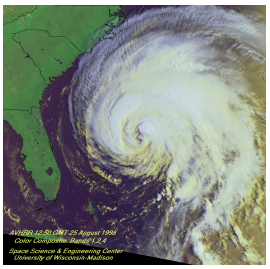


Transportation Analysis

Prepared by Post, Buckley, Schuh and Jernigan

EAST CENTRAL FLORIDA REGIONAL PLANNING COUNCIL
1999 HURRICANE EVACUATION STUDY

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Introduction

Overview

With the approach of each new hurricane season, the counties of east central Florida face the threat of an encounter with a severe hurricane. In response, these counties continue to increase their level of preparedness to be ready for future active hurricane seasons. The study area faces the potential of significant storm surge inundation, and has low-lying inland areas throughout the region, which are vulnerable to freshwater flooding. In addition, there is a significant mobile home population in the region, susceptible to severe hurricane force winds well before a system decays following landfall. Orlando in the interior of the region will serve as a major evacuation destination of coastal evacuees from many areas of Florida responding to a major hurricane.

In the event of a hurricane, officials in the east central area of Florida must be prepared to evacuate a vulnerable population on critical routes, concurrently with northbound evacuees from counties further to the south. Additional complications may occur during a peak tourist season, where inland hotel/motel space is fully occupied. This issue is especially critical in Volusia County, due to high tourist numbers. In addition, congestion of the roadway network must be considered when evacuees concurrently attempt to use I-95 and major east-west roadways which currently receive heavy traffic on a daily basis.

During a hurricane evacuation, the number of evacuating vehicles will vary according to the intensity of the hurricane, publicity and warnings provided about the storm and particular behavioral response characteristics of the vulnerable population. The response of evacuees to a storm advisory or evacuation order plays a large role in determining when evacuees and their vehicles will enter the roadway network. Factors such as the planned destinations of evacuees and the availability of acceptable destinations like public shelters, hotel/motel units and the homes of friends or relatives in non-surge prone areas determine when vehicles exit the roadway network. The length of time necessary for evacuating vehicles to move from origin to destination depends on the rate of traffic loadings on various roadway segments and the ability of the segments to handle a particular volume of vehicles each hour. Evacuation clearance time estimates must account for both out of county traffic, as well as evacuation traffic generated by neighboring counties using roadways within the study area.

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

Analysis Objectives and Scope

In order to expedite a smooth evacuation process, clearance times must continuously be adapted to match the level of growth in an area. The East Central Florida Regional Planning Council (ECFRPC) hired PBS&J, Inc. to update the evacuation clearance times for east central Florida. The major objectives of the update include the following:

- Use evacuation zones and scenarios developed by the ECFRPC and counties for transportation modeling and clearance time calculations for each county.
- Quantify the potential evacuation population for each scenario using socioeconomic data provided by the ECFRPC

- Identify the existing evacuation roadway network, noting improvements that have been made since the completion of the last hurricane evacuation study update by the ECFRPC.
- Develop hurricane evacuation clearance times for each county and storm scenario for a Year 2000 base year and projected for a Year 2005 future year.
- Determine regional evacuation traffic that is expected to cross county lines in order to increase the accuracy of operational planning.
- Identify local and regional bottlenecks/critical roadway segments and where applicable, recommend general traffic control strategies.
- Develop zone and road network graphics in an ArcInfo/ArcView usable format.
- Using the evacuation zone graphic for each county, develop GIS graphics displaying:
    - permanent occupied dwelling units by evacuation zone
    - mobile home units by evacuation zone
    - seasonal dwelling units by evacuation zone
    - evacuating people by evacuation zone by scenario
    - public shelter demand by evacuation zone by scenario
- Using the evacuation road network graphic for each county, develop GIS graphics displaying:
    - directional service volume per roadway segment
    - evacuation traffic congestion by roadway segment by scenario
- Develop a simplistic abbreviated "model" in a spreadsheet format that can be used by the ECFRPC to modify clearance times based on land use and system changes.

Coordination and Review Activities

The completion of the tasks entailed in this study involved a cooperative effort by the emergency management (EM) staff of each county, the State of Florida and the ECFRPC. This effort included the collection of essential data and development of hurricane evacuation zones, as well as coordination of the various technical inputs. Meetings were also held in order to discuss input assumptions and evacuation statistics developed in the study.

Transportation Analysis and Input Assumptions

In order to perform hurricane evacuation transportation modeling in the study area, a number of essential data inputs and assumptions about storm characteristics and anticipated evacuation behavior had to be developed. Clear assumptions about storm and population characteristics must be taken into account when guiding the projection of evacuation parameters for a particular region. Hurricanes vary in size, intensity, course and the time frame in which they achieve landfall. Individuals located in a potentially threatened area also perceive each storm differently. This variance can precipitate a wide range of responses to the threat of a hurricane and, in turn create a broad range of possible outcomes, which have a direct impact upon evacuation times.

The end result of the hurricane evacuation transportation analysis is a set of clearance times,

which are based upon a series of assumed conditions and behavioral responses. Because each hurricane and each county's population characteristics differ from one another, variables which could produce the greatest impact upon clearance times were identified and varied to establish the logical range within which the actual input assumptions might fall.

Key input assumptions guiding the transportation analysis are grouped under the following headings:

- Traffic Evacuation Zones
- Housing and Population Data
- Behavioral Characteristics of the Evacuating Population
- Roadway Network Assumptions

Traffic Evacuation Zones

The initial step of the study involved the development of a system of traffic evacuation zones. The counties (in concert with the ECFRPC and PBS&J) developed the boundaries of each zone in relation to well-known man-made or natural features, Traffic Analysis Zone (TAZ)/census boundaries and roadways. Most importantly, the zones reflect operationally the areas that will be asked to evacuate by local emergency management for specific storm scenarios. The zones were then grouped by potential storm surge category so that evacuation times by storm scenario could be developed. Zones include dwelling units in low-lying storm surge areas and inland mobile homes, which are vulnerable to hurricane force winds. Figures 2-1 through 2-2 illustrate the zone systems developed for the analysis of the region's coastal counties.

Several considerations were acknowledged in the development of the hurricane evacuation zones and potential storm surge category groupings. The zones needed to be accurate and directly related to anticipated storm surge limits for varying categories of hurricanes. However, they also had to be developed in a format by which information could be easily conveyed to the general public. The evacuation zone systems were developed to meet the following overall criteria:

- be based upon easily identifiable roadways or natural features for boundary identification
- relate to storm surge limits based on the most recent SLOSH model run
- be easily communicable over radio/TV media to the public
- allow coastal county residents to determine whether their home is in a storm surge vulnerable evacuation area
- be usable for transportation modeling/clearance time calculations
- be related to census/traffic analysis zone boundaries for population and dwelling unit tabulations and calculation of vulnerable populations

Figure 2-1: Traffic Evacuation Zones - Brevard County

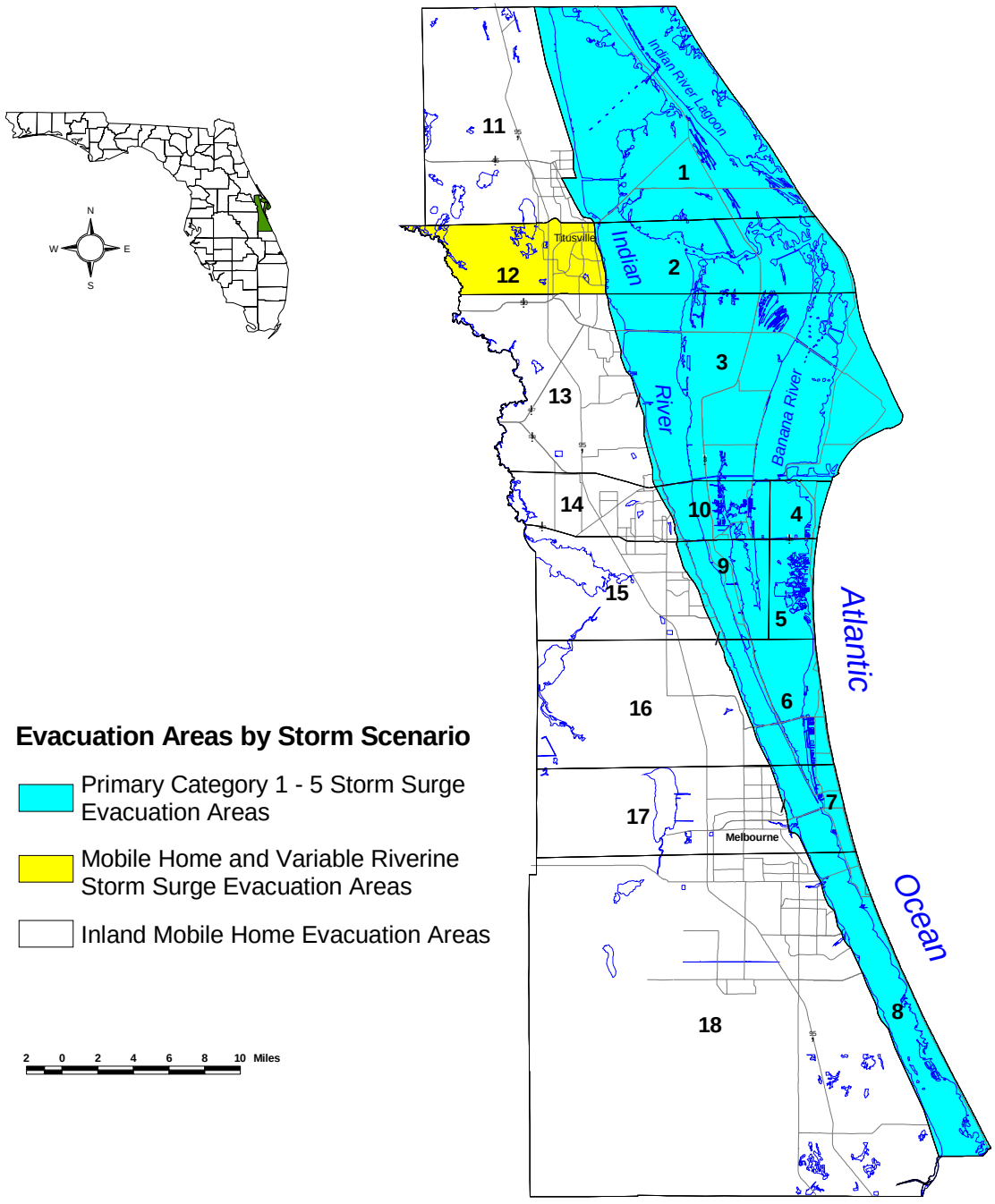
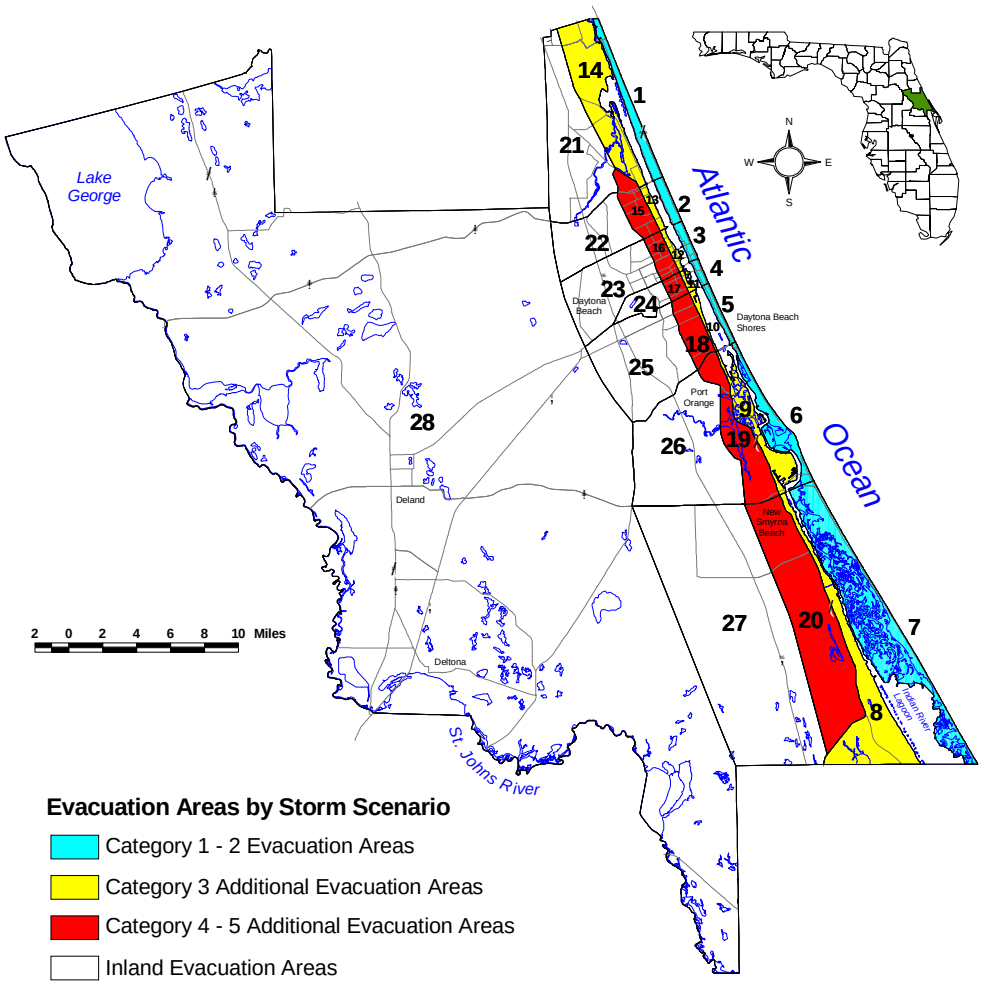


Figure 2-2: Traffic Evacuation Zones - Volusia County



Housing and Population Data

The ECFRPC supplied the data used to develop the dwelling unit and socioeconomic parameters within each traffic evacuation zone. This data was supplemented by current year mobile home and permanent occupied dwelling unit data provided by each county. Table 2-1 summarizes this data for each coastal and inland county. The Transportation Model Support Document provides the data by traffic evacuation zone.

The use of GIS technology (ArcView, ArcInfo) facilitated the production of color graphics, which could be used to quality control and display study socioeconomic inputs. Figures 2-3 and 2-4 illustrate the Year 2000 permanent dwelling units by zone by coastal county. Mobile home units by zone by coastal and inland county are shown in Figures 2-5 through 2-7. Figures 2-8 and 2-9 display tourist/seasonal units by zone by county.

Table 2-1: Key Population/Dwelling Unit Summary By County

Brevard County
Year 2000 permanent population- 498,900 people
Permanent occupied dwelling units- 201,988 units
Mobile home units- 25,000 units
Tourist/seasonal units- 8,392 units
People per permanent unit- 2.47 people
Vehicles per permanent unit- 1.66 vehicles

Volusia County
Year 2000 permanent population- 442,700 people
Permanent occupied dwelling units-182,913 units
Mobile home units- 25,000 units
Tourist/seasonal units- 17,153 units
People per permanent unit- 2.42 people
Vehicles per permanent unit- 1.53 vehicles

Orange County
Year 2000 permanent population-859,900 people
Permanent occupied dwelling units- 254,852 units
Mobile home units- 23,800 units
*Hotel/Motel units-61,415 units
People per permanent unit- 3.37 people
Vehicles per permanent unit- 1.63 vehicles

Seminole County
Year 2000 permanent population-361,900 people
Permanent occupied dwelling units- 107,657 units
Mobile home units- 6,000 units
*Hotel/Motel units-3,345 units

People per permanent unit- 3.36 people
Vehicles per permanent unit- 1.75 vehicle

Lake County

Year 2000 permanent population-203,200 people
Permanent occupied dwelling units- 63,616 units
Mobile home units- 28,700 units
*Hotel/Motel units- 1,922 units
People per permanent unit- 3.19 people
Vehicles per permanent unit- 1.53 vehicles

Osceola County

Year 2000 permanent population- 160,000 people
Permanent occupied dwelling units- 39,150 units
Mobile home units- 12,400 units
*Hotel/Motel units- 24,117 units
People per permanent unit- 4.09 people
Vehicles per permanent unit- 1.67 vehicles

*1998 Florida Statistical Abstract (Licensed hotels and licensed motels reported)

Figure 2-3: Year 2000 Permanent Occupied Dwelling Units by Zone - Brevard County

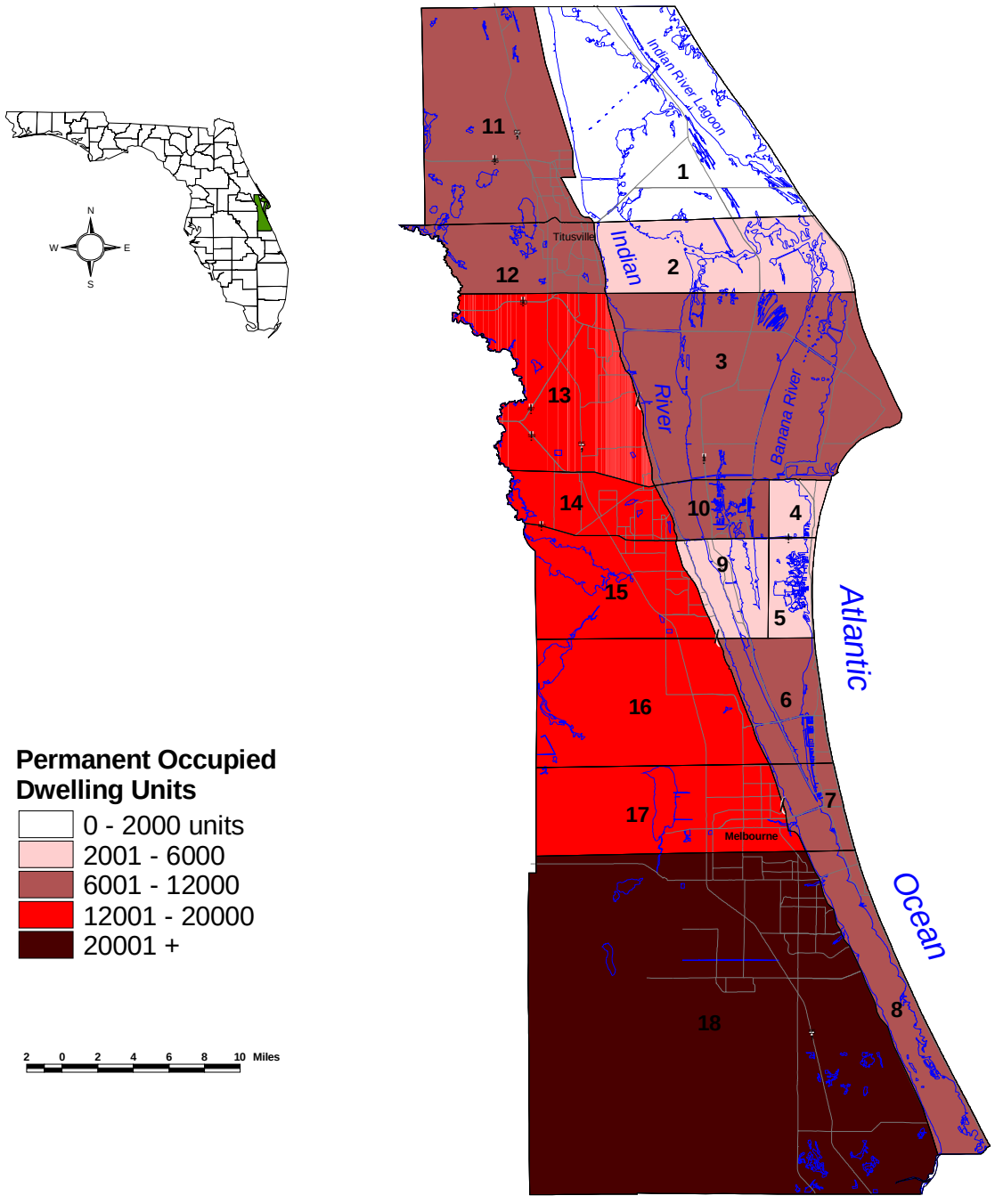


Figure 2-4: Year 2000 Permanent Occupied Dwelling Units by Zone - Volusia County

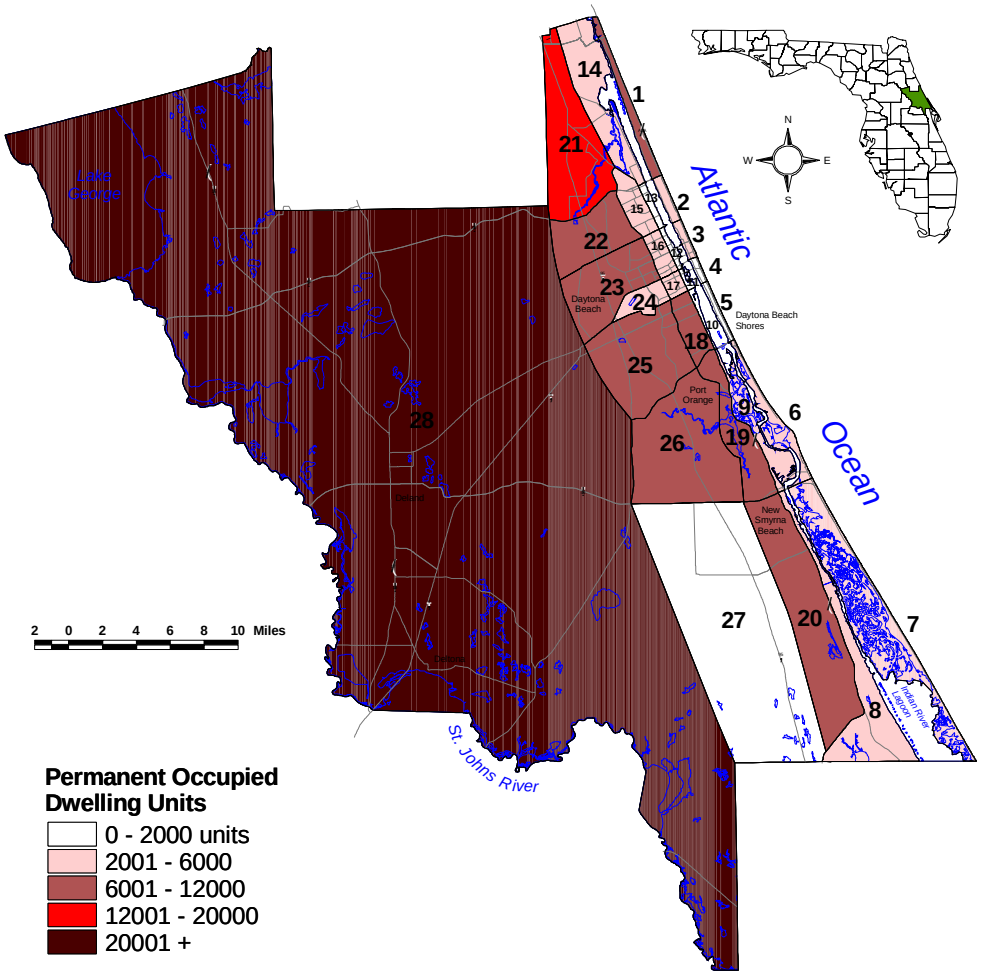


Figure 2-5: Mobile Home Units by Zone - Brevard County

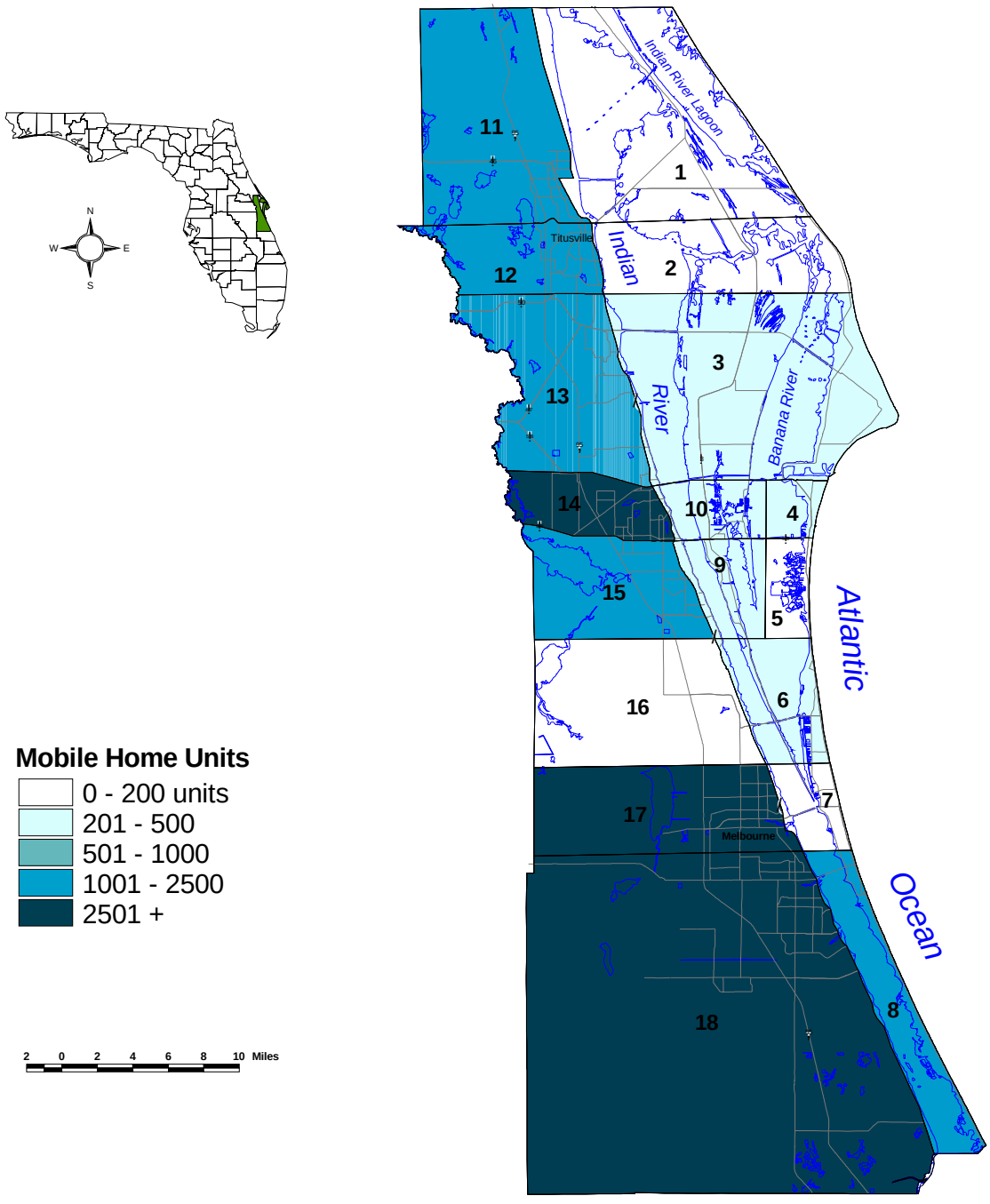


Figure 2-6: Mobile Home Units by Zone - Volusia County

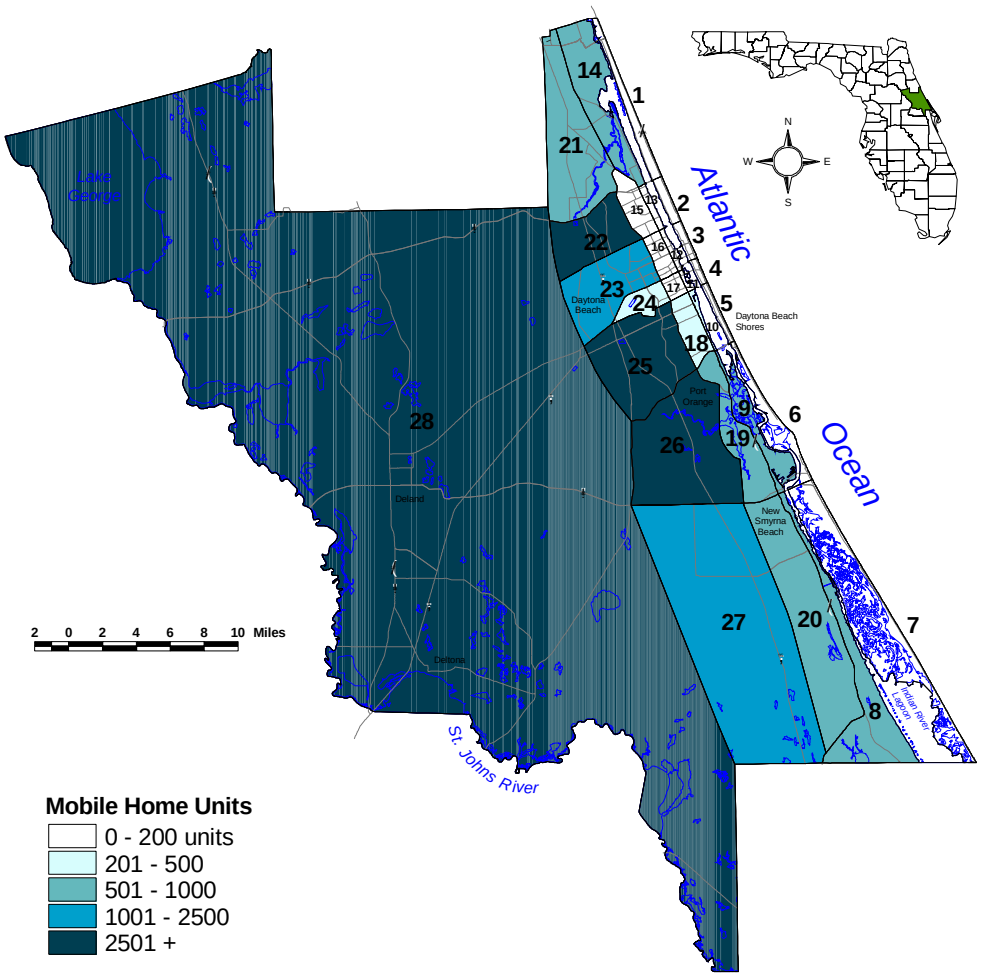


Figure 2-7: Mobile Home Units by Zone - Inland Counties

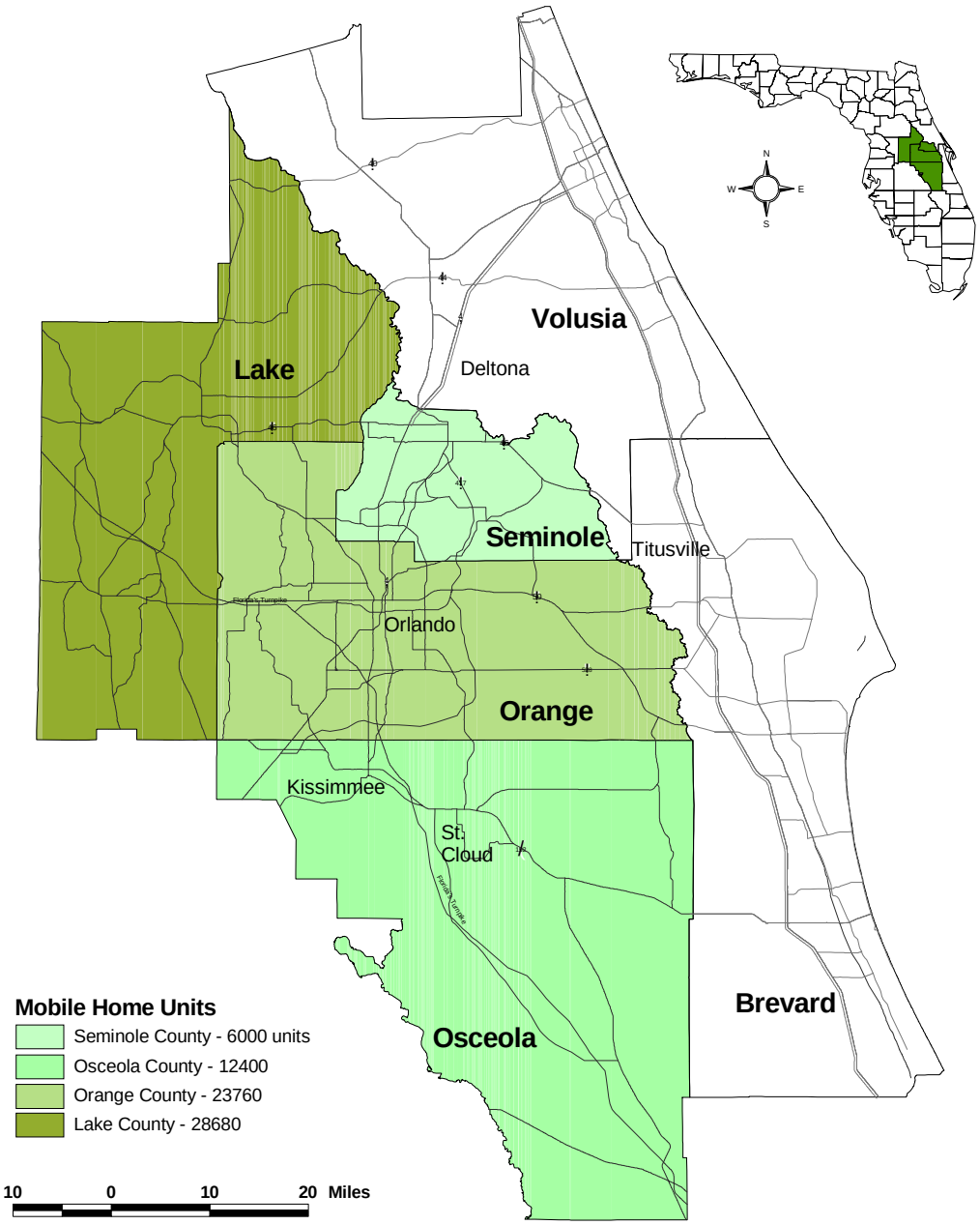


Figure 2-8: Seasonal Dwelling Units by Zone - Brevard County

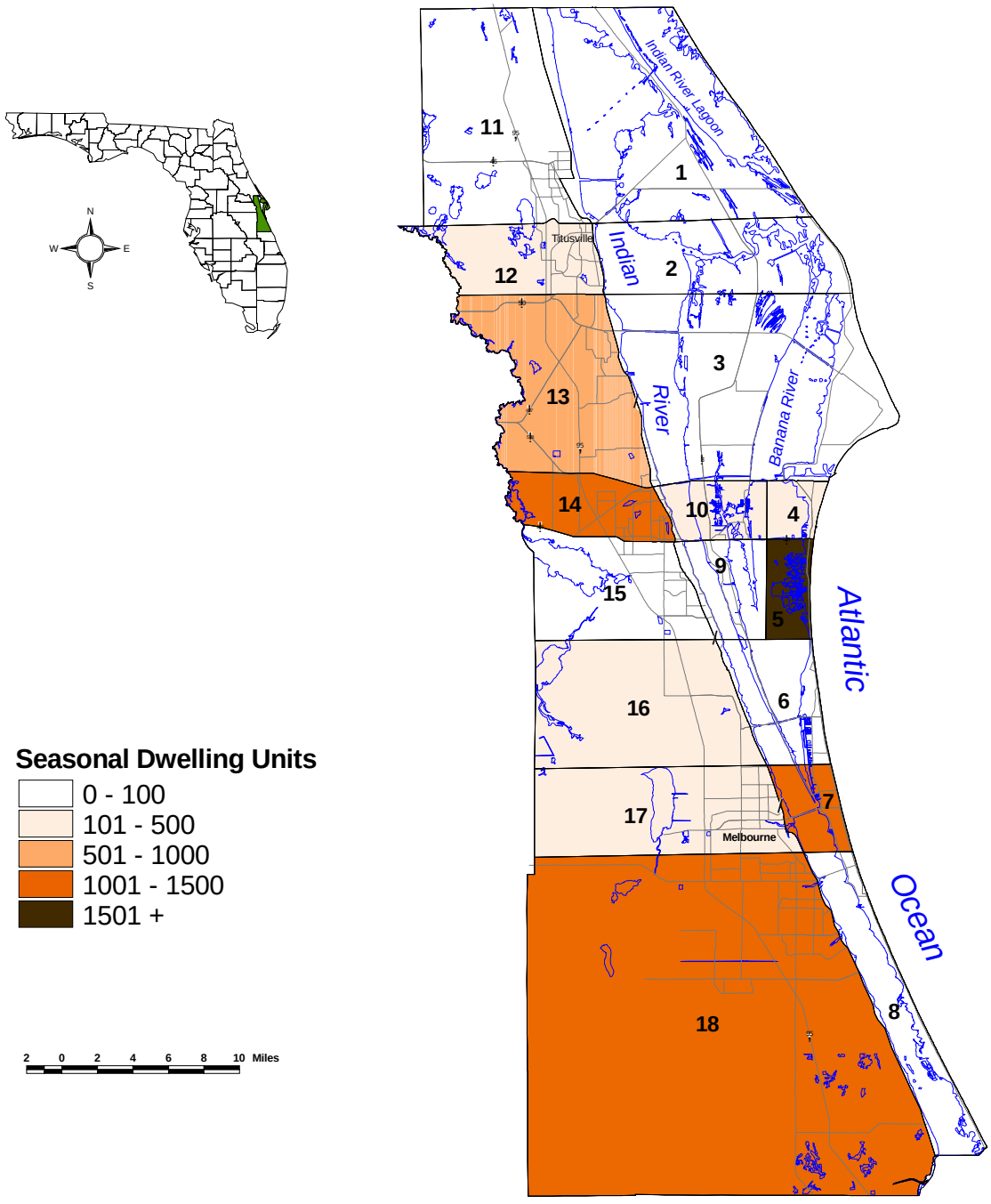
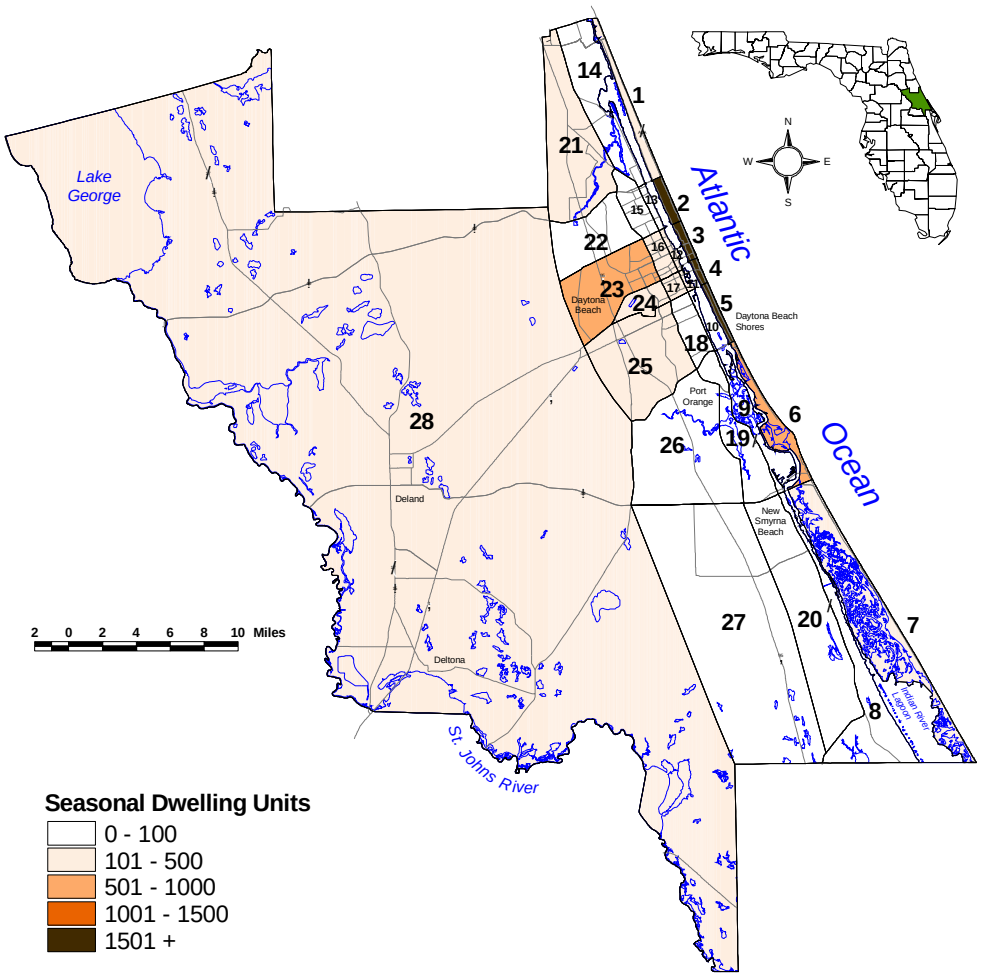


Figure 2-9: Seasonal Dwelling Units by Zone - Volusia County



Behavioral Assumptions

Several assumptions were made about the evacuation decisions potential evacuees across the region of east central Florida will make in the event of a hurricane. Those decisions will differ among individuals and groups depending on the severity of the impending storm, the previous hurricane experience of the population and several other factors. To make the most informed behavioral assumptions, PBS&J reviewed the behavioral analyses conducted for the region by the University of Central Florida, as well as post behavioral work from other coastal states. As sources of data were reviewed, the PBS&J team concentrated on data related to the following behavioral aspects:

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

PBS&J devised behavioral assumptions by zone, relying on the following sources:

- Discussions concerning expected behavioral response with emergency management staff from each county (at a meeting held by the ECFRPC).
- Review of past behavioral studies as a part of various hurricane planning efforts conducted by the U.S. Army Corps of Engineers and the Federal Emergency Management Agency (FEMA).
- Behavioral research by The University of Central Florida for the region: East Central Florida Hurricane Evacuation Study Behavioral Analysis, September 1998.

Even with these resources, a great deal of decision-making was involved in developing the necessary parameters on a zone-by-zone basis. However, PBS&J has had extensive experience in developing and applying behavioral parameters for evacuation analysis around the country in both pre- and post-storm scenarios.

Fundamental assumptions were laid out by zone and scenario prior to modeling. Summary sheets of all essential assumptions are provided in the evacuating people and vehicle/trip generation portion of the Transportation Model Support Document. Participation rates assumed for all zones in a county and for each scenario are also provided in the model document. The primary factors behind the participation assumptions are as follows:

- Storm surge evacuation zones were assumed to have a 100% participation rate for major hurricanes. Even though in actuality these rates will be lower, to promote public safety the clearance times calculated in this study should provide those who are vulnerable to storm surge the opportunity to evacuate. (ANNEX C of the Transportation Model Support Document provides data related to these scenarios.)

- All mobile homes in inland zones and counties were assumed to evacuate.
- A portion of the theoretically non-vulnerable population was also assumed to evacuate. This percentage will be higher than what was used (2%-15%), particularly for more intense hurricanes, but will be balanced out with the less than 100% of surge residents who will participate in an actual event.

The rapidity of evacuation response is critical in determining evacuation clearance times. Behavioral response curves describing mobilization by the vulnerable population, define the rate at which evacuating vehicles attempt to load onto the evacuation road network for each hourly interval relative to an evacuation order or advisory. Behavioral data from past hurricane evacuation research demonstrates that the mobilization and departure of an evacuating population can occur over a brief or an extended period of time. To take this variation into account, clearance times were tested for three evacuation response rates represented by different behavioral response curves. Figure 2-10 illustrates the curves which range from rapid response to long response and are intended to include a range of possible mobilization times that might be encountered in a future hurricane evacuation situation. For sensitivity analysis, the mobilization/traffic loading time was varied between four hours and ten hours.

Another essential behavioral input to the transportation analysis involved the destination percentages of evacuees, assumed to travel to one of four assumed general destination types. Assumptions were made by zone after reviewing the University of Central Florida behavioral studies to decide on evacuee destination percentages. Figures were then 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 differed for each zone in the county according to the category of risk (distance from the coastline) or special considerations in a zone, such as a high number of mobile home units. Assumptions were also varied for permanent residents versus tourists. Tourists were assumed to leave the coastal counties. For their evacuation movements, a small percentage (1-2%) was assumed to remain in the county.

It should be noted that destination percentages refer to destination preferences. Where in-county capacities (e.g., hotels/motels) cannot fulfill all destination desires, the transportation analysis assumed that a certain percentage of evacuees would have to leave the county to find acceptable refuge. The percentage of out of county evacuees was increased with each successive step in the storm intensity scenario. One built in assumption was that in the lower intensity scenarios in the non-surge area, most of the evacuees are mobile home residents who have a higher propensity to use local public shelters.

A final behavioral assumption involved vehicle usage during the evacuation. Vehicle usage refers to the percentage of vehicles available to the households, assumed to be used in the evacuation. Vehicle usage percentages were 70-80% (depending on distance from the coastline) for the study transportation analysis.

Table 2-2 summarizes the key behavioral concepts and assumptions used in the study. The Transportation Model Support Document provides all of the specific parameters utilized for each zone and county for all scenarios.

Figure 2-10: Behavioral Response Curves

[Home] [CD Contents]

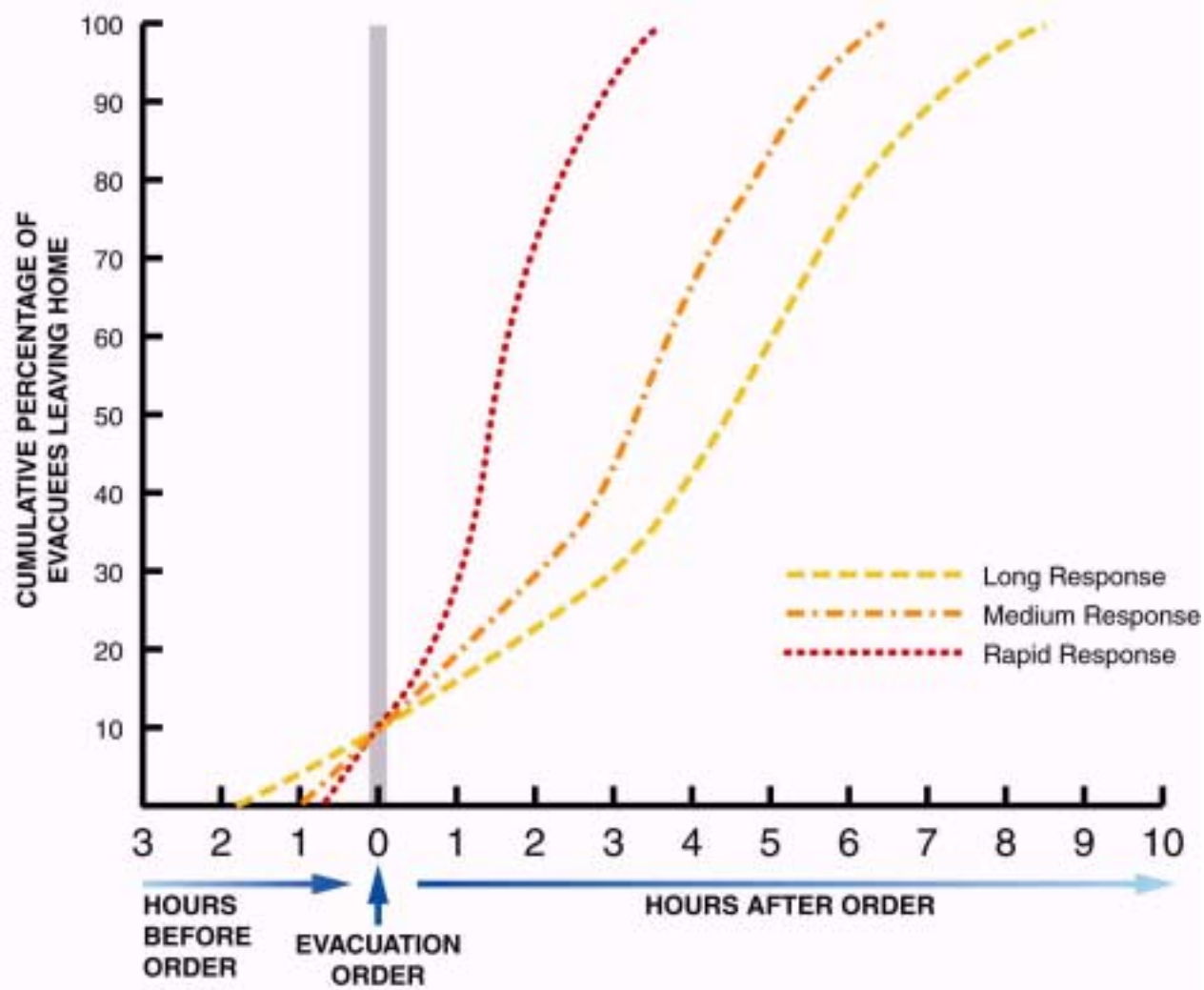


Table 2-2: Summary of Behavioral Assumptions

Participation Rates

Assumptions were necessary regarding what percent of the population will leave their dwelling unit in different areas of each county for various strengths of hurricanes. Although we know that even for the most intense hurricanes, it is unlikely that 100% of the people asked to evacuate will evacuate, the following was assumed for each scenario: 100% participation of people in storm surge evacuation areas plus all mobile homes and a small portion of the theoretically non-vulnerable population. Clearance times calculated in the transportation analysis under this assumption give vulnerable residents the opportunity to evacuate whether or not they choose to evacuate.

Destination Percentages

Assumptions included estimates of the percentage of evacuees going to each destination. These estimates included evacuees going to in-county public shelters, in-county homes of friends/relatives (including churches, masonic lodges), in county hotels/motels, or out of the county entirely. Assumptions were also made for evacuation zones with similar characteristics (e.g. barrier islands) within each county. Based on observations of past evacuations in Florida and other coastal areas around the country, the following ranges of values were developed for those evacuating:

Percent to Local Public Shelter

3% of high risk areas (beachfront, barrier islands)
5-15% of moderate risk areas (category 3-5 zones)
15-20% of low risk areas depending on income

Percent to Out-of-County

50-70% in a strong storm depending upon risk area and income
30-50% in a weak storm depending upon risk area and income

In-County Friends and Relatives Homes

17-35% in a strong storm depending upon risk area and income
20-55% in a weak storm depending upon risk area and income

Vehicle Utilization

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

Roadway Network Characteristics

A final group of assumptions used for input into the transportation analysis is related to the roadway system chosen for the evacuation network and traffic control measures considered for traffic movement. Although the assumptions developed for the transportation analysis are general, the efforts at state, county and municipal levels regarding traffic control and roadway selection must be quite detailed.

Several factors were considered in choosing roadways to be included in the evacuation network. An effort was made to include road facilities with sufficient elevations, little or no adjacent tree coverage, substantial shoulder width and surface, and most importantly roadways already included in existing county hurricane evacuation plans. In east central Florida, where there are low lying streets that flood in heavy rainfall events, these criteria can be difficult to meet.

In heavily urbanized areas, many intersections will be controlled by existing traffic signals. However, as resources permit, traffic control officers will be stationed at bottlenecks identified in this study, as well as any other areas of critical local concern. Law enforcement assignment to major bottlenecks involves extensive coordination among local and state officials.

In order to develop an evacuation routing plan, a "link-node" system was developed to identify roadway sections. Nodes are the points used to illustrate the intersection of two roadways or

changes in roadway characteristics. Links are the roadway segments connected by nodes. Each link is identified by a letter designation. Figures 2-11 through 2-12 illustrate the coded evacuation network for the coastal counties with link names and zone connections to the links shown by open circles and dashed lines. An inland regional road network was also developed to show inland rerouting of traffic and related traffic congestion. This graphic appears in Section 3.4 of this report.

Once the links and nodes were established for the evacuation routes, directional traffic service volumes (Level of Service D flow rates) were established for each link for the Year 2000. Information from the urban area transportation studies maintained by Metropolitan Planning Organizations (MPOs) and field reviews provided the number of lanes and facility type used to develop the directional service volumes. Florida Department of Transportation (FDOT) Tables were then consulted to specify a directional service volume based on link characteristics. Figures 2-13 through 2-14 show the Year 2000 directional service volumes/number of lanes for the evacuation clearance time analysis.

Important assumptions concerning the evacuation road network are as follows:

- The evacuation of all vehicles will occur prior to the arrival of sustained tropical storm winds (39 mph) and storm inundation of evacuation routes.
- Provisions will be made for the removal of vehicles in distress on the network through aggressive incident management and agreements worked out with tow truck operators.
- Signal timings will be "actuated" to provide the most green time for westbound movements away from the coast.
- The U.S. Coast Guard will be contacted to "lock down" draw bridges once evacuation orders or advisories are issued.

Figure 2-11: Evacuation Road Network-Brevard County

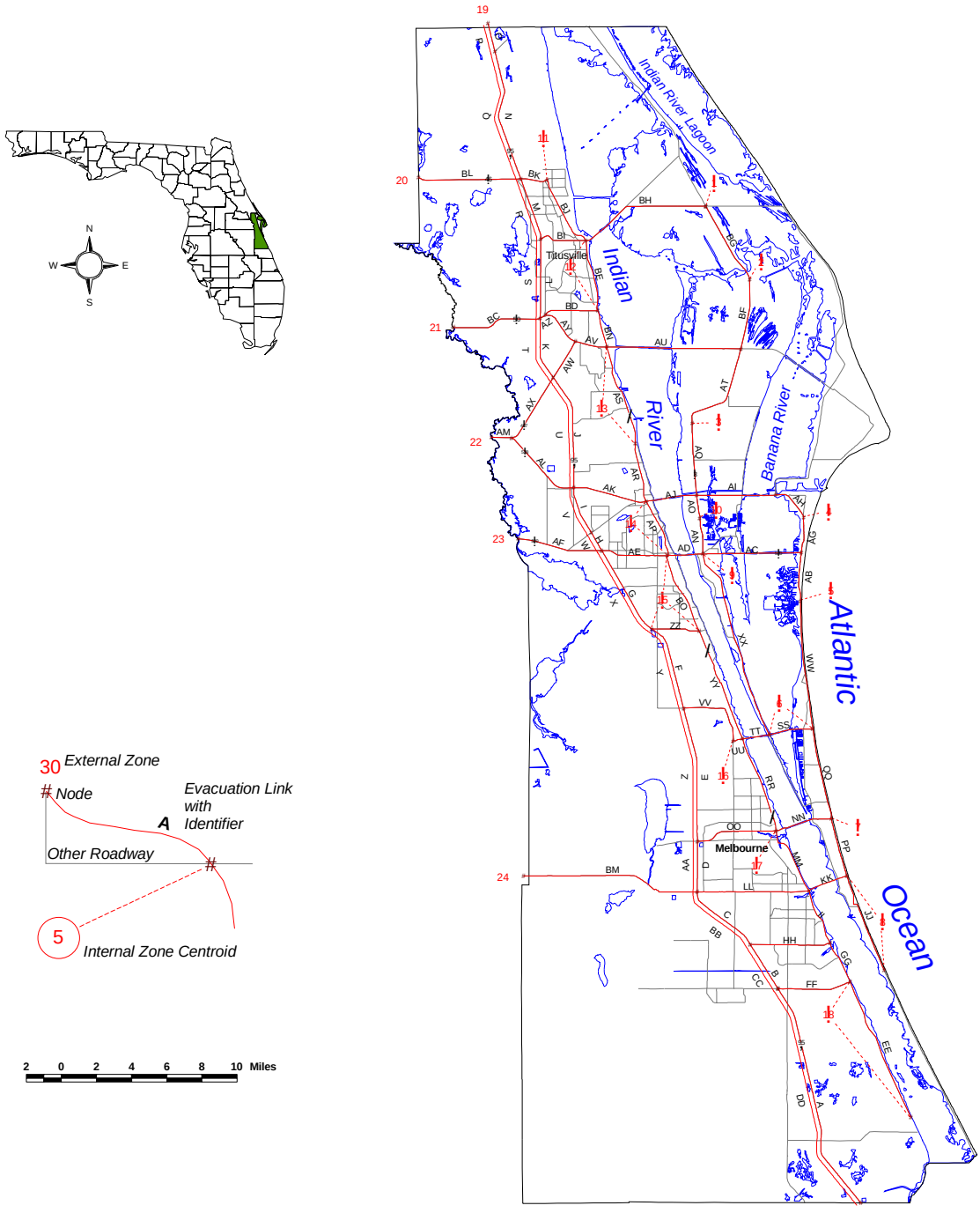


Figure 2-12: Evacuation Road Network-Volusia County

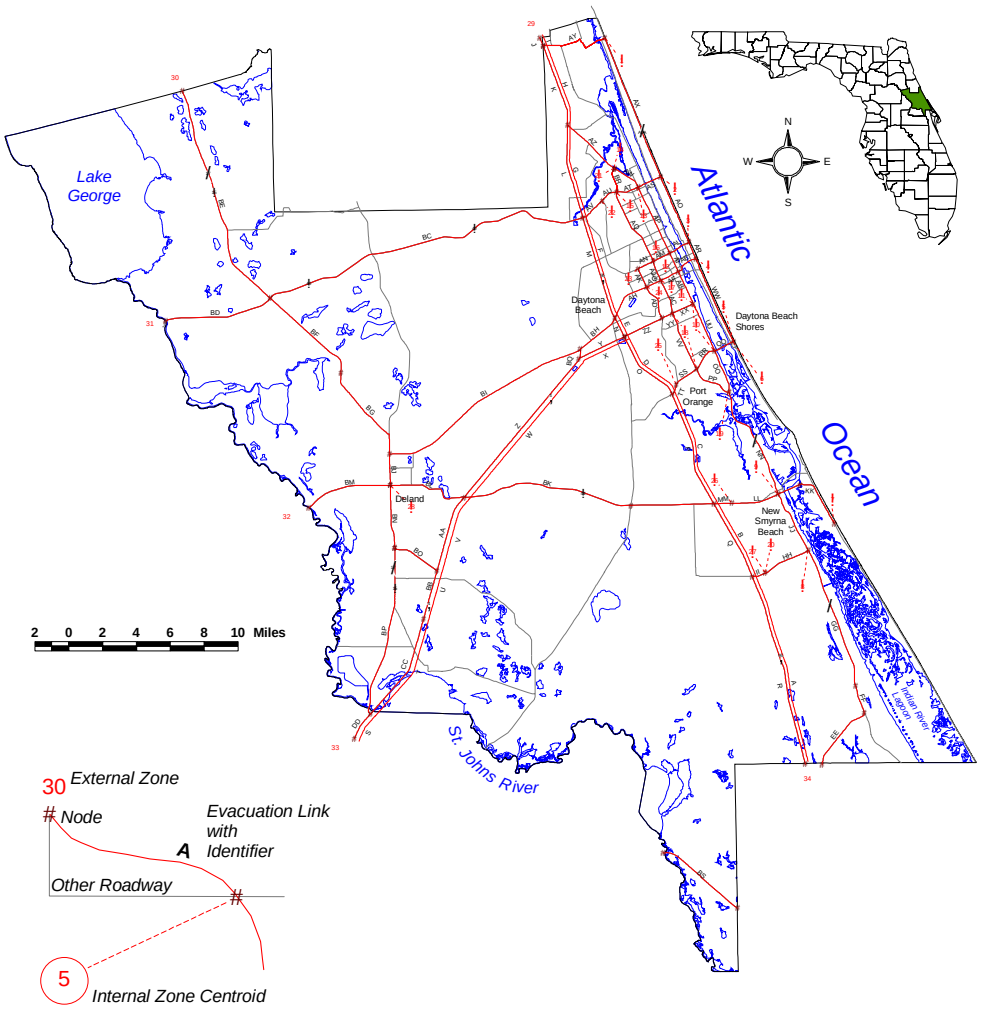


Figure 2-13: Directional Service Volume- Brevard County

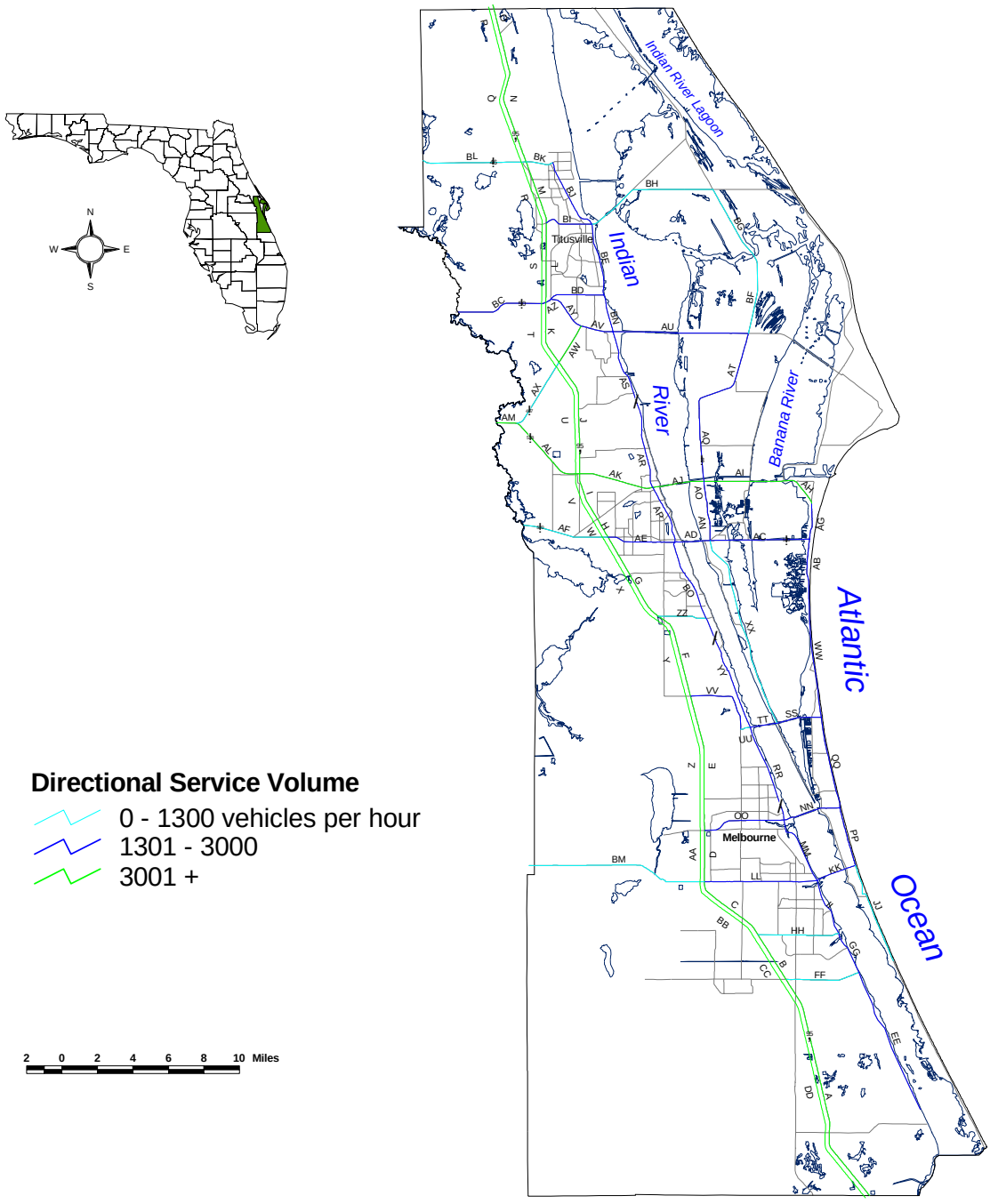
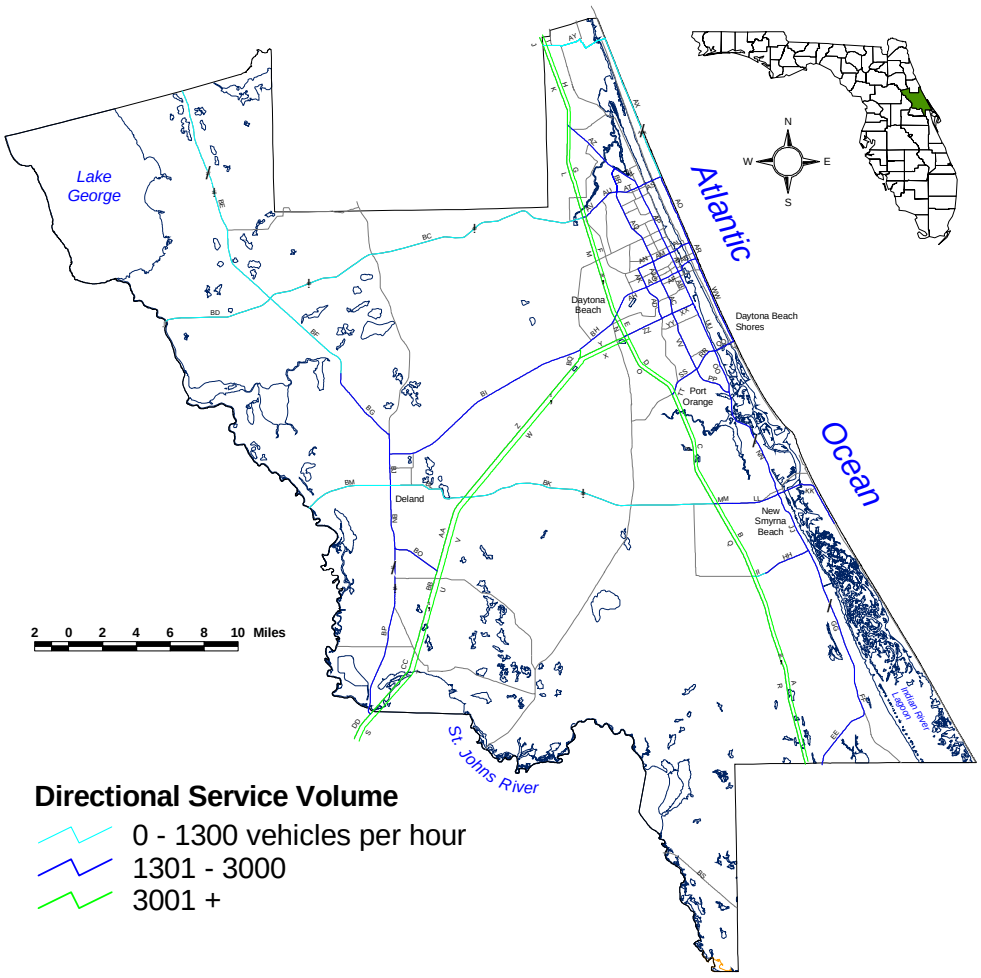


Figure 2-14: Directional Service Volume- Volusia County



Evacuation Clearance Time Model Application/System Forecasts

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

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

Although extensive data was produced in the transportation analysis (as provided in the Transportation Model Support Document), the items listed above constitute the most critical outputs necessary to plan for shelter needs, anticipate bottlenecks, and define the time constraints involved in an evacuation.

Clearance Time Model Description

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

The key steps include:

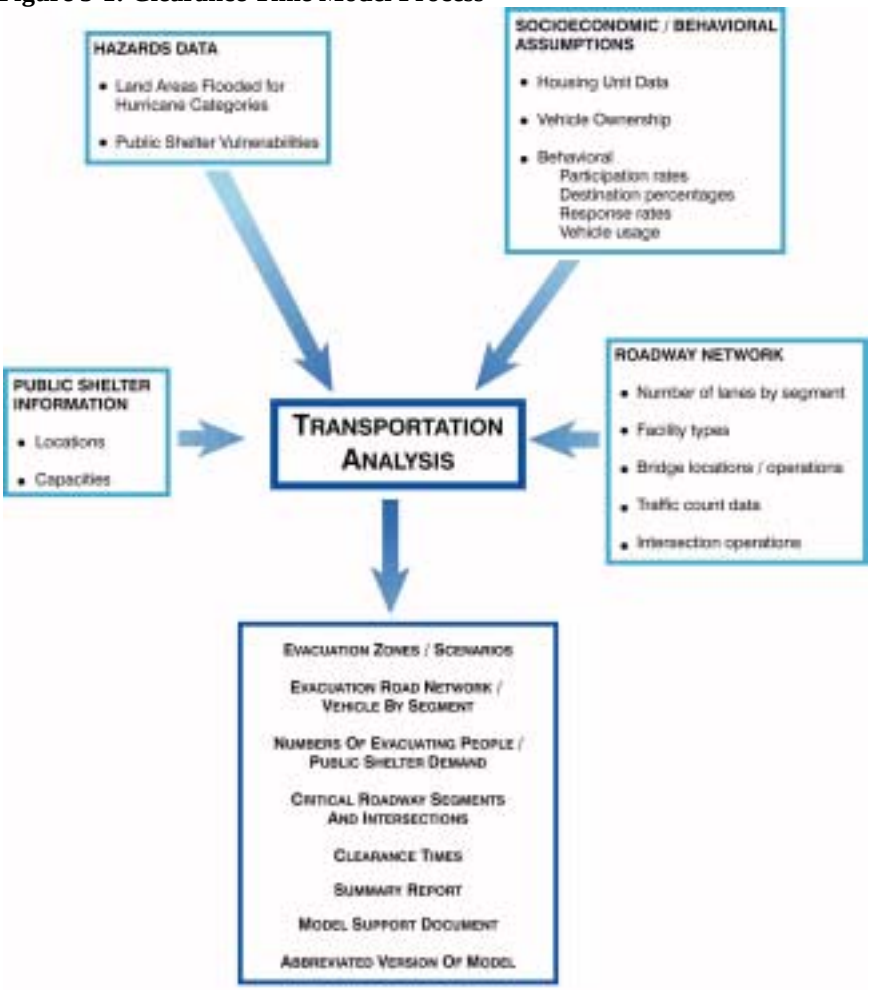
- Development of Traffic Evacuation Zones and Data - identifies who is vulnerable And evacuating
- Trip Generation - calculates how many evacuees will move by county sub area for a particular scenario
- Trip Distribution - determines where evacuees will go
- Development of Evacuation Road Network - identifies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

The major inputs and outputs of this process are illustrated in Figure 3-1. PBS&J developed an in-house set of computer programs to facilitate the transportation modeling steps described above. The programs are in a Lotus for Windows environment and were developed in late 1993/early 1994 by PBS&J for all of the firm's ongoing hurricane work. A spreadsheet will be provided by PBS&J to the ECFRPC in order to enable state and county officials to update the

clearance times produced by the model. This was necessary to ensure that officials could make alterations when large developments come on line or when road construction restricts normal flow.

The Transportation Model Support Document Appendix to this report contains details about elements of the model, file nomenclature and management, and model application. A beneficial aspect of operating in the Lotus environment for this study was the ability to import data files directly into the initial programs. Likewise, the output of later programs was easily exported to ArcView GIS for displays and mapping. In addition, the use of GIS greatly enhanced the quality of technical data development and documentation.

Figure 3-1: Clearance Time Model Process



Evacuating People and Vehicles by Scenario

After making assumptions regarding the percentage of evacuees traveling to each of the four destination types, the next step involved the generation of figures showing the total number of evacuating people and vehicles produced by each zone. Those totals were then divided by general destination type (trip purpose). The four overall destination types are in-county public shelter, in-county hotel/motels, in-county home of a friend or relative, and out-of-county. This process was completed for the Year 2000 base year, for each storm intensity. Category 4 and 5 scenarios were combined to form one scenario. The figures resulting from this process can be found in the Transportation Support Document.

Table 3-1 shows the number of residents and tourists estimated to leave dwelling units for each county and scenario. The number of people involved in an actual evacuation will most likely total less than these figures, due to the assumed 100 percent participation rate of people from units in storm surge vulnerable areas and mobile homes assumed for each scenario.

Figures 3-2 through 3-9 graphically show ranges of evacuating population by county by zone for the different storm intensity scenarios.

Table 3-1: Evacuating People Statistics

County/Scenario	Year 2000 Permanent Population***	Maximum Number of Residents and Tourists Evacuating Dwelling Units	Local Public Shelter Demand****
BREVARD COUNTY	498,900 People*		
Category 1		139,100 People**	8,500 People
Category 2		195,700 People**	12,200 People
Category 3		222,400 People**	15,700 People
Category 4-5		226,700 People**	16,500 People
	*includes 61,800 mobile home residents countywide	**includes 20,700 tourists countywide	
VOLUSIA COUNTY	442,700 People*		
Category 1		94,700 People**	5,800 People
Category 2		126,500 People**	8,400 People
Category 3		171,300 People**	12,300 People
Category 4-5		272,400 People**	27,500 People
	*includes 60,500 mobile home residents countywide	**includes 41,500 tourists countywide	
ORANGE COUNTY	859,900 People*		
Category 1		40,100 People	6,000 People
Category 2		40,100 People	6,000 People
Category 3		80,200 People	12,000 People
Category 4-5		80,200 People	12,000 People
	*includes 80,200 mobile home residents countywide		
SEMINOLE COUNTY	361,900 People*		
Category 1		10,100 People	1,500 People
Category 2		10,100 People	1,500 People
Category 3		20,200 People	3,000 People
Category 4-5		20,200 People	3,000 People

	*includes 20,200 mobile home residents countywide		
LAKE COUNTY Category 1 Category 2 Category 3 Category 4-5 *includes 91,600 mobile home residents countywide	203,200 People*	45,800 People 45,800 People 91,600 People 91,600 People	6,900 People 6,900 People 13,700 People 13,700 People
OSCEOLA COUNTY Category 1 Category 2 Category 3 Category 4-5 *includes 50,700 mobile home residents countywide	160,000 People*	25,400 People 25,400 People 50,700 People 50,700 People	3,800 People 3,800 People 7,600 People 7,600 People

***All socioeconomic data provided by the ECFRPC to PBS&J for input into the transportation analysis effort.

****Local public shelter demand could be greater when there is a late response and a higher percentage of evacuees going to public shelters. The ECFRPC can run these scenarios with an abbreviated version of the model as local EM needs indicate. Counties may experience higher numbers due to Treasure Coast evacuees requiring shelter in these counties. A high elderly population requiring shelter may also increase shelter demand.

Figure 3-2 Evacuating Population Category 1- Brevard County

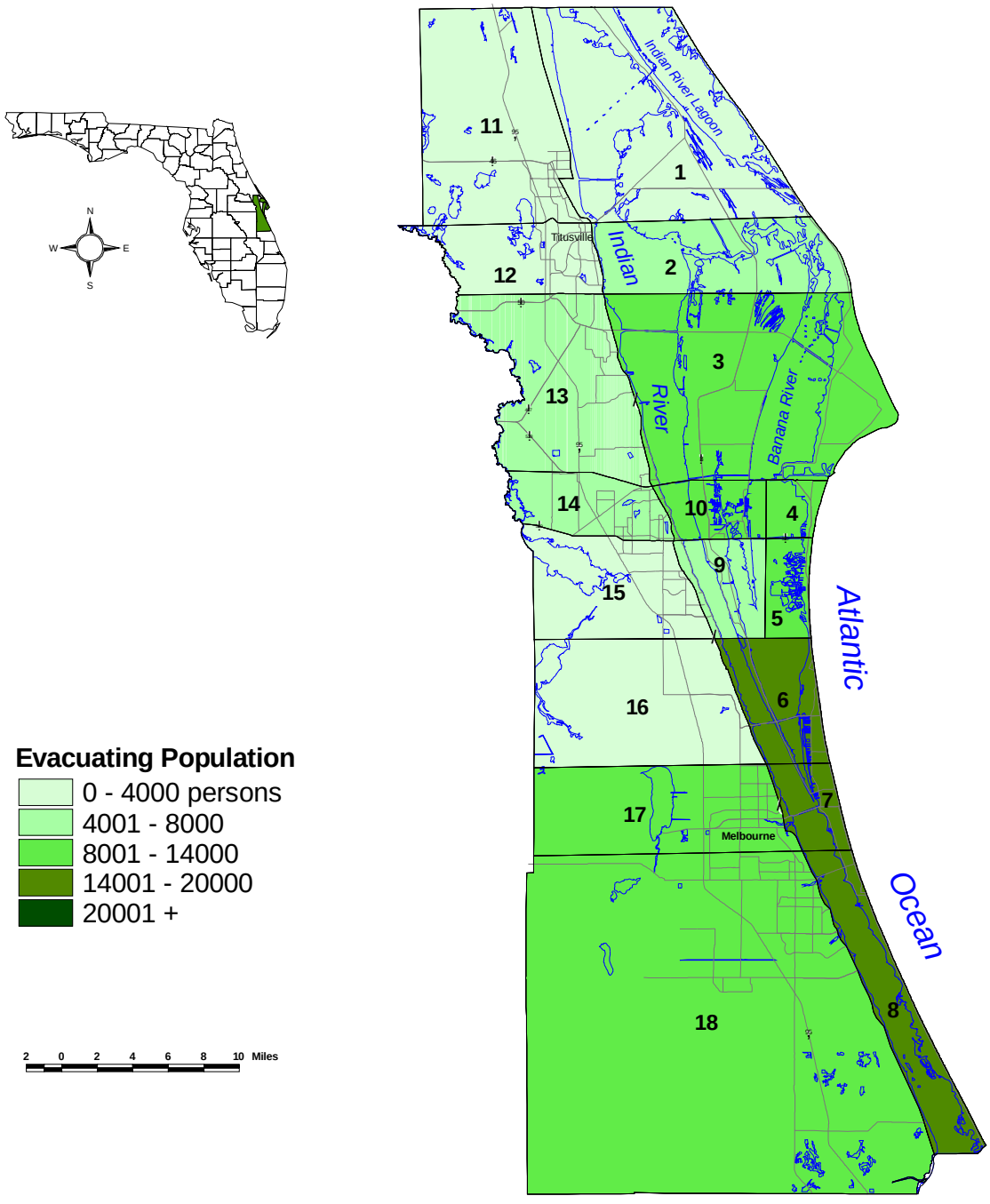


Figure 3-3: Evacuating Population Category 2- Brevard County

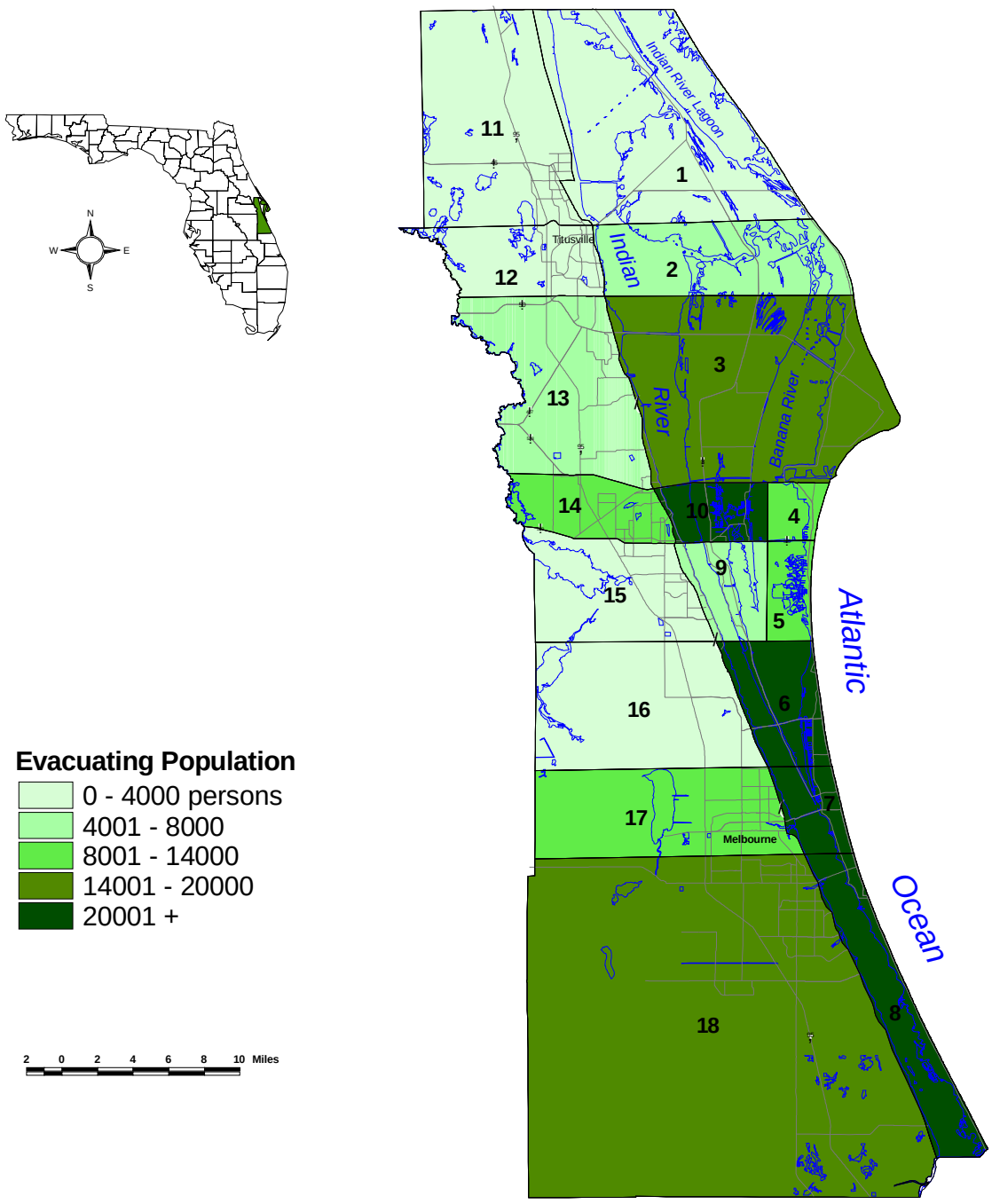


Figure 3-4: Evacuating Population Category 3- Brevard County

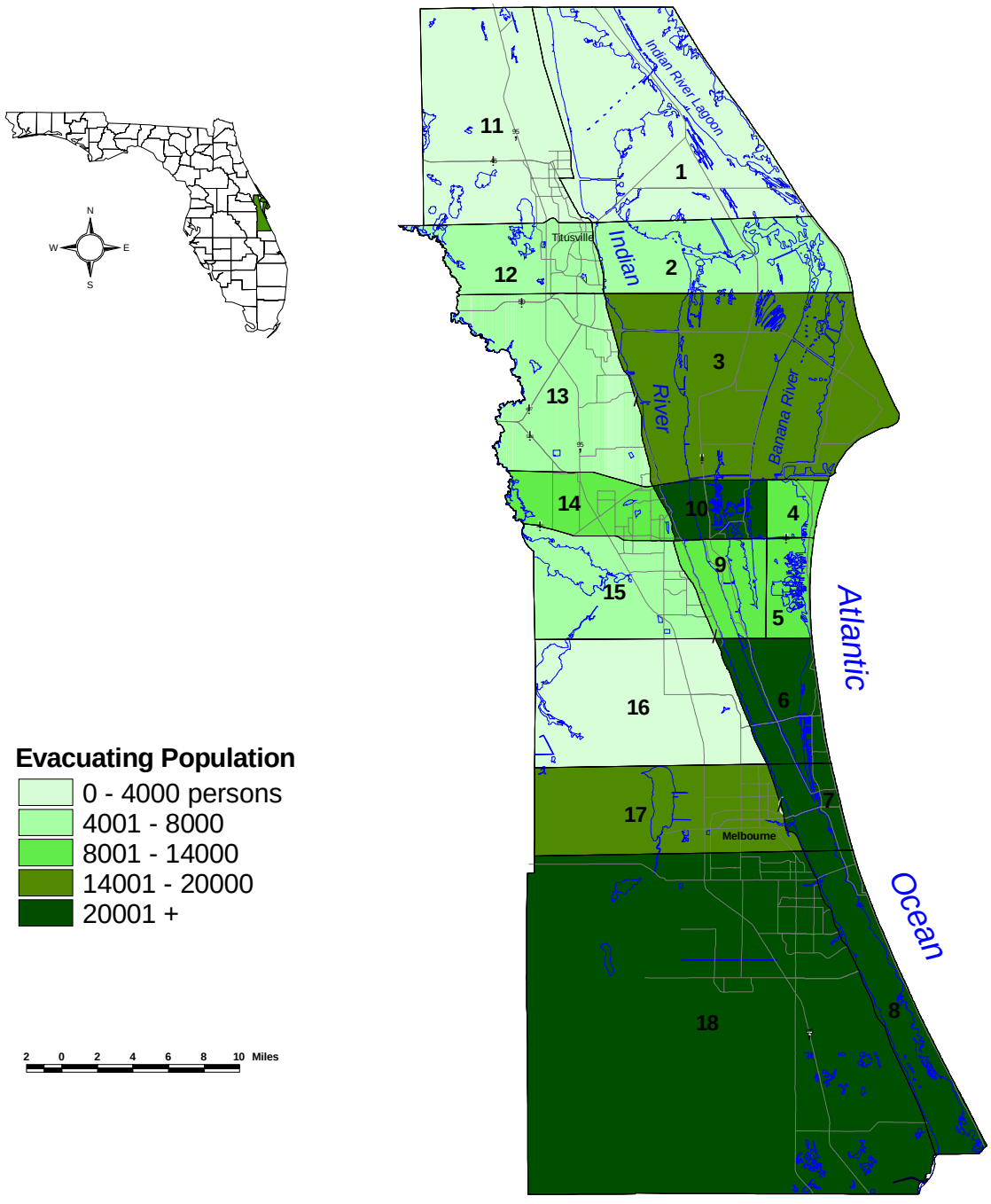


Figure 3-5: Evacuating Population Category 4-5 - Brevard County

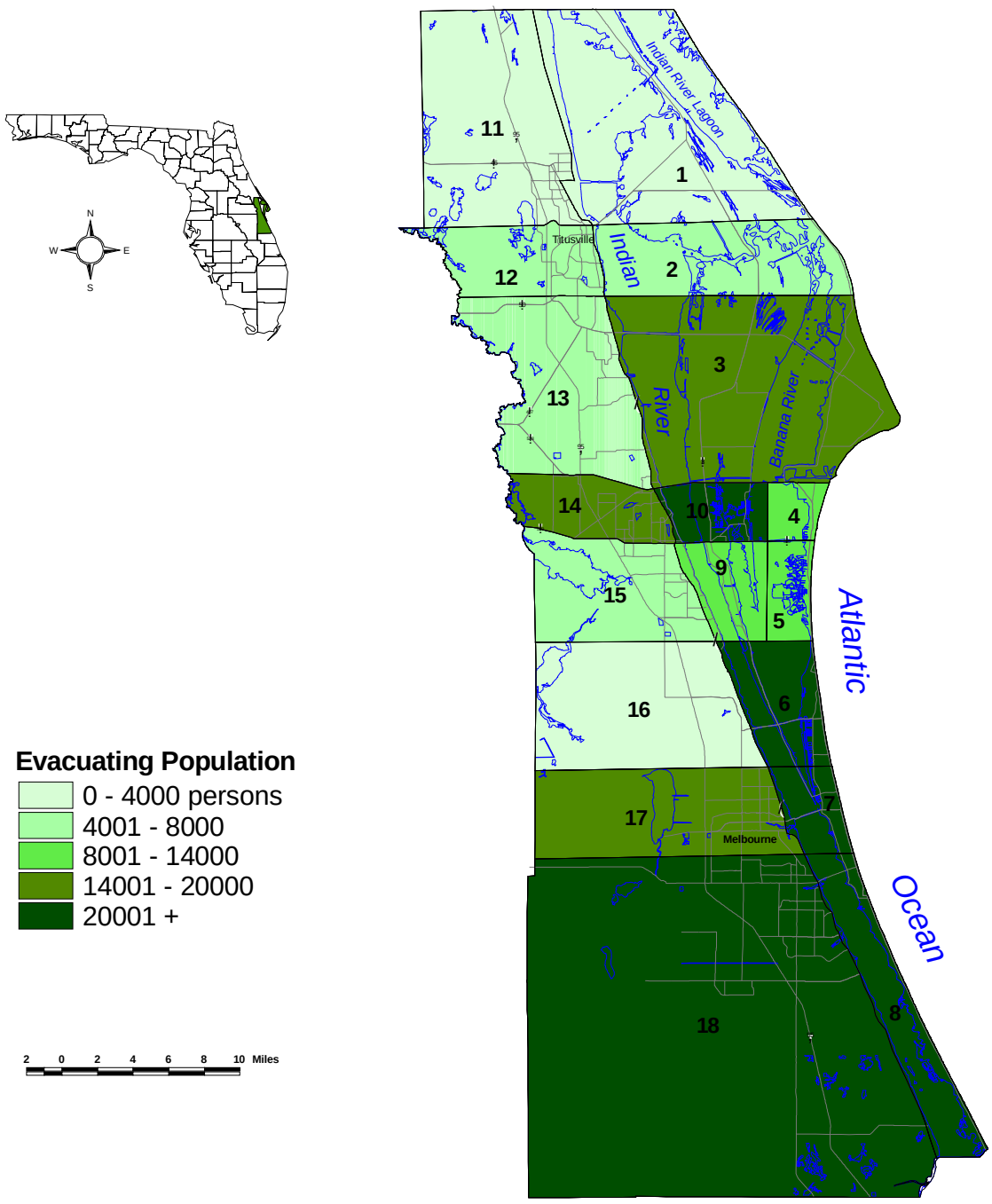


Figure 3-6: Evacuating Population Category 1- Volusia County

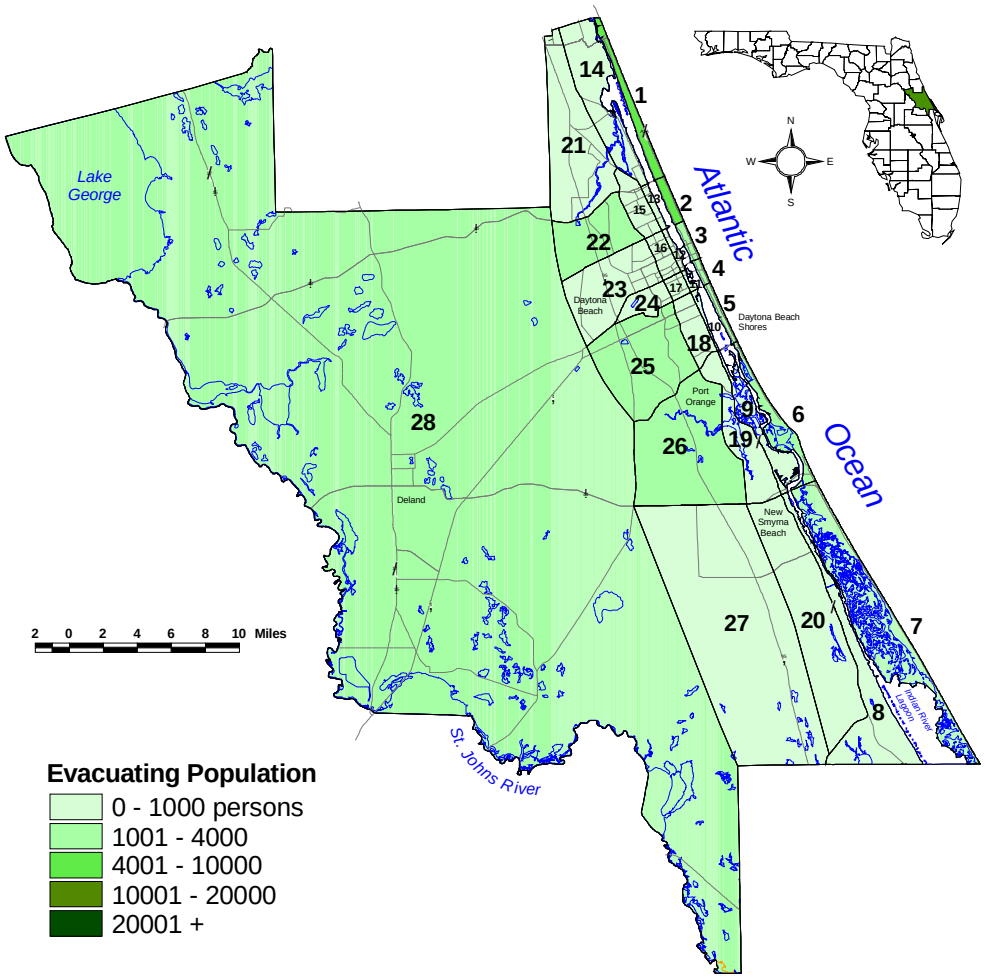


Figure 3-7: Evacuating Population Category 2 - Volusia County

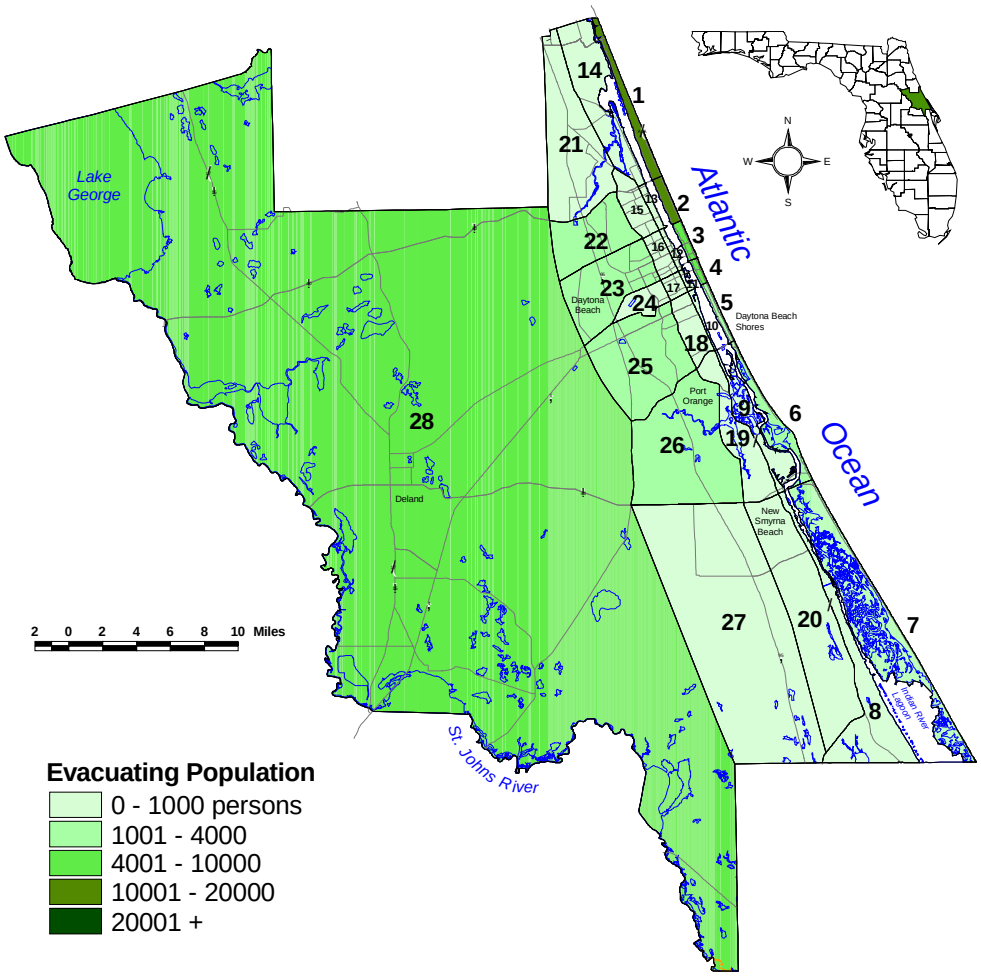


Figure 3-8: Evacuating Population Category 3- Volusia County

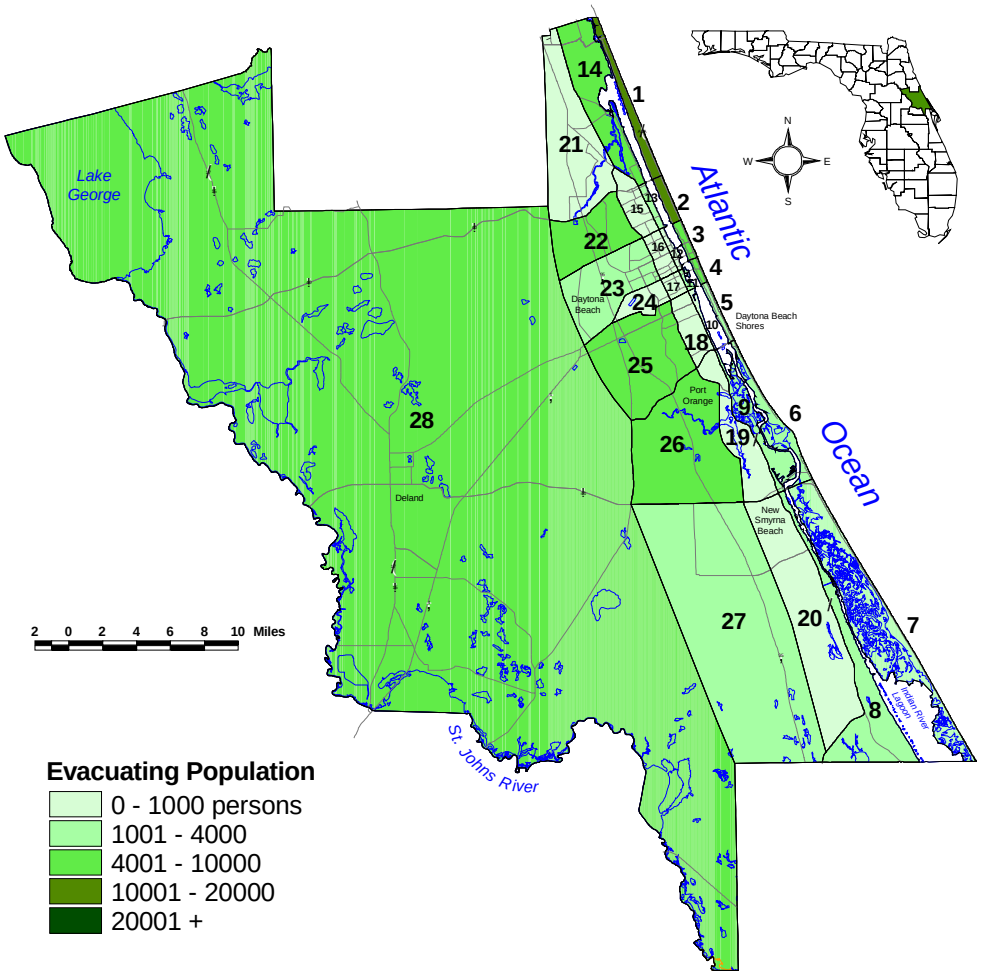
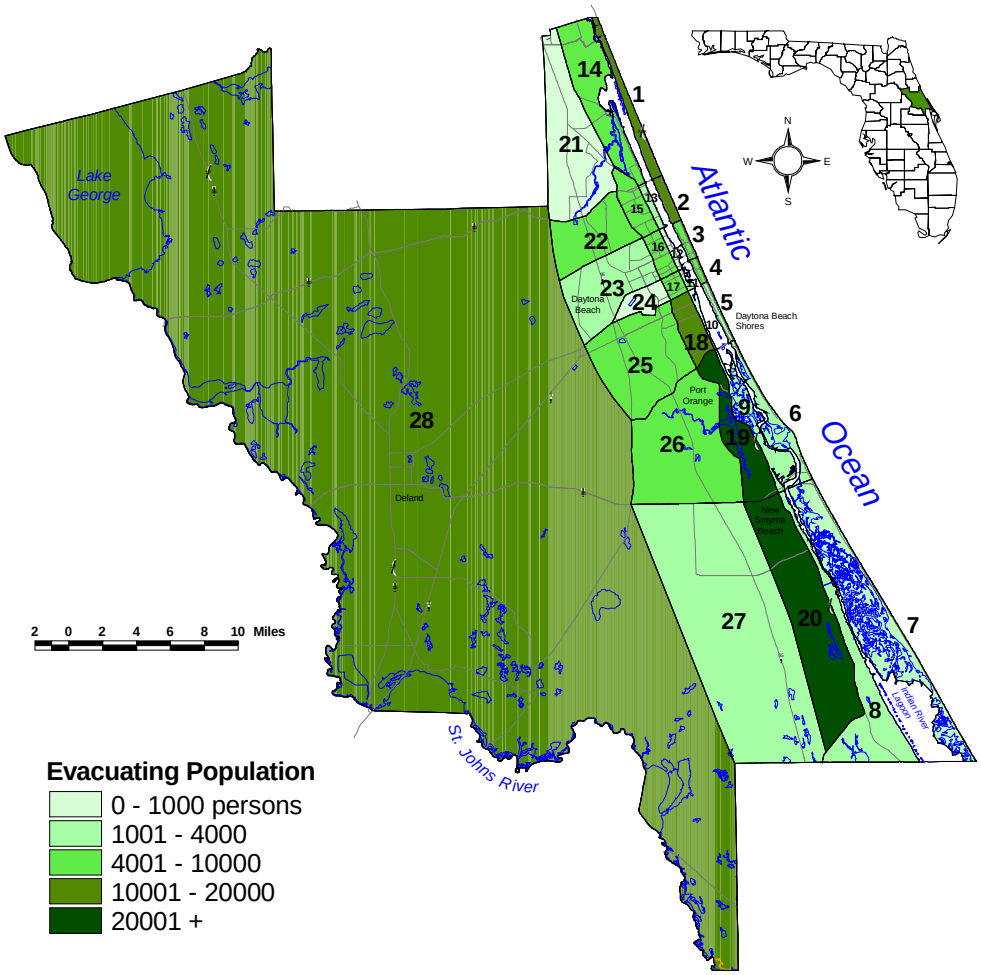


Figure 3-9: Evacuating Population Category 4-5- Volusia County



Public Shelter Demand/Capacity Considerations

Coordinating shelter location and capacity with the shelter needs of potential evacuees is one of the most crucial elements of hurricane planning. In this case, both counties have appropriate in-county public shelter capacities to meet public shelter demand for all categories of hurricanes. However, in the event of a Category 4 or 5 hurricane, depending upon actual participation rates, the citizens of Brevard County will need to activate backup shelters. Table 3-1 (provided previously) shows potential worst case local public shelter demand for each storm category. Because both counties possess a significant number of mobile homes and mobile home residents have a high propensity to use local public shelters, the amount of people requiring shelter will be considerable in both counties in most scenarios. Also, significant numbers of elderly residents in portions of each county could drive up public shelter demand.

Figures 3-10 through 3-17 illustrate the range of Year 2000 public shelter demand by zone for each storm scenario. As the counties continue to grow, the need for in-county public shelter space may increase, particularly if growth in the area of mobile homes continues. Appendix B provides an excerpt from the Florida Statewide Hurricane Evacuation Study (prepared in 1996), showing a way of calculating potential public shelter demand for the Orlando area for differing storm tracks in the state. Orlando will be a major evacuation destination, regardless of whether the east central Florida coastal counties are involved in the evacuation.

Figure 3-10: Public Shelter Demand Category1- Brevard County

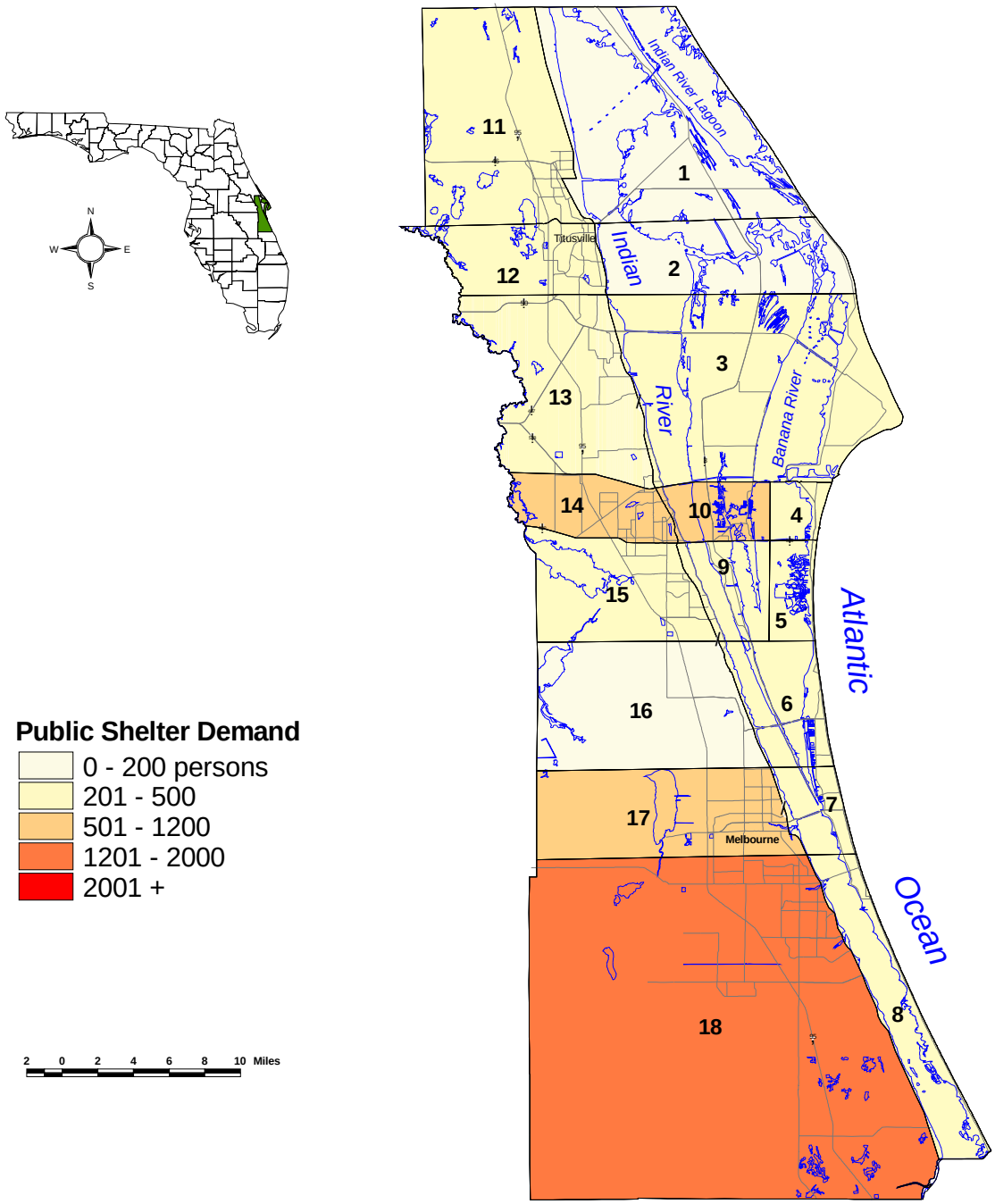


Figure 3-11: Public Shelter Demand Category 2- Brevard County

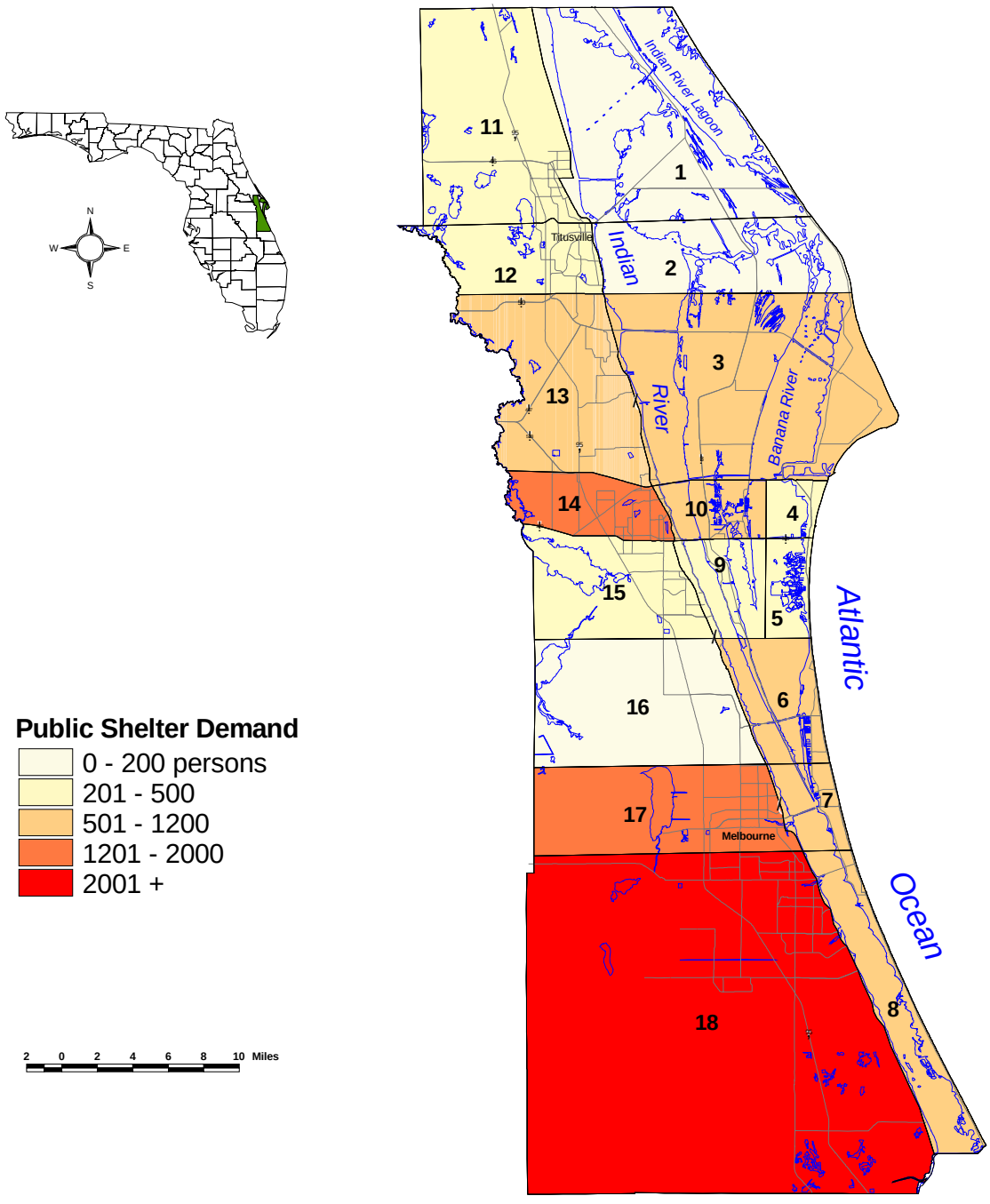


Figure 3-12: Public Shelter Demand Category 3 -Brevard County

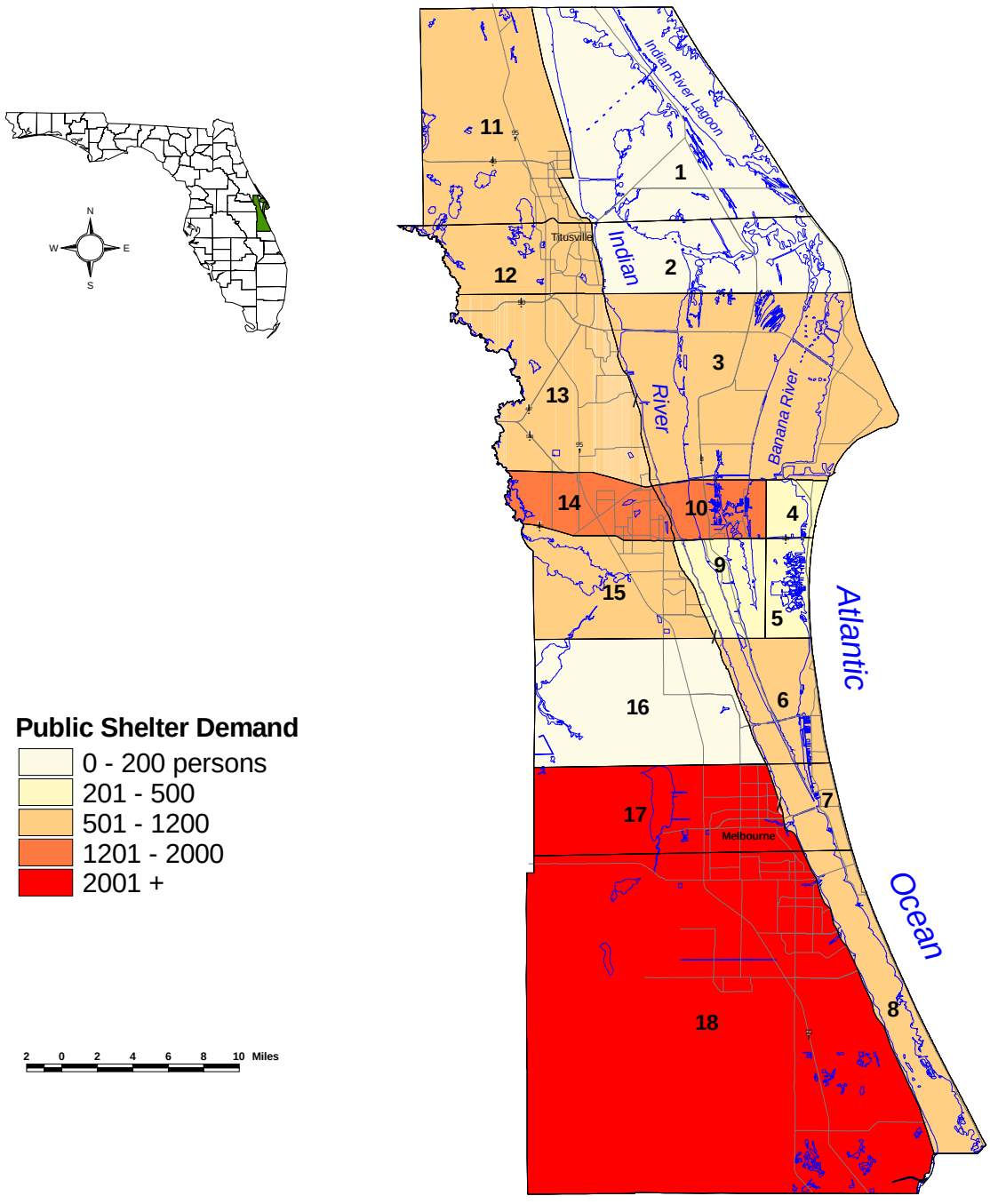


Figure 3-13: Public Shelter Demand Category 4-5- Brevard County

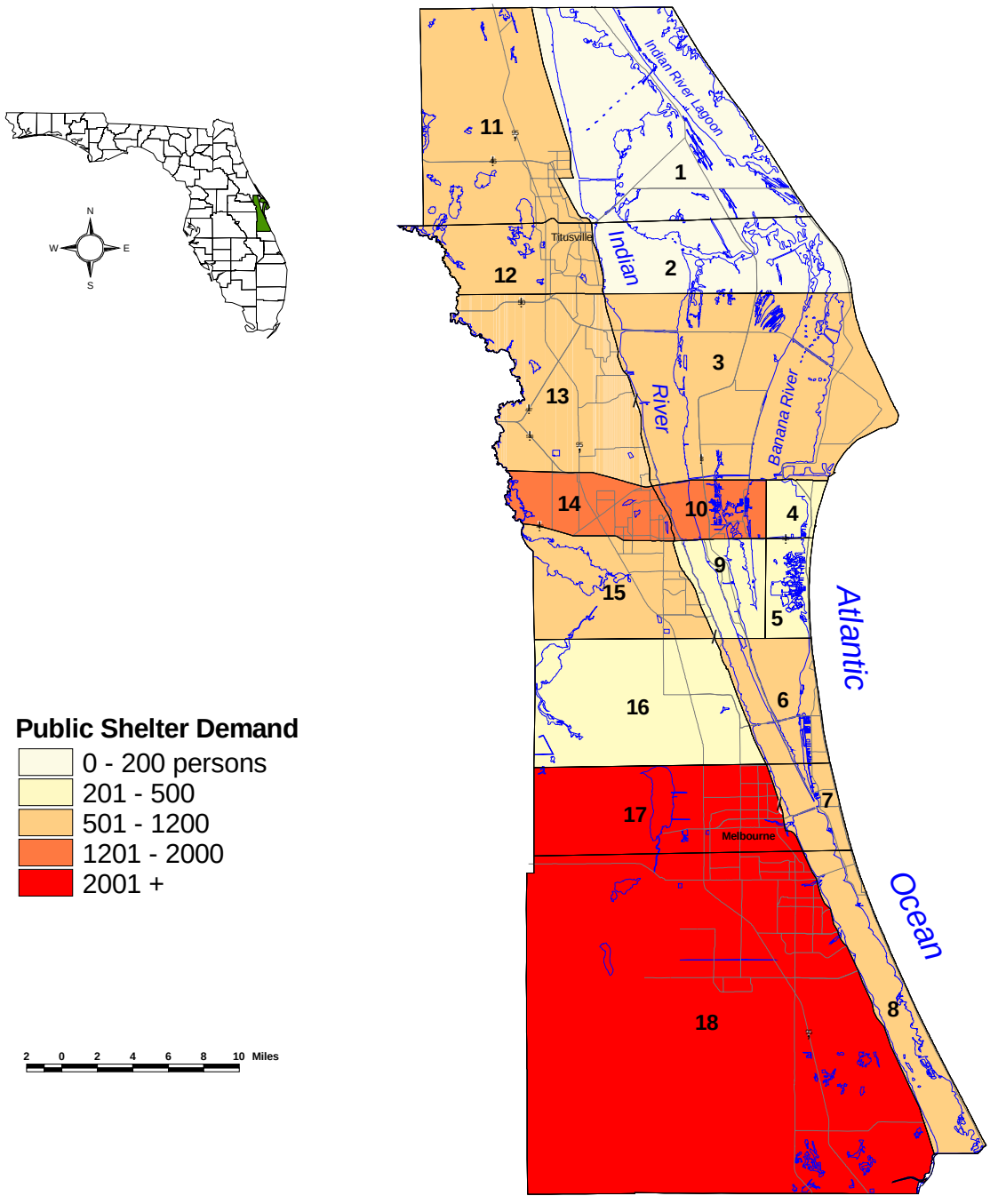


Figure 3-14: Public Shelter Demand Category 1 - Volusia County

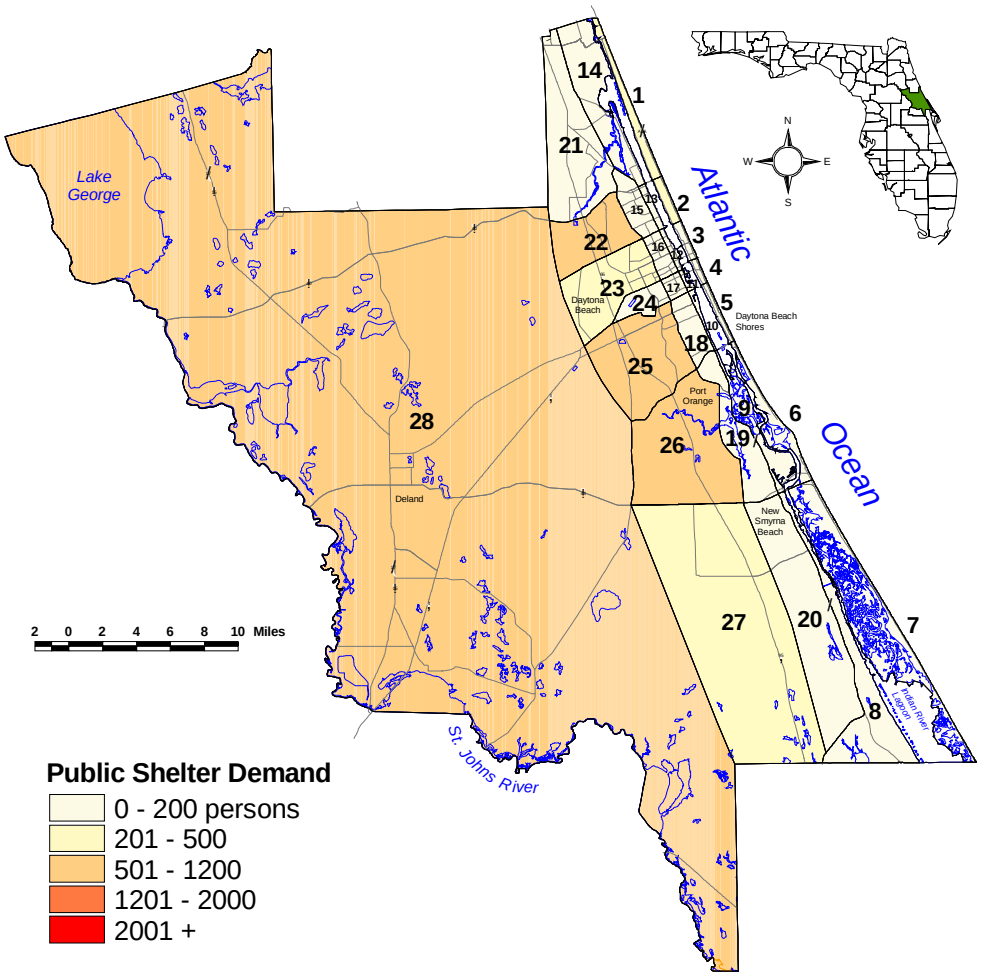


Figure 3-15: Public Shelter Demand Category 2- Volusia County

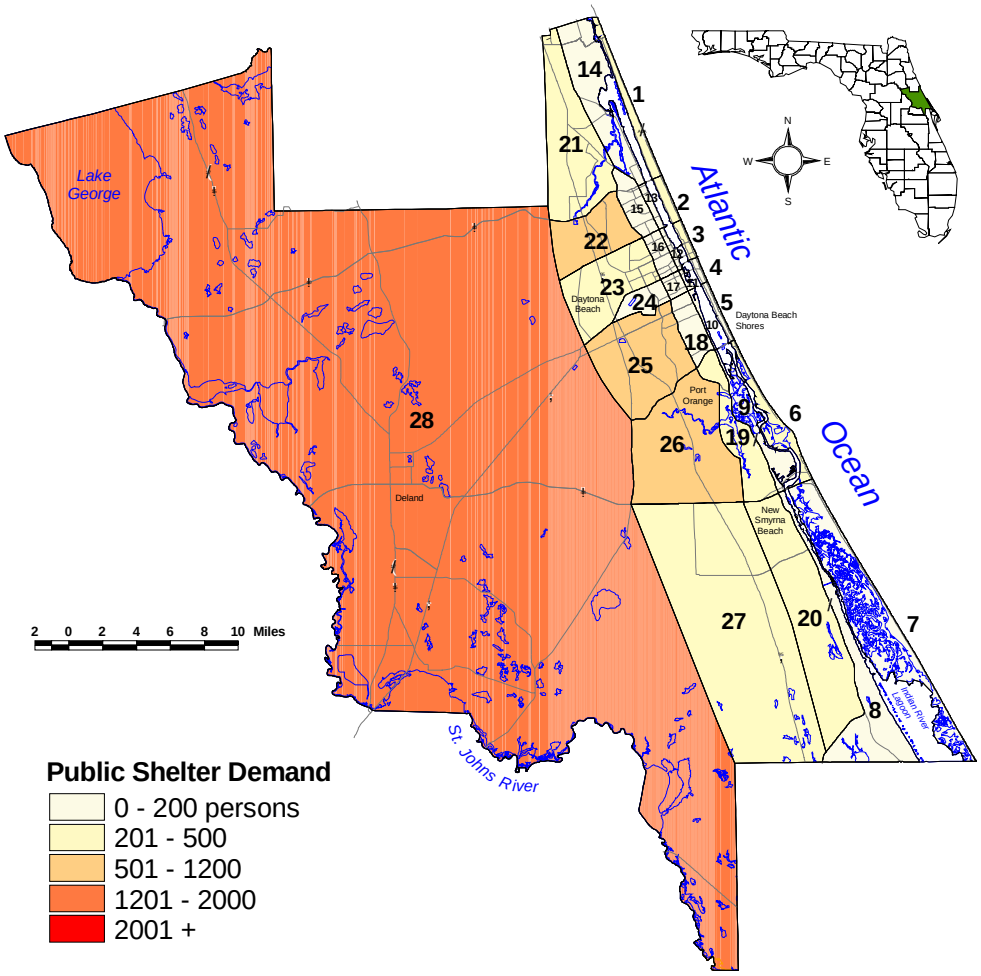


Figure 3-16: Public Shelter Demand Category 3- Volusia County

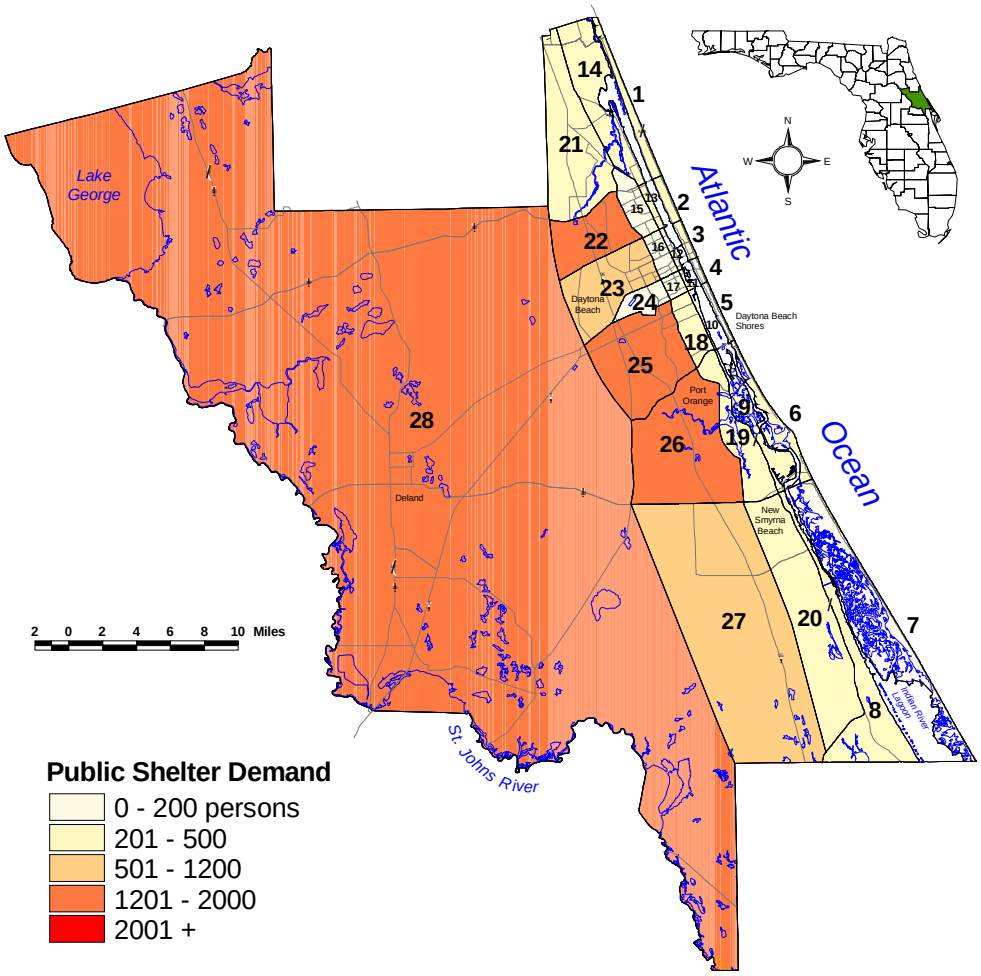
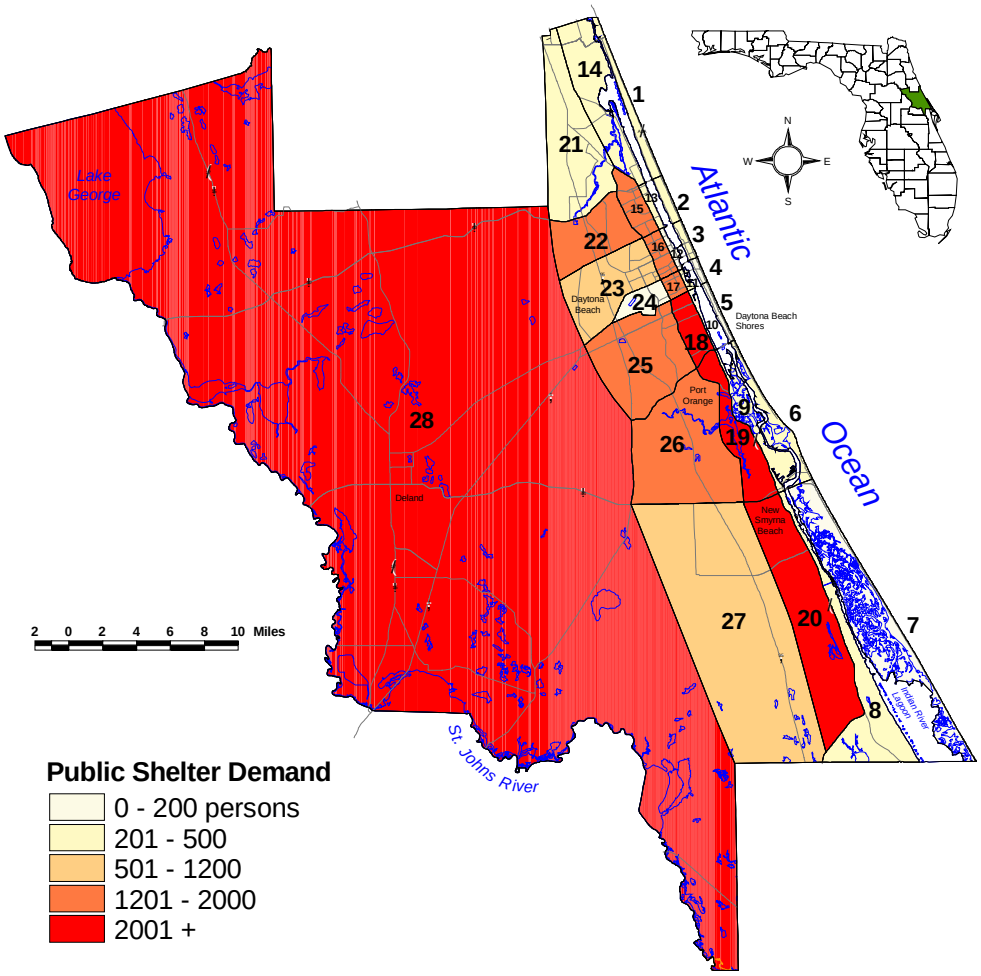


Figure 3-17: Public Shelter Demand Category 4-5- Volusia County



Evacuation Traffic Volumes and Critical Roadway Segments

The assigned evacuating vehicle figures for each county by roadway segment for each Year 2000 storm scenario are provided in the Transportation Model Support Document Appendix. In addition, the Appendix provides an evacuating vehicle to service volume ratio calculated for each roadway segment by scenario. Critical links are defined as those segments with the highest evacuation vehicle to service volume ratio in a particular scenario. (These ratios should not be confused with the v/c ratios used in traffic engineering to describe Level of Service). Traffic control and monitoring is imperative along these congested roadways, which control the flow of evacuation traffic during a hurricane. Most of these links will have to withstand loading not only from the evacuating public, but also from the non-evacuating public attempting to gather supplies and fuel for homes and vehicles. In some cases depending on the time of the evacuation, residents may have to travel from work to home before beginning their evacuation movement.

Table 3-2 lists the critical roadway segments in each county that will control the flow of evacuation traffic. Figures 3-18 through 3-25 illustrate potential evacuation traffic congestion in each county by roadway segment and storm scenario. Figures 3-26 and 3-27 show the potential evacuation traffic congestion by roadway segment and storm scenario in the inland counties of the region.

Table 3-2: Critical Roadway Locations/Segments

Brevard County
Pineda Causeway from US1 to Wickham Road
King/Willard Street (SR 520) from Merritt Island to I-95
I-95 northbound between SR 520 and Bee Line Extension (SR 528)
Bee Line Expressway westbound west of 528/407 interchange
I-95/Bee Line Expressway interchange
I-95 northbound on ramps
US 192 and I-95 interchange
Eau Gallie Blvd. at I-95
US1 at grade intersections
all high level bridges and causeway approaches

Volusia County
I-95 northbound north of I-4
Ormond Bridge/Granada Boulevard
Indian River Boulevard between Old Mission Road and I-95
SR 40 from I-95 to Marion County
SR 40 from Nova Road to I-95
SR 44 from I-95 to I-4
Old Dixie Hwy/Walter Boardman Lane/Highbridge Road from state recreation area to I-95
US 92 (International Speedway Boulevard) and I-95 interchange
I-95 northbound on ramps
SR 40 from Ormond Bridge to Nova Road
I-95 northbound to I-4 westbound on ramp
I-4 St. Johns River Bridge
all high level bridges and causeway approaches

Inland Counties
Florida Turnpike exit ramps (for scenarios involving Treasure Coast and South Florida)
Bee Line Expressway exit ramps
I-4 exit ramps
520 and SR 50 intersections

Please Note: In urban areas such as Volusia and Brevard, much of the road network will be congested in a hurricane evacuation. Segments listed above are those segments identified as potentially having the most congestion.

Figure 3-18: Evacuation Traffic Congestion 1 - Brevard County

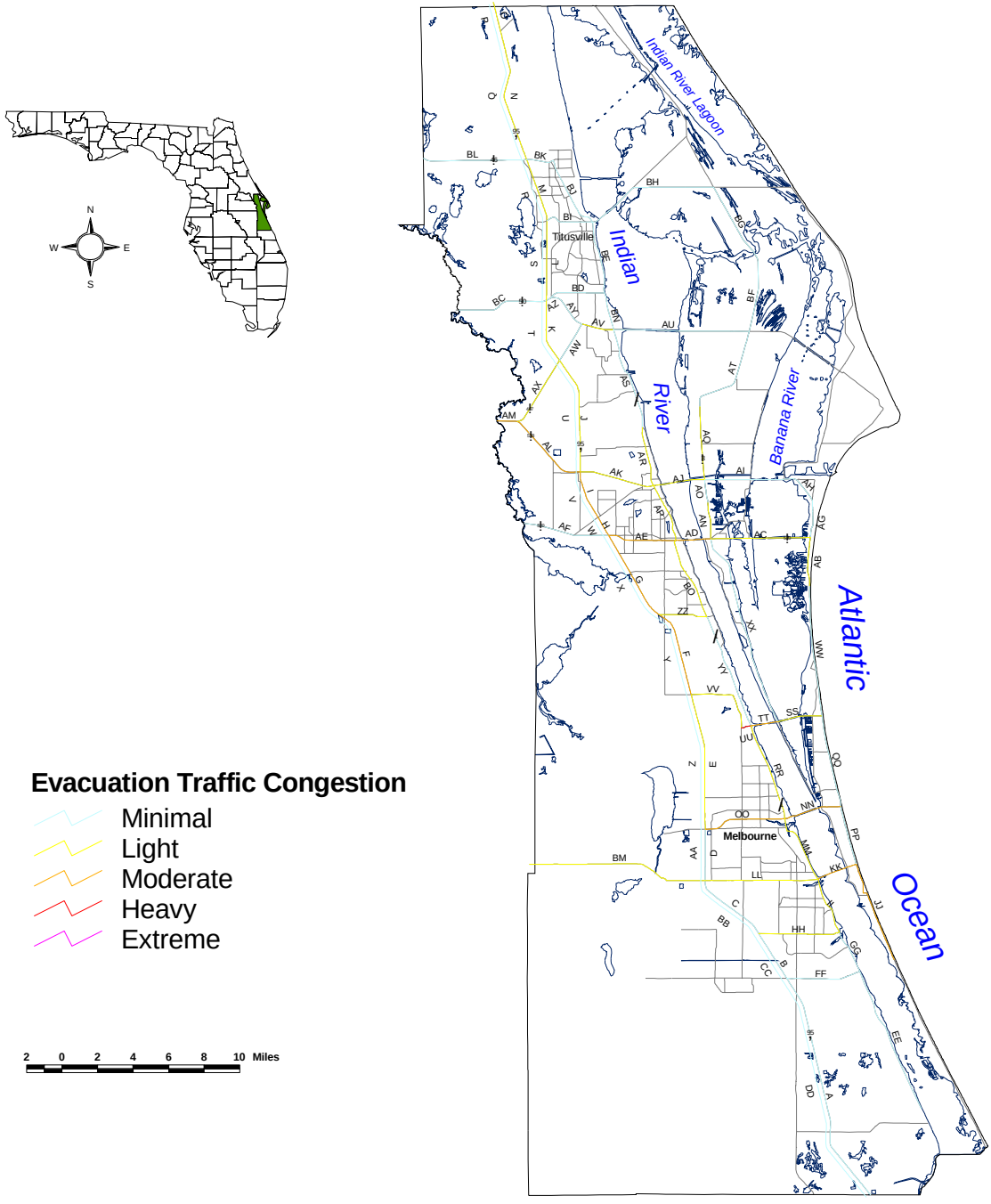


Figure 3-19: Evacuation Traffic Congestion Category 2 - Brevard County

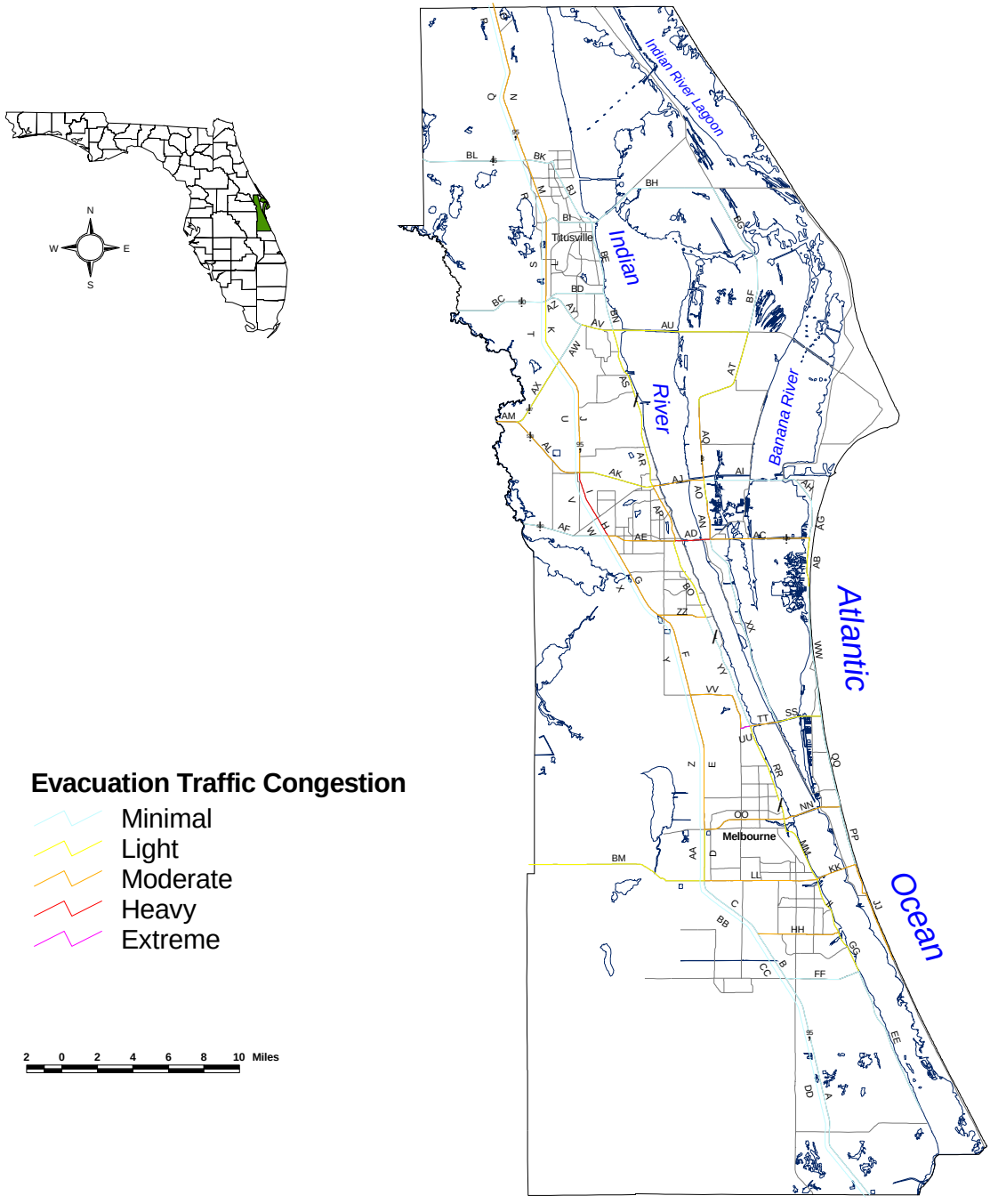


Figure 3-20: Evacuation Traffic Congestion Category 3 -Brevard County

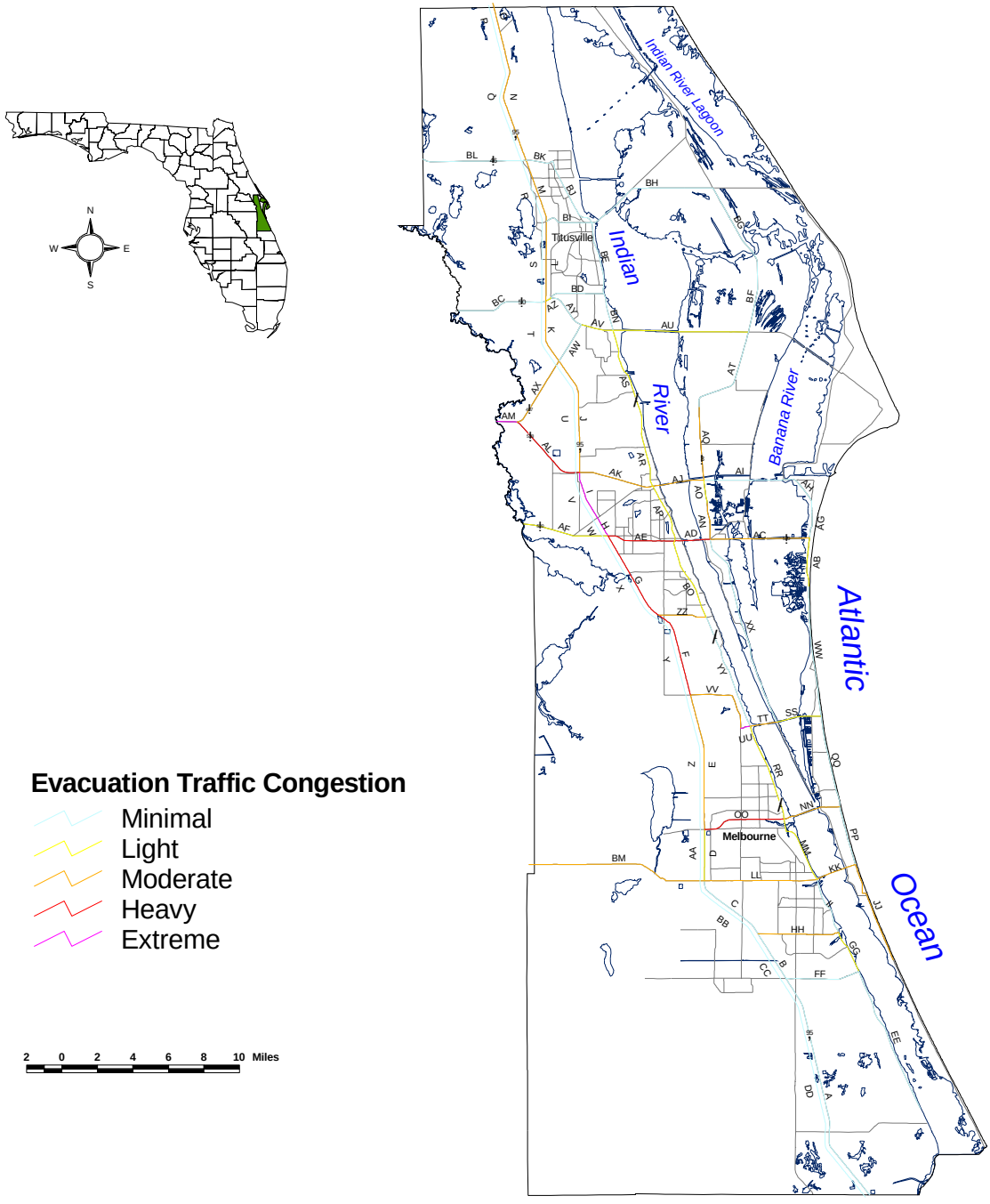


Figure 3-21: Evacuation Traffic Congestion Category 4-5- Brevard County

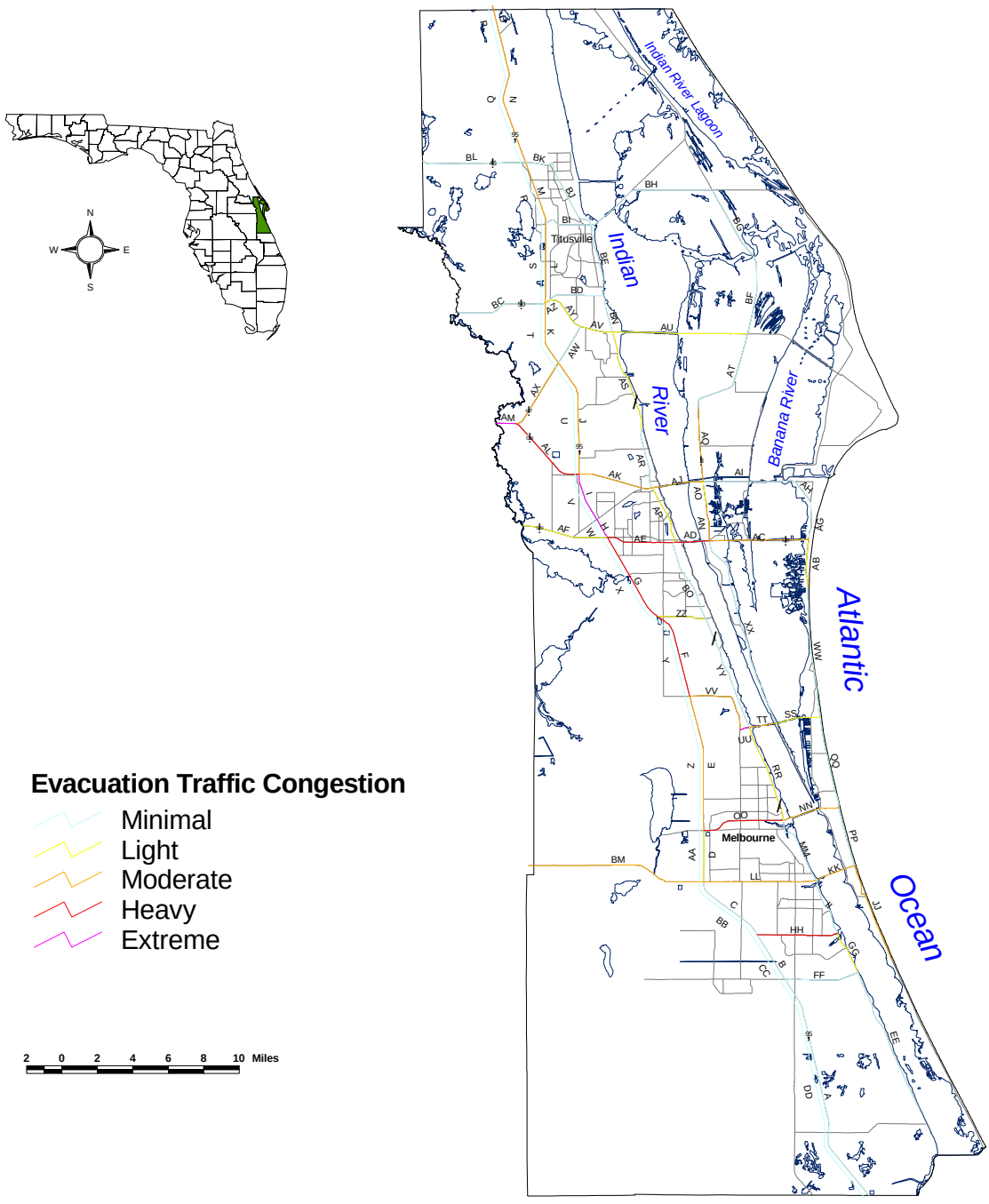


Figure 3-22: Evacuation Traffic Congestion Category1 - Volusia County

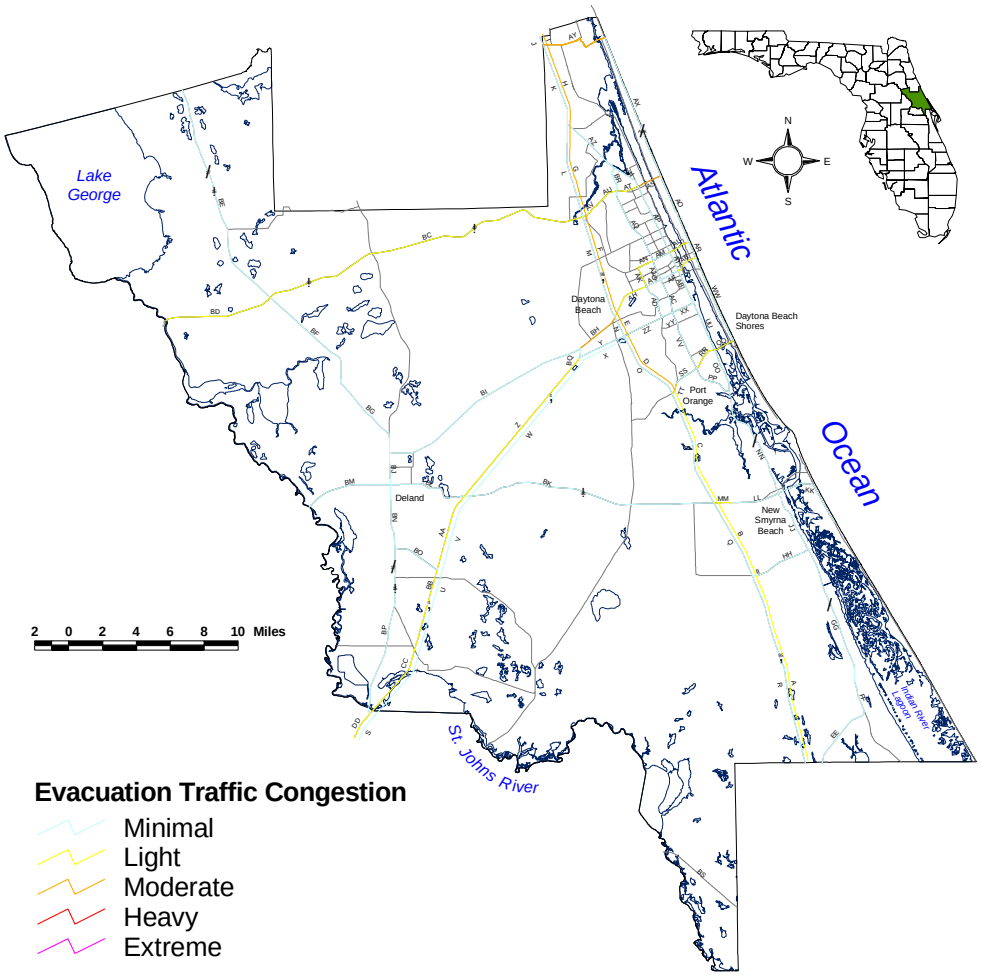


Figure 3-23: Evacuation Traffic Congestion Category 2 - Volusia County

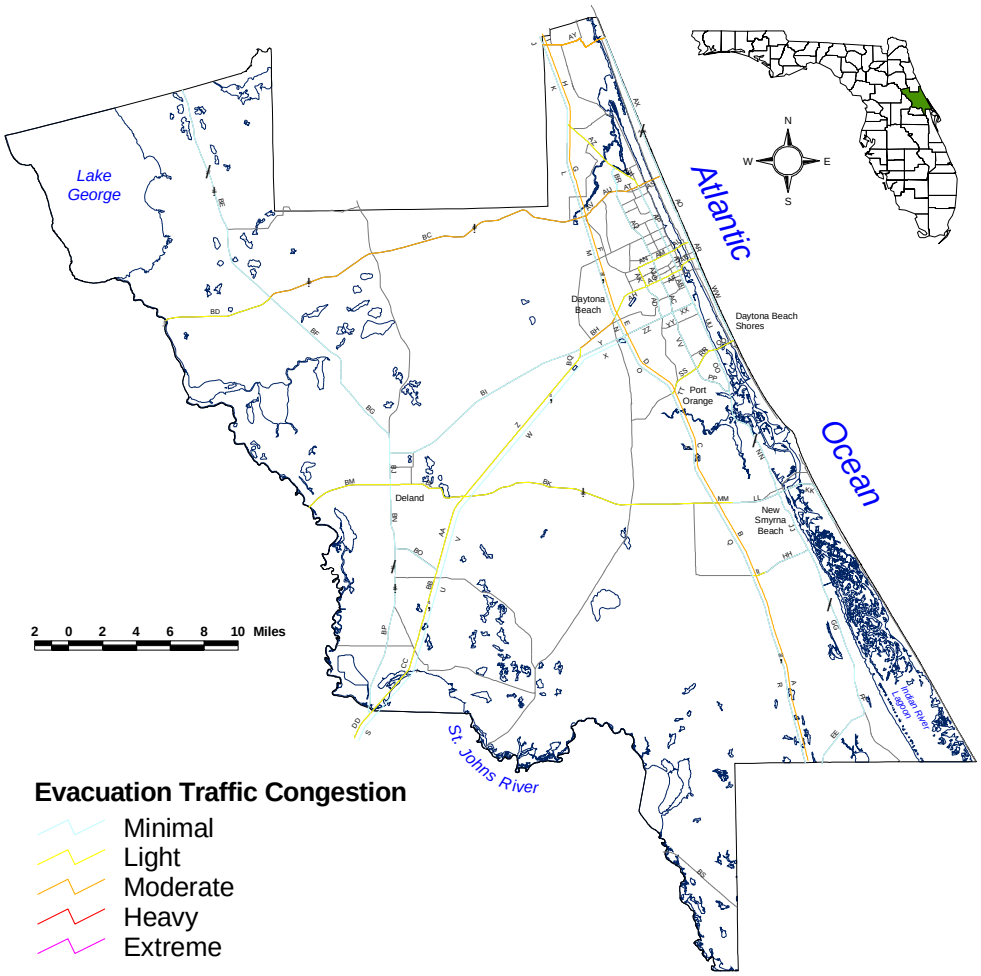


Figure 3-24: Evacuation Traffic Congestion Category 3- Volusia County

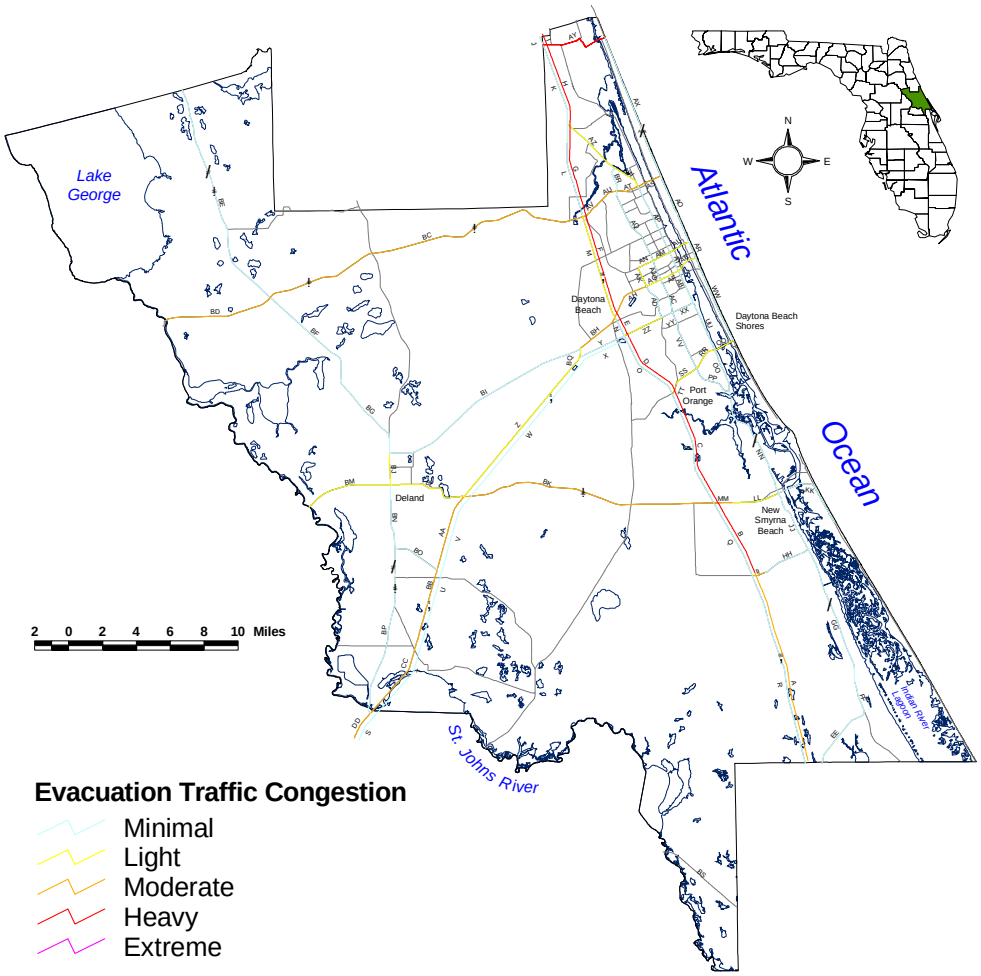


Figure 3-25: Evacuation Traffic Congestion Category 4-5- Volusia County

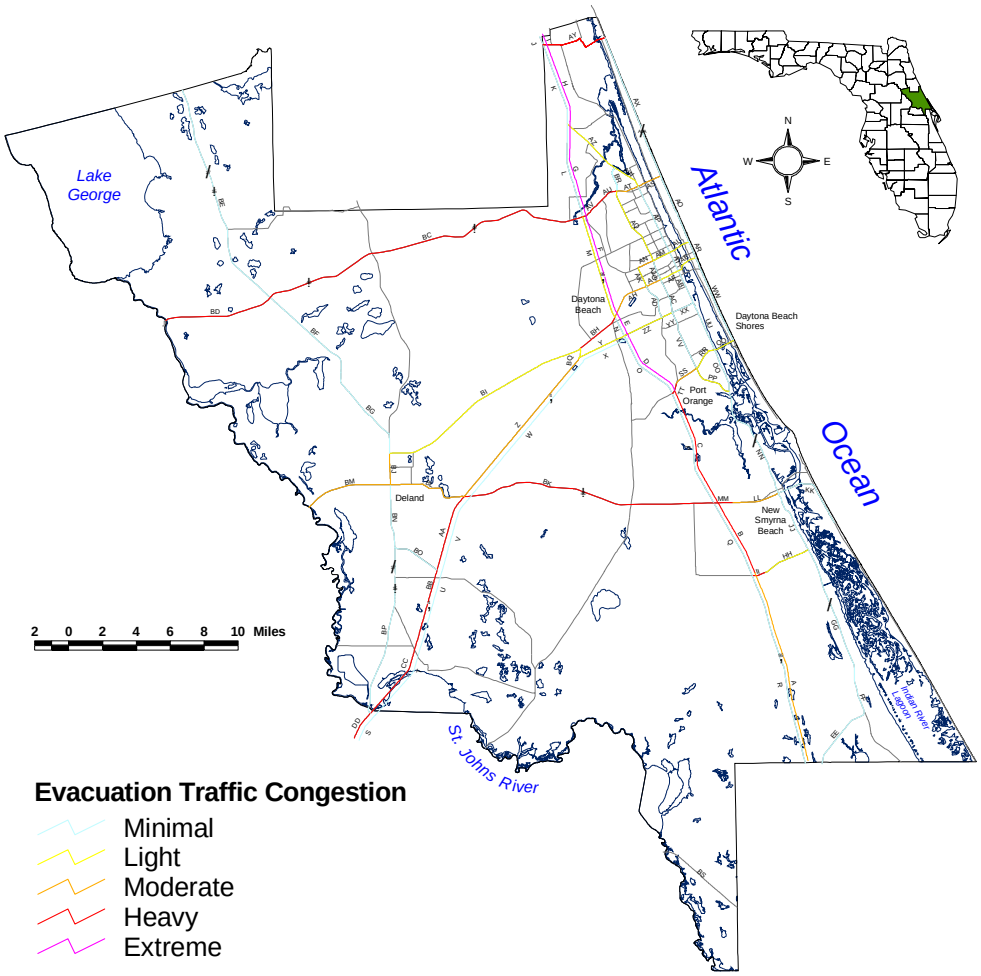


Figure 3-26: Evacuation Traffic Congestion Category 4-5- Inland Counties

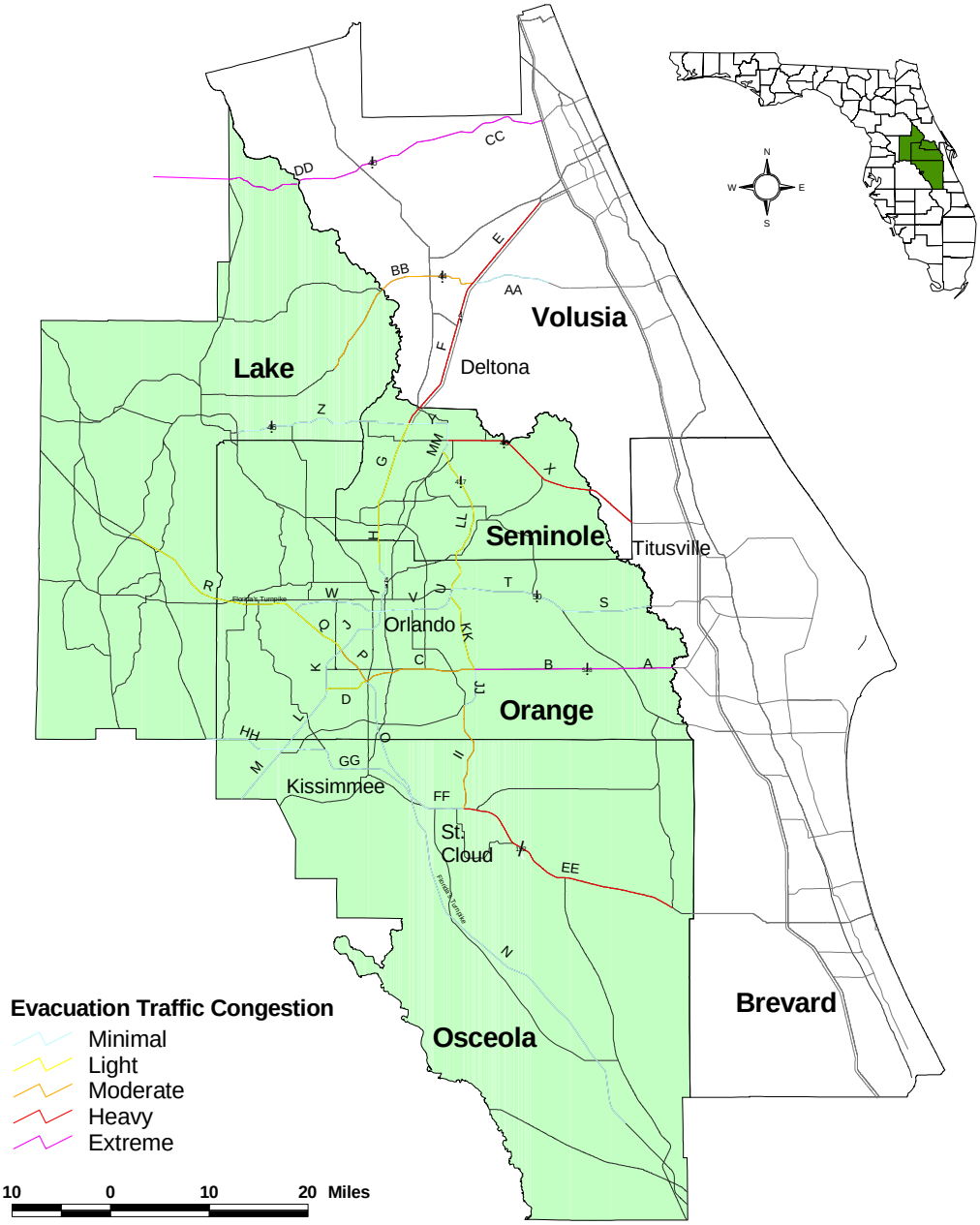
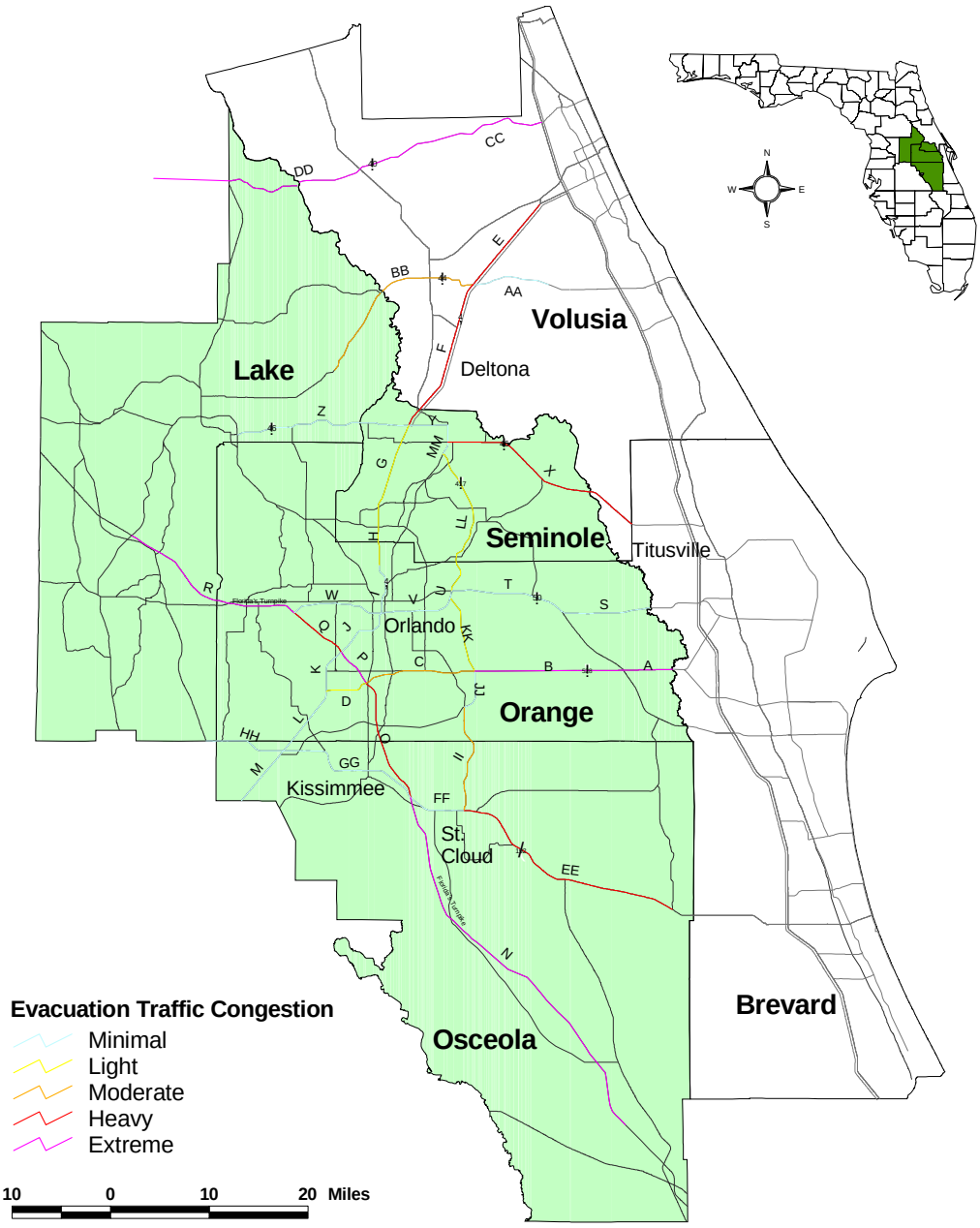


Figure 3-27: Evacuation Traffic Congestion Category 4-5- Inland Counties With Treasure Coast Through-Traffic



Estimated Evacuation Clearance Time

The final and most important product of the transportation analysis is the set of clearance times developed by storm scenario and behavioral characteristic for each county. The behavioral aspect of the study involves the development of categories under each storm category using three different rapidity of response times. The clearance times also factor in both light and heavy background traffic situations generated by the non-evacuating public. Estimated clearance times are one of the two most influential considerations involved in issuing an evacuation order or advisory. The other consideration involved is the timetable for the arrival of sustained tropical storm winds. Figure 3-28 illustrates these two evacuation issues and their relationship. It is essential that clearance times be closely coordinated with the estimated timing of pre-landfall hazards to ensure the completion of an evacuation prior to the arrival of sustained tropical winds.

Clearance time denotes the time required to clear a 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. (For this study, clearance times were ended for west bound traffic at Orlando and at Jacksonville for northbound traffic.) Clearance time includes the time required by evacuees to enter the road network (referred to as mobilization time), and the time evacuees spend traveling 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 and does not include time needed for local officials to assemble and make a decision to evacuate.

Table 3-3 contains the hurricane evacuation clearance times developed for each county for the Year 2000. Clearance times fall in the range of 6-20 hours for all of the Year 2000 scenarios. Clearance times reflect the effects of adjacent county traffic impacts, and in that regard assume that consistent evacuation decisions will be made and coordinated between adjacent counties and facilitated by the State of Florida DEM. Appendix A presents estimates of Year 2005 clearance times. These times were calculated by factoring up Year 2000 evacuation traffic expected at each bottleneck based on expected local growth trends.

Figure 3-28: Components of Evacuation Time

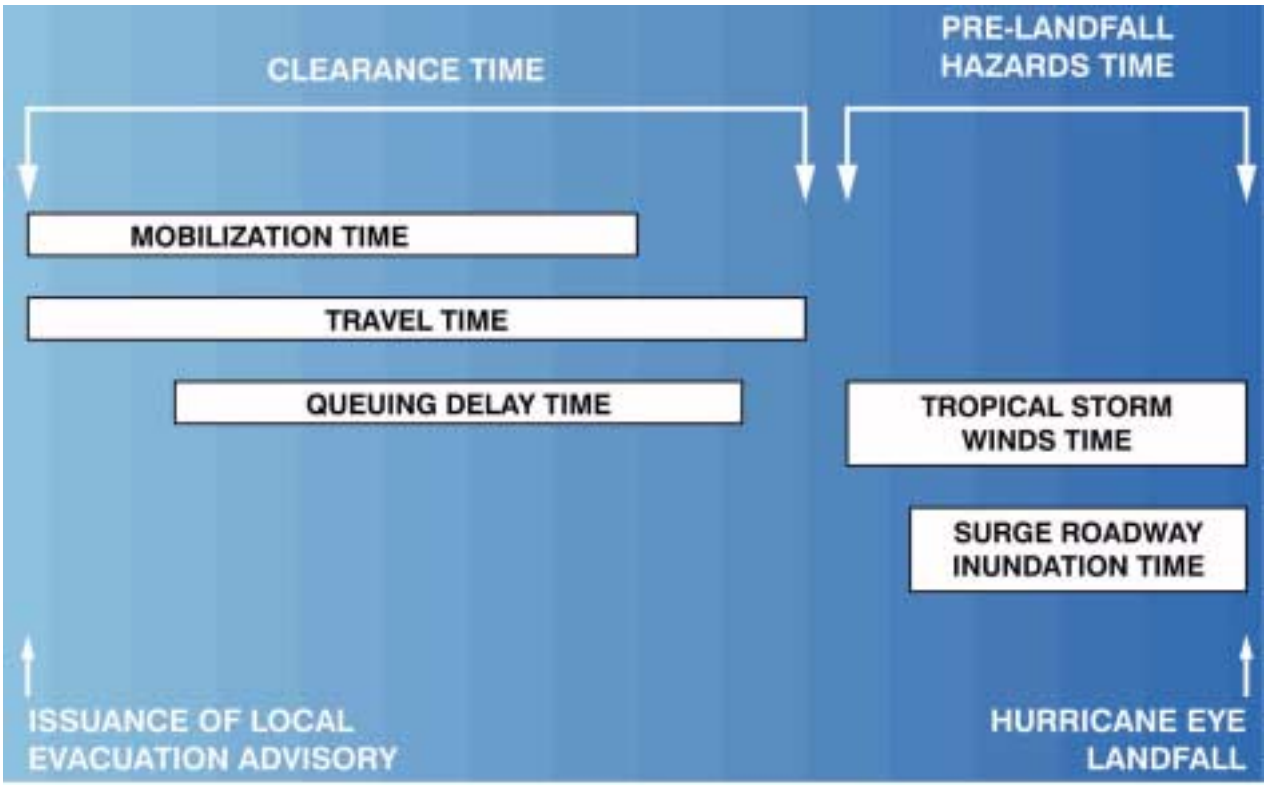


Table 3-3: Brevard County Year 2000 Clearance Times (in hours)

	Light Background Traffic	Heavy Background Traffic
Category 1 Hurricane		
Rapid Response	7	7 ½
Medium Response	7 ¾	8 ¼
Long Response	9 ½	9 ½
Category 2 Hurricane		
Rapid Response	9	9 ¾
Medium Response	9 ½	10 ½
Long Response	10 ¾	11 ½
Category 3 Hurricane		
Rapid Response	13 ¼	14 ¼
Medium Response	13 ¾	14 ¾
Long Response	14 ½	16
Category 4-5 Hurricane		
Rapid Response	14 ½	15 ¼
Medium Response	14 ¾	15 ¾
Long Response	15 ¼	17

Please Note: Heavy background traffic scenarios involve a work to home movement for many evacuees. For scenarios where Treasure Coast region counties are also evacuating, add 3 hours of time to the Category 1 and 2 scenarios, 6 hours of time to the Category 3 scenario, and 10 hours to the Category 4 and 5 scenarios.

Table 3-3: Volusia County Year 2000 Clearance Times (in hours)

	Light Background Traffic	Heavy Background Traffic
Category 1 Hurricane		
Rapid Response	6 ¾	7 ¾
Medium Response	7 ½	8 ½
Long Response	9 ½	10
Category 2 Hurricane		
Rapid Response	8 ½	9 ½
Medium Response	9 ¼	10 ½
Long Response	10 ¼	12

Category 3 Hurricane		
Rapid Response	12	13 ¼
Medium Response	12 ½	14
Long Response	13 ¼	15 ½
Category 4-5 Hurricane		
Rapid Response	16	17
Medium Response	16 ¼	18
Long Response	17	19 ¼

Please Note: Heavy background traffic scenarios involve a work to home movement for many evacuees. For scenarios where Treasure Coast region counties are also evacuating, add 3 hours of time to the Category 1 and 2 scenarios, 6 hours of time to the Category 3 scenario, and 10 hours to the Category 4 and 5 scenarios.

Time Constrained Evacuations

Evacuation clearance times calculated for the East Central Florida Hurricane Evacuation Study are generally less than 20 hours, which means that typical hurricane watch and warning time frames will allow for desired evacuation movements to take place. However, there will be storm threats due to unusual meteorological characteristics and/or late behavioral response (like Hurricane Opal in northwest Florida) where it is possible that only 18 or even 12 hours are available for evacuation movements. This could impact the number of evacuees who are able to make their desired evacuation movement.

For east central Florida, this would primarily be a problem for Brevard and Volusia coastal evacuees wanting to go out of county. Table 3-4 provides rough estimates of total evacuees able to make their desired evacuation movement under various time constrained evacuations. For Brevard County, the data implies that for a category 4-5 hurricane where only 12 hours are available for evacuation, up to 32,400 people might not be able to make their desired evacuation movement. Likewise for Volusia County, where only 12 hours are available for a category 4-5 hurricane evacuation, up to 50,000 people might not be able to make their desired evacuation movement. Bottlenecks would remain as those specified in Table 3-2 for each of the coastal and island counties.

Table 3-4: Evacuating People Statistics For Time Constrained Evacuations 12 and 18 Hours

Applicable County/Scenario	Maximum Unconstrained Evacuating Population	18 Hour Constrained Evacuating Population	12 Hour Constrained Evacuating Population
Brevard County			
Category 4-5 Hurricane	226,700 People	No reduction	194,300 People
Volusia County			
Category 4-5 Hurricane	272,400 People	263,800 People	222,400 People

Traffic Control Measures

Some general recommendations concerning traffic control are as follows:

- Where counties have sufficient personnel resources, officers should be stationed at critical intersections to facilitate traffic flow. Where intersections will continue to have signalized control, signal patterns providing the most “green time” for the westbound evacuation travel direction should be activated. This will be critical for east-west arterials in Brevard and Volusia Counties.
- If possible, arrangements should be made with tow truck operators so that they are prepositioned along key travel corridors and critical roadway facilities such as bridges. This is especially true in both Brevard and Volusia counties, which have roadways with low-lying areas that alternate with two lane bridges which do not have shoulders for vehicles to pull off.
- All draw/swing bridges needed for evacuation should be locked in the “down” position

during a hurricane warning, if possible. Boat owners must be made aware of flotilla plans and time requirements for securing vessels.

- The state and counties should work jointly on a statewide evacuation and shelter monitoring system which would monitor travel flow at key locations and report traffic tie-ups and shelter availability to the general public as they evacuate. Reporting the availability of hotel/motel space in the Orlando area will also be critical. The Orlando-Orange County Visitors and Convention Bureau has set up a 1-800 number to assist with this.
- Evacuees leaving Cape Canaveral and Cocoa Beach in Brevard County should be encouraged to travel west on 528, rather than on the more congested 520.

Evacuation Shutdown Time Frames

As Orlando and the east central Florida area are an origin for significant numbers of evacuees and a potential destination for significant numbers of downstate Florida evacuees, it will be important to implement evacuation shut down procedures so that evacuees aren't stranded on I-95 and I-4 as a storm arrives. This could be a particularly dangerous situation if sustained tropical storm winds or hurricane winds begin to effect the roadway and evacuees are still on the facility. Late in an evacuation, it will be important to make a coordinated decision about when to tell evacuees to stop entering I-95, I-4 and the Beeline.

Since the region and state's population will respond differently for various storm events, the time at which evacuees should be advised to stop entering I-95, I-4 and the Beeline should be based on actual traffic conditions and not modeled predictions such as clearance times calculated in the regional and statewide studies (which indicate when an evacuation should begin). There are FDOT permanent traffic count stations located along the facilities which should be used for travel speed monitoring (sites 9906 and 0292). Traffic conditions can be further monitored through Civil Air Patrol support and/or highway patrolmen stationed on the ground at strategic locations. Traffic can also be monitored using CCTV cameras within the Volusia County and Metro-Orlando area. Hourly snapshots of traffic volumes and average travel speeds at these locations, coupled with storm information regarding the radius of tropical storm winds and forward speed, will be critical to making prudent shut-down decisions. As average travel speeds are monitored hour to hour and the information fed back to the state and county Emergency Management Operation Centers (EOCs), data must be interpreted and the public notified of evacuation shut down.

The best indicator of evacuation traffic congestion and progression is average travel speed. Identifying the most congested sites in the appropriate direction and using Table 3-5, PBS&J would propose that the state and counties notify the public to stop entering I-95, I-4 and the Beeline in the hourly time frames shown. This should greatly help prevent people from being stuck on the roadway system as hazardous conditions arrive.

Table 3-5: Evacuation Closure/Evacuee Notification Time Frames (Expressed in Hours Before Expected Sustained Tropical Storm Winds to Discourage New Evacuees From Entering Regional Interstate Facilities)

Average Travel Speed of Evacuation Traffic at Congestion Monitoring Sites	I-4 Westbound (site 9906) near Deltona	I-95 Northbound (site 0292) in Flagler County
5 mph	6 Hours	12 Hours
15 mph	2 Hours	4 Hours
25 mph	1¼ Hours	2½ Hours
35 mph	1 Hour	2 Hours
45 mph	1 Hour	1½ Hours
55 mph	1 Hour	1 Hour
65 mph	1 Hour	1 Hour

Please Note: No permanent count station presently exists on the Beeline/SR 528 between Brevard County and Orlando. FDOT should implement a site here so that evacuations can be effectively monitored.

Appendix A: Year 2005 Clearance Time Tables

Brevard County Year 2005 Clearance Times (in hours)*

Category 1 Hurricane	Light Background Traffic	Heavy Background Traffic
Rapid Response	7 ½	8
Medium Response	8 ¼	8 ¾
Long Response	10	10
Category 2 Hurricane		
Rapid Response	10	10 ¼
Medium Response	10	11 ¼
Long Response	11 ½	12 ¼
Category 3 Hurricane		
Rapid Response	14	15
Medium Response	14 ½	15 ¾
Long Response	15 ¼	17
Category 4-5 Hurricane		
Rapid Response	15 ¼	16 ¼
Medium Response	15 ¾	16 ¾
Long Response	16 ¼	18

Please Note: Heavy background traffic scenarios involve a work to home movement for many evacuees. For scenarios where Treasure Coast region counties are also evacuating, add 3 hours of time to the Category 1 and 2 scenarios, 6 hours of time to the Category 3 scenario, and 10 hours to the Category 4 and 5 scenarios.

*A 6% growth rate was used to calculate Year 2005 clearance times.

Volusia County Year 2005 CLEARANCE TIMES (in hours)*

Category 1 Hurricane	Light Background Traffic	Heavy Background Traffic
Rapid Response	7 ¼	8 ¼
Medium Response	8	9
Long Response	10	10 ½
Category 2 Hurricane		
Rapid Response	9	10
Medium Response	9 ¾	11 ¼
Long Response	10 ¾	12 ¾
Category 3 Hurricane		
Rapid Response	12 ¾	14
Medium Response	13 ¼	14 ¾
Long Response	14	16 ½
Category 4-5 Hurricane		
Rapid Response	17	18
Medium Response	17 ¼	19
Long Response	18	20 ½

Please Note: Heavy background traffic scenarios involve a work to home movement for many evacuees. For scenarios where Treasure Coast region counties are also evacuating add 3 hours of time to the Category 1 and 2 scenarios, 6 hours of time to the Category 3 scenario, and 10 hours to the Category 4 and 5 scenarios.

*A 6% growth rate was used to calculate Year 2005 clearance times.

Appendix B: Excerpt from Florida Statewide Hurricane Evacuation Study Showing Potential Orlando Inland Public Shelter Demand

Sample Orlando-Inland Public Shelter Demand Calculation, Category 4-5 Hurricane, 24 Hour Evacuation Duration

Maximum Evacuees Entering/Passing Through by Storm Track

Evacuee Origin-Contributing Route	A	B	D	E	F	H	I
Florida Turnpike (Northbound)	153,120 people	115,720 people	153,120 people	22,880 people	2,640 people	153,120 people	46,640 people
I-4 (Eastbound)	47,960	65,340	82,500	109,340	121,880	15,400	145,640
Bee Line Expressway/ SR 528 (Westbound)		18,700		16,060		16,060	
SR 50 (Westbound)		7,040		6,160		6,380	
I-4 (Westbound)		4,400			4,840	880	
TOTALS	**201,080 people**	**211,200 people**	**235,620 people**	**154,440 people**	**129,360 people**	**191,840 people**	**192,280 people**
Public Shelter Demand @ 5% of Total Evacuees	10,000 people	10,600 people	11,800 people	7,700 people	6,500 people	9,600 people	9,600 people
Public Shelter Demand @ 10% of Total Evacuees	20,000 people	21,100 people	23,600 people	15,400 people	12,900 people	19,200 people	19,200 people
Public Shelter Demand @ 15% of Total Evacuees	30,200 people	31,700 people	35,400 people	23,200 people	19,400 people	28,800 people	28,800 people

*Does not include evacuees entering/passing through Orlando area searching for hotel/motel space; does not include mobile home evacuees that may be evacuating residences in the Orange County area and seeking local public shelter for certain storm tracks. For tracks also directly affecting Orange County, up to 12,000 local resident public shelter evacuees would need to be accommodated if fifteen percent of the local mobile home population goes to public shelter.