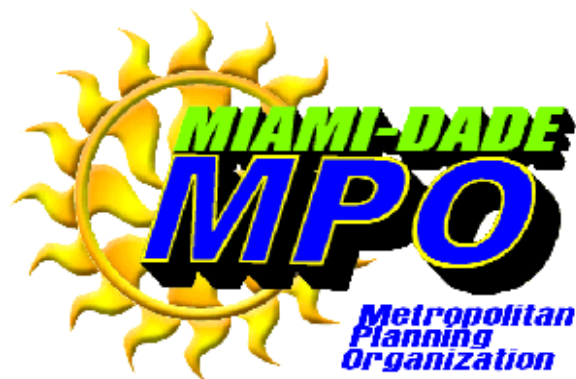


Simulation and Analysis of Potential Mass Evacuation of Miami-Dade Residents

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Executive Summary

The Simulation and Analysis of Potential Mass Evacuation of Miami-Dade Residents study was commissioned by the Miami-Dade Planning Organization (MPO) based on a request by the MPO's Citizen Transportation Advisory Committee (CTAC). The CTAC request was in response to the mass evacuation event that followed Hurricane Katrina's impact on New Orleans and Hurricane Rita's impact on Houston. The study provides the results of a simulated mass evacuation event using the MPO regional model and identifies applicable pre and post event transportation strategies that may be utilized to manage such an event should it occur in Miami-Dade County ("the County"). A Study Advisory Committee (SAC) was established and included:

- The Department of Emergency Management and Homeland Security (OEM&HS),
- The Florida Department of Transportation (FDOT) District VI,
- Miami Dade Transit (MDT),
- Miami Dade Public Works,
- Miami Dade Government Information Center,
- Other agencies, local governments such as the City of Miami Gardens and Pinecrest, and transportation providers such as Greyhound.

The report summarizes the existing emergency evacuation plans to ascertain the logic and coordination between the plans and identify whether mass evacuations strategies are being planned for by the different agencies. Six available plans were reviewed including the OEM&HS Comprehensive Emergency Management Plan (CEMP), the MDT Hurricane Manual, the Coastal Communities Transportation Master Plan (CCTMP), the 2006 South Florida Hurricane Evacuation Traffic Study (SFHETS), the FDOT Assessment of Contraflow Operations for Interstate I-75, and the Miami-Dade Public Works (MDPW) Department Hurricane Preparedness Plan. In general, the plans are very well coordinated between the agencies; however, mass evacuation is not recommended or planned for in any of these plans since the overall policy of the County is not to evacuate.

Next, the report identifies the baseline conditions in terms of population characteristics and existing infrastructure within the County to determine the potential impact of a mass evacuation scenario on the different communities. This analysis was conducted to ascertain whether the County's transit dependent populations had adequate access to transportation during emergency events. Although there are certain areas of the County with concentrations of transit dependent populations, the analysis found that they

were dispersed throughout different areas of the County and that their access to transportation services, similar to the access for other County residents, was adequate and periodically analyzed by OEM&HS to assure that all individuals in need of transportation during emergencies were adequately served.

To provide the desired evacuation simulation in order to establish transportation needs, a planning sketch level analysis was conducted using the MPO's existing Miami Urban Area Transportation System (MUATS) travel demand model. The simulation assumed a mass evacuation due to an emergency event that would substantiate a certain northerly exit of residents out of the County. This simulated mass evacuation scenario was run for the year 2000 and 2030 and Volume to Capacity Ratios (V/C) were determined for the designated County evacuation routes. The V/C ratios provide an indication of the level of congestion on the roadways as a result of the simulated evacuation event. Consistent with CTAC direction, an alternative mass evacuation scenario was also developed assuming contraflow conditions on all arterial facilities for base year 2000 and 2030. Aggregate V/C ratios were developed for the simulated evacuation scenario with and without contraflow for the years 2000 and 2030. The travel demand model results indicated that there would be potential benefits to implementing contraflow for mass evacuation and further studies should be conducted in this arena.

The model simulation conducted for this study does not replicate sophisticated hurricane evacuation modeling that can be provided by OEM&HS nor does it provide for an assessment of the manpower needed to implement contraflow operations. Contraflow operations have been studied extensively by the FDOT and other transportation agencies and their assessments are summarized in this report. OEM&HS and FDOT District VI currently do not recommend implementation of this strategy due to the extensive manpower required as well as the uncertainty of where the contraflow should be directed based on the changing course of hurricanes. Past studies conducted of contraflow operations along major interstate corridors indicated that contraflow should be implemented only as a last resort. Moreover, contraflow and mass evacuation in general is deemed more appropriate for areas where there would be a major flooding surge.

Based on the review of existing plans and conditions, the findings from the modeling analysis conducted, and initial feedback and discussion with CTAC members and the SAC, the study discusses the applicability of several strategies that can be further explored if a mass evacuation event were to occur in the County. Some of the strategies can be conducted pre-event while others are more appropriate post-event. The merits and shortcomings of some of the following strategies are discussed in detail in this report:

- Establishing a Centralized Lead Agency
- Providing Additional Evacuation Bus Pick-Up Sites and Evacuation Centers where needed (and disseminate this information)

- Continue Study of Contraflow Operations on applicable evacuation routes
- Utilization of HOV Lanes for additional capacity and/or emergency access only
- Use of Road Shoulders
- Continuing established pre-event Agreements for the use of Transit Buses and School Buses
- Executing pre-event agreements with private transportation agencies such as Greyhound and Amtrak, Tri-rail, cruise line and airline companies for transportation use during emergencies
- Maximizing the use of Intelligent Transportation Systems (ITS) for evacuation purposes
- Purchase and strategic placement of mobile fuel trucks to access stranded cars
- Identification of essential personnel and incentives for them to remain at work even in mass evacuation emergencies
- Prioritize all transportation improvement projects along designated evacuation routes
- Include roadway capacity enhancement projects along designated evacuation routes
- Continue to educate the public on the established OEM&HS procedures during emergency events
- Continue to fund and enhance emergency protection areas such as schools and shelters
- Continue to address substandard housing throughout the County since most of the damage during emergency events occurs in these areas which would require evacuation.

This study's main purpose is to continue the discussion on strengthening the emergency planning procedures for Miami-Dade County, including transportation strategies that may be applicable to mass evacuation events. The Miami-Dade MPO has the ability to fund the implementation of these strategies, such as capacity projects along evacuation routes, through its Long Range Transportation Plan and Transportation Improvement Program. Other strategies identified are under the purview of other county agencies and coordination with those agencies should continue.

Although the events that occurred in New Orleans and Houston continue the emergency preparedness dialogue throughout the country, it is important to note some major distinctions between these cities and Miami-Dade County. Due to these distinctions, there are many issues that are not necessarily applicable to Miami-Dade County. For example, rigorous planning for emergency related events has a very long history in Miami-Dade County and these planning efforts have been recognized and emulated by many

other communities throughout the country. Currently, the County is recognized by the Federal Emergency Management Agency (FEMA), FDOT and cities throughout the country as a model for executing localized evacuations successfully in cases of emergencies. Many issues, including transportation strategies for evacuation, have been studied in the past and continue to be explored. These pro-active planning efforts were not evident in the New Orleans and Houston situations. Secondly, the City of New Orleans mass evacuation occurred due to flood destruction because most of the City is below sea level whereas Miami-Dade County is not. There are very few areas in the County where storm surge is an issue that would require even localized evacuation (extreme South County and barrier islands). As an example, Miami-Dade County is only one of a few communities impacted by a Category 5 hurricane (Andrew) and mass evacuation was not recommended as a pre or post event during this situation. Emergency planners have studied the need for mass evacuation of residents (in terms of road capacity and clearance times) and have not recommended this as either a pre or post event strategy that would benefit the County or its citizens. According to these studies, the risks taken by residents during a mass evacuation in emergency situations are deemed greater than remaining in place and providing recovery efforts post event. Some of the risks include being stranded along roadways without fuel or food, the uncertainty of not finding a location to evacuate to, and being caught in the middle of a hurricane's changing path. Lastly, because of the many hurricanes sustained by the South Florida community, it has one of the strongest building codes in the country.

Nevertheless, the events in New Orleans and recent terrorist attacks underscore the necessity of revisiting the evacuation capacity of urban areas and an independent simulation and analysis for a potential mass evacuation as desired by the CTAC, the result of which is this report.

1. Introduction

Miami-Dade County is located in the southeastern part of the State of Florida (**Figure 1**). The County is one of three counties that comprise the South Florida metropolitan area along with Broward and Palm Beach Counties, making it the largest metropolitan area in the State of Florida. The County's total area is 2,200 square miles. There are 35 municipalities in the County. The County has a rich diversity of residents, including Hispanics, Caribbeans, and African-Americans. The County also encompasses a Tribal community, the Miccosukee Indians, located west of Krome Avenue and along Tamiami Trail. According to the 2005 census estimate, the County's population was approximately 2,376,000. The net population growth rate is 30,000 individuals per year. Current projections by the Miami-Dade Planning and Zoning Department suggest that by 2025, approximately three (3) million people will reside within the County boundaries. Unlike New Orleans, the County is not subject to life-threatening floods since it is above sea level, and dangerous storm surges from potential hurricanes are limited to the far southern portion of the County. Due to the many storm events that affect the area, the County also has the strongest building codes in the country.

1.1. Purpose

The purpose of this study is to provide the Metropolitan Planning Organization (MPO) with applicable transportation strategies that can be utilized to manage a mass (planned or unplanned) emergency evacuation event. For the purposes of this study and simulation, an emergency event would include natural disasters,



nuclear emergencies or severe epidemic disease for example, and terrorist events that would require or result in an unplanned or planned mass evacuation of a large number of County residents to neighboring communities to the north or west. The Department of Emergency Management & Homeland Security (OEM&HS) has studied mass evacuation for emergency purposes through desktop exercises and hurricane evacuation modeling and found that there would be no event or circumstance where they would require mass evacuation for any reason due to the uncertainty of keeping fleeing citizens safe. Mass evacuations could result in being trapped along roadways with no food or fuel or being in the middle of a changing hurricane path. However, this study was commissioned by the MPO at the request of the Citizens Advisory Transportation Committee (CTAC) subsequent to the 2005 mass emergency

evacuation experiences of the cities of Houston and New Orleans in order to reassess potential strategies that may be applicable to similar evacuation events that could occur in the County, including terrorist events that would require mass evacuation. Some of the specific topics the CTAC wanted researched was lessons learned from the Katrina experience that may be applicable to the County, and the potential for using contraflow lane operations for evacuations.

As part of this effort a Study Advisory Committee (SAC) of emergency management experts was created and consisted of:

- Miami Dade Transit (MDT)
- Department of Emergency Management and Homeland Security (OEM&HS)
- Miami Dade Public Works (MDPW)
- Florida Department Of Transportation (FDOT) District VI
- Miami Dade Police Department (MDPD)
- Miami Dade Expressway Authority (MDX)
- Pinecrest Police Department (PPD)
- City of Miami Gardens
- Miami Dade Government Information Center

Other municipalities located east of Interstate I-95 and agencies such as Miami Dade Aviation were also invited. The objective of the SAC was to provide technical review of the study results and report and provide additional recommendations based on the findings of the study. Two meetings of the SAC were held on October 17, 2006 and on March 19, 2007. At the second meeting, the study team presented the first draft of the report. Representatives from Amtrak, Greyhound, Tri-Rail and Jitney agencies were invited at CTAC's suggestion. Representatives from Greyhound and American Ambulance attended the March 19th meeting. The CTAC committee was briefed on the study progress on February 21, 2007.

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1.2. Lessons Learned: Hurricanes Rita and Katrina

Research conducted on these events focused on the New Orleans Metropolitan Area, centered on the City of New Orleans, which is the largest metropolitan area in the Gulf South. The metropolitan area includes seven parishes with a total population of 1.4 million. The area was hit by Hurricane Katrina in August of 2005 and caused a mass evacuation of residents mainly because most of the City is below sea level and subject to dangerous storm surges. In August 2005, the City of Houston became a shelter to more than 150,000 people from New Orleans who evacuated from Hurricane Katrina. According to the U.S. Census, Houston has a population of more than 2 million and a Metropolitan Statistical Area of 5.3



Evacuation in Houston during Hurricane Katrina

million residents in 10 counties. One month after Hurricane Katrina, approximately 2.5 million Houston area residents evacuated due to the approach of Hurricane Rita. The evacuation event marked the largest two-day urban evacuation in the history of the United States. Hurricane Rita did not produce significant damage in comparison to Hurricane Katrina. Houston escaped

major damage, apart from extensive loss of power (www.nhc.noaa.gov/pdf/TCR-AL182005_Rita.pdf). The consequences of the mass evacuation resulted in cars in 98 degree heat forced to turn off their air conditioners to avoid running out of fuel and in gridlocked highways.

Significant lessons learned from the mass evacuations conducted during Hurricanes Katrina in New Orleans and Rita in Houston included:

- Katrina's evacuation plan functioned relatively well for owners of private vehicles but it failed to serve people who depended on public transit
- Hurricane Rita's evacuation plan failed because of excessive reliance on the automobiles which resulted in traffic congestion and fuel shortages
- Poor emergency management planning efforts were in place

There were various transportation-related problems encountered during Hurricanes Katrina and Rita:

- Failure to have an effective plan for non-drivers
- Failure to implement transit and "school bus evacuation action plan"

- Failure to coordinate vehicle rentals and fuel service
- Failure to use contraflow lanes and road shoulders for evacuation traffic, in some cases where it was possible
- Failure to use charter buses and trains for evacuation due to their unavailability

Miami Dade County OEM&HS has coordinated plans with other agencies that address some of the problems exhibited in the Katrina and Rita events. There are established pick up sites for transit dependent individuals (who do not own vehicles) to transport them to shelters. These sites are reviewed annually. Additionally, use of road shoulders for evacuation purposes is recommended and implemented along US-1 between Key Largo and Florida City at the southern end of the County where storm surge would be an issue. In general, OEM&HS will recommend *voluntary* evacuations in areas subject to ponding within the 100 year flood zone. The only mandatory evacuation area is an 81/2 square mile area west of the L31 levee due to poor accessibility to emergency vehicles. If a voluntary evacuation order is issued, OEM&HS operates evacuation buses to transport individuals from their home. Buses are also used to transport individuals to evacuation centers. The biggest obstacle in these evacuations is that individuals are reluctant to leave their homes regardless of an evacuation order. In addition to these efforts, other possible transportation related strategies to address major congestion (as occurred in Katrina and Rita events) during a mass evacuation will be further discussed in this report.

1.3. Emergency Evacuation Report Card

In 2006 the American Highway User Alliance (AHUA) conducted a study which substantiated that automobile congestion is a major concern during emergency evacuations as was the case during the Houston evacuation. The AHUA study evaluated 37 urban areas with more than 1,000,000 populations to determine their evacuation capacity. The evacuation capacity index consisted of three criteria: 1) exit capacity (number of lanes-including contraflow use), (2) internal traffic flow (travel delay), and (3) automobile access. The Miami urbanized area was included in the study and was among twenty urban areas to receive the lowest overall score. Generally, the urban areas that scored better had lower population densities, greater capacity on their roadways and no geographical barriers blocking exit directions. Although the Miami area had a large number of residences (95%) with access to automobiles, it scored low for exit capacity and internal traffic flow. For the Miami urbanized area, the findings from the study highlighted the following:

- More roadway capacity was needed in the direction away from geographical barriers (in this case water) or north/south corridors

- Higher population densities must have a more robust roadway system to decrease congestion and expand the roadway capacity sufficient for maximizing evacuation capacity
- Automobile access should be expanded

1.4. Definitions

“Emergency evacuation” is the movement of persons from a dangerous place due to the threat or occurrence of a disastrous event. “Mass evacuation” is a planned or unplanned event, sometimes associated with panic situations, where a large number of individuals leave an area due to a dangerous threat. “Localized evacuation” is an event where individuals have to leave their homes temporarily due to storm surge and is conducted to inland areas. Localized evacuation is what is typically recommended in Miami-Dade County during hurricane events or during nuclear emergencies. There are numerous types of disasters which urban communities face today that could engender an evacuation event including:

- Major hurricanes and flooding,
- Terrorism,
- Contamination, and
- Potential nuclear radiation.

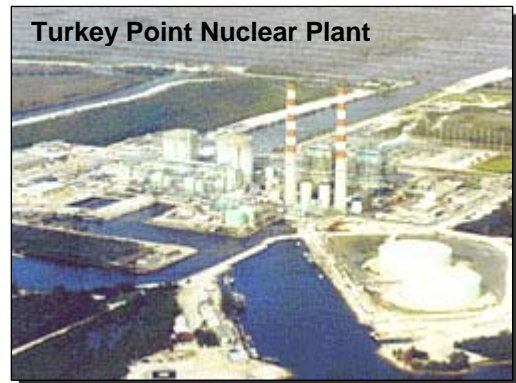
Some of these events are localized and mass evacuation orders may not be necessary and would be dependent on the area in question. For example, in New Orleans where the City is below sea level, major flooding was an event that required mass evacuation. Miami-Dade County has experienced many emergency evacuation-related events mostly due to hurricanes. The official response to these events is to require that the majority of residents remain in their places of residence and put up hurricane shutters, secure their boats, purchase supplies such as flashlights, non-perishable food and bottled water, and fill up cars with proper fuel. Miami-Dade residents who reside at or near the barrier islands are generally required to evacuate and find alternative locations and evacuation centers to ride out the storm. “Evacuation centers” are places used to house individuals during a hurricane, whereas “shelters” are more long-term facilities to house individuals who sustained major damage to their residence. Consistent with the OEM&HS direction, a majority of Miami-Dade residents remain at home during a hurricane event to prepare for a hurricane. According to the Florida International University Institute of Public Opinion Research, approximately 70% of evacuees stay close to home or in-county during hurricane events.

Terrorism can also play a role in potential mass evacuation. Although the events of September 11, 2001 in New York City did not trigger a mass evacuation order, hindsight would indicate that it may have been a prudent strategy for the immediate area given the amount of pollution created from the fall of the twin

towers. Other forms of terrorism could include bio-terrorism which is the deliberate use of microorganisms or toxins to induce death or disease. Biological and chemical agents that could be used include anthrax, small pox, Ebola, dengue fever, and botulism. Emergency evacuation can also occur in situations involving hazardous materials or possible contamination. However, since evacuees would be required to get decontaminated prior to being transported out of the contaminated area, these instances would not necessarily constitute a mass evacuation.

Lastly, in Miami-Dade County there is a major power plant that can have an impact on mass evacuation. The Turkey Point Nuclear Power Plant is owned by Florida Power and Light (FPL) and is located in the southeastern portion of the County approximately 10 miles south of Cutler Bay. According to OEM&HS, the entire County is within the 50-mile emergency planning zone (EPZ) which is used for ingestion pathway issues that would not necessarily involve evacuations. However, there are approximately 190,000

residents within the 10-mile EPZ. A potential exit of all of these residents in an emergency situation could constitute a mass evacuation. A Turkey Point Warning System using sirens or loud speakers to provide Emergency Public Information during a nuclear incident is currently in place. The full evacuation plan is tested annually and the sirens are tested quarterly.



2. Summary of Existing Plans

The following is a summary of readily available existing hurricane and emergency evacuation plans and recent studies conducted in the County. The plans were reviewed to determine if mass evacuation strategies were in place and to determine potential coordination for future planning:

- OEM&HS Comprehensive Emergency Management Plan (CEMP)
- Miami Dade Transit (MDT) Hurricane Manual
- The Coastal Communities Transportation Master Plan (CCTMP)
- 2006 South Florida Regional Hurricane Evacuation Traffic Study
- Miami-Dade Public Works Hurricane Preparedness Plan.

2.1. OEM&HS and the Comprehensive Emergency Management Plan (CEMP)



OEM&HS is the agency responsible for the coordination of all countywide response efforts relative to disasters and the CEMP is the official emergency management plan for the County. Most municipalities in the County follow the CEMP. According to OEM&HS, mandatory hurricane-related evacuation is based on several factors such as the category of the storm, projected penetration of storm surge, speed over the ground, tide conditions at landfall and even the day of the week or day of the month. The larger the

category of the storm, the more lead time is required to accomplish an evacuation because a much larger percentage of the population will evacuate for a major storm. As stated in the CEMP, the practice has been to first evacuate residents and tourists along the Atlantic Coast and low-lying areas. Mandatory evacuation orders within a designated area (evacuation zone) are implemented if imminent to save life and property. However, evacuees must relocate and seek refuge in inland, non-evacuation areas. OEM&HS also issues voluntary evacuation orders which are defined as a warning to persons within a designated area that a threat to life and property may be imminent. OEM&HS does not require mass evacuation of County residents to neighboring counties during an emergency situation but rather determines if evacuation is feasible.

The CEMP is designed to deal with all hazard threats to the County. In the case of a countywide emergency, the corporate resources of the County and the municipalities are responsible for the

protection of residents and visitors. The State of Florida is also responsible for supporting local governments in these activities. The state's primary goals are:

- To implement a hazard vulnerability reduction system
- To develop a level of awareness in relation to emergency preparedness
- To provide an efficient response/recovery system
- To accomplish a rapid return of essential services to its normal state
- To maintain a high level of community readiness
- To reduce the community's vulnerability to a hazard event

In the event of any emergency (hurricane and non hurricane related), the CEMP provides the County with a standard procedure for the establishment and continuation of a coordinated affiliation with the State and Federal Government. The CEMP has the mission of efficiently handling both large and small hazardous events. In order to achieve this task, a CEMP distribution list is updated semiannually by OEM&HS. As indicated below, other agency plans are well coordinated with the CEMP as the official Emergency Management Plan of the County.

2.2. Miami-Dade Transit (MDT) Hurricane Manual (2006)

The MDT manual provides a list of emergency operation sites, web sites to communicate information, and procedures for establishing task force teams during emergencies. The emergencies planned for in the manual are all hurricane related. MDT designates a Metrobus Central communications facility which is in control when evacuation begins. In coordination with the CEMP, MDT's responsibility is to transport Miami-Dade County evacuees to designated shelters throughout the County. Metrobus Central develops and maintains an updated list of Miami-Dade County evacuation pick up points and American Red Cross Shelters for use in hurricane evacuations. During evacuation operations, MDT buses are routed from pick up points in high risk areas of the County to general population evacuation centers. "Hurricane Evacuation Bus Pick up Site" signs indicate pick up points. Transportation services consist of evacuation from pickup points to drop off locations as well as medical trips. The medical trips are conducted by MDT's Special Transportation Service fleet and also by Miami-Dade public schools. Bus service is adjusted accordingly in emergency situations to accommodate the need for pick-up in evacuation zones. Four hours prior to the arrival of tropical force winds (40 mph), all MDT transportation activities stop. The manual also discusses post-hurricane Recovery and Damage Assessment tasks where all staff is to support recovery efforts. There are no provisions in the manual for mass evacuations.

2.3. Coastal Communities Transportation Master Plan (CCTMP): Origin/Destination Study

The City of Miami Beach, in coordination with other coastal communities such as Aventura and Sunny Isles Beach, recently completed an origin destination study to identify where trips occurring in the area start and end. The study's main purpose was to evaluate the magnitude of the trips within the study area (coastal communities) and between the study area and the Mainland of Miami-Dade and Broward Counties and recommend improvements to address the travel needs identified in the study. The study focused on daily travel and not on emergency evacuation travel. The study found that 85% of the total trips attracted to the CCTMP study area came from east of NW 17th Avenue and north of the Miami River. In addition, 90% of the trips generated in the study area stay within the study area. These statistics indicate that many people on the east side of the County live and work close to the coast and many people living in the coastal communities live and work in the area as well. Evacuations resulting from a hurricane are more likely to impact these coastal and eastern communities.

The study identified that the majority of east-west travel occurred close to the Broward County line, at the Haulover Inlet area, and at NW 65th street. Although the study did not address emergency evacuation in specific, it does highlight the east-west travel corridors that would most likely be used during emergency evacuations, including the Broad, Sunny Isles and Lehman Causeways. These causeways should therefore be targeted for improvement, not just to address peak hour daily travel but also potential emergency evacuation travel.

2.4. 2006 South Florida Hurricane Evacuation Traffic Study (SFHES)

The SFRPC, in coordination with the Florida Department of Community Affairs (DCA), recently completed a regional hurricane evacuation traffic study that used a newly developed regional model integrating Monroe, Miami-Dade, and Broward Counties. The model facilitates the analysis of existing and future regional hurricane evacuation dynamics making it possible to better understand South Florida residents' capability to evacuate to secure locations in the event of a regional hurricane. The traffic study process included analyzing six baseline hurricane evacuation scenarios, which were combinations of tourist occupancy and storm severity. The 1A and 1B scenarios are related to a lower class storm and the 3A and 3B scenarios to more severe storms. With the interactive user model, alternative results were obtained using different assumptions. A stakeholder group and a Technical Advisory Team (TAT) were designated to advise the traffic study process. The model analyzed the evacuation of vehicles and people by origin and destination and generated maps of traffic congestion based on these evacuation scenarios. Generally, the study found:

- Tourist occupancy and storm severity impact the number of vehicles that evacuate (a high tourist occupancy during the same storm severity event equates to a higher number of vehicles evacuating).

- Depending on the tourist occupancy and storm severity (the scenarios tested), clearance times on different roadways vary. For example, fewer roads are impacted and clearance times are less (4 hours) under low tourist occupancy and a low storm severity. More roads are impacted and clearance times are higher (12 to 24 hours) during a severe storm event and high tourist occupancy. (See Appendix A- Maps from the SFRPC).

However, it is important to note that generally the tourist season in South Florida is highest outside of the traditional hurricane season. The SFRPC study information was used to inform this MPO study effort. Moreover, it is noted that the SFRPC study identified roadway facilities that would be congested in evacuation conditions that were also included in the simulation analysis for this MPO study effort.

2.5 Technical Memorandum – Evacuation Plan and Contraflow Evacuation Assessment of Contraflow Plan Risks and Mitigation Strategies for Interstate 75 (I-75) Alligator Alley North and South

Following Hurricane Floyd, Governor Bush initiated a Hurricane Evacuation Task Force whose responsibility was to study the ability to radically increase the carrying capacity of its limited access evacuation routes by establishing “contraflow” lanes (reverse lane of routes), or create viable third lanes over existing paved shoulders in cases where it was appropriate. Contraflow provides for changing incoming highway lanes to an area to outbound lanes. This potentially doubles the number of lanes available for outbound evacuation traffic. However, not all lanes are converted as there is a need to provide access for return trips to the area for additional evacuation efforts.

As part of the Hurricane Evacuation Task Force efforts, seven roadways were identified for study including Alligator Alley (I-75) between Naples and Fort Lauderdale. The study assumed that at least 72 hours before hurricane landfall, the I-75 Alligator Alley contraflow operations would begin and would conclude 24 hours prior to the storm landfall. FDOT recognized that during the contraflow operation effort, the course of the storm could change and a new evacuation route would be needed. Additionally, the severity of the hurricane may change while contraflow evacuation is being implemented making contraflow unnecessary. In order to potentially implement contraflow along I-75, FDOT and partner agencies agreed to:

- Conduct an annual review and refinement of existing contraflow plans
- Conduct annual tabletop exercises with involved partners
- Participate in national contraflow workshops
- Deal with areas where contraflow plans may be warranted

- Deploy various devices to help implementation of contraflow easier with less workforce
- Resolve logistical issues such as improving the timing relationship between the commencement of contraflow and the storm path and communication between all the agencies that respond during an evacuation and contraflow implementation.

The potential risks/challenges associated with contraflow were discussed in the FDOT study including:

- The plan calls for Florida Highway Patrol (FHP) to use its aircraft to conduct aerial surveys of traffic conditions, but this doesn't take into consideration the potential need for night time reporting if the contraflow route cannot be cleared during daylight hours.
- The plan relies on temporary traffic control devices such as barricades and traffic cones for the implementation of contraflow operations. These devices may not be readily available in the quantity needed to implement the contraflow plan and they may be difficult to procure just prior to the storm event.
- The contraflow plans depend on operational support from the FHP, Road Rangers and FDOT staff. However, personnel resources of this type may be limited depending on the evacuation scenario. The need for multiple shifts of personnel to replace previously deployed responders is not explicitly addressed.
- There is no assurance that contract personnel such as Road Rangers and the access management contractor will be available for contraflow deployment given their multiple responsibilities.
- The number of exits and entrances to Alligator Alley are constrained on both sides of the Alley; therefore incident response would be difficult.
- During contraflow operations, the reinsertion of response personnel presents a serious concern for the operational viability of the plan because response personnel will be out of service for some time as they circle back to an insertion point.
- Public information regarding ramp closures will be needed to ensure the public will be aware of how the contraflow plan will operate.
- FDOT does not practice full contraflow plan implementation at this time, only tabletop exercises.
- Not all responders may be familiar with the contraflow plan, especially contract employees.

The *Contraflow Plan for the Florida Interstate Highway System*, prepared in 2005, identifies potential contraflow use along the Florida Turnpike, Interstate 4, Interstate 10, Interstate 75 and State Road 528

during emergency situations. In recent years the trend for many State Departments of Transportation has been to develop contraflow evacuation plans so that emergency vehicles can get into an urban area. Use of contraflow lanes along roadways has been used throughout the world to mitigate the effects of congestion and optimize roadway performance. They have been applied on a variety of roadway types using many different methods of control to address an assortment of needs, including the movement of unbalanced directional traffic associated with peak commuter periods, emergency evacuations, roadway construction work zones, and other major gatherings and events. Despite the long and varied history of contraflow operations along roadways there are a limited amount of established guidelines and standards to guide their planning, design, and operation (*Reversible Lane Systems: Synthesis of Practice Journal of Transportation Engineer, Volume 132, Issue 12, pp. 933-944 (December 2006)*).

Use of contraflow lanes are generally considered to be an emergency measure only, as the contraflow lanes (and any associated ramps at interchanges) lack proper signage, signals, and other traffic control devices needed to orderly and safely conduct traffic in the opposite direction. Generally, a significant number of police officers, or other officials, are needed to manually direct traffic during a lane reversal (especially at interchanges, where ramp traffic in the wrong direction must intersect with other roadways operating normally). Authorities in Texas activated a contraflow plan along Interstate 45 in order to evacuate Houston and other coastal cities in anticipation of the arrival of Hurricane Rita.

A study commissioned by the Texas Department of Transportation (TX DOT) and conducted by the Texas Transportation Institute after Hurricane Rita, provides a comprehensive summary of recommended practices for traffic operations for hurricane evacuation. The recommendations were developed through extensive reviews of “lessons learned” reports, and interview with staff members of departments of transportation of states that border the Gulf of Mexico or the Atlantic Ocean and have experience conducting hurricane evacuations. Some of these recommendations may not be applicable to Miami-Dade County and are only applicable to conditions in Texas. Reviews of state hurricane evacuation plans and associated literature point to many similarities among these states in their approach to evacuations; e.g., most states have some form of contraflow freeway operations. The following recommendations for contraflow operations were developed as part of the TTI study and apply to the Texas coastal areas:

- When feasible, operate contraflow during daylight hours
- Quantify the required lead time prior to initial operation of the contraflow and emergency shoulder lane plan so that the “go/no go” decision can be made early enough to allow setup time for these exceptional operations
- Restrict trucks to non-contraflow lanes
- Establish criteria for implementing the contraflow plan

- Establish criteria for shutting down the contraflow operation
- When contraflow is operating, ensure that DOT and local agencies, especially emergency services agencies, understand which alternate routes are available for accessing the coastal communities
- Install horizontal signing with exit numbers on exit ramps on contraflow routes to facilitate communications between aerial observers and EOC personnel
- Display mile markers on front and back on the contraflow route
- Use flip-down signs for detours necessary where contraflow is in operation
- Completely close coast-bound entrance ramps with barricades and on-site personnel. For lengthy contraflow operations (e.g., more than 50 miles), it is recommended that contraflow traffic be allowed to exit the highway to access public services, e.g., restrooms, fuel stations, etc., at a limited number of locations along the evacuation route. Motorists that exit the contraflow lanes may not re-enter but may enter the normal inland-bound lanes
- An alternative to closing most intermediate exit points is to allow contraflow traffic to depart the freeway at most, or all, interchanges. This option requires law enforcement and DOT personnel at each interchange. Additionally, this type of operation is improved if the contraflow side has two-sided mile markers and flip-down signs with exit numbers and destination signs
- If background traffic can be minimized, it is best to terminate contraflow operations at an interchange with another controlled-access highway where the two normal inland-bound lanes are forced onto the intersecting highway via normal ramps, and, downstream of this point, the contraflow traffic is crossed over to the normal inland-bound lanes
- Install a positive barrier in the median on highways with contraflow to prevent unauthorized crossovers

In addition to the challenges outlined in the above studies, other challenges for instituting contraflow along major Miami-Dade County evacuation routes include:

- If evacuations were to occur from the coastal zone areas and drivers exited from both the Venetian and McArthur Causeways, there is still potential for chaos since the on-ramps to I-95 are not designed for contraflow operations.
- There would be a need for strict enforcement from a significant number of County and municipal personnel in order to monitor and control traffic specifically at major intersections. This manpower

would be difficult to plan for and execute. Moreover, the manpower needed for a mass evacuation would themselves evacuate, especially during a panic evacuation mode.

- There would still be an issue of how to overcome the existing median barrier along the limited access facility to access other lanes. Therefore, the use of movable barriers at key locations along expressways should be studied further for future potential contraflow operations.
- OEM&HS and FDOT VI have stated that there would be no instance where contraflow would be recommended in the County for emergency evacuations. The primary reason is due to the unpredictability of the hurricane and the manpower needed. Contraflow could be instituted in one direction and then not be applicable if the hurricane course changes. Shelter in place is recommended for wind storm events and evacuation is only recommended during flooding events. As indicated previously, evacuation was warranted in New Orleans because of their being below sea level whereas Miami-Dade County is not.
- The use of contraflow lanes for evacuation, if ever instituted in Miami-Dade County, would appear to be more practical if necessary as a post event strategy and not a pre event strategy. However, as previously indicated, the only occasion where this strategy would be appropriate is if there was major flood damage to properties that would be uninhabitable.

2.5. Miami-Dade Public Works Department (MDPW) Traffic Engineering Division 2006 Hurricane Preparedness Plan

The MDPW plan discusses standard operating procedures for the Director's office during a hurricane emergency. It addresses safety of employees during hurricanes and the overall direction and supervision of the Public Work's Divisions in their work related to hurricane emergencies. The purpose of the plan is to create Standard Operating Procedures (SOP) for the Traffic Engineering Division (TED) to deal with all natural event threats to Miami-Dade County. The responsibilities from the various divisions and the roles of staff are outlined. The roles of the Causeway Chiefs at the Venetian and Rickenbacker Causeways are to secure and maintain the toll facilities, vehicles, electronic toll equipment, and revenues at these Causeways. MDPW Construction Division secures facilities, supplies and equipment in order to prevent damage during hurricane emergencies. Under hurricane evacuation scenarios, the MDPW and supporting highway, causeway, construction, finance, land development, mosquito control, Office of Management and Budget, highway engineering, human resources, right-of-way aesthetic and assets management, Road, Bridge, and Canal Maintenance Divisions are responsible to secure and protect County buildings. In relation to an evacuation, MDPW coordinates closely with OEM&HS to provide assistance to residents during an emergency requiring evacuation of County residents. Mass evacuation scenarios are not discussed in the manual.

2.6. Summary Observations of Existing Plans and Studies

Many of the plans reviewed include efforts to maximize coordination before, during and after an emergency event. Ninety percent of the emergency events discussed in these plans relate to the most predominant form of emergency in South Florida which are hurricanes. The plans are coordinated with the CEMP, which is the official emergency management plan for the County, and they identify manpower requirements for addressing emergency events and training requirements for employees who may be involved in evacuations. As indicated, though, none of the plans recommend mass evacuation for emergency purposes (hurricane or non-hurricane related) nor do they recommend or plan for contraflow operations in case of evacuation.

3. Existing Conditions

As with all studies, it is important to understand the baseline conditions for the area that would be impacted by potential evacuation scenarios to determine if targeted improvements are needed.

3.1. Airports

Miami-Dade County has a total of seven airports. They include Miami International Airport (MIA), Opa-locka Airport, Kendall-Tamiami Airport, and Homestead Air Reserve Station. Only MIA provides commercial passenger flights. Opa-Locka and Homestead Air Reserve can handle heavy cargo flights and Kendall Tamiami and Homestead General are general aviation airports for light aircraft. Most major airlines cease operations and move their aircraft to safety as a hurricane approaches. Given this standard operating procedure for hurricanes and the existence of Federal Aviation Administration (FAA) regulations, it would be highly unlikely that in a mass evacuation emergency, air travel would be an applicable mode. However, if permitted by the FAA, the general aviation airports may continue to be explored for mass evacuations not associated with hurricanes.

3.2. Emergency Management Support Facilities

The County has a main Emergency Operations Center and seven divisional emergency operations centers that operate on a permanent basis. Other centers are set up on a provisional basis and are dependent on varying circumstances. These include 1) Rapid Impact Assessment Team (RIAT) landing sites 2) RIAT Operation sites 3) Staging sites for personnel 4) Staging sites for material 5) Logistical Centers for perishable goods and 6) Logistical Centers for non-perishable goods. These centers handle a variety of functions, including response and recovery efforts during an emergency, depending upon the extent of the hazard being addressed.

3.3. Miami-Dade County Evacuation Routes

The designated hurricane evacuation routes are along major arterials and roadways that provide access to evacuation centers. One general transportation related recommendation will be to analyze these evacuation routes in greater detail to identify potential choke points and prioritize improvements along these facilities where possible. Similar to the findings of the Coastal Communities Master Plan and the AHUA study, the roadways used for evacuation purposes will generally tend to be those utilized during the normal course of travel on a daily basis. **Figure 2** displays these designated evacuation routes as included in the CEMP prepared by OEM&HS. Capacity and other operational (ITS) improvements are recommended along these routes:

Primary Barrier Island Evacuation Routes:

- A-1-A
- Lehman Causeway (SR-856)
- Sunny Isles Causeway (SR-826)
- Broad Causeway (SR-922)
- Kennedy Causeway
- Julia Tuttle Causeway (I-195)
- Venetian Causeway
- MacArthur Causeway (I-395)
- Rickenbacker Causeway (SR-913)

Primary Mainland North-South Evacuation Routes:

- US-1 (SR-5)
- I-95
- US-441 (SR-7)
- 27th Avenue
- Palmetto Expressway (SR-826)
- Florida's Turnpike (SR-91)
- Homestead Extension of the Florida Turnpike (SR-821)
- Don Shula / South Dade Expressway (SR-874) [SW-NE]
- Okeechobee Road (US-27) [SE-NW]
- I-75
- Krome Avenue (SR-997)

Primary Mainland East-West Evacuation Routes:

- Palmetto Expressway (SR-826)
- Gratigny Parkway (SR-924)
- Airport Expressway (SR-112)
- Dolphin Expressway (SR-836)
- Tamiami Trail (US-41)
- Snapper Creek Expressway (SR-878)
- Kendall Drive (SR-94)
- Quail Roost Drive (SR-994)

Figure 2: Hurricane Evacuation Routes & Zones

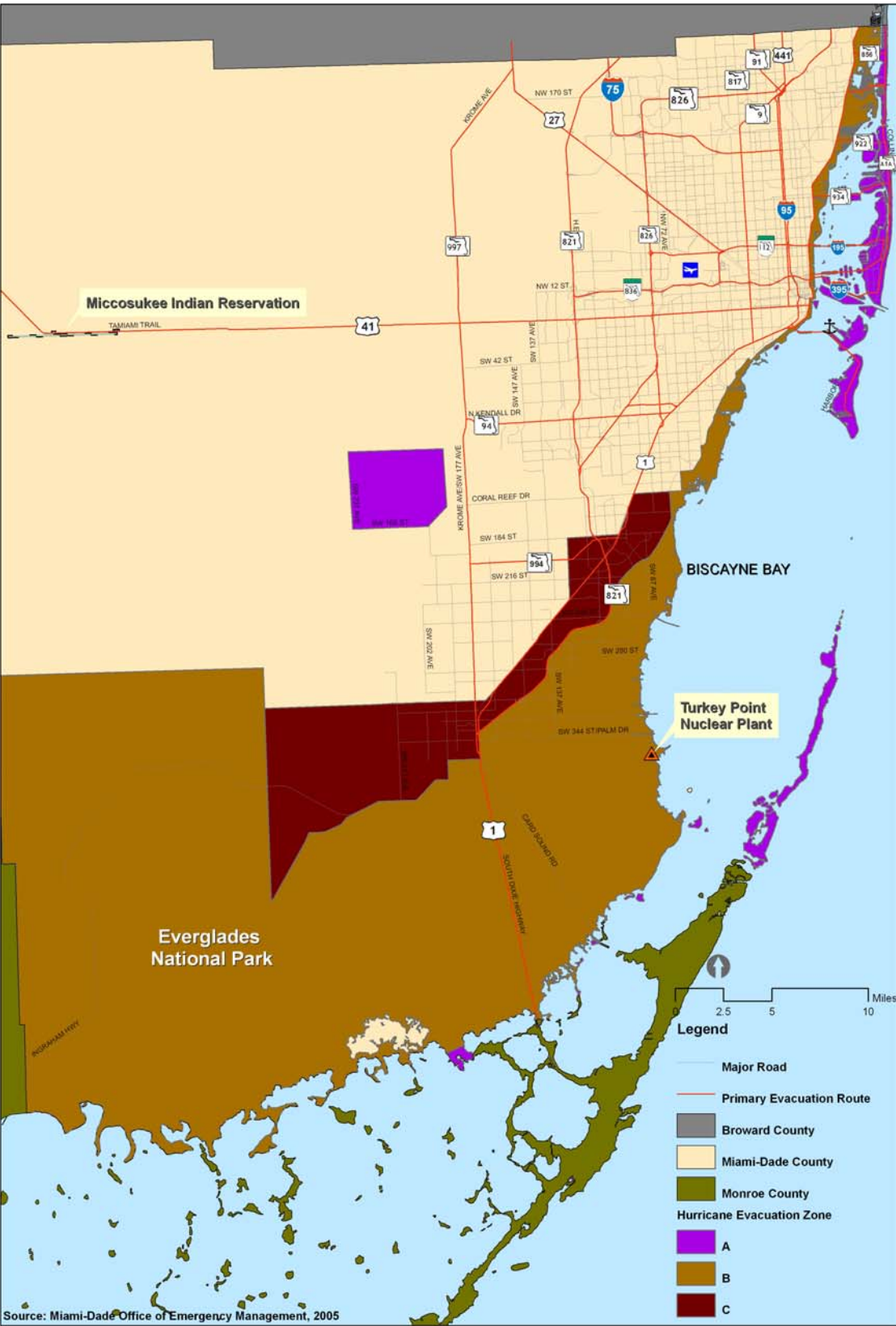


Table 1 lists proposed improvements to some of these facilities that are currently in the FDOT 5 year work program. Only 8 out of the 28 routes identified have funds programmed for improvement.

Table 1: Proposed Projects along Evacuation Routes in Five-Year Work Program

06-07		07-08		09-10		10-11	
McArthur Causeway (I-395) MPO #DT2516861				Type Of Work: ADV Traveler Information System			
US-1				Type of Work: Widen//Resurface Existing Lanes (from 284 street to 304 street) MPO#DT4106251		Type of Work: Widen/Resurface Existing Lanes (from 284 street to 266 street) MPO# DT4106252	
I-95	Type of Work: Add Auxiliary Lanes From N.W. 125TH Street to N.W. 135TH Street- MPO# DT2516693		Type of Work: ITS Freeway Management From NW 62 Street To SR 860/Miami Gardens Drive MPO#DT2516822				
Palmetto Expressway (SR-826)			Type of Work: Interchange (Major) and Add lanes & Reconstruct From 32 Street to 16 th Street- MPO #DT24996481				
Homestead Extension of the Florida Turnpike (SR-821)	Type of Work: Add Lanes from Kendall to SR 836 & reconstruct Interchange at NW 74TH ST- MPO#TP4061041		Type of Work: Add lanes & Reconstruct from 117 th street to Kendall and Eureka Drive to 117 th Avenue (MPO# 4154871) and from 216 street to Eureka Drive (MPO# TP 4154881)		Type of Work: Interchange (Major) MPO #TP 2519831		
Okeechobee Road (US-27)	Type of Work: Add Lanes and Reconstruct from W.12 Avenue to W. 19 th Street (MPO# DT2501051)						
Krome Avenue			Type of Work: Add Thru Lanes and Add Turn Lanes from Kendall to 8street and from 8 street to Okeechobee MPO#DT2496143		Type of Work: Add lanes and reconstruct from US 1 to 328 street MPO #DT4055753		
Airport Expressway (SR-112)			Type of Work: Interchange (Major) from 87 th Avenue to 57 th Avenue (MPO# DT2495811 and Interchange improvement from I-95 to Mcarthur Causeway Bridge (MPO#DT2516881)				

3.4. Seaports

The Dante B. Fascell, Port of Miami (POM) is the County's major container port and one of the world's largest cruise ports. It is the largest truck generator in the County with over 4,000 trips per day. Cruise ship activities at POM in 2003 were over 3.9 million passengers. The Port of Miami River is the fifth busiest port in the state of Florida. At least 24 hours in advance of the arrival of tropical storm force winds (40 mph), the U.S. Coast Guard captain of the port (which includes all coastal areas between Ft. Pierce and Key West) orders that all oceangoing vessels of 500 gross tons or larger depart the area. The POM is closed entirely if deemed necessary by the Coast Guard captain and if the winds are greater than 40 mph. Due to these standard operating procedures and the uncertainty of hurricane paths, it is highly unlikely that cruise ships could be used to execute a mass evacuation in the County unless it was unrelated to a hurricane. However, depending on the emergency and the cooperation of cruise line companies, the use of cruise ships to assist in post event efforts (such as transportation or temporary housing) as occurred in New Orleans, may still be a viable opportunity to explore.

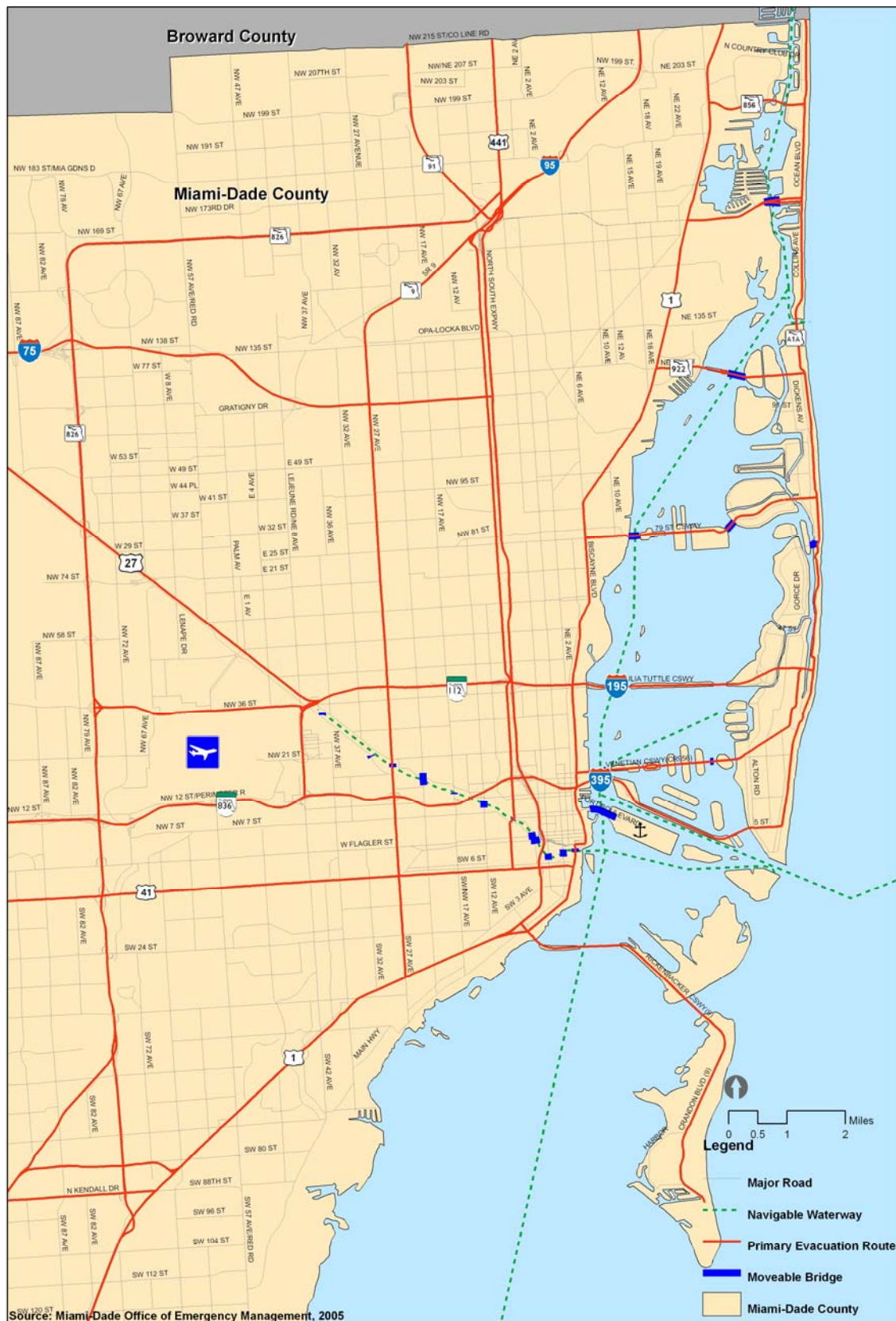
3.5. Bridges

There are a total of 21 movable bridges in the County. Both the Sunny Isles Causeway Bridge and the 2nd Avenue Bridge have two separate spans. Of the 21 moveable bridges, 7 are located along the Intracoastal Waterway (**Figure 3**). The Town of Bay Harbor Islands owns 1 (Broad Causeway), Florida East Coast Railway (FEC) and CSX each owns 1, and the remainder are owned either by the State of Florida or the County. The moveable bridges are locked down during emergency evacuation periods due to safety concerns. If winds are strong enough the bridges could be damaged if at an upright position. Moveable bridges may impact barrier island residents' abilities to evacuate in the event of bridge failure due to lack of power, therefore, it is extremely important that barrier island residents evacuate early if necessary.

3.6. Railroad Systems

There are two independent railroad systems in the County, FEC and CSX. FEC carries only freight, whereas the CSX system provides for freight and passenger services (Tri-Rail and Amtrak). Passenger rail services cease operations prior to the arrival of tropical storm force winds (40mph). Therefore, the ability to use these facilities during a mass evacuation is unlikely unless the event is not hurricane related. Opportunity does exist for discussion with Tri-Rail and Amtrak for potential service needs post event. For example, in New Orleans, the City entered into an agreement with Amtrak for chartered buses to travel to established pick up points for evacuation by rail. Two existing rail yards located in Hialeah and at Airport West can serve as potential staging areas for any type of evacuations. However, space is limited at these facilities and relief supplies following hurricanes usually arrive by truck and not rail. A more likely potential staging area for emergency events is at Metro Zoo where space is more abundant.

Figure 3: Moveable Bridges



3.7. Transit-Dependent Populations

Given the experiences during Hurricane Katrina, the CTAC wanted to focus on transit dependent populations in the County to assure that their ability to evacuate was met unlike in New Orleans. As indicated in the AHUA study, about 5% of the Miami urbanized area does not have access to automobiles, therefore, providing transportation during emergencies to this population is essential. **Figures 4-7** indicate where the concentrations of transit dependent populations are located in the county in relation to evacuation zones, evacuation centers and evacuation pick up sites. Transit dependent may include the young and elderly, households with disabilities, zero-car households and low income households. Information to indicate their location and concentration was secured from the U.S. Census and it is important to note that tracts along the western part of the County are larger so that concentrations within these tracts are shown for the entire tract although the actual location of the population in question may only be in pockets within the larger tracts.

As indicated in these figures, there are many transit dependent populations located in evacuation areas, however, these populations are spread out throughout the County so that transportation during emergencies to target these populations will continue to be challenging. OEM&HS manages an Emergency Evacuation Assistance program (EEAP) which maintains a registry of the special needs population. These populations are directed to special needs evacuation centers and medical management facilities. The elderly or slightly disabled go the special needs centers while those that are oxygen dependent or electrically dependent go to the medical management facilities. All populations, including the transit dependent, that live within an evacuation zone are served by evacuation buses. Pick up sites are reviewed on an annual basis and new sites should be prioritized to serve the transit dependent concentration areas.

As indicated in **Figures 6 and 7**, a significant number of zero-car populations and low income populations reside in cities located near barrier islands and along the Intracoastal Waterway. All households at these locations are especially vulnerable during a hurricane since Barrier Island residents are the first required to evacuate during a hurricane event. Although tribal lands are not located in an evacuation zone, OEM&HS does coordinate with the Tribal community (located west of Tamiami Trail) in case of emergencies. Hurricane evacuation buses serve the Gator Park mobile home community in close proximity (12 miles) to the tribal lands during emergency evacuation events. Additional coordination with this community to locate pick up locations in closer proximity to the tribal lands should continue.

Figure 4: Population under 18 and above 65 years

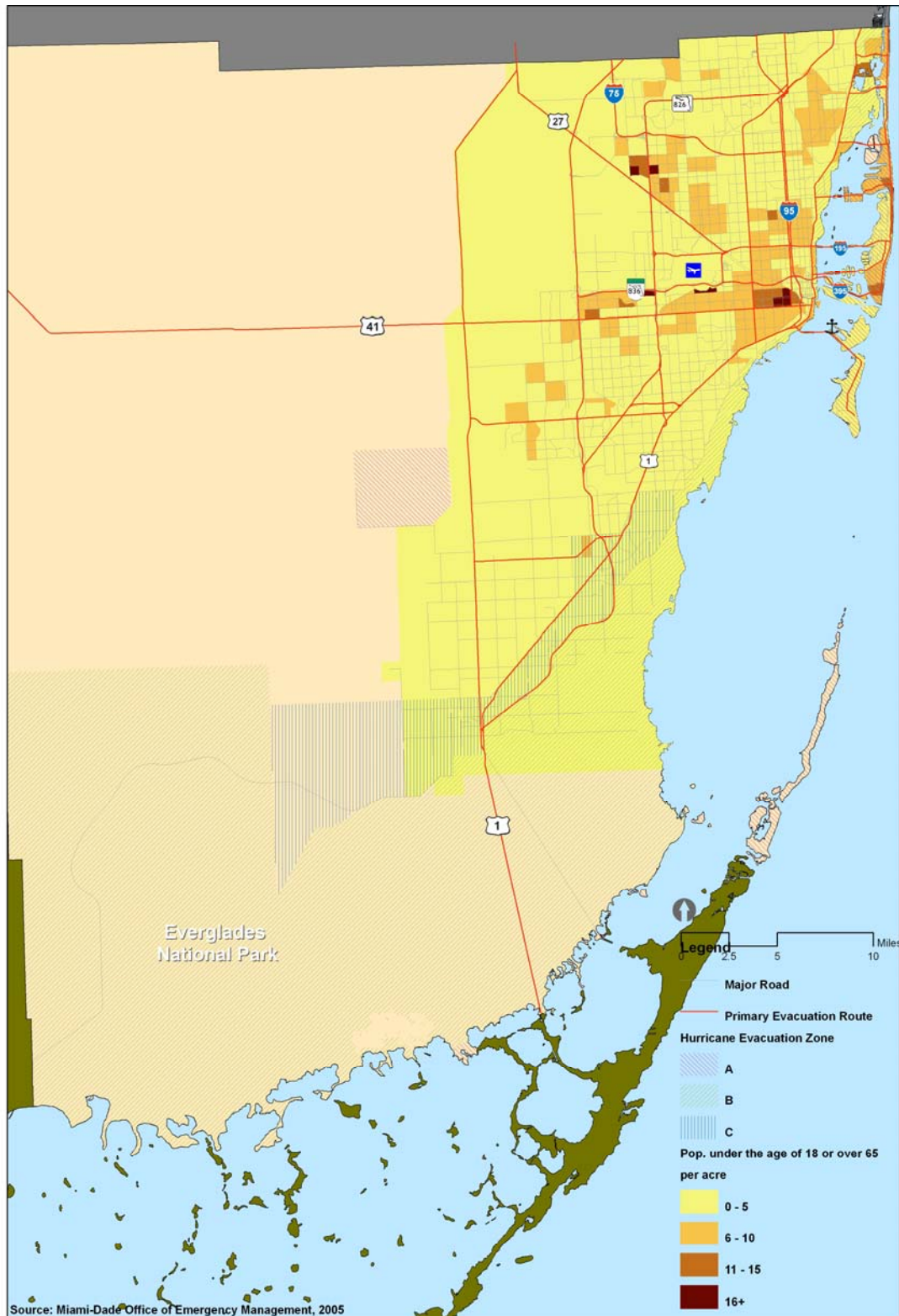


Figure 5: Disabled Population

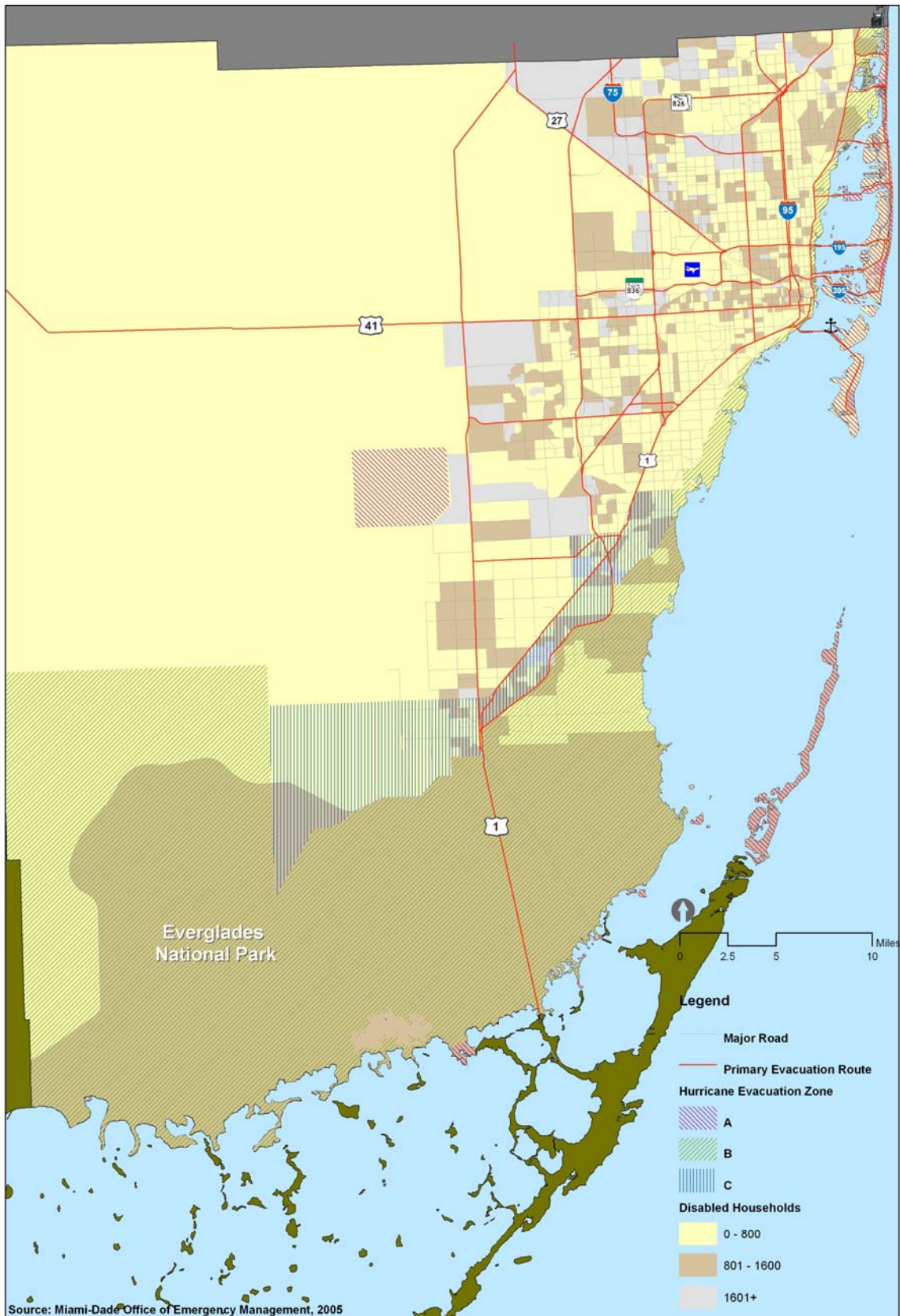


Figure 6: Zero-Car Households

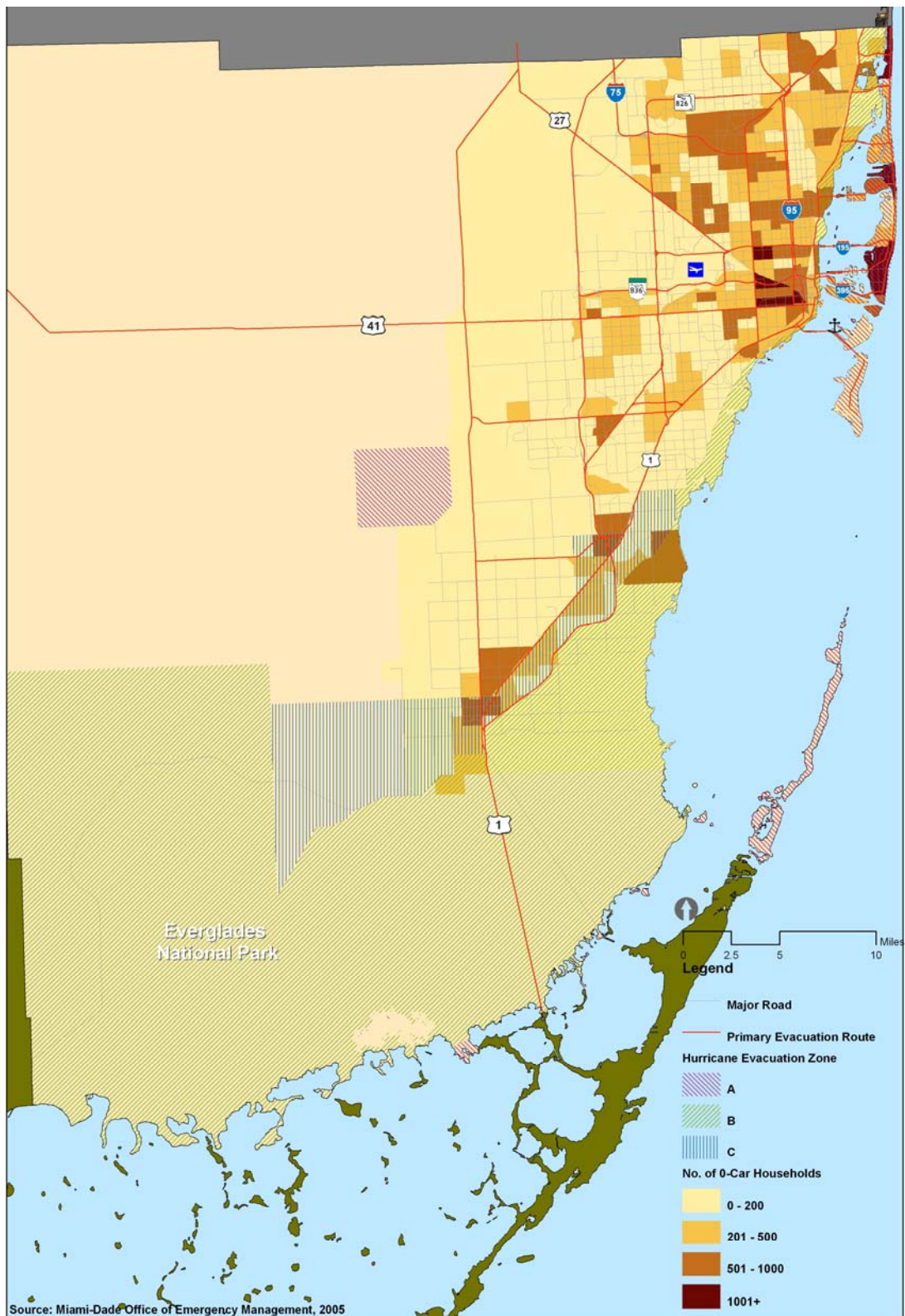
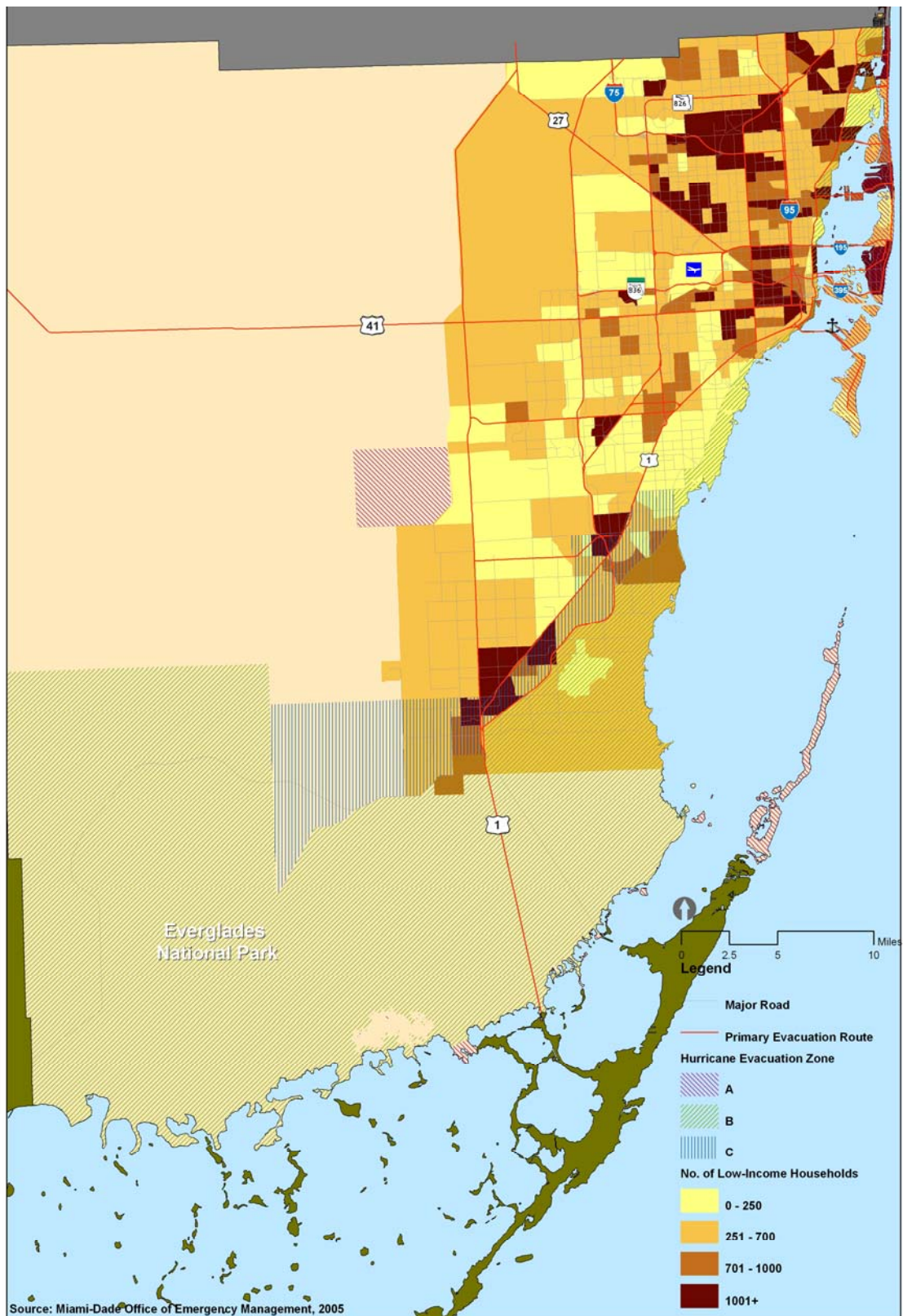


Figure 7: Low-income Population



3.8. Hurricane Bus Stop & Shelter Locations

MDT, in coordination with OEM&HS, identifies several hurricane bus stop locations along designated evacuation routes (**Figure 8**). The County currently has 130 designated hurricane bus stops. These are reviewed annually and following each actual evacuation. The signs are shown below and are in three languages. MDT operates public transportation buses to pre-designated evacuation pick up points for hurricanes and Turkey Point evacuations. These same locations would be utilized for any potential mass evacuation. Depending on a variety of factors such as size of event, number of people to be evacuated, time frame, and time of day, MDT gathers its resources and responds accordingly. Hurricane bus stop locations are available for the transit-dependent as well as those individuals who prefer to take the bus to area shelters or other destinations. MDT's policy during a hurricane-related emergency is to serve its regular routes with diminished service in non-evacuation areas in order to increase service in the priority areas. The main issue with using MDT buses to conduct mass evacuation is to identify the actual destination for transporting individuals and the end points' ability to accommodate these individuals. If contraflow operations were in place, there would always be a lane available for the return trip for these buses to pick up additional individuals.



The Department of OEM&HS has inspected 82 sites located throughout the County and deemed them appropriate for use as hurricane shelters (**Figure 8**). Twenty (20) of these sites have been designated as shelters (15 high schools and 5 middle schools). Public school sites are utilized as locations for shelters since they offer certain amenities (kitchens, dining rooms, showers, generators) that other buildings do not. In addition, all schools built or renovated since the establishment of the Florida Building Code must include an “enhanced hurricane protective area” that is reinforced to a wind load capacity of more than 140 mph. Shelters would not be located in evacuation zones. If Miami-Dade residents conducted a mass evacuation to northern and western counties, these shelters would probably be filled with the County’s respective residents. Moreover, if the mass evacuation occurred due to hurricane or flooding, Collier and Lee counties would not be recommended for evacuation since they are below base flood elevation.



Figure 8: Hurricane Evacuation Bus Stops/Shelters



3.9. Fuel Locations

Fuel facilities and their location are important to note during an evacuation. A total of 616 fuel facilities are located throughout the County and in areas at or near evacuation routes (**Figure 9**). However, depending on the emergency, these fuel facilities may not be operating due to power outages. One of the main education efforts for emergency managers in Miami-Dade and Monroe is to stress filling up gas tanks prior to an emergency. Access to fuel is one of the reasons mass evacuations are not recommended. The County does not have authority over the establishment of additional fuel facilities, however, it was noted that there was a limited number of fuel facilities in close proximity to the Florida Turnpike and along certain designated evacuation routes: Tamiami Trail, Krome Avenue, SW 200 Street/Quail Roost Drive, South Dade Expressway, North Kendall Drive and State Road 9. A potential mass evacuation of individuals along these routes may result in traffic congestion, traffic delays, and vehicles running out of gas.

One strategy recommended for study is the applicability of roving fuel trucks that would have the ability to fuel up stranded cars in emergency situations. Currently, the FDOT and Florida's Turnpike have safety patrol trucks that could be equipped with additional fuel during emergencies. These patrols could use the shoulders for access to stranded vehicles.

Figure 9: Fuel Facilities



4. Preliminary Modeling Analysis

4.1. Baseline Assumptions

The Miami Urban Area Transportation System (MUATS) travel demand model developed for the 2030 Miami-Dade Long Range Transportation Plan (LRTP) was used to simulate a mass evacuation event in this study. This model is used to predict highway and transit travel in Miami-Dade County and was adapted solely for this study. It is not a hurricane evacuation model.

The model simulates a “typical” 24-hour weekday in the peak season in Miami-Dade County and provides an assessment of congestion along major roadways. Volume to capacity (V/C) ratios were identified by the model for designated evacuation routes for the validation year (2000) and horizon year (2030) as depicted in **Figures 10** and **11**. Volume-to-capacity is a standard measure of congestion. A V/C of 1.0 indicates a maximum use of capacity and can be considered level of service “F”. Levels of Service range from “A” which is free flow conditions to “F” which are congested conditions. The aggregate bi-directional Volume-to-Capacity ratio for designated evacuation routes in 2000 is 0.89, which represents an approximate level of service “C”. In the year 2030, the model indicates a V/C ratio on evacuation routes of 1.10, representing a level of service “F”, so that for typical commuting patterns, these facilities will be congested in 2030. As anticipated, many of the evacuation routes are some of the County’s most highly traveled facilities. Therefore, any additional improvements to these facilities beyond what is planned in 2030 would also ultimately help emergency evacuation efforts.

BROWARD
MIAMI-DADE

BISCAYNE BAY

0.5 1 2 3 4 Miles

Legend

Volume to Capacity Ratio

- 0.00 - 0.70
- 0.71 - 0.80
- 0.81 - 0.90
- 0.91 - 1.00
- Greater than 1.00

Broward County
Miami-Dade County
Monroe County

[illegible]

The MUATS travel demand model was adapted and utilized to simulate a mass evacuation scenario in the case of an emergency evacuation. Several assumptions were made to adapt this model to a mass evacuation resulting from a natural or man-made disaster. These assumptions were discussed with MPO staff and include:

- 100% of households in the designated mandatory hurricane evacuation zones (typically the barrier islands) will evacuate to points north of Miami-Dade County.
- 80% of households in the inland areas will evacuate north out of Miami-Dade County;
- 100% of households in Monroe County will evacuate through Miami-Dade County to points north;
- The peak hour factor used to relate highway capacities to the evacuation period is 20%, effectively simulating a 5-hour evacuation period (U.S. Army Corps of Engineers, Behavioral Analysis for Residents of Northeastern North Carolina). This factor was used to compress the traffic into a defined time period for modeling purposes only since the MUATS is a 24 hour model.
- Evacuation traffic will be distributed across major highway facilities exiting Miami-Dade County proportionate to capacities on the respective facilities.

These assumptions were prepared for simulation purposes only and agreed upon with MPO staff. It is understood that in many emergency evacuation events there is a natural resistance to evacuation since residents do not want to leave their household and belongings. The purpose of the extreme number of household evacuation was to simulate and analyze a worst case scenario as desired by the CTAC. The peak hour factor used to relate highway capacities to the evacuation period was the only readily available information from a reputable agency. No peak hour factor was available for use from the information prepared by the SFRPC.

The model was then used to simulate mass evacuations for the year 2000 (base year model) and a future year 2030. The results of these simulations are presented in the following tables and maps in terms of volume-to-capacity ratios (V/C), which represent a quantitative measure of level of service. **Figure 12** depicts the V/C results in the year 2000 for typical directional traffic, indicating a high level of congestion countywide with major chokepoints at the Miami-Dade/Broward County boundary. During an evacuation simulation, the corresponding aggregate V/C for evacuation routes in 2000 is 1.05, which includes the evacuation of 685,700 households, including 34,000 Monroe County households. It is important, as a point of reference, to note that this ratio in 2000 is similar to the anticipated traffic congestion along evacuation routes in 2030 as discussed above.

Figure 13 depicts the same results for the year 2030, indicating roughly the same pattern of congestion and an aggregate V/C for evacuations routes of 1.20, corresponding to the evacuation of 961,000 households, including 37,500 Monroe County households.

Figure 12: 2000 Evacuation Route Volume to Capacity Ratios (Directional Traffic, No Contraflow Conditions)

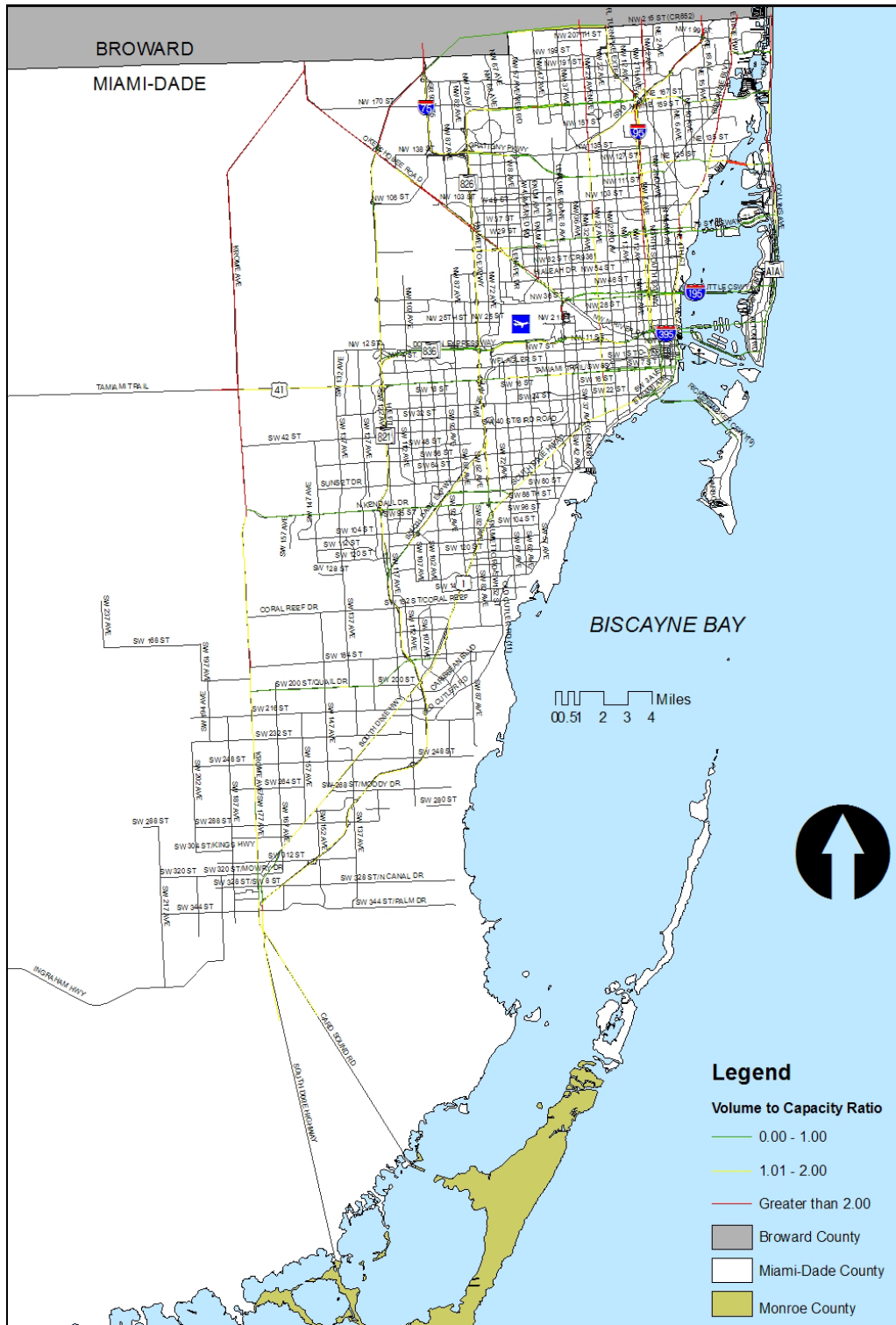


Figure 13: 2030 Evacuation Route Volume to Capacity Ratios (Directional Traffic, No Contraflow Conditions)

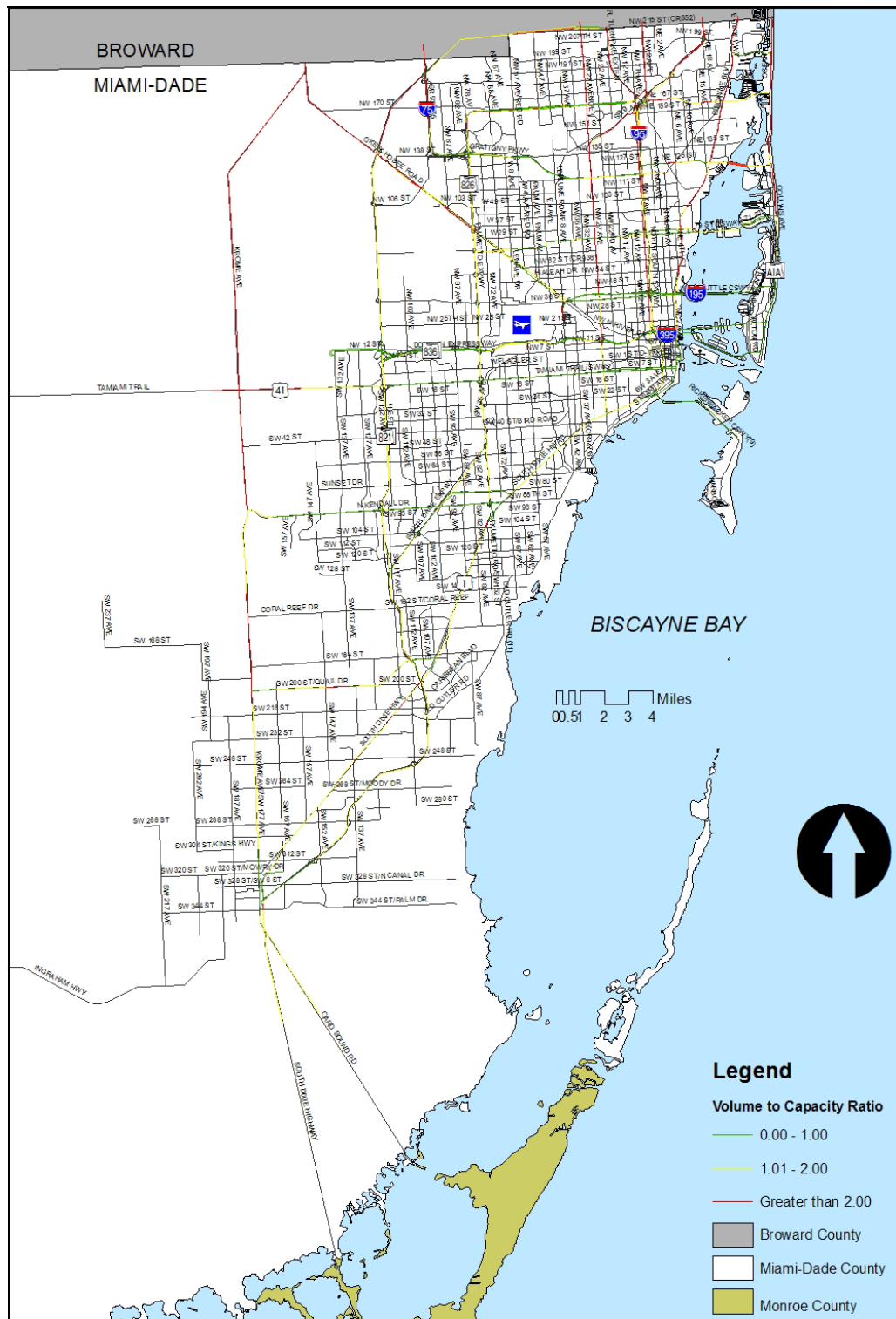


Table 2 depicts the V/C ratios for both 2000 and 2030 by facility types, indicating a higher level of congestion on arterial evacuation routes than limited access facilities. Reasons for this phenomenon include the fact that the arterials have lower capacities than the limited access facilities and they, in part, serve as collectors, distributing the majority of trips to the major north/south limited access facilities.

Table 2: Volume-to-Capacity Ratios for Evacuation Routes by Year and Facility Type

Year	Facility Type	Directional Traffic
2000	Limited Access	1.03
	Arterial	1.08
	Other	0.96
2030	Limited Access	1.12
	Arterial	1.32
	Other	1.28

4.2. Contraflow Modeling Analysis



An alternative modeling scenario was developed that, on the supply side (evacuating trips) utilizes the same assumptions, as described in **Section 4.1** above, but on the demand side (highway facilities), simulates contraflow conditions on all arterial facilities for their entire length. The analysis did not include a penalty to equate with the difficulty encountered with implementation of contraflow on limited access facilities (expressways). Limitations on implementation of contraflow along limited access facilities were outlined in FDOT's analysis of Alligator Alley in Section 2.5. OEM&HS and FDOT District VI do not recommend contraflow for Miami-Dade County due to the unpredictability of hurricanes and the manpower required. However, as indicated in

Section 2.5, contraflow continues to be studied by FDOT and the Florida Turnpike as a radical way (and possibly as a last resort) to increase capacities on the roadways quickly. The contraflow image depicted

above is a rendering of Turnpike contraflow operations for emergency situations. The Turnpike Enterprise completed emergency traffic routing plans for each service plaza on the system including both regular traffic flow and contraflow operations. In addition, the Turnpike Enterprise has established emergency “strike teams”, employees who volunteer to assist at service plazas during emergency situations, to address manpower issues associated with contraflow.

As would be suspected, the effective result of the contraflow scenario analysis conducted for this study is the doubling of capacities on those arterial facilities designated for contraflow and the alleviation of some of the traffic on the limited access facilities. **Figure 14** depicts the V/C results in the year 2000 for this scenario, indicating a significantly lower level of congestion than the baseline scenario. The corresponding aggregate V/C for evacuation routes in 2000 is 0.85. **Figure 15** depicts the same results for the year 2030, indicating an aggregate V/C for evacuations routes of 1.00. Both of these V/C ratios are below the V/C ratios established for the baseline on existing evacuation routes and for the evacuation simulation without contraflow.

Table 3 depicts the V/C ratios for 2000 and 2030 for both the baseline and contraflow scenario, indicating a significant reduction in the levels of congestion on arterials and a smaller reduction in congestion on limited access facilities. Obviously, converting all arterial evacuation routes in the County is not necessarily a reasonable scenario and has many limitations; however, this contraflow scenario analysis indicates that the impact of such a policy may be beneficial if not pre event then potentially post event. Further study is recommended to identify the critical routes and narrow the use of contraflow conditions to a level that maximizes the benefit but is also logistically feasible. Agreement on this further study would need to be secured from OEM&HS and FDOT District VI who do not recommend contraflow implementation for any emergency evacuation purpose.

Table 3: Volume-to-Capacity Ratios for Evacuation Routes by Year and Facility Type

Year	Facility Type	Baseline	Contraflow*
2000	Limited Access	1.03	0.99
	Arterial	1.08	0.74
	Other	0.96	0.80
2030	Limited Access	1.12	1.08
	Arterial	1.32	0.91
	Other	1.28	1.18

*Contraflow conditions were modeled on non-limited access facilities only

In addition to the use of contraflow conditions on relevant facilities, a critically important policy issue that relates directly to the levels of congestion simulated in this study is the peak hour factor. As described above, the peak hour factor used in this study is 0.2. In modeling terms, the impact of such a factor is effectively a 5-hour evacuation of all trips. While the specific period and pattern of evacuation is a function of the circumstances of a given emergency, a geographically phased evacuation in a period greater than 5 hours would significantly reduce the congestion from the levels simulated in this study. Further study is warranted to test more specific policy options. Moreover, the peak hour factor is the *methodology* used to simulate the worst case scenario event so that transportation deficiencies are clearly highlighted. This process is not determining clearance times for evacuation which is a different concept. Clearance times are actual hurricane modeling *results* that indicate how long it would take for the last person to evacuate a certain area. These times have been established for Miami-Dade and Monroe counties through extensive modeling.

Figure 14: 2000 Evacuation Route Volume-to-Capacity Ratios (Directional Traffic, Contraflow Conditions on Arterials)

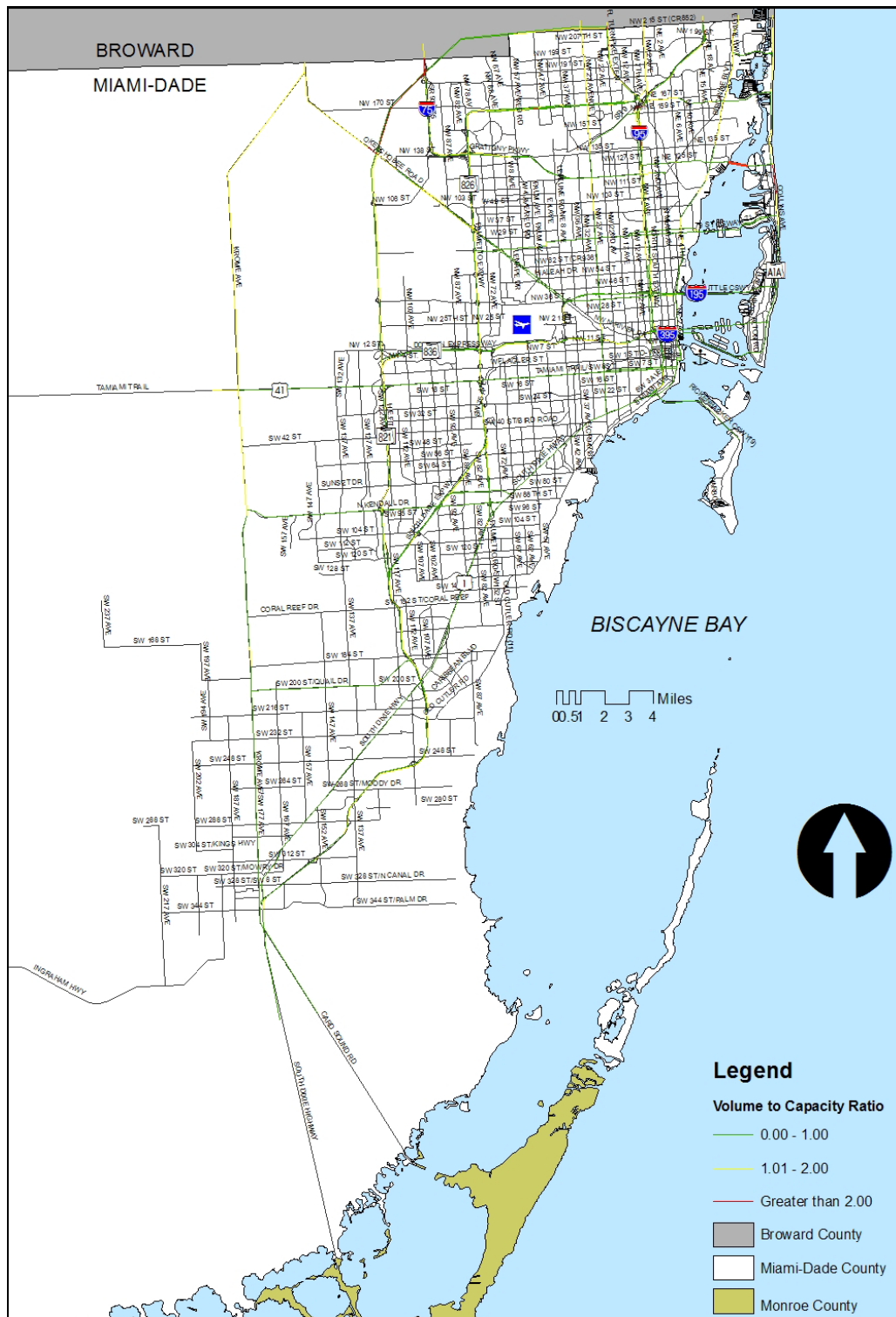
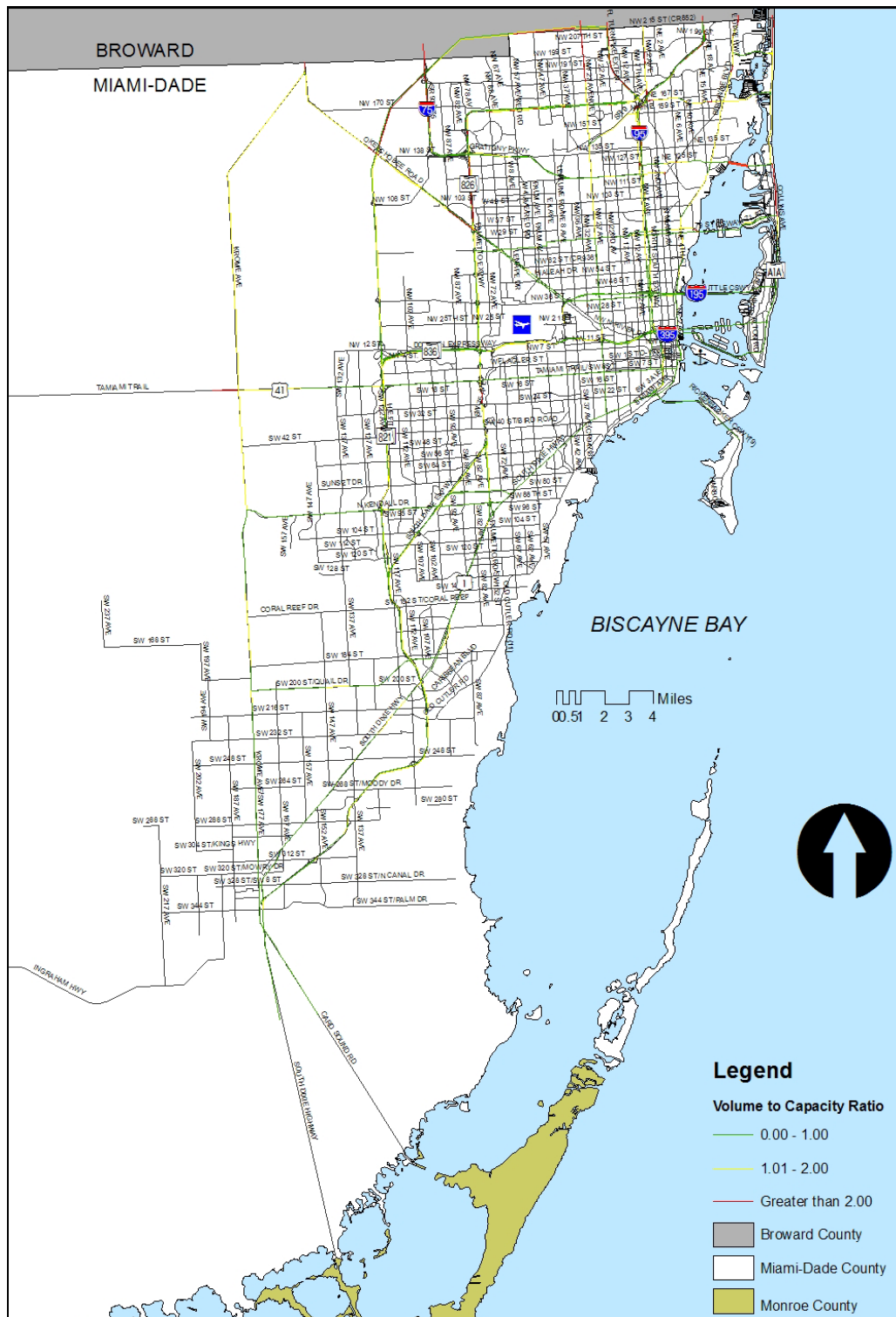


Figure 15: 2030 Evacuation Route Volume-to-Capacity Ratios (Directional Traffic, Contraflow Conditions on Arterials)



5. Pre and Post Event Strategies

Based on the research, analysis and comment provided for this study, several strategies were identified for further study and implementation. Discussions regarding the applicability of these strategies are included in this section. It is important to note that mass evacuation has the potential to create panic conditions (unplanned evacuation) and the challenge will be how the County can prepare effectively and safely for these conditions. Recommendations from the CTAC regarding how to better plan for panic situations includes providing education to the county residents and information on how to react should a panic situation occur. Numerous issues are anticipated with implementation of some of the strategies due to financial and agency personnel implications. Continued discussion on how to anticipate and prepare for these issues is the main goal of this study. Lastly, many of these strategies are pre event strategies that contribute to emergency planning. Other strategies may not be applicable pre event but may be necessary post event depending on the emergency in question.

5.1. Centralized Lead Agency

As in the lessons learned from the 2005 Hurricanes Katrina and Rita, lack of communication between public agencies can be a stumbling block for effective evacuation. Regional agreements between public and non-profit entities must be in place for eventual implementation during emergencies. In Miami-Dade County, OEM&HS is the designated lead agency for emergency events. They maintain agreements with Miami-Dade County Public Schools, MDT, MDX and other relevant agencies. They are also the official emergency managers for all the cities in the County. Any additional agreements with private providers such as Greyhound would be coordinated with OEM&HS. One of the main issues identified by these private providers is the uncertainty of where to take individuals during a mass evacuation and what resources would be at the end point location to accommodate them. OEM&HS continues to work with all agencies to educate the public about emergencies and to provide needed manpower during evacuations. Additional funding should be secured to support their lead agency centralized efforts for better preparation for a mass evacuation event, should it occur (planned or unplanned).

5.2. Evacuation Bus Pick-Up Sites and Evacuation Centers

As mentioned previously, MDT and OEM&HS keep an inventory of all existing hurricane bus stops and pick up sites and review them annually. During this review, additional stops or signs are determined. Maps of these pick-up sites should be available and distributed to the public in three languages as an additional education effort. Continued funding to support these education efforts, where bus pick-up sites and shelters are located, should be identified.

5.3. Continue to Study Reverse Lane/Contraflow Operations

As indicated in the background information in Section 2 and in the simulation analysis in Section 4, reverse Lanes or “contraflow” operations can be beneficial for quick emergency evacuation of an area. Incoming highway lanes to an area are changed to outbound lanes. This potentially doubles the number of lanes available for outbound evacuation traffic. Crossover sections or intersection locations are used to move outgoing traffic to these lanes. All incoming traffic is blocked until the end of the contraflow program. Contraflow planning must be analyzed and implemented at a regional level since instituting contraflow in Miami-Dade County along major arterials would be inoperable once the contraflow lanes reach adjacent county lines. In the example below, there is only one contraflow lane, however, contraflow operations can convert as many lanes as desired by the agency involved. A return flow lane is always recommended for emergency service purposes.

Despite the benefits of contraflow, this report has also highlighted the many limitations of contraflow use, especially for emergency evacuation purposes during an uncertain hurricane path. Manpower training and availability are also a major issue, as is education of the public regarding contraflow, especially



during potential panic situations. Overall, transportation officials in Florida consider the use of contraflow as a last resort option. The only exception studied by the Department of OEM&HS as potential contraflow during emergency evacuations was the possible modification of traffic flow on the Julia Tuttle and MacArthur Causeways to one way (west bound) as a last resort action to expedite late stage Barrier Island evacuees. Their analysis determined that this contraflow strategy would not be successful. Although contraflow may not be a useful tool during a hurricane related pre event due to its many limitations, it could have some benefit under other non hurricane related emergency conditions and in post event situations where deemed warranted.

5.4. Utilization of HOV Lanes

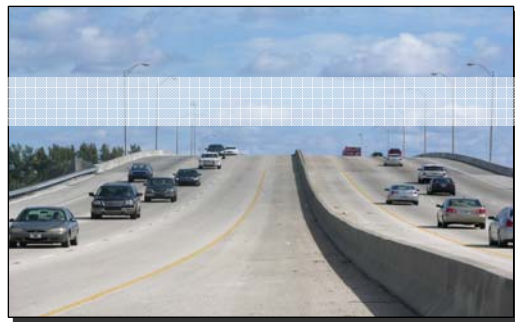
Another potential strategy is to have the County work with the Turnpike Enterprise, MDX, FDOT and other public agency officials to execute agreements, if needed, for utilization of road shoulders and designated High Occupancy Vehicle (HOV) lanes as



additional lanes during an evacuation. Similar to the HOV lane example in Toronto, use of HOV lanes can increase capacity during emergency evacuation situations. Similar to the Florida Turnpike analysis, HOV lanes can be temporarily striped for emergency vehicle use only during a potential mass evacuation. The HOV lanes would provide priority to transit staff to transport transit-dependent or special needs evacuees out of the County in the event of a mass evacuation. Enforcement, however, would be required which entails manpower. Additionally, restriping to respond to a quick evacuation scenario would require time that may not be available during a mass evacuation event. In Miami-Dade County, the only HOV lanes currently in place are along I-95.

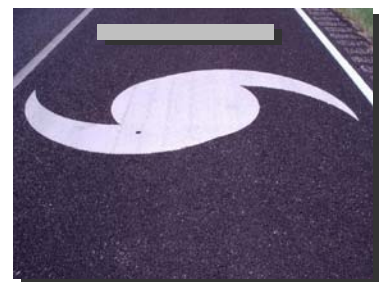
5.5. Use of Road Shoulders

Road shoulders are a reserved area alongside the verge of the road. Generally a road shoulder is kept clear of all traffic. In the event of an emergency or breakdown, a motorist can pull into the road shoulder to get out of the flow of traffic and obtain an element of safety. During mass evacuation, the use of road shoulders may provide additional lane capacity (again a strategy being considered by the Florida Turnpike for emergencies). To support the



use of additional traffic along these shoulders, consideration should be given to strengthening and leveling the pavement along the shoulders of evacuation routes or at other key locations. For example, I-75 south of Sarasota has three northbound lanes. South of this area, there are only two northbound lanes for a 21-mile distance beginning in Port Charlotte. FDOT operates a hurricane evacuation emergency shoulder lane on this 21-mile segment, thereby temporarily extending the three-lane section between Port Charlotte and Sarasota.

One of the advantages that emergency shoulder lanes have over contraflow lanes is time. Unlike contraflow, there is no need for law enforcement personnel to flush lanes, a task that can take hours depending on the length of the highway with contraflow. Once the emergency shoulder lane begins operation, it can continue until traffic



demands are exhausted instead of being subject to a time limit, as some states have with their contraflow operations. Additionally, emergency shoulder lanes require much less staff resources from the FDOT during the evacuation. This strategy is implemented along US 1 between Key Largo and Florida City during evacuations. However, analyzing and planning for the future use of road shoulders for evacuation should continue.



5.6. Agreements on the Use of Transit Buses, School Buses, Tri-Rail



Executing pre-event agreements with School Districts, Tri-Rail, Amtrak and Greyhound to provide transportation to residents was a major lesson learned from the Katrina experience. Officials in New Orleans failed to deploy 500 existing transit and school buses in order to assist with the evacuation due to the lack of pre-event agreements. It is estimated that with multiple trips, the total number of transit dependent that could have been evacuated using these buses was between 10,000 to 30,000 residents during the 48-hour evacuation period. Several public agencies such as the New Orleans Health Department and the Red Cross were in the process of creating a strategy to use Amtrak and city buses to evacuate residents in the event of an emergency. The plan failed because the city did not have regional agreements already in place (Preston, 2005). Miami-

Dade County's Department of OEM&HS has executed agreements with some of these agencies where feasible and coordinates all evacuations with MDT. However, some transportation providers such as Amtrak and Tri-rail standard operating procedures include the cessation of operations during severe hurricane events. Therefore, depending on the event, it would be unlikely that they would continue operations during a mass evacuation unless assured that there would be no danger in their operation. In these instances, use of passenger rail could be deployed as a post event strategy. As with all transportation to points outside of the County, the main issue remains where to transport people to. Greyhound for example expressed a hesitation in having an agreement unless they were certain of the destinations. The uncertainty of a hurricane or any other emergency for that matter limits the ability to identify these destinations.

5.7. Work Zones and Construction

Another strategy being currently implemented during hurricane evacuations is to ensure that all equipment on major roads that are under construction be cleared so that traffic and emergency vehicles may use those roads during an emergency situation. Fines are issued to contractors who do not comply with this order. This coordination would also need to occur during mass evacuations and again manpower would be the main



issue for implementation.

5.8. Intelligent Transportation Systems

Further application of Intelligent Transportation Systems (ITS) would be extremely beneficial for use during emergency evacuations. ITS could be used to communicate the end point locations that are available for occupancy, operational adjustments to traffic, availability of fuel locations, immediate bus pick up sites and other information. The County's ITS is a cooperative effort between FDOT and other transportation agencies and funds should be identified to help maximize the use of ITS for emergency evacuations. For example, ITS along I-395 can improve the safety, efficiency, and speed of evacuations. The FDOT is expanding its Smart Route System, *Smart Route*, a state-funded initiative introduced in 2005. Information is delivered on real-time traffic information through a network of roadside signs, phone lines and a website. There are fourteen Dynamic Message Signs distributed in the County along Interstate 95, State Road 826, and Florida's Turnpike. The system warns travelers of delays but could potentially be utilized to provide minute by minute information to evacuees and residents during an emergency situation. FDOT should explore the possibility of building double sided variable message signs should contraflow or reversible lane operations be instituted. The County could also consider implementing bi-directional traffic signs and signals along evacuation routes for updates and information during emergency events and for safe routing and funds should be identified for this effort. As an example, FDOT's District 5 inserted a "floodgate" message at the front end of the branching menu that normally is presented to callers during the hurricane season. The floodgate message can provide some overriding message regarding evacuation or re-entry that all motorists should hear if they want to receive additional information on this subject, they are then directed to select a particular numeric code; otherwise, they are presented with the normal 511 menu. It is assumed that during an emergency event requiring mass evacuation, standard operation procedures regarding incident management will not apply as is the case during hurricanes.

OEM&HS has a list of private owners of variable message signs. A potential CTAC recommended strategy was to use these during evacuations. This is a possibility that could be explored with a pre event agreement for reimbursement or payment to these private owners.

5.9. Removal of Tolls and Traffic Control Devices & Signalization

In an effort to increase the flow of traffic during hurricane emergency evacuations, OEM & HS makes requests to FDOT, MDX and Turnpike Enterprise to lift all tolls along County roadways. This procedure would also apply during mass evacuations. According to OEM & HS, an evacuation software program to enhance traffic signalization during hurricane emergencies will be developed. Currently, MDPW staff has the ability to manually override normal signal timing patterns and implement patterns for faster exit along roadways during emergencies. MDPW have used this feature on several occasions over the past twenty

years to increase the capacity of South Dixie Highway northbound when the Florida Keys are being evacuated and to increase the capacity of the westbound causeways when the beach areas are being evacuated. In the next few years, all of the traffic signals in the County will be transferred to the Advanced Traffic Management System which will have similar capabilities as the current systems to control and monitor traffic during hurricane and emergency evacuation events.

5.10. Fuel Facilities

It was noted that there was a limited number of fuel facilities in close proximity to the Florida Turnpike and along certain designated evacuation routes: Tamiami Trail, Krome Avenue, SW 200 Street/Quail Roost Drive, South Dade Expressway, North Kendall Drive and State Road 9. A potential mass evacuation of individuals along these routes may result in traffic congestion, traffic delays, and cars running out of gas. One strategy recommended for study is the applicability of roving fuel trucks that would have the ability to fuel up stranded cars in emergency situations. Currently, the FDOT and Florida's Turnpike have safety patrol trucks that could be equipped with additional fuel during emergencies. These patrols could use the shoulders for access to stranded vehicles.

5.11. Essential Personnel

If a mass evacuation of County residents is required, manpower issues would be more exacerbated than in a typical hurricane evacuation event. Police and public works staff would be assigned to guide, control, and monitor traffic at each intersection throughout the County where there may be possible gridlock. As mentioned previously, manpower is a big deterrent to implementation of contraflow, especially during emergency events. For a mass evacuation, similar to what occurred during Katrina, many of the essential personnel to assist with evacuation efforts actually evacuated themselves. There may be a possibility to incentivize employees to remain at work during emergency situations at pre event stages. However, these same employees will need transportation at the late stage evacuation which may have ceased operations. Therefore, especially if they are transit dependent, their ability to return home would be hindered. Additional funding should be identified for these incentives as well as for additional education campaigns for residents on how to react to emergency events. Another strategy proposed by the CTAC consisted of exploring automated systems that could assist with evacuations which would lessen the manpower requirements for mass evacuations. Additional funding should be provided for these efforts as well.

5.12. Moveable Barrier Wall

To facilitate the potential for future use of contraflow, the County should continue to study adding moveable median barrier walls on limited access facilities. These would be implemented at key locations

along the highways to create an opening to allow emergency crossover. Additional funding should be identified for the planning and implementation of this effort.

5.13. Prioritize Improvement Projects along Evacuation Routes

The main impact that the MPO can have on facilitating mass evacuation throughout the county is to prioritize all transportation improvements projects in the Transportation Improvement Program (TIP) and FDOT Work Program that are concentrated on major choke points along evacuation routes and support capacity improvements and ITS improvements along these routes. **Table 1** provided a list of projects in the current work program along evacuation routes that should be expedited. As identified in this report, many of the evacuation routes are also the major roadway facilities that carry high volumes of daily traffic. Therefore, additional funds should be identified along these routes for emergency evacuation purposes as well as for congestion relief. Any Long Range Transportation Planning (LRTP) projects along evacuation routes that increase capacity should also be identified and prioritized during the next LRTP update process.

5.14. Individual Family Evacuation and Preparedness Plans

There are providers that can assist families to prepare individual plans in case of emergencies via a checklist of questions. The County could start by requiring all county employees to establish these individual plans. Additionally, the American Red Cross now provides a database for individuals to sign up with personal information so that the database could be used post event to facilitate finding individuals.

5.15. Corrective actions toward substandard housing

As in past hurricane related events, the areas in the County with substandard housing will usually sustain the most damage due to the associated high winds. It is in these situations where individuals living in substandard housing would have to be relocated to shelters on a longer term basis. This is different than what occurred in New Orleans where the damage was mostly related to water and flooding along areas below sea level. As indicated previously, major flooding damage is unlikely for Miami-Dade County. However, depending on the emergency, to prevent necessary evacuation from areas with substandard housing, the County should continue to focus on diminishing the amount of this particular housing stock.

5.16. Other CTAC identified strategies

- Discuss with private cell phone companies the possibility of sending instant messaging to customers with updated emergency evacuation information. This would require extensive coordination with private providers of a service. Some providers already send information to tourists and residents via text messaging on a subscription basis and in some cases provide it to low income residents at no

cost. To assure that providers would perform this service during an emergency evacuation event, pre-event agreements should be in place.

- Explore as a post event strategy the use of cruise ships for transportation and/or lodging. In these discussions with cruise companies, explore establishing agreements with cruise line companies to provide assistance during mass evacuations that result from a non-hurricane related emergency.
- Explore funding for restoration efforts such as the purchase of new signs on major routes that are affected after the emergency.