Volume 1-11
Technical Data Report

South Florida Region

Chapter VI
Regional Evacuation Transportation Analysis 2015 Update

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CHAPTER VI
REGIONAL EVACUATION TRANSPORTATION ANALYSIS

The evacuation transportation analysis discussed in this chapter documents the methodology, analysis, and results of the transportation component of the Statewide Regional Evacuation Study Program (SRESP). Among the many analyses required for the SRESP study, transportation analysis is probably one of the most important components in the process. By bringing together storm intensity, transportation network, shelters, and evacuation population, transportation analysis explicitly links people's behavioral responses to the regional evacuation infrastructure and helps formulate effective and responsive evacuation policy options. Due to the complex calculations involved and numerous evacuation scenarios that need to be evaluated, the best way to conduct the transportation analysis is through the use of computerized transportation simulation programs, or transportation models.

A. Background and Purpose

Over the years, different planning agencies have used different modeling approaches with varying degrees of complexity and mixed success. Some have used full-blown conventional transportation models such as the Florida Standard Urban Transportation Modeling System (FSUTMS); others have used a combination of a simplified conventional model and a spreadsheet program, such as the Abbreviated Transportation Model (ATM). These models have different data requirements, use different behavioral assumptions, employ different traffic assignment algorithms, and produce traffic analysis results with different levels of detail and accuracy. These differences make it difficult for planning agencies to share information and data with each other. They also may produce undesirable conditions for staff training and knowledge sharing.

One of the objectives of the SRESP is to create consistent and integrated regional evacuation data and mapping, and by doing so, to facilitate knowledge sharing between state, regional, county and local partners. To achieve this objective, it is important for all Regional Planning Councils to adopt the same data format and to use the same modeling methodologies for their transportation analyses. The primary purpose of the transportation component of the SRESP is to develop a unified evacuation transportation modeling framework that can be implemented with the data collected by the Regional Planning Councils.

B. Study Area

The study area for this analysis includes the three-county South Florida Regional Council area. The transportation modeling methodology includes some processes that are performed at the statewide level, in order to determine the impacts of evacuations from other regions impacting the evacuation clearance times in the South Florida region. While the impact of other regions is

included in the South Florida analysis, it is important to note that the results of the transportation analysis presented in this document are only reported for the three counties included in the South Florida Regional Council. Transportation analysis results for other regions and counties are reported in the corresponding Volume 4 report for those regions.

C. Input and Coordination

The SRESP transportation methodology and framework was developed during 2008 and 2009 in coordination with all eleven regional planning councils in Florida, along with the Division of Emergency Management, Department of Transportation, Department of Economic Opportunity (formerly the Department of Community Affairs), and local county emergency management teams, with CDM Smith serving as the transportation consultant.

During the development of this study, completed in 2015, the South Florida Regional Council convened two regional meetings, which were hosted by the Miami-Dade County Emergency Management Office. The first was held on March 5, 2015, to review model inputs with local county emergency managers, and to define the characteristics for the operational scenarios to be used in the calculation of updated clearance times. The second meeting was held on September 15, 2015, to review the draft documents that present the results of the updated clearance time estimates. Based on the issues raised at the meeting, it was decided to re-run the scenarios, incorporating additional and revised input data. The results presented in the following pages reflect the revised results.

D. Study Comparisons

It is important to note that this study contains significant updates and revisions in comparison to the 2010 SRESP study for the South Florida region. These revisions include updates to population projections based on the 2010 census, new evacuation zones based on updated topography data, modifications to the roadway network due to recently completed and planned construction projects, and changes to the location and size of available shelters. These revisions have significant impacts on evacuating vehicle behavior for the region and caused changes to the calculated clearance times in each county. These updates and revisions make comparisons to the previous 2010 study difficult.

E. Evacuation Modeling Methodology and Framework

The methodology used in the South Florida Regional Council Evacuation Transportation Analysis is identical to the methodology used for all eleven Regional Planning Councils, and is summarized in the following sections[1]:

[1] Modifications to model flow rates (lane capacities) in Monroe County were made to the South Florida Regional Council model in accordance with the "maximum sustainable traffic flow rates per functional evacuation lane" identified in correspondence from the Florida Department of Transportation, District 6, to the Florida Department of Community Affairs. These flow rates are different than model flow rates used throughout the rest of Florida to accommodate the unique roadway characteristics of Monroe County.

- **Behavioral Assumptions** – In 2008, the Statewide Regional Evacuation Study Program (SRESP) commissioned a survey of Florida residents. The purpose of this survey was to develop an understanding of the behavior of individuals when faced with the prospect of an impending evacuation. These data were used to develop a set of "planning assumptions" that describe the way people respond to an order to evacuate and are an important input to the SRESP Evacuation Model. The behavioral data provides insights into how people respond to the changing conditions leading up to and during an evacuation. The primary application of the survey data was to help anticipate how people would respond with respect to five behaviors:
  - How many people would evacuate?
  - When they would leave?
  - What type of refuge they would seek?
  - Where they would travel for refuge?
  - How many vehicles would they use?

  These evacuation behaviors are distinguished based on several descriptive variables as listed below:
  - Type of dwelling unit (site-built home versus mobile home);
  - The evacuation zone in which the evacuee reside; and
  - The intensity of the evacuation that has been ordered.

- **Zone System and Highway Network** – The SRESP evacuation model relies upon data that covers the entire State of Florida as well as areas covering the States of Georgia, Alabama, Mississippi, South Carolina, North Carolina, and Tennessee. While the primary focus of the model is with evacuation behavior within Florida, areas outside of the state had to be considered in order to allow a more precise routing of evacuation traffic. This allows the model to measure the flow of traffic across the state line if needed.

  The data included in this system contain the demographic information crucial to modeling evacuation traffic. The demographic information is labeled as "small area data". These data provide population and dwelling unit information that will identify where the individuals in the region reside. The planning assumptions developed from the behavioral analysis conducted for this study were applied to these demographic data. The result is a set of evacuation trips generated by the evacuation model. The number of these trips will vary depending on the hazard conditions that prompt the evacuation. Small area data geographies were aggregated into larger units known as Transportation Evacuation Zones (TEZ). These TEZs form the basic unit of analysis in the evacuation model. The final TEZ system has 8,829 zones within State of Florida and 627 located outside of the State. This number provides sufficient detail to accurately accommodate the assignment of evacuation trips onto an evacuation network.

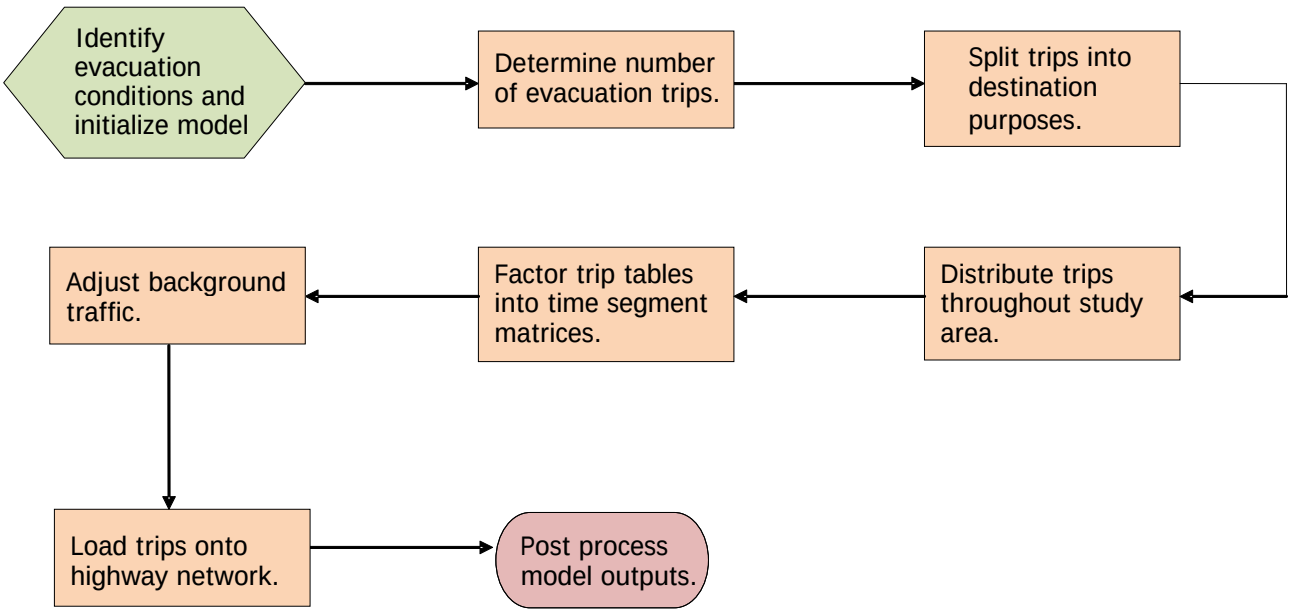
- **Background Traffic** – The traffic that consumes the roadway capacity of a transportation system during an evacuation can be divided into two groups. The first group is the evacuation traffic itself. Once the evacuation demand is determined, this information is converted into a number of vehicles evacuating over time. These evacuation trips are then placed on a representation of the highway network by a

model. The model determines the speed at which these trips can move and proceeds to move the evacuation trips accordingly. The result is a set of clearance times.

The second group of traffic is known as background traffic. Background traffic, as its name implies, is not the primary focus of an evacuation transportation analysis and is accounted for primarily to impede the movement of evacuation trips through the network. These trips represent individuals going about their daily business mostly unconcerned with the evacuation event. For the most part, background traffic represents trips that are relatively insensitive to an order to evacuate and are thus said to be occurring in the "background." Even though background traffic is relatively insensitive to evacuation orders, it is important to account for background traffic since it can have a dramatic impact on available roadway capacity. This in turn can severely affect evacuation clearance times.

- **Evacuation Traffic** – The model flow for the evacuation model is divided into a total of eight modeling steps. The following eight steps are represented graphically in the flowchart in **Figure VI-1**:
  1. Identify evacuation conditions and initialize model;
  2. Determine number of evacuation trips;
  3. Split trips into destination purposes;
  4. Distribute trips throughout study area;
  5. Factor trip tables into time segment matrices;
  6. Adjust background traffic;
  7. Load trips onto highway network; and,
  8. Post process model outputs.

Figure VI-1 General Model Flow



- **Dynamic Traffic Assignment** - Dynamic traffic assignment (DTA) was utilized in the evacuation methodology because it is sensitive to individual time increments. DTA works by assigning a certain number of vehicles to the highway network in a given interval of time. The model then tracks the progress of these trips through the network over the interval. Another set of vehicles is assigned during the following time interval. The model then tracks the progress of these trips through the network along with the progress of the trips loaded in the previous time interval. As vehicles begin to arrive at the same segments of roadway, they interact with one another to create congestion. When vehicles that were loaded to the network in subsequent intervals of time arrive at the congested links, they contribute to the congestion as well. This results in a slowing down of the traffic and eventually spill-backs and queuing delays. It is this time dependent feature of DTA that makes it well suited to evacuation modeling. By dynamically adjusting the travel times and speeds of the vehicles moving through the network as they respond to congestion the model is able to do the following:

  - The evacuation model is able to estimate the critical clearance time statistics needed for this study;
  - The model takes into account the impact of compounded congestion from multiple congestion points;
  - The model is able to adjust the routing of traffic throughout the network as a function of congestion as it occurs throughout the evacuation; and,
  - The model is capable of adjusting its capacities from time segment to time segment, making it possible to represent such phenomena as reverse lane operations and background traffic.

- **Prototype Model Development** – CDM Smith developed a prototype model to test the modeling methodology used to calculate evacuation clearance times. The prototype model demonstrated the viability of the methodology developed for this study. This included the use of dynamic traffic assignment, background traffic curves, regional sub-area trip balancing, the use of survey rates, the use of 100% participation rates, response curves, and county-by-county phasing of evacuations. The prototype model served as the backbone for all regional evacuation models that have been developed for this study. The models implemented for each RPC use a structure similar to the prototype with identical methodology.

  The SRESP evacuation model relies upon data that covers the entire State of Florida as well as areas covering the States of Georgia, Alabama, Mississippi, South Carolina, North Carolina, and Tennessee. While the primary focus of the model is with evacuation behavior within Florida, areas outside of the state had to be considered in order to allow a more precise routing of evacuation traffic. This allows the model to measure the flow of traffic across the state line if needed.

F. Regional Model Implementation

The regional model developed for the South Florida Region used a series of input data provided by the Council, including the following:

- **Regional Model Network** – The road network is a key component of the evacuation model. The roadway variables in the network include area type, functional class, number of through lanes, capacity, speed, and several others. The regional model network consists of the Council-designated evacuation routes as well as a supporting roadway network that facilitates movement of evacuation traffic. The 2005 Florida Department of Transportation (FDOT) Statewide Model Network was used as a basis for developing the regional model network, while the evacuation routes were obtained from the South Florida Regional Council. The Council received input from the emergency managers of its constituent counties on roads designated as evacuation routes. Policy in both Miami-Dade County and Broward County encourages in-county evacuations, away from surge areas to the inland portions of the county, not out of county. As a result, some inter-county connectors had to be added in order to compose the regional evacuation network that was developed for the study.

  Lane capacities for the segments of US 1 in Monroe County were defined in accordance with the "maximum sustainable traffic flow rates per functional evacuation lane" identified in correspondence from the Florida Department of Transportation, District 6, to the Florida Department of Community Affairs. FDOT District 6 has identified potential changes in the number of functional evacuation lanes on US 1 as a result of the incorporation of completed and planned shoulder improvements within Monroe County through 2015. Study parameters do not provide for the additional scenarios required to analyze the possibility of utilizing additional lanes in an evacuation. However, through the TIME interface and the regional model for South Florida, additional analysis can be conducted on these resources in the future as part of the detailed planning process.

  The resulting model network was updated to 2010 conditions and is referred to as the base model network. **Figure VI-2** identifies the model network and evacuation routes for the SFRC. County level details of the regional model network are provided in the Volume 5-11 report. The regional model network for the South Florida Region is made up of key roadways within the three-county region, including I-75, I-95, I-195, I-395, Florida's Turnpike, US 1, US 27, US 41, US 441, SR 826, SR 836, SR 869, SR 924, and SR 997.

- **Regional Zone System** – The regional zone system is based on Transportation Evacuation Zones (TEZ) and contains the regional demographic information, which includes housing unit and population data that is essential to modeling evacuation traffic. The TEZs were developed statewide, and generally represent the aggregation of traffic analysis zones used in traffic models developed by metropolitan planning organizations, where they exist, as well as census geography where existing traffic models do not yet exist. There are 1,051 TEZs located within the three-county South Florida region, as illustrated in **Figure VI-3**. Miami-Dade County has the largest number of TEZs with 632 and Broward County follows with 379 TEZs. Monroe County contains 40 TEZS and has the lowest number of TEZs within the Region. The larger number of TEZs generally reflects counties with dense urban structure and higher population densities.

- **Regional Demographic Characteristics** – Demographic data were developed for census block groups for Monroe County and for traffic analysis zones for Broward County and Miami-Dade County. Estimates for 2010 and projections for 2015 and 2020 were prepared by the Council with the aid of the Florida Department of Transportation, Districts 4 and 6,

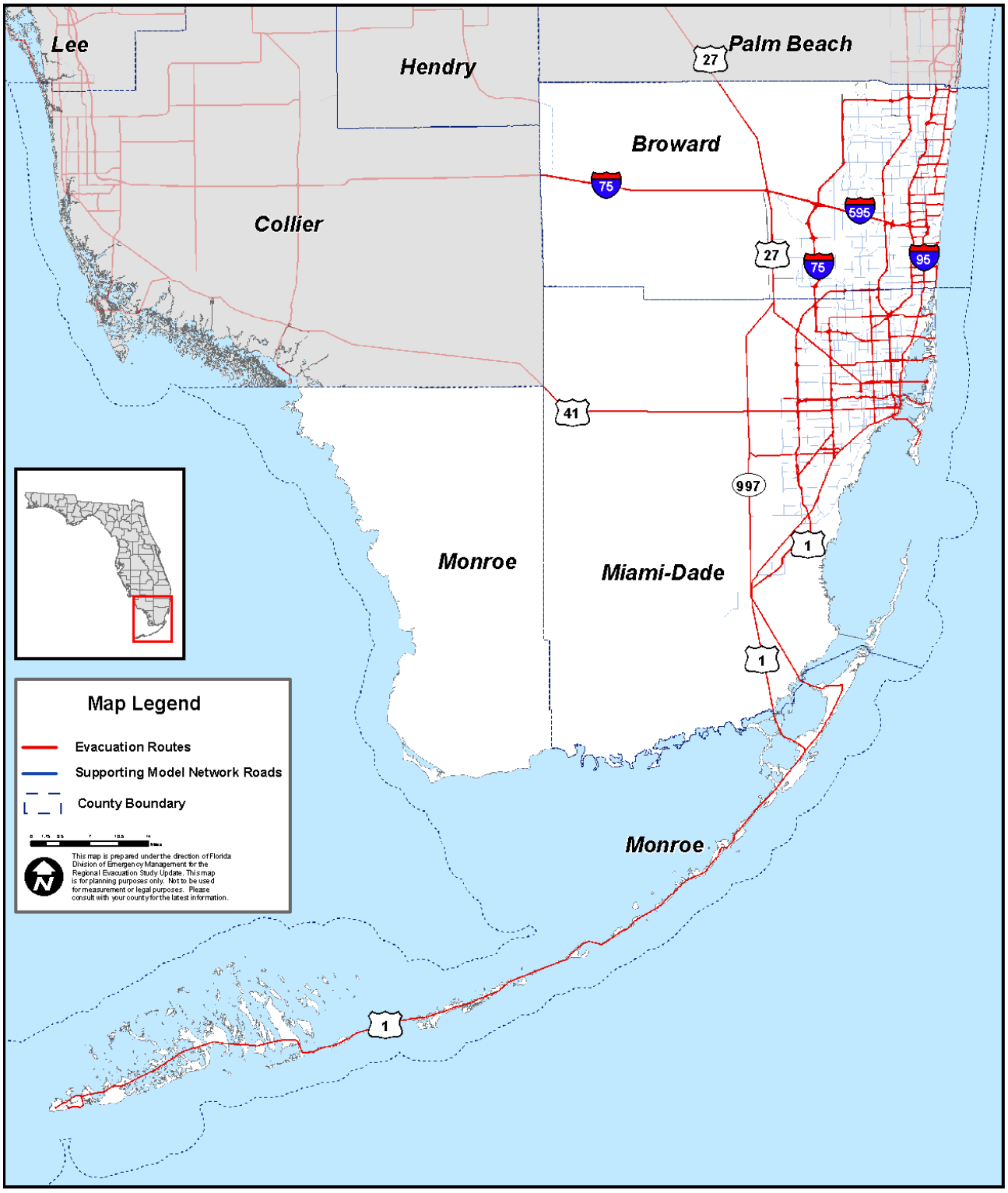
the Miami-Dade Metropolitan Planning Organization, the Broward County Metropolitan Planning Organization, and local planners, based on the 2010 Census. This data was subsequently converted to the TEZ geography by CDM Smith.

A summary of the key demographic data used in the transportation analysis for each county in South Florida is presented in **Table VI-1**. The table lists the number of occupied dwelling units for site-built homes and the permanent population in site-built homes, as well as the number of occupied dwelling units for mobile homes and the permanent population in mobile homes. The mobile home category includes RVs and boats and the permanent population in those housing options. The demographic characteristics summary also includes hotels and motels because many of these units are in vulnerable areas, and the proportion of seasonal units and hotel/motel units that are occupied at any point in time will have an important impact on the total population that may participate in an evacuation. Detailed demographic data for each individual TEZ within the region is included in Volume 5-11.

South Florida's resident population is projected to grow by over 330,000 permanent residents between 2010 and 2020, reaching almost 4.4 million in 2020. Miami-Dade County has the largest population in the region, and is projected to reach over 2.5 million residents by 2020. Broward County follows with over 1.7 million residents in 2020. Monroe County, with modest growth over the decade, and a population of just over 80 thousand in 2020, has the largest proportion of mobile home residents, although the proportion declines from 14.0% in 2010 to 11.4% in 2020. The number of hotel-motel units in the region is projected to grow to over 95,000 by 2020.

Figure VI-2

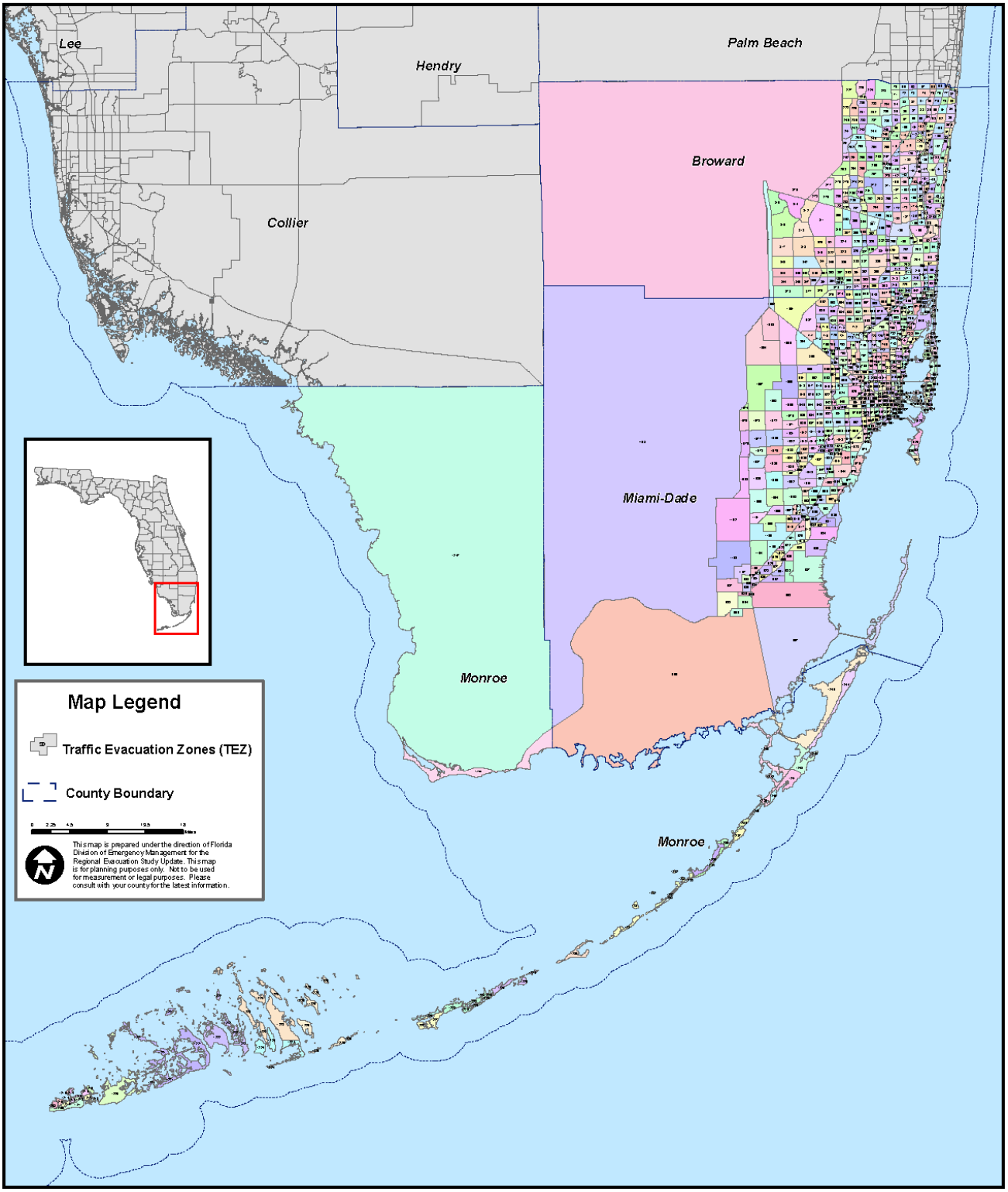
South Florida Regional Model Network



Sources: South Florida Regional Council, CDM Smith

Map Printed: August, 2015

Figure VI-3
South Florida Regional Model Transportation Evacuation Zone System (TEZ)



Sources: South Florida Regional Council, CDM Smith

Map Printed: August, 2015

Table VI-1 South Florida Demographic Characteristic Summary

County	Characteristic	Year		
		2010	2015	2020
Monroe	Occupied site-built homes	28,028	28,674	30,108
	Population in site-built homes	61,126	69,094	72,631
	Occupied mobile homes	4,601	4,483	4,137
	Population in mobile home	9,944	10,052	9,340
	Occupied hotel/motel units	13,765	13,751	13,751
Miami-Dade	Occupied site-built homes	853,802	900,184	947,847
	Population in site-built homes	2,284,122	2,393,577	2,506,494
	Occupied mobile homes	13,520	13,505	13,505
	Population in mobile home	38,087	37,319	36,484
	Occupied hotel/motel units	46,159	47,922	49,805
Broward	Occupied site-built homes	667,690	691,332	714,425
	Population in site-built homes	1,598,591	1,645,560	1,692,369
	Occupied mobile homes	18,343	19,092	19,720
	Population in mobile home	36,726	39,410	41,954
	Occupied hotel/motel units	32,226	32,182	32,182
South Florida	Occupied site-built homes	1,549,520	1,620,190	1,692,380
	Population in site-built homes	3,943,839	4,108,232	4,271,494
	Occupied mobile homes	36,464	37,080	37,362
	Population in mobile home	84,757	86,781	87,778
	Occupied hotel/motel units	92,150	93,856	95,739

Source: South Florida Regional Council. See discussion on page IV-6 for more information on the source of the small area data.

- **Planned Roadway Improvements** – To correspond to the three different sets of demographic data, three model networks were ultimately developed: the base 2010 network and two future year networks to correspond to the 2015 demographic data and the 2020 demographic data. The 2010 base model network was updated to reflect roadway capacity improvement projects completed between 2011 and 2015 to create the 2015 network. The 2015 network was then updated to reflect planned roadway capacity improvement projects expected to be implemented between 2016 and 2020 to create the 2020 network.

  The planned roadway improvements that were added to the network generally include only capacity improvement projects such as additional through lanes. **Table VI-2** identifies capacity improvement projects completed between 2011 and 2015 that were included in the 2015 network. Likewise, **Table VI-3** identifies capacity improvement projects planned for implementation between 2016 and 2020. The tables identify each roadway that will be improved as well as the extent of the improvement. For example, by 2015 in Broward County, SR 7 from Hallandale Beach Boulevard to Fillmore Steet will be widened to 6 lanes.

Table VI-2 South Florida Region Roadway Improvements, 2011-2015

County	Roadway	From	To	Number of Lanes
Miami-Dade	SR 924 (Gratigny Pkwy)	NW 46th Avenue	NW 43rd Avenue	8
	Dolphin Expressway	W of NW 17th Avenue	NW 12th Avenue	10
	Dolphin Expressway/NW 57th Avenue Interchange			8
	Dolphin Expressway (MIM)	W of 102nd Avenue	NW 107th Avenue	10
	Dolphin Expressway/NW 107th Ave Interchange			8
	SR 836	W of 127th Avenue	E of 137th Avenue	6
	SR 826	SW 40th Street	SR 826/874 Intersection	6
	SR 874	SR 826/874 Intersection	S of SW 56th Street	8
	SR 874	S of SW 56th Street	Snapper Creek Expressway	6
	SR 874	Snapper Creek Drive	Killian Parkway	10
	SR 823/NW 57th Avenue	W 49th St/103rd St	TO W 53rd St	6
	SR 821 (HEFT)	Bird Road	SR 836 (Dolphin Expressway)	10
	SR 821 (HEFT)	SW 216th Street	N of Eureka Drive	8
	SR 821 (HEFT)	S of Killian Parkway	N of SW 72nd Street	8
	NW 74th St/HEFT Interchange			N/A
	Turnpike/Campbell Drive Interchange	Campbell Drive		N/A
	Port of Miami Tunnel	Port of Miami	SR 836/I-395	4
Broward	SR 7	Hallandale Beach Blvd	Fillmore St	6
	Turnpike	Atlantic Blvd	Sawgrass Expressway	8
	Turnpike (SR 91)	Sawgrass Expressway	Palm Beach County line	8
	Turnpike	Homestead Extension-Turnpike (HEFT)	Griffin Rd	8
	Turnpike	Griffin Rd	Sunrise Blvd	8
	I-595/P3/CEI	I-75	W of I-95	10
	I-95	East Sample Rd	Palm Beach County line	10
	Andrews Ave Extn	NW 18th St	Copans Rd	4
	Pine Island Rd	I-595	Nova Dr	6
	I-95	Golden Glades	I-595	12
	Turnpike (SR 91)	HEFT (SR 821)	N of Johnson St	8
	Sawgrass Expressway	Atlantic Blvd	Coral Ridge Dr	6
	Eller Dr/ICTF (ICTF Overpass)			N/A

Sources: FDOT SIS First Five Year Plan, FDOT SIS Second Five Year Plan, South Florida Regional Council
Note: Projects included in this table are roadway improvement projects completed between 2006 and 2010 on roadways that are included in the regional transportation model network. Only projects that added roadway capacity, such as additional through lanes, were included. The list is not intended to be all inclusive of every transportation improvement project completed within the region. A list of historical projects completed during the last five years was included in this report because the base regional network developed for the study, along with the base demographic data, is for the year 2010.

It is important to note that Tables IV-2 and IV-3 are not intended to be all inclusive of every transportation improvement project completed within the region. The tables only identify key capacity improvement projects that impact the evacuation model network and are anticipated to have an impact on evacuation clearance times.

Table VI-3 South Florida Planned Roadway Improvements, 2016-2020

County	Roadway	From	To	Number of Lanes
Miami-Dade	SR 874 Extension	SR 874/Turnpike Intersection	128th Street	4
	Dolphin Expressway	I-95	SR 826	8+
	SR 997/Krome Avenue	SR 94 (Kendall Drive)	SR 90/SW 8th Street	4
	SR 997/Krome Avenue	SW 136th Street	SR 94 (Kendall Drive)	4
	NW 25th Street	NW 89th Court	NW 67th Avenue	6
	NW 25th Street Viaduct	NW 82nd Avenue	NW 68th Avenue	2
	SR 821 (HEFT)	SW 288th Street	SW 216th Street	6
	SR 997/Krome Avenue	SW 312 Street/Campbell Drive	SW 296 Street (Truck Bypass)	4
	SR 997/Krome Avenue	SW 184th Street	S of SW 136th Street	4
	SR 821 (HEFT)	SW 72nd Street	Bird Road	10
	SR 821 (HEFT)	NW 106th Street	I-75	10
	SR 821 (HEFT)	SR 836	NW 106th Street	10

Sources: FDOT SIS First Five Year Plan, FDOT SIS Second Five Year Plan, South Florida Regional Council
Note: Projects included in this table are roadway improvement projects planned for completion between 2016 and 2020 on roadways that are included in the regional transportation model network. Only projects that are planned to add roadway capacity, such as additional through lanes, were included. The list is not intended to be all inclusive of every transportation improvement project planned for completion within the region.

Note regarding Monroe County: Lane capacities for the segments of US 1 in Monroe County were defined in accordance with the "maximum sustainable traffic flow rates per functional evacuation lane" identified in correspondence from the Florida Department of Transportation, District 6, to the Florida Department of Community Affairs. FDOT District 6 has identified potential changes in the number of functional evacuation lanes on US 1 as a result of the incorporation of completed and planned shoulder improvements within Monroe County through 2015. Study parameters do not provide for the additional scenarios required to analyze the possibility of utilizing additional lanes in an evacuation. However, through the TIME interface and the regional model for South Florida, additional analysis can be conducted on these resources in the future as part of the detailed planning process.

- **Behavioral Assumptions** – For the South Florida Region, evacuation rates for site-built homes and mobile/manufactured homes are provided by county and summarized in **Figure VI-4** through **Figure VI-9**. Other rates, such as out of county trip rates, vehicle use rates, public shelter use rates, friend/relative refuge use rates, hotel/motel refuge use rates, and other refuge use rates, are detailed by county, storm threat, and evacuation zone in Volume 5-11.

A review of the evacuation rates for the South Florida region illustrates that evacuation participation rates increase as the evacuation level increases, and participation rates for persons living in mobile/manufactured homes are generally higher than for persons living in site-built homes. It should be noted that in Broward and Miami-Dade Counties a certain percentage of the population evacuates, even when they are not living in an area that is ordered to evacuate. These people are commonly referred to as shadow evacuees. Shadow evacuation rates are also included in **Figure VI-4** through **Figure VI-9**.

Please note that the original behavioral response rates provided by SRESP in Volume 2 were modified to fit the evacuation zones created by Broward County. The original rates were based on a five-zone system; however, Broward changed to a 4-zone system (for SRESP): Zone A/B, Zone C, Zone D, Zone E. In the original study published in 2010, Miami-Dade County used a three-zone system (Zone A, Zone B/C and Zone D/E), and a corresponding adjustment was made in the behavioral response rates; the County revised its evacuation zones after the original study and now uses a five-zone system, so the un-adjusted response rates were used in the current update. Monroe County's four evacuation zones are not based on storm surge, but are apportioned geographically by sub-regions of the county: Key West, Lower Keys, Middle Keys and Upper Keys.

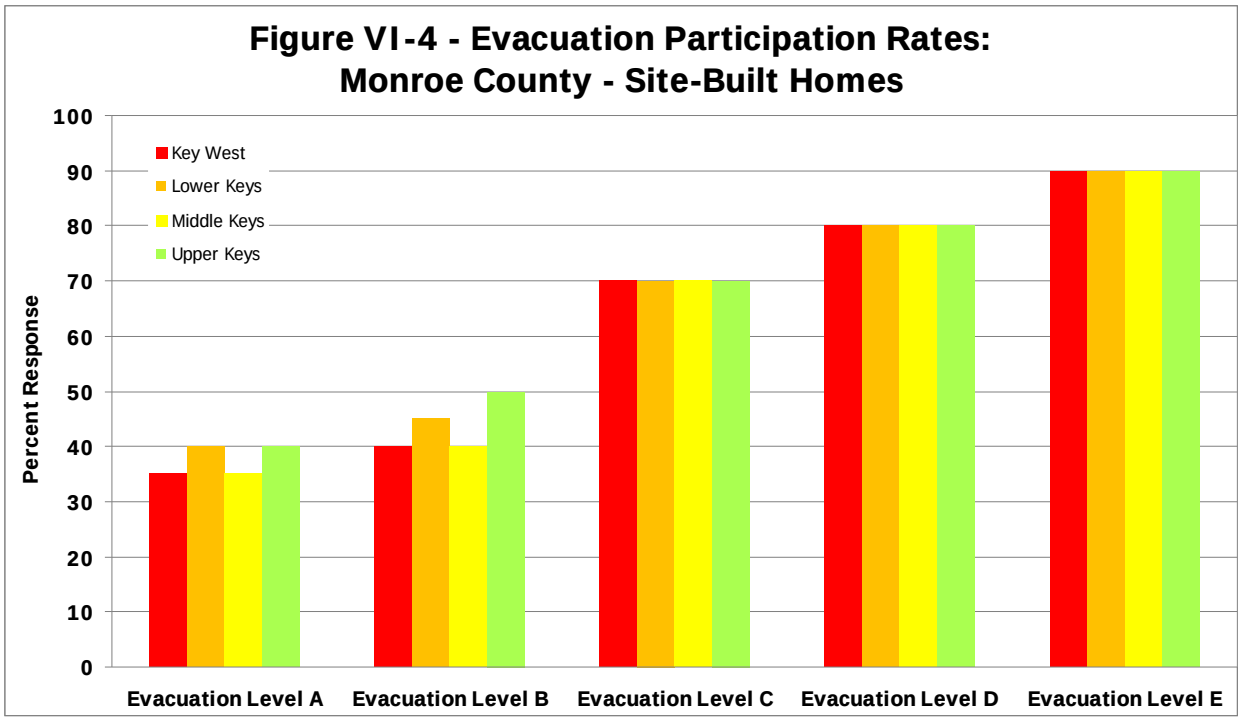


Figure VI-4 - Evacuation Participation Rates:
Monroe County - Site-Built Homes
Percent Response
100
90
80
70
60
50
40
30
20
10
0
Key West
Lower Keys
Middle Keys
Upper Keys
Evacuation Level A
Evacuation Level B
Evacuation Level C
Evacuation Level D
Evacuation Level E

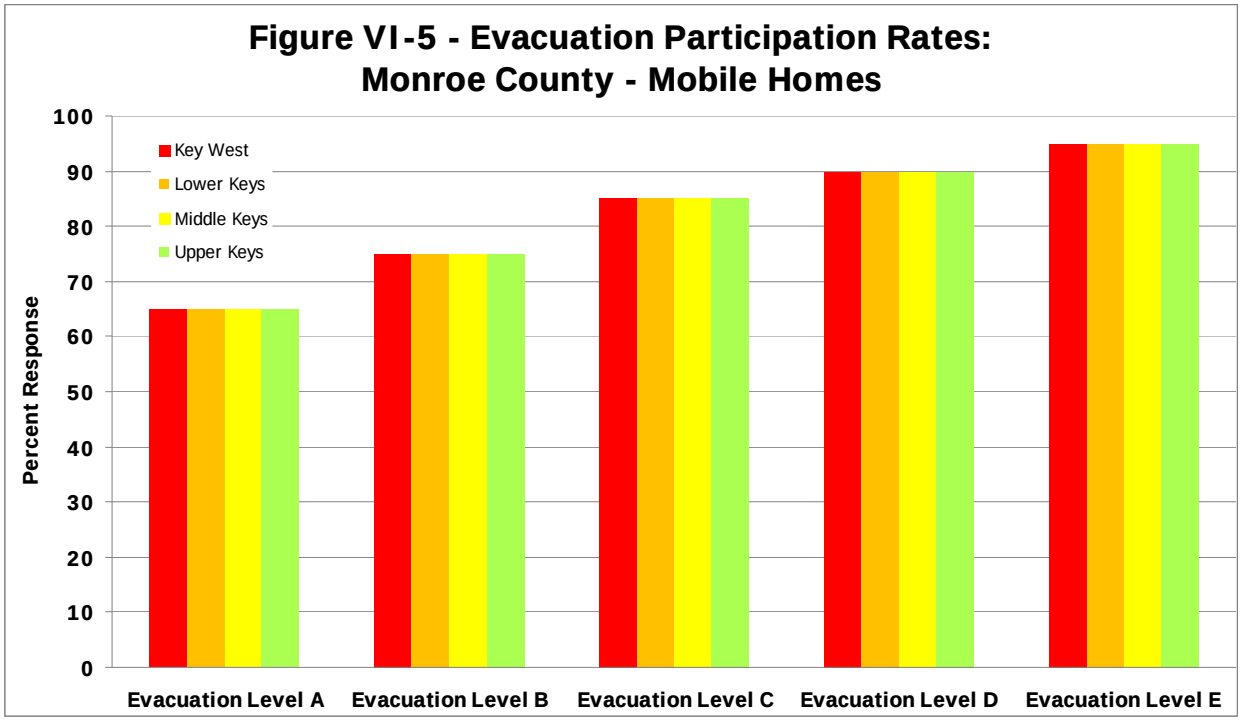


Figure VI-5 - Evacuation Participation Rates:
Monroe County - Mobile Homes
Percent Response
100
90
80
70
60
50
40
30
20
10
0
Key West
Lower Keys
Middle Keys
Upper Keys
Evacuation Level A
Evacuation Level B
Evacuation Level C
Evacuation Level D
Evacuation Level E

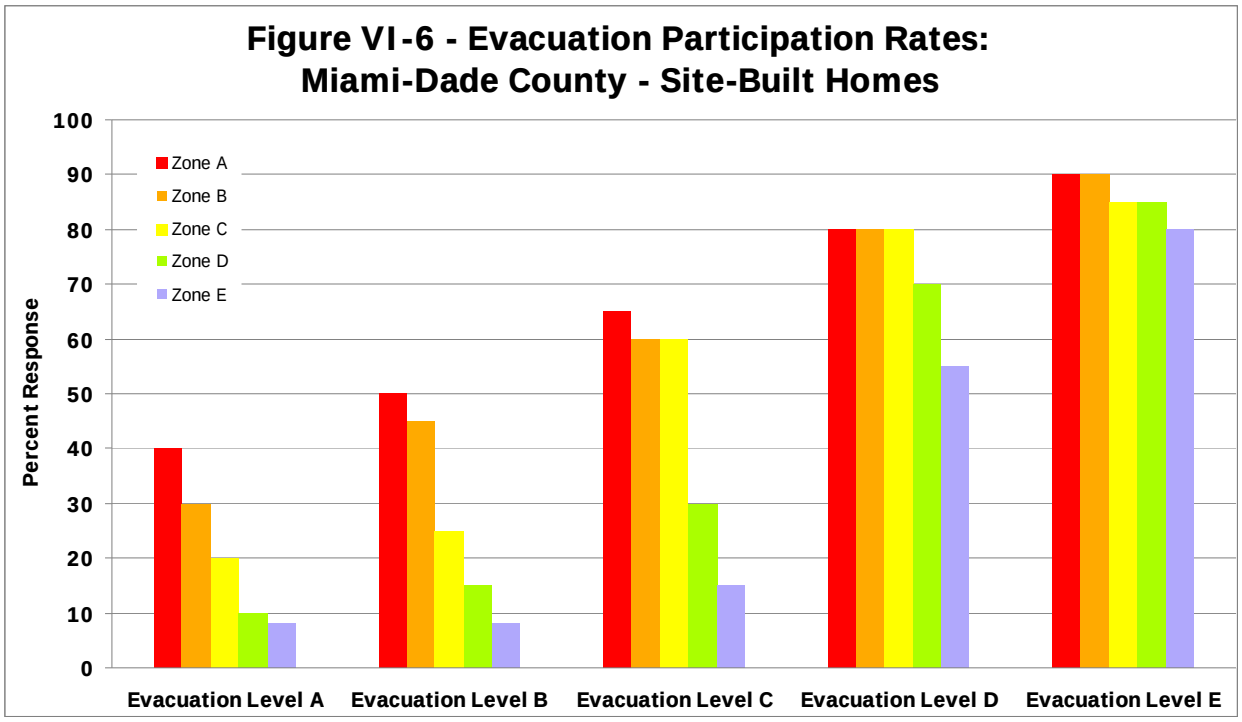


Figure VI-6 - Evacuation Participation Rates:
Miami-Dade County - Site-Built Homes
Percent Response
100
90
80
70
60
50
40
30
20
10
0
Zone A
Zone B
Zone C
Zone D
Zone E
Evacuation Level A
Evacuation Level B
Evacuation Level C
Evacuation Level D
Evacuation Level E

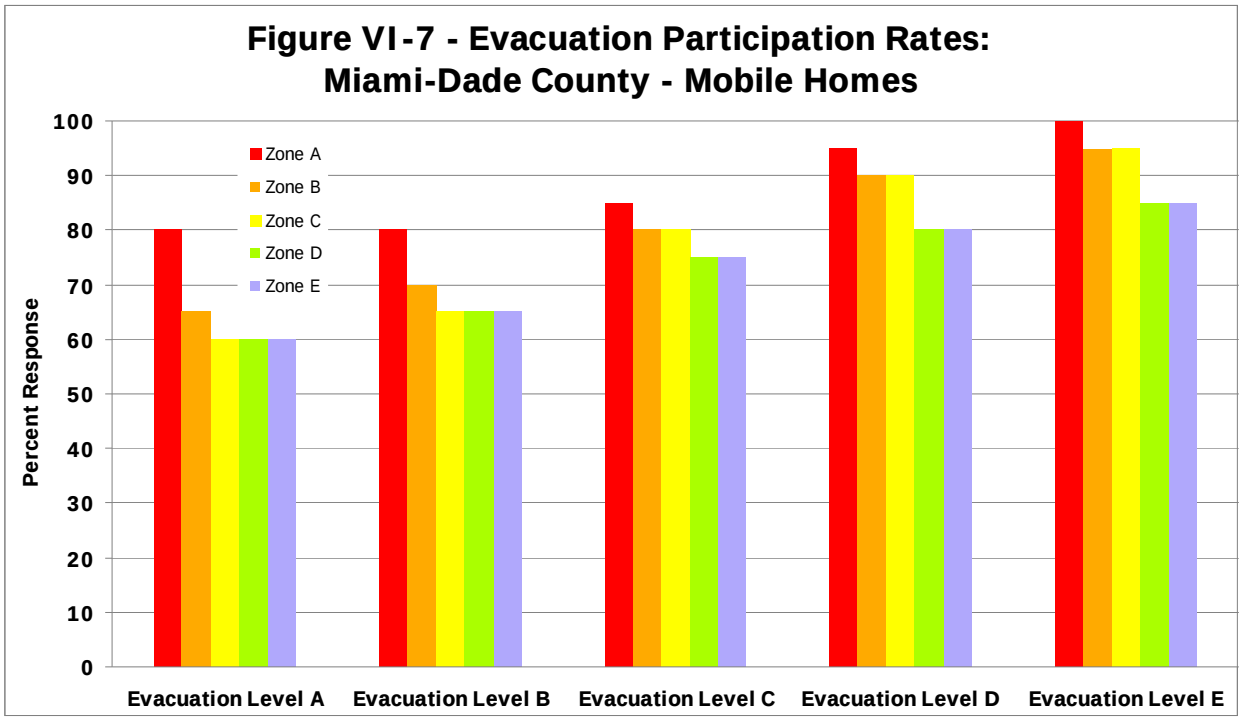


Figure VI-7 - Evacuation Participation Rates:
Miami-Dade County - Mobile Homes
Percent Response
100
90
80
70
60
50
40
30
20
10
0
Zone A
Zone B
Zone C
Zone D
Zone E
Evacuation Level A
Evacuation Level B
Evacuation Level C
Evacuation Level D
Evacuation Level E

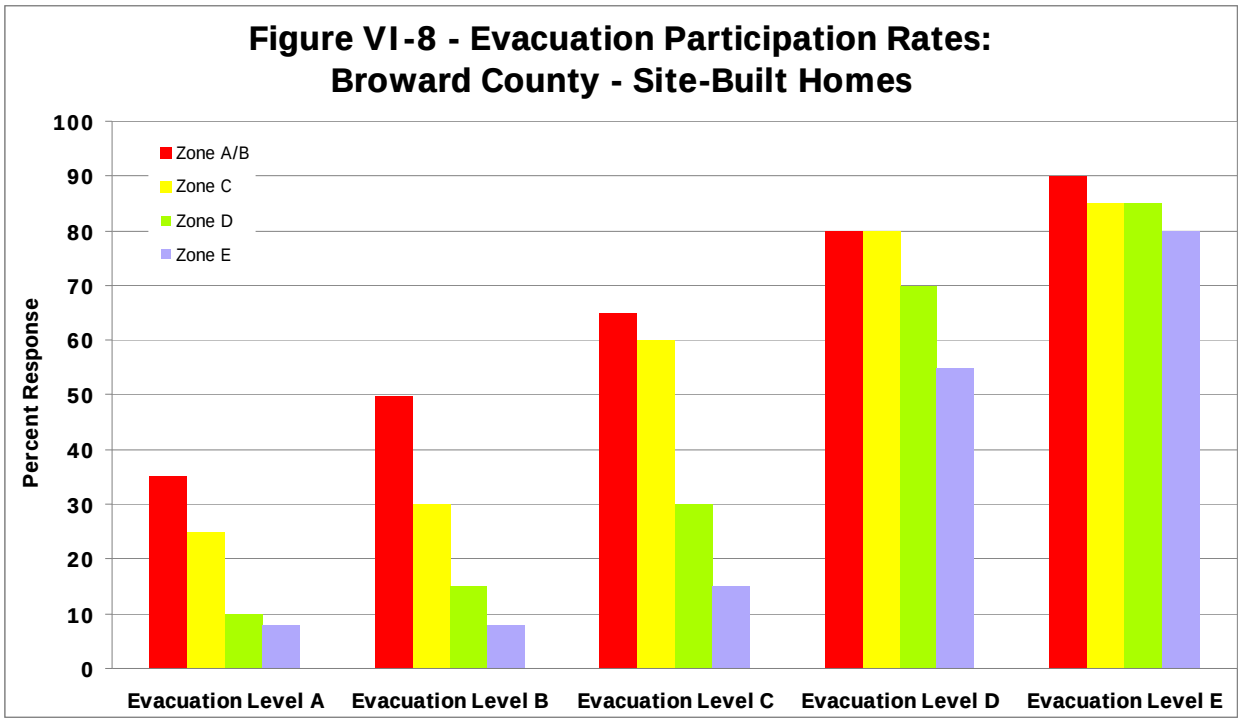


Figure VI-8 - Evacuation Participation Rates:
Broward County - Site-Built Homes
Percent Response
100
90
80
70
60
50
40
30
20
10
0
Zone A/B
Zone C
Zone D
Zone E
Evacuation Level A
Evacuation Level B
Evacuation Level C
Evacuation Level D
Evacuation Level E

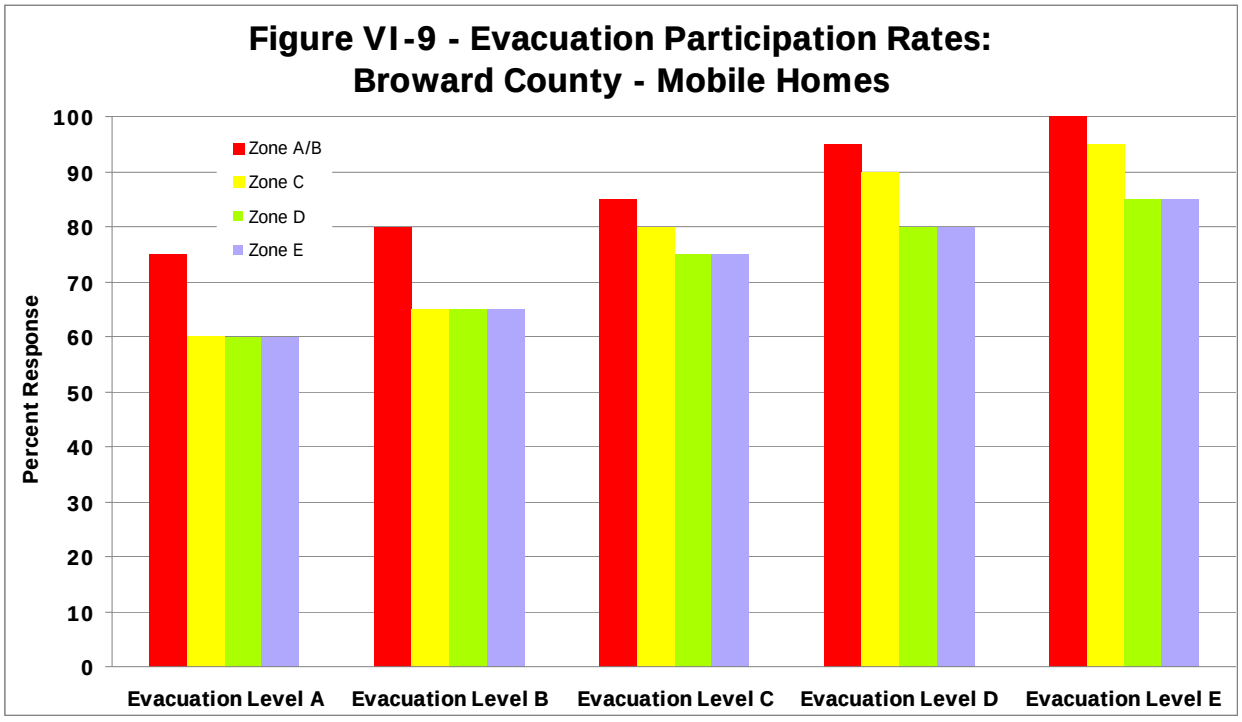


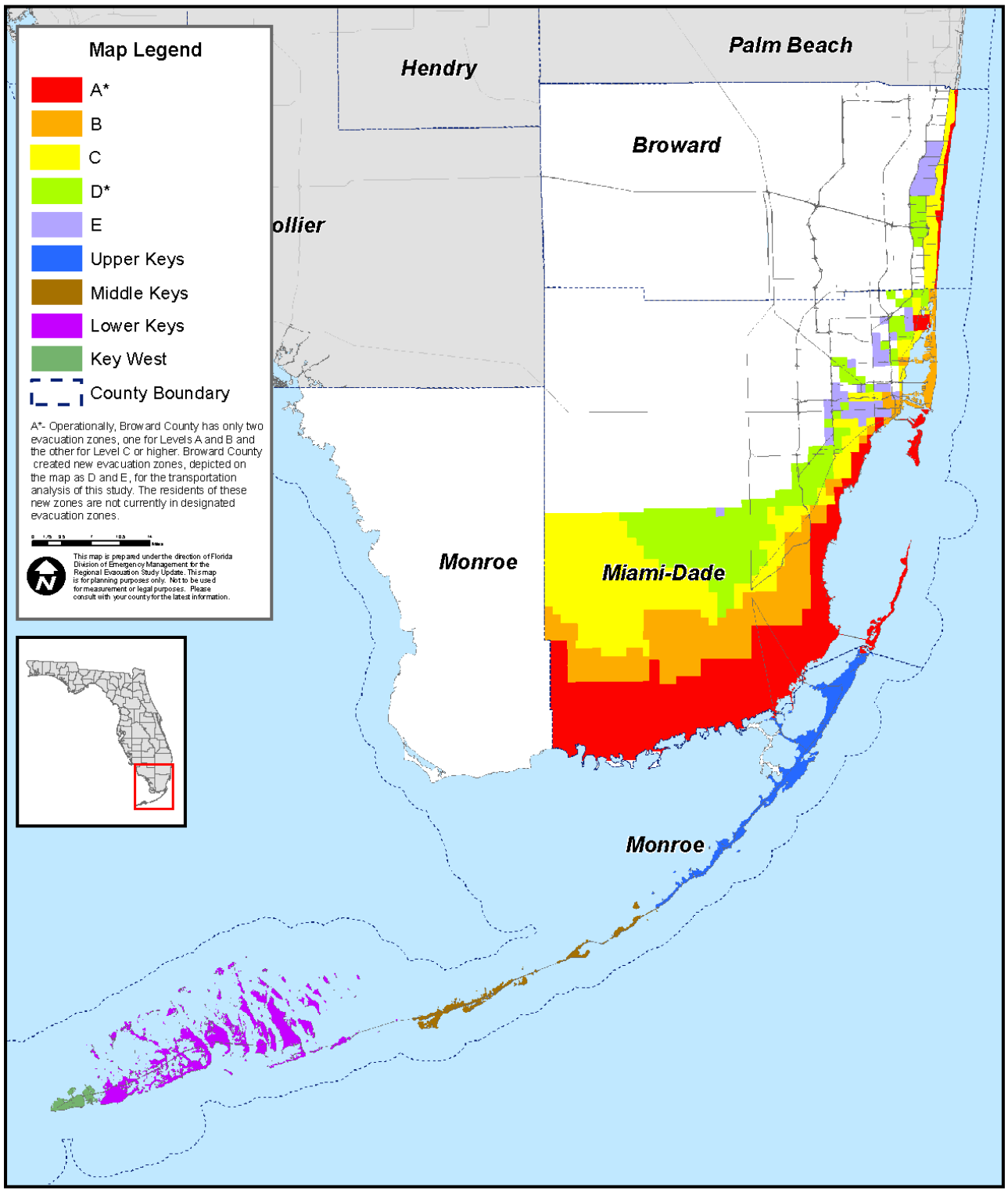
Figure VI-9 - Evacuation Participation Rates:
Broward County - Mobile Homes
Percent Response
100
90
80
70
60
50
40
30
20
10
0
Zone A/B
Zone C
Zone D
Zone E
Evacuation Level A
Evacuation Level B
Evacuation Level C
Evacuation Level D
Evacuation Level E

- **Shelters** – In order for the transportation model to accurately assign public shelter trips to the correct location, a complete list of available public shelters needs to be available. The shelters were categorized as either primary or other, with primary indicating that the shelter is compliant with American Red Cross standards for a shelter and other indicating all other shelters. In the three-county region there is a total of 113 primary shelters, which can host more than 156,000 persons during an evacuation event. The shelters in Monroe County are available only for Level A and B storms; all storms of Level C or higher engender a general evacuation order for all visitors and residents.

- **Evacuation Zones** – The final input variable that is needed to complete the transportation evacuation model is the delineation of evacuation zones for all coastal counties. Local county emergency managers have the responsibility of identifying and defining evacuation zones for their county. Operationally, Broward County has only two evacuation zones, one for Levels A and B and the other for Levels C, D and E. However, for the transportation analysis of this study, Broward County created new evacuation zones D and E. Miami-Dade County reviewed the results of the 2010 Study and developed a set of Storm Surge Planning Zones that revised the County's original three-zone system to a five-zone system, and significantly expanded the geographic extent of the County's evacuation zones. The new zones were used for the current update. Evacuation zones for the South Florida Region are illustrated in **Figure VI-10**. County level evacuation zone maps are also included in Volume 5-11.

Figure VI-10

South Florida Regional Evacuation Zones



Sources: South Florida Regional Council, CDM Smith

Map Printed: August, 2015

G. TIME User Interface

CDM Smith Associates developed the Transportation Interface for Modeling Evacuations (TIME) to make it easier for RPC staff and transportation planners to use the model and implement the evacuation methodology. The TIME interface is based on an ArcGIS platform and is essentially a condensed transportation model, which provides a user friendly means of modifying input variables that would change the clearance times for various evacuation scenarios.

The evacuation model variables include a set of distinguishing characteristics that could apply to evacuation scenarios as selection criteria. These following variables may be selected using the TIME interface and allow the user to retrieve the best results from various evacuation alternatives:

- Analysis time period;
- Highway network;
- Behavioral response;
- One-way evacuation operations;
- University population;
- Tourist occupancy rates;
- Shelters;
- Counties evacuating;
- Evacuation level;
- Response curve hours; and,
- Evacuation Phasing.

H. Vulnerable Population

Using a combination of the demographic data, behavioral assumptions, and evacuation zones, the vulnerable population in each county could be determined by evacuation level. For the purposes of the transportation analysis, the vulnerable population, or population-at-risk, is defined as the total population living within the county designated evacuation zones for each evacuation level. This population is living in an area that is at risk for severe flooding during a storm event. The vulnerable population for the South Florida Region for 2015 is identified in **Table VI-4**, summarized by evacuation zone and split between site-built homes and mobile/manufactured homes. Vulnerable population for 2020 is summarized in **Table VI-5**.

Table VI-4 Vulnerable Population in South Florida for 2015

	Evacuation Zone A	Evacuation Zone B	Evacuation Zone C	Evacuation Zone D	Evacuation Zone E
Monroe County*					
Site-built Homes	69,095				
Mobile/Manuf. Homes	10,052				
TOTAL	79,147				
Miami-Dade County					
Site-built Homes	70,688	358,786	289,508	390,224	280,235
Mobile/Manuf. Homes	815	3,515	4,895	5,715	3,645
TOTAL	71,504	362,300	294,403	395,939	283,881
Broward County*					
Site-built Homes	48,951		97,706	41,104	88,550
Mobile/Manuf. Homes	30		1,032	793	2,972
TOTAL	48,981		98,739	41,897	91,522

Note: Vulnerable population determined using SRESP small area data and county-provided evacuation zones. Vulnerable population numbers are not inclusive, meaning population numbers listed for a higher zone are not included in the lower zone. For example, vulnerable population listed for Evacuation Zone B does not include vulnerable population listed for Evacuation Zone A.
** For the purposes of this study, Broward County has a combined A/B zone and all of Monroe County is considered vulnerable.*

Table VI-5 – Vulnerable Population in South Florida for 2020

	Evacuation Zone A	Evacuation Zone B	Evacuation Zone C	Evacuation Zone D	Evacuation Zone E
Monroe County*					
Site-built Homes	72,632				
Mobile/Manuf. Homes	9,340				
TOTAL	81,972				
Miami-Dade County					
Site-built Homes	75,891	392,899	308,081	401,609	295,978
Mobile/Manuf. Homes	822	3,520	4,715	5,543	3,659
TOTAL	76,713	396,419	312,796	407,153	299,637
Broward County*					
Site-built Homes	50,715		100,357	45,901	91,994
Mobile/Manuf. Homes	30		1,055	827	3,008
TOTAL	50,745		101,413	46,728	95,002

Note: Vulnerable population determined using SRESP small area data and county-provided evacuation zones. Vulnerable population numbers are not inclusive, meaning population numbers listed for a higher zone are not included in the lower zone. For example, vulnerable population listed for Evacuation Zone B does not include vulnerable population listed for Evacuation Zone A.
** For the purposes of this study, Broward County has a combined A/B zone and all of Monroe County is considered vulnerable.*

In addition, based again on the demographic data, behavioral assumptions, and evacuation zones, the planned destinations of vulnerable population in each county could be determined by evacuation level. Destinations include friends and family, hotel/motel, public shelter, and other locations. Vulnerable population destinations for the South Florida Region are identified in **Table VI-6** for 2015 and in **Table VI-7** for 2020.

The vulnerable shadow population is provided in **Table VI-8** for both 2015 and 2020. The vulnerable shadow population was determined using the behavioral assumptions for evacuating shadow population and is based on evacuation level (storm category), not evacuation zone.

Table VI-6 Vulnerable Population by Destination for 2015

	Evacuation Zone A	Evacuation Zone B	Evacuation Zone C	Evacuation Zone D	Evacuation Zone E
Monroe County*					
To Friends and Family	49,402				
To Hotel/ Motel	18,607				
To Public Shelter	3,502				
To Other Destination	7,636				
Miami-Dade County					
To Friends and Family	46,477	235,495	191,362	257,360	184,522
To Hotel/ Motel	14,219	72,109	58,391	78,616	56,412
To Public Shelter	3,616	18,291	14,965	39,594	28,388
To Other Destination	7,191	36,406	29,685	20,368	14,559
Broward County*					
To Friends and Family	36,733		73,951	31,343	68,344
To Hotel/ Motel	7,347		14,811	6,285	13,728
To Public Shelter	982		4,989	2,134	4,725
To Other Destination	3,919		4,989	2,134	4,725

Note: Vulnerable population destinations determined using SRESP small area data and county-provided evacuation zones. Vulnerable population numbers are not inclusive, meaning population numbers listed for a higher zone are not included in the lower zone. For example, vulnerable population listed for Evacuation Zone B does not include vulnerable population listed for Evacuation Zone A.

** For the purposes of this study, Broward County has a combined A/B zone and all of Monroe County is considered vulnerable.*

Table VI-7 Vulnerable Population by Destination for 2020

	Evacuation Zone A	Evacuation Zone B	Evacuation Zone C	Evacuation Zone D	Evacuation Zone E
Monroe County*					
To Friends and Family	51,282				
To Hotel/ Motel	19,249				
To Public Shelter	3,553				
To Other Destination	7,888				
Miami-Dade County					
To Friends and Family	49,863	257,672	203,317	264,649	194,764
To Hotel/ Motel	15,260	78,932	62,088	80,876	59,562
To Public Shelter	3,877	19,997	15,876	40,715	29,964
To Other Destination	7,712	39,818	31,515	20,912	15,348
Broward County*					
To Friends and Family	38,056		75,954	34,963	70,951
To Hotel/ Motel	7,612		15,212	7,009	14,250
To Public Shelter	1,017		5,123	2,378	4,901
To Other Destination	4,060		5,123	2,378	4,901

Note: Vulnerable population destinations determined using SRESP small area data and county-provided evacuation zones. Vulnerable population numbers are not inclusive, meaning population numbers listed for a higher zone are not included in the lower zone. For example, vulnerable population listed for Evacuation Zone B does not include vulnerable population listed for Evacuation Zone A.
** For the purposes of this study, Broward County has a combined A/B zone and all of Monroe County is considered vulnerable.*

Table VI-8 Vulnerable Shadow Evacuation Population, 2015 and 2020

	Evacuation Level A	Evacuation Level B	Evacuation Level C	Evacuation Level D	Evacuation Level E
2015					
Monroe County	0	0	0	0	0
Miami-Dade County	314,712	264,762	273,021	316,978	264,937
Broward County	160,048	166,987	153,115	245,635	332,972
2020					
Monroe County	0	0	0	0	0
Miami-Dade County	331,727	273,933	280,933	329,525	272,009
Broward County	165,759	173,082	159,460	253,545	342,195

Note: Vulnerable shadow population determined using SRESP behavioral data and county-provided evacuation zones. As opposed to Tables VI-4 through VI-7, vulnerable population numbers used for this table are inclusive, meaning population numbers listed for a higher zone are included in the lower zone. For example, vulnerable population listed for Evacuation Zone B does include vulnerable population listed for Evacuation Zone A. The resulting numbers are then subtracted from the evacuating population as reported in the modeling results to provide the vulnerable shadow evacuation population amount by county, per evacuation level.

I. Evacuation Model Scenarios

There are literally thousands of possible combinations of variables that can be applied using the evacuation transportation model, which will result in thousands of possible outcomes. For the purposes of this analysis, two distinct sets of analyses were conducted using the SRESP evacuation transportation model, including one set of analysis for growth management purposes and one set of analysis for emergency management purposes. The two sets of analysis include the following:

- **Base Scenarios** – The base scenarios were developed to estimate a series of worst case scenarios and are identical for all eleven RPCs across the State. These scenarios assume 100 percent of the vulnerable population evacuates and includes impacts from counties outside of the RPC area. These scenarios are generally designed for growth management purposes, in order to ensure that all residents that choose to evacuate during an event are able to do so. The base scenarios for South Florida are identified in **Table VI-9**.

- **Operational Scenarios** – The operational scenarios were developed by the RPCs in coordination with local county emergency managers and are designed to provide important information to emergency management personnel to plan for different storm events. These scenarios are different from region to region and vary for each evacuation level. The operational scenarios for South Florida are identified in **Table VI-10**.

Because of the numerous possible combinations of variables that can be applied in the model, the evacuation transportation model is available for use through the South Florida Regional Council to continue testing combinations of options and provide additional information to emergency managers.

Table VI-9 Base Scenarios

	Base Scenario 1 Level A 2015	Base Scenario 2 Level B 2015	Base Scenario 3 Level C 2015	Base Scenario 4 Level D 2015	Base Scenario 5 Level E 2015
Demographic Data	2015	2015	2015	2015	2015
Highway Network	2015	2015	2015	2015	2015
One-Way Operations	None	None	None	None	None
University Population	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring
Tourist Rate	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary	Primary	Primary
Response Curve	12-hour	12-hour	12-hour	12-hour	12-hour
Evacuation Phasing	None	None	None	None	None
Behavioral Response	100%	100%	100%	100%	100%
Evacuation Zone	A	B	C	D	E
Counties Evacuating	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier
	Base Scenario 6 Level A 2020	**Base Scenario 7 Level B 2020**	**Base Scenario 8 Level C 2020**	**Base Scenario 9 Level D 2020**	**Base Scenario 10 Level E 2020**
Demographic Data	2020	2020	2020	2020	2020
Highway Network	2020	2020	2020	2020	2020
One-Way Operations	None	None	None	None	None
University Population	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring
Tourist Rate	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary	Primary	Primary
Response Curve	12-hour	12-hour	12-hour	12-hour	12-hour
Evacuation Phasing	None	None	None	None	None
Behavioral Response	100%	100%	100%	100%	100%
Evacuation Zone	A	B	C	D	E
Counties Evacuating	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier

Table VI-10 Operational Scenarios

	Operational Scenario 1 Level A 2015	Operational Scenario 2 Level B 2015	Operational Scenario 3 Level C 2015	Operational Scenario 4 Level D 2015	Operational Scenario 5 Level E 2015
Demographic Data	2015	2015	2015	2015	2015
Highway Network	2015	2015	2015	2015	2015
One-Way Operations	None	None	None	None	None
University Population	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring
Tourist Rate	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary	Primary	Primary
Response Curve	12-hour	12-hour	12-hour	12-hour	12-hour
Evacuation Phasing	None	None	None	None	None
Behavioral Response	Planning	Planning	Planning	Planning	Planning
Evacuation Zone	A	B	C	D	E
Counties Evacuating	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier
	Operational Scenario 6 Level A 2020	**Operational Scenario 7 Level B 2020**	**Operational Scenario 8 Level C 2020**	**Operational Scenario 9 Level D 2020**	**Operational Scenario 10 Level E 2020**
Demographic Data	2020	2020	2020	2020	2020
Highway Network	2020	2020	2020	2020	2020
One-Way Operations	None	None	None	None	None
University Population	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring
Tourist Rate	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary	Primary	Primary
Response Curve	12-hour	12-hour	12-hour	12-hour	12-hour
Evacuation Phasing	None	None	None	None	None
Behavioral Response	Planning	Planning	Planning	Planning	Planning
Evacuation Zone	A	B	C	D	E
Counties Evacuating	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier	Broward Miami-Dade Monroe Palm Beach Collier

J. Clearance Time Results

Each of the ten base scenarios and ten operational scenarios were modeled for the South Florida Region using the regional evacuation model. Results were derived from the model to summarize the evacuating population, evacuating vehicles, clearance times, and critical congested roadways. Detailed results are discussed in Volume 4-11, Chapter IV. Clearance times are presented here, since the determination of clearance time is one of the most important outcomes from the evacuation transportation analysis.

Calculated clearance times are used by county emergency managers as one input to determine when to recommend an evacuation order. This calculation can include the population-at-risk, shadow evacuees, as well as evacuees from other counties anticipated to pass through the county. Clearance time is developed to include the time required for evacuees to secure their homes and prepare to leave, the time spent by all vehicles traveling along the evacuation route network, and the additional time spent on the road caused by traffic and road congestion. Clearance time does not relate to the time any one vehicle spends traveling along the evacuation route network, nor does it guarantee vehicles will safely reach their destination once outside the County. The four clearance times that are calculated as part of the evacuation transportation analysis include the following:

- **Clearance Time to Shelter** – The time necessary to safely evacuate vulnerable residents and visitors to a "point of safety" within the county based on a specific hazard, behavioral assumptions and evacuation scenario. Calculated from the point in time when the evacuation order is given to the point in time when the last vehicle reaches a point of safety within the county. Key points to remember for clearance time to shelter include:
  - All in-county trips reach their destination within the county; and,
  - This definition does not include any out-of-county trips.

- **In-County Clearance Time** – The time required from the point an evacuation order is given until the last evacuee can either leave the evacuation zone or arrive at safe shelter within the county. This does not include those evacuees leaving the county on their own. Key points to remember for in-county clearance time include:
  - All in-county trips reach their destination within the county;
  - All out-of-county trips exit the evacuation zone, but may still be located in the county; and,
  - This definition does not include out-of-county pass-through trips from adjacent counties, unless they evacuate through an evacuation zone.

- **Out-of-County Clearance Time** – The time necessary to safely evacuate vulnerable residents and visitors to a "point of safety" within the county based on a specific hazard, behavioral assumptions and evacuation scenario. Calculated from the point an evacuation order is given to the point in time when the last vehicle assigned an external destination exits the county. Key points to remember for out-of-county clearance time include:
  - The roadway network within the county is clear;
  - All out-of-county trips exit the county, including out-of-county pass-through trips from adjacent counties; and,
  - All in-county trips reach their destination.

- **Regional Clearance Time** – The time necessary to safely evacuate vulnerable residents and visitors to a "point of safety" within the (RPC) region based on a specific hazard, behavioral assumptions and evacuation scenario. Calculated from the point in time when the evacuation order is given to the point in time when the last vehicle assigned an external destination exits the region. Key points to remember for regional clearance time include:
  - The roadway network within the RPC is clear;
  - All out-of-county trips exit the RPC, including out-of-county pass-through trips from adjacent counties;
  - All in-county trips reach their destination; and,
  - Regional clearance time is equal to the largest out-of-county clearance time for a given scenario for any of the counties within the RPC, since the out-of-county clearance time includes out-of-county pass-through trips from adjacent counties.

Calculated clearance times are used by county emergency managers as one input to determine when to recommend an evacuation order. Clearance times for each of the base scenarios are summarized in **Table VI-11** and **Table VI-12**, while clearance times for each of the operational scenarios are summarized in **Table VI-13** and **Table VI-14.** Clearance time includes several components, including the mobilization time for the evacuating population to prepare for an evacuation (pack supplies and personal belongs, load their vehicle, etc.), the actual time spent traveling on the roadway network, and the delay time caused by traffic congestion.

Base Scenarios

For South Florida in 2015, in-county clearance times for the base scenarios range from 13 hours in Broward County for the evacuation Level A scenario to 87 hours for evacuation Level E scenario. Clearance Time to Shelter shows a similar pattern, with clearance times for the base scenarios ranging from 13 hours for Broward County in the evacuation Level A scenario to 86.5 hours for Miami-Dade County for the evacuation Level E scenario in 2015. In-county clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low.

In 2020, in-county clearance times for the base scenarios range from 14.5 hours for the evacuation Level A scenario to 86 hours for the evacuation Level E scenario. Clearance Time to Shelter shows a similar pattern, with clearance times for the base scenarios ranging from 14.5 hours for the Broward County evacuation Level A scenario to 85.5 hours for Broward County for evacuation Level E scenario. In-county clearance times for Miami-Dade County are typically equal to or above Monroe County out-of-county clearance times. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county. Miami-Dade County has an evacuation zone where US 1 enters from Monroe County, so in-county clearance time for Miami-Dade in all base scenarios will reflect the out-of-county clearance time for Monroe County.

In 2015, out-of-county clearance times for the base scenarios range from 25 hours in Monroe County for the base evacuation Level A scenario to 87 hours in Broward County for the evacuation Level E scenario. Out-of-county clearance times range from 25 hours in Monroe County for the base evacuation Level A scenario to 86 hours in Broward County in 2020.

Regional clearance time for the three-county South Florida region ranges from 27 hours to 87 hours in 2015 and from 27 to 86 hours in 2020.

Operational Scenarios

In-county clearance times for the 2015 operational scenarios range from 12.5 hours to 74.5 hours, depending upon the county and the scenario. Clearance Time to Shelter for the 2015 operational scenarios ranges from 12.5 hours to 74 hours. In-county clearance times for Broward County remain close to the 12-hour response curve for lower level evacuation scenarios. Clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low.

In 2020, in-county clearance times for the operational scenarios vary from 12.5 hours for the Level A scenario in Broward County to 71.5 hours for the Level E evacuation in Broward County. Clearance Time to Shelter shows a similar pattern, with clearance times for the base scenarios ranging from 12.5 hours to 71 hours. In-county clearance times for Miami-Dade County are typically equal to or above Monroe County out-of-county clearance. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county. Miami-Dade County has an evacuation zone where US 1 enters from Monroe County, so in-county clearance time for Miami-Dade in all regional evacuations will reflect the out-of-county clearance time for Monroe County.

Out-of-county clearance times for the 2015 operational scenarios range from 23.5 hours to 74.5 hours. Out-of-county clearance times range from 23.5 to 71.5 in 2020. Regional clearance times for the three-county South Florida region range from 25.5 hours to 74.5 hours in 2015. This time ranges from 25.5 to 71.5 hours in 2020, a reduction of 3 hours, which likely reflects additional roadway improvements.

Table VI-11 2015 Clearance Times for Base Scenarios

	Evacuation Level A Base Scenario 1	Evacuation Level B Base Scenario 2	Evacuation Level C Base Scenario 3	Evacuation Level D Base Scenario 4	Evacuation Level E Base Scenario 5
Clearance Time to Shelter					
Monroe – Key West					
Monroe – Lower Keys					
Monroe – Middle Keys					
Monroe – Upper Keys					
Monroe – Total					
Miami-Dade County	15.0	28.0	37.0	72.0	86.5
Broward County	13.0	17.5	31.5	53.5	60.0
In-County Clearance Time					
Monroe – Key West	13.0	13.0	13.0	13.0	13.0
Monroe – Lower Keys	15.0	16.0	18.0	18.0	18.0
Monroe – Middle Keys	19.5	20.5	23.5	23.5	23.5
Monroe – Upper Keys	25.5	26.0	26.5	26.5	26.5
Monroe – Total					
Miami-Dade County	25.5	28.0	37.0	72.0	86.5
Broward County	13.0	17.5	31.5	72.0	87.0
Out-of-County Clearance Time					
Monroe – Key West	12.5	12.5	12.5	12.5	12.5
Monroe – Lower Keys	14.5	15.5	17.5	17.5	17.5
Monroe – Middle Keys	19.0	20.0	23.0	23.0	23.0
Monroe – Upper Keys	25.0	25.5	26.0	26.0	26.0
Monroe – Total					
Miami-Dade County	26.0	28.0	37.0	72.0	86.5
Broward County	27.0	29.0	42.0	72.5	87.0
Regional Clearance Time					
South Florida	27.0	29.0	42.0	72.5	87.0

Note: In-county clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low. The base scenarios use a 12-hour response curve. Also, in-county clearance times for Miami-Dade County are typically equal to or above Monroe County out-of-county clearance times for all level B or higher scenarios that include Monroe County evacuating. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county, including the Miami-Dade County evacuation zone located where US 1 enters from Monroe County.

Table VI-12 2020 Clearance Times for Base Scenarios

	Evacuation Level A Base Scenario 6	Evacuation Level B Base Scenario 7	Evacuation Level C Base Scenario 8	Evacuation Level D Base Scenario 9	Evacuation Level E Base Scenario 10
Clearance Time to Shelter					
Monroe – Key West					
Monroe – Lower Keys					
Monroe – Middle Keys					
Monroe – Upper Keys					
Monroe – Total					
Miami-Dade County	16.0	29.5	41.5	63.0	85.5
Broward County	14.5	17.0	33.5	43.5	55.0
In-County Clearance Time					
Monroe – Key West	13.0	13.0	13.0	13.0	13.0
Monroe – Lower Keys	15.5	16.0	18.5	18.5	18.5
Monroe – Middle Keys	20.0	21.0	24.0	24.0	24.0
Monroe – Upper Keys	25.5	25.5	27.5	27.5	27.5
Monroe – Total					
Miami-Dade County	25.5	29.5	41.5	63.5	85.5
Broward County	14.5	17.0	33.5	63.5	86.0
Out-of-County Clearance Time					
Monroe – Key West	12.5	12.5	12.5	12.5	12.5
Monroe – Lower Keys	15.0	15.5	18.0	18.0	18.0
Monroe – Middle Keys	19.5	20.5	23.5	23.5	23.5
Monroe – Upper Keys	25.0	25.0	27.0	27.0	27.0
Monroe – Total					
Miami-Dade County	26.5	29.5	41.5	63.5	85.5
Broward County	27.0	30.5	42.5	63.5	86.0
Regional Clearance Time					
South Florida	27.0	30.5	42.5	63.5	86.0

Note: In-county clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low. The base scenarios use a 12-hour response curve. Also, in-county clearance times for Miami-Dade County are typically equal to or above Monroe County out-of-county clearance times for all Level B or higher scenarios that include Monroe County evacuating. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county, including the Miami-Dade County evacuation zone located where US 1 enters from Monroe County.

Table VI-13 2015 Clearance Times for Operational Scenarios

	Evacuation Level A Operational Scenario 1	Evacuation Level B Operational Scenario 2	Evacuation Level C Operational Scenario 3	Evacuation Level D Operational Scenario 4	Evacuation Level E Operational Scenario 5
Clearance Time to Shelter					
Monroe – Key West					
Monroe – Lower Keys					
Monroe – Middle Keys					
Monroe – Upper Keys					
Monroe – Total					
Miami-Dade County	14.0	20.0	27.5	41.5	74.0
Broward County	12.5	13.0	19.0	27.5	53.5
In-County Clearance Time					
Monroe – Key West	13.0	13.0	13.0	13.0	13.0
Monroe – Lower Keys	14.5	15.5	14.0	15.0	16.5
Monroe – Middle Keys	19.0	20.0	17.5	19.5	21.5
Monroe – Upper Keys	24.0	26.0	21.0	22.0	24.5
Monroe – Total					
Miami-Dade County	24.0	26.0	27.5	41.5	74.5
Broward County	12.5	13.0	19.0	41.5	74.5
Out-of-County Clearance Time					
Monroe – Key West	12.5	12.5	12.5	12.5	12.5
Monroe – Lower Keys	14.0	15.0	13.5	14.5	16.0
Monroe – Middle Keys	18.5	19.5	17.0	19.0	21.0
Monroe – Upper Keys	23.5	25.5	20.5	21.5	24.0
Monroe – Total					
Miami-Dade County	24.5	27.0	27.5	41.5	74.5
Broward County	25.5	27.5	28.0	45.0	74.5
Regional Clearance Time					
South Florida	25.5	27.5	28.0	45.0	74.5

Note: In-county clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low. The base scenarios use a 12-hour response curve. Also, in-county clearance times for Miami-Dade County are typically equal to or above Monroe County out-of-county clearance times for all Level B or higher scenarios that include Monroe County evacuating. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county, including the Miami-Dade County evacuation zone located where US 1 enters from Monroe County.

Table VI-14 2020 Clearance Times for Operational Scenarios

	Evacuation Level A Operational Scenario 6	Evacuation Level B Operational Scenario 7	Evacuation Level C Operational Scenario 8	Evacuation Level D Operational Scenario 9	Evacuation Level E Operational Scenario 10
Clearance Time to Shelter					
Monroe – Key West					
Monroe – Lower Keys					
Monroe – Middle Keys					
Monroe – Upper Keys					
Monroe – Total					
Miami-Dade County	14.5	21.0	29.0	51.5	71.0
Broward County	12.5	13.5	19.5	36.5	45.0
In-County Clearance Time					
Monroe – Key West	13.0	13.0	13.0	13.0	13.0
Monroe – Lower Keys	14.5	15.5	14.0	15.5	17.0
Monroe – Middle Keys	19.0	20.5	18.0	20.0	22.0
Monroe – Upper Keys	24.0	26.5	21.5	23.0	25.0
Monroe – Total					
Miami-Dade County	24.5	26.5	29.0	51.5	71.0
Broward County	12.5	13.5	19.5	51.5	71.5
Out-of-County Clearance Time					
Monroe – Key West	12.5	12.5	12.5	12.5	12.5
Monroe – Lower Keys	14.0	15.0	13.5	15.0	16.5
Monroe – Middle Keys	18.5	20.0	17.5	19.5	21.5
Monroe – Upper Keys	23.5	26.0	21.0	22.5	24.5
Monroe – Total					
Miami-Dade County	25.0	27.0	29.0	51.5	71.0
Broward County	25.5	28.0	29.5	52.0	71.5
Regional Clearance Time					
South Florida	25.5	28.0	29.5	52.0	71.5

Note: In-county clearance times are generally not less than the response curve unless in-county or to shelter population numbers are very low. The base scenarios use a 12-hour response curve. Also, in-county clearance times for Miami-Dade County are typically equal to or above Monroe County out-of-county clearance times for all Level B or higher scenarios that include Monroe County evacuating. By definition, in-county clearance time includes out-of-county trips from other counties that pass through evacuation zones in the evacuating county, including the Miami-Dade County evacuation zone located where US 1 enters from Monroe County.

K. Maximum Evacuating Population Clearances

From an emergency management standpoint, it is important to get an understanding of the maximum proportion of the evacuating population that can be expected to evacuate at various time intervals during an evacuation. Should storm conditions change during an evacuation, emergency managers will need to be able to estimate what portion of the evacuating population is estimated to still remain within the county trying to evacuate.

Using the base scenarios, which assume 100% of the vulnerable population is evacuating, along with shadow evacuations and evacuations from adjacent counties, an estimate was made of the evacuating population actually able to evacuate out of each county by the time intervals of 12, 18, 24, and 36 hours. The estimated maximum evacuating population by time interval for 2015 is identified in **Table VI-15** and for 2020 in **Table VI-16**. From a transportation standpoint, the number of evacuating vehicles is equally as important as the evacuation populations. Evacuating vehicles for the base scenarios are summarized by county for 2015 in **Table VI-17** and for 2020 in **Table VI-18**.

It is important to note that these estimates take into account many variables, including roadway capacity, in-county evacuating trips, out of county evacuating trips, evacuating trips from other counties, and background traffic that is impeding the evacuation trips. For this reason, the maximum evacuation population by time interval will vary slightly between evacuation level and either increase or decrease from one evacuation level to the next.

Table VI-15 Maximum Evacuating Population by Time Interval for 2015

	Evacuation Level A	Evacuation Level B	Evacuation Level C	Evacuation Level D	Evacuation Level E
Estimated Evacuating Population Clearing Monroe County					
12-Hour	33,190	34,638	31,907	31,907	31,907
18-Hour	49,784	51,957	47,861	47,861	47,861
24-Hour	66,379	69,276	63,814	63,814	63,814
36-Hour	69,145	73,606	69,132	69,132	69,132
Estimated Evacuating Population Clearing Miami-Dade County					
12-Hour	178,254	299,385	324,723	240,187	232,087
18-Hour	267,380	449,078	487,084	360,281	348,131
24-Hour	356,507	598,771	649,445	480,375	464,175
36-Hour	386,216	698,566	1,001,228	1,441,124	1,672,963
Estimated Evacuating Population Clearing Broward County					
12-Hour	92,902	89,366	85,953	72,042	84,705
18-Hour	139,353	134,049	128,929	108,063	127,057
24-Hour	185,804	178,732	171,906	144,083	169,410
36-Hour	209,029	215,968	300,835	435,252	254,115

Note: These estimates take into account many variables, including roadway capacity, in-county evacuating trips, out-of-county evacuating trips, evacuating trips from other counties, and background traffic that is impeding the evacuation trips. For this reason, the maximum evacuation population by time interval will vary between evacuation levels and either increase or decrease from one evacuation level to the next. See section E for the source of the small area data.

Table VI-16 Maximum Evacuating Population by Time Interval for 2020

	Evacuation Level A	Evacuation Level B	Evacuation Level C	Evacuation Level D	Evacuation Level E
Estimated Evacuating Population Clearing Monroe County					
12-Hour	33,483	35,743	32,267	32,267	32,267
18-Hour	50,224	53,614	48,400	48,400	48,400
24-Hour	66,966	71,485	64,533	64,533	64,533
36-Hour	69,756	74,464	72,600	72,600	72,600
Estimated Evacuating Population Clearing Miami-Dade County					
12-Hour	184,954	303,891	308,490	287,736	247,681
18-Hour	277,431	455,836	462,735	431,605	371,521
24-Hour	369,908	607,782	616,980	575,473	495,362
36-Hour	408,440	747,065	1,066,861	1,522,605	1,764,727
Estimated Evacuating Population Clearing Broward County					
12-Hour	96,224	88,063	87,986	85,499	88,756
18-Hour	144,336	132,095	131,979	128,248	133,133
24-Hour	192,448	176,126	175,972	170,997	177,511
36-Hour	216,504	223,827	311,617	452,430	266,267

Note: These estimates take into account many variables, including roadway capacity, in-county evacuating trips, out-of-county evacuating trips, evacuating trips from other counties, and background traffic that is impeding the evacuation trips. For this reason, the maximum evacuation population by time interval will vary between evacuation levels and either increase or decrease from one evacuation level to the next. See section E for the source of the small area data.

Table VI-17 – Evacuating Vehicles by Base Scenario for 2015

	Evacuation Level A Base Scenario	Evacuation Level B Base Scenario	Evacuation Level C Base Scenario	Evacuation Level D Base Scenario	Evacuation Level E Base Scenario
Monroe County – Key West					
Site-built Homes	4,064	4,644	11,610	11,610	11,610
Mobile/Manuf. Homes	1,216	1,216	0	0	0
Tourists	5,227	5,227	0	0	0
TOTAL	10,507	11,087	11,610	11,610	11,610
Monroe County – Lower Keys					
Site-built Homes	2,615	2,942	6,537	6,537	6,537
Mobile/Manuf. Homes	1,044	1,044	0	0	0
Tourists	440	440	0	0	0
TOTAL	4,099	4,426	6,537	6,537	6,537
Monroe County – Middle Keys					
Site-built Homes	2,479	2,833	7,083	7,083	7,083
Mobile/Manuf. Homes	1,031	1,031	0	0	0
Tourists	2,490	2,490	0	0	0
TOTAL	6,000	6,354	7,083	7,083	7,083
Monroe County – Upper Keys					
Site-built Homes	5,098	6,373	12,745	12,745	12,745
Mobile/Manuf. Homes	2,582	2,582	0	0	0
Tourists	2,947	2,947	0	0	0
TOTAL	10,627	11,902	12,745	12,745	12,745
Monroe County – Total					
Site-built Homes	14,256	16,792	37,975	37,975	37,975
Mobile/Manuf. Homes	5,873	5,873	0	0	0
Tourists	11,104	11,104	0	0	0
TOTAL	31,233	33,769	37,975	37,975	37,975
Miami-Dade County					
Site-built Homes	155,159	274,615	401,488	579,190	671,071
Mobile/Manuf. Homes	14,400	14,400	14,400	14,400	14,400
Tourists	511	18,562	22,980	25,975	29,487
TOTAL	170,070	307,577	438,868	619,565	714,958
Broward County					
Site-built Homes	83,537	87,253	131,046	197,178	283,932
Mobile/Manuf. Homes	18,731	18,731	18,731	18,731	18,731
Tourists	11,098	11,098	13,839	14,999	16,354
TOTAL	113,366	117,082	163,616	230,908	319,017

Table IV-18 – Evacuating Vehicles by Base Scenario for 2020

	Evacuation Level A Base Scenario	Evacuation Level B Base Scenario	Evacuation Level C Base Scenario	Evacuation Level D Base Scenario	Evacuation Level E Base Scenario
Monroe County – Key West					
Site-built Homes	4,197	4,797	11,992	11,992	11,992
Mobile/Manuf. Homes	1,125	1,125	0	0	0
Tourists	5,227	5,227	0	0	0
TOTAL	10,549	11,149	11,992	11,992	11,992
Monroe County – Lower Keys					
Site-built Homes	2,795	3,145	6,988	6,988	6,988
Mobile/Manuf. Homes	915	915	0	0	0
Tourists	440	440	0	0	0
TOTAL	4,150	4,500	6,988	6,988	6,988
Monroe County – Middle Keys					
Site-built Homes	2,551	2,915	7,288	7,288	7,288
Mobile/Manuf. Homes	956	956	0	0	0
Tourists	2,490	2,490	0	0	0
TOTAL	5,997	6,361	7,288	7,288	7,288
Monroe County – Upper Keys					
Site-built Homes	5,436	6,795	13,589	13,589	13,589
Mobile/Manuf. Homes	2,400	2,400	0	0	0
Tourists	2,947	2,947	0	0	0
TOTAL	10,783	12,142	13,589	13,589	13,589
Monroe County – Total					
Site-built Homes	14,979	17,652	39,857	39,857	39,857
Mobile/Manuf. Homes	5,396	5,396	0	0	0
Tourists	11,104	11,104	0	0	0
TOTAL	31,479	34,152	39,857	39,857	39,857
Miami-Dade County					
Site-built Homes	164,964	293,800	427,977	612,719	708,913
Mobile/Manuf. Homes	13,764	13,764	13,764	13,764	13,764
Tourists	511	19,131	23,619	26,713	30,503
TOTAL	179,239	326,695	465,360	653,196	753,180
Broward County					
Site-built Homes	86,128	90,023	135,073	204,111	293,008
Mobile/Manuf. Homes	19,802	19,802	19,802	19,802	19,802
Tourists	11,098	11,098	13,839	14,999	16,354
TOTAL	117,028	120,923	168,714	238,912	329,164

L. Sensitivity Analysis

As discussed previously, there are literally thousands of possible combinations of variables that can be applied using the evacuation transportation model, which will result in thousands of possible outcomes. As part of the analysis process, a sensitivity analysis was conducted using the prototype model to evaluate the effect of different response curves on the calculated evacuation clearance times. Calculated clearance times will never be lower than the designated response time, since some evacuating residents will wait to evacuate until near the end of the response time window. For example, using a 12-hour response curve in the analysis means that all residents will begin their evacuation process within 12 hours, and some residents will choose to wait and begin evacuating more than 11.5 hours from when the evacuation was ordered. This will generate a clearance time of more than 12 hours.

The sensitivity analysis identified that clearance times will vary by scenario and by any of the numerous parameters that can be chosen in a particular scenario model run (demographics, student population, tourist population, different counties that are evacuating, response curve, phasing, shadow evacuations, etc.). A few general rules of thumb did emerge from the sensitivity analysis that can provide some guidance to the region regarding the sensitivity of the response curve to the calculated clearance times:

- For low evacuation levels A and B, clearance time will vary by as much as 40 percent depending on the response curve. Low evacuation levels A and B have fewer evacuating vehicles that can be accommodated more easily on the transportation network. In most cases, clearance times typically exceed the response curve by one to two hours. Thus, a 12-hour response curve may yield a clearance time of 13 or 14 hours, while an 18-hour response curve may yield a clearance time of 19 or 20 hours. This leads to a higher level of variability than larger evacuations.

- For mid-level evacuations such as C and sometimes D, clearance time varied by as much as 25 percent during the sensitivity analysis. The number of evacuating vehicles is considerably higher than for levels A and B, and lower response curves tend to load the transportation network faster than longer response curves. The variability in clearance times is less in these cases than for low evacuation levels.

- For high-level evacuations such as some level D evacuations and all E evacuations, clearance time variability is reduced to about 10 to 15 percent. Large evacuations involve large numbers of evacuating vehicles, and the sensitivity test identified that clearance times are not as dependent on the response curve as lower level evacuations since it takes a significant amount of time to evacuate a large number of vehicles.

The counties within the South Florida Region are encouraged to test additional scenarios beyond what has been provided in this study. Each model run will provide additional information for the region to use in determining when to order an evacuation. Due to advancements in computer technology and the nature of the developed transportation evacuation methodology, this study includes a more detailed and time consuming analysis process than used in previous years studies. Counties interested in testing various response curves for each scenario can easily do so using the TIME interface to calculate clearance times for different response curves.

M. Summary and Conclusions

Through a review of the results of the 20 different scenarios (10 base and 10 operational), several conclusions could be reached regarding the transportation analysis, including the following:

- Demographic data from the 2010 US Census identifies a change in population for the three-county region from estimates used in the previous study. This change includes a decrease from previous 2010 and 2015 population projections used in the 2010 South Florida Evacuation Transportation Analysis. This population change is reflected in both the 2015 and 2020 population projections used in this study.

- The revision of evacuation zones by Miami-Dade County after completion of the 2010 study significantly increased the number of persons that would be ordered to evacuate, especially for higher-level storms (D and E). Despite the reduced population projections observed in the previous bullet, the current results reflect an increase overall in the number of evacuating vehicles, to more than a million in a Level E storm in 2015.

- Critical transportation facilities within the South Florida region include the Florida Turnpike (with the Homestead Extension), I-95, I-595, I-395, I-75, the Sawgrass Expressway and US 1 (especially in Monroe County). For large storm events, such as Level D and E evacuations, other federal and state facilities also play an important role, such as US 41, SR 836 and SR 826 in Miami-Dade County, and US 27 in Broward County.

- During the level A and B evacuation scenarios, the roadway segments with the highest vehicle queues are primarily concentrated along the major Interstate and State Highway system. During these levels of evacuation, State and County officials should coordinate personnel resources to provide sufficient traffic control at interchanges and major intersections along these routes.

- In contrast, for the higher level C, D, and E evacuation scenarios, many other roadway facilities, both within and outside of the region, will require personnel resources for sufficient traffic control at interchanges and major intersections.

- South Florida counties, in coordination with the State, should continue public information campaigns to clearly define those that are vulnerable and should evacuate versus those who choose to evacuate on their own. During large storm events, in the operational scenarios, evacuations by the vulnerable population in the three counties are impacted by shadow evacuations occurring in other parts of the counties and in areas outside the South Florida region.

- The Florida Department of Transportation should continue to work with local counties on implementing intelligent transportation system (ITS) technology, which will provide enhanced monitoring and notification systems to provide evacuating traffic with up to date information regarding expected travel times and alternate routes.

- The State can use the data and information provided in this report (specifically the

evacuating vehicle maps in Volume 5-11) to estimate fuel and supply requirements along major evacuation routes to aid motorists during the evacuation process;

- For major evacuation routes that have signalized traffic control at major intersections, traffic signal timing patterns should be adjusted during the evacuation process to provide maximum green time for evacuating vehicles in the predominant northbound direction.

- The counties within the South Florida Region are encouraged to test additional transportation scenarios beyond what has been provided in this study. Counties interested in testing various response curves for each scenario can easily do so using the TIME interface to calculate clearance times for different evacuation conditions, such as different evacuation levels, different behavioral response assumptions, and different response curves.

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