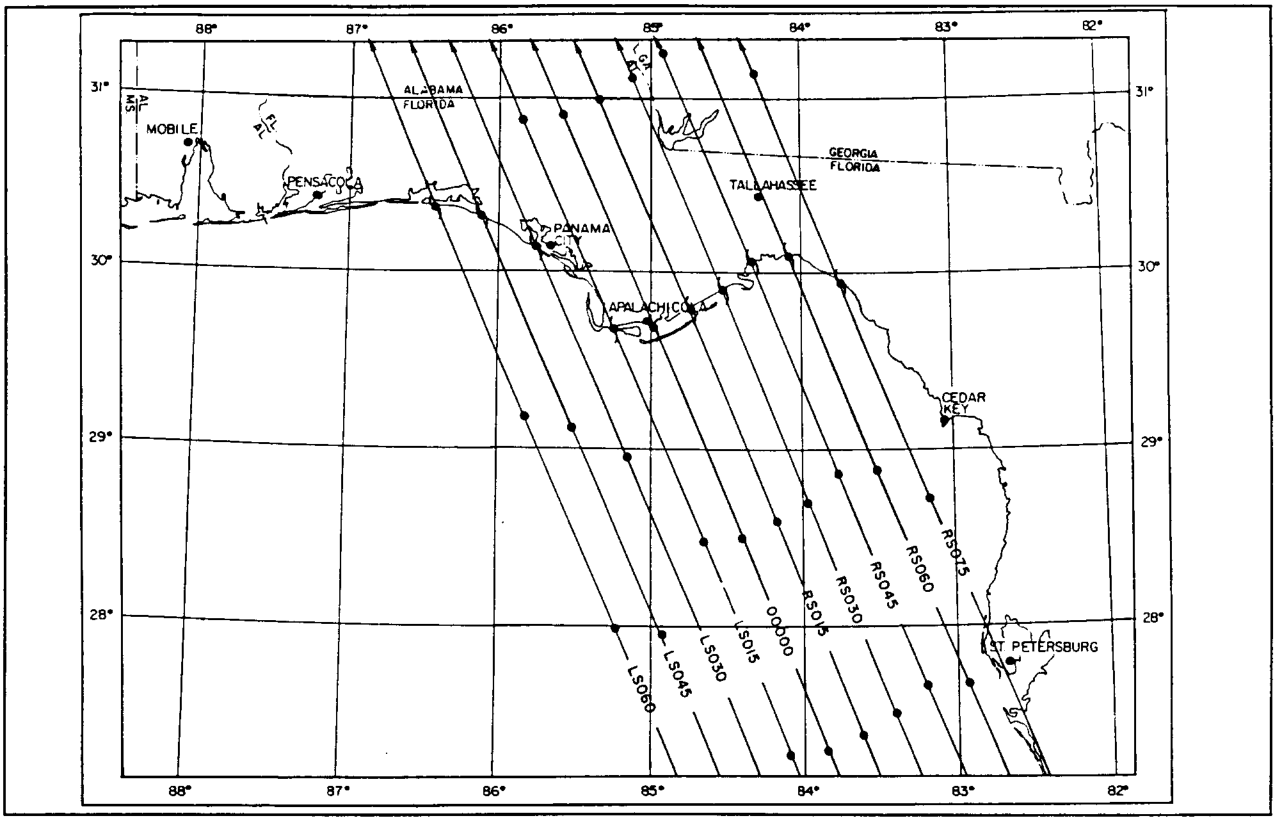


Figure 2-5 Simulated storms moving Northwest.

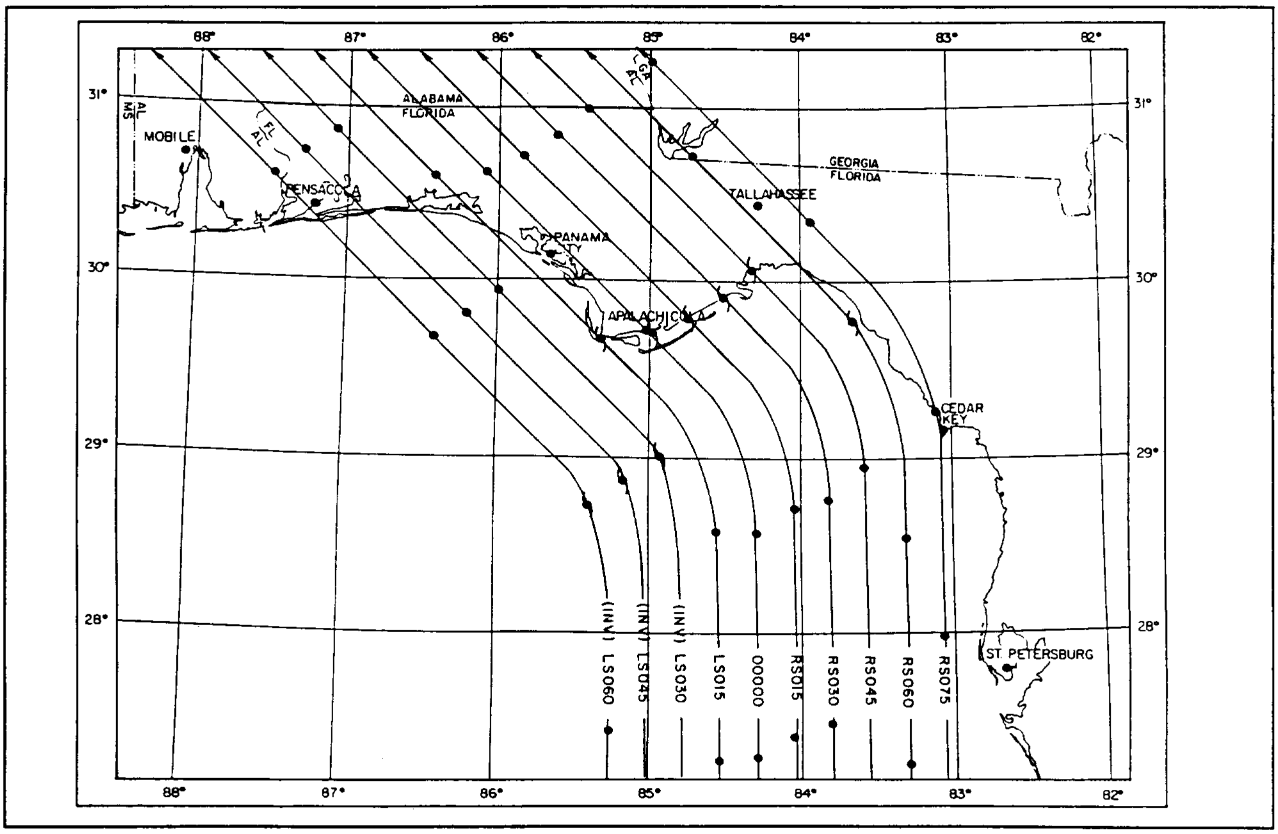


Figure 2-6 Simulated storms moving North northwest.

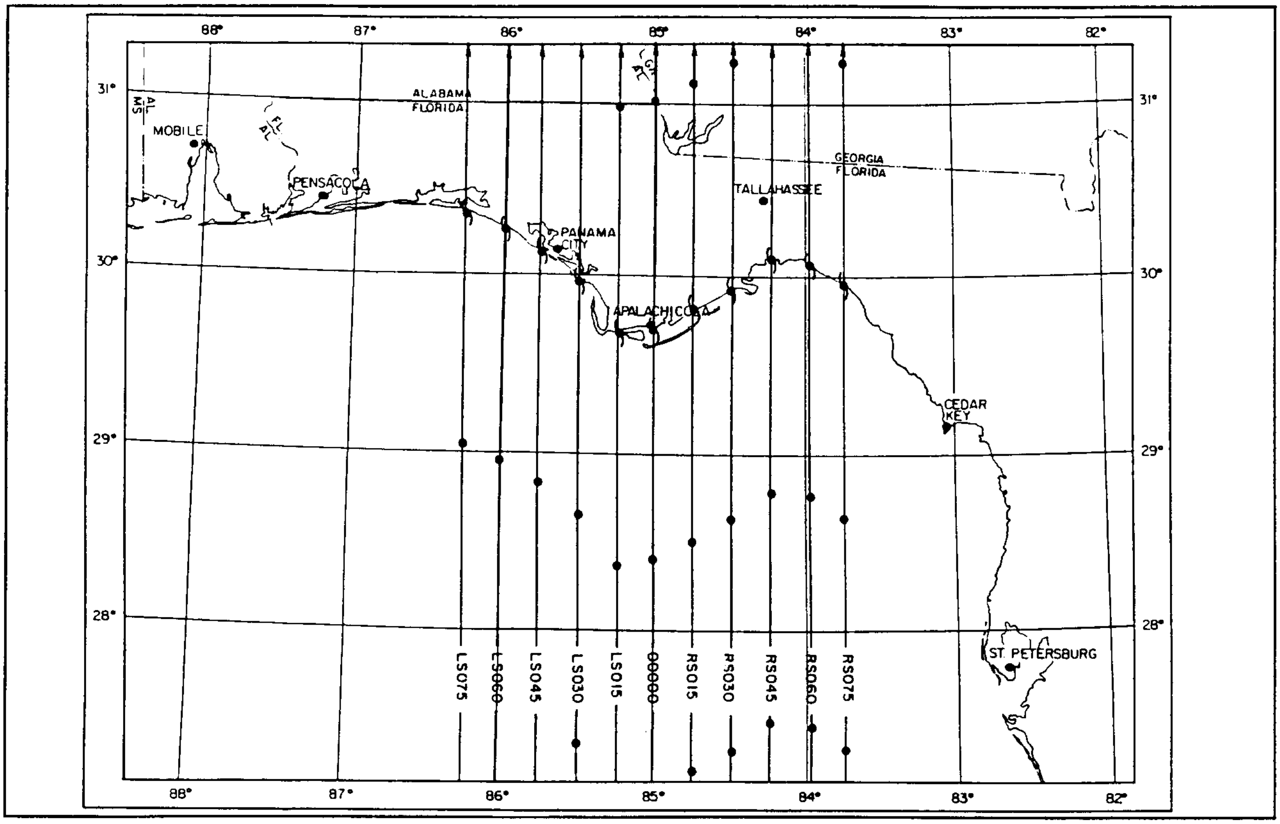


Figure 2-7 Simulated storms moving North.

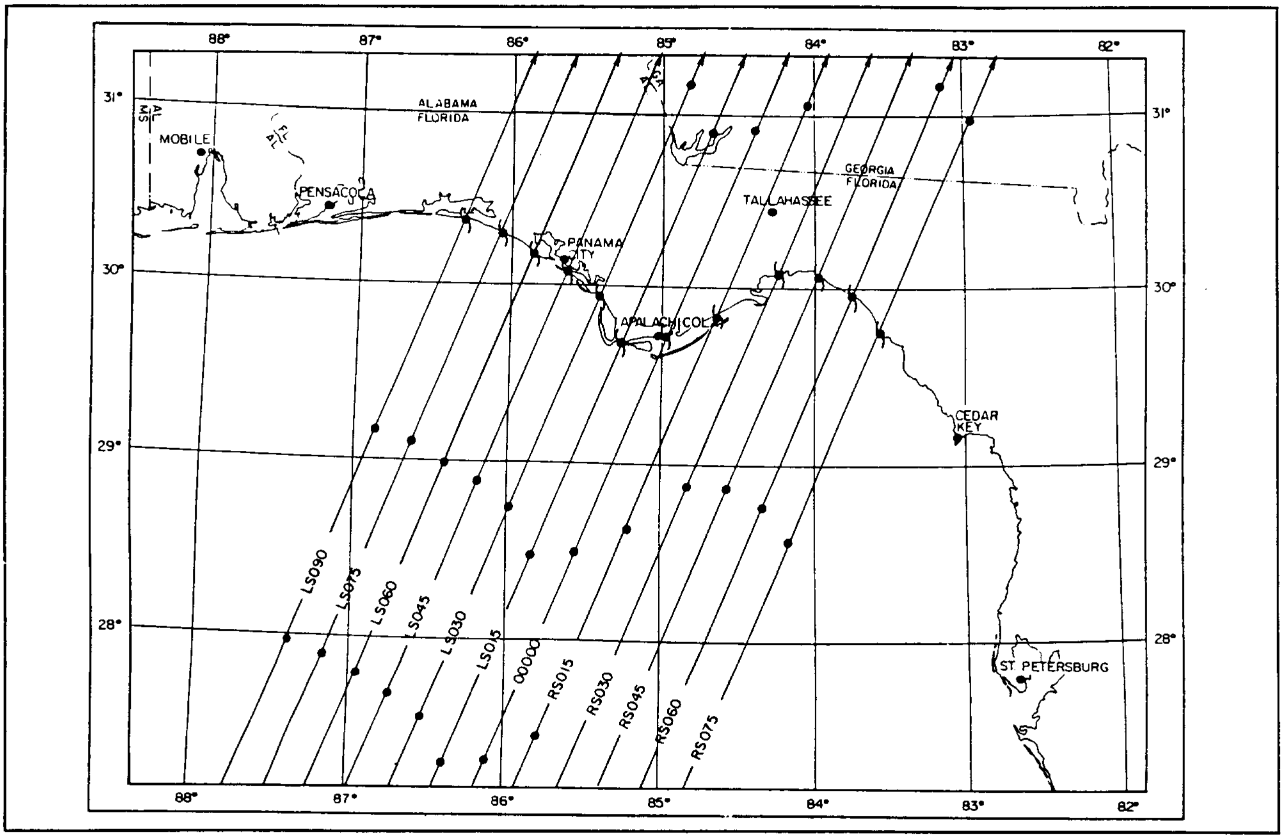


Figure 2-8 Simulated storms moving North northeast.

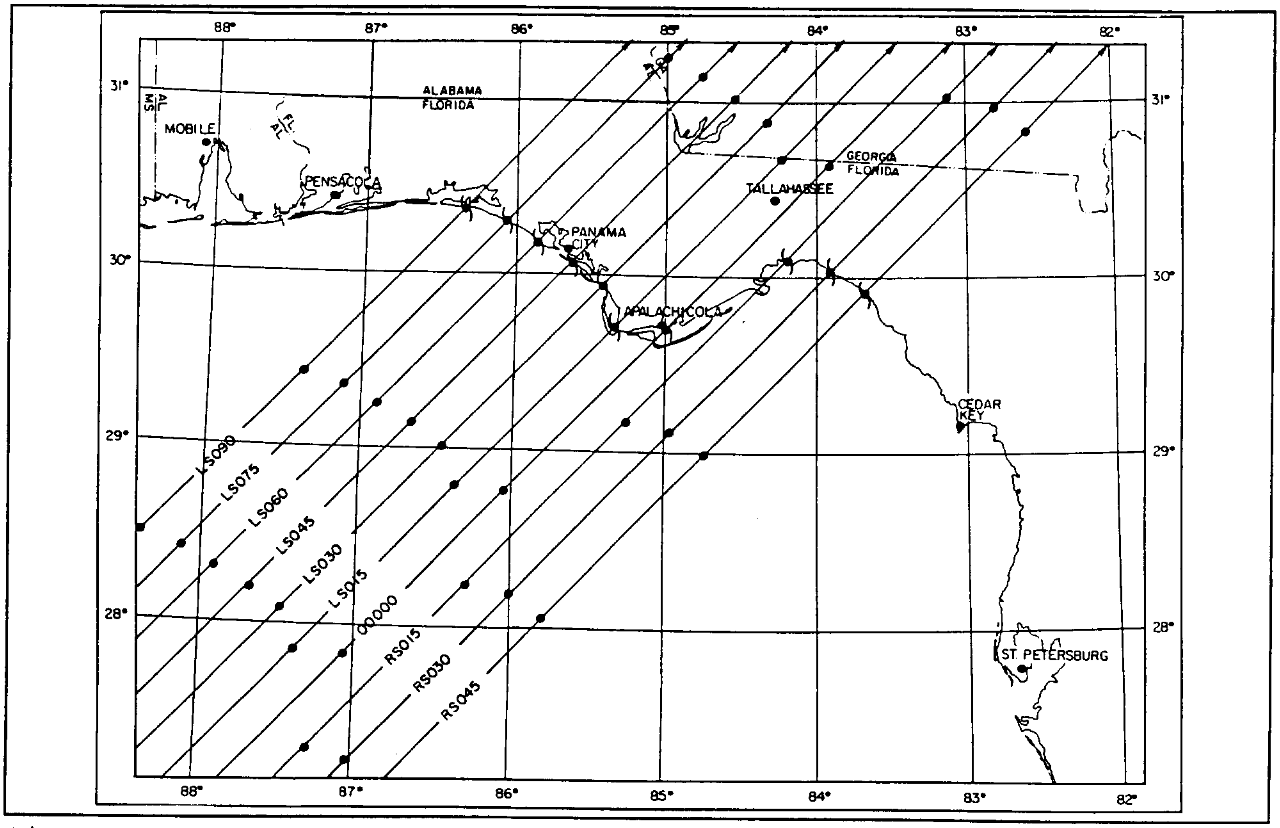


Figure 2-9 Simulated storms moving Northeast.

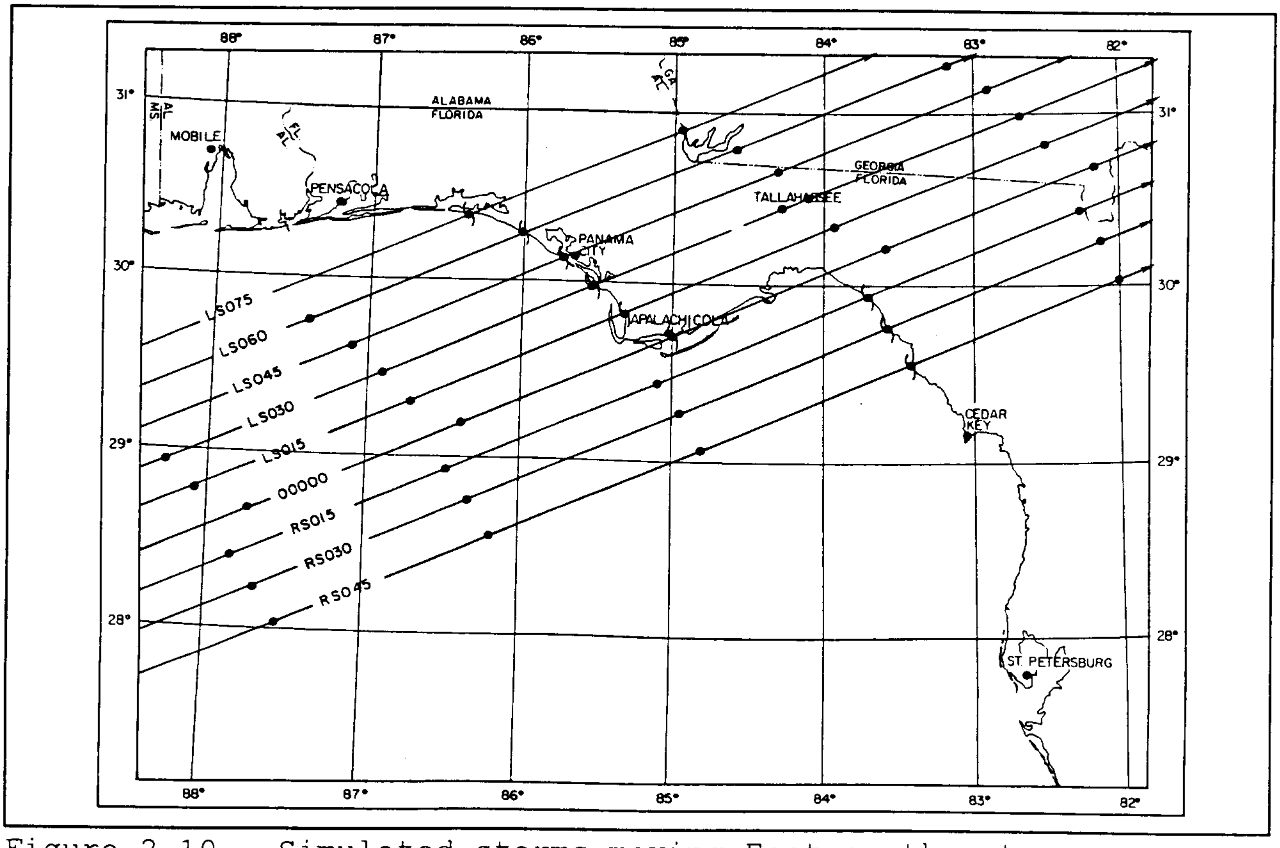


Figure 2-10 Simulated storms moving East northeast.

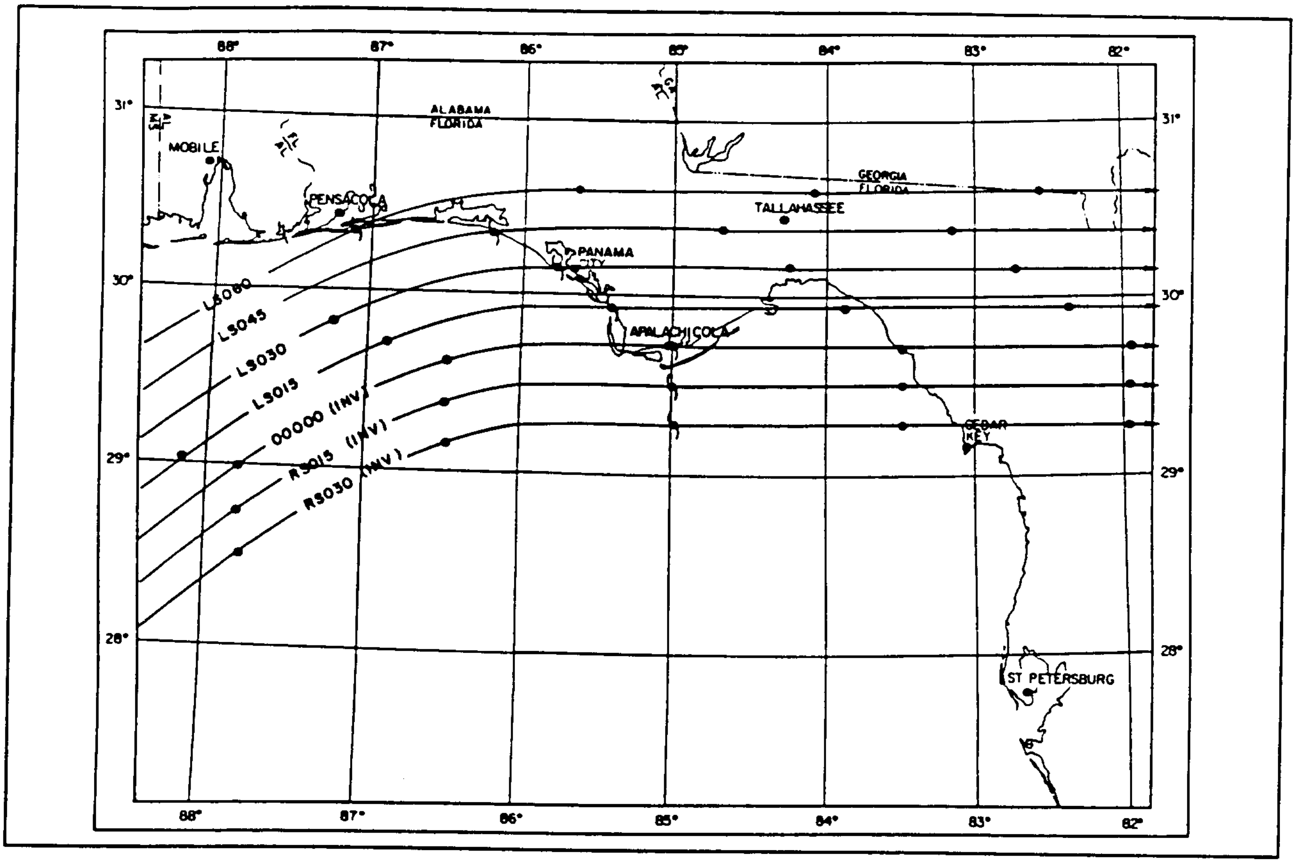


Figure 2-11 Simulated storms moving East

b. Maximum Envelopes of Water (MEOWs)

The highest surges reached at all locations within the affected area of the coastline during the passage of a hurricane are called the maximum surges for those locations; the highest maximum surge in the affected area is called the peak surge. The location of the peak surge depends on where the eye of a hurricane crosses the coastline, hurricane intensity, the bathymetry of the basin, configuration of the coastline, the approach direction, and the radius of maximum winds. As discussed previously, the peak surge from a hurricane usually occurs to the right of the storm path and within a few miles of the radius of maximum winds.

Due to the inability to precisely forecast the ultimate landfall location, forward speed, approach direction, and other characteristics of a threatening hurricane, the objective of the hazards analysis is to determine the potential peak surges for all locations within the study area. For that purpose, MEOWs are utilized. MEOWs were developed by the National Hurricane Center from an array of peak surges calculated for individual hurricanes that differ only in point of landfall. In this manner, maximum water surface elevations are calculated for a particular class of hurricane defined by approach direction, forward speed, and intensity but independent of the point of landfall.

Initially, 138 MEOWs were developed for the Apalachee Bay SLOSH model. These MEOWs consisted of computer printouts showing peak surge values developed for each combination of category, approach speed, and approach direction modeled for the study, without regard to storm track. Therefore, the values contained on these original MEOWs were the peak surge height values for each of the model's grid points regardless of where landfall may have occurred.

The results of the 138 original MEOWs were analyzed to determine which changes in storm parameters (i.e., intensity, approach speed, and approach direction) resulted in the greatest differences in the values of the peak surges for all locations and those that could reasonably be combined to facilitate evacuation decision-making. In most instances, a change in storm category accounted for the greatest change in peak surge heights. With this in mind, careful consideration was given to the impacts of the various combinations of approach speeds, approach directions, and Saffir/Simpson categories on hurricane evacuation planning and decision-making. To simplify these processes, the National Hurricane Center was asked to compile additional MEOWs.

The National Hurricane Center subsequently created an additional layer of MEOWs (MEOWs of the MEOWs, or MOMs) eliminating consideration of hurricane approach speed and direction but maintaining the separation of categories 1, through 5 and the tropical storm. The MOM's are shown on Plates 2-1 through 2-6 at the end of this Chapter. It was from those MOMs that the hurricane surge atlases were developed. Those inundation maps depict maximum storm surge heights that could be generated by the different storm intensities, without regard to approach speed, direction, or track. Table 2-4 shows maximum surge heights by Saffir/ Simpson hurricane categories.

c. Adjustments to SLOSH Model Values

The surge height values contained in the MOMs represent the water surface elevations produced by the driving forces of the modeled hurricanes in combination with the 1.0-foot tide anomaly and a 1.5 high tide condition resulting in a 2.5 foot water height at the onset of the storm.

d. Time-History Point Data

One hundred and ten grid points were selected in the Apalachee Bay region for the time-history tabulation of surge height, wind speed, and wind direction. These grid points were chosen to coincide with critical locations identified by county Emergency Management Directors for their respective jurisdictions. They are located at low-lying roads and bridges that would be critical to an evacuation, at potentially vulnerable population centers, or at significant natural or manmade barriers. The time-history information produced by the SLOSH model for the 110 critical points includes still-water surge heights, wind speeds, and wind direction at 30-minute intervals for 72 hours. Plate 2-7 thru 7-10, at the end of this chapter, shows the location of the selected time history points and table 2-4 shows the maximum surge heights for each point for the tropical storm to the category 5 hurricane.

The purpose of the time-history data is to determine the prelandfall hazards distances for each of the counties within the study area. Prelandfall hazards distance is the distance from the eye of an approaching hurricane to each jurisdiction at the time an evacuation would be curtailed by hazardous weather conditions. This distance must be accounted for in timing evacuation decision-making. For the Apalachee Bay Hurricane Evacuation Study, two specific conditions were evaluated: the arrival of sustained gale-force winds (34-knot sustained wind speed, 1-minute average) and the onset of storm surge inundation of low-lying roads, bridges, or other critical areas. The first of these two conditions to occur determines the prelandfall hazard distance.

The time of arrival of sustained tropical storm winds is one selected goal for completing an evacuation because high-profile vehicles and vehicles pulling campers or boats could easily be overturned, especially on high-rise bridges. Such an accident would most certainly cripple or halt traffic flow on that evacuation route. That arrival of sustained tropical force winds is also the time, under the majority of hurricane threats, when heavy rainfall begins. Generally, one-half of the total amount of rainfall received from a hurricane occurs from the arrival of sustained tropical storm winds until the eye reaches the coastline.

Storm surge inundation is the other condition limiting evacuation, but should not be a significant factor in most of the study area prior to the arrival of sustained tropical storm winds. The lowest roadway elevations in the study area should be considered when determining the prelandfall hazards distance. As discussed in the section above, however, **evacuation decision-making officials should be aware that the coincidental occurrence of astronomical high tide and rising storm surge could cause moderate flooding in low-lying areas, particularly on causeways, prior to the arrival of sustained tropical storm winds.**

Table 2-4 Apalachee Bay time history point surge heights

POINT No.	POINT NAME	Grid Cell** Ground Elevation	TS	CAT1	CAT2	CAT3	CAT4	CAT5
					SURGE HEIGHTS ABOVE MSL BY STORM CATEGORY HURRICANE EVENT			
	---------------------- FRANKLIN COUNTY------------------------------------							
1	Fort Gadsden State Park	6	4.2	4.2	6.2	9.2	14.5	19.6
2	Breakaway Lodge	0	5.0	5.2	9.0	12.1	15.8	19.1
3	Apalachicola River	0	5.2	5.5	10.2	13.7	17.1	20.2
4	Apalachicola Bay	0	5.3	5.6	10.4	14.0	17.2	20.2
5	Apalachicola Airport	14	5.4	5.6	10.6	14.1	17.0	19.6
6	Eleven Mile	0	5.2	5.7	10.6	14.6	17.1	18.8
7	Nine Mile	0	5.4	5.6	10.5	14.4	16.9	18.9
8	Whiskey George Creek	3	5.0	5.5	10.6	14.6	17.9	21.6
9	Cash Creek	2	5.1	5.5	10.5	14.7	18.0	21.6
10	Magnolia bluff	0	5.3	5.7	10.7	14.6	17.5	21.2
11	Eastpoint	0	5.8	6.8	10.6	15.1	18.8	21.4
12	Greenpoint	0	6.0	7.3	12.2	15.5	18.5	22.7
13	Marsh Point	0	6.1	7.6	12.2	16.7	19.8	23.5
14	Indian Pass	0	5.2	6.3	9.5	12.7	16.1	18.1
15	Oyster Pond	0	5.1	6.2	10.1	13.1	16.0	17.8
16	Cape St.George-Ocean	0	5.1	5.1	9.1	12.3	14.9	17.2
17	Cape St. George - Bay	0	5.1	5.2	9.1	12.3	14.9	17.2
18	Sikes Cut	0	5.1	5.2	9.4	12.6	15.8	18.3
19	Nicks Hole-Ocean	0	5.5	6.4	9.9	13.3	16.1	18.6
20	Nicks Hole -Bay	0	5.1	5.4	9.5	12.7	15.6	18.3
21	St. George Comm.- Ocean	0	5.6	6.4	9.9	13.3	16.7	19.4
22	St. George Comm. - Bay	0	5.6	6.5	10.1	13.8	17.2	20.0
23	Ocean Mile - Ocean	0	5.7	6.4	10.1	13.5	17.1	19.8
24	Ocean Mile - Bay	0	5.7	6.8	10.6	13.9	17.5	20.2
25	St. George Park - Bay	0	6.1	7.4	11.9	16.0	19.4	22.6
26	St. George Park - Ocean	0	5.9	6.9	11.5	15.5	19.0	22.2
27	Cannonball Point - Ocean	0	5.9	6.9	11.5	15.5	19.0	22.2
28	Dog Island - Ocean	0	6.1	7.0	11.6	15.6	19.3	22.7
29	Dog Island - Bay	4	6.4	7.8	12.0	16.1	19.7	23.2
30	Cannonball Point -Bay	0	6.4	7.7	12.3	16.6	20.1	23.5
31	Carrabelle Beach	0	6.6	7.9	12.8	17.3	20.7	24.2
32	Three Rivers	2	4.8	5.8	8.6	14.5	18.8	24.0
33	Pine Log Creek	2	4.0	4.9	9.6	16.0	20.3	25.5
34	Carrabelle	0	5.6	6.8	10.4	17.4	20.9	24.2
35	Lanark	0	6.8	8.3	13.2	17.8	21.5	25.5
36	US 319 ~ US 98	0	6.9	8.6	13.7	18.0	22.2	25.2
37	St. Teresa Beach	0	7.0	8.7	13.9	18.3	22.3	26.1
38	Alligator Harbor	0	7.0	9.2	14.0	17.3	21.6	25.3
39	Alligator Point	0	6.8	7.8	12.4	16.6	20.7	24.7
40	US 319 al Ochlockonee Rv.	1	5.1	6.3	13.3	18.7	23.2	27.3
41	Ochlockonee Bridge	0	7.1	8.4	14.1	18.9	23.7	27.0
42	Turtle Island	0	6.8	7.7	14.3	19.3	23.8	27.5
43	Howards Creek	0	4.1	4.2	6.8	10.7	15.0	19.5
	----------------------- JEFFERSON COUNTY--------------------------------							
1	Jeff County Line	0	8.7	10.5	17.0	22.4	26.6	31.7
2	US98 @ State Rd. 59	12	NA	NA	16.6	23.1	29.4	35.4
3	Center NE	6	8.8	11.0	17.6	23.4	28.1	34.5
4	River Mouth @ Gulf	0	8.6	10.8	16.7	22.5	26.8	31.4
5	River Junction	6	8.6	10.8	17.1	23.1	27.6	33.0

** This is the average ground elevation in the grid cell, specific site ground elevations will vary.

Table 2-4 Apalachee Bay time history point surge heights (con't)

POINT No.	POINT NAME	Grid Cell** Ground Elevation	SURGE HEIGHTS ABOVE MSL BY STORM CATEGORY HURRICANE EVENT TS	CAT1	CAT2	CAT3	CAT4	CAT5
	GULF COUNTY							
1	Overstreet NW	0	4.4.	4.8	6.2	7.2	8.4	10.2
2	Overstreet	8	NA	NA	NA	NA	11.2	11.2
3	Beacon Hill	0	5.0	5.9	9.1	12.5	14.7	17.8
4	St. Joe Beach	0	4.9	5.8	8.8	12.1	14.4	17.9
5	Palm Point	0	4.9	5.4	8.4	11.4	14.2	18.3
6	Highland View	0	4.9	5.5	8.5	11.4	14.2	18.4
7	St.JoePaper Co.	0	4.9	5.6	8.6	11.6	14.5	18.2
8	Court House	15	4.9	5.6	8.6	11.6	14.5	18.2
9	Gulf Pines Hospital	12	4.9	5.6	8.7	11.8	14.7	18.2
10	Oak Grove	0	4.9	5.6	8.7	11.8	14.7	18.2
11	Jones Homestead	12	4.9	5.6	8.7	12.0	14.7	17.6
12	Simmons Bayou	0	4.9	5.7	8.9	12.1	14.5	17.0
13	Treasure Lodge	0	4.8	5.7	9.0	11.9	13.9	15.4
14	St. Josephs StatePark	0	46	5.1	7.7	10.1	12.8	14.9
15	Eagle Harbor	0	4.9	5.4	8.4	11.3	14.1	16.7
16	Barrier Dunes	0	4.6	5.0	7.5	9.0	12.0	14.5
17	Rish Park	0	4.5	4.9	7.2	9.4	11.3	13.6
18	Pig Island	0	4.8	5.5	8.6	11.4	13.3	14.8
19	Stump Hole	0	4.6	4.8	7.0	9.1	11.2	12.8
20	Lighthouse Bay	0	4.8	5.5	8.6	11.3	13.0	13.7
21	Salinas Park	0	4.8	5.2	8.5	12.2	15.5	17.2
22	Indian Pass Campground	0	5.2	6.1	9.1	12.3	15.5	17.3
23	White City	14	NA	NA	7.3	10.7	15.3	19.1
24	Lake Wimico	0	4.5	4.4	7.3	10.6	15.3	19.2
25	Howards Creek	5	4.1	4.2	6.8	10.7	15.0	19.5
26	Lake Grove	17	NA	NA	NA	NA	NA	17.0
27	Dalkeith	7	NA	NA	6.9	9.5	13.6	19.3
28	Breakaway Lodge	0	5.0	5.2	9.0	12.1	15.8	19.1
29	Indian Pass	0	5.2	6.3	9.5	12.7	16.1	18.1
30	Gaskin Park	0	NA	NA	NA	NA	NA	17.0
31	Gulf Forest Prison	0	NA	NA	7.3	11.4	15.5	19.7
	WAKULLA COUNTY							
1	Ochlockonee Bridge @ U.S. 98	0	7.1	8.4	14.1	18.9	23.2	27.0
2	Turtle Island	0	6.8	7.7	14.3	19.3	23.8	27.5
3	Sopchoppy River	1	6.8	8.2	14.8	19.5	24.1	28.2
4	Ochlockonee River@U.S.319	1	5.1	6.3	13.3	18.7	23.2	27.3
5	State Rd. 375 @ Hwy 22	17	NA	NA	14.9	19.1	24.4	28.4
6	Bone Bluff	3	3.8	4.5	10.7	18.7	23.5	27.5
7	Sanborn	5	3.8	4.0	11.9	18.9	24.6	28.6
8	Red Lake	6	NA	NA	10.8	16.9	21.1	26.1
9	Smith Creek	13	NA	NA	10.9	16.8	20.6	23.7
10	Mashes Island	0	7.6	8.6	14.1	18.4	22.6	26.5
11	Panacea	0	8.1	9.4	15.2	20.0	24.5	28.1
12	Purify Creek	0	8.3	9.8	15.4	20.6	24.9	28.8
13	Spring Creek	0	8.5	10.1	15.9	21.0	24.9	28.8
14	Wakulla Beach	0	8.6	10.8	16.4	21.4	25.7	29.8
15	Live Oak Island	1	8.5	10.0	15.5	20.5	24.9	28.8
16	Hyde Park	8	7.0	8.0	8.0	15.0	23.0	33.9
17	Newport	8	8.0	10.2	17.2	23.3	29.3	34.4
18	St. Marks	3	8.0	10.2	17.3	22.7	27.5	32.4
19	Lighthouse	0	8.5	10.2	15.9	21.1	25.1	28.9
20	Jeff County Line	0	8.7	10.5	17.0	22.4	26.6	31.7

** This is the average ground elevation in the grid cell, specific site ground elevations will vary.

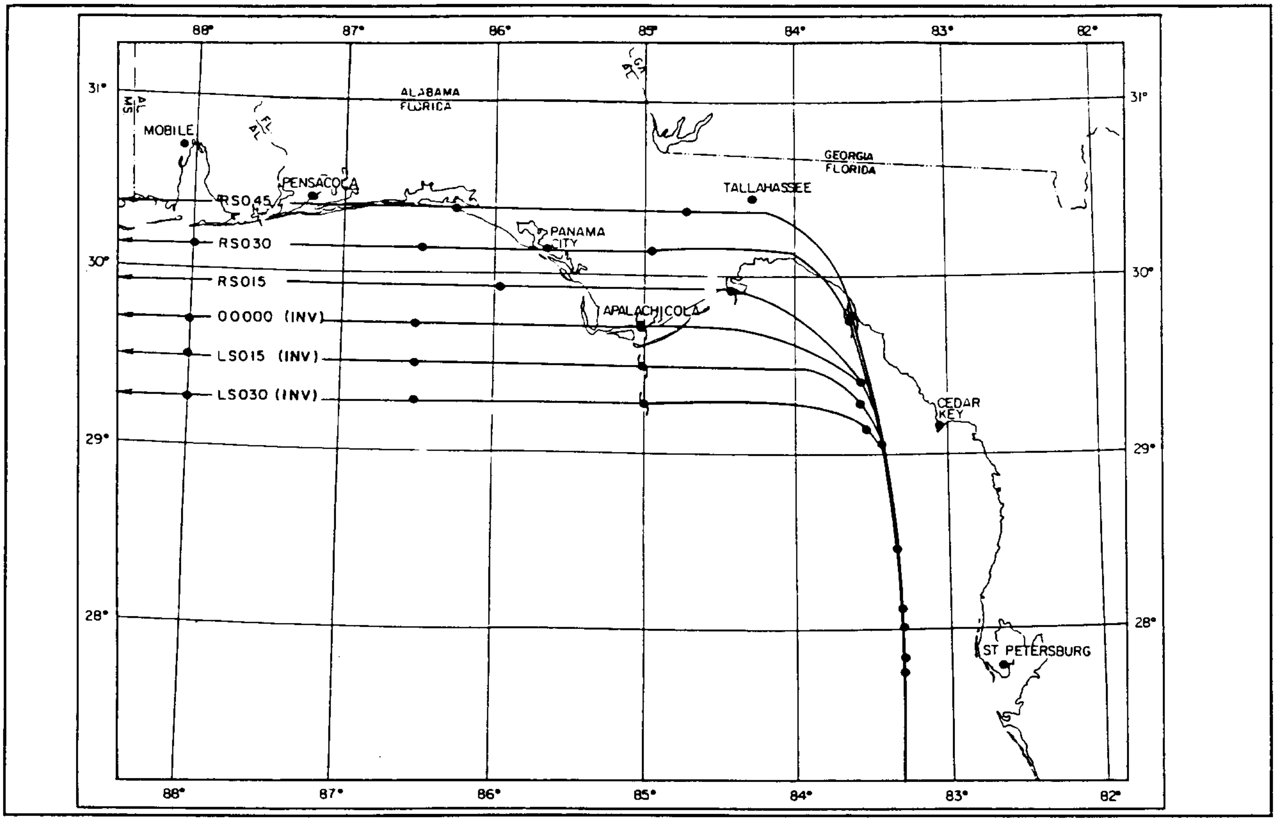


Figure 2-3 Simulated storms moving West.

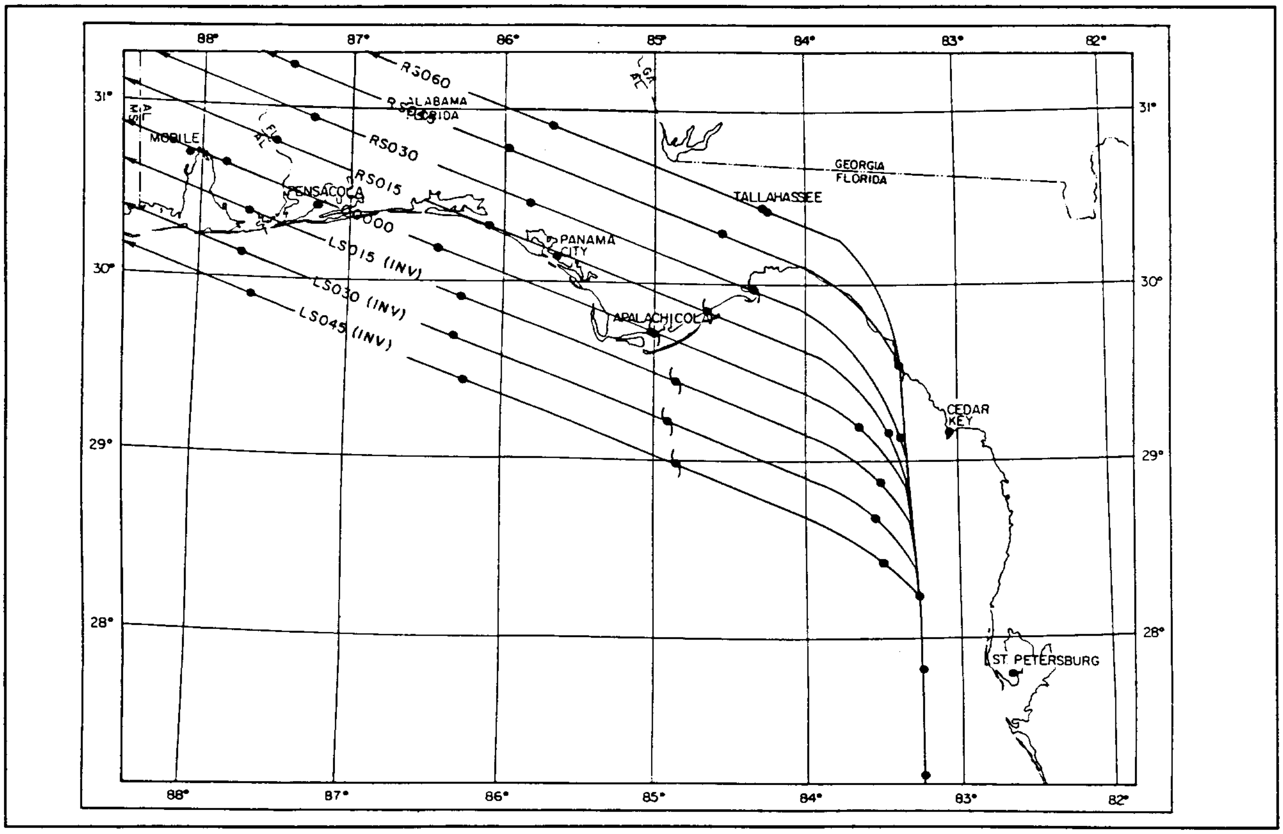


Figure 2-4 Simulated storms moving West Northwest.

For evacuation planning purposes, it is perhaps more important to consider potential wave effects for less than sustained tropical storm winds. If wave heights above theoretical still-water levels exceed the elevations of roads, bridges, or other critical areas near the coastline, evacuation could be curtailed sooner than expected, increasing the prelandfall hazards distance. Evacuation planners should be aware that low-lying sections of highway could be subject to some wave action and overwash prior to the arrival of sustained tropical storm winds, especially with the coincidental occurrence of astronomical high tide.

INLAND WINDS

After hurricane Hugo in North Carolina and Andrew in south Florida it became apparent that storm surge was not the only life threatening feature of hurricanes. Destructive hurricane force winds and tornados effected many inland counties as far as 100 miles from the coast.

Studies by the National Hurricane Center (NHC) have resulted in modifying the Tropical Cyclone Advisory to include additional information to help inland counties prepare for threatening high wind conditions. An inland wind computer model prepared in connection with the HURREVAC model has been completed and provided to inland communities. The computer program is designed to be used ONLY in the LAST HOURS before storm landfall, when the NHC track and windfield forecast errors are relatively low.

FRESHWATER FLOODING

Amounts and arrival times of rainfall associated with hurricanes are highly unpredictable. For most hurricanes, rainfall begins near the time of arrival of sustained tropical storm winds and generally reaches maximum rainfall rates as the center passes by. Unrelated weather systems in advance of the hurricane can also contribute significant rainfall amounts within a basin.

Due to the unpredictability of rainfall from hurricanes, no attempt was made to employ sophisticated modeling or analysis in quantifying those effects for the study area. Locations and facilities which are in the 100-year floodplain boundaries shown on the National Flood Insurance Rate Maps for the counties or have historically flooded during periods of heavy rainfall should be considered to be vulnerable to freshwater flooding from hurricane conditions.

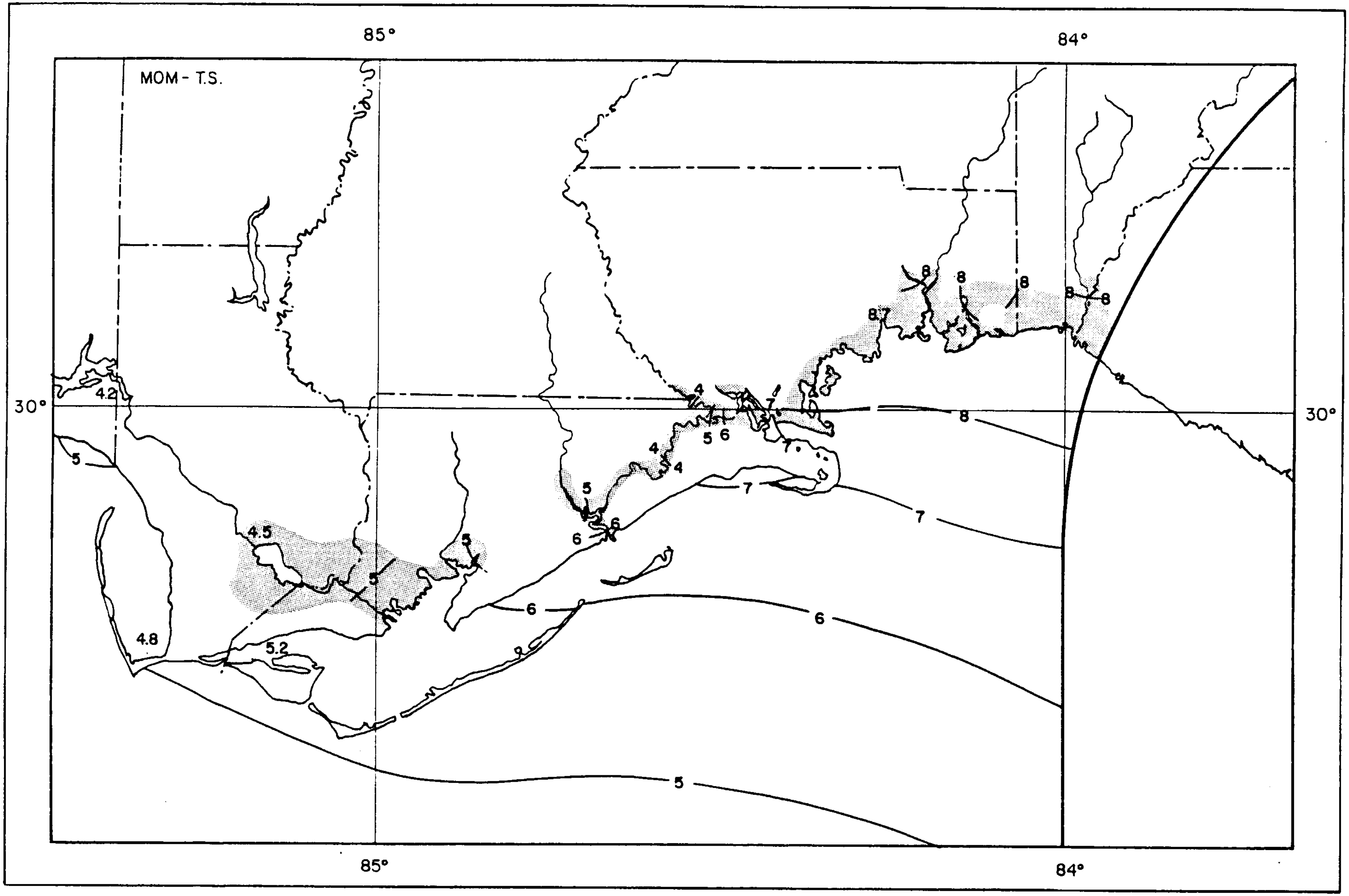

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PLATE 2-1

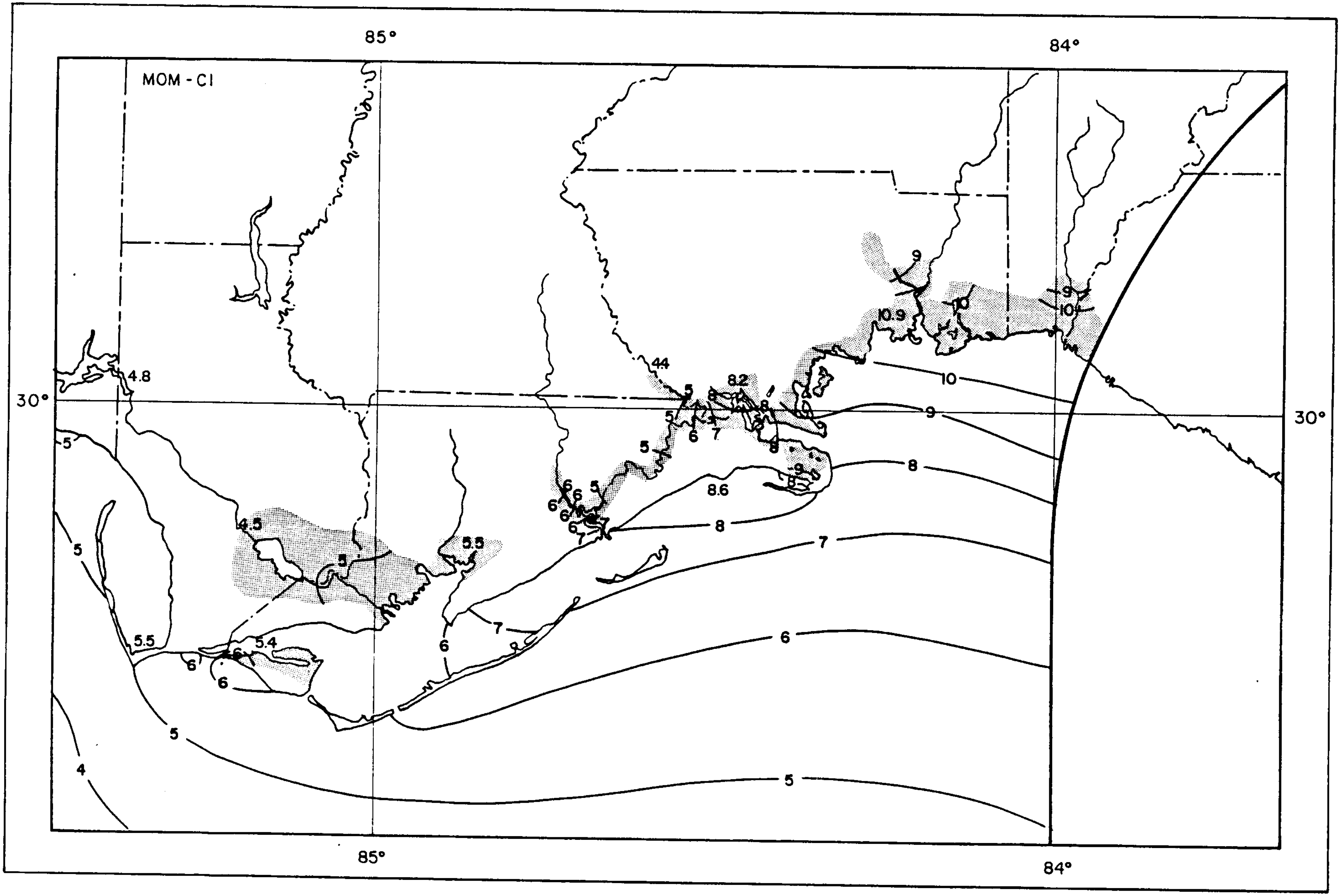

PLATE 2-2

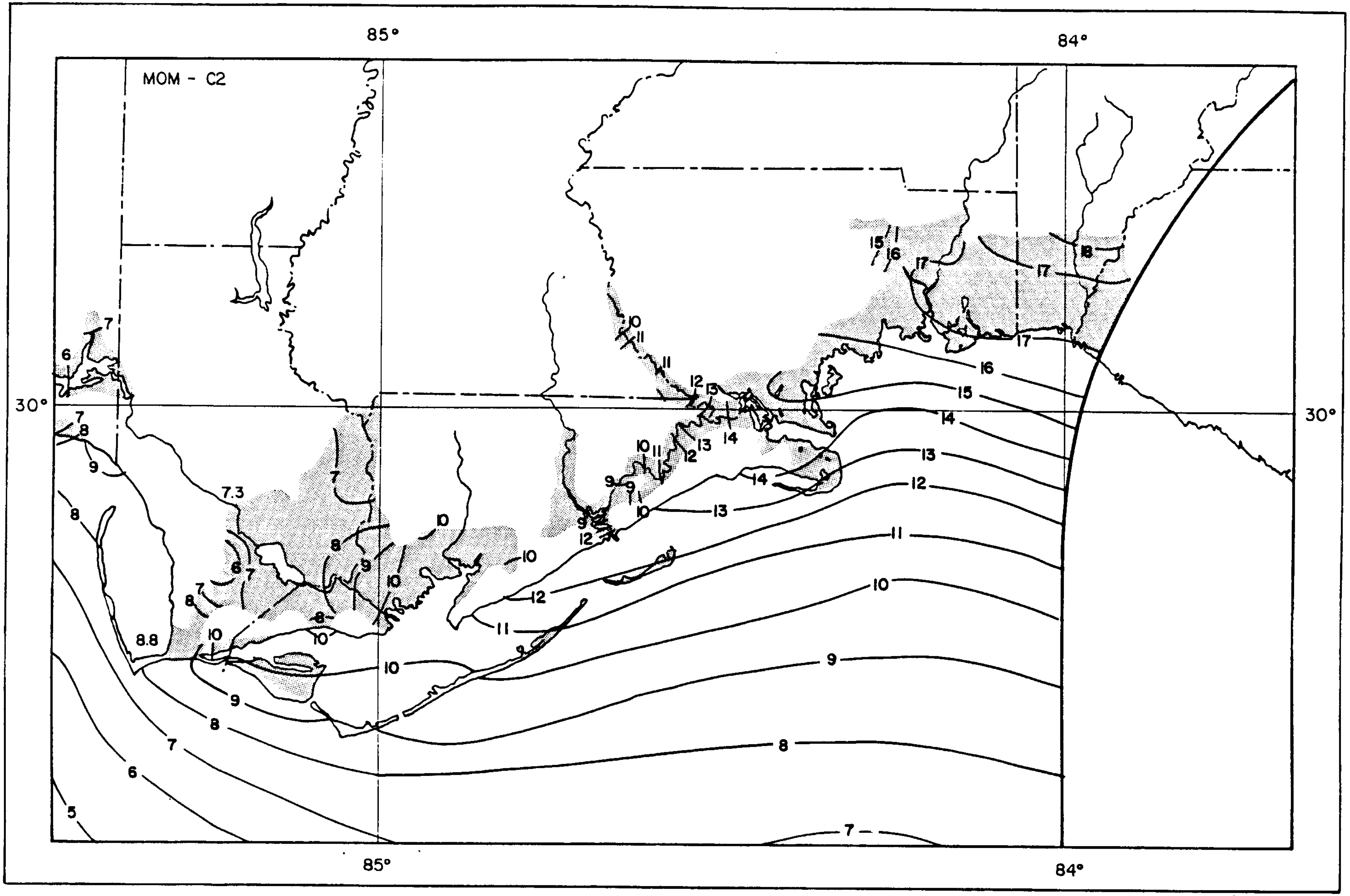

PLATE 2-3

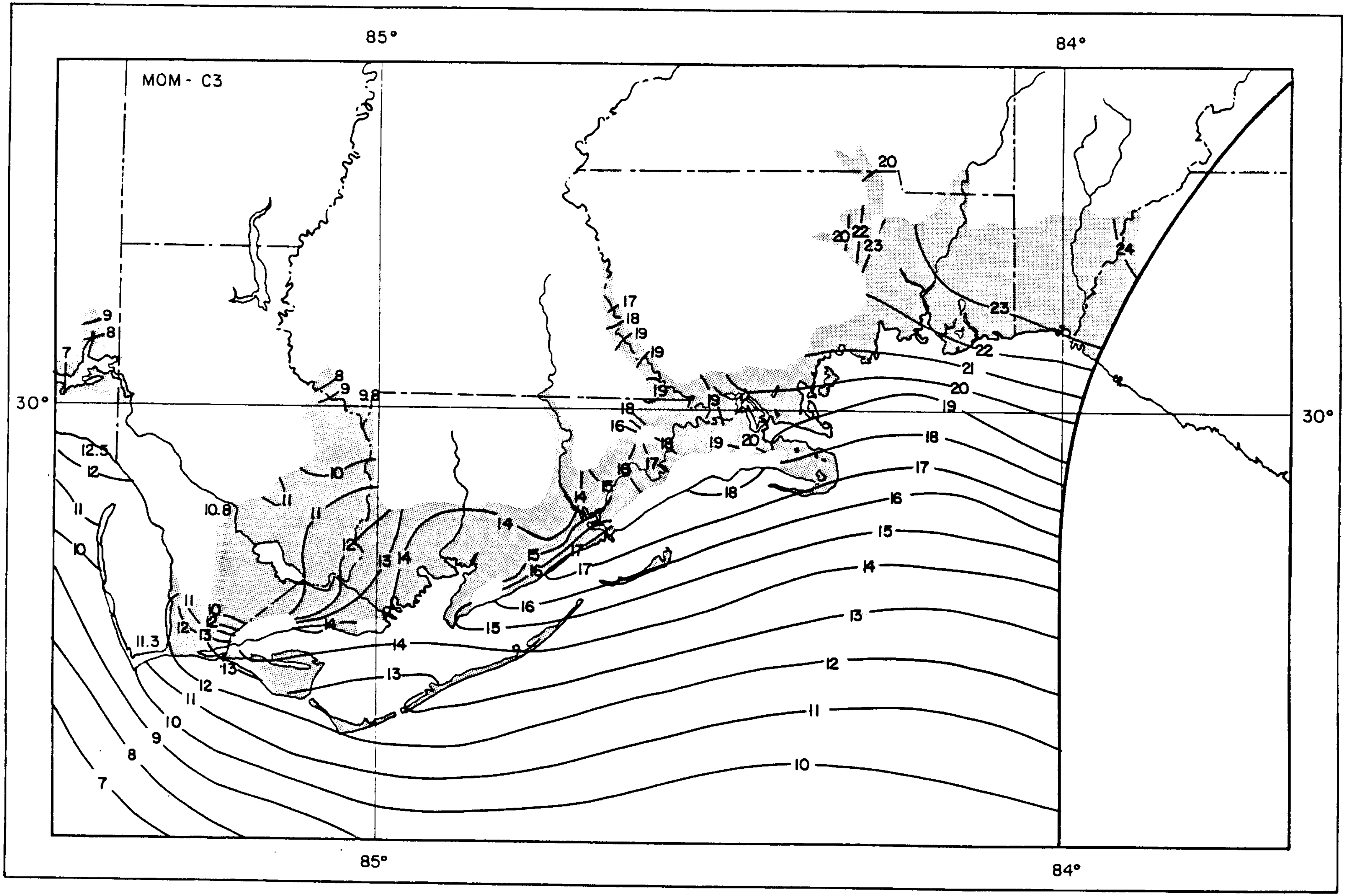

PLATE 2-4

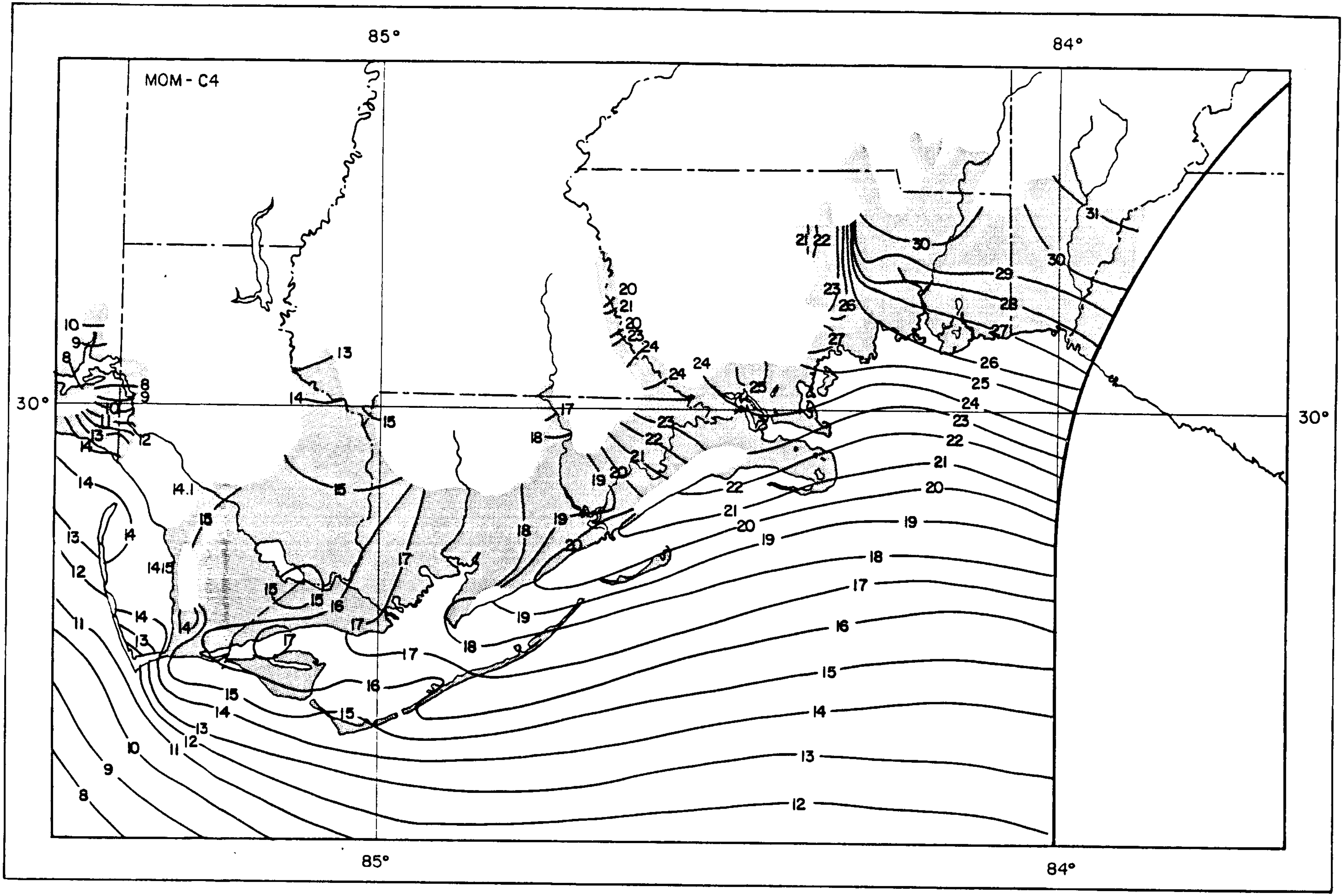

PLATE 2-5

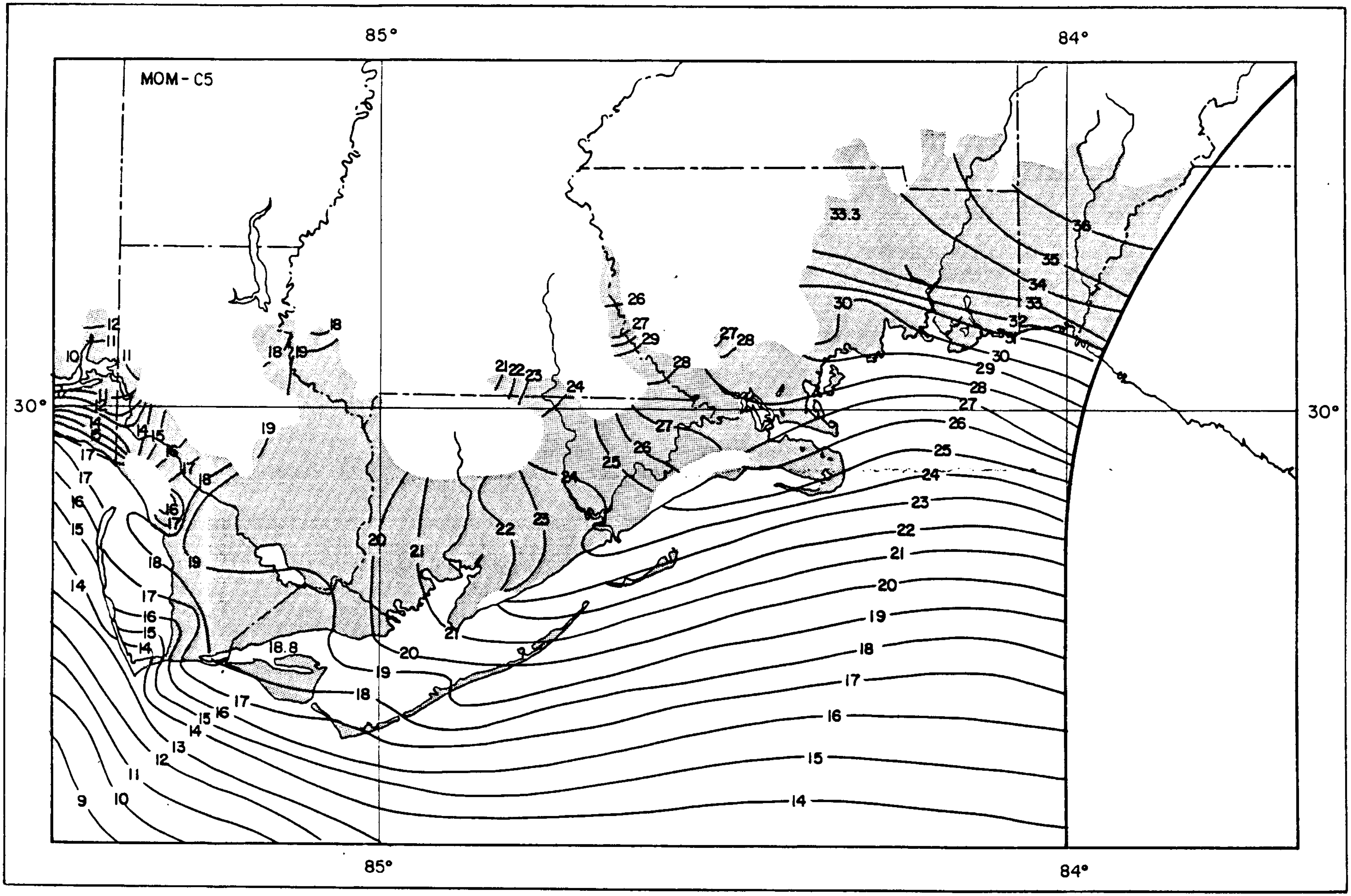
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PLATE 2-6

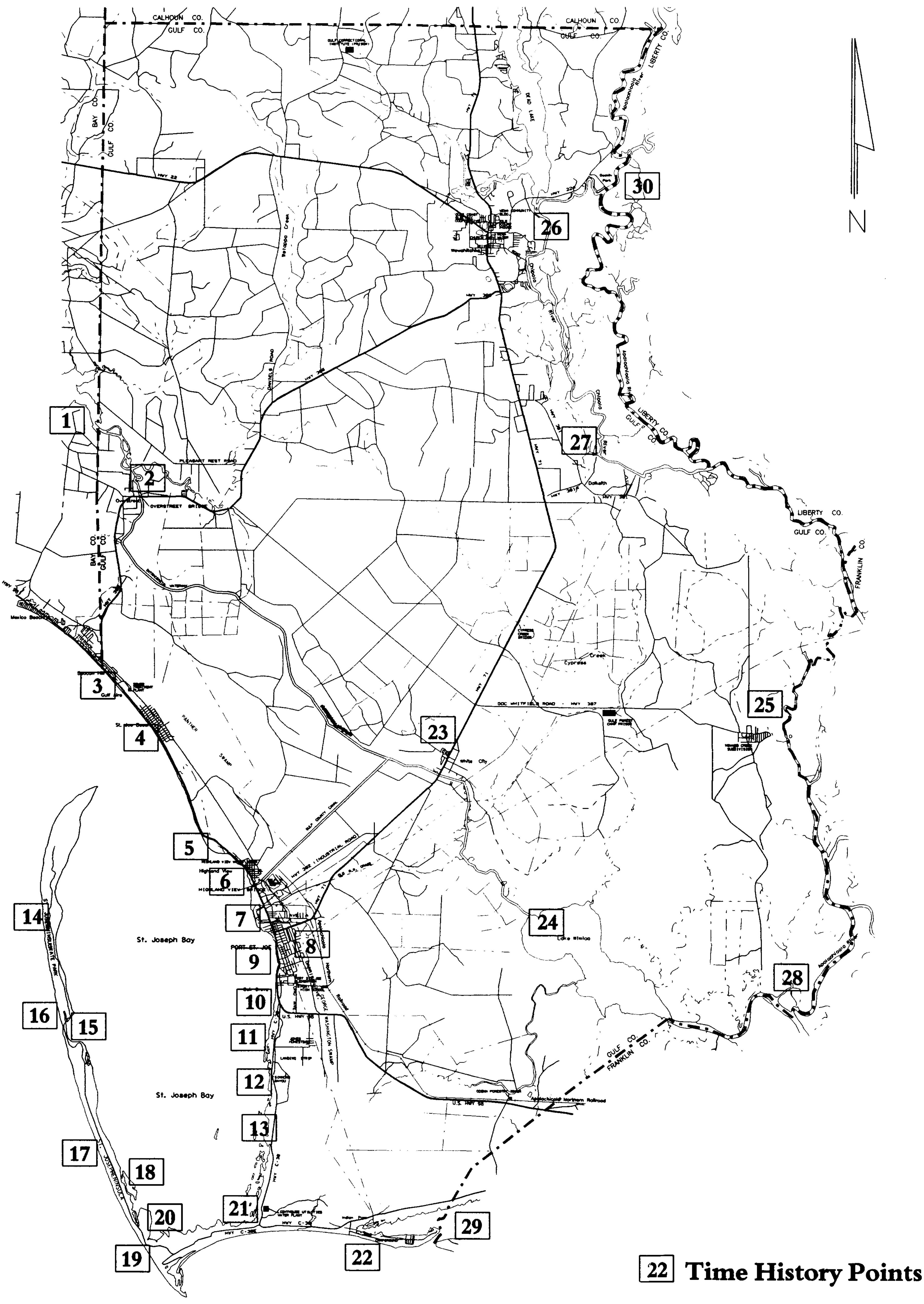
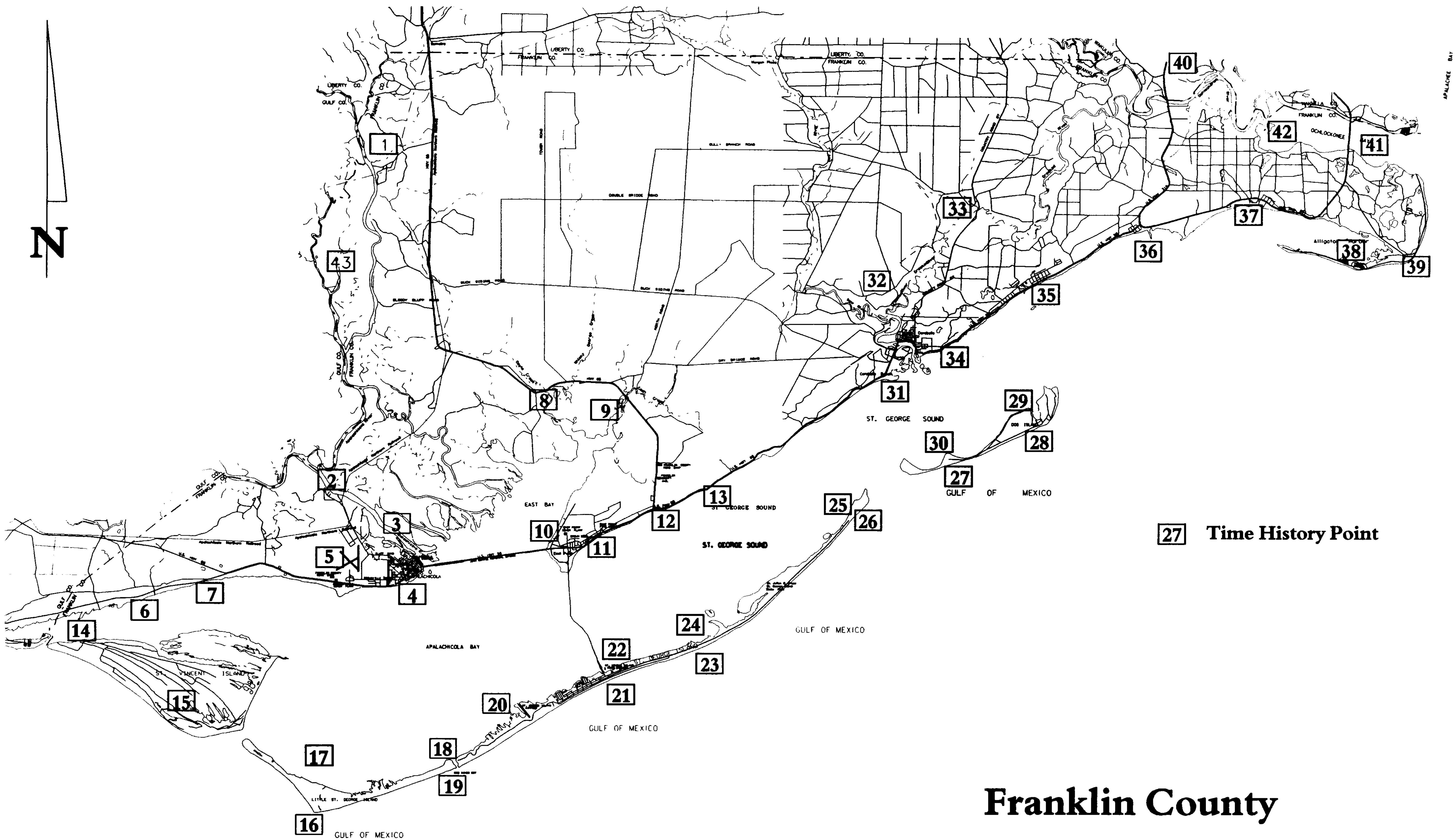


Plate 2-7

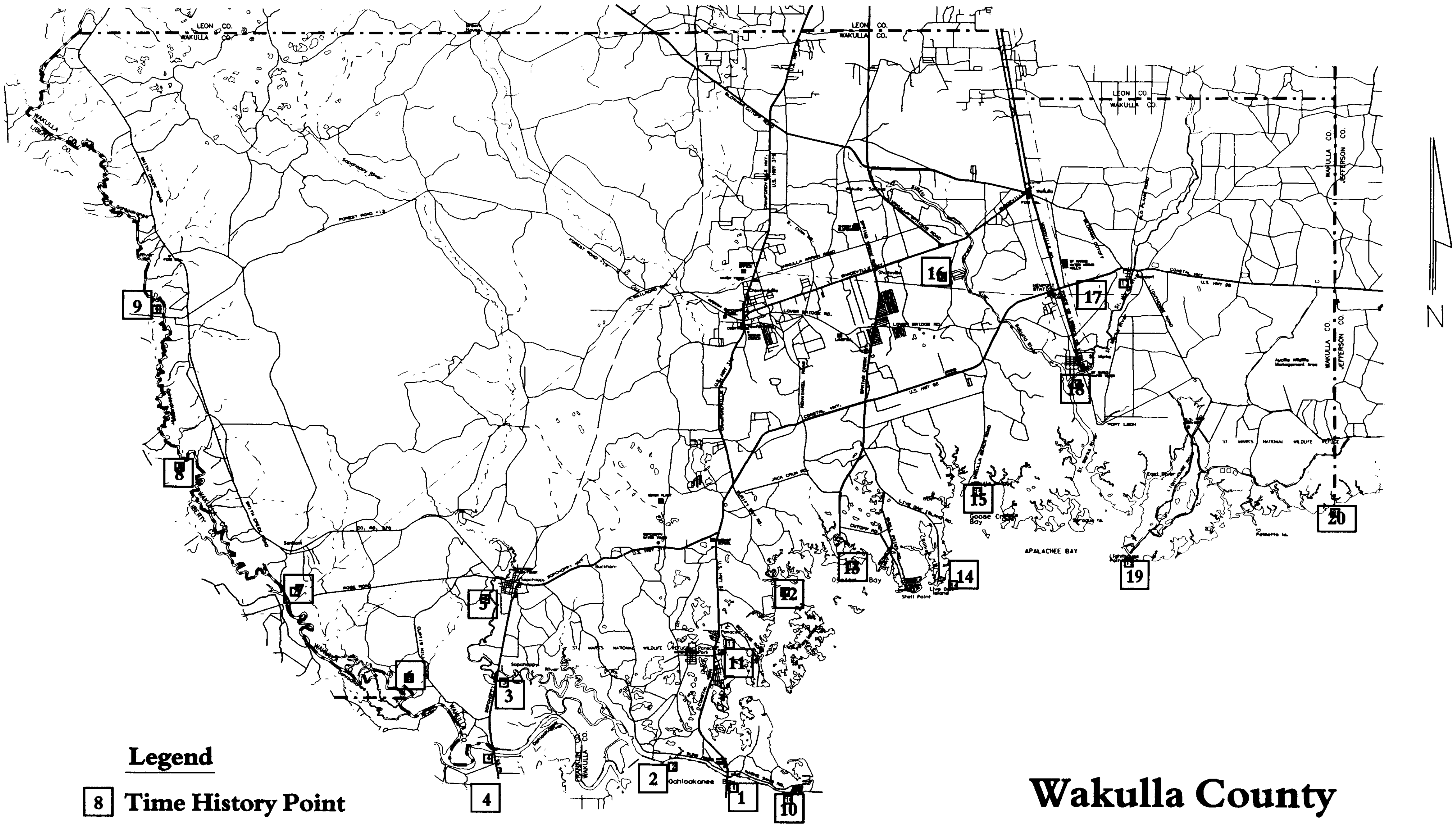
GULF COUNTY

APALACHEE REGION HURRICANE EVACUATION STUDY



APALACHEE REGION HURRICANE EVACUATION STUDY

Plate 2-8



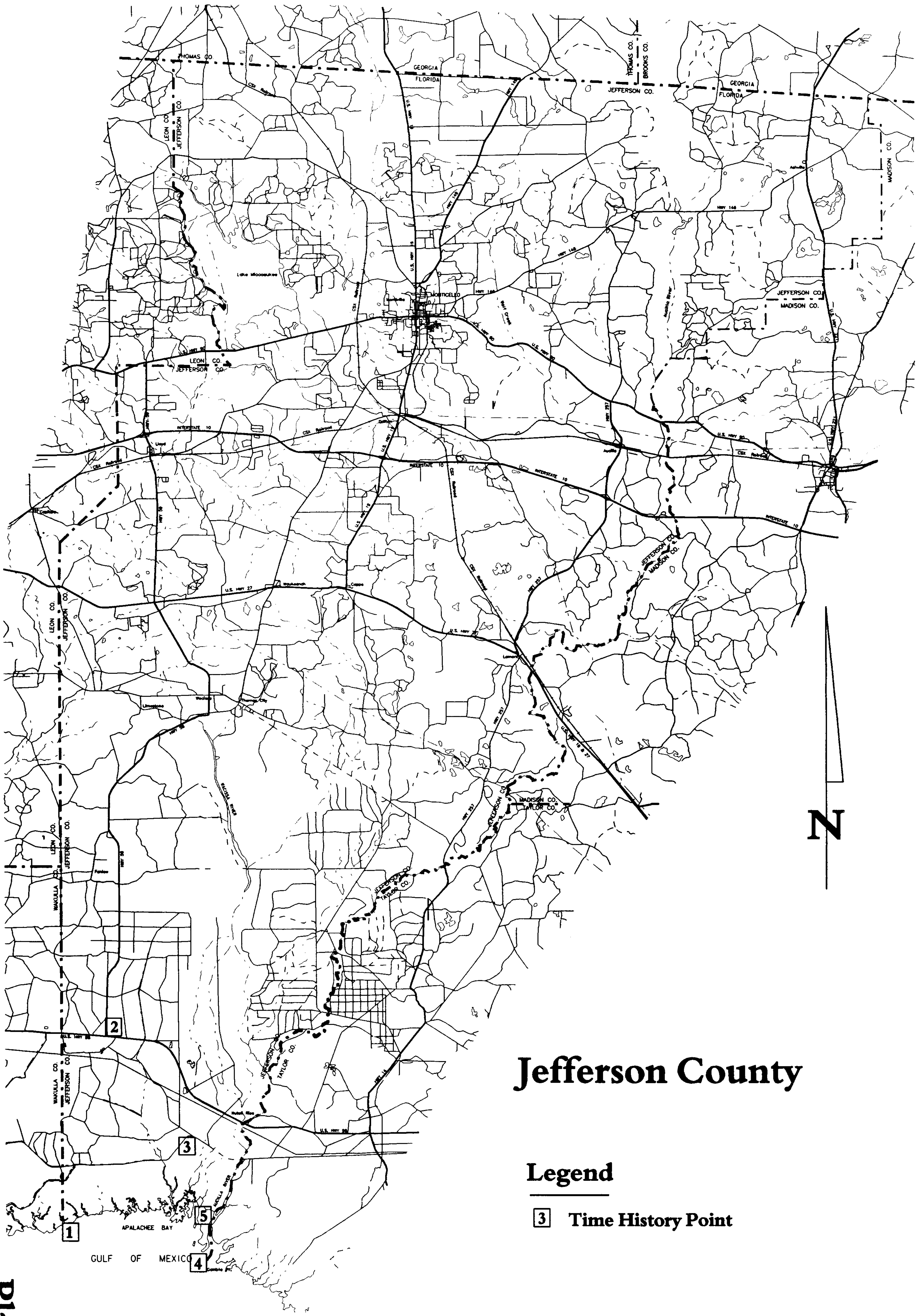
Legend

8 Time History Point

Wakulla County

APALACHEE REGION HURRICANE EVACUATION STUDY

Plate 2-9



Jefferson County

Legend

3 Time History Point

Plate 2-10

APALACHEE REGION HURRICANE EVACUATION STUDY

VULNERABILITY ANALYSIS

CHAPTER THREE - VULNERABILITY ANALYSIS

PURPOSE

The primary purpose of the vulnerability analysis is to identify the areas, populations, and facilities that are vulnerable to storm surge and to wind damage. Storm surge data from the hazards analysis were used to map inundation areas; to develop evacuation scenarios and evacuation zones; to quantify the vulnerable population; and to identify major medical, institutional, and other facilities that are potentially vulnerable to storm surge.

Since mobile homes have proven to be particularly susceptible to wind damage, they have been given special attention in the vulnerability analysis. No attempt has been made to identify other types of construction that may have a high risk of wind damage.

STORM SURGE INUNDATION

Because of unavoidable inaccuracies in hurricane forecasting, the MEOW approach is used for preparedness planning. The inundation maps (Hurricane Surge Atlases) depict peak surge values from the MOMs computed by the SLOSH model. (See chapter 2, Apalachicola Bay Modeling Process, paragraph b.) These maps show the maximum extent of storm surge flooding at high tide that is expected to be produced by any category hurricane or tropical storm, regardless of its track. The maps are based on still water surge heights that include an upward adjustment for observed tidal anomalies before the arrival of the hurricane, and the coincidence of the surge arriving at the mean high astronomical tide. These factors add an additional +2.5 feet to the computed surge height. Since the extent of flooding will actually depend a great deal on the hurricane track, the overall flooded area shown on the inundation maps for each hurricane category will never be exactly duplicated by a single storm.

To produce the inundation maps, areas vulnerable to storm surge were delineated on U.S. Geological Survey 7.5-minute series topographic maps at scale 1 inch equals 2,000 feet. The surge limits were then digitized over a 1:100,000 scale base map. The final atlases were printed in color at scale of 1 inch equals 4,000 feet. Potential flooding shown on these maps covers large areas in each county.

In order to determine the potential depth of flooding at a particular location, the elevation of the ground must be known. The depth of flooding above the ground can be calculated by subtracting the known ground elevation (using local field survey data referenced to the National Geodetic Vertical Datum) from the pertinent surge elevation.

HURRICANE EVACUATION ZONES

Hurricane evacuation zones are the areas that need to be evacuated for a particular hurricane scenario to protect residents at risk from flooding or high winds. Evacuation zones were developed with each county taking into consideration the following parameters:

a. Evacuation zones should include all populated areas having a serious risk of flooding.

b. Evacuation zones may sometimes need to include non-flood areas if they are cut off or completed surrounded by flooded areas.

c. Evacuation zones need to be easily communicated to the public and usually follow well know and easily identifiable geographic features such as major roads, railroads, or other landmarks.

Each of the four coastal counties in the Apalachee Bay Region have established several evacuation zones. These evacuation zones have been used to estimate the evacuating population and number of evacuating vehicles. This information is a key element to the transportation analysis. Table 3-1 shows the evacuation zones and the hurricane categories they include for each county. Plates 3-1 through 3-4 show a map of the evacuation zones for the four coastal counties.

Table 3-1 Hurricane Evacuation Zones

County	Evacuation Zones	Saffir-Simpson Category
Gulf	Evacuation Zone TS-Cat1	TS-Cat1
	Evacuation Zone Cat 2-3	Cat. 2-3
	Evacuation Zone Cat 4-5	Cat. 4-5
Franklin	Evacuation Zone TS-Cat1	TS -Cat1
	Evacuation Zone Cat 2-5	Cat. 2-5
Wakulla	Evacuation Zone TS-Cat1	TS -Cat1
	Evacuation Zone Cat 2-5	Cat. 2-5
Jefferson	Evacuation Zone TS-Cat2	TS -Cat2
	Evacuation Zone Cat 3-5	Cat. 3-5

VULNERABLE POPULATION

The vulnerable population, or population at risk, for each of the study area counties comprises all of those persons residing within the evacuation zones subject to storm surge and the residents of mobile homes which may be threatened by high winds. It is important to emphasize that there are special provisions for mobile home residents. Because of their proven vulnerability to strong winds, mobile home residents are usually advised to evacuate when they may be subjected to hurricane winds. The potential tourist population, based on a 70-80 percent occupancy rate of tourist units, is also included in the population of each evacuation zone. Table 3-2 summarizes the 1990 population data for the four coastal counties.

Table 3-2 Coastal County Population Data (Based on 1990 Census data)

COUNTY NAME	MOBILE HOME POPULATION	Non MOBILE HOME POPULATION	TOTAL PERMANENT POPULATION	TOURIST POPULATION
GULF	4,400	7,100	11,500	3,000
FRANKLIN	3,100	5,900	9,000	3,000
WAKULLA	8,000	6,200	14,200	2,000
JEFFERSON	4,000	7,300	11,300	200

Table 3-3, on the next page, shows the estimated number of evacuees (vulnerable population) for coastal and inland counties for each evacuation zone, based on 1990 census data. The estimated 1994 population for the counties is somewhat higher then the 1990 figures (see table 1-1) therefore, conservative assumptions regarding participation in future evacuations were made to offset any discrepancy in this regard.

CRITICAL FACILITIES

Critical facilities include facilities that may need assistance or special consideration during evacuation or immediately after the storm has past. Medical facilities, nursing homes or correctional institutions are examples of critical facilities needing special consideration and planning if they are to be evacuated. Other critical facilities include those that supply critical services and supplies after a hurricane such as food, water, power fuel, medical services and building and repair supplies. Tables 3-4 through 3-7 list the critical facilities compiled by each of the four counties. The table shows the facility name, the city it is located in, the critical function it performs and what hurricane category storm surge it is in. If the facility shows a "N.A." for the Hurricane Category column, it is located above the category 5 hurricane surge.

Administrative officials should be aware of the potential for wind damage to multi-story buildings. Post-hurricane surveys in other areas show that extreme winds can inflict major damage to substantial structures, exposing occupants to life-threatening danger. Hurricane preparedness plans based on moving people from potential surge levels vertically to upper floors must take into account the location and size of windows and doors, as well as the structural integrity of the building itself. Fortunately there are very few large multi-story buildings in the study area. Agencies responsible for hurricane preparedness of special needs facilities (hospitals, nursing homes, adult homes, and correctional facilities) should ensure that proper attention is given to the complex task of planning and coordinating emergency response.

Table 3-3 Evacuating Population Data (Based on 1990 Census Data)

County/Evacuation Zone	Mobile Home Evacuees	Non-Mobile Home Evacuees	Tourist Evacuees (Non-residents)	Estimated Total Evacuees
GULF COUNTY				
Tropical Storm - Category 1	4,400	1,250	2,250	7,900
Category 2-3	4,400	4,450	2,250	11,100
Category 4-5	4,400	5,750	2,250	12,400
FRANKLIN COUNTY				
Tropical Storm - Category 2	3,100	5,200	2,100	10,400
Category 3-5	3,100	6,100	2,100	11,300
WAKULLA COUNTY				
Tropical Storm - Category 1	8,000	2,850	1,600	12,450
Category 2-5	8,000	5,950	1,600	15,550
JEFFERSON COUNTY				
Tropical Storm - Category 2	4,000	440	160	4,600
Category 3-5	4,000	1,240	160	5,400
LEON COUNTY				
Category 1-2	25,000	5,000	0	30,000
Category 3-5	25,000	15,000	0	40,000
LIBERTY COUNTY				
All Hurricanes	2,700	0	0	2,700
CALHOUN COUNTY				
All Hurricanes	3,300	0	0	3,300
GADSDEN COUNTY				
All Hurricanes	11,400	0	0	11,400
JACKSON COUNTY				
All Hurricanes	10,300	0	0	10,300

***Important Notes:**

The Franklin County figure of 11,300 evacuees includes approximately 2,500 seasonal residents. On a fall weekday many of these will not be present. On a summer weekend these will be present as well as several thousand day visitors not tied to specific seasonal dwelling units. The Gulf County database includes 1,190 seasonal dwelling units which were assumed to be 75% occupied for each storm scenario.

The Leon County figures include all of the county's approximately 25,000 mobile home residents plus a portion of the remaining permanent population, other inland counties figures reflect current mobile home populations.

For each coastal county figures include all permanent and seasonal residents in potential surge flooded areas (as delineated by the U.S. Army Corps of Engineers, Mobile District). Aggressive pre-storm public education and strong evacuation notices would have to be issued to the public for actual response to come close to these numbers.

Table 3-4 Franklin County Critical Facilities

FACILITY	CITY	EMERGENCY_FUNCTION	HURR CAT.

FRANKLIN COUNTY FACILITIES

EASTPOINT WTR PLANT	EASTPOINT	WATER SYSTEM/ELEVATED TANK	N.A.
RADIO STATION WOYS	EASTPOINT	EMERGENCY BROADCAST STATION	N.A.
FRANKLIN COUNTY COURTHOUSE	APALACHICOLA	GOVERNMENT BUILDING	1
FRANKLIN CO SHERIFFS DEPT	EASTPOINT	LAW ENFORCEMENT-COMMUNICATIONS	5
APALACHICOLA CITY HALL	APALACHICOLA	GOVERNMENT BLDG CITY EOC	2
CARRABELLE CITY HALL	CARRABELLE	GOVERNMENT BLDG	3
ALLIGATOR POINT WTR	ALLIGATOR POINT	OFC/ELEVATED TANK	1
ALLIGATOR POINT WTR	ALLIGATOR POINT	WELL SITE WATER SYSTEM	1
ST GEORGE ISLAND UTILITY	ST GEORGE ISLAND	WATER SYSTEM/ELEVATED TANK	2
CARRABELLE WATER PLANT	CARRABELLE	WATER SYSTEM	3
CARRABELLE SEWER PLANT	CARRABELLE	SEWER PLANT	4
APALACHICOLA MUNICIPAL AIRPORT	APALACHICOLA	LANDING ZONE/AIRPORT	4
CARRABELLE FLIGHT STRIP	CARRABELLE	LANDING ZONE/AIRPORT	4
ST GEORGE ISLAND HELIPAD	ST GEORGE ISLAND	LANDING HELIPAD	2
ALLIGATOR POINT FIRE DEPT	ALLIGATOR POINT	FIRE DEPT/OPERATING CENTER	1
APALACHICOLA FIRE DEPT	APALACHICOLA	FIRE DEPT	2
DOG ISLAND FIRE DEPT	CARRABELLE	FIRE DEPT/OPERATING CENTER	1
EASTPOINT FIRE DEPT	EASTPOINT	FIRE DEPT/OPERATING CENTER	5
LANARK VILLAGE FIRE DEPT	LANARK VILLAGE	FIRE DEPT/OPERATING CENTER	3
ST TERESA FIRE DEPT	ST TERESA	FIRE DEPT	3
EMERALD COAST HOSPITAL	APALACHICOLA	MEDICAL HOSPITAL	4
APALACHICOLA HEALTH CARE CTR	APALACHICOLA	NURSING HOME	4
BAY ST GEORGE NURSING HOME	EASTPOINT	NURSING HOME	N.A.
FRANKLIN CO SR CITIZENS CTR	CARRABELLE	DISASTER APP CTR	4
INNER HARBOR HOSPITAL	CARRABELLE	MEDICAL CLINIC/FACILITY	3
APALACHICOLA HIGH SCHOOL	APALACHICOLA	SHELTER/ALTERNATE LANDING ZONE	4
BROWN ELEMENTARY SCHOOL	EASTPOINT	SHELTER	3
CARRABELLE HIGH SCHOOL	CARRABELLE	SHELTER/RECOVERY STAGING AREA	3
FRANKLIN CO. EMERGENCY OP. CTR	APALACHICOLA	EMERGENCY OPERATIONS CENTER	1
FRANKLIN CO ROAD CAMP	EASTPOINT	RECOVERY STAGING AREA/STORAGE	4
ST GEORGE ISLAND FIRE DEPT	ST GEORGE ISLAND	FIRE DEPT	N.A.
FLORIDA NATIONAL GUARD ARMORY	APALACHICOLA	LAW ENFORCEMENT	2
APALACHICOLA SEWERAGE PLANT	APALACHICOLA	SEWER PLANT	2
CHAPMAN ELEMENTARY SCHOOL	APALACHICOLA	SHELTER/DISASTER APPLICATION CTR	4
EASTPOINT SEWERAGE PLANT	EASTPOINT	SEWERAGE TREATMENT PLANT	4
LANARK VILLAGE SEWERAGE PLANT	LANARK VILLAGE	SEWERAGE TREATMENT PLANT	3
LANARK VILLAGE WATER PLANT/ TANK	LANARK VILLAGE	WATER SYSTEM	3
CARRABELLE FIRE DEPARTMENT	CARRABELLE	FIRE STATION	2

Table 3-5 Gulf County Critical Facilities

FACILITY	CITY	EMERGENCY_FUNCTION	HURR. CAT.
GULF COUNTY FACILITIES			
GULF COAST ELECTRIC COOP. INC.	WEWAHITCHKA	SUBSTATION ON W. RIVER ROAD	N.A.
GULF PINES HOSPITAL	PORT ST. JOE	HOSPITAL	1
GULF COUNTY PUBLIC HEALTH UNIT	PORT ST. JOE	HEALTH FACILITY	4
GULF COUNTY HEALTH DEPARTMENT	WEWAHITCHKA	HEALTH DEPT.	N.A.
WEWAHITCHKA MEDICAL CENTER	WEWAHITCHKA	MEDICAL CENTER	N.A.
PORT ST. JOE POLICE DEPARTMENT	PORT ST. JOE,	POLICE DEPARTMENT	3
PORT ST. JOE CITY HALL	PORT ST. JOE,	GOV'T BLDG.	3
PORT ST. JOE FIRE DEPARTMENT	PORT ST. JOE	FIRE DEPARTMENT	3
BEACHES VOLUNTEER FIRE DEPT.	PORT ST. JOE	FIRE DEPARTMENT	N.A.
SOUTH GULF VOLUNTEER FIRE DEPT	PORT ST. JOE	FIRE DEPARTMENT	
HIGHLAND VIEW VOL. FIRE DEPT	PORT ST. JOE	FIRE DEPARTMENT	3
WHITE CITY VOLUNTEER FIRE DEPT	WHITE CITY	FIRE DEPARTMENT	3
HOWARD CREEK VOL. FIRE DEPT	WEWAHITCHKA	FIRE DEPARTMENT	4
OVERSTREET VOL. FIRE DEPARTMENT	PORT ST. JOE	FIRE DEPARTMENT	1
DALKEITH VOLUNTEER FIRE DEPT	WEWAHITCHKA	FIRE DEPARTMENT	N.A.
WEWAHITCHKA VOL. FIRE DEPT	WEWAHITCHKA	FIRE DEPARTMENT	N.A.
WEWAHITCHKA EMER. MED. SERVICES	WEWAHITCHKA	MEDICAL SERVICES	N.A.
WEWAHITCHKA CITY HALL	WEWAHITCHKA	GOVERNMENT BLDG.	N.A.
GULF FORESTRY CAMP	WHITE CITY	PRISON WORK CAMP	3
GULF CORRECTIONAL INSTITUTION	WEWAHITCHKA	CORRECTIONAL FACILITY	N.A.
HIGHLAND VIEW ELEM.	PORT ST. JOE	SCHOOL	2
PORT ST. JOE ELEM. SCHOOL	PORT ST. JOE	SCHOOL	4
PORT ST. JOE HIGH SCHOOL	PORT ST. JOE	SCHOOL	4
WEWAHITCHKA ELEM. SCHOOL	WEWAHITCHKA	SCHOOL	N.A.
WEWAHITCHKA HIGH SCHOOL	WEWAHITCHKA	SCHOOL	N.A.
UNITED STATES POST OFFICE	PORT ST. JOE	POST OFFICE	2
UNITED STATES POST OFFICE	WEWAHITCHKA	POST OFFICE	N.A.
PORT ST. JOE CENTENNIAL BUILDING	PORT ST. JOE	BUILDING DAC/SHELTER	3
WEWAHITCHKA COMMUNITY CENTER	WEWAHITCHKA	COMMUNITY CENTER	N.A.
WPBH RADIO STATION C/O WPAP	PORT ST. JOE	RADIO STATION	3
ST. JOSEPH TELECOMMUNICATIONS	PORT ST. JOE	TELECOMMUNICATIONS	4
ST. JOSEPH TELECOM. BEACH OFFICE	PORT ST. JOE	TELECOMMUNICATIONS	
ST. JOSEPH TELECOM. WEWA OFFICE	PORT ST. JOE	TELECOMMUNICATIONS	N.A.
PORT ST. JOE WASTE WATER PLANT	PORT ST. JOE	WASTE WATER TREATMENT PLANT	5
WEWAHITCHKA WASTE WATER PLT	WEWAHITCHKA	WASTE WATER TREATMENT PLANT	N.A.
GULFAIRE WASTE WATER PLANT	PORT ST. JOE	WASTE WATER TREATMENT PLANT	N.A.
CITY OF PORT ST. JOE WATER PLT	PORT ST. JOE	WATER TREATMENT PLANT	4
CITY OF WEWAHITCHKA WATER PLT	WEWAHITCHKA	WATER TREATMENT PLANT	N.A.
MEXICO BEACH WATER PLANT	MEXICO BEACH	WATER TREATMENT PLANT	
LIGHTHOUSE UTILITIES WATER PLT	PORT ST. JOE	WATER TREATMENT PLANT	1
BAYSIDE LUMBER/ BUILDING SUPPLY	PORT ST. JOE	LUMBER/ BUILDING SUPPLY	1
ST. JOE HARDWARE COMPANY	PORT ST. JOE	HARDWARE	3
BEACH LUMBER AND SUPPLY	PORT ST. JOE	LUMBER/ BUILDING SUPPLY	3
FISHER'S BUILDING SUPPLY	WEWAHITCHKA	LUMBER/ BUILDING SUPPLY	N.A.
SAVEWAY FOOD STORE	PORT ST. JOE	FOOD	4
BIG STAR FOODS	PORT ST. JOE	FOOD	2
DAVID RICH'S IGA	PORT ST. JOE	FOOD	3
DAVID RICH'S IGA	WEWAHITCHKA	FOOD	N.A.
WALKER'S DIXIE DANDY STORE	PORT ST. JOE	FOOD	2
DIXIE DANDY	WEWAHITCHKA	FOOD	N.A.
MILLER AGENCY, INC.	PORT ST. JOE	PETROLEUM WHOLESALER	4

Table 3-5 Gulf County Critical Facilities con't

FACILITY	CITY	EMERGENCY_FUNCTION	HURR. CAT.
GULF COUNTY FACILITIES con't			
BARFIELD'S LAWN & GARDEN CENTER	PORT ST. JOE	LAWN & GARDEN CENTER	2
WEWAHITCHKA CONGREG. MEAL SITE	WEWAHITCHKA	SPECIAL NEEDS POPULATION	N.A.
GULF AVIATION, INC.	PORT ST. JOE	AVIATION	4
FIVE POINT LANDFILL	PORT ST. JOE	DEBRIS DISPOSAL	5
WETAPPO LANDFILL	WEWAHITCHKA	DEBRIS DISPOSAL	N.A.
APALACHICOLA NORTHERN RAILROAD	PORT ST. JOE	RAILROAD OFFICE BUILDING	3
LONG AVE BAPTIST CHURCH & GYM	PORT ST. JOE	CHURCH	1
BAY ST. JOSEPH CARE CENTER, INC.	PORT ST. JOE	NURSING HOME	3
TEST SITE D-3 (VITRO TECH. SERV.,)	PORT ST. JOE	FED GOVT SITE	
ST. JOE PAPER COMPANY	PORT ST. JOE	PAPER COMPANY	2
ARIZONA CHEMICAL COMPANY	PORT ST. JOE	CHEMICAL COMPANY	4
ST. JOE RENT-ALL, INC.	PORT ST. JOE	EQUIPMENT RENTAL	3
GULF COUNTY COURTHOUSE	PORT ST. JOE	EOC TOWER	4
GULF COUNTY COURTHOUSE	PORT ST. JOE	HELICOPTER LANDING SITE	3
GULF COUNTY COURTHOUSE	PORT ST. JOE	COURTHOUSE RADIO TOWER	4
KIRK'S ICE	PORT ST. JOE	ICE	3
HIGHLAND VIEW WATER TANK	PORT ST. JOE	WATER	3
OVERSTREET BOAT RAMP	PORT ST. JOE	BOAT RAMP	1
OLD GULF COUNTY COURTHOUSE	WEWAHITCHKA	GOV'T BLDG.	N.A.
GULF COUNTY ROAD DEPARTMENT	WEWAHITCHKA	TRANSPORTATION	N.A.
FLORIDA POWER CORPORATION	MONTICELLO	BEACON HILL SUBSTATION	3
FLORIDA POWER CORPORATION	MONTICELLO	PORT ST. JOE INDUSTRIAL SUBSTATION	N.A.
FLORIDA POWER CORPORATION	MONTICELLO	PORT ST. JOE SUBSTATION	3
GULF COUNTY SENIOR CITIZENS	PORT ST. JOE	SPECIAL NEEDS POPULATION	4

Table 3-6 Jefferson County Critical Facilities

FACILITY	CITY	EMERGENCY_FUNCTION	HURR. CAT.
JEFFERSON COUNTY FACILITIES			
JEFFERSON NURSING CENTER	MONTICELLO	NURSING HOME	N.A.
GERRY MEDICAL CLINIC	MONTICELLO	MEDICAL CLINIC	N.A.
JEFFERSON COUNTY EOC	MONTICELLO	EMERGENCY OPERATIONS	4
JEFFERSON COUNTY AEOC	MONTICELLO	ALTERNATE EMER OPERATION CNTR	N.A.
JEFFERSON COUNTY HEALTH UNIT	MONTICELLO	PUBLIC HEALTH	3
JEFFERSON COUNTY FIRE RESCUE	MONTICELLO	FIRE AND AMBULANCE SERVICE	2
FAMILY PHYSICIAN OFFICE	MONTICELLO	DOCTORS OFFICE	N.A.
JEFFERSON COUNTY COURTHOUSE	MONTICELLO	COUNTY SEAT	N.A.
WYNN DIXIE STORES, INC.	MONTICELLO	GROCERIES	N.A.
JEFFERSON ELEMENTARY SCHOOL	MONTICELLO	SHELTER	N.A.
HOWARD MIDDLE SCHOOL	MONTICELLO	SHELTER	N.A.
JEFFERSON HS AUDITORIUM	MONTICELLO	PRIMARY PUBLIC SHELTER	N.A.
JEFFERSON HS MEDIA CENTER	MONTICELLO	SPECIAL NEEDS SHELTER	N.A.
JEFFERSON HS CAFETERIA	MONTICELLO	SHELTER	N.A.
MONTICELLO WATER PLANT	MONTICELLO	WATER FOR CITY OF MONTICELLO	N.A.
MONTICELLO SEWER FACILITY	MONTICELLO	WASTE WATER TREATMENT PLANT	N.A.
JEFFERSON COUNTY SHERIFFS OFF.	MONTICELLO	LAW ENFORCEMENT	N.A.
MONTICELLO SEWER LIFT STATION #1	MONTICELLO	WASTEWATER PUMP	N.A.
MONTICELLO SEWER LIFT STATION	MONTICELLO	WASTEWATER PUMP	N.A.
FOODWAY OF MONTICELLO	MONTICELLO	GROCERIES	N.A.
MONTICELLO WATER PLANT	MONTICELLO	DRINKING WATER	N.A.
SEWER LIFT STA (BUSBARN)	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.
SEWER LIFT STA(HERITAGE MANOR)	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.
SEWER LIFT STA S. JEFFERSON ST.	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.
SEWER LIFT STATION MAYS ST.	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.
SEWER LIFT STATIONHICKORY ST.	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.
SEWER LIFT STATION HOLLY HILLS	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.
JEFFERSON SHERIFFS OFFICE	MONTICELLO	LAW ENFORCEMENT	N.A.
SEWERLIFT STA INDEPENDENT ST.	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.
SEWERLIFT STA. SHEPARDS ST.	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.
MONTICELLO PEARL ST WATER WELLS	MONTICELLO	POTABLE WATER WELLS	N.A.
SEWER LIFT STA. US 19 TRAILER PARK	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.
SEWER LIFT STA. SHADY LANE	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.
SEWER LIFT STA. US19 JCKC	MONTICELLO	PUMPS WASTEWATER TO SEWER PLANT	N.A.

Table 3-7 Wakulla County Critical Facilities

FACILITY	CITY	EMERGENCY_FUNCTION	HURR. CAT.
WAKULLA COUNTY FACILITES			
APALACHEE BAY VOL. FIRE DEPT	WAKULLA	FIRE DEPT.	TS
GOVERNMENT COMPLEX	WAKULLA	GOVERNMENT	5
HEALTH DEPARTMENT	WAKULLA	HEALTH	4
LIFT STATION #8	WAKULLA	WASTEWATER	TS
MEDART FIRE / AMBULANCE	WAKULLA	MEDICAL	5
SPRINT CELLULAR BLDG.	WAKULLA	COMMUNICATIONS	5
STATION # 6	WAKULLA	FIRE	5
WATER TANK	WAKULLA	WATER SUPPLY	5
WATER TANK AND PUMP	PANACEA	WATER SUPPLY	TS
OLIN ORDNANCE PLANT	ST MARKS	ORDNANCE PLANT	TS
LOUIS DREYFUS ENERGY	ST MARKS	ENERGY	TS
MURPHY OIL USA - ST MARKS TERMINAL	ST MARKS	OIL TERMINAL	TS
ARGUS SERVICES TRANSFER STATION	WAKULLA	TRANSFER STATION	TS
PANACEA LAND FILL	WAKULLA	LAND FILL	TS
SPRING CREEK LAND FILL	WAKULLA	LAND FILL	TS
WAKULLA COUNTY AIRPORT	PANACEA	AIRPORT	TS
ENVIR. RESEARCH INC. LAND FILL	WAKULLA	LAND FILL	2
NEWPORT STATION LAND FILL	WAKULLA	LAND FILL	2
WAKULLA COUNTY ADULT SCHOOL	WAKULLA	SCHOOL	2
WAKULLA CLUB AIRPORT	WAKULLA	AIRPORT	2
CITY OF SOPCHOPPY WATER TREATMENT	WAKULLA	WATER TREATMENT	2
ST. MARKS WATER TREATMENT	WAKULLA	WATER TREATMENT	2
SOPCHOPPY LAND FILL	WAKULLA	LAND FILL	3
MEDART LAND FILL	WAKULLA	LAND FILL	3
DUGGAR CEMETERY LAND FILL	WAKULLA	LAND FILL	3
HYDE PARK (#1) LAND FILL	WAKULLA	LAND FILL	3
HYDE PARK (#2) LAND FILL	WAKULLA	LAND FILL	3
CITY OF SOPCHOPPY WATER TREATMENT	WAKULLA	WATER TREATMENT	3
CITY OF SOPCHOPPY WATER TREATMENT	WAKULLA	WATER TREATMENT	3
LOWER BRIDGE LANDFILL	WAKULLA	LAND FILL	4
"CRAB SCRAP COMPOST R,D&D PROJECT"	WAKULLA	LAND FILL	4
HARRELL BROTHERS LAND FILL	WAKULLA	LAND FILL	4
CRAWFORDVILLE LAND FILL	WAKULLA	LAND FILL	4
SHADEVILLE ELEMENTARY SCHOOL	WAKULLA	SCHOOL	4
WAKULLA MIDDLE SCHOOL	WAKULLA	SCHOOL	4
SOPCHOPPY ELEMENTARY SCHOOL	WAKULLA	SCHOOL	4
"SEWAGE TREATMENT 100,000+ GAL."	PANACEA	SEWAGE TREATMENT	4
CITY OF SOPCHOPPY WATER TREATMENT	WAKULLA	WATER TREATMENT	4
CITY OF SOPCHOPPY WATER TREATMENT	WAKULLA	WATER TREATMENT	4
LEON CO. REGIONAL WATER TREATMENT	WAKULLA	WATER TREATMENT	4
CRAWFORDVILLE ELEMENTARY SCHOOL	WAKULLA	SCHOOL	5
CITY OF SOPCHOPPY WATER TREATMENT	WAKULLA	WATER TREATMENT	5
LEON CO. REGIONAL WATER TREATMENT	WAKULLA	WATER TREATMENT	5

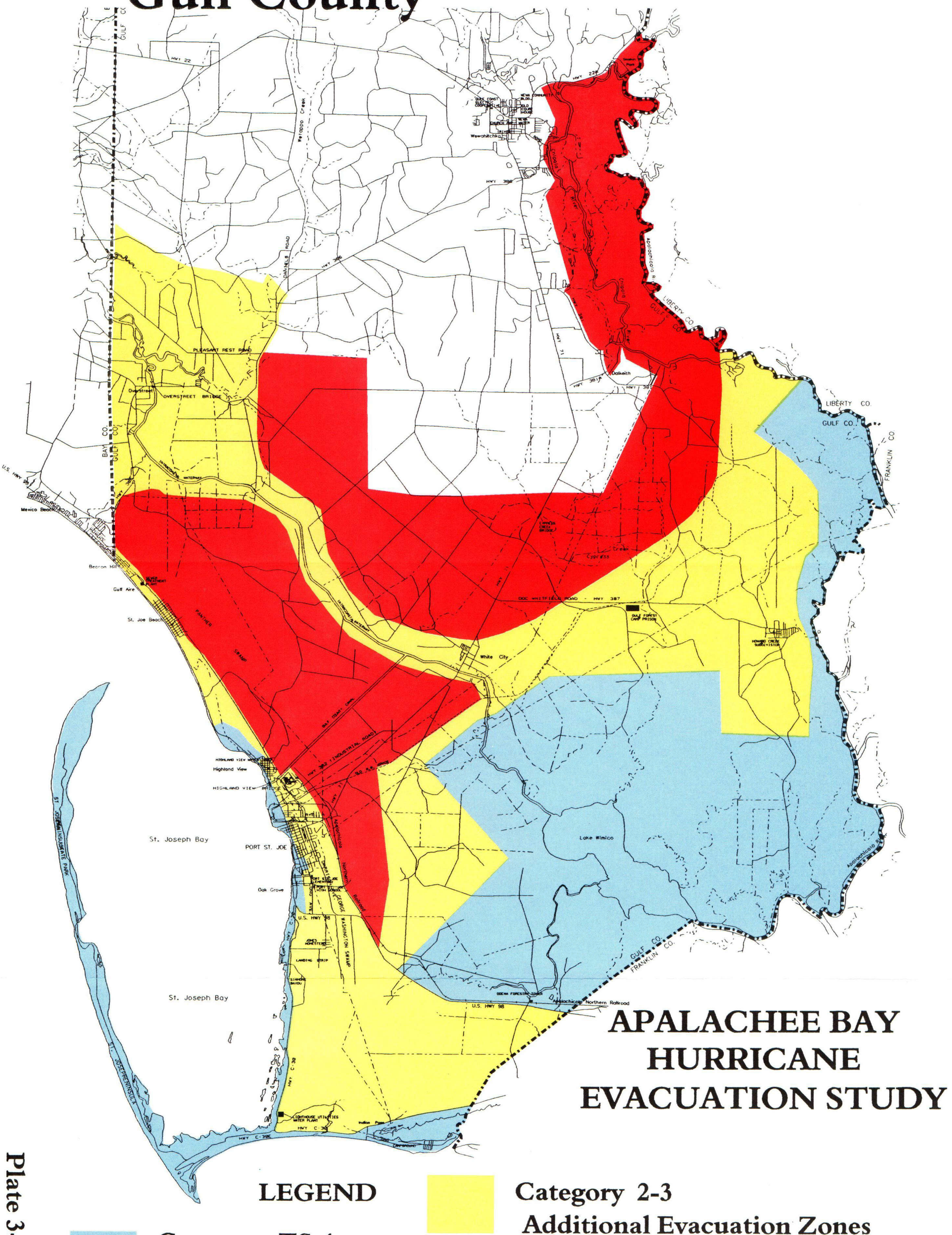
EVACUATION ROUTE FLOODING

Evacuation route flooding can be caused by two sources: rainfall runoff and storm tide. Hurricane evacuations are normally timed so that evacuees can reach safe shelter prior to the arrival of sustained tropical storm winds. Because of the wide variation in amounts and times of occurrence from one storm to another, rainfall can only be addressed in general terms. For most hurricanes, the heaviest rainfall begins near the time of arrival of sustained tropical storm winds. In some cases, however, over 20 inches of rain has preceded an approaching hurricane by as much as 24 hours.

EMERGENCY TRANSPORTATION NEEDS

Evacuation preparedness plans should consider all persons who do not have access to a private vehicle and therefore would have to rely on public transportation for evacuation. Local government should attempt to arrange for adequate resources to meet the demand for public transportation. Planning for adequate special needs emergency transportation for the infirm residing in private homes is usually the responsibility of local emergency management officials, while transportation for those in health-related facilities should be the responsibility of the individual facilities. Although detailed information concerning residents of private homes may be difficult to obtain, each local government should develop procedures for maintaining an up-to-date roster of persons likely to need special assistance. Non-ambulatory patients will require transportation that can easily accommodate wheelchairs, stretchers, and, possibly, life-sustaining equipment. Lack of resources for these needs could result in critical evacuation delays and increased hazards for the evacuees. The State of Florida has identified a shortage in some counties for these resources.

EVACUATION ZONES
Gulf County

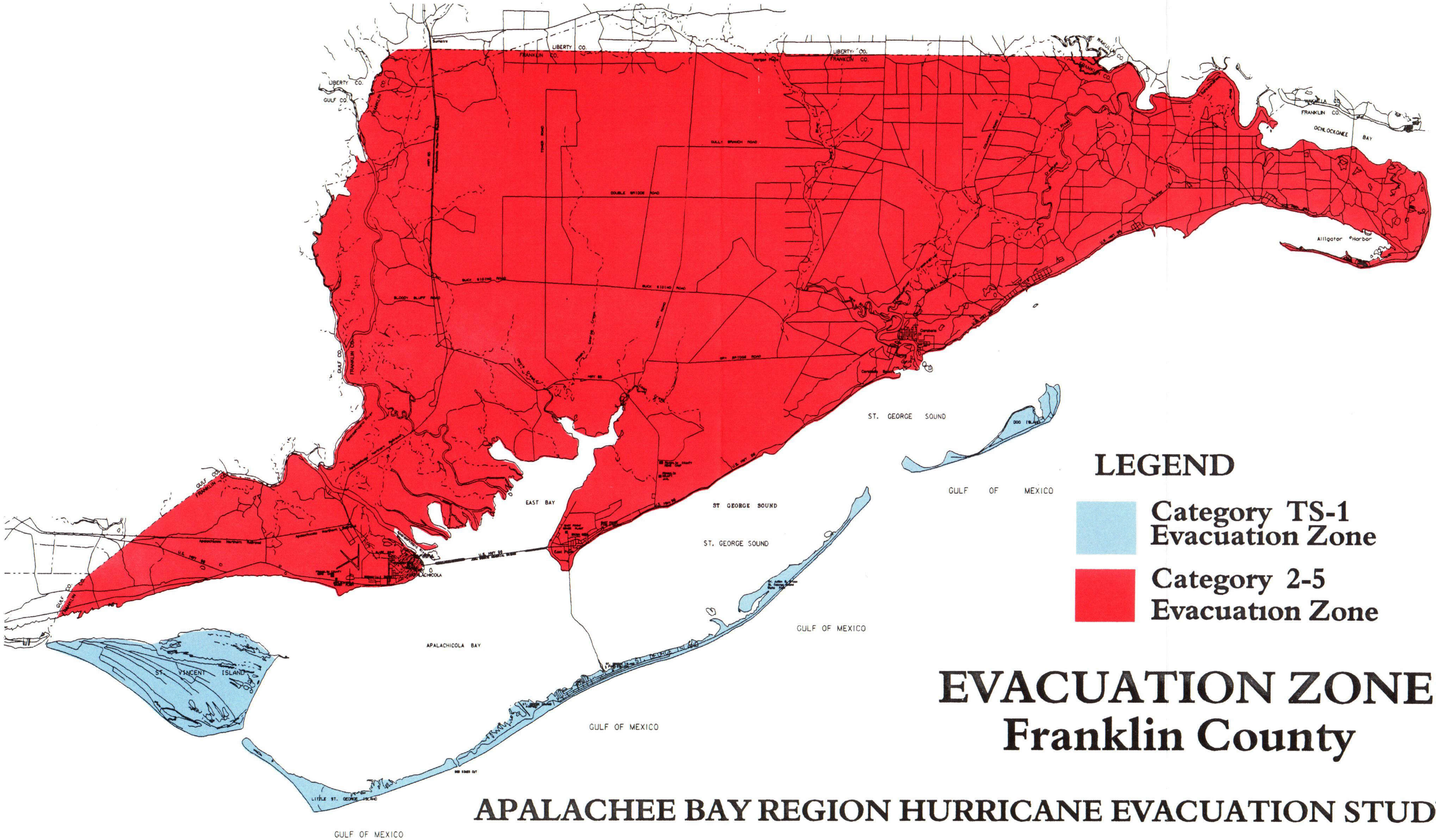


APALACHEE BAY HURRICANE EVACUATION STUDY

LEGEND

- Category TS-1 Evacuation Zones
- Category 2-3 Additional Evacuation Zones
- Category 4-5 Additional Evacuation Zones

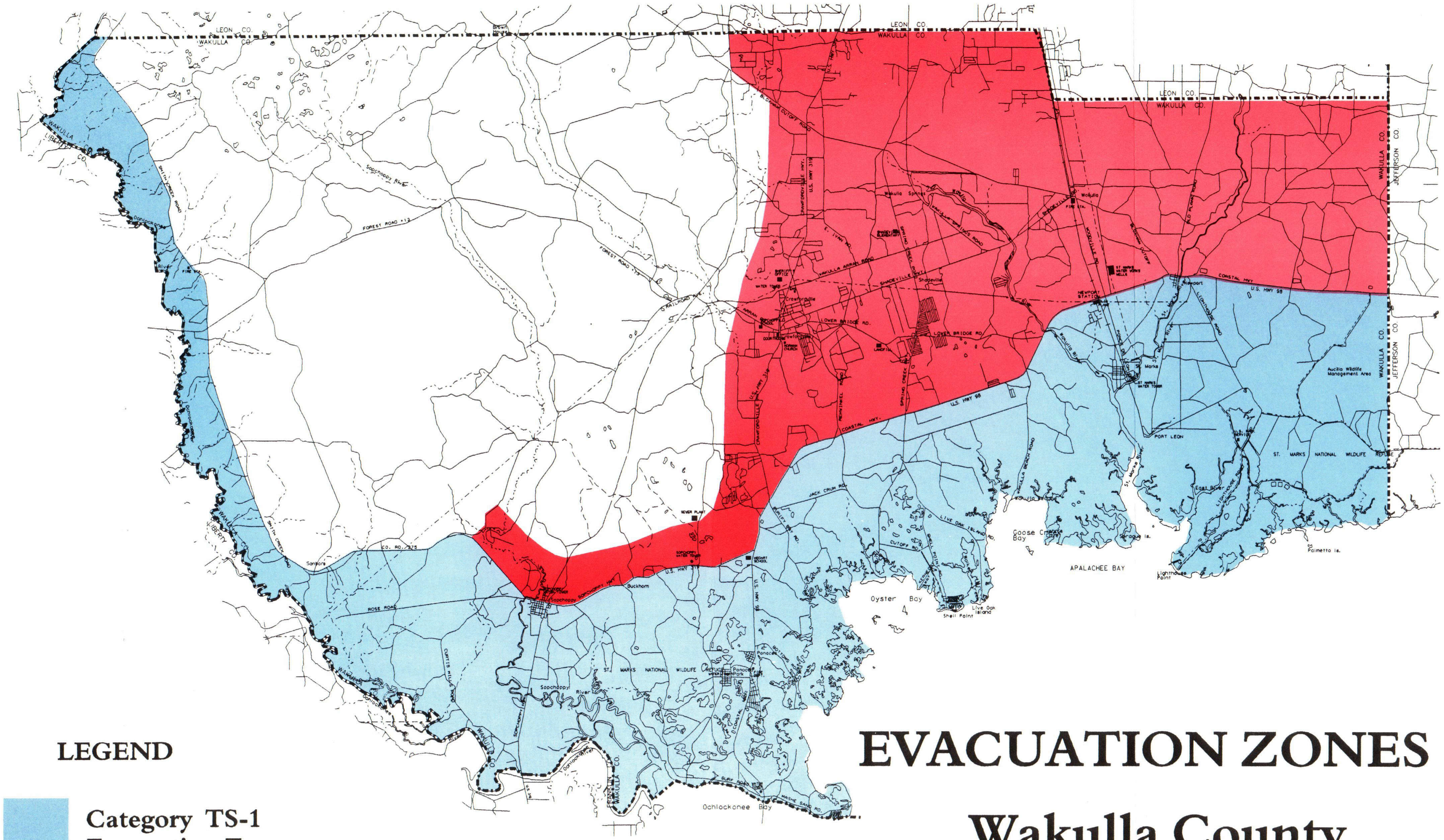
Plate 3-1



EVACUATION ZONES
Franklin County

APALACHEE BAY REGION HURRICANE EVACUATION STUDY

Plate 3-2



EVACUATION ZONES

Wakulla County

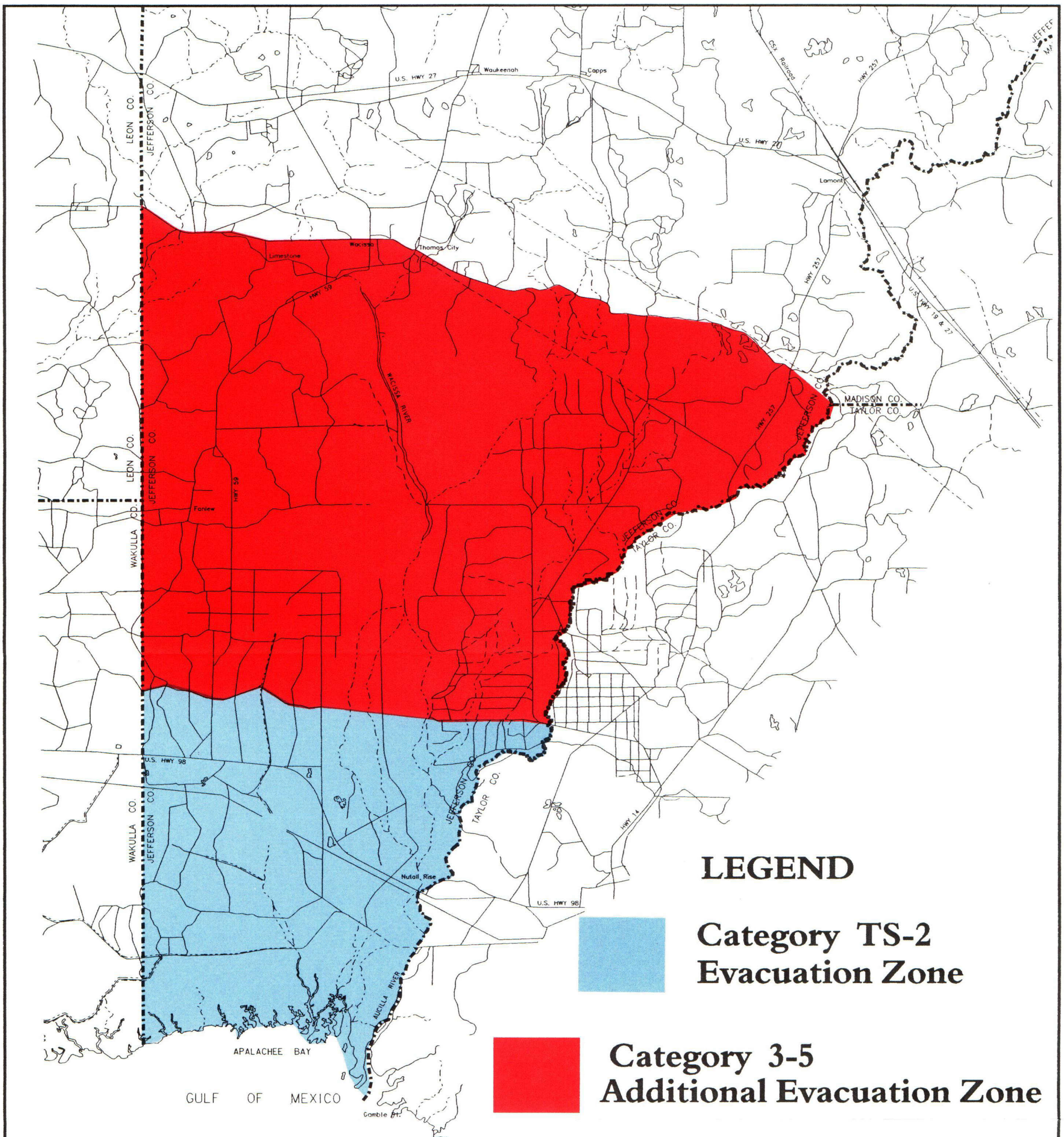
LEGEND

Category TS-1 Evacuation Zones

Category 2-5 Additional Evacuation Zones

APALACHEE BAY HURRICANE EVACUATION STUDY

Plate 3-3



EVACUATION ZONES
Jefferson County

Plate 3-4

Apalachee Bay Hurricane Evacuation Study

BEHAVIORAL
ANALYSIS

CHAPTER FOUR - BEHAVIORAL ANALYSIS

PURPOSE

The behavioral analysis is conducted to provide reliable estimates of public response to a variety of hurricane threats. These estimates are used in the shelter analysis and transportation analysis, and as guidance in emergency decision-making and public awareness efforts. The study includes the permanent population and tourists that may be visiting the area.

OBJECTIVES

The specific objectives of the behavioral analysis are to determine the following:

a. The percentages of the population that will evacuate under a range of hurricane threat situations or in response to evacuation advisories.

b. When the evacuating population will leave in relation to an evacuation advisory given by local officials or other persons of authority.

c. The number of vehicles that the evacuating population will use during a hurricane evacuation.

d. The percentage of the total number of evacuating vehicles which may be towing boats, camper trailers, or other vehicular equipment.

e. The probable destinations of the evacuating households. These data consist of percentages of the total number of evacuees going to local public shelters, staying locally with friends or relatives, staying locally in a hotel/motel, or leaving the county for out-of-region destinations.

f. How the threatened population will respond based upon forecasts of hurricane intensity, probability, or other information provided during a hurricane emergency.

g. The evacuation responses of tourists.

METHODOLOGY

Regardless of how detailed, formal, or quantitative an evacuation plan appears, it contains assumptions about behaviors such as those discussed above. Even if the assumptions are not deliberately and explicitly addressed, there are implicit or implied values for them. For example, planners who say they make no assumptions at all regarding whether people outside the recommended evacuation zone will evacuate are in fact assuming that none of those people will leave. Any time an evacuation plan is "tested" to ascertain the length of time required to complete an evacuation under the plan, the test includes quantitative assumptions regarding behavioral factors. The issue is not whether such assumptions should be made, because they must; the issue is what the assumptions should be.

There are at least three basic ways to derive behavioral assumptions:

1. Conduct interviews with people in a large number of locations asking what they did in multiple hurricane threats, documenting patterns of behavior under various conditions (general response model).

2. Conduct interviews asking people what they did in one particular evacuation (single event survey).

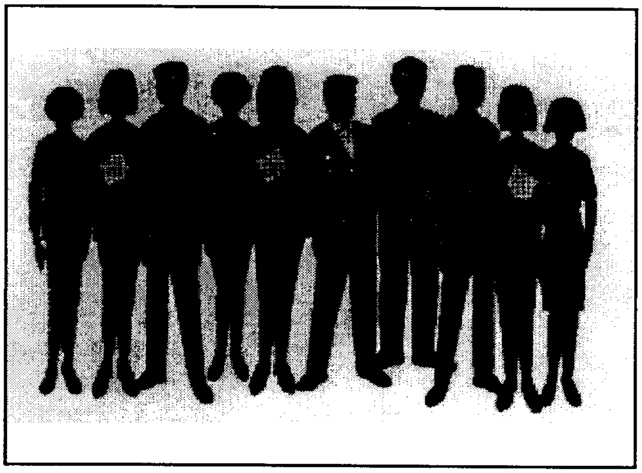
3. Conduct interviews asking people what they would do during a hurricane threat (hypothetical survey).

a. General Response Model.

A response model can be constructed to indicate quantitative values of specific responses, given a particular set of circumstances which the planner specifies. The extent of evacuation in hurricanes, can be forecast by specifying the severity of the storm, hazardousness of the neighborhood, and actions taken by public officials.

This is the heart of the approach to formulating behavioral assumptions for hurricane evacuation planning. It is fortunate to have actual response data from many hurricane evacuations spanning a wide geographical area and a variety of hurricane threat circumstances over a period of roughly three decades.

The Apalachee region was one of the first locations where general response modelling was used for hurricane evacuation planning, and it has since been enhanced by surveys concerning public response in hurricanes Alicia, Diana, Elena (1985), Kate (1985), Gloria, Hugo, and Andrew. Thus, for each of the behaviors to be anticipated, the model predicts a quantitative value, depending upon specific situations and circumstances specified.



A concern sometimes expressed about the general response model is that it is based upon responses of people in "other places" and that "our people are different." Actually the strength of the general model is that it accounts for differences in responses as they vary because of demographic characteristics of the population, actions by emergency management personnel, physical hazards of the study area, and so forth. Evidence of the model's validity lies in its history of accurately explaining and forecasting actual response behavior observed in a variety of places.

b. Single Event Response Data.

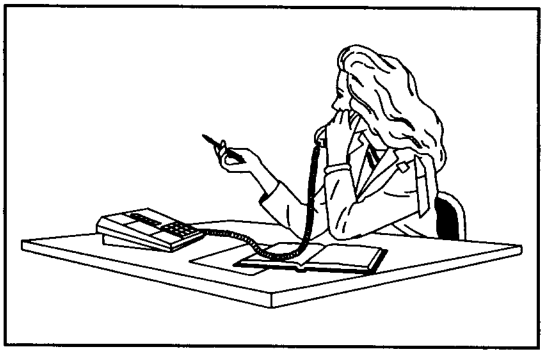
It is tempting to overgeneralize from a single evacuation in a particular location. Even the same people will respond differently in different sets of circumstances. Single event data can be very useful if not overused, however. If an evacuation occurs late at night, for example, and the evacuation is urgent, those circumstances tend to lead to fewer people leaving the local area than other circumstances. Thus, if the single event was a late night, urgent evacuation, it might provide an indication of the "worst case" to expect in that location for certain types of behaviors.

Single events also provide opportunities to validate the use of the general response model for forecasting in a specific location. Actual behavior in a single event can be documented and compared to that which would have been predicted by the general response model. Its "fit" gives a clue to how much the model would have to be adjusted to work for the specific location and hazard. As part of this project, telephone interviews were conducted in which Apalachee region respondents were asked how they responded during hurricanes Elena and Kate in 1985.

c. Hypothetical Responses.

Although hypothetical response data can hardly ever be used literally for quantitative forecasts, it does have limited utility when used carefully. It can also be very misleading. There are certain consistent biases in hypothetical response data, for example. People are more likely to say they would evacuate in "low risk" situations than they usually do, more likely to say they would leave earlier than they usually do, and more likely to say they would use public shelters more than they usually do. Hypothetical response data can be adjusted to account for those sorts of known biases. Hypothetical data in one location can be compared with that collected elsewhere for an indication of relative variation between the samples. If more people in one location say they would refuse to leave than in another, they probably really are more likely to refuse. At least more effort will be required to have them move. So, although the magnitude of people saying they wouldn't leave might not be quantitatively valid, it at least gives a relative indication. This can be particularly useful when actual response data is also available.

d. Sample Surveys



The 1983 Apalachee region behavioral study included telephone interviews in which residents were asked how they would respond if a hurricane threatened. A new survey was conducted in 1994 for the three coastal counties of Wakulla, Franklin, and Gulf. The counties were divided into three risk zones, in each of which 100 interviews were completed. The *high risk* zone consisted of St. George Island, Shell Point, Alligator Point, Cape San Blas, and other beach areas subject to flooding in Category 1 hurricanes, as well as parts of Apalachicola, St. Marks, Port St. Joe, Carabelle, and Panacea. The *moderate risk* zone was subject to storm surge but was inland of the high-risk locations. These included the largest parts of the coastal non-beach communities mentioned above. The *coastal inland* zone was generally vulnerable only to wind, although some might receive flooding from rivers and lakes, and minimal flooding from Category 4 and 5 storms. These included Wewahitchka, Howard Creek, White City, and most of Crawfordville and Sopchoppy. Jefferson County was treated as an inland county. In 1995, 200 telephone surveys were made to determine how mobile home residents in inland counties would respond to a hurricane threat. One-hundred telephone interviews were made in Leon County and 100 were distributed among Jackson, Calhoun, Liberty, Gadsden, and Jefferson. This produced two additional zones; *Leon County* and *Other inland.*

Surge inundation maps were used to identify risk areas. Street maps were used to identify the names of streets in built-up areas to include in the high-risk zone. Telephone directories were used as the source for phone numbers to be randomly sampled.

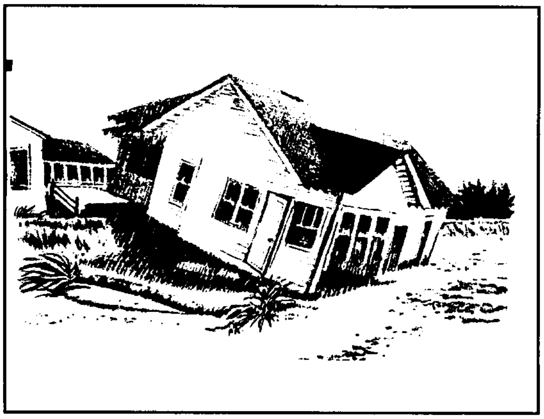
ANALYSIS OF SURVEYS

Readers should remember that the figures reported in surveys cited in this report are based upon samples taken from larger populations. The sample values provide estimates of the values of the larger populations from which they were selected, but are usually not precisely the same as the true population values. In general, the larger the number of people in the sample, the closer the sample value will be to the true population value. A sample of 100 will provide estimates which one can be 90% "confident" are within 5 to 8 percentage points of the true population values. With a sample of 50, one can be 90% "confident" of being within 7 to 11 percentage points of the actual population value. A sample of 25 is 90% "accurate" only within 10 to 17 percentage points. The sample size was too small to report separate findings for each risk zone by county, for example.

This is particularly noteworthy in drawing conclusions about whether two survey results are "different" from one another. Differences of a few percentage points in sample results of 100 or less do not necessarily mean the populations from which the samples were drawn are different. When the aggregate samples are broken down into subgroups, the reliability of estimates for the subgroups suffers.

a. Evacuation Participation Rates.

The percentage of Apalachee region residents who will evacuate during hurricane threats will depend upon several factors, but the most important is whether they believe their safety would be at risk if they stayed in their homes during a hurricane. That belief will be affected by the actual hazardousness of their location (mainly its propensity to flooding from storm surge and battering from waves), whether they have confidence in the protection their own structure will provide against wind and water, and what they believe they hear from public officials during an actual threat.



b. Responses to Evacuation Orders

To assess residents' intentions to respond to future threats several questions were asked. The first posed the following hypothetical hurricane threat scenario:

> *Let's say there's a pretty severe hurricane in the Gulf of Mexico, say a Category 3, a dangerous storm, and it looks like it could hit this area. The National Hurricane Center has issued a hurricane Watch for this area -- that means the storm probably won't hit within the next 24 hours if it hits at all, but low places in roads could be flooded before the worst of the hurricane arrives. Local officials haven't advised any specific actions yet.*
>
> *I know you can't say for sure what you would do in that situation, but do you think you and the rest of the people living with you would evacuate under those circumstances? When I say evacuate, I mean going someplace you think would be safer if the hurricane hit; it could be nearby or far away.*

Responses to the question are given in Table 4 - 1, broken down by type of risk area. More than half the respondents in the first three risk areas said they would leave their homes during the threat. The percent giving that response in the high-risk area is common in most locations, but the percent doing so in the moderate and inland areas is unusually high. In real hurricane threats matching the hypothetical situation posed in the survey, not nearly so many residents actually leave from the coastal counties. Fewer inland mobile home residents said they would leave, but those levels are also higher than occur in actual threats.

Table 4-1. Intended responses in Cat 3 hurricane, with a watch, and no recommendation or order from officials (percents).

	Leave	Stay	Don't Know
High Risk	59	37	4
Moderate Risk	63	29	8
Coastal Inland	57	32	11
Leon County (mobile home)	38	57	5
Other Inland (mobile home)	52	46	6

Respondents were then told the following:

> *Let's say the same storm is a lot closer now. The Hurricane Center has issued a Warning for this area, and local officials have ordered an evacuation. Where do you think you would go? Would you go to a public shelter, a church, a friend or relative's, a hotel or motel, home, workplace, or someplace else?*

The question does not explicitly offer respondents the option of saying they will not evacuate at all. If they gave that answer, it was recorded, however. Those who insist they would not leave at all when ordered, are in fact the least likely to leave during an actual threat. Those saying they would not evacuate or who say they don't know what they would do are given in Table 4 - 2. In all areas, only a handful (less than 10% in surge areas) say they would not leave if ordered. The figures show that there is a much greater response with an evacuation order.

Table 4-2. Intended responses in Cat 3 hurricane, with a warning, and an evacuation order from officials (percents).

	Leave	Stay	Don't Know
High Risk	92	5	3
Moderate Risk	91	6	3
Coastal Inland	79	13	8
Leon County (mobile home)	78	12	9
Other Inland (mobile home)	86	5	9

c. Perception of Vulnerability

Likelihood of evacuating is often a product of how coastal residents perceive their own vulnerability to hurricanes. A series of questions was asked to assess those perceptions. The first set of questions involved a "weak" hurricane, with winds below 100 MPH.

Respondents were asked whether they believed:

1. *their home would be at risk to dangerous flooding from storm surge or waves;*
2. *it would be safe to stay in their home, considering both wind and water; and*
3. *officials would call for the evacuation of their neighborhood.*

Results appear in Tables 4 - 3, 4 - 4, and 4 - 5. Very few people believe their homes would flood in a weak hurricane, and most, even in the high-risk locations, believe their homes would be safe. However, a majority of those in surge areas also believe officials would call for evacuation of their neighborhood. This is good because, if residents believe in advance that their area would be told to evacuate, they are more likely to understand that an evacuation notice for an actual hurricane applies to them. A number of respondents appear to believe that their home is safer than others in their neighborhood.

Table 4-3. Belief home would be at risk to flooding in a weak hurricane (percents).

	Yes	No	Don't Know
High Risk	27	67	6
Moderate Risk	24	70	7
Coastal Inland	15	81	4
Leon County (mobile home)	10	88	3
Other Inland (mobile home)	18	72	10

Table 4-4. Belief home would be safe from wind and water in a weak hurricane (percents).

	Yes	No	Don't Know
High Risk	54	45	2
Moderate Risk	65	30	2
Coastal Inland	76	22	1
Leon County (mobile home)	63	28	6
Other Inland (mobile home)	64	28	6

Table 4-5. Belief officials would evacuate neighborhood in a weak hurricane (percents).

	Yes	No	Don't Know
High Risk	65	22	13
Moderate Risk	57	29	14
Coastal Inland	32	53	16
Leon County (mobile home)	46	29	25
Other Inland (mobile home)	35	51	14

Respondents were asked the same questions about a strong hurricane, one having winds of at least 125 MPH. The corresponding responses appear in Tables 4 - 6, 4 - 7, and 4 - 8. Roughly a third of those living in surge areas said their homes would not flood in a strong storm, and 18% in the high-risk area and 27% in the moderate risk area said it would be safe to remain in their homes.

More people in the moderate risk areas and Leon County believe they would be called upon to evacuate than in the high risk areas. Almost as many coastal inland residents believe they would be told to evacuate also. These responses suggest that a strong hurricane could lead to too many people leaving from inland areas and possibly too few from high-risk areas.

Table 4-6. Belief home would be at risk to flooding in a strong hurricane (percents).

	Yes	No	Don't Know
High Risk	58	34	8
Moderate Risk	48	37	15
Coastal Inland	22	75	3
Leon County (mobile home)	46	46	9
Other Inland (mobile home)	23	70	7

Table 4-7. Belief home would be safe from wind and water in a strong hurricane (percents).

	Yes	No	Don't Know
High Risk	18	80	2
Moderate Risk	27	67	7
Coastal Inland	37	55	8
Leon County (mobile home)	27	68	6
Other Inland (mobile home)	23	67	10

Table 4-8. Belief officials would evacuate neighborhood in a strong hurricane (percents).

	Yes	No	Don't Know
High Risk	88	7	5
Moderate Risk	97	1	2
Coastal Inland	84	11	5
Leon County (mobile home)	91	4	6
Other Inland (mobile home)	75	12	14

d. Response in Elena and Kate

In 1985 there were three separate hurricane threats in the Apalachee region: two from Elena and one from Kate. If interviews had been possible within a year or two following those threats, detailed questions about each would have elicited valuable information about public response in the Apalachee region. Given the passage of time, it is unlikely that most residents would still be able to give accurate accounts of the details of each threat. It is likely, however, that many residents do recall at least certain aspects of their responses during the 1985 hurricane season.

Respondents were asked if they were living in the area and present in 1985 when either hurricane Elena or Kate happened. If so they were asked what they did then and whether they heard from public officials that they should evacuate. If respondents reported their actions in each of the three threats, then all three were recorded. Few people indicated more than one evacuation. Results are given in Table 4 - 9.

Table 4-9. Evacuated in Elena or Kate in 1985 (percents).

High Risk	73
Moderate Risk	81
Coastal Inland	34
Leon County (mobile home)	29
Other Inland (mobile home)	33

The difference between surge areas and coastal inland locations in Elena and Kate are much more normal than the intended responses reported earlier. One way of interpreting the data is that the figures in Table 4 - 9 indicate the percentage of people who evacuated at least once in response to a total of three hurricane threats. As such, the rates are not as high as one might hope. It is true that none of the three hurricane threats resulted in landfall in the interview locations (except possibly near Port St. Joe), and had the storms actually moved ashore, additional residents would have eventually left or tried to leave their homes. Still, the surge area rates, especially those for the highest risk areas, are lower than desirable.

Part of the explanation lies in Table 4 - 10. Although a large majority say they heard officials say to evacuate (in at least one of the threats), not everyone in the surge areas did. Almost half in the inland locations said they heard officials say they should evacuate. Overall, people who believe they heard officials say to evacuate were more than twice as likely to do so as other people.

Table 4-10. Heard officials say to evacuate in Elena or Kate in 1985 (percents).

High Risk	77
Moderate Risk	83
Inland	46
Leon County (mobile home)	28
Other Inland (mobile home)	31

Obviously there was little difference between the high risk and moderate risk areas in terms of response. Of the respondents saying they lived within one block of the Gulf of Mexico, 18% said they did not evacuate in 1985, which was essentially the same as the rates for those living within a quarter mile and a mile of the Gulf. Only when distance (as reported by respondents) was greater than one mile did evacuation rate change appreciably. Overall, mobile homes were no more likely to evacuate than other dwellings.

In general, respondents who said they heard from officials that they should leave their homes to go someplace safer in Elena and Kate were more likely to evacuate than others. It is probably unsound to try to relate behavior in Elena and Kate to current beliefs about propensity to flooding, safety of one's home, and expectation that officials would call for evacuation, because opinions could be different today than they were in 1985.

PLANNING RECOMMENDATIONS

Evacuation rates will vary not only among risk areas, but also from threat to threat. Table 4 - 11 presents two scenarios: one for a weak hurricane in which evacuation is ordered or recommended only in Category 1 surge areas and for all mobile homes, and one for a strong hurricane in which evacuation is ordered at least through Category 3 surge areas as well as for all mobile homes. The figures in the scenarios assume that officials are successful in reaching the public with evacuation notices. If they are not, the participation rates will be lower. Although there was no difference between mobile homes and other housing in Elena and Kate, in most evacuations there will be.

Response will vary depending upon the severity of the storm and how officials disseminate evacuation notices. It is assumed that in all cases emergency management officials at least strongly advise mobile home residents to leave and go to someplace safer. The distinction between literally issuing a mandatory notice that residents must evacuate and issuing a strong worded recommendation is not as great as one might think. This is shown in the bottom half of Table 4 - 11.

Table 4-11. Evacuation participation rates to be used for planning.

	Severe Storm Evacuation Ordered in High and Moderate Risk Areas and Mobile Homes			Weak Storm Evacuation Ordered in High Risk Areas Only but All Mobile Homes		
	RISK AREA			RISK AREA		
	High	Mod	Inland	High	Mod	Inland
Housing Other Than Mobile Homes	90%	85%	35%	80%	65%	20%
Mobile Homes	95%	90%	70%	90%	75%	50%

Inland county mobile home evacuation participation rates to be used for planning.

	Severe Storm	Weak Storm
Notice disseminated door-to-door	75%	55%
Notice disseminated by media	50%	35%

EVACUATION TIMING

Empirical evidence in evacuation after evacuation demonstrates emphatically that the very same people will leave promptly or slowly depending upon the circumstances of the particular threat. When people believe they have the luxury of taking their time to depart, most tend to do so. However, when the urgency of immediate response is communicated to people, they respond very swiftly, even leaving between midnight and daybreak. One other factor is also clear: very few evacuees (less than 20%) leave before officials issue an evacuation notice.

Therefore, people are not going to leave in substantial numbers until someone in a position of authority tells them to and then they will leave as promptly as they are told they must. The urgency of evacuations varies because of the error inherent in hurricane forecasting. If a storm intensifies, increases forward speed, or changes course unexpectedly, it usually becomes more necessary for evacuees to leave quickly.

Regardless of the proficiency of emergency management officials, circumstances are going to arise sometimes in which very prompt evacuation is necessary. In other cases the notice will be issued earlier, and evacuation can proceed more leisurely. For planning, the three different timing response curves shown in Figure 4 - 1 should be evaluated, because eventually the Apalachee region will experience all three. In each threat scenario occupants of inland areas will tend to wait longer to evacuate than those living in surge-prone locations.

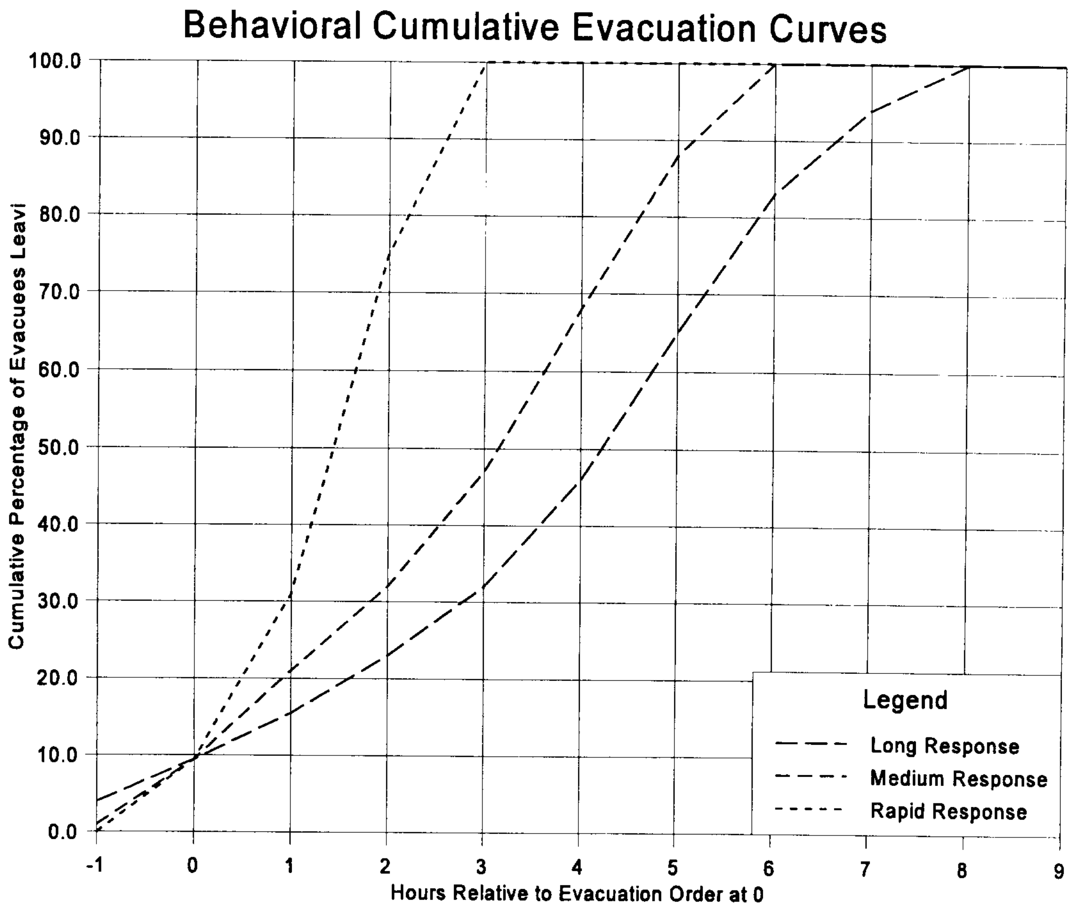
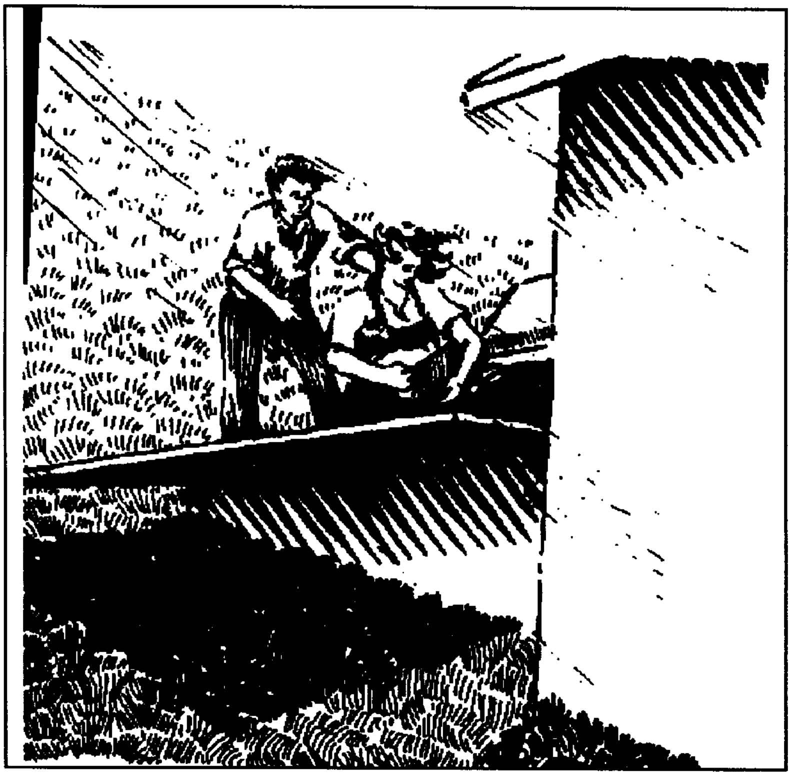


Figure 4-1 Behavioral Response Curve.

TYPE OF REFUGE



In most locations the majority of evacuees stay with friends and relatives, and that tendency is reflected in Table 4 - 12 for the Apalachee region. When asked which type of refuge they would seek when ordered to evacuate, almost half the surge zone evacuees said they would stay with friends and relatives. More respondents say they will use public shelters than actually do in real evacuations. Most of those saying they would go to public shelters said they had friends and relatives in safe locations where they could stay. Blacks were more likely (30%) than whites (8%) to say they would use public shelters, and people with household incomes below $40,000 per year were more likely to say they would use public shelters than wealthier respondents (14% vs. 5%). The hotel/motel figure could be high if sufficient numbers of rooms are not available. It is probably a good indicator of how many will seek hotel and motel rooms, however. The "other" category includes locations such as churches, workplaces and homes (for those being interviewed at vacation residences).

Table 4-12. Intended type of refuge if ordered to evacuate (percents)

	Public Shelter	Friend/ Relative	Hotel/ Motel	Other	Don't Know
High Risk	7	47	31	11	4
Moderate Risk	11	47	20	19	3
Coastal Inland	14	39	17	19	10
Leon County	20	51	5	6	18
Other Inland	17	47	4	11	21

Table 4 - 13 indicates the types of refuges respondents said they used in 1985 during hurricane Elana or Kate. The public shelter use rates are higher than the intended rates reported earlier. The reason for this is not clear; as stated above, in most instances survey respondents overstate the likelihood of using shelters when responding to hypothetical threats. There were an unusual number of "other" responses among high-risk respondents in Elena and Kate. Many went out of town fairly long distances and didn't indicate the type of refuge they used. Few if any would have used public shelters, however.

For mobile home residents, few respondents were present in 1985 which evacuated in one or more of the hurricane threats, and also recalled where they went, so the figures in Table 4 - 13 for Leon County and Other Inland are statistically tenuous for inland residents.

Table 4-13. Types of refuge used in Elena and Kate in 1985 (percents)

	Public Shelter	Friend/ Relative	Hotel/ Motel	Other
High Risk	20	24	29	27
Moderate Risk	19	40	31	10
Coastal Inland	20	56	12	12
Leon County (mobile home)	0	94	0	6
Other Inland (mobile home)	9	56	22	13

Percentage estimates for projecting demand for public shelters are given in Table 4 - 14. The two most consistent predictors of shelter demand are risk area and income. Evacuees from more hazardous locations tend to use public shelters less than those from inland areas. Poorer people tend to use shelters more than wealthier people. Table 4 - 14 is derived primarily from the general response model but is tailored to the Apalachee region based upon the survey findings. One final variable to consider is race. There is recent evidence that blacks are more likely to use public shelters than whites, even when income is accounted for.

Table 4-14. Public shelter use rates for evacuation planning (percents).

	RISK AREA		
	High	Moderate	Low
INCOME			
High	5%	10%	10%
Medium	10%	15%	20%
Low	20%	30%	40%

EVACUATION DESTINATIONS

A strong majority of respondents in all three risk areas say they would go to destinations outside their own county when evacuating (Table 4 - 15). It is relatively uncommon for more than half the evacuees to leave their own county, but in the Apalachee region it is probably in recognition of the fact that a large portion of the developed areas of the counties would be affected by storm surge in strong hurricanes. Thus, residents don't believe there would be public shelters, motels, or even many friends and relatives whose homes would be safe in the coastal counties.

Table 4-15. Location of intended destinations (percents)

	Same County	Out of County	Don't Know
High Risk	8	82	9
Moderate Risk	17	64	20
Coastal Inland	12	79	9
Leon County	52	41	7
Other Inland	60	30	10

Allocating evacuees to specific destinations is less clear, however. More than a third (38%) in each of the risk zones say they don't know where out of county they would go. The most common destination was Tallahassee, where 39% of the high-risk, 25% of the moderate risk, and 30% of the inland evacuees say they would evacuate. Leon county was named as the county where a plurality of out-of-town evacuees would go by 58% from high-risk areas, 33% from moderate-risk areas, and 39% from inland areas. Many of those planning to go out of county plan to go out of state, as indicated in Table 4 - 16. Table 4 - 17 contains a list of towns and counties, respectively, where respondents said they would evacuate.

Table 4-16. State of intended destinations (percents)

	Florida	Georgia	Alabama	Other	Don't Know
High Risk	71	17	6	2	4
Moderate Risk	50	17	20	4	9
Coastal Inland	55	23	13	0	9
Leon County	29	53	15	3	0
Other Inland	63	22	15	0	0

Table 4-17. Intended City / County destinations by out-of-county evacuees.

Number	Percent	City / County Name
79	37.3	DON'T KNOW
68	32.1	Tallahassee, Fl.
12	5.7	Dothan, Al.
6	2.8	Atlanta, Ga.
4	1.9	Blountstown, Fl.
3	1.4	Joe Key/Marianna, Fl.- Cairo/Thomasville,Ga.
2	.9	Birmingham/ Montgomery, Al. - Tilojee, Fl. - Valdosta/Savannah, Ga
1	.5	Melbourne/ Lake City/ South Beach/ Vernon/ Wewahitchka/ Bartow/ Monticello/ Tifton/ Quincy/ Calaway, Fl. - Mobile/ Centerville, Al. - Columbus/ Colquitt/ Jessup/ Donaldsonville, Ga. - Memphis, Tn. - Houston, Tx. - Charlotte, N.C.

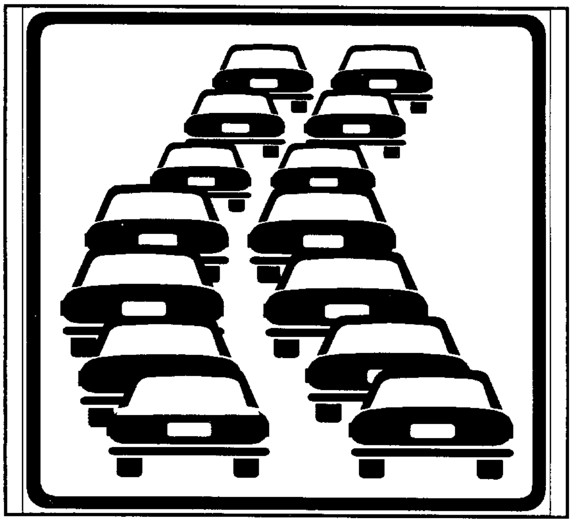
In Elena and Kate 68% of the evacuees from high-risk areas, 90% from moderate-risk areas, and 67% from inland locations said they went to out-of-town destinations. Most went to motels or to friends and relatives. Out-of-county evacuation behavior is highly variable from one location to the next. Therefore the general response model is relied upon less in this instance, and the intended response data and the Elena-Kate response data are relied upon more. It is normal for more evacuees from high-risk locations to go out of county than from moderate-risk locations and more from moderate-risk location than from inland locations. Evacuees in higher risk locations tend to leave earlier and tend to be wealthier (therefore being more able to afford hotels and motels). This distinction might not be appropriate in the Apalachee region, however. The high out-of-town rate in Elena and Kate reported by evacuees from moderate-risk areas is probably higher than will usually be the case, but rates will be high from all three risk areas. A rate of 65% should normally be assumed. In very strong storms receiving much media attention, the rate could be 75%.

These figures should not be confused with participation rates, however. The percent of residents evacuating from each of the areas will vary (see Table 4 - 11). To each of the participation rates indicated earlier, the 65% (or 75%) out of county destination rate should be applied. The best guidance to the breakdown of specific destinations among those going out of county is probably provided by the intended responses shown in Table 4 - 17.

These figures have significant implications for inland shelter demand. Of those who said they would go to public shelters (Table 4 - 12), only 23% said they would go to a shelter in their own county (54% said out of county and 17% didn't know where it would be). More importantly, if those planning to stay in hotels and motels can't find accommodations, they will create additional demand for shelters in host regions.

TRANSPORTATION

Not all available vehicles are used in evacuations, because many families prefer not to separate more than necessary. According to intentions expressed in the telephone survey, 73% of the available vehicles would be used in high-risk locations, 71% in moderate-risk areas, and 63% in inland locations. It would be reasonable to assume that between 65% and 75% of the available vehicles will be used in an evacuation. This averages to 1.3 vehicles per household *at risk* (not necessarily evacuating) in the high- and moderate-risk areas and 1.2 in inland areas.



In the high-risk areas 16% of the respondents said they would pull trailers or boats or take motor homes. In moderate-risk and inland areas 9% and 12% gave that response, respectively. These are probably indications of the maximum percentages of households which would actually do so, and in most evacuations fewer would follow through with their intentions.

Approximately 6% of the respondents in the region said they would need assistance from an agency in order to be able to evacuate. Roughly an equal number said they would receive assistance from a friend or relative. Those simply needing transportation assistance and those having special needs were equally divided.

SHELTER
ANALYSIS

CHAPTER FIVE - SHELTER ANALYSIS

PURPOSE

The general purpose of the shelter analysis is to estimate the number of evacuees that will seek public shelter and determine the number of shelter spaces available. This information is used by County and State emergency management offices to develop a management plan for shelter operation to insure that the evacuees seeking public shelter will have adequate and safe shelter space. The shelter data is also used in the transportation analysis to calculate clearance times. The transportation analysis is covered in Chapter 6.

SHELTER ANALYSIS

The shelter analysis discusses shelter locations, vulnerability, capacity, and demand. Data developed in the hazards, vulnerability and behavioral analyses were used to evaluate shelter criteria. It is important to note that the identification of a shelter in this report does not indicate that the facility will be used in a given hurricane evacuation. The choice of public shelters for a specific evacuation is a County and State emergency management decision. Shelters will be opened by county and municipal authorities based on a variety of circumstances including season, storm intensity, and direction, and availability of qualified shelter operators, including American Red Cross (ARC) personnel. Furthermore, shelter designation may change based on new construction, structure modifications, ownership changes or other factors impacting shelter selection. The following paragraphs will discuss shelter vulnerability, shelter demand (number of evacuees seeking public shelter) and shelter inventories and capacities. This portion of the report will be periodically updated by County or State offices to reflect current shelter inventories.

a. Shelter Vulnerability

Criteria contained in ARC publication 4496, Guidelines for Hurricane Evacuation Shelter Selection, dated July 1992, is a good tool to predesignate shelters within the study area. The ARC offices of emergency management have reviewed the areas of potential flooding shown on the inundation maps and will usually only open shelters located outside of any potential hurricane surge flood area. **It is vitally important that any government or private entity intending to operate a public hurricane shelter carefully consider the ARC guidelines and ensure that the shelter is above any expected storm surge elevations.**

b. Shelter Demand

Public shelter demand (number of evacuees seeking public shelter) has been calculated for several hurricane evacuation scenarios for each county. These evacuation zone scenarios are discussed for each county in Chapter 3. Generally the percent of evacuees planning to use public shelters ranges from 5-15 % depending upon their risk zone, the storm intensity and their income. (see Tables 4-12 & 4-14). Table 5-1 shows the shelter demand for each coastal county by evacuation scenario and the percent of the total evacuating population shown in Table 3-3. No out-of-county evacuees are expected to seek shelter in the coastal counties. The analysis assumes an adequate warning period for an approaching hurricane and sufficient public knowledge concerning the locations of shelters. It should be noted that some counties do not plan to open shelters for some of the more severe hurricane scenarios. Nevertheless, it is expected that there will still be some evacuees seeking shelter as a result of leaving to late or other problems in evacuating. These evacuees are labeled as (refugees) in the Table 5-1.

Table 5-1 Public Shelter Demand for Coastal Counties
(Based on 1990 census data)

County/Evacuation Zone	Potential In-County People Going to In-County Public Shelter*	% of Total Evacuating Population	Evacuees Going out of County
GULF COUNTY			
Tropical Storm - Category 1	680 people	8.6%	4,775
Category 2-3 Hurricane	1,010 people	9.1%	7,253
Category 4-5 Hurricane	730 people (refugees)	5.9%	9,430
FRANKLIN COUNTY			
Tropical Storm - Category 1	740 people	7.1%	8,584
Category 2-5 Hurricane	150 people (refugees)	1.3%	10,477
WAKULLA COUNTY			
Tropical Storm - Category 1	930 people (refugees)	7.5%	9,011
Category 2-5 Hurricane	470 people (refugees)	3.0%	13,736
JEFFERSON COUNTY			
Tropical Storm - Category 2	680 people	14.8%	742
Category 3-5 Hurricane	770 people	14.3%	1,739

*Does not include public shelter evacuees seeking shelter in inland counties. See Table 5-3 for inland public shelter demand potential.

Most of the evacuees from the coastal counties will be leaving their county for refugee farther inland. The behavioral studies in Chapter 4 (Tables 4-15 thru 4-17) provided statistical estimates of destinations of evacuees from the region. The data for the region was further broken down to show the destinations of evacuees from Gulf, Franklin and Wakulla counties. The percentage of evacuees from these coastal counties going to selected inland destinations is shown in Table 5-2 below.

Table 5-2 General Destinations for Coastal Counties
(Based on % of evacuees and 1990 census data)

TO:	FROM GULF COUNTY	FROM FRANKLIN COUNTY	FROM WAKULLA COUNTY
Tallahassee - Leon County	40%	70%	70%
Southwest Georgia	4%	5%	13%
Southeast Alabama	11%	3%	---
Marianna - Jackson County	15%	5%	2%
Blountstown - Calhoun County	10%	---	---
Bristol - Liberty County	---	5%	---
Quincy - Gadsden County	2%	5%	---
Other Georgia	16%	6%	9%
East, South, Central Florida	2%	1%	6%
TOTAL	100%	100%	100%

The percentages shown in Table 5-2 were applied to the out-of-county evacuees for each coastal county (shown in Table 5-1) to determine the total number of evacuees at each inland destination. Based on the behavioral studies in Chapter 4, the percentage of evacuees planning to go to inland county shelters ranges from 15-30%. Table 5-3 shows the estimated shelter demand at several inland counties or destinations for different evacuation scenarios. The shelter demand shown in Table 5-3 estimates that 20% of the coastal county evacuees going to an inland destination will seek public shelter, 15% of Leon Counties mobile home evacuees will seek public shelter and 30% of the other inland county mobile home evacuees will seek public shelter in their own counties. The percentages are based on behavioral studies.

Table 5-3 Inland Public Shelter Demand*
(Based on 1990 census data)

Evacuee Destination	Out-of-County Evacuees from: Gulf County	Franklin County	Wakulla County	Public Shelter Demand from Coastal Evacuees at 20%	Public Shelter Demand from In-County Residents**	Total Public Shelter Demand
Tallahassee						
TS-Cat. 2	1,910	6,000	6,300	2,800	4,500	7,300
Cat. 3-5	3,770	7,300	9,600	4,100	6,000	10,100
Liberty Co.						
TS-Cat. 2	--	430	---	90	810	900
Cat. 3-5	--	520	---	105	810	915
Gadsden Co.						
TS-Cat. 2	100	30	---	110	3420	3530
Cat. 3-5	190	520	---	140	3420	3560
Calhoun Co.						
TS-Cat. 2	480	---	---	100	990	1090
Cat. 3-5	950	---	---	190	990	1180
Jackson Co.						
TS-Cat.2	720	430	180	270	3090	3360
Cat. 3-5	1420	520	270	440	3090	3530
Southeast Alabama						
TS-Cat.2	525	260	---	160	undetermined	undetermined
Cat. 3-5	1040	315	---	270	undetermined	undetermined
Southwest Georgia						
TS-Cat. 2	670	430	1170	455	undetermined	undetermined
Cat. 3-5	1320	520	1790	730	undetermined	undetermined

*Estimates are based on specific destination data obtained by Hazards Management Group in their February 1994 report entitled: Behavioral Assumptions for Hurricane Evacuation Planning in the Apalachee Region of Florida. Estimates should be taken as very general guidance as coastal participation rates and behavior will vary widely by storm. Figures do not include shelter demand from Bay County and points west. This is important as one considers potential shelter demand for Jackson County, Southeast Alabama, and to some degree, Tallahassee.

**Figures in this column are 15% of Leon County mobile home evacuees and 30% of other inland county mobile home evacuees.

c. Shelter Inventories and Capacities

The tables on the following pages provide an inventory of potential hurricane evacuation shelters and capacities by county, that might be used during an evacuation. This shelter information was provided by the State of Florida and is periodically updated in their Florida Statewide Sheltering Plan. Table 5-4 below summarizes the shelter demand, capacity and need for the coastal and inland counties.

Table 5-4 County Shelter Demand, Capacity and Need

County	Shelter Demand	Shelter Capacity	Shelter Space Need	Shelter Space Excess
Gulf Co.				
TS-Cat. 1	680	160	520	0
Cat. 2-3	1010	0	1010	0
Cat. 4-5	730	0	730	0
Franklin Co.				
TS-Cat.2	740	2440	0	1700
Cat. 3-5	150	0	150	0
Wakulla Co.				
TS-Cat. 1	930	0	930	0
Cat. 2-5	470	0	470	0
Jefferson Co.				
TS-Cat. 2	680	1938	0	1258
Cat. 3-5	770	1938	0	1168
Leon Co.				
TS-Cat. 2	7,300	1905	5395	0
Cat. 3-5	10,100	1905	8195	0
Liberty Co.				
TS-Cat. 2	900	0	900	0
Cat. 3-5	915	0	915	0
Gadsden Co.				
TS-Cat. 2	3530	9236	0	5706
Cat. 3-5	3560	9236	0	5676
Calhoun Co.				
TS-Cat. 2	1090	0	1090	0
Cat. 3-5	1180	0	1180	0
Jackson Co.				
TS-Cat.2	3360	4487	0	1127
Cat. 3-5	3530	4487	0	957

Table 5-5
Gulf County Shelter Data

GULF COUNTY										
			SHELTER	ARC	SHELTER	SHELTER	ARC	Sp Needs	Shelter	Shelter
SHELTER NAME	SHELTER ADDRESS	CITY	CAPACITY	CAPACITY	ELEVATION	CATEGORY	APPROVED	Shelter	Latitude	Longitude
Wewahitchka Elem	River Road	Wewahitchka	80	80	40	1	Y	N		
Wewahitchka H.S.	River Road	Wewahitchka	80	80	40	1	Y	N		
		TOTAL	**160**							
Category 1 Shelter Capacity		160								
Category 2 Shelter Capacity		0								
Category 3 Shelter Capacity		0								
Category 4 Shelter Capacity		0								
Category 5 Shelter Capacity		0								

Table 5-6
Franklin County Shelter Data

FRANKLIN COUNTY

SHELTER NAME	SHELTER ADDRESS	CITY	SHELTER CAPACITY	ARC CAPACITY	SHELTER ELEVATION	SHELTER CATEGORY	ARC APPROVED	Sp Needs Shelter	Shelter Latitude	Shelter Longitude
Apalachicola H.S	190 14th St.	Apalachicola	300	350	16	1	Y		29/43.25	84/59.50
Brown Elem	School Rd.	Eastpoint	393	393	15	1	Y		29/44.36	84/52.34
Carrabelle H.S.	Grey Street	Carrabelle	940	300	13.5	1	Y		29/51.15	84/39.24
Chapman Elem	115 Ave. E	Apalachicola	400	450	16	1	Y		29/43.20	84/59.30
		TOTAL	**2,033**	**1,493**						
Additional ARC Shelters										
American Legion Post	Oak Street	Lanark Village	54	54			Y			
Church of God	New Ferry Road	Eastpoint	102	102			Y			
Church of God	Three Rivers Rd.	Carrabelle	64	64			Y			
Fellowship Baptist Church	Ryan Drive	Carrabelle	102	102			Y			
First Baptist Church	46 9th Street	Apalachicola	80	80			Y			
First Baptist Church	New Ferry Road	Eastpoint	106	106			Y			
First Baptist Church	E. 1st Street	Carrabelle	170	170			Y			
Holiness Church	Jefferson Street	Eastpoint	71	71			Y			
Lanark Community Church	Spring Street	Lanark Village	68	68			Y			
Methodist Church	N. Avenue B	Carrabelle	176	176			Y			
Mormon Church	Prado Street	Apalachicola	30	30			Y			
Mt. Zion Missionary Church	100 Avenue E	Apalachicola	100	100			Y			
Ochlockonee Bay United Meth		Panacea		125			Y			
United Methodist Church	75 5th Street	Apalachicola	60	60			Y			
		TOTAL	**1,183**	**1,308**						
The Arc shelters above are post-disaster shelters										
Category 1 Shelter Capacity		2,440								
Category 2 Shelter Capacity		0								
Category 3 Shelter Capacity		0								
Category 4 Shelter Capacity		0								
Category 5 Shelter Capacity		0								

Table 5-7
Wakulla County Shelter Data

WAKULLA COUNTY										
SHELTER NAME	SHELTER ADDRESS	CITY	SHELTER CAPACITY	ARC CAPACITY	SHELTER ELEVATION	SHELTER CATEGORY	ARC APPROVED	Sp Needs Shelter	Shelter Latitude	Shelter Longitude
Shadeville Elem	US Hwy 319	Shadeville	350	350	25	T/S	Y	Y	30'12.97	84'19.11
Wakulla H.S.	US Hwy 98	Medart	290	290	30	T/S	Y	Y	30'06.45	84'22.66
Mormon Church	US Hwy 319 South	Crawfordville	40	40					30'10.05	84'22.66
		TOTAL	**680**	**680**						
Category 1 Shelter Capacity		0								
Category 2 Shelter Capacity		0								
Category 3 Shelter Capacity		0								
Category 4 Shelter Capacity		0								
Category 5 Shelter Capacity		0								
Note: Wakulla County only has T/S and host shelter spaces (680) available.										
For Cat. 1 or above, all residents seeking public shelter will do so out of county.										

Table 5-8
Jefferson County Shelter Data

JEFFERSON COUNTY										
SHELTER NAME	SHELTER ADDRESS	CITY	SHELTER CAPACITY	ARC CAPACITY	SHELTER ELEVATION	SHELTER CATEGORY	ARC APPROVED	Sp Needs Shelter	Shelter Latitude	Shelter Longitude
Primary Shelters										
Jefferson Co. H.S. Comple	125 W. Washington St.	Monticello	1,500			5	Y		30/32	83/52
Jefferson Elem	960 E. Rocky Branch Rd.	Monticello	260	170		5			30/33	83/51
Methodist Church	W. Walnut St.	Monticello	178	170		5	Y		30/32	83/52
		TOTAL	**1,938**	**170**						
Additional ARC Shelters										
First Baptist Church	Monticello						Y			
Jefferson County H.S.	South Water Street	Monticello	170	170			Y			
Mormon Church	Spring Hollow Rd.	Monticello	40	40			Y			
		TOTAL	**210**	**210**						
Category 1 Shelter Capacity		1,938								
Category 2 Shelter Capacity		1,938								
Category 3 Shelter Capacity		1,938								
Category 4 Shelter Capacity		1,938								
Category 5 Shelter Capacity		1,938								

Table 5-9
Leon County Shelter Data

LEON COUNTY										
SHELTER NAME	SHELTER ADDRESS	CITY	SHELTER CAPACITY	ARC CAPACITY	SHELTER ELEVATION	SHELTER CATEGORY	ARC APPROVED	Sp Needs Shelter	Shelter Latitude	Shelter Longitude
Belle Vue M.S.	2214 Belle Vue Way	Tallahassee	300	300		5	Y		30/26.30	84/19.42
Bethel AME Church	501 W. Orange Ave.	Tallahassee							30/24.46	84/17.40
Faith Presbyterian Church	2200 N. Meridian Rd.	Tallahassee	120	120		5	Y		30/28.22	84/16.58
Forest Heights Baptist Church	1200 W. Tharpe St.	Tallahassee	125	125		5	Y		30/27.55	84/18.20
Kate Sullivan Elem	927 Miccosukee Rd.	Tallahassee	350	350		5	Y	350	30/27.15	84/15.54
Lakeview Baptist Church	222 W. 7th Ave.	Tallahassee	150	150		5	Y		30/27.23	84/17.12
Mormon Church	312 Stadium Dr.	Tallahassee	165	165		5	Y		30/26.54	84/19.42
Mormon Church	3717 Thomasville Rd.	Tallahassee	125	125		5	Y		30/31.31	84/14.13
Oak Ridge Elem	4350 Shelfer Rd.	Tallahassee	300	300		5	Y		30/23.11	84/16.58
Senior Citizens' Center	1400 N. Monroe St.	Tallahassee	200	200		5	Y		30/27.53	84/17.03
1st Baptist Church of Woodvil	SR 363	Woodville	70	70		5	Y		30/18.39	84/15.03
		TOTAL	**1,905**	**1,905**						
Category 1 Shelter Capacity		1,905								
Category 2 Shelter Capacity		1,905								
Category 3 Shelter Capacity		1,905								
Category 4 Shelter Capacity		1,905								
Category 5 Shelter Capacity		1,905								
** Leon County may include public school buildings as shelters if needed.										

Table 5-10
Liberty County Shelter Data

LIBERTY COUNTY										
			SHELTER	ARC	SHELTER	SHELTER	ARC	Sp Needs	Shelter	Shelter
SHELTER NAME	SHELTER ADDRESS	CITY	CAPACITY	CAPACITY	ELEVATION	CATEGORY	APPROVED	Shelter	Latitude	Longitude

Table 5-11
Gadsden County Shelter Data

GADSDEN COUNTY										
SHELTER NAME	SHELTER ADDRESS	CITY	SHELTER CAPACITY	ARC CAPACITY	SHELTER ELEVATION	SHELTER CATEGORY	ARC APPROVED	Sp Needs Shelter	Shelter Latitude	Shelter Longitude
Carter-Parramore Jr. H.S.	South Stewart	Quincy	950	950	249	5	Y		30’34”42	84’34”50
Chattahoochee Elem	Maple Street	Chattahoochee	708	708	218	5	Y		30’41”58	84’50”04
Chattahoochee H.S.	Chattahoochee Street	Chattahoochee	586	586	224	5	Y		30’41”51	84’50”21
Gadsden Vo-Tech	Experiment Sta. Rd.	Quincy	647	647	244	5	Y		30’34”38	84’34”31
George W. Monroe Elem	West King Street	Quincy	705	705	244	5	Y		30’35”27	84’36”03
Greensboro Elem	Hwy 270 West	Greensboro	435	435	263	5	Y		30’34”25	84’45”48
Gretna Elem	Hwy 90	Gretna	625	625	290	5	Y		30’36”22	84’39”24
Havana H.S.	Webster Street	Havana	711	711	226	5	Y		30’37”25	84’23”59
Havana M.S.	6th Street	Havana	506	506	238	5	Y		30’37”35	84’24”43
Quincy M.S.	West King Street	Quincy	962	962	266	5	Y		30’35”28	84’34”58
Shanks H.S.	West King Street	Quincy	1,069	1,069	260	5	Y		30’35”27	84’35”41
Southside Elem	Lincoln Drive	Chattahoochee	140	140	221	5	Y		30’41”29	84’50”06
St. John Elem	Hwy 267 North	Quincy	590	590	244	5	Y		30’38”51	84’36”06
Stewart Street Elem	South Stewart Street	Quincy	602	602	244	5	Y		30’34”31	84’34”54
		TOTAL	**9,236**	**9,236**						
Additional ARC Shelters										
Arnet Chapel AME Church	201 S. Duval	Quincy			224	5	Y		30’35”08	84’34”27
Centenary Methodist Church	N. Madison St.	Quincy	100	100	250	5	Y		30’35”41	84’34”29
Chattahoochee Presb. Church	425 Main Street	Chattahoochee			180	5	Y		30’41”58	84’50”27
Florida State Hospital	HWY 90	Chattahoochee			230	5	Y	225	30’42”21	84’50”34
Greensboro H.S.	S.R. 12	Greensboro			250	5	Y		30’33”38	84’45”02
Havana Elem	4th Street	Havana	683	683	234	5	Y		30’36”55	84’25”08
Mormon Church	S. Roberts Rd.	Quincy	40	40	232	5	Y		30’34”14	84’35”35
National Guard Armory	Lake Talquin Rd.	Quincy			258	5	Y		30’33”19	84’35”33
New Bethel AME Church	US Hwy 90 East	Quincy			254	5	Y		30’35”11	84’34”08
Old Bethel AME Church	High Bridge Rd.	Quincy			244	5	Y		30’33”26	84’34”01
Quincy Reconational Center	122 N. Graves St.	Quincy	100	100	250	5	Y		30’35”20	84’35”39
St. James AME Church	514 S. 11th St.	Quincy			250	5	Y		30’34”51	84’35”16
St. John AME Church	Old Bainbridge Rd.	Quincy			283	5	Y		30’35”48	84’22”06
		TOTAL	**923**	**923**						
Category 1 Shelter Capacity		9,236								
Category 2 Shelter Capacity		9,236								
Category 3 Shelter Capacity		9,236								
Category 4 Shelter Capacity		9,236								
Category 5 Shelter Capacity		9,236								

Table 5-12
Jackson County Shelter Data

JACKSON COUNTY										
SHELTER NAME	SHELTER ADDRESS	CITY	SHELTER CAPACITY	ARC CAPACITY	SHELTER ELEVATION	SHELTER CATEGORY	ARC APPROVED	Sp Needs Shelter	Shelter Latitude	Shelter Longitude
1st United Methodist	2901 Caledonia	Marianna	135		165	5				
Ascension Luthrean	3975 Hwy 90	Marianna	45		110	5				
Chipola Jr. College	3094 Indian Circle	Marianna	200		130	5				
Christian Center	4791 Sheffield Dr.	Marianna	75		130	5				
Church of God	Jefferson Street	Marianna	22		115	5				
Cottondale Elem	2766 Levy St.	Cottondale	113		130	5				
Cottondale H.S.	2680 Levy St.	Cottondale	113		135	5				
East Side Baptist	4878 Hwy 90	Marianna	60		130	5				
G-Ridge St. Citizen Ctr.	Illinois Street	Grand Ridge	35		130	5				
Golson Elem	4258 2nd Ave.	Marianna	113		170	5				
Grace Methodist	4203 Kelson Ave.	Marianna	120		125	5				
Graceville Civic Ctr.	Hwy 77	Graceville	200		140	5				
Graceville Elem	5331 Alabama St.	Graceville	113		140	5				
Graceville H.S.	5539 Brown St.	Graceville	113		170	5				
Grand Ridge H.S.	6925 Florida St.	Grand Ridge	113		130	5				
Hope School	2031 Hope School Rd.	Marianna	113		85	5				
Lovedale Baptist	6595 Lovedale Rd.	Greenwood	85		110	5				
Malone H.S.	5361 9th St.	Malone	113		140	5				
Marianna 1st Baptist	2897 Green St.	Marianna	100		170	5				
Marianna H.S.	2979 Daniels St.	Marianna	113		170	5				
Marianna M.S.	4144 South St.	Marianna	113		150	5				
National Guard	3645 Hwy 90	Marianna	200		160	5				
New Hope Baptist	3006 New Hope Rd.	Marianna	83		170	5				
Providence Baptist	6940 Prov. Chr. Rd.	Grand Ridge	85		125	5				
Riverside Elem	2958 Cherokee St.	Marianna	113		140	5				
Sneads Elem	1961 Lockey Dr.	Sneads	113		125	5				
Sneads H.S.	8066 Old Spanish	Sneads	113		120	5				
St. Lukes Baptist	2871 Orange St.	Marianna	423		170	5				
St. Lukes Episcopal	4362 Lafayette	Marianna	281		170	5				
Theological College	5400 College Dr.	Graceville	869		160	5				
		TOTAL	**4,487**							
Category 1 Shelter Capacity		4,487								
Category 2 Shelter Capacity		4,487								
Category 3 Shelter Capacity		4,487								
Category 4 Shelter Capacity		4,487								

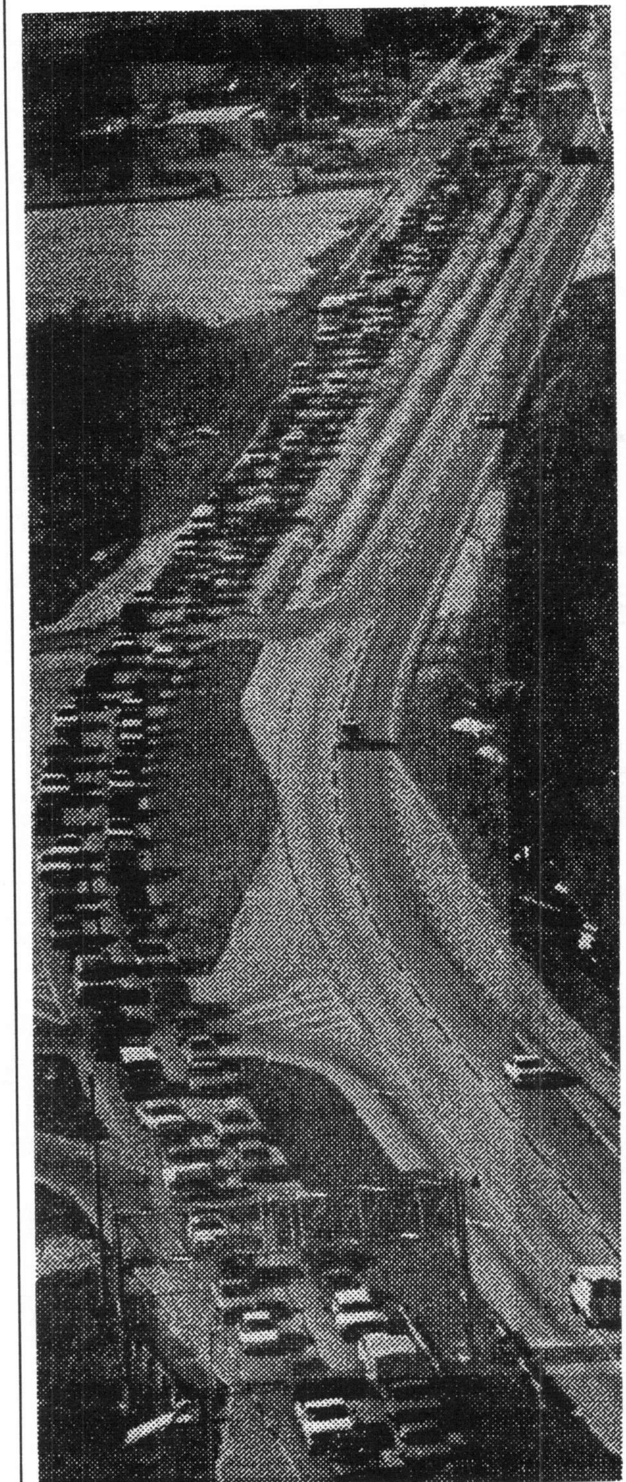
Table 5-13
Calhoun County Shelter Data

CALHOUN COUNTY										
SHELTER NAME	SHELTER ADDRESS	CITY	SHELTER CAPACITY	ARC CAPACITY	SHELTER ELEVATION	SHELTER CATEGORY	ARC APPROVED	Sp Needs Shelter	Shelter Latitude	Shelter Longitude

TRANSPORTATION
ANALYSIS

CHAPTER 6 - TRANSPORTATION ANALYSIS

INTRODUCTION

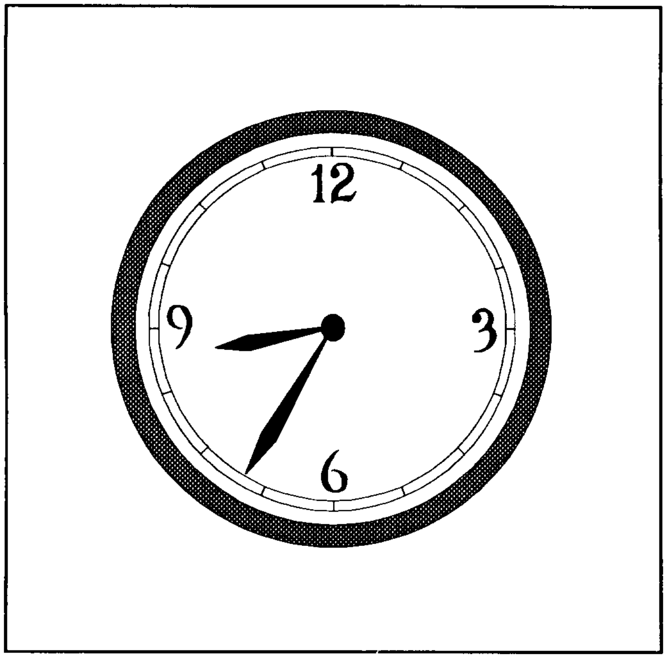


During a hurricane evacuation effort, a significant number of vehicles have to be moved across a road network in a relatively short period of time. Although the number of vehicles and evacuees for an area such as the Apalachee region of Florida, is not particularly large compared to some other areas of Florida, many low-lying beach and inland communities coupled with a limited road network make for some significant evacuation issues. With limited sheltering available for a major hurricane in the coastal counties, most evacuees will go to inland counties creating inland traffic bottlenecks and shelter demand.

The magnitude of evacuating vehicles varies depending upon the intensity of the hurricane, publicity and warnings given about the storm and certain behavioral response characteristics of the vulnerable population. Vehicles enter the road network at different times depending on the evacuee's response relative to an evacuation order or advisory. Conversely, vehicles leave the road network depending on both the planned destinations of evacuees and the availability of acceptable destinations such as public shelters, hotel/motel units and friends' or relatives' homes in non-flooded areas. Vehicles move across the road network from trip origin to destination at a speed dependent on the traffic loadings on various roadway segments and the ability of the segments to handle a certain volume of vehicles each hour.

ANALYSIS OBJECTIVES

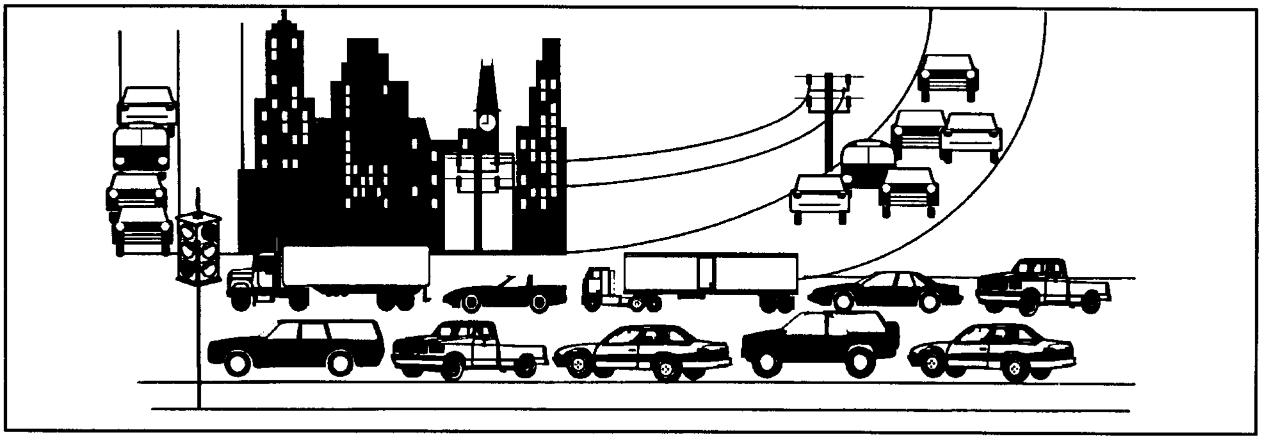
The overall goals of the transportation analysis performed for the Apalachee Region Hurricane Evacuation Study were to estimate clearance times (the time it takes to clear a county's roadway of all evacuating vehicles), to define the evacuation road network, and to examine general traffic control issues that could affect traffic flow along critical roadway segments. Clearance time is a value resulting from transportation engineering analysis performed under a specific set of assumptions. It must be coupled with pre-landfall hazards data (sustained tropical storm winds and/or roadway flooding prior to eye landfall) to determine when a strong evacuation advisory must be issued to allow all evacuees time to reach safe shelter before the arrival of sustained tropical storm winds. Factors that influence clearance time must be studied intensively to determine which factors have the strongest influence. Therefore, a sensitivity analysis was performed and a range of clearance times calculated for each county by varying key input parameters.



The transportation analysis task initially identified the kinds of traffic movements associated with a hurricane evacuation that must be considered in the development of clearance times. Basic assumptions for the transportation analysis were then developed related to storm scenarios, population-at-risk, behavioral and socioeconomic characteristics, the roadway system and traffic control. A transportation modeling methodology and a roadway system representation were developed for each county in the study area to facilitate model application and development of clearance times. General information and data related to the transportation analysis are presented in summary form in this report. A Transportation Model Support Document is available through the Mobile District, U.S. Army Corps of Engineers and includes detailed transportation modeling statistics and zone by zone data listings for each county.

EVACUATION TRAVEL PATTERNS

The movements associated with hurricane evacuation have been identified for the purposes of this analysis by five general patterns as follows:



A. In-County Origins to In-County Destinations. Trips made from primarily storm surge vulnerable areas and mobile home units in an individual county to destinations within the same county, such as public shelters, hotel and motel units, churches, and friends or relatives outside the storm surge vulnerable areas.

B. In-County Origins to Out-of-County Destinations. Trips made that originate in an individual county but have destinations in other counties of the study area or outside the study area entirely. This is a significant category for the Apalachee Region as many coastal evacuees seek safe destinations in Tallahassee, southwest Georgia, and southeast Alabama.

C. Out-of-County Origins to In-County Destinations. Trips made as in category A that enter an individual county from other counties in the study area.

D. Out-of-County Origins to Out-of-County Destinations. Trips passing through an individual jurisdiction while traveling from one county in the study area to another or outside the study area entirely.

E. Background Traffic. Trips made by persons preparing for the arrival of hurricane conditions; these trips are primarily shopping trips to gather supplies. In the Tallahassee area, trips from work to home to assist the family in evacuation could impact evacuation of coastal evacuees. Background traffic can also include transit vehicles (vans/buses) used to pick up evacuees without personal transportation.

Figure 6-1 graphically depicts these traffic movement patterns associated with hurricane evacuation situations in the Apalachee Region. It is important to recognize that three of the five defined patterns involve traffic movement patterns generated outside of one county's boundaries. It is evident that, depending on the assumed storm track, these inter-county movements can and do result in a number of regional traffic impacts. During the transportation analysis task, these movements were quantified to facilitate estimation of demand for roadway segment and resulting clearance times.

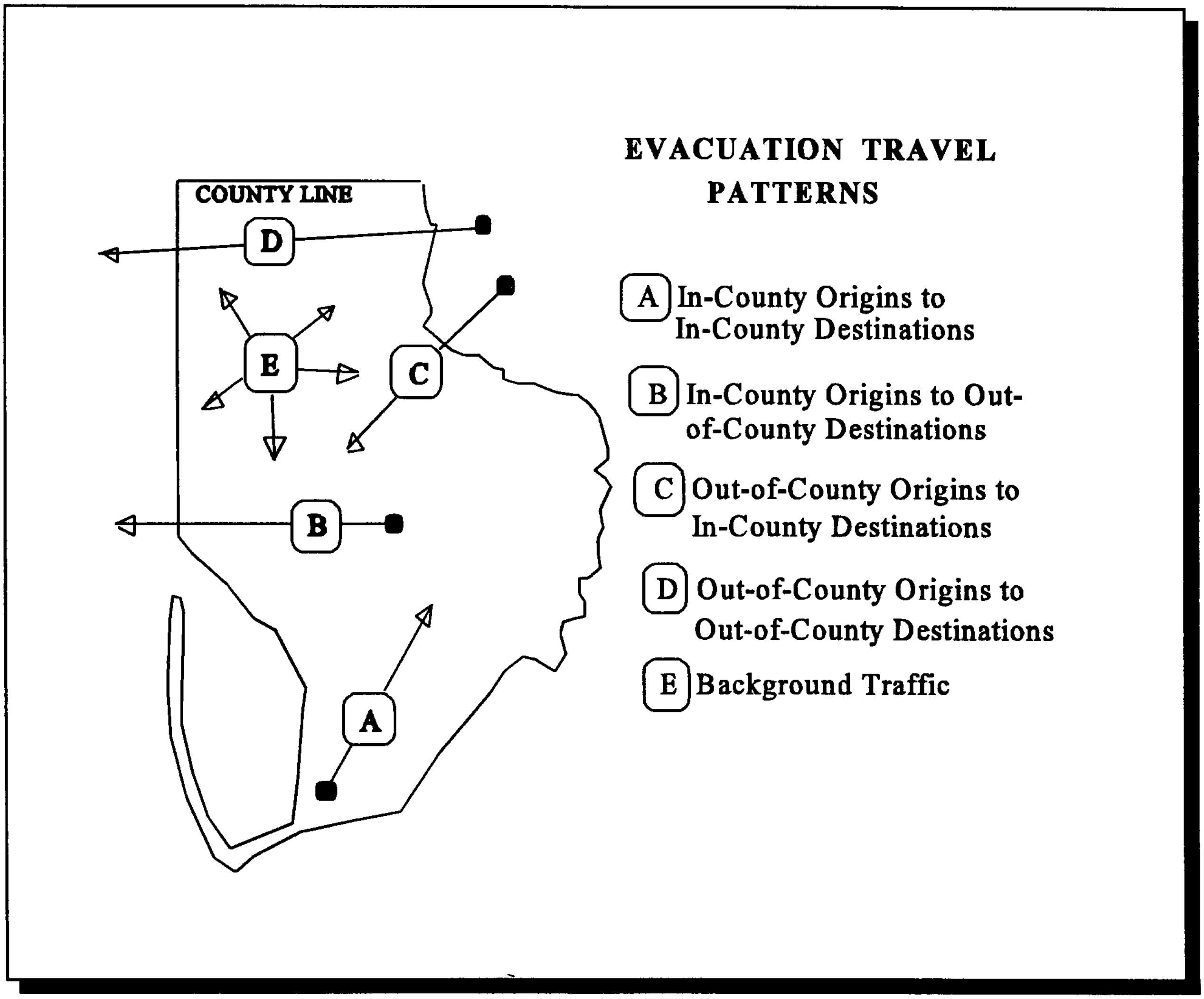


Figure 6-1 Evacuation Travel Patterns

TRANSPORTATION ANALYSIS INPUT ASSUMPTIONS

Since all hurricanes differ from one another in some respect, it becomes necessary to set forth clear assumptions about storm characteristics and evacuees' expected response before transportation modeling can 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 cause a wide variance in the behavior of the vulnerable population. Even the time of day at which a storm makes landfall influences the time parameters of an evacuation response.

The 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 assumptions guiding the transportation analysis are grouped into five areas.

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

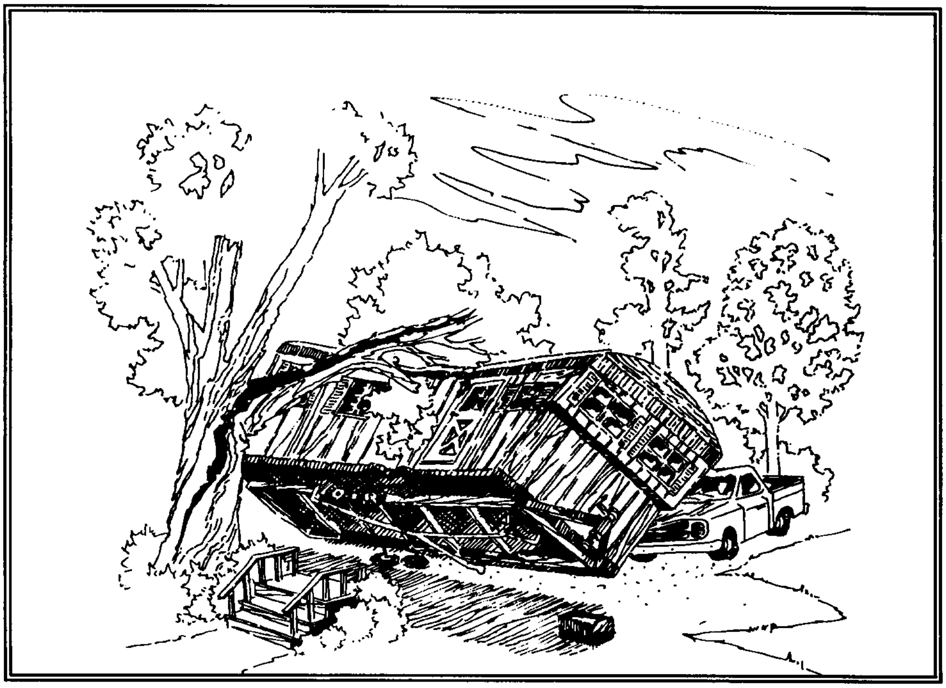
These five areas and their assumed parameters are described in the following paragraphs. Those parameters which were varied for sensitivity analysis are noted.

a. Housing and Population Data

The data base for each coastal county was developed using 1990 census data. This source of data provided a base for permanent population parameters and seasonal unit data on a sub-county basis. Since data are regularly updated for census units, their use provides a means to facilitate updating of the evacuation study in the future. Any future update of the transportation analysis should take a careful look at the seasonal dwelling unit data in the sub areas of each county.

Numbers for seasonal units were generally a combination of hotel/motel units and other units listed as seasonal in nature by the U.S. Census. St. George Island in Franklin County at peak season can have as many as 10,000 people including day trippers. With recent development pressure in Wakulla County, the 1990 census figures are lower than the number of actual units in 1994. Conservative assumptions regarding participation in future evacuations were made to off-set any discrepancy in this regard.

Current permanent population estimates for the four coastal counties range from approximately 9,000 in Franklin County to 15,000 in Wakulla County. Over 40% of these residents live in mobile homes. Throughout the region there is a significant mobile home population. Leon County, with over 190,000 people, has just under 25,000 mobile home residents. Over 25,000 more mobile home residents live in the inland counties of Calhoun, Gadsden, Jackson and Liberty.



Past experience with Hurricanes Hugo and Andrew showed that mobile homes can be severely damaged and totally destroyed by hurricane winds . Recent studies on the in land extent of damaging winds from hurricanes shows that fast moving hurricanes can effect inland counties a hundred miles or more from the coast. Future inland wind warnings and mobile home evacuations in inland counties adds dramatically to the number of hurricane-vulnerable people in the area. The Transportation Model Support Document lists the number of permanent dwelling units, mobile homes, and seasonal units by coastal county by evacuation zone and census unit.

b. Evacuation Zones

The hazards analysis identified those storm tracks causing the worst possible and probable storm surge in each county of the study area for tropical storms as well as each of five hurricane intensity categories (corresponding to the Saffir-Simpson scale). When five storm intensities are factored by several varying behavioral parameters, the number of hypothetical hurricane situations can quickly reach a great number. Calculation of clearance times for a great number of storm situations would be cumbersome and unusable by local emergency preparedness officials and would be inappropriate given the relative level of accuracy of hurricane storm forecasting. Storm forecasting for the period 12 to 24 hours prior to eye landfall is generally not precise enough to allow for more than 2 or 3 storm scenarios (grouping by intensity) per county.

Census tracts were compared with storm surge limits corresponding to the five hurricane categories. This procedure identified where major differences in storm surge limits and number of vulnerable population exist relative to each progressive step in hurricane intensity. Table 6-1 describes the evacuation zones for each county. These are also discussed in Chapter 3 and shown by county on Plates 3-1 through 3-4.

Table 6-1 Evacuation Zones

County	Evacuation Zones	Saffir-Simpson Category
Gulf	Evacuation Zone TS-Cat1	TS-Cat1
	Evacuation Zone Cat 2-3	Cat. 2-3
	Evacuation Zone Cat 4-5	Cat. 4-5
Franklin	Evacuation Zone TS-Cat1	TS -Cat1
	Evacuation Zone Cat 2-5	Cat. 2-5
Wakulla	Evacuation Zone TS-Cat1	TS -Cat1
	Evacuation Zone Cat 2-5	Cat. 2-5
Jefferson	Evacuation Zone TS-Cat2	TS -Cat2
	Evacuation Zone Cat 3-5	Cat. 3-5

c. Traffic Zones

Through the hazards analysis, those areas which will receive hurricane storm surge were identified and graphically shown on the storm tide atlases developed by the Mobile District, U.S. Army Corps of Engineers. This information became one of the key inputs to the transportation analysis.

Within the transportation analysis it was assumed that persons living in areas flooded by storm surge should be evacuated. This evacuee group included permanent residents living in single-family, multi-family, or mobile home units, as well as tourists staying in hotel/motel, condominium, and rental units located in storm surge vulnerable areas. In addition, mobile home residents living outside the hurricane flooded areas of each county were assumed to evacuate due to high wind vulnerability.

Having established those persons who should evacuate during a particular storm situation, it was then necessary to develop a series of zones to geographically locate and quantify the vulnerable population. Evacuation zones also provide a base to model traffic movements from one geographic area to another. A series of zones was established for each coastal county based on the following factors.

- Zones should relate to expected surge flooding limits (based on Maximum Envelope of Water - MEOWs) for each storm scenario.
- Zones should relate well to census, traffic analysis zones, or other data base unit.
- Zones should be set up, if possible, for ease of use in issuing an evacuation order or advisory.
- Zonal boundaries should include identifiable natural features, roadways, landmarks, etc.
- Small "pocket" zones that would be isolated by surrounding surge should be avoided.
- Zones should be able to be served by major evacuation routes.
- Zones must allow for appropriate transportation modeling.

Table 6-2 provides the number of traffic zones for the transportation analysis and assumed vulnerability of the zones for evacuation scenarios in each coastal county of the study area. The number of traffic zones range from 12 in Jefferson to 23 in Franklin County.

Table 6-2 Transportation Analysis Traffic Zones
Assumed Vulnerability by Evacuation Zone and County

County	Total Number of Traffic Zones	Hurricane Evacuation Zones	Population to Evacuate: Everyone in Traffic Zones	Population to Evacuate: Mobile Home Residents in Traffic Zones
Gulf	20	Evacuation Zone TS-Cat1	1-5	6-20
		Evacuation Zone Cat 2 -3	1-12	13-20
		Evacuation Zone Cat 4 -5	1-16	17-20
Franklin	23	Evacuation Zone TS-Cat1	1-3	4-23
		Evacuation Zone Cat 2 -5	1-23	----
Wakulla	20	Evacuation Zone TS-Cat1	1-9	10-20
		Evacuation Zone Cat 2 -5	1-18	19-20
Jefferson	12	Evacuation Zone TS-Cat2	1	2-12
		Evacuation Zone Cat 3 -5	1-3	4-12

Plates 6-1 through 6-4 located at the end of this chapter show the Evacuation Zones and Traffic Zones established in each coastal county for the transportation analysis.

d. Behavioral Assumptions

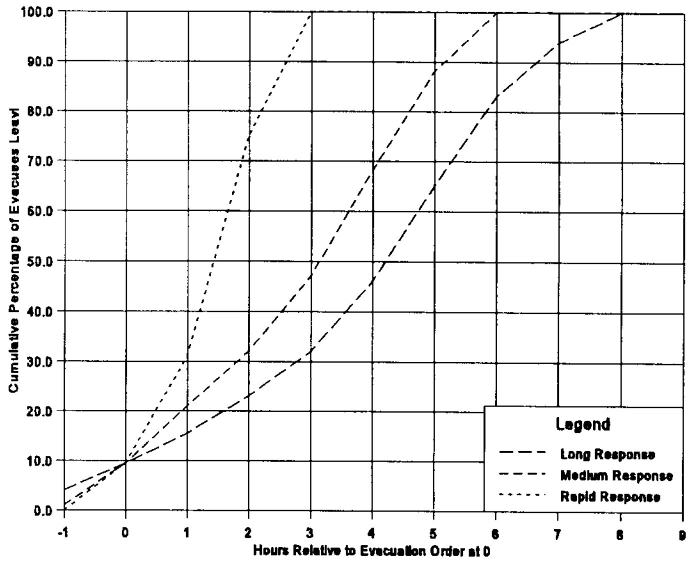
The evacuation of an endangered population due to a hurricane approaching the Apalachee Bay Region involves the coordinated action of thousands of individuals. Information from the behavioral analysis described in Chapter 3 was used to derive the best assumptions possible for the transportation analysis. Specifically, for transportation purposes, the following behavioral aspects were addressed:

- Participation rates
- Evacuation rates (rapidity of response)
- Destination desires
- Vehicle usage

An important behavioral aspect is that of participation rates. Several elements were incorporated in the transportation analysis regarding participation in the evacuation. At the request of local emergency management officials, participation rates of those residing in surge flooded zones were assumed to be 100%. A 100% participation by those evacuees living in mobile homes outside the surge flooded areas was also assumed. In addition, a small percentage (1 to 5% depending on storm intensity) of the "non-vulnerable" population was assumed to evacuate their dwelling units in the coastal counties. The Transportation Model Support Document provides a listing of all participation rates assumed by storm scenarios for each county in the study area.

A critical behavioral aspect that must be considered for the transportation analysis is the evacuation rate of the evacuating population. Behavioral data from research of past hurricane evacuation shows that mobilization and actual departures of the evacuating population occur over a period of many hours and sometimes several days. For the Apalachee Region study, clearance times were tested for three evacuation response rates represented by different behavioral response curves. Behavioral response curves describing mobilization by the vulnerable population define the rate at which evacuating vehicles load onto the evacuation street network for each hourly interval relative to an evacuation order or strong advisory. The percentage of evacuees leaving dwelling units is then available for the calculations relating to traffic loadings at critical links along the evacuation network. The behavioral response curves shown below range from rapid response to long response and are intended to include a potential 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 four hours and nine hours.

Behavioral Cumulative Evacuation Curves



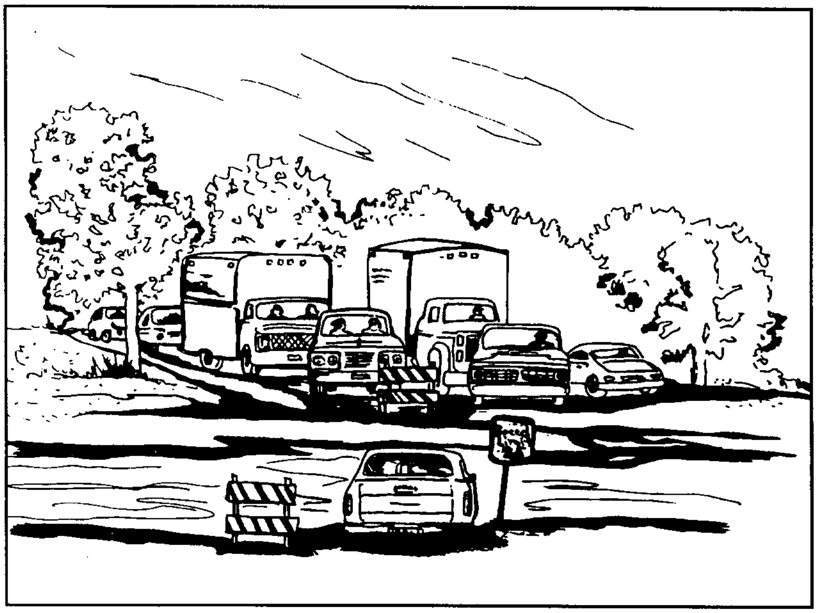
The percentage of evacuees assumed to go to one of four general destination types was another important behavioral input to the transportation analysis. Evacuee destination percentages were discussed with emergency management staff in each area after careful review of information available in the behavioral analysis. Figures were developed for the expected percent of evacuees going to local public shelters, hotel/motel units, the home of a friend or relative, or out of the county entirely. Destination percentages were varied for each evacuation zone in each county depending on category of risk (distance from coastline) or special characteristics of a zone such as high number of substandard housing units or low income residents. Specific assumptions for each scenario and evacuation zone are provided in the Transportation Model Support Document. It should be noted that these destination percentages refer to destination desires. Where destination desires could not be satisfied with in-county capacities, the transportation analysis assumed that these evacuees would have to leave the county to find acceptable shelter.

A final behavioral assumption refers to vehicle usage and the percent of households expected to pull a trailer or recreational vehicle during an evacuation. Review of the behavioral survey and discussions with local officials produced the needed parameters.

Vehicle usage percentages refer to the percentage of vehicles available at the home origin that are assumed to be used in the evacuation. Vehicle usage percentages were approximately 75% to 80% (depending on distance from the coastline) for the Apalachee Region. The percent of households expected to pull a boat, trailer or RV was approximately 10 percent in the immediately coastal area zones.

e. Roadway Network and Traffic Control Assumptions

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 selected 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. Detailed law enforcement assignments to major intersections and bridges 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.



In choosing roadways to be used for the evacuation network, an effort was made to include street facilities with sufficient elevations, little or no adjacent tree coverage, substantial shoulder width and surface, and roadways already contained in existing hurricane evacuation plans. In an area such as the Apalachee Region of Florida, where there are many low lying rural 2-lane highways these criteria are difficult to meet. Another objective was to include north-south arterials that would provide the smoothest (least disjointed) possible traffic flow.

In order to determine the routing of evacuation a representation of the roadway system was developed. A traditional "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 as defined by the nodes when connected. Each link is identified by a letter designation.

Once the links and nodes for the evacuation routes were identified, roadway characteristics were specified for each link. The characteristics of each link were defined by the number of travel lanes and the type of facility.

Plates 6-5 through 6-8 show the roadway system representations (evacuation networks) for each coastal county in the study area. The significance of link-node segments and zone connectors (dashed lines) is explained in the Transportation Model Support Document. The figures consist of base maps showing all the major streets in the study area with identification of the nodes and centroid connectors in color. Detailed roadway link information is contained in the Transportation Model Support document.

It was assumed that special personnel (highway patrolman, local policemen, sheriffs, deputies), will be assigned to critical intersections in the study area. This would allow for smoother traffic flow and would allow north-south traffic movements more intersection "green time." The transportation modeling task also assumes that provisions would be made for removal of vehicles in distress during the evacuation. Because of the expected concentration of regional evacuation traffic in and through Tallahassee, inland traffic control planning will be very important to the overall success of evacuations in the Apalachee region.

Assumptions concerning the road network are that the evacuation of all vehicles will occur prior to the arrival of sustained tropical storm winds (39 mph) and storm surge inundation.

In summary, data inputs to the transportation analysis can be classified into one of four categories as shown in Table 6-3.

Table 6-3 Transportation Analysis Data Inputs

Hazards Data	**Socioeconomic Data**
* Land Areas Flooded for each Category Hurricane	* Housing Unit Data
* Public Shelter Useability by Hurricane Category	* People Per Housing Unit
* Time of Arrival of Tropical Storm Winds / Roadway Inundation	* Vehicles Per Housing Unit
	* Occupancy Assumptions
	* Presence of Tourists/Visitors

Behavioral Data	**Roadway Network**
* Rapidity of Response	* Number of Lanes by Link
* Participation Rates	* Facility types by Link
* Destination Percentages	* Traffic Count Data
* Vehicle Usage	* Elevation - "Low Spots"
* Percent Pulling Trailer/Boat	* Critical Links / Intersections Capacity Data

TRANSPORTATION MODELING METHODOLOGY

The transportation modeling methodology developed and employed for the Apalachee Region study area involved a number of manual and computer techniques. The methodology, while very technical, was designed to be consistent with the accuracy level of the modeling inputs and assumptions. The methodology is unique in that it is sensitive to the key behavioral aspects of evacuees.

The Transportation Model Support document specifies and explains the steps carried out in the transportation modeling at a detailed technical level. In summary, the modeling methodology involved seven major steps. These steps are briefly described below:

1. Evacuation Zonal Data Development - Data gathered by census tract and block group were stratified by evacuation zone. Numbers of permanent residential dwelling units, mobile homes, and seasonal units were compiled by zone and formatted for input into trip generation.

2. Evacuation Road Network Preparation - This step involved developing information for those roadways selected for inclusion in the evacuation road network. Information was coded into a "link file" for use by the assignment computer module. The end product of the step was a computerized representation of the roadway system.

3. Trip Generation - Specific dwelling unit variables were used in the trip generation calculations to produce total evacuating people and vehicles originating from each evacuation zone. Originating vehicles and people were stratified by destination type based on behavioral and population parameters previously established. Hotel/motel information coupled with public shelter capacity information were used to develop estimates of the number of evacuating vehicles that would find acceptable destinations in each zone.

4. Trip Distribution - This step concentrated on those trips originating in a county and finding acceptable destinations within the same county. Productions from each zone were matched with available attractions in all zones. The end product of the step was a trip table showing trips between each zone and all other zones for each evacuation destination type. A unique trip table was developed for each storm scenario and for each tested behavioral assumption. Trip tables were also produced for trips originating in a county and leaving the county at assumed exit points. Information from the behavioral analysis provided excellent guidance on inland destinations of traffic exiting coastal counties.

5. Roadway Capacity Development - Number of lanes and facility type information for each roadway link in the evacuation network were translated into a level of service D directional hourly service volume for comparative purposes. Specific hourly flow rates were then developed for the most critical roadway segments and intersections.

6. Trip Assignment - This step included the use of another computer program to assign zone-to-zone trips onto the roadway system. All other categories of evacuation travel patterns (out-of-county to in-county, out-of-county to out-of-county, and background) were then added to arrive at total evacuation vehicles per roadway segment. This step then developed a series of volume-to-service volume ratios to determine which roadway segments would be most congested by evacuation vehicles. Those links with the highest volume-to-service volume ratios were identified for each county.

7. Calculation of Clearance Times - Travel Time/Queuing Delay Analysis - This step involved a detailed look at the critical links and intersections identified for the four coastal counties and inland areas of the region. Initially, evacuation zones using the critical link of interest were identified. Evacuation vehicles from each zone were then released into the network in accordance with a behavioral response curve. Based on an assumed hourly flow rate for the critical link, the hourly volume desiring to use the link was then translated into a queuing delay time at the link and an evacuation travel time. The end product of this major step was a set of clearance times for each storm scenario.

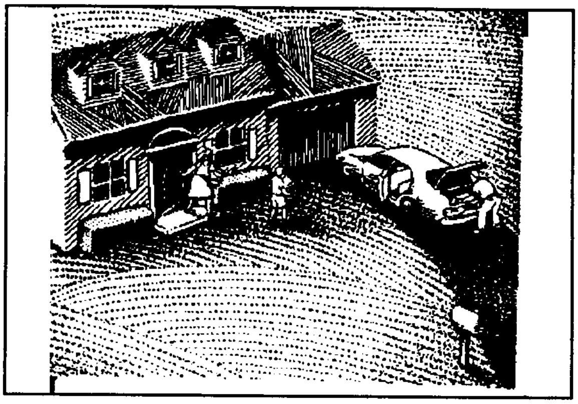
MODEL APPLICATION

Application of the transportation modeling methodology produced several key data items for hurricane evacuation planning and preparedness. Completion of the transportation modeling produced the following:

1. Evacuating people and vehicle parameters
2. Shelter demand and capacity considerations
3. Traffic volumes and critical roadway segments
4. Estimated clearance times

Although many pieces of information are produced in the transportation analysis, these data items are most critical to planning shelter needs, addressing traffic control issues, and defining the timing requirements of an evacuation.

a. Evacuating People and Vehicles



Using a computer process, total evacuating vehicles and people produced by each zone were split by destination type (public shelter, hotel/motel unit, friend or relative's home, or out of the county). This was accomplished for each storm scenario and further refined by assumed behavioral characteristics of the population-at-risk. Table 6-4 below provides this trip generation data by evacuation scenario for each coastal county.

Table 6-4. Type of refuge by Coastal County and Evacuation Zone

	Total Evacuees	Public Shelter	Friend/Family	Hotel / Motel	Out-of-County
Gulf County Evacuation Zone TS-Cat1	7900	680	2413	36	4775
Gulf County Evacuation Zone Cat 2-3	11107	1009	2562	286	7253
Gulf County Evacuation Zone Cat 4-5	12378	730	2220	0	9430
Franklin County Evacuation Zone TS-Cat1	10421	741	1062	36	8584
Franklin County Evacuation Zone Cat 2-5	11262	148	598	36	10477
Wakulla County Evacuation Zone TS-Cat1	12444	932	2337	166	9011
Wakulla County Evacuation Zone Cat 2-5	15533	466	1165	166	13736
Jefferson County Evacuation Zone TS-Cat2	4598	683	3106	71	742
Jefferson County Evacuation Zone Cat 3-5	5371	774	2775	86	1739

Table 6-5 provides ranges of evacuating people and vehicles for each county within the study area. The number of people evacuating and vehicles expected to be utilized in hurricane evacuations varies due to the effect of testing different storm scenarios and behavioral parameters. Figures are based on census population and previously discussed behavioral aspects of vulnerability areas relating to the SLOSH Maximum Envelope of Water limits for all hurricane directions and speeds. It is important to remember evacuating people figures include mobile home residents, some seasonal population and a small percentage of persons who will evacuate although theoretically not vulnerable. Since participation rates of 100% were used for storm surge areas, these statistics will generally be higher than what will usually be experienced in an actual event. This is especially true for tropical storms where only limited voluntary evacuations have been called for - recent tropical storms Alberto and Beryl underscore this point.

Table 6-5 Evacuating people and vehicle statistics

County/Evacuation Zone	Maximum Number of People Evacuating Dwelling Units*	Maximum Number of Vehicles Leaving Dwelling Units
GULF COUNTY		
Tropical Storm - Category 1 Hurricane	7,900 people	3,350 vehicles
Category 2-3 Hurricane	11,100 people	4,800 vehicles
Category 4-5 Hurricane	12,400 people	5,400 vehicles
FRANKLIN COUNTY		
Tropical Storm - Category 2 Hurricane	10,400 people	4,550 vehicles
Category 3-5 Hurricane	11,300 people	4,900 vehicles
WAKULLA COUNTY		
Tropical Storm - Category 1 Hurricane	12,450 people	6,100 vehicles
Category 2-5 Hurricane	15,550 people	7,600 vehicles
JEFFERSON COUNTY		
Tropical Storm - Category 2 Hurricane	4,600 people	2,000 vehicles
Category 3-5 Hurricane	5,400 people	2,300 vehicles
LEON COUNTY		
Category 1-2 Hurricane	30,000 people	13,000 vehicles
Category 3-5 Hurricane	40,000 people	17,400 vehicles
LIBERTY COUNTY		
All Hurricanes	2,700 people	1,170 vehicles
CALHOUN COUNTY		
All Hurricanes	3,300 people	1,435 vehicles
GADSDEN COUNTY		
All Hurricanes	11,400 people	4,950 vehicles
JACKSON COUNTY		
All Hurricanes	10,300 people	4,480 vehicles

***Important Notes:**

The Franklin County figure of 11,300 evacuees includes approximately 2,500 seasonal residents. On a fall weekday many of these will not be present. On a summer weekend these <u>will</u> be present as well as several thousand day visitors not tied to specific seasonal dwelling units. The Gulf County database includes 1,190 seasonal dwelling units which were assumed to be 75% occupied for each storm scenario.

The Leon County figures include all of the county's approximately 25,000 mobile home residents plus a portion of the remaining permanent population, other inland counties figures reflect current mobile home populations.

For each coastal county figures include all permanent and seasonal residents in potential surge flooded areas (as delineated by the U.S. Army Corps of Engineers, Mobile District). Aggressive pre-storm public education and strong evacuation notices would have to be issued to the public for actual response to come close to these numbers.

b. Shelter Demand/Capacity Considerations

While the data presented above are extremely important, they are most useful when matched with available sheltering. It is important to note that evacuating people and vehicle statistics generated for each county, evacuation zone, and destination type reflect where evacuees would go assuming enough safe destinations were available. After matching evacuee's destination desires with available shelters, the transportation analysis revealed that hotel/motel space will not be as widely available within the study area as perceived by the evacuating population. For transportation modeling purposes, those evacuees unable to be accommodated by study area hotel/motel space were assumed to find hotel/motel space outside the study area.

Table 5-2 in Chapter 5 provides the calculated public shelter demand and available capacity by storm scenario for the coastal counties. (Shelter locations and capacities were provided by each county to the U.S. Army Corps of Engineers, Mobile District for the transportation analysis). Shelter space is generally adequate in the study area counties for in-county demand during a minor hurricane. However, in the coastal counties for the most intense hurricanes, in-county shelter space will be unavailable.

An important part of the Apalachee Hurricane Evacuation Study transportation analysis involved looking beyond the coastal counties boundaries to anticipate potential inland traffic and shelter demand. Table 5-3 in Chapter 5 shows potential inland shelter demand figures for some major inland destinations. Using expected out-of-county evacuee statistics from the coastal counties and behavioral analysis guidance concerning intended destinations, gross estimates of inland shelter demand were tabulated. Total public shelter demand for an inland area is the sum of coastal evacuees who end up looking for or needing shelter in that area plus local evacuees (primarily mobile home residents) who desire public sheltering.

c. Traffic Volumes and Critical Roadway Segments

The Transportation Model Support Document provides the assigned evacuating vehicle figures for all roadway segments in each coastal county's evacuation network. In addition, the appendix provides the volume-to-service volume ratios calculated for each link. Those roadway segments with the highest ratios were identified as the critical links for each county. Evacuating vehicle volumes for inland road segments are also provided in the model document. Table 6-6 lists the critical roadway segments by county. Critical links and intersections are listed in order of severity. These links control the flow of evacuation traffic during a hurricane evacuation and are key areas for traffic control and monitoring. Important to the study is the finding that the regions most congested roadway segments will be well inland, primarily in Leon County.

Table 6-6 Critical roadway segments and intersections

GULF COUNTY

SR 71 through Wewahitchka (intersection of SR 22 and SR 71)
CR 386 at SR 71 intersection south of Wewahitchka
SR 71/SR 20 intersection at Blountstown (in Calhoun County)
SR 73 at US 231 intersection north of Cottondale (in Jackson County)

FRANKLIN COUNTY

US 98 through Eastpoint
St George Island Causeway intersection with US 98
US 319 and Capital Circle intersection south of Tallahassee (in Leon County)
US 319 through Crawfordville (in Wakulla County)
US 319 and US 98 intersections at Medart (in Wakulla County)
US 319 and SR 61 intersection south of Tallahassee (in Leon County)
SR 20 and Capital Circle intersection west of Tallahassee (in Leon County)
(Gulf County critical segments for westbound traffic)

WAKULLA COUNTY

US 319 through Crawfordville
US 319 and US 98 intersections at Medart
US 319 and Capital circle intersection south of Tallahassee (in Leon County)
US 319 and SR 61 intersection south of Tallahassee (in Leon County)
Woodville Highway and Capital Circle intersection south of Tallahassee (in Leon county).

JEFFERSON COUNTY

CR 259 and US 19 intersection
US 27 and US 19 intersection at Capps

LEON COUNTY

US 319 (Crawfordville Road) and Capital Circle intersection
US 319 (Crawfordville Road) and SR 61 intersection
Woodville Highway and Capital Circle intersection
SR 20 and Capital Circle intersection
Capital Circle between Crawfordville Highway and Apalachee Parkway
Thomasville Road and Capital Circle N.E. intersection
Capital Circle between Apalachee Parkway and Centerville Road
Thomasville Road between I-10 and Georgia state line
Monroe Street between Magnolia and the Fairgrounds
Adams Street between Orange Avenue and FAMU
US 90 W. and Capital Circle intersection
(Connector streets (Gaile, Paul Russell, Orange and Magnolia) between Adams and Monroe Streets)

d. Estimated Clearance Times

The most important product of the transportation analysis is the clearance times developed by storm scenario and by behavioral characteristics for each county. Clearance time is one of two major considerations involved in issuing an evacuation or storm advisory. Clearance time must be weighed with respect to the arrival of sustained tropical storm winds to make a prudent evacuation decision. Figure 6-2 illustrates these two timing issues of evacuation and their relation.

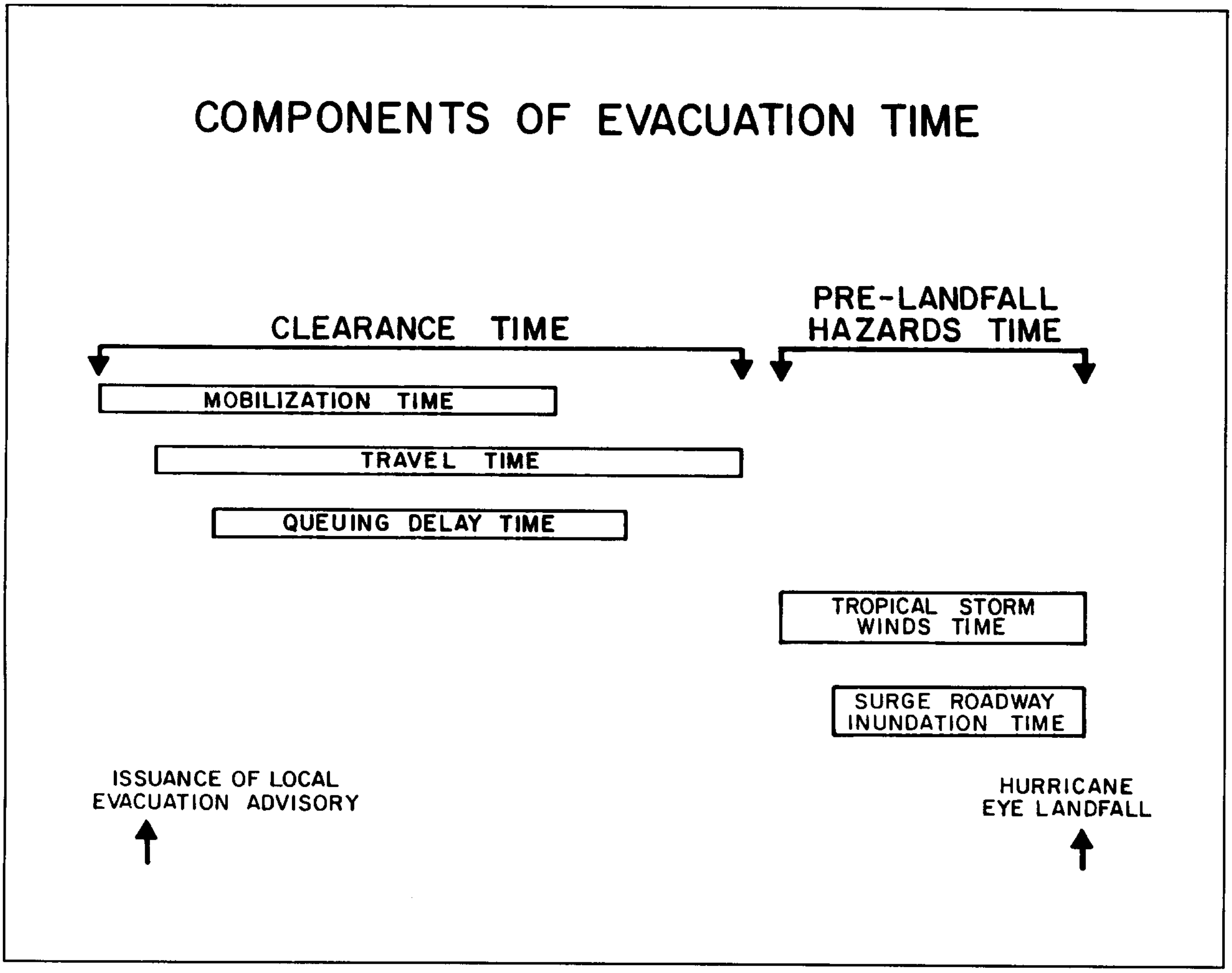


Figure 6-2 Components of Evacuation Time

Clearance time is the time required to clear the roadway of all vehicles evacuating in response to a hurricane situation. 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 secure their homes and prepare to leave (referred to as mobilization time), the time spent by evacuees traveling along the road network (referred to as travel time), and the time spent by evacuees waiting along the road network 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.

Generally, clearance times allow for the last vehicle leaving to reach the county line. However, for the Apalachee Region there are some regional clearance time issues that require us to look beyond one county or study area's boundaries. Traffic congestion could be significant in Leon County due to through traffic and evacuees desiring refuge there.

Table 6-7 presents the clearance times estimated for each county and for the region as a whole. Clearance times are stratified by intensity of hurricane (storm scenario), by rate of response on the part of the evacuating population, and by seasonal characteristic. It is important to note that clearance times are based on the assumptions that local officials will be successful in evacuating residents out of dwelling units located in the areas shown as flooded by storm surge (by the SLOSH model). The hazards analysis chapter of the Technical Data Report defines these surge limits and the theory behind their derivation.

Table 6-7 Clearance times (in hours)
Gulf and Franklin Counties

Storm Scenario	Gulf County* Clearance Times (in hours)	Franklin County** Clearance Times (in hours)	
Tropical Storm through Category 1 Hurricane		Normal	Peak Season
Rapid Response	4-1/2	4-3/4	6
Medium Response	6-1/4	6-3/4	6-3/4
Long Response	9-1/4	9-3/4	9-3/4
Category 2 through Category 3 Hurricane			
Rapid Response	6	4-3/4	6-1/4
Medium Response	7	6-3/4	7
Long Response	9-1/4	9-3/4	9-3/4
Category 4 through Category 5 Hurricane			
Rapid Response	7	4-3/4	6-1/4
Medium Response	8	6-3/4	7
Long Response	9-1/4	9-3/4	9-3/4

*Evacuation decision making in Gulf County must consider times to clear Bay and Gulf County evacuees through the intersection of SR 73 and US 231 in Jackson County (see regional times sheet). Local officials feel that for some hurricanes involving a nighttime evacuation or a slow moving storm, behavioral response will be longer than 9 hours pushing clearance time duration to as much as 20 hours. Gulf County times include a portion of Apalachicola traffic that will evacuate through Gulf County.

**Evacuation decision making in Franklin County must consider times to clear bottlenecks in Wakulla and Leon Counties (see regional times sheet).

Table 6-7 Clearance times (in hours) (Continued)
Wakulla and Jefferson Counties

Storm Scenario	Wakulla County* Clearance Times (in hours) Normal	Wakulla County* Clearance Times (in hours) Peak Season	Jefferson County Clearance Times (in hours)
Tropical Storm - Cat. 1 Hurricane			
Rapid Response	6-3/4	8-3/4	4-1/4
Medium Response	7-1/2	9-1/2	6-1/4
Long Response	9-1/4	11	9-1/4
Category 2 thru 5 Hurricane			
Rapid Response	7-1/4	9-1/4	4-1/4
Medium Response	8	10	6-1/4
Long Response	9-1/4	11-1/4	9-1/4

*Evacuation decision making in Wakulla County must consider times to clear bottlenecks in Leon County (see regional times sheet).

Regional clearance times (in hours)

Storm Scenario	Leon County/ Southwest Georgia bottlenecks		Jackson County/* Southeast Alabama bottlenecks	
	Normal	Peak Season at Coast	Normal	Peak Season at Coast
Tropical Storm - Cat 2 Hurricane				
Rapid Response	8-3/4	10-3/4	8-1/2	10-3/4
Medium Response	10-1/4	12-1/4	9-1/4	11-1/4
Long Response	12-1/2	14-1/2	10-1/4	12-1/4
Category 3 - 5 Hurricane				
Rapid Response	10-3/4	12-3/4	10	12-3/4
Medium Response	12-1/4	14-1/4	10-1/2	13
Long Response	14-1/2	16-1/2	11-1/2	14

*These times will be updated in an upcoming hurricane study for the Bay County and panhandle area.

TRAFFIC CONTROL ISSUES

The movement of evacuating vehicles during hurricane evacuations requires extensive traffic control efforts to make maximum use of roadway capacity and to expedite safe escape from hurricane hazards. The development of traffic control techniques for critical evacuation roadway links and intersections should always be developed by local sheriffs, police, state highway patrolmen, state DOT, local traffic engineers, emergency management personnel and the U.S. Coast Guard working together cooperatively. The following traffic control issues are recommended for consideration:

1. As manpower supply allows, ideally officers should be stationed at critical intersections to move traffic, and to assist disabled vehicles. Critical links and intersections discussed previously should be used as a starting point in developing assignments.

2. Available tow trucks should be positioned or on call along key travel corridors and critical links. At a minimum, tow trucks should be at major bridge crossings to remove disabled vehicles.

3. Where intersections will continue to have signalized control, signal patterns providing the most "green time" for the approach leading away from the coast should be actuated.

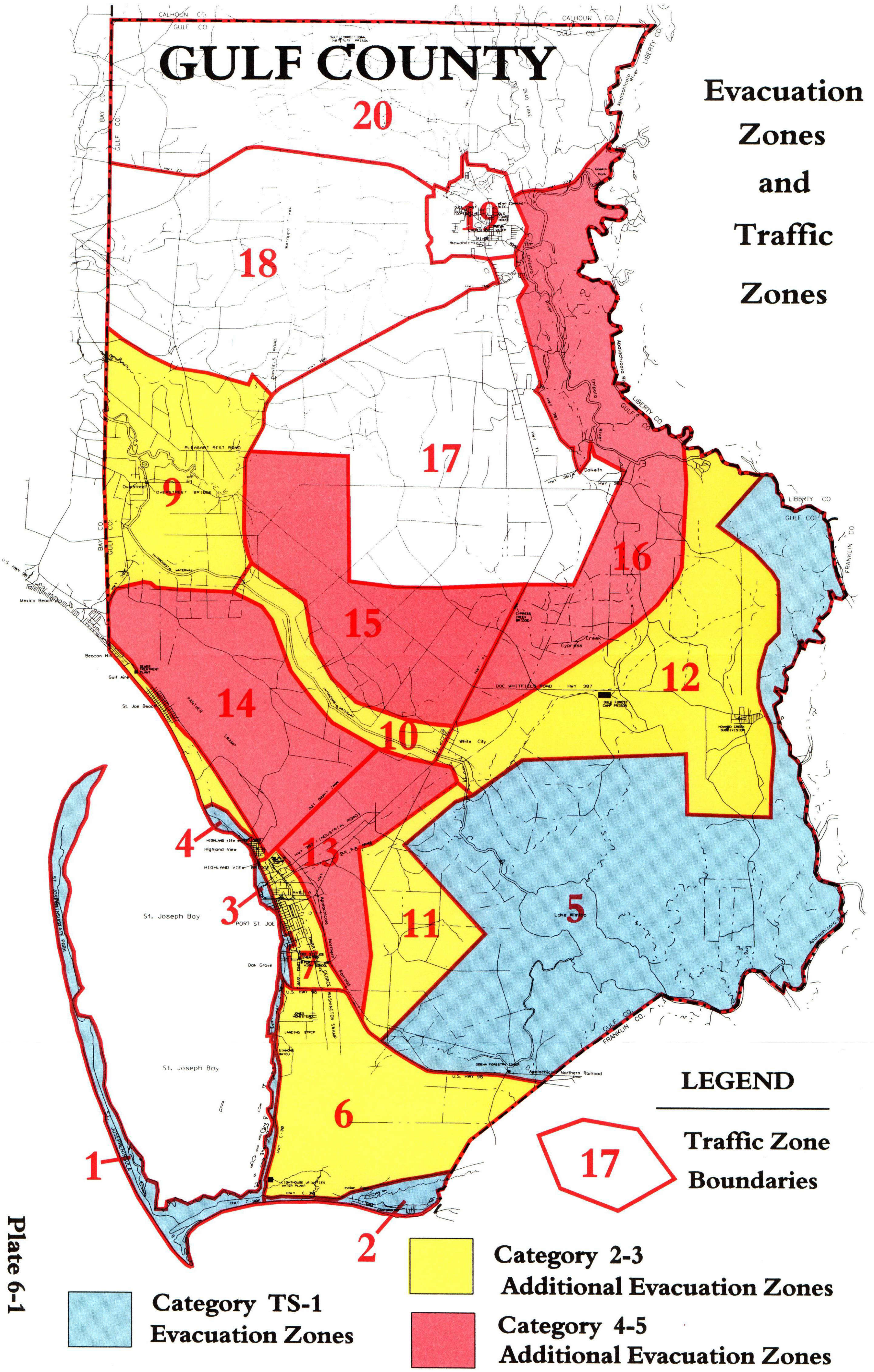
4. All draw/swing bridges needed for evacuation should be locked in the "down" position during a hurricane warning if possible. Boat owners must be made aware of flotilla plans and time requirements for securing vessels. Optimally, recreational vehicles should be moved to safe harbor during or before a hurricane watch. This judgement will need to be made on a case by case basis through discussions between the U.S. Coast Guard, local emergency officials and the State DOT.

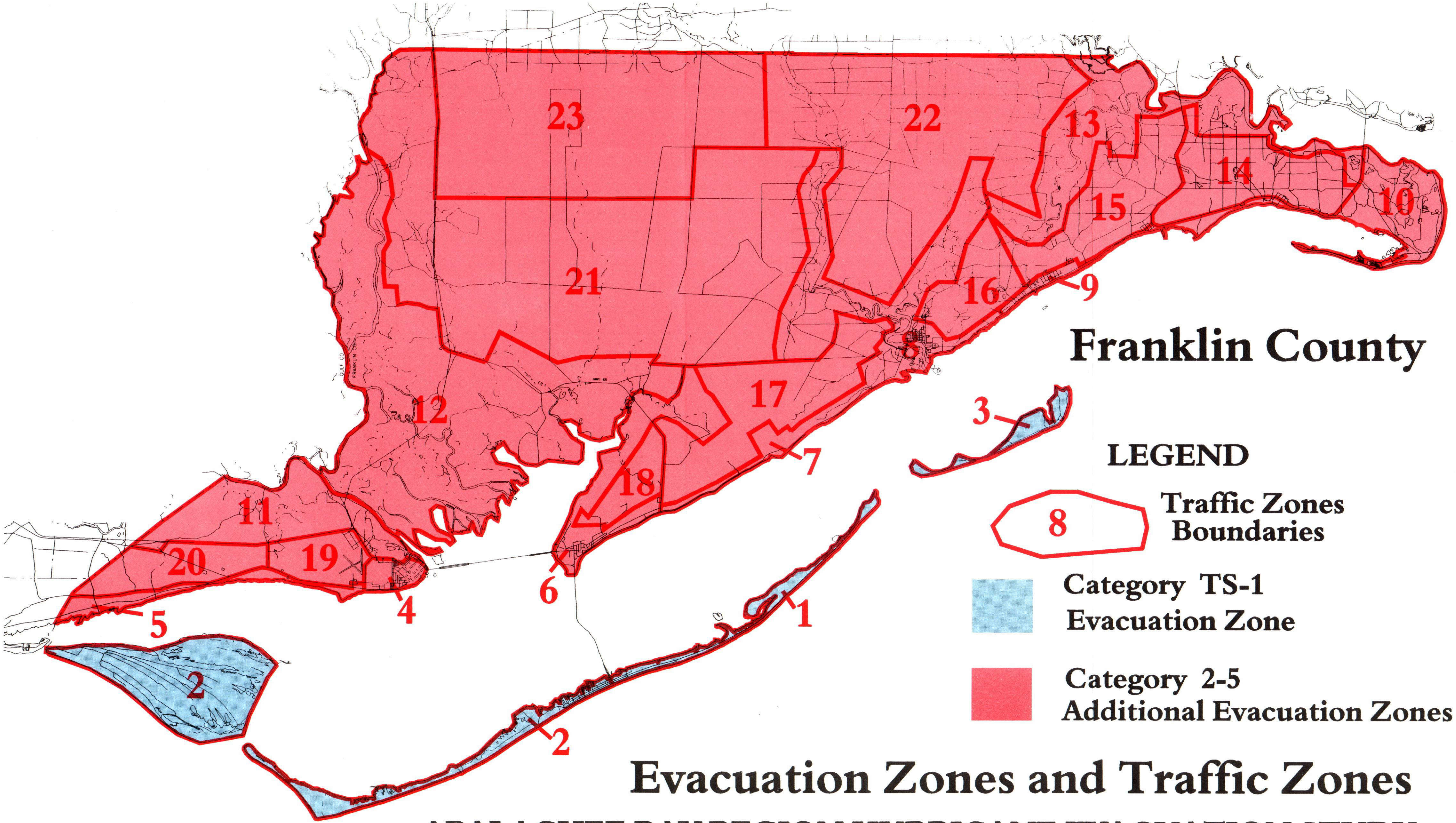
5. The movement of mobile homes, campers and boat trailers along evacuation routes should be minimized late in an evacuation as wind becomes a problem.

6. Local and state emergency management officials must continue to aggressively pursue the identification and facilitation of some major inland shelter facilities.

7. Traffic control in Leon County will be essential to a successful evacuation of the coast. Movements from the south through Capital Circle will need to move as continuously as possible. Traffic flowing along Capital Circle westbound/ northbound to Apalachee Parkway and beyond will also need to keep moving. An important concern is how to handle traffic desiring to get from Crawfordville Road/S. Adams Street to Monroe Street. Signage/communications means for routes to public shelter should be considered. The Transportation Model Support Document includes expected evacuating vehicles entering the Tallahassee area by route.

APALACHEE BAY HURRICANE EVACUATION STUDY



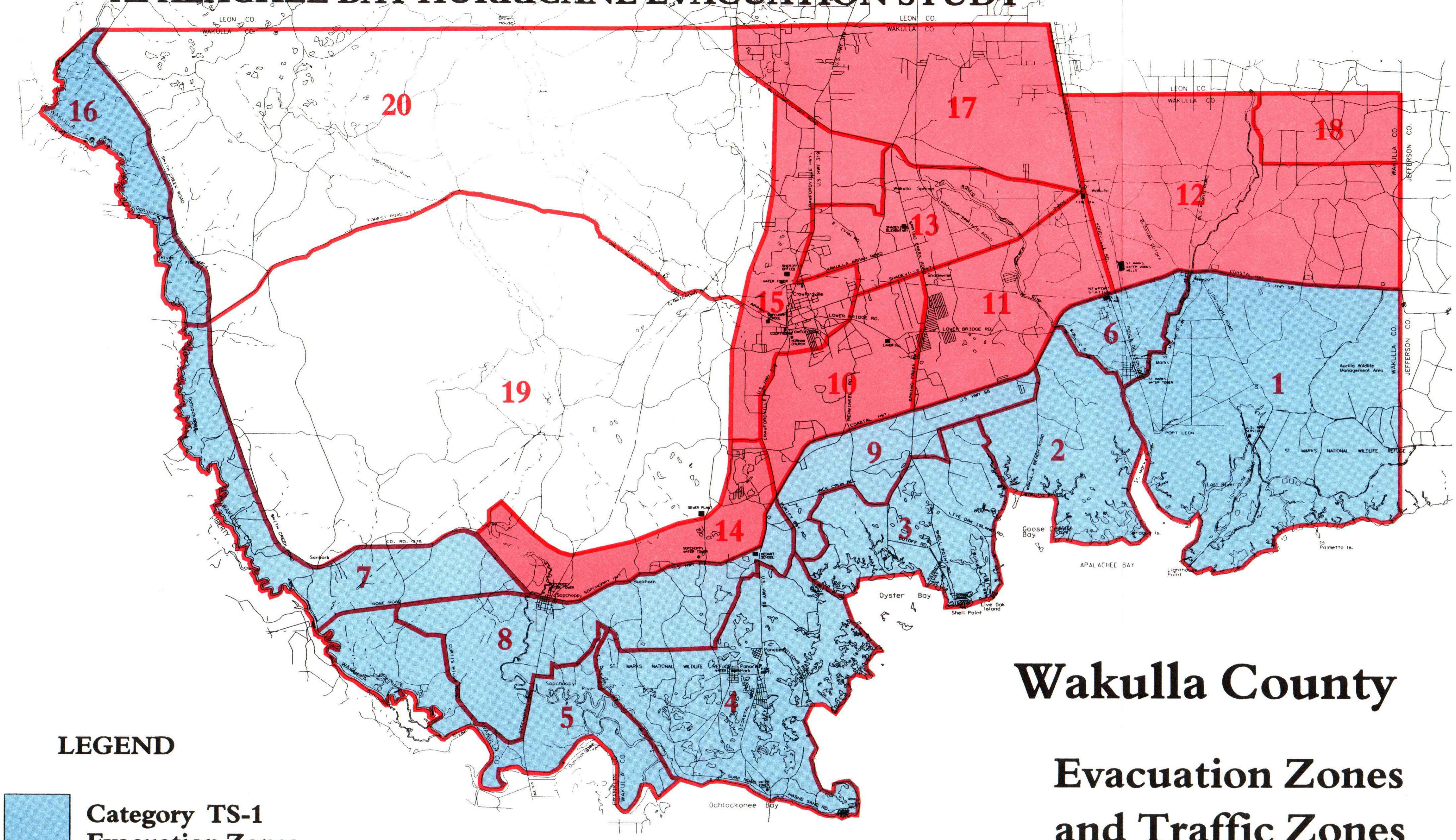


Evacuation Zones and Traffic Zones

APALACHEE BAY REGION HURRICANE EVACUATION STUDY

Plate 6-2

APALACHEE BAY HURRICANE EVACUATION STUDY



Wakulla County

Evacuation Zones and Traffic Zones

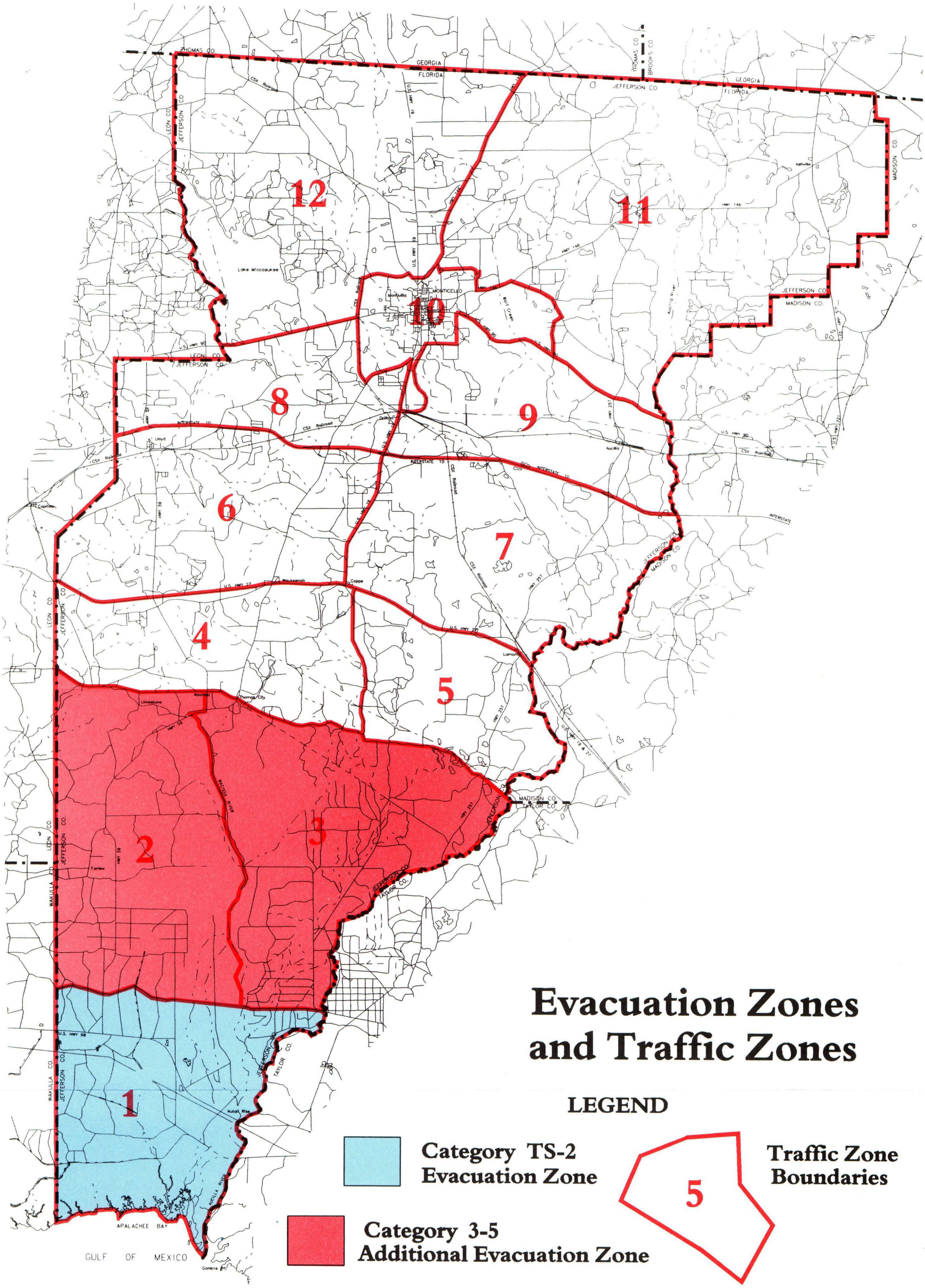
LEGEND

Category TS-1 Evacuation Zones

Category 2-5 Additional Evacuation Zones

4 Traffic Zone Boundaries

Plate 6-3

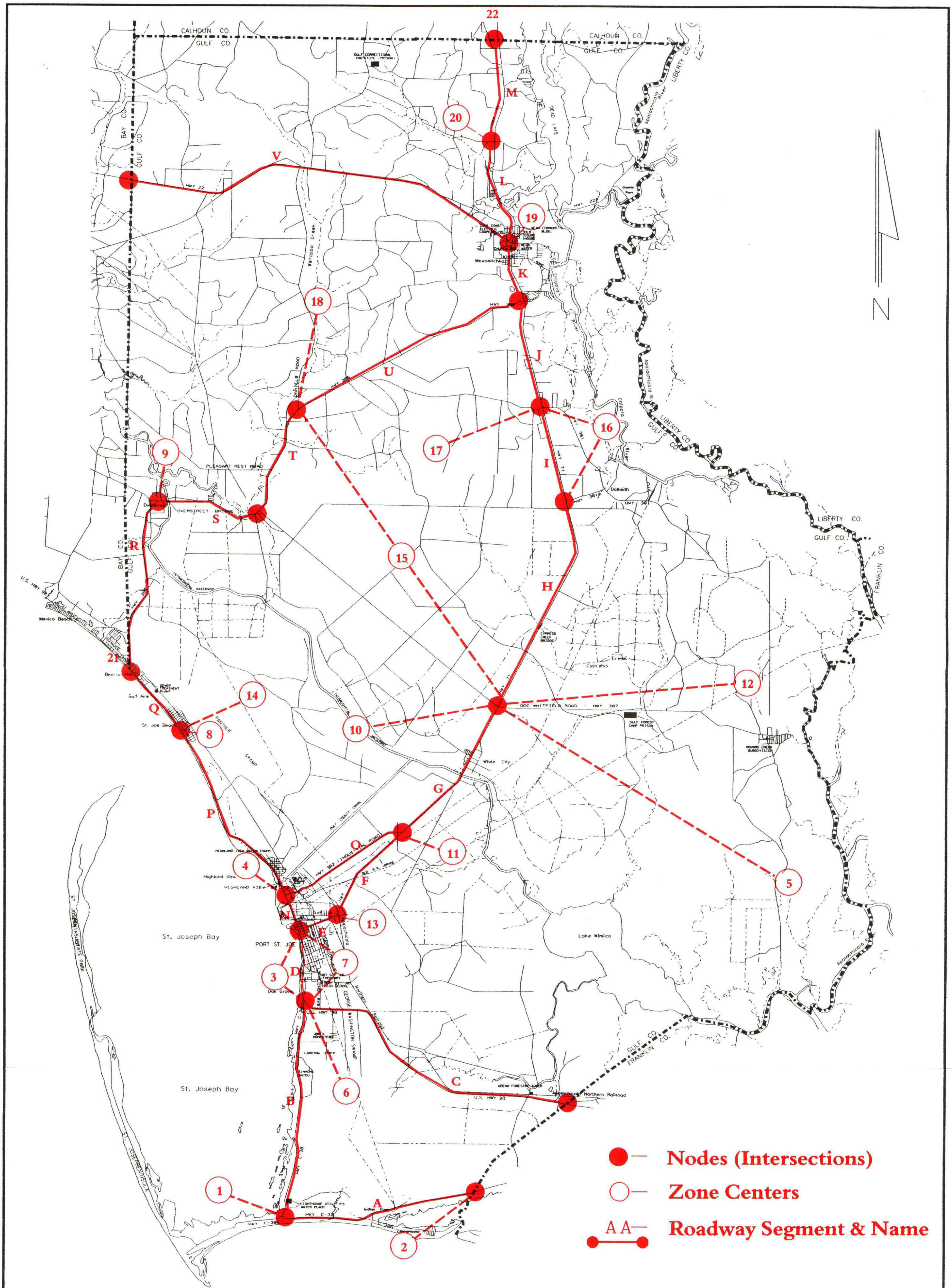


Evacuation Zones and Traffic Zones

JEFFERSON COUNTY

Apalachee Bay Hurricane Evacuation Study

Plate 6-4

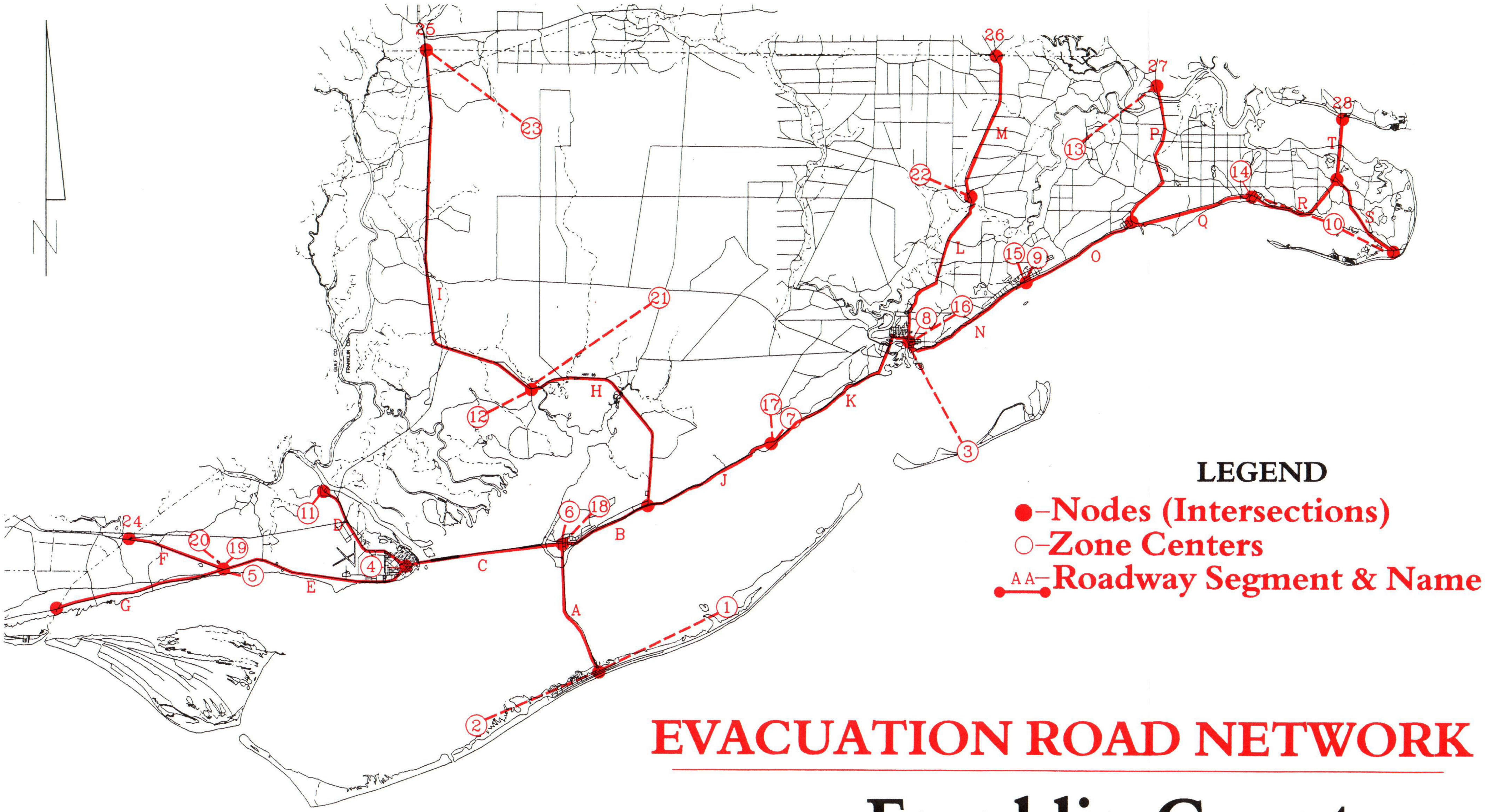


EVACUATION ROAD NETWORK

GULF COUNTY

APALACHEE REGION HURRICANE EVACUATION STUDY

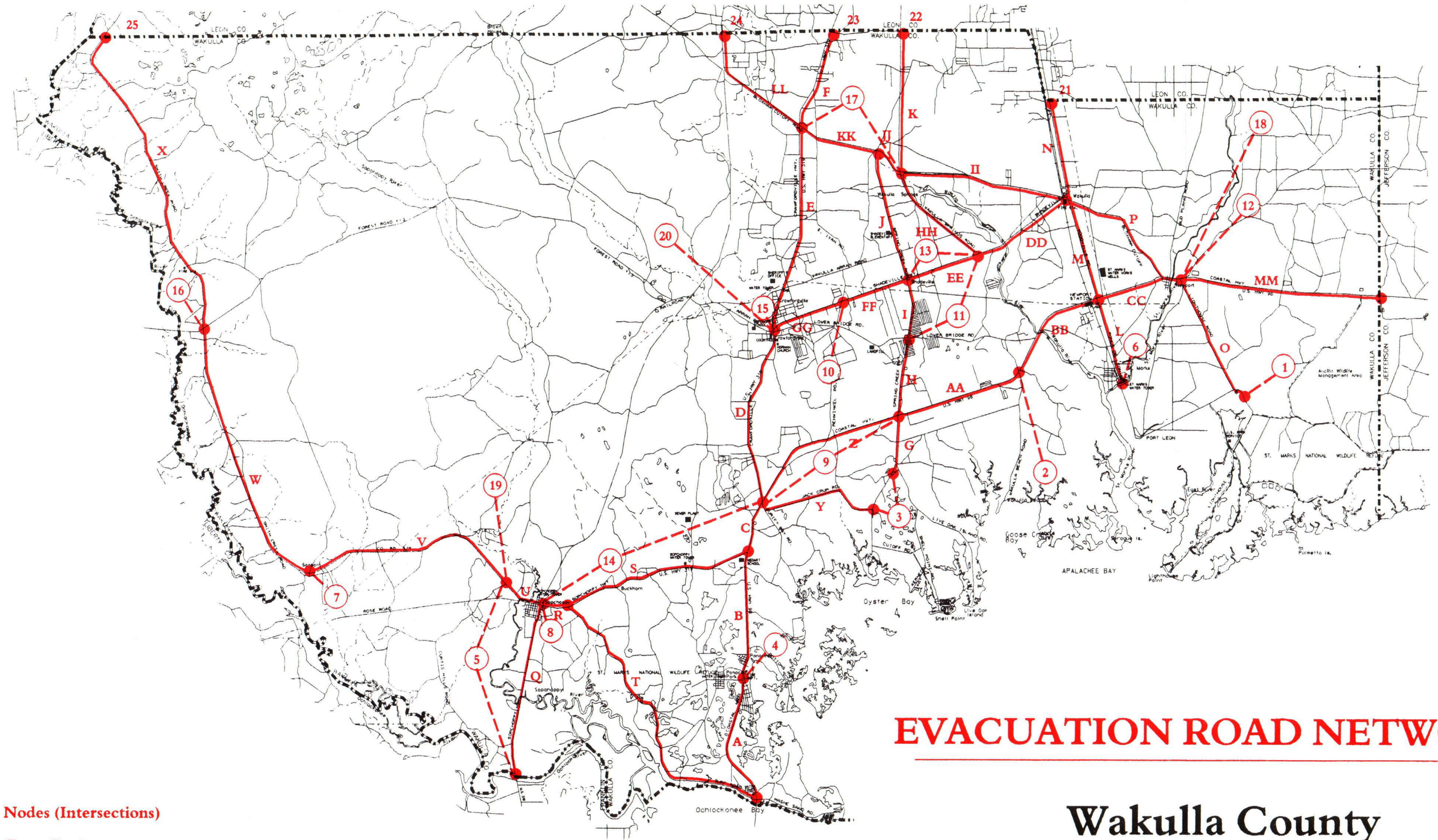
Plate 6-5



EVACUATION ROAD NETWORK

Franklin County

APALACHEE REGION HURRICANE EVACUATION STUDY **Plate 6-6**



● — Nodes (Intersections)

○ — Zone Centers

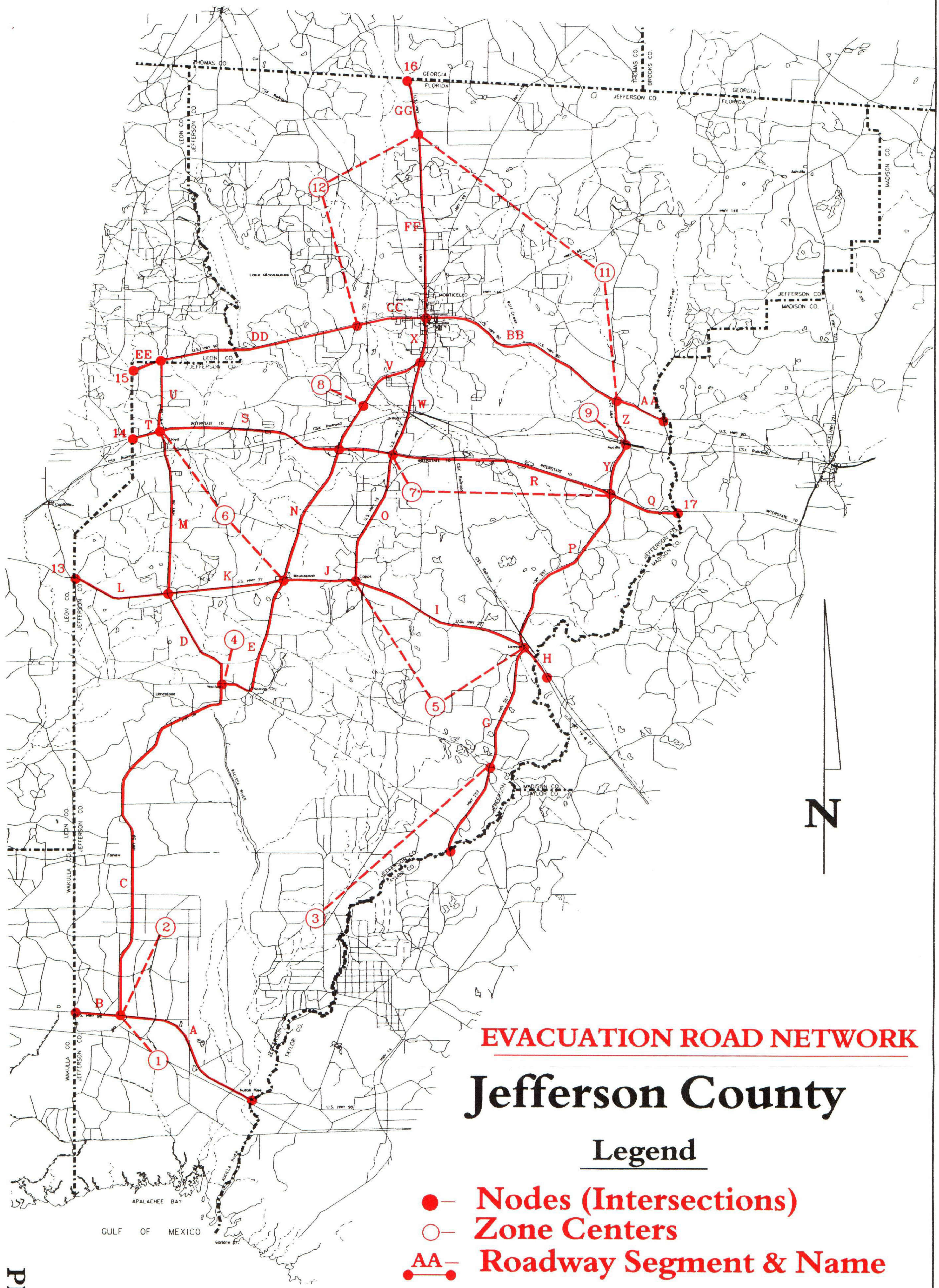
●—AA—● Roadway Segment & Name

EVACUATION ROAD NETWORK

Wakulla County

APALACHEE REGION HURRICANE EVACUATION STUDY

Plate 6-7



EVACUATION ROAD NETWORK

Jefferson County

Legend

- ● Nodes (Intersections)
- ○ Zone Centers
- AA Roadway Segment & Name

Plate 6-8

DECISION ARCS

CHAPTER SEVEN - DECISION ARCS

PURPOSE

This chapter describes the Decision Arc Method, a hurricane evacuation planning and decision-making tool that uses clearance times in conjunction with National Hurricane Center advisories to help determine when and if evacuations should begin.

BACKGROUND

Hurricanes do not always approach land from a direction perpendicular to the coastline and frequently enter the mainland on an angular track. When a hurricane is still 24 hours off the coast an error of 10 degrees in predicting the hurricane track can easily mean a 100-mile difference in the point of landfall. The average error of landfall positions in a 12-hour forecast is roughly 50-60 miles.

When a hurricane approaches a coastline at an acute angle, an error in forecast landfall position will increase or decrease the distance to landfall, possibly resulting in a significant error in forecast time of landfall. The forward motion of hurricanes can also accelerate and decelerate, causing the time of landfall to be even more unpredictable. Since hurricane evacuation decision-making and mobilization have typically been dependent upon forecast landfall position and time of landfall, a method was needed that would help compensate for forecast errors by relating evacuation operations to hurricane position.

It is recommended that hurricane vulnerable jurisdictions investigate the various hurricane evacuation decision-making computer programs in use today. These programs incorporate Hurricane Evacuation Study data, including some form of the Decision Arc Method presented in this chapter. Computer assistance can be very useful in speeding needed calculations and displaying important information and relationships. Even if a computer program(s) is used, emergency management officials should be familiar with the concepts presented in this chapter. This will promote confidence in the software and ensure that decision-making can proceed despite power outages or computer failure.

DECISION ARC EQUIPMENT

The Decision Arc Method employs two separate but related components which, when used together, present a graphic depiction of the hurricane situation. A specialized hurricane tracking chart called the Decision Arc Map, is teamed with a transparent two-dimensional hurricane graphic called the STORM, to describe the approaching hurricane and its relation to the area considering evacuation.

a. Decision Arc Map

In order to properly evaluate the last reported position and forecast track of an approaching hurricane, a special hurricane tracking chart has been developed for the study area. Superimposed on an ordinary tracking chart is a series of concentric arcs centered on the southernmost boundary of the study area and spaced at 50-nautical-mile intervals. These arcs are labeled alphabetically and in nautical miles measured from their center. Plate 7-1 through 7-4 included at the end of this Chapter are small-scale examples of Decision Arc Maps for each county in the study area.

b. Storm Tool

The Special Tool for Observing Range and Motion (STORM) is used as a two-dimensional depiction of an approaching hurricane. It is a transparent disk with concentric circles spaced at 25-nautical-mile intervals, their center representing the hurricane eye. These circles form a scale used to note the radii of 34-knot (tropical storm) winds reported by the National Hurricane Center in the Marine Advisory. Plate 7-5 included at the end of this Chapter is a small-scale example of the STORM tool.

c. National Hurricane Center Tropical Cyclone Advisory

Marine advisories on tropical storms are normally issued by the National Hurricane Center every 6 hours: 0500EDT, 1100EDT, 1700EDT, and 2300EDT. At times, supplementary intermediate advisories are also issued. These advisories contain information on present and forecast position, intensity, size, and movement that is used in the Decision Arc Method.

DECISION ARC CONCEPT

A hurricane evacuation should be completed prior to the arrival of sustained 34-knot (tropical storm) winds or the onset of storm surge inundation, whichever occurs first. In the Apalachee Bay Region, the limiting factor for hurricane evacuation is primarily the arrival of sustained 34-knot winds.

The clearance time is the time required to clear the roadways of all evacuating vehicles. It therefore determines the minimum time period, in hours prior to the arrival of sustained 34-knot winds, necessary for a safe evacuation. Clearance times are based on three variables: (1) the Saffir/Simpson hurricane category, (2) the expected evacuee response rate, and (3) the tourist occupancy situation (where applicable).

Decision Arcs are clearance times converted to distance by accounting for the forward speed of the hurricane. To translate a clearance time into nautical miles (a Decision Arc distance) for use with the Decision Arc Map, a simple calculation of multiplying the clearance time by the forward speed of the hurricane in knots is necessary. This calculation yields the distance in nautical miles that the 34-knot wind field will move while the evacuation is underway.

a. Should Evacuation be Recommended

Probability values shown in the National Hurricane Center's (NHC) Probability Advisory describe in percentages the chance that the center of a storm will pass within 65 miles of the listed locations. The maximum probability the NHC uses for predicting a direct hit varies with the length of time before landfall. Table 7-1 shows these maximums. The total probability value for your location, shown on the right side of the Marine Advisory probabilities table, should be compared to other locations and to the maximums shown in table 7-1. This will indicate the relative vulnerability of your location as compared with adjacent locations and with the maximum possible probability.

Table 7-1 Maximum Probability Values by Forecast Period

Forecast period Hours	Maximum probability Percent
72	10
60	11
48	13
42	16
36	20
30	27
24	35
18	45
12	60

b. When Evacuation Should Begin

As a hurricane approaches, the Decision Arc Method requires officials to make an evacuation decision prior to the time at which the radius of sustained 34-knot winds touches the appropriate Decision Arc (the Decision Point). For example, with a clearance time of 15 hours, and a hurricane forward speed of 10 knots, the evacuation should be initiated before the sustained 34-knot winds get within 150 nautical miles (15 hours x 10 knots = 150 nautical miles)of the area being evacuated. This would correspond to Arc "H" on the decision arc map. For convenience, a Decision Arc Table has been developed for the Apalachee Bay Region that converts an array of clearance times and forward speeds to respective Decision Arcs. This Table is shown on Plate 7-6. Once the sustained 34-knot winds move across the Decision Arc, there may not be sufficient time to safely evacuate the vulnerable population.

DECISION ARC PROCEDURE

The following procedure has been developed to assist emergency managers in determining, **WHEN** an evacuation decision must be made and **IF** you should initiate an evacuation. The National Hurricane Center hurricane probability advisory is used to assist in this decision-making process. All notes and cautions shown in this procedure should be heeded as appropriate.

There are four basic "tools" you will need in your evacuation decision procedure: (1) Decision Arc Map; (2) Decision Arc tables; (3) transparent STORM disk; and (4) the NHC Tropical Cyclone Advisory.

1. From the NHC Tropical Cyclone Advisory, plot the last reported position of the hurricane eye on the Decision Arc Map. Notate position with date/time. ZULU time (Greenwich mean time) used in the advisory should be converted to eastern daylight time by subtracting four (4) hours. Plot and notate the five forecast positions of the hurricane given in the advisory (ie, 12 hr, 24 hr, 36 hr, 48 hr, 72 hr).

2. From the Tropical Cyclone Advisory, note the maximum radius of 34-knot winds (observed or forecast), the maximum sustained wind speed (observed or forecast), and the current forward speed. Plot the maximum radius of 34-knot winds onto the STORM disk. See note a. for information on nautical miles/knots.

3. Determine the forecast forward speed of the hurricane in knots. The forecast speed of the hurricane can be determined for each forecast position by dividing the distance between each position by the time interval between each position. Compare these forecast forward speeds to the current forward speed noted in previous advisories. A forecast speed greater than the current or previous forward speed indicates that the hurricane is expected to accelerate, which reduces the time available to the decision-maker.

4. Using the maximum sustained wind speed, determine the category of the approaching hurricane based on the Saffir/Simpson Hurricane Scale. **NOTE:** Because of potential forecast and SLOSH model inaccuracies, it may be wise to add one category to the forecast landfall intensity.

5. From table 6-7, select the pertinent clearance time. Using that clearance time and the appropriate forecast forward speed of the storm select the appropriate Decision Arc from the Decision Arc Table on Page 7-7. Mark this arc on the Decision Arc Map.

6. Using the center of the STORM disk as the hurricane eye, locate the STORM on the Decision Arc Map at the last reported hurricane position. Determine if the radius of 34-knot winds falls within the selected Decision Arc (the point at which the radius of 34-knot winds crosses into the selected Decision Arc). If so, available traffic control measures should be implemented and public advisories issued in order to ensure a rapid public response and completion of the evacuation prior to the arrival of sustained 34-knot winds (or no evacuation advisory is issued). See note b. for additional evacuation timing information.

7. Move the STORM to the first forecast position. Determine if the radius of 34-knot winds has passed the Decision Point. If so, the Decision Point will be reached prior to the hurricane eye reaching the first forecast position.

8. If the raius of 34-knot winds has not crossed the decision arc you can estimate the hours remaining before a decision must be made by dividing the number of nautical miles between the current radius of 34-knot winds and the Decision Point by the forward speed used for the Decision Arc table. Determine if the next NHC Tropical Cyclone Advisory will be received prior to the Decision Point.

9. Compare probabilities shown in the Tropical Cyclone Advisory to determine where an evacuation is likely to take place (see note c.). Determine how an evacuation of your jurisdiction would affect the readiness of others and when they should be notified of your evacuation. Check inundation maps to determine where flooding may occur and evacuation zone maps for zones that should prepare to evacuate.

10. At the Decision Point, evacuation decision-makers should compare the latest probabilities for their location with those for surrounding areas and the maximums shown in table 7-1. In addition to that forecast track information, they should also consider the storm's intensity and the potential inundation.

11. Steps 1 through 10 should be repeated after each NHC advisory until an evacuation decision is made or the hurricane threat has passed.

NOTES

a. Because information given in the Tropical Cyclone Advisory is in nautical miles and knots, the scale of the Decision Arc Maps and STORM is nautical miles. When utilizing hurricane information from sources other than the Marine Advisory, care should be taken to ensure that distances are given in or converted to nautical miles and speeds to knots. Statute miles can be converted to nautical miles by dividing the statute miles value by 1.15. Similarly, miles per hour can be converted to knots by dividing the miles per hour value by 1.15.

b. In the Decision Arc Method, there is no time specifically allocated for evacuation decision-making or mobilizing support personnel. Hurricane readiness operations should progress so that, if evacuation becomes necessary, preparations will be complete and the recommendation to evacuate can be given at the Decision Point.

c. Probability values shown in the Marine Advisory describe in percentages the chance that the center of a storm will pass within 65 miles of the listed locations. To check the relative probability for your particular area, the total probability value for the closest location, shown on the right side of the probability table in the advisory, should be compared to other locations. A comparison should also be made with the possible maximums for the applicable forecast period shown in the table of maximum probability values included in these instructions. These comparisons will show the relative vulnerability of your location to adjacent locations and to the maximum possible probability.

TABLE 7-2

DECISION ARCS[1]

ESTIMATED CLEARANCE TIME(HRS.)[2]	FORECAST HURRICANE FORWARD SPEED (KNOTS)[3]						
	5	10	15	20	25	30	35
	DECISION ARC[4]						
4	A	B	C	D	E	F	G
5	A	C	D	E	G	H	I
6	A	C	E	F	H	I	K
7	B	D	F	G	I	K	M
8	B	D	F	H	J	L	N
9	B	E	G	I	L	N	P
10	B	E	H	J	M	O	R
11	C	F	I	K	N	Q	T
12	C	F	I	L	O	R	U
13	C	G	J	M	Q	T	W
14	C	G	K	N	R	U	Y
15	D	H	L	O	S	W	AA
16	D	H	L	P	T	X	BB
17	D	I	M	Q	V	Z	DD
18	D	I	N	R	W	AA	FF
19	E	J	O	S	X	CC	HH
20	E	J	O	T	Y	DD	II

[1]This table can be used with any combination of clearance time and forward speed.

[2]See Table 6-7 for clearance times.

[3]See Procedure (Step 5) of Evacuation Decision Worksheet for methods of determining forecast forward speed.

[4]"Arcs" refer to concentric circles on the County Decision Arc Map.

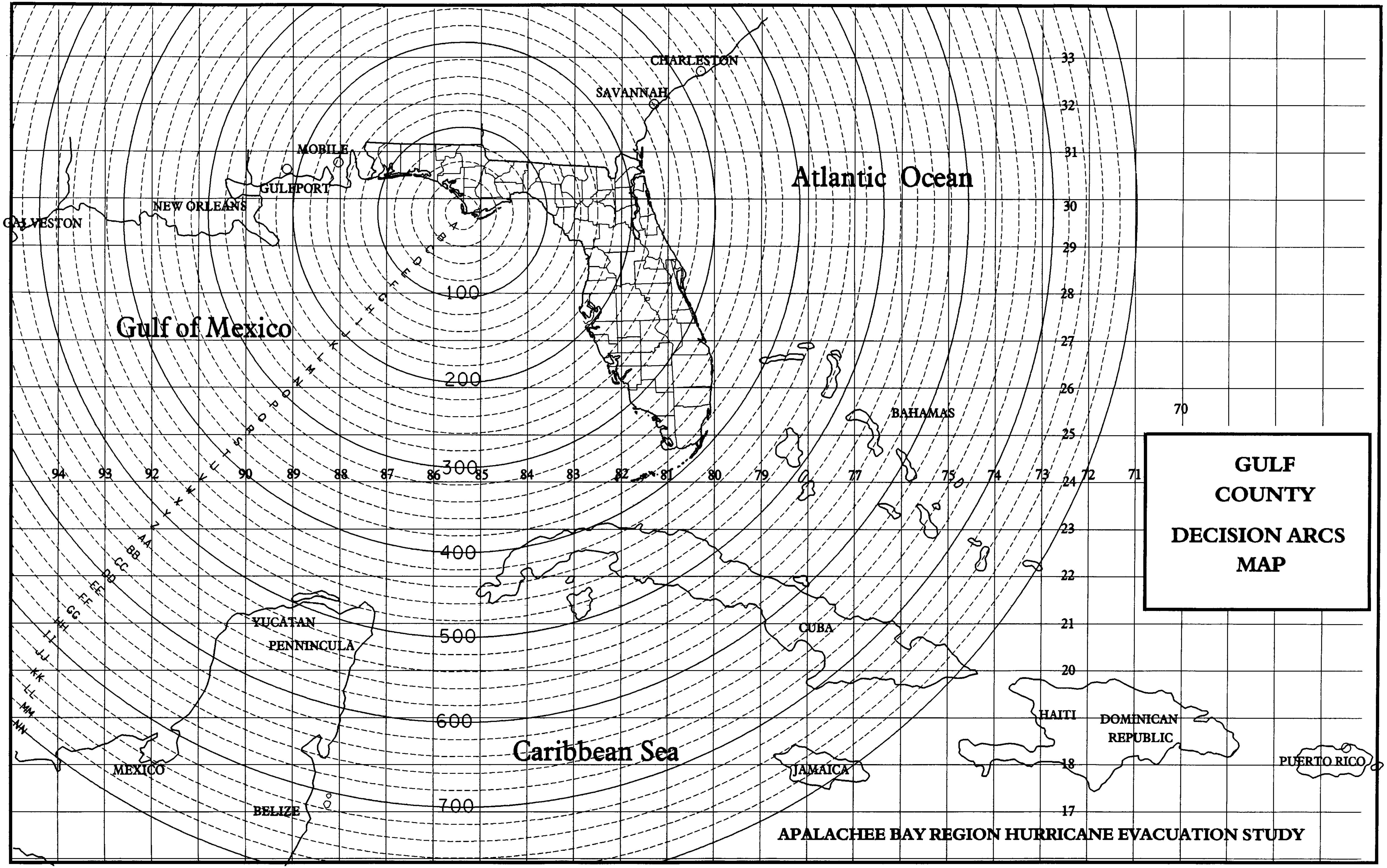
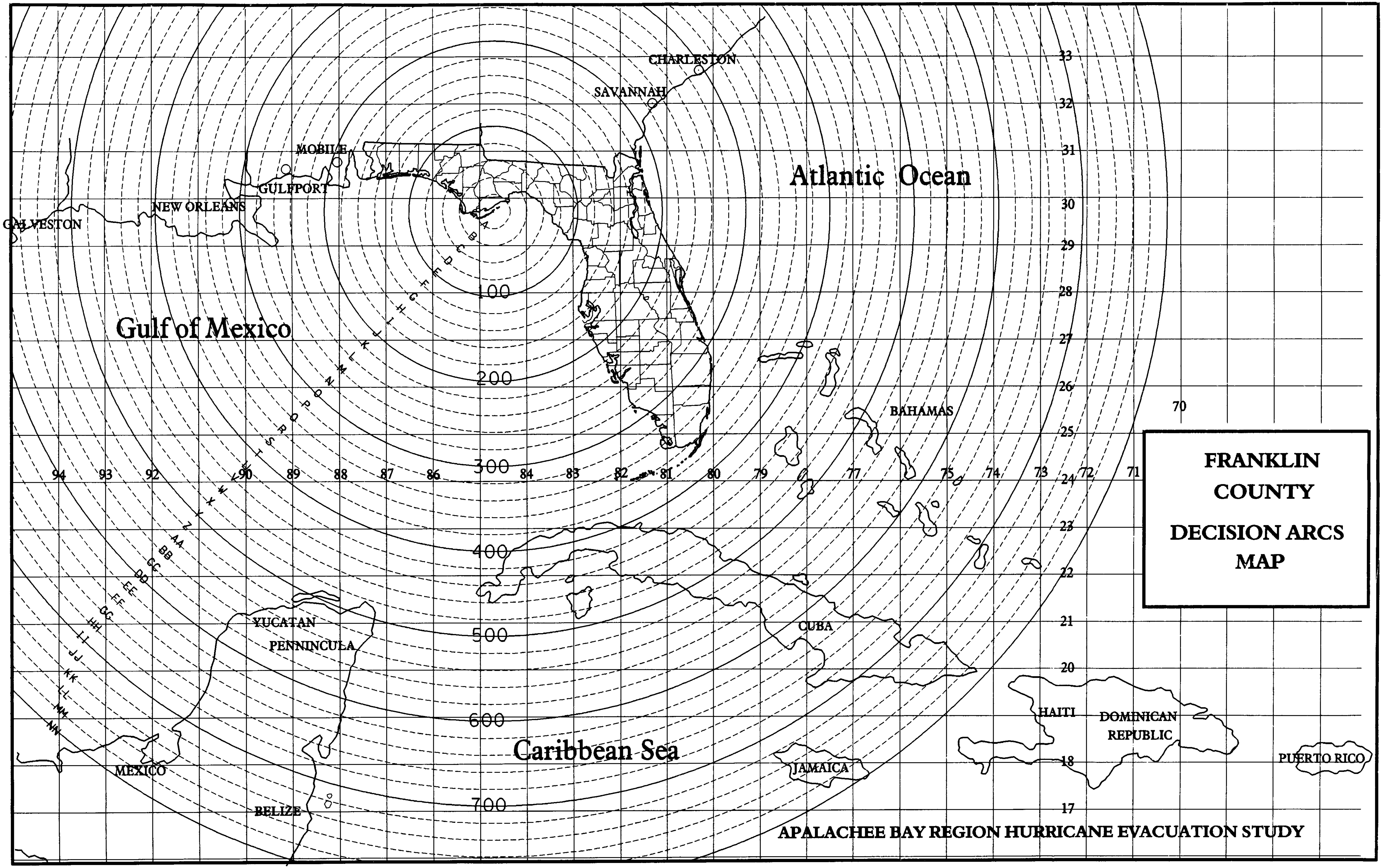

GULF COUNTY
DECISION ARCS MAP
APALACHEE BAY REGION HURRICANE EVACUATION STUDY
Atlantic Ocean
Gulf of Mexico
Caribbean Sea
CHARLESTON
SAVANNAH
MOBILE
GULFPORT
NEW ORLEANS
GALVESTON
BAHAMAS
CUBA
YUCATAN PENNINCULA
MEXICO
BELIZE
JAMAICA
HAITI
DOMINICAN REPUBLIC
PUERTO RICO
100
200
300
400
500
600
700

PLATE 7-1


FRANKLIN COUNTY
DECISION ARCS MAP
Atlantic Ocean
Gulf of Mexico
Caribbean Sea
CHARLESTON
SAVANNAH
MOBILE
GULFPORT
NEW ORLEANS
GALVESTON
BAHAMAS
YUCATAN
PENNINCULA
CUBA
HAITI
DOMINICAN
REPUBLIC
PUERTO RICO
JAMAICA
MEXICO
BELIZE
100
200
300
400
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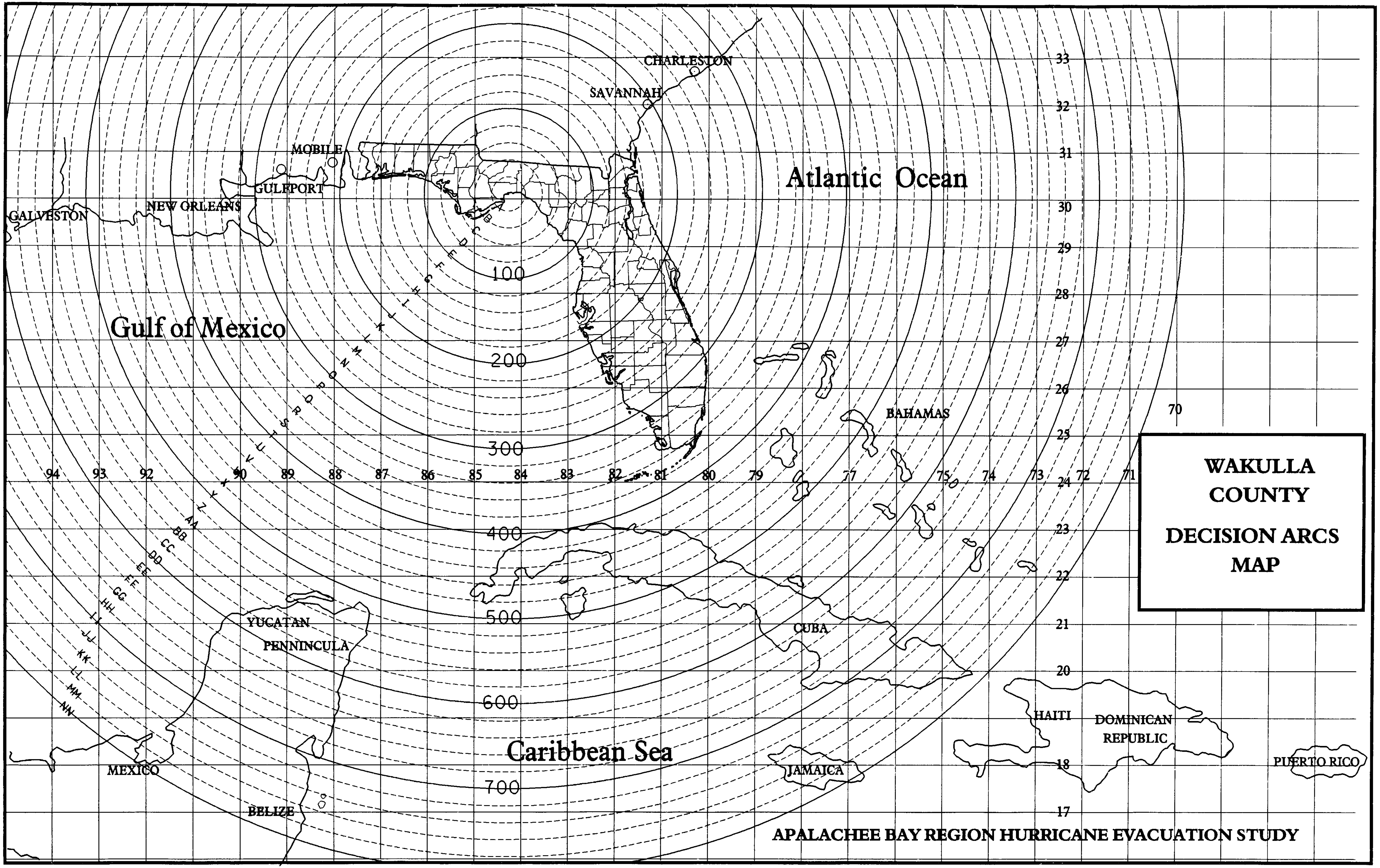
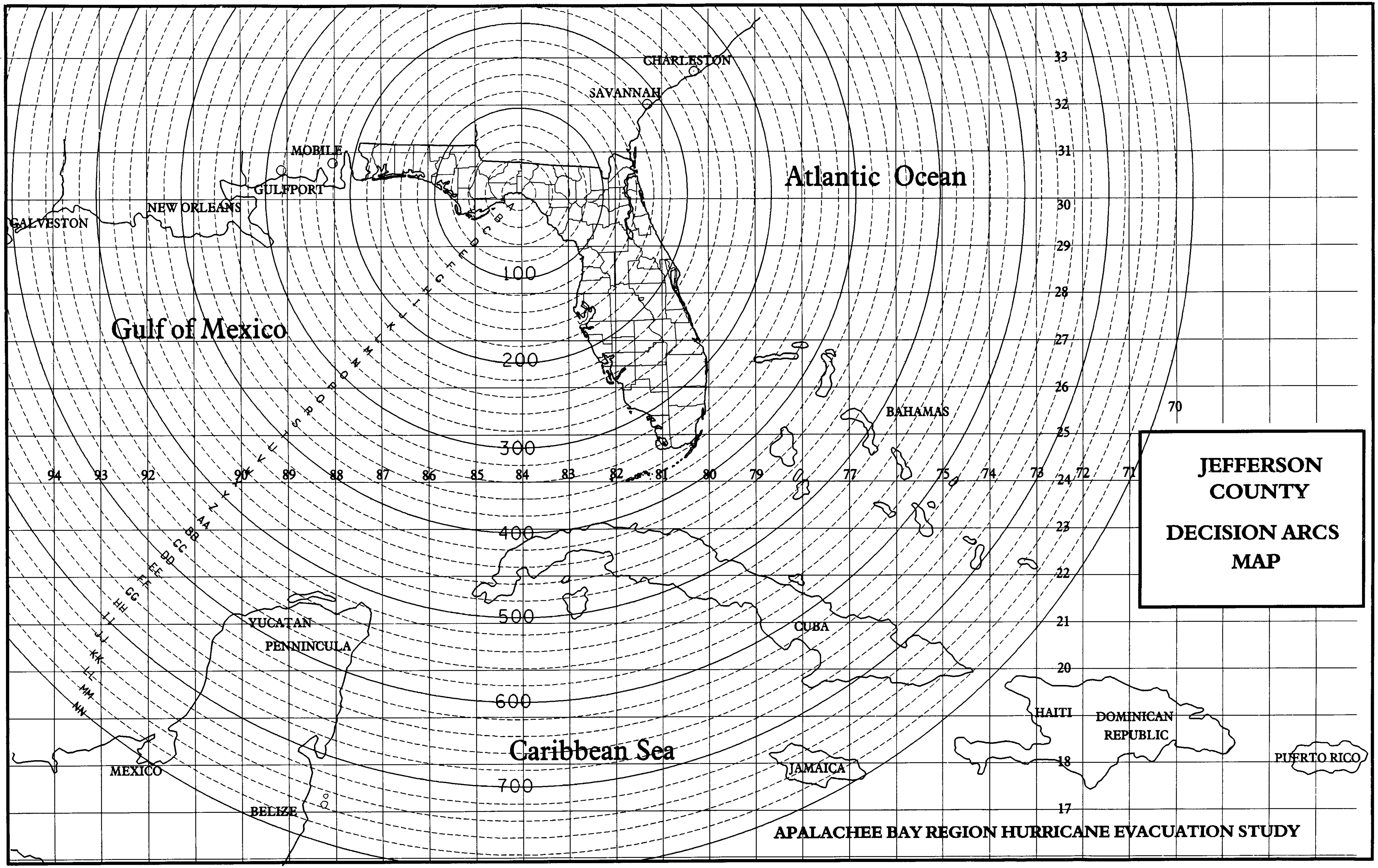
600
700
APALACHEE BAY REGION HURRICANE EVACUATION STUDY

PLATE 7-2



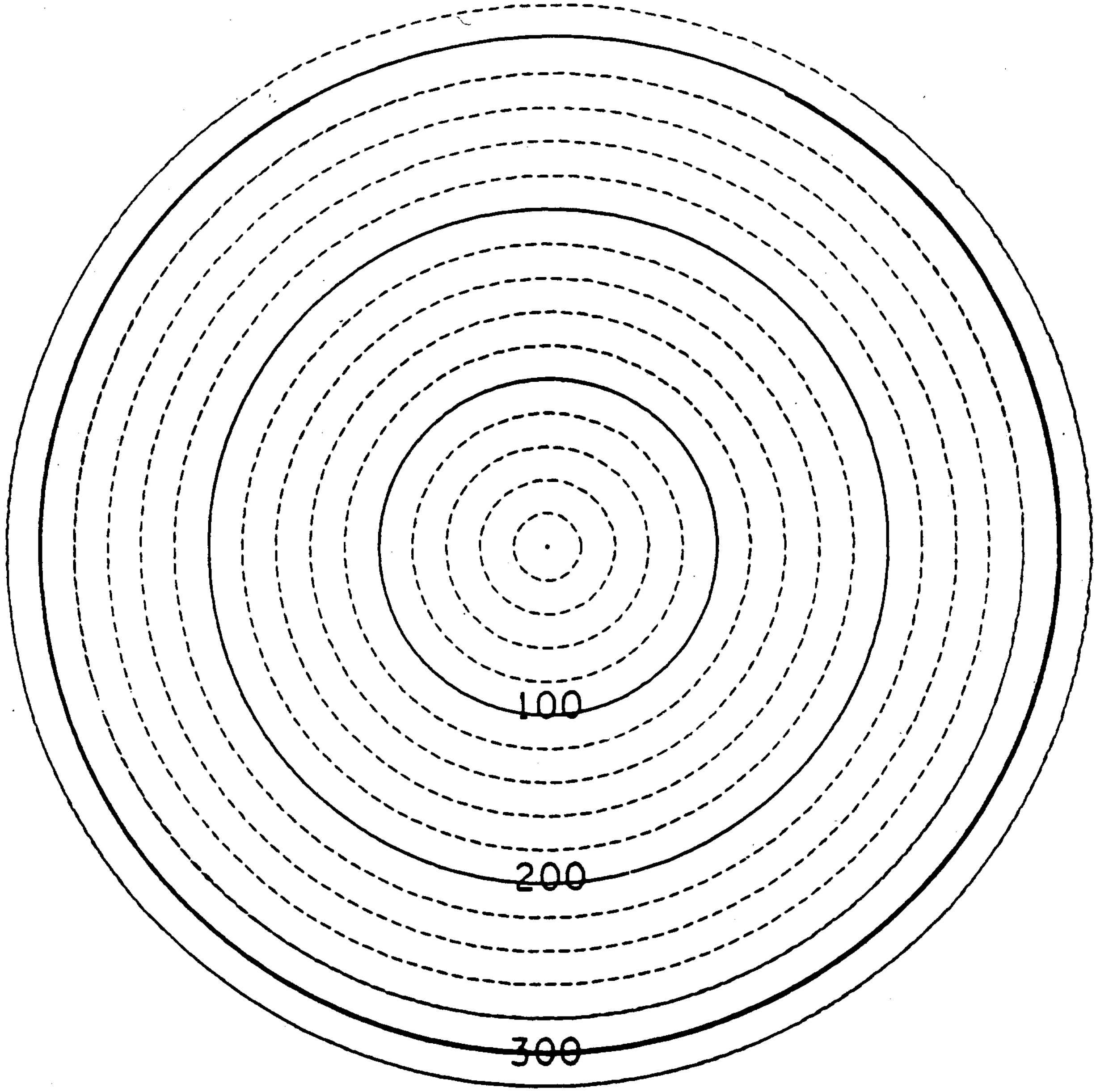
CHARLESTON
SAVANNAH
MOBILE
GULFPORT
NEW ORLEANS
GALVESTON
Atlantic Ocean
Gulf of Mexico
100
200
300
400
500
600
700
BAHAMAS
YUCATAN
PENNINCULA
CUBA
Caribbean Sea
HAITI
DOMINICAN
REPUBLIC
JAMAICA
PUERTO RICO
MEXICO
BELIZE
WAKULLA
COUNTY
DECISION ARCS
MAP
APALACHEE BAY REGION HURRICANE EVACUATION STUDY

PLATE 7-3



JEFFERSON COUNTY
DECISION ARCS MAP
APALACHEE BAY REGION HURRICANE EVACUATION STUDY
Atlantic Ocean
Gulf of Mexico
Caribbean Sea
CHARLESTON
SAVANNAH
MOBILE
GULFPORT
NEW ORLEANS
GALVESTON
BAHAMAS
CUBA
YUCATAN PENNINCULA
MEXICO
BELIZE
JAMAICA
HAITI
DOMINICAN REPUBLIC
PUERTO RICO
100
200
300
400
500
600
700

PLATE 7-4



STORM TOOL

DECISION ARCS

DEPARTMENT OF THE ARMY

MOBILE DISTRICT, CORPS OF ENGINEERS
MOBILE, ALABAMA

Plate 7-5