Tampa Bay Disaster Resiliency Study

Part I – Regional Description

1921 Hurricane – Bayshore Trolley Damage

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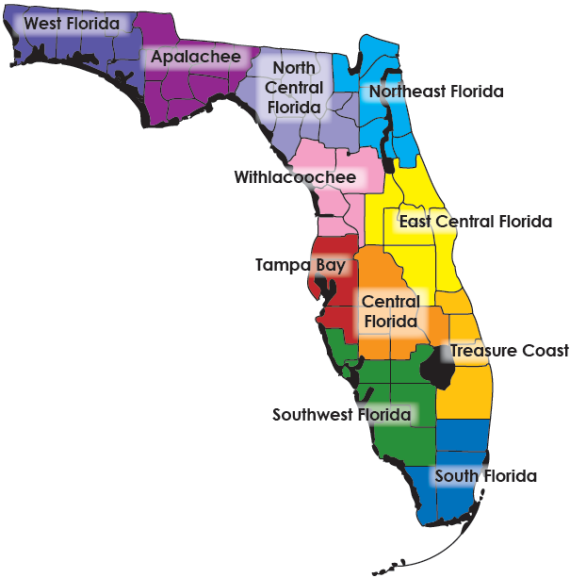
Regional Description

The Tampa Bay Area is located on the west central area of Florida on the Gulf of Mexico. Due to the various geographies and population centers in Florida, the Tampa Bay region can be defined in a number of ways by utilizing or not utilizing neighboring counties. In this study the boundaries of the Tampa Bay Area are defined as the Tampa Bay Economic Development District (TBEDD). The region encompasses the Hillsborough, Manatee, Pasco and Pinellas counties. Within these counties are the cities of Tampa, Temple Terrace, Plant City, Anna Maria, Bradenton, Bradenton Beach, Holmes Beach, Longboat Key, Palmetto, Dade City, New Port Richey, Port Richey, San Antonio, St. Leo, Zephyrhills, Belleair, Belleair Beach, Belleair Shore, Clearwater, Dunedin, Gulfport, Indian Rocks Beach, Indian Shores, Kenneth City, Largo, Madeira Beach, North Redington Beach, Oldsmar, Pinellas Park, Redington Beach, Redington Shores, Safety Harbor, Seminole, South Pasadena, St. Pete Beach, St. Petersburg, Tarpon Springs, and Treasure Island.

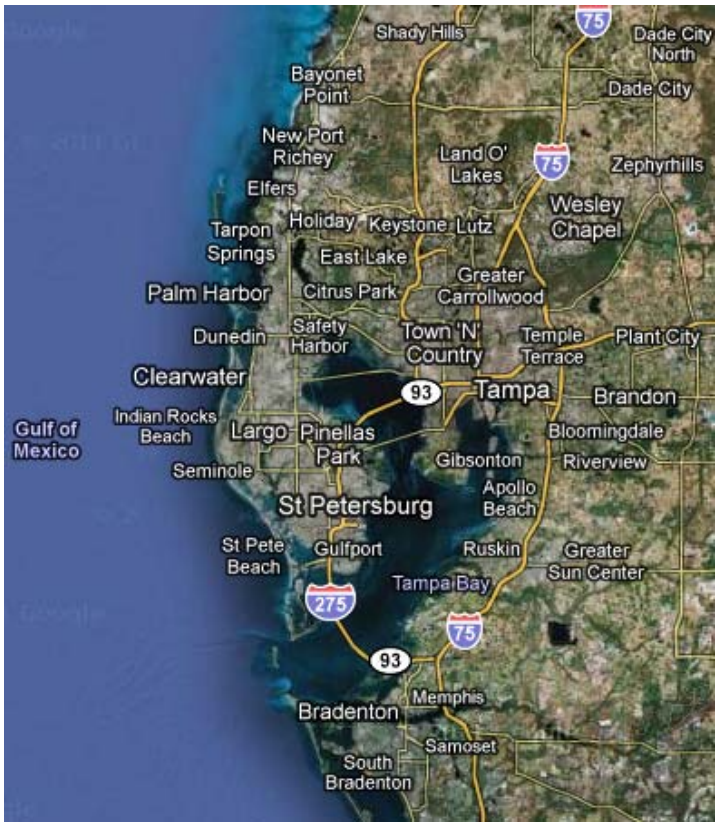


The region is the 19th Largest Metropolitan Statistical Area (MSA) in the United States of America. The latest Census put the region's population at 2.9 million residents. That figure represents a 16% increase in population or just over 400,000 new residents for the decade 2000 – 2010. The largest county, Hillsborough, recorded the largest raw population influx, a 23% increase to reach 1.3 residents in 2010. The second largest county, Pinellas, actually saw a slight decrease, dropping 0.5% to 916,542 residents. This drop is most likely attributed to Pinellas County being essentially built out and a lack of developable land to grow. Percentage-wise, Pasco County grew the most, increasing 35% to 464,700 residents. Manatee County experienced a 22% increase in population, growing to 322,833 residents. The growth the region experienced is not abnormal to Florida, which grew at 17.6% over the same decade.

The Tampa Bay Area is a vital hub to Florida and the U.S. The region is the second most populous metropolitan area and is the second largest economy in the state. As of 2010, employment is estimated at 1.6 million workers within the region, which is lower than years past due to the effects of the national recession. The region commanded $118 million in Gross Domestic Product (GDP) in 2010, roughly 17% of Florida's total GDP and 1% of the entire national GDP. The United States Central Command and the United States Special Operations Command are located at MacDill Air Force Base in Hillsborough County. The United States Coast Guard installation in Pinellas County is

the largest air station in the country. The two seaports and three international commercial airports provide access to goods and is an economic driver for the state.

The region's growth and vitality are often attributed to its climate and location. Each county has ample access to water. The entire region contains just over 2,800 square miles of land and 818 square miles of water area with 900 miles of coastline. The humid subtropical climate provides an average climate of 73°F and over 53 inches of rain annually. Pinellas County lies on a peninsula between Tampa Bay and the Gulf of Mexico, and much of the city of Tampa lies on a smaller peninsula jutting out into Tampa Bay. This proximity to large bodies of water both moderates local temperatures and introduces large amounts of humidity into the atmosphere. In general, the communities furthest from the coast have more extreme temperature differences, both during a single day and throughout the seasons of the year. Despite its tropical location and warm reputation, the region has never recorded a temperature exceeding 100°F.



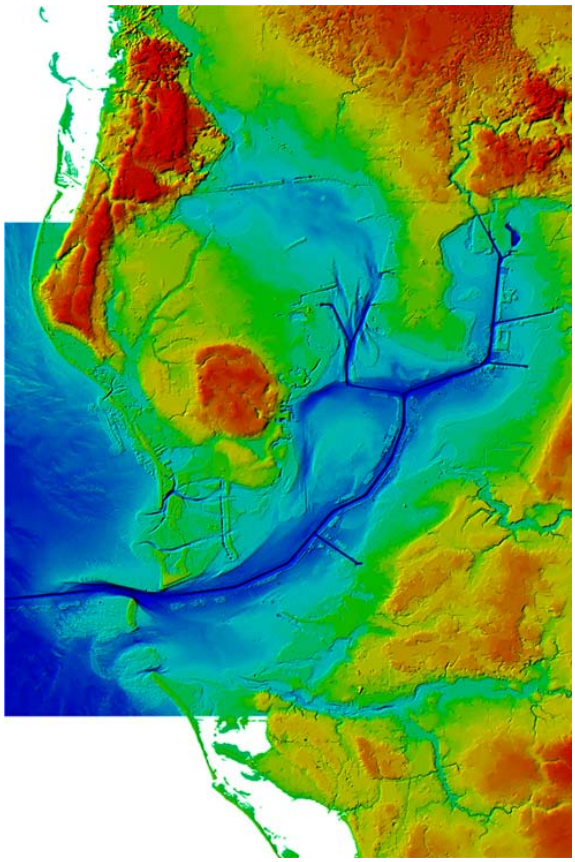
Naturally, the density of population intensifies as it approaches the biggest amenity, the Gulf of Mexico and Tampa Bay (the body of water as opposed to the region). The elevation in the area is typically flat. The average altitude in the region is not much higher than sea level. The accompanied image from the United States Geological Survey demonstrates the elevation changes of both the land and sea. The dark red areas reach up to 105 ft above sea level and the dark blue up to 94 feet below sea level.

The proximately to water coupled with the low elevation creates a perfect scenario for flooding and storm surge in the rainy season. Hurricanes are the most common storm the area is associated with, but the area is susceptible to a number of hazards.

Regional Threats

Naturally, the density of population intensifies as it approaches the biggest amenity, the Gulf of Mexico and Tampa Bay (the body of water as opposed to the region). The elevation in the area is typically flat. The average altitude in the region is not much higher than sea level.

The image to the right from the United States Geological Survey demonstrates the elevation changes of both the land and sea. The dark red areas reach up to 105 ft above sea level and the dark blue up to 94 feet below sea level.



The proximity to water, coupled with the low elevation, creates a perfect scenario for flooding and storm surge in the rainy season. Hurricanes are the most common storm the area is associated with, but the area is susceptible to a number of hazards. Not all hazards are water related, but having the entire western border of the region adjacent to a gulf leaves one less viable evacuation direction. Additionally the state of Florida is narrow and only has two interstates running north and south. One is on the Atlantic side (I-95) and one is on the Gulf of Mexico side (I-75), making mass evacuations very difficult.

The Statewide Regional Evacuation Study

Studies Program identified twelve major hazards that occur in the region. The descriptions of hazards and a summary table are provided below detailing the Hazard, Methodology of Identification, Significant Concerns, and Potential to Initiate a Regional Evacuation.

Table: Hazards in Florida

Hazard	Methodology of Identifications	Significant Concerns	Potential to Initiate a Regional Evacuation
Floods (including related potential for dam failure)	• Review of past disaster declarations. • Review of Federal Flood Insurance Rate Maps (FIRMs) • Input from state floodplain manager. • Identification of NFIP repetitive loss properties in the state.	• Florida is affected by flooding nearly every year. • Floods have caused extensive damage and loss of life in the state in the past. • The most recent federally declared disaster event (Feb 8 2007) in Florida included flooding from severe storms. • There are a number of dams in the state that could impact the nearby population.	Yes; although more difficult to determine which areas are vulnerable to a particular event.
Coastal Storms & Hurri-canes	• Review of past disaster declarations. • Review of National Climatic Data Center (NCDC) Severe Storms Database. • National Oceanographic and Atmospheric Association (NOAA) climatology data • Research including new media and the Internet	• Hurricanes and coastal storms affect Florida every year. • Hurricanes have caused extensive damage and loss of life across the state for the last 50 years. • 8 out of the last 10 federally declared disaster events in Florida were hurricanes.	Yes; this hazard requires the evacuation of coastal areas and mobile home residents, even in minor tropical storm events. Major hurricanes can have catastrophic impacts.

Severe Storms & Tornadoes	• Review of past disaster declarations. • Review of National Climatic Data Center (NCDC) Severe Storms Database. • National Weather Service input and data. • Public input including newspapers and media.	• Florida experiences a tornado nearly every year. • Tornadoes have caused extensive damage and loss of life to county residents. • The two most recent federally declared disaster event in Florida (Feb 8 and Feb 3 2007) were a severe storm with tornadoes.	No; these events provide little to no warning and the specific areas cannot be determined prior to the event. Exceptions: Tornado warnings can send residents to safe rooms or mobile home parks community centers, etc.
Wildfire	• Florida Division of Forestry statistics and input. • USDA Forest Service Fire, Fuel, and WUI mapping. • Input from FL DEM about wildfires and the EOC activations. • Public input including newspapers and media.	• Florida experiences wildfires every year. • Development in much of the state is occurring at the Wildland-Urban Interface (WUI). • Cyclical drought patterns result in increases of brush and other dry materials. This increases the overall risk for significant fires. • Fires in 2007 were significant due to the number and magnitude including closures to the interstate system.	Yes; while we can determine areas that may be more vulnerable and plan accordingly, it is difficult to predict where a wildfire may ignite.
Drought & Extreme Heat	• National Weather Service data. • National Oceanographic and Atmospheric Association (NOAA) paleoclimatology data. • The US Drought Monitor • Keetch Byram Drought Index (KBDI) • Agricultural community throughout the state.	• Significant drought trends during the last 10 years including moderate and severe drought index conditions in2007 and 2008 for parts of the state. • Drought has a severe economic impact on the state due to the large amounts of citrus, agriculture and livestock.	No; this event does not typically initiate an evacuation.

Winter Storms and Freezes	• Review of past disaster declarations. • Review of NCDC Severe Storms Database. • National Weather Service input and data. • Public input including newspapers and media.	• Florida is affected by winter storms cyclically • Significant freezes particularly during the 1980s that affected the citrus industry • 5 federally declared disasters since 1971 • The population is unprepared for cold weather with many having inadequate heating capabilities.	No; this event does not typically initiate an evacuation, although cold weather shelters may be opened for homeless, special needs or those with no power.
Erosion	• Coordination with the Florida Department of Environmental Protection – Bureau of Beaches and Coastal systems. • Statewide Hazard Mitigation Plan - interview and input. • Evaluation of Erosion Hazards, the report from the Heinz Center that was presented to FEMA in April 2000. • Public input including newspapers and media.	• Due to the gradual, long-term erosion, as many as one in four houses along the coast, could fall into the ocean in the next 60 years • Eighty to 90 percent of the nation's sandy beaches are facing erosion problems. • Significant economic impact for the state due to property damages, loss of actual beach front real estate and affects on tourism.	No; this event does not typically initiate an evacuation, but it may result in a retreat from the coast over long period of time or following a major coastal storm.

Sinkholes, Landslides and Seismic Events	• Coordination with the Florida Geographical Survey • The Florida Sinkhole Database • Coordination with the Florida Department of Transportation • Input from the Central United States Earthquake Consortium • USGS Landslide Hazard maps.	• Sinkholes are a common feature of Florida's landscape. • 2843 sinkholes have been reported in the state since the 1970s. • Growing issues as development continues in high risk areas. • Impact on the roads and physical infrastructure of the state. • Earthquake risk is considered extremely low.	Earthquake is considered very low risk. Sinkholes, while prevalent, will not initiate an evacuation at a regional scale.
Tsunamis	• Input from the NOAA Center for Tsunami Research • Coordination with the Florida Division of Emergency Management • Input from the United States Geological Survey	• Tsunamis are common events that occur in large bodies of water. • Almost all perimeters of Florida's boundaries are made up of large bodies of water. • Recent Tsunamis from around the world have caused widespread destruction. • Residential and commercial development along Florida's coastlines are at risk to the effects of Tsunamis.	This event has an extremely low probability of occurrence. If a Cumbre Vieja tsunamis event were to occur, it could have a catastrophic impact on the east coast of Florida. A maximum of 6 hours would be available for evacuations. Typically, there is little to no warning.

Techno-logical	Coordination with the State Emergency Response Commission • Interaction with the Local Emergency Planning Committees (LEPC) • Coordination with the Nuclear Regulatory Commission (NRC) • Communications with the FL Department of Environmental Protection	• Numerous accidental hazardous material releases occur every year • Potential for human and environmental impacts • Threat of radiation from a nuclear related incident	Yes, these incidents may initiate evacuations, but it is impossible to predict precise location, extent and timing. Nuclear power plant evacuation planning conducted w/NRC
Terrorism	• Coordination with FEMA and Department of Homeland Security • Coordination with the Florida Department of Law Enforcement (FDLE) • Interaction with local law enforcement agencies	• National priority with federal government requirements • Potential for devastating impacts to life and infrastructure • Protection for the citizens of Florida and the USA	Yes, these incidents may initiate evacuations, but it is impossible to predict precise location, extent and timing.
Mass Migration	• Coordination with the US Citizens and Immigration Service (USCIS) • Data from local law enforcement	• Historic precedence for migration to Florida by boat • Large amounts of unpatrolled coastlines	No; evacuation is not the solution.

Coastal Storms and Hurricanes

A hurricane is defined as a weather system with a closed circulation developing around a low pressure center over tropical waters. The winds rotate counterclockwise in the Northern Hemisphere (clockwise in the Southern Hemisphere). Tropical storms and hurricanes act as safety valves that limit the build-up of heat and energy in the tropical regions by maintaining the atmospheric heat and moisture balance between the tropics and the pole-ward latitudes (***Statewide Hazard Mitigation Plan*** (SHMP, 2009). Tropical cyclones are named when their winds reach tropical storm strength (sustained 39 mph).

• **Tropical Depression**: The formative stages of a tropical cyclone in which the maximum sustained (1-minute mean) surface wind is <39 mph.

• **Tropical Storm:** A warm core tropical cyclone in which the maximum sustained surface wind (1-minute mean) ranges from 39 to <74 mph.

• **Hurricane:** A warm core tropical cyclone in which the maximum sustained surface wind (1 minute mean) is at least 74 mph.

The table below displays the Saffir-Simpson Scale used to define and describe the intensity of hurricanes. The central pressure of the hurricanes is measured in millibars or inches. The wind speed is also a significant indicator in determining the category of the storm. The wind speed is tied to both wind damage and potential storm surge and resulting coastal flooding damages.

Table: Saffir-Simpson Hurricane Wind Scale

Category	Wind Speeds	Potential Damage
Category 1	Sustained winds 74-95 mph	**Very dangerous winds will produce some damage**
Category 2	Sustained winds 96-110 mph	**Extremely dangerous winds will cause extensive damage**
Category 3	Sustained winds 111-130 mph	**Devastating damage will occur**
Category 4	Sustained winds 131-155 mph	**Catastrophic damage will occur**
Category 5	Sustained winds of 156 mph and above	**Catastrophic damage will occur**

Hurricane Hazards

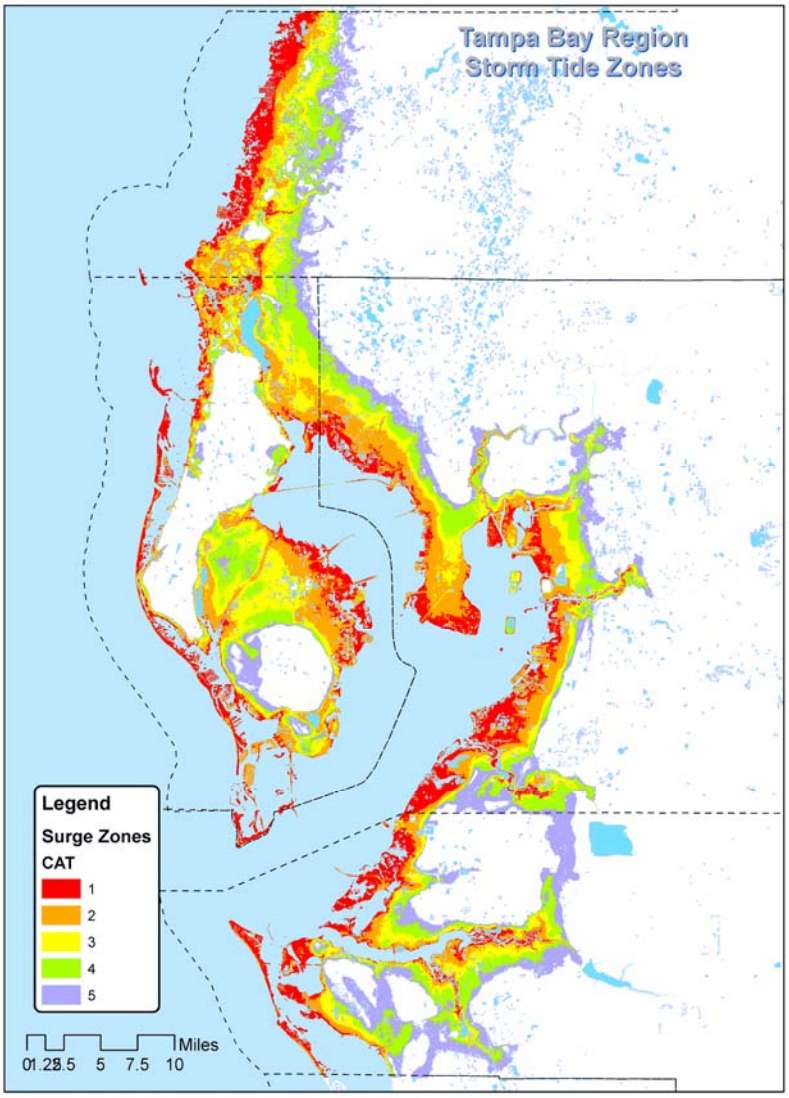
The five major hazards produced by a hurricane are the storm surge, high winds, tornadoes, and rainfall (freshwater flooding) and the potential for hazardous material incidents.

The **storm surge** is the abnormal rise in water level caused by the wind and pressure forces of a hurricane or tropical storm. Storm surge produces most of the flood damage and drownings associated with storms that make landfall or that closely approach the coastline. Of the hurricane hazards, the storm surge is considered to be the most dangerous as nine out of ten hurricane-related deaths are caused by drowning.

The **high winds** also can have a devastating effect on persons outside, in mobile homes, in unsound, substandard structures or in structures with unprotected windows or glass exposures. Previous studies (TBRPC, 1986) have concluded that while a fully engineered multi-story structure could withstand the storm surge of a major storm, without protection on the windows and other cladding, occupants within any structure would be at serious risk. This factor held true for all types of structures exposed to **Hurricane Shelter Alternative Study**, TBRPC and USACOE, 1986 sustained winds in excess of 115 mph. The winds of Hurricane Andrew (1992) caused major destruction in South Florida throwing the insurance industry into a tailspin.

Rainfall associated with hurricanes varies with hurricane size, forward speed and other meteorological factors. The rainfall associated with a hurricane is from 6-12 inches on average, with higher amounts common.

Freshwater flooding has not historically been considered a life-threatening hazard. Over the past 20 years, however, freshwater flooding had become the leading cause of death related to hurricanes. This is due in part to the successful evacuation planning efforts in the United States which had significantly reduced the number of deaths (in the U.S.) related to storm surge. The freshwater flooding associated with a hurricane, may also inundate potential evacuation routes and prevent people from evacuating areas vulnerable to storm surge. Flooded roads and storm drains resulted in fatal accidents in the Bay Area in the 1982 No-Name Storm and in flooding in September 1988. Hillsborough County experienced excessive flooding in 1988 when I-4 near Plant City was cut off for several days and numerous residences were flooded.



Hurricanes can also produce **tornadoes** that add to the storm's destructive power. Tornadoes are most likely to occur in the right front quadrant of the hurricane, but they are also often found elsewhere embedded in the rain bands well away from the center of the hurricane. Some hurricanes seem to produce no tornadoes, while others develop multiple ones. Studies have shown that more than half of the land falling hurricanes produce at least one tornado; Hurricane Buelah (1967) spawned 141 according to one study. According to the NOAA, Hurricane Ivan (2004) spawned 117 tornadoes. Like Murphy's Law, sometimes one emergency event can trigger another. Facilities which generate or store quantities of potentially hazardous materials, propane storage facilities, natural gas pipeline terminals, fuel storage facilities and tank farms all pose additional potential threats in a hurricane.

Storm Surge: The SLOSH Model

The principal tool utilized in this study for analyzing the expected hazards from potential hurricanes affecting the study area is the Sea, Lake and Overland Surges from Hurricane (**SLOSH**) numerical storm surge prediction model. The SLOSH computerized model predicts the storm surge heights that result from hypothetical hurricanes with selected various combinations of pressure, size, forward speed, track and winds. Originally developed for use by the National Hurricane Center (NHC) as a tool to give geographically specific warnings of expected surge heights during the approach of hurricanes, the SLOSH model is utilized in regional studies for several key hazard and vulnerability analyses.

The SLOSH modeling system consists of the model source code and model basin or grid. SLOSH model grids must be developed for each specific geographic coastal area individually incorporating the unique local bay and river configuration, water depths, bridges, roads and other physical features. In addition to open coastline heights, one of the most valuable outputs of the SLOSH model for evacuation planning is its predictions of surge heights over land which predicts the degree of propagation of the surge into inland areas.

The first Tampa Bay SLOSH model basin was completed in 1979 and represented the first application of SLOSH storm surge dynamics to a major coastal area of the United States. The model was developed by the Techniques Development Lab of the National Oceanic and Atmospheric Administration (NOAA) under the direction of the late Dr. Chester P. Jelesnianski.

In December 1990 the National Hurricane Center updated the SLOSH model for the Tampa Bay basin. A major improvement to the model was the incorporation of wind speed degradation overland as the simulated storms moved inland. This duplicated the pressure "filling" and increases in the radii of maximum winds (RMW) as the hurricanes weaken after making landfall. The grid configuration also provided more detail and additional information including storm surge projections for northern Pasco County (not included in the 1979 basin). The model also included tropical storm scenarios.

The newest generation of the SLOSH model basin incorporated in the 2010 Statewide Regional Evacuation Study reflects major improvements, including higher resolution basin data and grid configurations. Faster computer speeds allowed additional hypothetical storms to be run for creation of the MOMs (maximum potential storm surge) values for each category of storm. Storm tracks were run in ten different directions. And for each set of tracks in a specific direction storms were run at forward speeds of 5, 10, 15 and 25 mph. And, for each direction, at each speed, storms were run at two different sizes (20 statute mile radius of maximum winds and 35 statute miles radius of maximum winds.) Finally, each scenario was run at both mean tide and high tide.

Hurricane Wind Analysis

As discussed previously, hurricane winds are a devastating element of the hurricane hazard. Based on the Saffir-Simpson Hurricane Wind Scale (see Table II-2), hurricane force winds range from sustained winds of 74 mph to more than 155 mph. The intensity of a landfalling hurricane is expressed in terms of categories that relate wind speeds and potential damage. According to the Saffir-Simpson Hurricane Wind Scale, a Category 1 hurricane has lighter winds compared to storms in higher categories. A Category 4 hurricane would have winds between 131 and 155 mph and, on average, would usually be expected to cause 100 times the damage of the Category 1 storm. Depending on circumstances, less intense storms may still be strong enough to produce damage, particularly in areas that have not prepared in advance. Tropical storm force winds are strong enough to be dangerous to those caught in them. For this reason emergency managers plan on having their evacuations complete and their personnel sheltered before the onset of tropical storm force winds, not hurricane force winds.

Hurricane force winds can easily destroy poorly constructed buildings and mobile homes. Debris such as signs, roofing material, and small items left outside become flying missiles in hurricanes. Extensive damage to trees, towers, water and underground utility lines (from uprooted trees), and fallen poles cause considerable disruption.

High-rise buildings are also vulnerable to hurricane force winds, particularly at the higher levels since wind speed tends to increase with height. Recent research suggests you should stay below the tenth floor but still above any floors at risk for flooding. It is not uncommon for high-rise buildings to suffer a great deal of damage due to windows being blown out. Consequently, the areas around these buildings can be very dangerous. The strongest winds usually occur in the right side of the eyewall of the hurricane. Wind speed usually decreases significantly within 12 hours after landfall. Nonetheless, winds can stay above hurricane strength well inland.

Tornadoes

In general, tornadoes associated with hurricanes are less intense than those that occur in the Great Plains (see the Enhanced Fujita-Pearson Intensity Scale). Nonetheless, the effects of tornadoes, added to storm surge and inland flooding and the larger area of hurricane force winds, can produce substantial damage.

Sixty–nine percent of all tornadoes are weak tornadoes, EF0-EF2 sizes. Twenty-nine percent of all tornadoes are strong and can last 20 minutes or longer. Two percent of all tornadoes fall into the EF-4 and EF-5 categories. The most powerful tornadoes are spawned by what are called supercell thunderstorms. These are storms that, under the right conditions, are affected by horizontal wind shears (winds moving in different directions at different altitudes.) These wind shears cause horizontal columns of air to begin to rotate the storm. This horizontal rotation can be tilted vertically by violent updrafts, and the rotation radius can shrink, forming a vertical column of very quickly swirling air. This rotating air can eventually reach the ground, forming a tornado.

We have no way at present to predict exactly which storms will spawn tornadoes or where they will touch down. The Doppler radar systems have greatly improved the forecaster's warning capability, but the technology usually provides lead times from only a few minutes up to about 30 minutes. Consequently, early warning systems and preparedness actions are critical.

Damage f scale		Little Damage	Minor Damage	Roof Gone	Walls Collapse	Blown Down	Blown Away
		f0	f1	f2	f3	f4	f5
Windspeed F scale		17 m/s – 32	32 – 50	50 – 70	70 – 92	92 – 116	116 – 142
		F0	F1	F2	F3	F4	F5
		40 mph – 73	73 – 113	113 – 158	158 – 207	207 – 261	261 – 319
To convert f scale into F scale, add the appropriate number							
Weak Outbuilding	-3	f3	f4	f5	f5	f5	f5
Strong Outbuilding	-2	f2	f3	f4	f5	f5	f5
Weak Framehouse	-1	f1	f2	f3	f4	f5	f5
Strong Framehouse	0	F0	F1	F2	F3	F4	F5
Brick Structure	+1	-	f0	f1	f2	f3	f4
Concrete Building	+2	-	-	f0	f1	f2	f3

Fig. 2.4-1 The Fujita tornado scale (F scale) pegged to damage-causing windspeeds. The extent of damage expressed by the damage scale (f scale) varies with both windspeed and the strength of structures.

Enhanced Fujita-Pearson Tornado Intensity Scale

The Enhanced F-scale is a set of wind estimates (not measurements) based on damage. It uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage (listed at www.spc.noaa.gov/faq/tornado/efscale.html.) These estimates vary with height and exposure. Important to note that the 3 second gust is not the same wind as in standard surface observations. Standard measurements are taken by weather stations in open exposures, using a directly measured, "one minute mile" speed.

• **EF0 Gale Tornado** 65-85 mph
Some damage to chimneys. Tree branches broken off. Shallow rooted trees uprooted.

• **EF1 Moderate Tornado** 86-110 mph
Peels surface off roofs. Mobile homes overturned. Moving autos pushed off roads.

• **EF2 Significant Tornado** 111-135 mph
Considerable damage. Roofs torn off frame houses. Large trees snapped or uprooted. Light object missiles generated.

• **EF3 Severe Tornado** 136-165 mph
Severe damage. Roofs and some walls torn off well constructed homes. Trains overturned. Most trees in forests uprooted. Heavy cars lifted off ground.

• **EF4 Devastating Tornado** 166-200 mph
Well-constructed houses leveled. Structures with weak foundations blown off some distance. Cars thrown and large missiles generated.

• **EF5 Incredible Tornado** Over 200 mph
Strong frame houses lifted off foundations and disintegrated. Automobile-sized missiles fly through the air in excess of 100 mph. Trees debarked.

Hazardous Materials

One emergency event can trigger another. Facilities which generate or store quantities of potentially hazardous materials, propane storage facilities, natural gas pipeline terminals, fuel storage facilities and tank farms all pose an additional potential threat in a hurricane. Identifying the location of these facilities is important to (1) provide additional information to facility managers to secure their operation and protect the employees, facility and inventory before the storm and (2) assist emergency responders in safe re-entry into areas after the storm has passed. It may also serve to identify where mitigation strategies should be implemented to reduce the risk to resident and the environment.

The Hazard Materials Information System (HMIS) database was accessed to identify the current Extremely Hazardous Substances (EHS) facilities – also known as Section 302 facilities – in the Tampa Bay Region. The geo-coded inventory of the Section 302 facilities is included in the **Critical Facility Inventory Data Base**.

Freshwater Flooding and the Inundation of Evacuation Routes

Inland riverine and freshwater flooding often becomes a significant factor as a result of tropical storms and hurricanes. Typically the rainfall associated with, and in advance of, a hurricane does not in itself necessitate the emergency evacuation of residents during the passage of a hurricane unlike storm surge. Following a storm, however, the coastal flooding and rainfall – particularly from slow moving storms - necessitates an evacuation of flooded inland residents days after as swollen rivers and streams breach their bank or levees.

As noted previously, due to Tropical Storm Fay's very slow motion, total storm rainfall amounts in some areas were staggering including a few locations in east-central Florida that received more than two feet of rain. Fay's rain induced floods caused significant damage and were directly responsible for numerous deaths in the Dominican Republic, Haiti and Florida.

During a hurricane evacuation the rainfall may cause the early inundation of roadways used as evacuation routes by vehicles attempting to escape from areas vulnerable to the approaching storm surge. In addition, given Florida climatology and the normal summer weather, flooding may occur as a disassociated event prior to the hurricane, flooding evacuation routes and saturating the ground.

Those roadways known historically to be vulnerable from freshwater flooding have been identified by the county and municipal emergency management/law enforcement/emergency response personnel. Contingency plans including rerouting, sandbagging and pumping will be coordinated with local and state law enforcement and the State Department of Transportation. The impacts of road closures, rain and ambient conditions on evacuation times are addressed in the transportation analysis. An evacuation simulation of the closing of these major routes was modeled as part of the transportation analysis to determine the impact on clearance times.

Rainwater inundation of evacuation routes must be addressed in an evacuation plan. The planning strategy to address this problem is to plan for the passage of all vehicles over such roadways before substantial rainfall from the hurricane was expected to arrive. Hourly records of rainfall rates and accumulation for past hurricanes indicate that rates high enough to surpass drainage capabilities normally parallel in time the arrival of sustained tropical storm force winds. Using this as an assumption of the timing of freshwater roadway inundation, the pre-landfall hazards time quantification for sustained tropical storm force winds will also compensate for early rainfall inundation of evacuation routes.

History of Hurricanes in the Tampa Bay Region

Hurricanes are a natural yet very dangerous phenomenon, one for which the Tampa Bay Region must always be prepared. Packing 74-200 mph winds and a storm surge, which can exceed 35 feet in the back bay areas of the Tampa Bay region, hurricanes represent a serious threat to the safety of residents and visitors and economic health of this metropolitan region.

Emergency management and atmospheric scientists agree that global weather patterns have moved back into a period of increased tropical storm activity and of increased frequency of major hurricanes, a category 3 or higher on the Saffir-Simpson Hurricane Wind Scale particularly in the state of Florida. An analysis of hurricane activity since the 1920's demonstrates that hurricane activity appears cyclical and that, after a period of relative inactivity since the early 1960's, the state of Florida and Tampa Bay are in a more active period.

Until the 1840's Florida hurricanes were only experienced in the cities and ports along the east coast, the northwest panhandle and the Keys. But the new settlements along the southwest coast soon began to confront devastating hurricanes. In 1848 the “small village” of Tampa was hit by a major hurricane causing the tide in the bay to rise fifteen feet above normal. The massive flood completely inundated Fort Brooke as well as the stores and homes along Tampa Bay. “After the hurricane, Tampa was a scene of devastation. Magnificent old oaks were toppled by the hurricane’s winds. At Fort Brooke the barracks, horse shed, and other structures were gone. The pine forest north of the garrison was filled with wreckage and debris. The hurricane’s powerful surge had shifted sand all along the coast and reshaped many of the keys near Tampa Bay.

Navigation routes were filled in and closed, making charts of the area produced before 1848 almost useless after the hurricane. In terms of intensity and destruction, the 1848 storm remains perhaps the greatest in Tampa’s history.” (Barnes, 1999) Two weeks later, another storm made landfall along the west coast. Its effects were felt from Cape San Blas to Tampa Bay. Fort Brooke again experienced approximately 10 feet of storm surge.

Historians identify a flurry of major hurricane activity in the late 20's, the 1930's and 1940's. In the 1920's, a time characterized by economic prosperity and growth in the resort areas of Florida, the Tampa Bay area was just beginning to feel the effects of “Florida fever” when it experienced its worst hurricane in over seventy years in October of 1921. The hurricane of 1921 produced a storm surge of 10.5 feet which was the highest recorded since the hurricanes of 1848. Locally it created both Longboat Pass (which now separates the City of Bradenton Beach and Longboat Key) and Hurricane Pass in Dunedin. Passage Key, located between Egmont Key and Anna Maria Island, before the storm, was the home to a fishing village and fresh water lake. Following the storm and continuing today, Passage Key is a sand bar with little vegetation and a National Bird Sanctuary.

This was the last major hurricane (a category three on the Saffir Simpson Scale when it hit the coast) to actually make landfall in the Tampa Bay Region. At that time there were 160,000 residents in the 4-county region, most of whom lived in communities on high ground. (Today there are almost 4 million residents in the region most of whom live along the coast and low-lying areas or in manufactured housing.)

Although they did not directly affect Tampa Bay, it should be noted the 1920's were forever marked with tragedy. There was the devastating hurricane in 1926 that made landfall in Miami and the 1928 storm which caused the banks of Lake Okeechobee to rise 15 feet and drown 1200 people. The September 1926 hurricane is the most costly hurricane in U.S. history. The hurricane of September 1928 remains Florida's "single greatest tragedy", with an official death toll of 2500 (Barnes, 1998 and Blake, 2007).

Florida and the Gulf coast states were hit hard in the 1930's by both the Great Depression and hurricanes. Many seniors still remember the horrifying storm of 1935 that swept across the Florida Keys killing 400 people. In the 1940's, Florida was the target of seven major hurricanes, although none made a direct hit as a major storm in Tampa Bay. The October 18-19, 1944 hurricane, later known as the Havana-Florida hurricane, tracked over the Dry Tortugas after destroying entire villages in Cuba and Grand Cayman Island. Warnings from the new weather forecast office, which later would become the National Hurricane Center, helped to evacuate low-lying areas along the coast and were credited with saving many lives. The storm was extremely large and felt over much of the state as it moved up the Gulf coast and inland near Sarasota. Tampa and Orlando reported wind gusts over 100 mph and Miami experienced winds of 65 mph. While not a major hurricane when it made landfall on the Florida coast near Bradenton, the hurricane of October 7, 1946, caused significant damage (approximately $5 million) especially to Florida's citrus crop. In 1950 Hurricane Easy parked itself over the west coast of Florida drenching residents with record-breaking rains. "Its remarkable doubleloop track caused it to strike the same region of the Florida coast (Tampa Bay) twice in the same day!" According to an Associated Press report, "Tides from six and a half to eight feet above normal swept the pretty resort area from Clearwater to Sarasota, washing out roads, toppling beachfront houses, sinking a few small boats, putting a tug in distress and piling sea water like lakes around homes and hotels." (Barnes, 1999)

In the 1950's the pattern shifted with hurricanes directing their fury on the eastern Atlantic coast. Hurricane Donna (1960) was the only major hurricane to make landfall in Florida in a decade. The brunt of the hurricane was felt in the Keys, Collier and Lee counties; however, gusts were recorded at 120 mph in Manatee County. In the 1960's and 1970's hurricane activity was decreased and concentrated along the western Gulf coast of Texas, Louisiana and Mississippi. Even with hurricanes David (a glancing blow along the east coast) and Frederic (the most costly hurricane up to that time) -- both of which made landfall in 1979 -- the 1970's still had the lowest number of hurricanes (12) and the lowest number of major hurricanes (4) to make landfall in the United States of any decade in the twentieth century (Barnes, 1999). Meanwhile the state and the region were experiencing explosive population growth along the coast. In the 1980's again the state of Florida was spared the direct hit of a major hurricane, although 1985 had the most

named storms to hit the U.S. since 1916 -- a total of six hurricanes and two tropical storms.

On **Labor Day weekend 1985, Hurricane Elena** threatened the Tampa Bay region and approached within 80 miles of the coast. Evacuations in Louisiana, Mississippi, Alabama and Florida were of unprecedented proportions. Almost 1 million residents and visitors were affected in the initial evacuation orders in the Florida panhandle and coastal region of Alabama, Mississippi and Louisiana. Then, as the storm turned and the warnings shifted, ten additional Florida counties including those in Tampa Bay were ordered to evacuate. The threat of Elena initiated an evacuation which forced over 500,000 to leave vulnerable areas in the Tampa Bay region and seek shelter. Many sought shelter in the homes of friends and relatives in inland areas of Florida and Georgia. Others went to hotels and motels filling every room (and lobby) in the state particularly along the I-75 and I-4 corridors. More than 300,000 sought public shelter in the Tampa Bay Region alone - one of the largest evacuations and shelter operations in U.S. history. After stalling off the coast for two days Hurricane Elena turned toward the Florida Panhandle again forcing the evacuation of thousands of coastal residents just returning after the earlier round of evacuations, ultimately making landfall near Biloxi, Mississippi.

Although Hurricane Elena remained more than 80 miles offshore, Elena did produce gusty winds up to 80 mph and constant rainfall. While sustained hurricane-force winds (>74 mph) were not experienced in the region, over $118 million in damage was caused in Pinellas County, mostly by the 6-7 foot storm surge, which hammered the coastal areas along the Gulf and Tampa Bay. Although it did not affect Tampa Bay, the 1985 season Hurricane Kate, a rare landfalling November storm, was considered the first direct hit of a hurricane in Florida in ten years.

The 1990's went down in history as an extremely costly and deadly decade of hurricane activity. The last decade of the millennium brought Tampa Bay several flooding events including Tropical Storm Josephine (1996) and the 1998 evacuation from Hurricane Georges (which did not ultimately affect the region). Other areas of Florida and the Caribbean were not as lucky. Hurricane Andrew struck the east coast near Homestead on August 24, 1992 and Hurricane Opal struck the panhandle in 1995 - two costly storms. Hurricane Mitch (1998) made landfall in Honduras and killed tens of thousands. While Hurricane Andrew did not directly strike the Tampa Bay region, it did however, affect the entire state in many ways. Only two other hurricanes in history, both category 5 storms - the Labor Day storm of 1935, Camille in 1969 - were stronger than Hurricane Andrew when they made landfall in the United States. It struck South Florida with a storm surge of over 16 feet and winds which gusted over 175 mph. The scale of the disaster was enormous and the massive recovery that ultimately ensued was of epic proportions. The damages were staggering -- surpassing $50 billion – affecting emergency management policies and procedures, the insurance industry and land development regulations including the statewide building code).

Hurricane forecasters and scientists had warned with Hurricane Hugo (1989) that the strengthening of El Nino and rainfall patterns in the African Sahel desert were signaling

increased patterns of hurricane activity. The 1995 hurricane season certainly gave credence to those predictions. Two tropical storms and two hurricanes struck the state of Florida, the most since 1953 -- Hurricanes Opal (October) and Erin (August) and Tropical Storms Jerry (August) and Allison (June). Hurricane activity has indeed increased but it has been in the last five years that the deadly predictions have come to fruition and while the Tampa Bay Region has been spared the direct hit of a major hurricane, the region has experienced both evacuations and impacts from exiting storms. In addition the experiences in other parts of Florida as well as the other states have resulted in a greater awareness of the challenges and obstacles facing this metropolitan region.

The 2004 Hurricane Season
In 2004 the State of Florida was hit by an unprecedented four (4) hurricanes: Charley, Frances, Ivan, and Jeanne.

August 9 – 14, 2004 - Hurricane Charley strengthened rapidly just before striking the southwestern coast of Florida as a Category 4 hurricane on the Saffir-Simpson Hurricane Wind Scale. Charley was the strongest hurricane to hit the United States since Andrew in 1992 and, although small in size, it caused catastrophic wind damage in Charlotte County, Florida. Serious damage occurred well inland over the Florida peninsula. In the Tampa Bay Region, dead center for the 24 hour forecast track, evacuations were ordered in all four counties. Charley was directly responsible for ten deaths – primarily from flying debris and fallen trees. There were an additional 20 indirect deaths.

August 25 – Sept. 8, 2004 – Hurricane Frances was a Cape Verde-type hurricane that reached a peak intensity of category 4 on the Saffir-Simpson Hurricane Wind Scale. It affected the Bahamas as a category 3 hurricane and the Florida east coast as a category 2 hurricane. The Tampa Bay Region experienced tropical storm and minimal hurricane force winds with some coastal and more extensive inland flooding caused by more than 10 inches of rainfall. Frances is directly responsible for seven deaths -- five in Florida, one in the Bahamas, and one in Ohio. Three deaths were caused by wind, two by storm surge, one by freshwater flooding, and one by lightning. The hurricane is indirectly responsible for 42 deaths -- 32 in Florida, 8 in Georgia, 1 in the Bahamas, and 1 in Ohio.

September 2- 24, 2004 – Hurricane Ivan was a classical, long-lived Cape Verde hurricane that reached Category 5 strength on the Saffir-Simpson Hurricane Wind Scale (SSHS) three times. It was also the strongest hurricane on record that far south east of the Lesser Antilles. Ivan caused considerable damage and loss of life as it passed through the Caribbean Sea. Despite the unfavorable environmental conditions, the presence of cooler shelf water just offshore and eyewall replacement cycles, Ivan weakened only slowly and made landfall as a 105 kt hurricane (category 3 on the SSHS) on September 16th, just west of Gulf Shores, Alabama. By this time the eye diameter had increased to 40-50 nautical miles, which resulted in some of the strongest winds occurring over a narrow area near the southern Alabama-western Florida panhandle border. The forces of Ivan were directly responsible for 92 deaths. In the United States 14 deaths occurred in Florida, 8 in North Carolina, 2 in Georgia, and 1 in Mississippi. The breakdown of U.S.

deaths by cause is as follows: tornado (7), storm surge (5), fresh water floods (4), mud slides (4), wind (3), and surf (2). Ivan was also indirectly responsible for 32 deaths in the United States.

Ivan caused extensive damage to coastal and inland areas of the United States. Portions of the Interstate 10 bridge system across Pensacola Bay, Florida were severely damaged in several locations as a result of severe wave action on top of the 10-15 ft storm surge. As much as a quarter-mile of the bridge collapsed into the bay. The U.S Highway 90 Causeway across the northern part of the bay was also heavily damaged. To the south of Pensacola, Florida, Perdido Key bore the brunt of Ivan's fury and was essentially leveled. In addition, extensive beach erosion caused severe damage to or the destruction of numerous beachfront homes, as well as apartment and condominium buildings. Thousands of homes in the three-county coastal area of Baldwin, Escambia, and Santa Rosa were damaged or destroyed. Cleanup efforts alone in Escambia County resulted in debris piles that were more than three-quarters of a mile long and 70 feet high. In all, Ivan was the most destructive hurricane to affect this area in more than 100 years. Strong winds also spread well inland damaging homes and downing trees and power lines. At one point more than 1.8 million people were without power in nine states.

September 13 – 28, 2004 – Hurricane Jeanne produced heavy rain over Guadeloupe, Puerto Rico and the Dominican Republic and caused an estimated 3000 or more deaths in Haiti, from torrential rainfall flooding. Finally, Jeanne hit the northern Bahamas and then the central Florida east coast as a category three hurricane. Jeanne moved across central Florida while weakening and began to recurve around the western periphery of the migratory ridge. The hurricane weakened to a tropical storm while centered about 30 nautical miles north of Tampa September 26th and then weakened to a tropical depression about 24 hours later while moving northward across central Georgia accompanied by heavy rain. Winds were somewhat higher in the Tampa Bay Region for Hurricane Jeanne than Hurricane Frances resulting in wind damage and minimal coastal flooding. Areas still flooded from Frances (three weeks before) received additional flood waters.

The impact of the 2005 Atlantic hurricane season and the resulting death, injury, destruction, and population displacement were unprecedented in U.S. history. During 2005, 15 tropical storms became hurricanes. For the first time four major hurricanes made landfall in the United States; three of those reached Category 5 intensity.

The worst effects were felt from Hurricanes Katrina and Rita. These storms did not seriously impact the state of Florida, however, they have had a significant impact on emergency management and hurricane planning at the national, state and local levels.

On August 29, Hurricane Katrina struck the U.S. Gulf Coast, causing severe damage from a two-story storm surge, powerful winds, and heavy rains. Approximately 80% of New Orleans was flooded after the surge from the Gulf of Mexico forced breaks in a levee, releasing water from Lake Pontchartrain into the city. Katrina became the deadliest U.S. hurricane since 1928 and likely the costliest natural disaster on record in the United

States. On September 24, response and recovery activities in the wake of Katrina were interrupted when Hurricane Rita struck the Gulf Coast. Rita rendered more homes uninhabitable and thousands more seeking shelter elsewhere. More than 200,000 persons were displaced by the hurricanes and dispersed to evacuee shelters in 18 states. The economic and health consequences of Hurricanes Katrina and Rita extended far beyond the Gulf region and ultimately affected states and communities throughout the United States.

Hurricane Katrina – August 23 -30, 2005 Katrina was a large and intense hurricane that struck a portion of the United States coastline along the northern Gulf of Mexico that is particularly vulnerable to storm surge, leading to loss of life and property damage of immense proportions. The scope of human suffering inflicted by Hurricane Katrina in the United States has been greater than that of any hurricane to strike this country in several generations.

The total number of fatalities known, as of this writing, to be either directly or indirectly related to Katrina is 1336, based on reports to date from state and local officials in five states: 1090 fatalities in Louisiana, 228 in Mississippi, 14 in Florida, 2 in Georgia, and 2 in Alabama. The number of direct fatalities is highly uncertain and the true number might not ever be known, especially for Louisiana and Mississippi.

Presumably, most of the deaths in Louisiana were directly caused by the widespread storm surge-induced flooding and its miserable aftermath in the New Orleans area. The vast majority of the fatalities in Mississippi were probably directly caused by the storm surge in the three coastal counties. In Florida three of the direct fatalities were caused by downed trees in Broward County, and the three others were due to drowning in Miami-Dade County. Two deaths were also reported in Georgia with one directly caused by a tornado and the other occurring in a car accident indirectly related to the storm. Alabama reported two indirect fatalities in a car accident during the storm. Despite the fact that inland fresh water floods produced the majority of fatalities due to tropical cyclones during the past few decades, Katrina provides a grim reminder that storm surge poses the greatest potential cause for large loss of life in a single hurricane in this country.

Where Katrina ranks among the deadliest hurricanes on record in the United States is somewhat uncertain due to the unknown number of fatalities caused directly by this hurricane and by some others in the past. Katrina is surpassed by the Galveston, Texas hurricane in 1900 that claimed at least 8000 lives, and it appears to be surpassed by the 1928 Lake Okeechobee, Florida hurricane with over 2500 fatalities. If the assumption is correct that most of the Katrina related fatalities were caused directly by the storm, then Katrina ranks as the third deadliest hurricane in the United States since 1900 and the deadliest in 77 years. However, two hurricanes in 1893 might each have been directly responsible for more fatalities in the United States than Katrina. One of these struck the southeastern Louisiana barrier island of Cheniere Caminanda and killed about 2000 people, while another struck Georgia and South Carolina and claimed somewhere

between 1000 and 2000 lives. As a result, Katrina ranks fourth or fifth on the list of the deadliest hurricanes on record in the United States.

The extent, magnitude, and impacts of the damage caused by Katrina are staggering and are well beyond the scope of this report to fully describe. Thousands of homes and businesses throughout entire neighborhoods in the New Orleans metropolitan area were destroyed by flood. Strong winds also caused damage in the New Orleans area, including downtown where windows in some high rise buildings were blown out and the roof of the Louisiana Superdome was partially peeled away. The storm surge of Katrina struck the Mississippi coastline with such ferocity that entire coastal communities were obliterated, some left with little more than the foundations on which homes, businesses, government facilities, and other historical buildings once stood. Despite being more distant from the eye of Katrina, the storm surge over Dauphin Island, Alabama destroyed or damaged dozens of beachfront homes and cut a new canal through the island's western end.

Many of the most severely impacted areas along the northern Gulf coast could take years to completely rebuild. Katrina's heavy rains in southern Florida flooded some neighborhoods, primarily in Miami-Dade County. Many other structures from Florida and Georgia westward to Louisiana that avoided surge or fresh water floods, including some areas well inland, were damaged by strong winds and tornadoes. Considerable damage to some homes and agricultural facilities was caused by several tornadoes in Georgia. Strong winds caused significant tree damage throughout much of Mississippi and Alabama. Combining all of the areas it impacted, Katrina left about three million people without electricity, some for several weeks.

The economic and environmental ramifications of Katrina have been widespread and could in some respects be long-lasting due to impacts on large population and tourism centers, the oil and gas industry, and transportation. The hurricane severely impacted or destroyed workplaces in New Orleans and other heavily populated areas of the northern Gulf coast, resulting in thousands of lost jobs and millions of dollars in lost tax revenues for the impacted communities and states.

Along the Mississippi coast several large casinos on floating barges were damaged or destroyed when the surge pushed them onshore. Large numbers of evacuees did not return home, producing a shortage of workers for those businesses that reopened. Major beach erosion occurred along the tourism dependent Mississippi and Alabama coasts. A significant percentage of United States oil refining capacity was disrupted after the storm due to flooded refineries, crippled pipelines, and several oil rigs and platforms damaged, adrift or capsized. An oil rig under construction along the Mobile River in Alabama was dislodged, floated 1.5 miles northward, and struck the Cochrane Bridge just north of downtown Mobile. An offshore oil rig washed up near the beach of Dauphin Island, Alabama. Several million gallons of oil were spilled from damaged facilities scattered throughout southeastern Louisiana. While several facilities have since resumed operations, as of this writing oil and natural gas production and refining capacity in the northern Gulf of Mexico region remains less than that prior to Katrina. Key transportation arteries were disrupted or cut off by the hurricane. Traffic along the Mississippi River

was below normal capacity for at least two weeks following the storm. Major highways into and through New Orleans were blocked by floods. Major bridges along the northern Gulf coast were destroyed including several in Mississippi and the Interstate 10 Twin Span Bridge connecting New Orleans and Slidell, Louisiana.

Estimates of the insured property losses caused by Katrina vary considerably and range between about $20 billion and $60 billion. The American Insurance Services Group (AISG) estimates that Katrina is responsible for $38.1 billion of insured losses in the United States. A preliminary estimate of the total damage cost of Katrina is assumed to be roughly twice the insured losses (using the AISG estimate), or about $75 billion. This figure would make Katrina the costliest hurricane in United States history by far. Even after adjusting for inflation, the estimated total damage cost of Katrina is roughly double that of Hurricane Andrew (1992). Normalizing for inflation and for increases in population and wealth, only the 1926 hurricane that struck southern Florida surpasses Katrina in terms of damage cost. However, this would not be the case if the values on the higher end of the range of Katrina estimates are later found to be the most accurate. The Insurance Information Institute reports that, mostly due to Katrina but combined with significant impacts from the other hurricanes striking the United States this year, 2005 was by a large margin the costliest year ever for insured catastrophic losses in this country.

Data provided by the Federal Emergency Management Agency (FEMA) indicate that over 1.2 million people along the northern Gulf coast from southeastern Louisiana to Alabama were under some type of evacuation order, but it is not clear how many people actually evacuated. Media reports indicate that many displaced residents have moved either temporarily or permanently to other areas in the United States. A large number of these people might never return to live in their pre-Katrina homes or cities. Thousands of people are still living in hotels and temporary shelters.

Hurricane Rita, September 18-26, 2005 Rita was an intense hurricane that reached Category 5 strength (on the Saffir-Simpson Hurricane Wind Scale) over the central Gulf of Mexico, where it had the fourth-lowest central pressure on record in the Atlantic basin. Although it weakened prior to making landfall as a Category 3 hurricane near the Texas/Louisiana border, Rita produced significant storm surge that devastated coastal communities in southwestern Louisiana, and its winds, rain, and tornadoes caused fatalities and a wide swath of damage from eastern Texas to Alabama. Rita also caused floods due to storm surge in portions of the Florida Keys.

The approach of Rita provoked one the largest evacuations in U. S. history. Just weeks after the country watched in horror the devastation of Hurricane Katrina, media reports indicate that the number of evacuees in Texas could have exceeded two million. Additional evacuations involving smaller numbers took place in Louisiana.

Hurricane Wilma - October 15-25, 2005 Wilma formed and became an extremely intense hurricane over the northwestern Caribbean Sea. It had the alltime lowest central pressure for an Atlantic basin hurricane and it devastated the northeastern Yucatan

Peninsula as a category 4 hurricane. Wilma also inflicted extensive damage over southern Florida.

Despite the strong shear in its surroundings, Wilma strengthened over the southeastern Gulf of Mexico and its winds reached about 110 kt as it approached Florida. Maximum sustained winds were estimated to be near 105 kt (category 3 intensity) when landfall of the center occurred in southwestern Florida near Cape Romano October 24th. Continuing to accelerate and now moving at a forward speed of 20 to 25 kt, the hurricane crossed the southern Florida peninsula in 4.5 hours with the center emerging into the Atlantic just southeast of Jupiter. Maximum winds had decreased to near 95 kt (category 2) during the crossing of Florida. Twenty-two deaths have been directly attributed to Wilma: 12 in Haiti, 1 in Jamaica, 4 in Mexico, and 5 in Florida.

Damage was reported to have been very severe in portions of the northeastern Yucatan Peninsula, where Wilma dealt a major blow to the tourist industry in that area. In southern Florida, damage was unusually widespread, including numerous downed trees, substantial crop losses, downed power lines and poles, broken windows, extensive roof damage, and destruction of mobile homes. Wilma caused the largest disruption to electrical service ever experienced in Florida. A preliminary amount of total insured damage compiled by the Property Claims Service is $6.1 billion. Using a doubling of insured losses to obtain the total damage gives a current estimate of Wilma's U.S. damage to be $12.2 billion.

The 2006, 2007 and 2008 Seasons

The 2006 Hurricane season was a much quieter season for the state of Florida, with only one hurricane affecting the state, Hurricane Ernesto, which was actually a tropical storm when it impacted Florida. Tropical Storm Alberto also crossed the eastern Florida panhandle. The 2007 Hurricane Season was also a relatively quite season, with no hurricanes directly affecting the State of Florida. The 2008 Atlantic Hurricane Season marked the end of a season that produced a record number of consecutive storms to strike the United States and ranks as one of the more active seasons in the 64 years since comprehensive records began. Overall, the season is tied as the fourth most active in terms of named storms (16) and major hurricanes (5), and is tied as the fifth most active in terms of hurricanes (8) since 1944, which was the first year aircraft missions flew into tropical storms and hurricanes.

For the first time on record, six consecutive tropical cyclones (Dolly, Edouard, Fay, Gustav, Hanna and Ike) made landfall on the U.S. mainland and a record three major hurricanes (Gustav, Ike and Paloma) struck Cuba. This is also the first Atlantic season to have a major hurricane (Category 3) form in five consecutive months (July: Bertha, August: Gustav, September: Ike, October: Omar, November: Paloma).
The National Hurricane Center attributes the 2008 above-normal season to conditions that include:

• An ongoing multi-decadal signal. This combination of ocean and atmospheric conditions has spawned increased hurricane activity since 1995.

• Lingering La Niña effects. Although the La Niña that began in the Fall of 2007 ended in June, its influence of light wind shear lingered.

• Warmer tropical Atlantic Ocean temperatures. On average, the tropical Atlantic was about 1.0 degree Fahrenheit above normal during the peak of the season.

In 2008 Tropical Storm Fay made history as the only storm on record to make landfall four times in the state of Florida and to prompt tropical storm and hurricane watches and warnings for the state's entire coastline (at various times during its August lifespan).

Though Florida was spared a direct hit from a major hurricane, Floridians saw major flooding throughout the State from Tropical Storm Fay. Fay came ashore in the Florida Keys August 18 and continued northward up the Florida Peninsula. Fay made records as the first storm to make four landfalls in one state impacting the Florida Keys, South Florida, exiting off the east coast and coming back inland near Flagler Beach and exiting off the Gulf Coast and making landfall again near Carrabelle. The slow-moving storm also caused record rainfall and flooding throughout the state with some areas getting as much as 25 inches of rain. Millions of dollars in damage and 15 deaths were caused in Florida by Fay.

Hurricane Gustav brought tropical storm force winds to the Florida Keys and storm surge and severe thunderstorms to the Florida Panhandle. As Gustav headed for the Louisiana coast, many residents evacuated to Florida to escape the storm. Many Florida counties, in conjunction with the American Red Cross, opened shelters throughout the state for evacuees.

Probability of Future Hurricane Events

The Table below provides the number of direct hits on the mainland U.S. coastline (1900-2006) for individual states. Florida is divided into four sections. The Tampa Bay Region is located in the Southwest area. (Please note that the Florida Keys are also included in the SW area.)

The following Table provides the total of major hurricane direct hits on the mainland (1900-2006) by month. Most major hurricanes occur in the later part of the hurricane season in September, October and November. Category one and two hurricanes tend to "spring up" in the Caribbean affecting the southwest Florida area in the early part of the season. Storms can affect more than one area in the state. Therefore, the total number of storms affecting Florida is less than the total number affecting all regions.

Major Hurricane Direct Hits on the U.S. Coastline 1851-2006 by Month

	Jun	Jul	Aug	Sep	Oct	All
U.S. (Texas to Maine)	2	4	30	44	16	96
Texas	1	1	10	7	0	19
(North)	1	1	3	2	0	7
(Central)	0	0	2	2	0	4
(South)	0	0	5	3	0	8
Louisiana	2	0	7	8	3	20
Mississippi	0	1	4	4	0	9
Alabama	0	1	1	4	0	6
Florida	0	2	6	19	10	37
(Northwest)	0	2	1	7	3	13
(Northeast)	0	0	0	1	0	1
(Southwest)	0	0	2	5	6	13
(Southeast)	0	0	4	8	3	15
Georgia	0	0	1	1	1	3
South Carolina	0	0	2	2	2	6
North Carolina	0	0	4	8	1	13
Virginia	0	0	0	1	0	1
Maryland	0	0	0	0	0	0
Delaware	0	0	0	0	0	0
New Jersey	0	0	0	0	0	0
Pennsylvania	0	0	0	0	0	0
New York	0	0	1	4	0	5
Connecticut	0	0	1	2	0	3
Rhode Island	0	0	1	3	0	4
Massachusetts	0	0	0	3	0	3
New Hampshire	0	0	0	0	0	0
Maine	0	0	0	0	0	0

Freshwater Flooding: The 100-Year Flood Plain

Inland /Riverine Flooding Profile

Flooding refers to the *general or temporary conditions of partial or complete inundation of normally dry land areas by surface water runoff from any source* (*Statewide Hazard Mitigation Plan*, 2009). The State of Florida and the Tampa Bay Region are affected by a large number of weather systems which result in flooding.

Flooding can be divided into two major categories: Coastal and Riverine. As indicated previously, interrelated hazards, such as hurricanes and severe storms, can result in both types of flooding, sometimes in difference locations. Many areas of Florida are susceptible to flooding from both storm surge and watershed runoff.

Coastal flooding is usually the result of a severe weather system such as a tropical cyclone, hurricane, tropical storm or "northeaster" which contains the element of wind. The damaging effects of coastal floods are caused by a combination of higher water levels of the storm surge, the winds, rains, erosion and battering by debris. Loss of life and property damage are often more severe since it involves velocity wave action and accompanying winds.

Riverine flooding is associated with a river's watershed, which is the natural drainage basin that conveys water runoff from rain. Riverine flooding occurs when the flow of runoff is greater than the carrying capacities of the natural drainage systems. Rainwater that is not absorbed by soil or vegetation seeks surface drainage lines following natural topography lines. These lines merge to form a hierarchical system of rills, creeks, streams and rivers. Generally, floods can be slow or fast rising depending on the size of the river or stream. The rivers in north Florida drain portions of Alabama and Georgia and excessive rainfall in those states often causes flood conditions in Florida.

Flash floods are much more dangerous and flow much faster than riverine floods. They can result from tropical storms, dam failures or excessive rain and snow. Flash floods pose more significant safety risks because of the rapid onset, the high water velocity, the potential for channel scour and the debris load.

The variations of flooding including severe thunderstorms, hurricanes, seasonal rain and other weather related conditions are a natural part of the earth's hydrologic system; however, when buildings and infrastructure are constructed within the natural drainage system, there are significant losses. Based on frequency, floods are the most destructive category of natural hazards in the United States. The loss of life, property, crops, business facilities, utilities and transportation are major impacts of flooding. Economic losses from impacts to major transportation routes and modes, public health and other environmental hazards are key factors in long-term recovery. (*Statewide Hazard Mitigation Plan*, 2009)

Probability of Flooding: FIRM Maps

The probability of freshwater flooding has been quantified by the Federal Emergency Management Agency (FEMA) through the National Flood Insurance Program. Areas subject to flooding, the Velocity Zone, 100-year flood plain and the 500-year floodplain, have been delineated on Flood Insurance Rate Maps (FIRMs) for every jurisdiction in the region. Moderate to low risk areas include zones B, C and X. High risk areas include zones A, AE, AH, AO, and AR. High risk coastal areas include the Velocity zones (Zones V, VE, V1-V30 and undetermined risk areas (Zone D).

Definitions of NFIP Zones

AE Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. In most instances base flood elevations (BFEs) derived from detailed analyses are shown at selected intervals within these zones.
X500 An area inundated by 500-year flooding; an area inundated by 100-year flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; or an area protected by levees from the 100-year flooding.

X Areas outside the 1-% annual chance floodplain, areas of 1% annual chance sheet flow flooding where average depths are less than 1 foot, areas of 1% annual chance stream flooding where the contributing drainage area is less than 1 square mile, or areas protected from the 1% annual chance flood by levees. No Base Flood Elevations or depths are shown within this zone. Insurance purchase is not required in these zones.

A Flood zone area with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas, no depths of base flood elevations are shown within these zones.

ANI An area that is located within a community or county that is not mapped on any published FIRM.

IN An area designated as within a “Special Flood Hazard Area” (of SFHA) on a FIRM. This is an area inundated by 100-year flooding for which no BFEs or velocity may have been determined. No distinctions are made between the different flood hazard zones that may be included within the SFHA. These may include Zones A, AE, AO, AH, AR, A99, V, or VE.

VE Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.

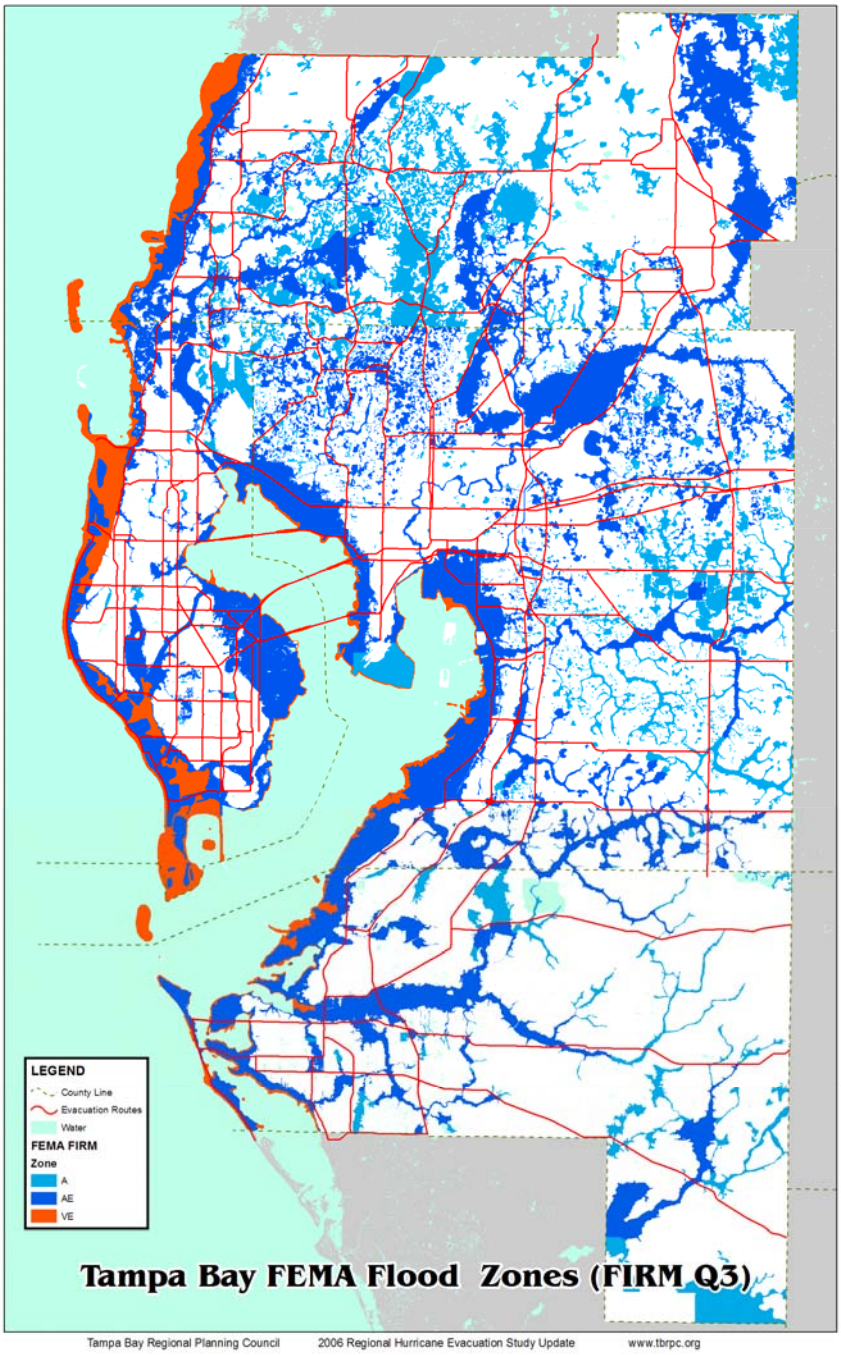
UNDES A body of open water, such as a pond, lake, ocean, etc., located within a community's jurisdictional limits that has no defined flood hazard.

AO River or stream flood hazard areas and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones.

D Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk.

AH Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.

V Coastal areas with a 1% or greater chance of



flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. No base flood elevations are shown within these zones.

100IC An area where the 100-year flooding is contained within the channel banks and the channel is too narrow to show to scale. An arbitrary channel width of 3 meters is shown. BFEs are not shown in this area, although they may be reflected on the corresponding profile.

The model used to determine the flood plain, like the SLOSH MEOWs or MOMs and the Inland Wind model, is a cumulative model. In other words, it is based on several storm events; no one storm will inundate all the areas within the flood zone. In addition, because there is a return interval (1% or greater chance of flooding in any given year) associated with the flood level, there is a basis for planning and cost-benefit analysis.

While the 6-12 inches of rain typically associated with a hurricane is not considered life-threatening, freshwater flooding along rivers and streams can and does cause significant property damage and has the potential of causing personal injury and deaths. Hurricane Floyd (September 1999) caused billions of dollars in property damage in North Carolina alone. Over the past two decades, freshwater flooding has become a leading cause of death in hurricane events with most of those deaths the result of driving or walking in flood waters.

In order to identify the potential magnitude of inland flooding, the 100-year flood plain was delineated using FEMA's most recent digital files. Within the flood zone it is recognized that there are properties which have sustained repeated damage from flooding and are extremely susceptible to flood damage. These local neighborhoods should be warned prior to hurricane events that flooding is very probable.

The total acreage within the flood plain by county is presented below. It was calculated using the total acreage as determined by the Soil Conservation Service and the FEMA FIRM Maps as of 2009.

County	Total Acreage	Flood Plain Acreage	Percent of Acreage in Flood Plain
Hillsborough	665,600	227,681	34.2%
Manatee	466,640	94,386	20.2%
Pasco	475,000	165,540	35.1%
Pinellas	179,200	73,967	41.3%

Source: Soil Conservation Service (Total Acreage); FEMA (Digital Inventory of Flood Plain Acreage)

Dam Failure

A flood event may also trigger a dam failure. The dam impounds water in the reservoir or upstream area. The amount of water impounded is measured in acre-feet. *Dam failures are not routine but the results can be significant. Two factors influence the potential severity of a dam failure: (1) the amount of water impounded and (2) the density, type and value of the development downstream.* (*Statewide Hazard Mitigation Plan*, 2009)

The "dam hazard" is a term indicating the potential hazard to the downstream area resulting from failure or mis-operation of the dam or facilities. According to the USGS National Inventory of Dams, there are 149 major dams in the state of Florida which have been identified by a hazard risk of low, significant and high.

- *Low hazard: A dam where failure or mis-operation results in no probable loss of human life and low economic and/or environmental loss. Losses are principally limited to the owner's property.*
- *Significant hazard: A dam where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities or impact other concerns. These dams are often located in predominantly rural or agricultural area but could be located in areas with population and significant infrastructure.*
- *High – A dam where failure or mis-operation will probably cause loss of human life. (Statewide Hazard Mitigation Plan*, 2009)

Dams in the Tampa Bay Region

DAM NAME	NID ID	LONG	LAT	COUNTY	RIVER	HAZARD
LAKE MANATEE DAM	FL00280	-82.33	27.49	MANATEE	MANATEE RIVER	H
PINEY POINT(1)	FL10038	-82.53	27.62	MANATEE		S
PINEY POINT(2)	FL10039	-82.53	27.62	MANATEE		S
PINEY POINT(3)	FL10040	-82.53	27.62	MANATEE		S
PINEY POINT(4)	FL10041	-82.52	27.62	MANATEE		S
PINEY POINT(6)	FL10043	-82.52	27.62	MANATEE		S
MANATEE COOLING WATER RESERVOIR	FL00642	-82.32	27.62	MANATEE	LITTLE MANATEE RIVER	H
PINEY POINT(5)	FL10042	-82.52	27.63	MANATEE		S
BIG FOUR MINE BF-1	FL00613	-82.08	27.75	HILLS	LAKE BRANCH ALAFIA RIVER	L
CLAY SETTLING AREA AL	FL00611	-82.10	27.76	HILLS	SOUTH PRONG ALAFIA RIVER	L
GYPSUM FIELD DIKE	FL00174	-82.39	27.87	HILLS	SEE REMARKS	L
EXISTING STACK	FL10026	-82.38	27.87	HILLS	ARCHIE CREEK	S
GIBSONTON EXISTING STACK	FL10030	-82.38	27.87	HILLS		S
GIBSONTON (SW2)	FL10035	-82.38	27.87	HILLS		S
GIBSONTON (SW1)	FL10036	-82.38	27.87	HILLS		S
GIBSONTON (SE)	FL10033	-82.37	27.87	HILLS		S
GIBSONTON (S)	FL10034	-82.37	27.87	HILLS		S
GIBSONTON (NE)	FL10037	-82.37	27.87	HILLS		S

DAM NAME	NID ID	LONG	LAT	COUNTY	RIVER	HAZARD
EDWARD MEDARD RESERVOIR DAM/PLEASANT GROVE	FL00434	-82.16	27.91	HILLS	LITTLE ALAFIA RIVER	H
STRUCTURE 160/BLUE CYPRESS	FL00173	-82.36	27.98	HILLS	CANAL 135 PALM RIVER	L
STRUCTURE 162	FL00442	-82.35	27.98	HILLS	SIX MILE CREEK	S
STRUCTURE 161	FL00640	-82.37	28.01	HILLS	CANAL 136	H
CITY OF TAMPA WATERWORKS DAM	FL00169	-82.43	28.02	HILLS	HILLSBOROUGH RIVER	H
STRUCTURE 159/L-112	FL12001	-82.34	28.04	HILLS	CANAL 135	H
STRUCTURE 551	FL00168	-82.70	28.05	PINE	C-531 (LAKE TARPON CANAL)	L
STRUCTURE 155/L-112	FL12000	-82.35	28.08	HILLS	HILLSBOROUGH RIVER	H
TEMPLE TERRACE (SW)	FL10029	-82.13	28.15	HILLS		S
INACTIVE GYPSUM DIKE	FL10107	-82.13	28.15	HILLS	BIG DITCH-OS	L

Source: US Army Corps of Engineers, (2009)

History of Inland Flooding

Based on data collected by the National Climatic Data Center (NCDC), there were 993 flooding events in Florida between 1950 and 2009, for an average of 16.83 flooding events per year. Total property damages were estimated at $1.43 billion with an additional $972.01M in crop related damages. Below is a summary of the major flooding events in the Tampa Bay Region from 1993-2008:

March 1998, El Nino Effect: On March 1st, Alachua, Baker, Bradford, Citrus, Clay, Columbia, DeSoto, Duval, Flagler, Gilchrist, Hamilton, Hillsborough, Marion, Nassau, Pasco, Putnam, St. Johns, Suwannee, and Union Counties were flooded. More than 2,800 homes and over 175 businesses were destroyed and property damage totaled $25.5 million. Flooding was claimed to be related to El Nino.

September 2001, Tropical Storm Gabrielle: Heavy rainfall of six to eight inches with isolated pockets in excess of nine inches associated with Tropical Storm Gabrielle occurred over most of Manatee and southern portions of Pinellas and Hillsborough counties. Widespread road, home and business flooding occurred over large portions of Manatee County, mainly from Anna Maria east across Bradenton to Parrish. Minor to moderate road and home flooding occurred over southern Pinellas and Hillsborough counties mainly along the coast and low lying areas. In Pasco County rainfall of five to eight inches occurred over a broad portion of the county with most of the road and residential flooding occurring along the U.S. Highway 301 corridor from Dade City south to Zephyrhills. The overall property damage estimate was $26 million.

June 23, 2003: A series of severe thunderstorms swept through southwest Central Florida during June 21-24, 2007. Precipitation associated with these storms resulted in flooding in parts of several Florida counties including Charlotte, Citrus, DeSoto, Dixie, Hardee, Levy, Manatee, Sarasota, and Taylor. Floodwater from these thunderstorms caused damage to public and private property amounting to more than $11 million and damaged or destroyed more than 100 homes.

A federal disaster declaration allowed the affected state and local governments to apply for aid. The relief aid would pay up to 75 percent of the approved costs for debris removal, emergency services related to the disaster, and the repair or replacement of damaged public facilities. The aid was authorized under a major disaster declaration issued by President Bush following a review of FEMA's analysis of the state's request for federal relief. The declaration covers damage to public property from severe storms and flooding beginning on June 13.

June 23, 2003, Dam Failure: The Manatee River flooded on June 23, 2003 in Manatee County, Florida in conjunction with complications of a dam malfunction. More than a foot of rain fell in Manatee County and two of its neighboring counties which led to complications. During several days of rain two of the dam's spillways were opened but the third spillway jammed, prompting emergency officials to order hundreds of homes evacuated as water approached the top of the 50-foot high dam. Two homes collapsed

during the deluge and many others were completely inundated. Red Cross shelters in Arcadia and Sarasota housed more than 230 evacuees from the 600 homes that were threatened in Manatee County's riverside and lakeside communities. An additional shelter opened at Port Charlotte to house local families displaced by the continuous flooding conditions.

February 03, 2006, Flash Floods: The combination of tropical moisture flowing into a line of thunderstorms and an approaching upper level disturbance allowed a train of intense thunderstorms to repeatedly cross over parts of the Tampa Bay area. Between eight and more than 11 inches of rain fell in roughly a five-hour period in a five-mile wide stripe extending from Madeira Beach northeast through Pinellas Park, then across Old Tampa Bay to west Tampa, including Tampa International Airport. The area of heaviest rain was so concentrated that downtown St. Petersburg, less than 10 miles away, recorded less than an inch of rain during the same period. The torrential rains caused flash flooding in the areas where more than eight inches fell. The flash flooding prompted the mayor of St. Petersburg to term the event a "hundred year flood." In Lealman an entire mobile home community was evacuated, and at least 60 of the homes were flooded. A partial roof collapse was reported at a big box store in St. Petersburg. Water pouring into the store washed out several cash register stands and injured one employee as he was washed into the parking lot. Another roof collapsed at Treasure Island. Hundreds of vehicles were stranded by the flood waters. Total property damage was estimated at $2.0 million. Pinellas County Rain Reports Pinellas Park (Upper Highlands Canal): 11.17 inches. Saint Petersburg/Clearwater International Airport: 8.20 inches; Seminole: 7.01 inches; Largo: 6.44 inches; Clearwater: 5.81 inches. Hillsborough County Rain Reports Tampa International Airport: 8.24 inches; Citrus Park: 6.90 inches; and Thonotosassa: 4.35 inches.

Repetitive Loss Areas

The location of repetitive loss structures[1] helps to identify specific areas in the community where flooding continues to be a problem and where mitigation efforts should be concentrated. For many of these floodprone areas, mitigation will involve significant property owner investment and will probably be delayed until redevelopment/ reconstruction occurs. New construction or significant remodeling will require adherence to current floodplain management regulations. In regards to evacuation planning, these areas are important to consider as they represent the most vulnerable areas subject to flooding from significant rainfall and minor tropical storm activity. In addition, these areas may not be coastal or reside in hurricane evacuation areas. Therefore, the residents in these areas may constitute additional evacuation impacts. A breakdown of the properties by structure type is provided in the table below.

Repetitive Loss Properties

Community Name	Repetitive Loss Structures	SF	2-4 Family	Other Res	Condo Assoc.	Non-Res.
Hillsborough County	215	192	13	0	2	8
Tampa	210	179	7	3	3	18
Temple Terrace	1	1	0	0	0	0
Plant City	1	1	0	0	0	0
Manatee County	93	59	0	8	24	2
Anna Maria	42	32	5	2	0	2
Bradenton	59	54	3	2	0	0
Bradenton Beach	31	16	0	13	0	2
Holmes Beach	60	30	13	10	1	6
Longboat Key	80	67	3	5	3	2
Palmetto	7	7	0	0	0	0
Pasco County	465	436	9	2	8	10
New Port Richey	29	28	0	0	0	1
Port Richey	134	132	0	0	1	1
St. Leo	0	0	0	0	0	0
Zephyrhills	0	0	0	0	0	0
Dade City	0	0	0	0	0	0
San Antonio	0	0	0	0	0	0
Belleair Beach	86	27	12	34	9	4
Belleair	6	6	0	0	0	0
Clearwater	87	64	1	11	3	8
Dunedin	98	97	0	1	0	0
Gulfport	16	6	2	2	2	4
Indian Rocks Beach	33	30	9	0	0	1
Indian Shores	18	5	4	7	1	1
Kenneth City	0	0	0	0	0	0
Largo	13	11	0	1	0	1
Madeira Beach	171	121	35	3	2	10
North Redington Beach	6	3	0	1	1	1
Oldsmar	5	4	1	0	0	0
Pinellas County	89	69	8	0	3	9
Pinellas Park	21	19	0	1	0	1
Redington Beach	90	87	0	1	2	0
Redington Shores	21	14	5	1	0	1
Safety Harbor	3	0	1	0	0	2
South Pasadena	2	1	1	0	0	0
St. Pete Beach	75	42	7	6	3	17

Community Name	Repetitive Loss Structures	SF	2-4 Family	Other Res	Condo Assoc.	Non-Res.
St. Petersburg	395	371	4	3	3	14
Tarpon Springs	69	55	6	0	1	7
Treasure Island	141	77	36	10	4	14

Source: *Local Mitigation Strategy* Plans for Hillsborough, Manatee, Pasco and Pinellas Counties, Florida Division of Emergency Management, NFIP (Numbers based on latest Repetitive Loss List dated 06/30/09)

Wildfires and the Urban Interface

Florida is home to millions of residents who enjoy the state's beautiful scenery and warm climate. But few people realize that these qualities also create severe wildfire conditions. Each year, thousands of acres of wildland and many homes are destroyed by fires that can erupt at any time of the year from a variety of causes, including arson, lightning and debris burning. Adding to the fire hazard is the growing number of people living in new communities built in areas that were once wildland. This growth places even greater pressure on the state's wildland firefighters. As a result of this growth, fire protection becomes everyone's responsibility.

Wildfire Hazard Profile

A wildfire is any fire occurring in the wildlands (i.e., grasslands, forest, brushland, etc). Wildfires have burned across the woodlands of Florida for centuries and are part of the natural management of much of Florida's ecosystems. (*Statewide Hazard Mitigation Plan*, 2009) There are four types of forest fires:

- Surface fires are the most common type of wildfire burns along the floor of the forest, moving slowly killing or damaging trees.
- Ground fires (muck fires) are usually started by carelessness, burn on or below the forest floor. These fires are hard to detect and even harder to extinguish.
- Crown fires are spread rapidly by the wind and move fastest of all types of fires by jumping along the tops of trees.
- Wildland-Urban Interface (WUI) fires are in a geographical area where structures and other human development meet or intermingle with wildlands or vegetative fuels.

Florida's typical fire season is from January to May. During relatively dry months the potential for wildfires increases dramatically. The driest months, combined with low humidity and high wind, have the highest number of fires reported (January, February and March). During these months, fine fuels (i.e., grass, leaves, pine needles) are in optimal burning condition. The largest number of fires caused by lighting occur in July coinciding with the peak of the thunderstorm season.
Each wildfire, especially near development, can threaten human life, structures and natural resources. Urban development has moved into wildland areas where the hazard is more severe and fire control is more difficult.

Hstory of Wildfire in the Region

Florida's typical forest fire season is the dry portion of the year between January and May. The largest number of naturally caused fires occurs in July due to lightning and coincides with the height of the thunderstorm season. However, lightning accounts for only 11.7% of the fires started during 1974 - 1990. Other sources are manmade, including arson, carelessness, debris/trash burning, and operating equipment which may emit sparks. Because so much of the region is comprised of timber lands, a major portion of the region is vulnerable to forest fires, although the threat to the population at large is not considered significant.

In the spring of 1985 a drought which had been underway in the state since August 1984 created numerous spot fires around the state. On May 16, 1985, a wildfire was discovered west of the Palm Coast Development in Flagler County. Palm Coast is a 42,000 acre planned community situated in the coastal plain flat woods along the East Coast of Florida. A wildfire burned through Palm Coast and destroyed 100 homes, damaged 200 more and burned 13,000 acres. This disaster was a mixed wildland urban interface fire associated with urban sprawl type development where the hydro-period is drastically altered and cuts the land into many unmanaged tracts of fire vulnerable wildlands.

In 1989 there were a record number of acres burned (645,326) as a result of 7,291 fires. A large percentage of the acres burned were located in the Everglades. A record number of wildfires occurred in 1981, with 14,042 fires that burned 587,400 acres as a result of a drought that started in July of 1980 and continued throughout 1981. In 1985, another drought stricken year, there were 8,261 fires that burned 443,811 acres.

From 1981 through 1996, an average of 6,080 wildfires occurred per year, burning 219,725 acres. Because of changing weather conditions, the yearly figures range from a low of 3,985 wildfires (86,944 acres burned) in 1991 to a record high of 14,042 wildfires (587,400 acres burned) in 1981. Florida experienced a record high (645,326 acres burned) in 1989 as a result of drought conditions around the state.

The beginning months of 1998 brought widespread flooding. After the rain stopped severe drought conditions developed and lasted from April through June of 1998. As a result of the extreme drought conditions, high temperatures and buildup of flammable wildland fuels, the 1998 wildfires began. The first fire broke out on May 25th in the Apalachicola National Forest. In a two-month period almost 500,000 acres of the state had burned in approximately 2,300 separate wildfires. The cost of this event reached over $160 million. The wildfires of 1998 damaged or destroyed over 300 homes and the value of lost timber exceeded $300 million.

Spring/Summer 2007 - The wildfires that put much of Florida in a several weeks-long smoky haze were started May 5 by a lightning strike on Bugaboo Island in Georgia's Okefenokee National Wildlife Refuge. Thick smoke from area wildfires forced officials to close stretches of I-75 and I-10 in northern Florida. A section of I-95 in Duval County, from Pecan Park to State Road A1A, was also closed due to smoke, as was a section of I-

75 in Broward County near fire-ravaged Collier County in southern Florida. The fires scorched at least 212,000 acres, according to the joint information center, a coalition of state and federal agencies. Of those acres, 101,000 were in Florida and about 111,000 were in Georgia. Interstate 75 was closed from Valdosta, Georgia south to Lake City, Florida and Interstate 10 was closed from Sanderson, Florida, eastward to Live Oak.

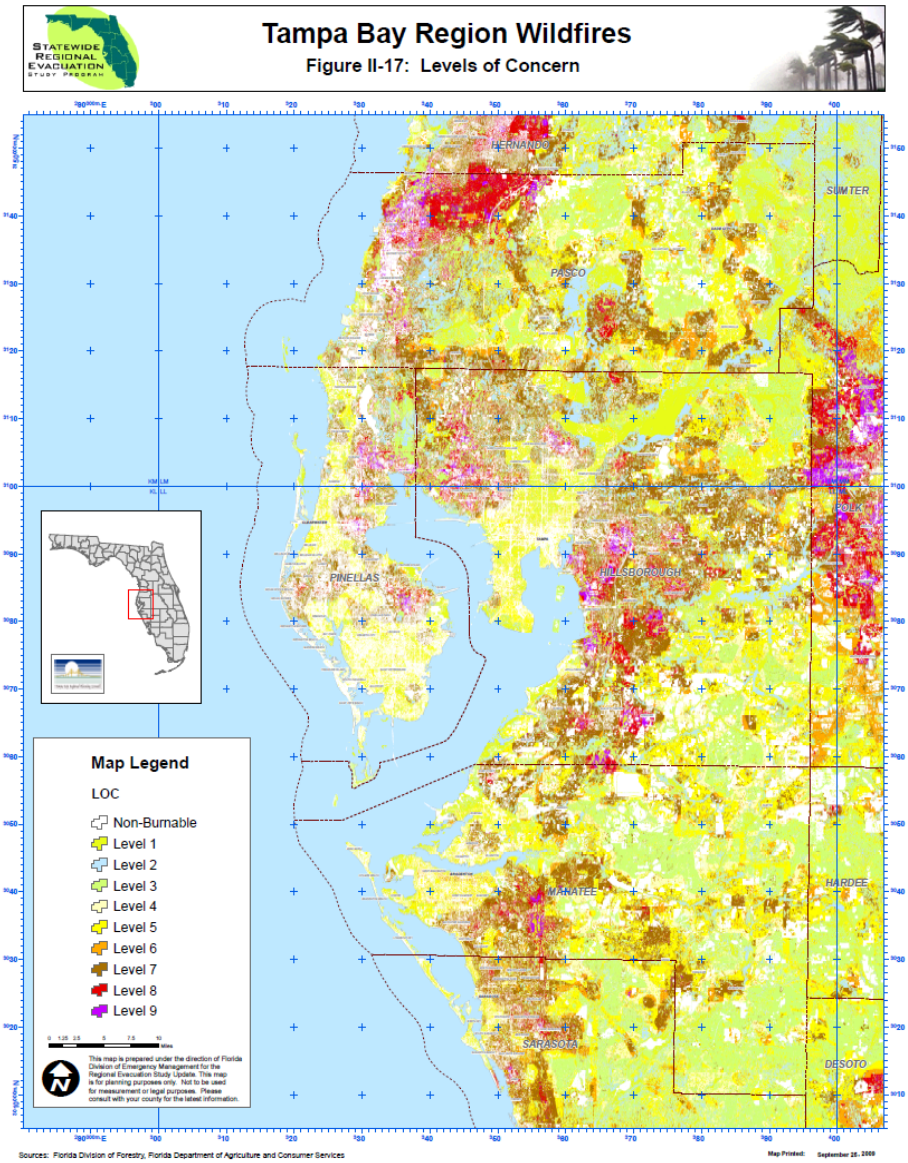
June 2007 – The Florida Division of Forestry produced the map below to show the active wildfires in the state. There were 17 wildfires burning with over 300 acres and a much larger number of smaller fires.

Wildland-Urban Interface (WUI)

The Florida Division of Forestry (DOF) provides risk maps for wildfire. The web-based risk system produces maps for Level of Concern (LOC), Fuels, Wildland Fire Susceptibility Index (WFSI), and the likelihood of the number of fires per 1000 acres per year (FOA). Unfortunately, the website does not offer a vulnerability output in terms of dollars lost and the data was last updated in 2005. Data layers are in the process of being updated and for the release of DOF's new web-based mapping risk assessment program, due out in late 2009 or early 2010.

Methodology

The Wildland Fire Risk Assessment System (FRAS) combines indices of Wildland Fire Susceptibility and Fire Effects to generate a "Level of Concern" map. Data layers used to develop the Wildland Fire Susceptibility Index include: fuel and crown closure classifications and non-burnable areas from Landsat TM data, and topographic and fire weather data from existing data sets.



The Fire Effects Index uses data layers derived from a variety of existing data sets. These data included location of critical

facilities, forest plantations, utility corridors, urban interface areas, roads, and firefighting resource locations; as well as, suppression cost--based on soil and fuel types.

The Levels of Concern (LOC) were computed by multiplying the Wildland Fire Susceptibility Indices by the Fire Effects Indices. The LOC values were then assigned to nine categories of risk and mapped for each Florida Division of Forestry District. Another component of FRAS is the Fire Response Accessibility Index (FRAI). The FRAI is a relative measure of travel time from the nearest fire station to reach a particular mapped cell. Values are assigned into one of six categories of time ranging from class 1 (greater than 120 minutes) to class 6 (0-14 minutes). Accessibility is based on the location of roads and wildland firefighting resource dispatch stations. The Fire Response Accessibility Index is coupled with the Levels of Concern data on District maps.

The fire behavior model, FlamMap is used in FRAS. FlamMap calculates the behavior of a fire occurring in each 30x30 meter cell under defined weather conditions given topographic, fuels, and crown closure data. The accompanied map illustrates the risk for wildfire within the region using the data provided by the Florida Division of Forestry.

Hazardous Material Incidents

A hazardous material is generally considered as any item or agent (biological, chemical, physical) which has the potential to cause harm to humans, animals or the environment, either by itself or through interaction with other factors. Almost every community deals with hazardous materials on a daily basis through transport, use, storage and/or disposal. The benefits Chemicals bring into our lives through their designed uses have become vital to our standard of living. Although major chemical emergencies are extremely rare, there always remains a chance that one will occur. In the State of Florida, the county emergency management agencies plan for hazardous material incidents and coordinate regionally for response through the Local Emergency Planning Committees (LEPCs)

History of the Local Emergency Planning Committees (LEPCs)

Public awareness of the potential danger from accidental releases of hazardous substances has increased over the years as serious chemical accidents have occurred around the world, including a significant release in Bhopal, India in 1984 which killed thousands and a more localized event in Institute, West Virginia. In response to this public concern and the hazards that exist, EPA began its Chemical Emergency Preparedness Program (CEPP) in 1985. CEPP was a voluntary program to encourage state and local authorities to identify hazards in their areas and to plan for potential chemical emergencies. This local planning complemented emergency response planning carried out at the national and regional levels by the National Response Team and Regional Response Teams organized by EPA, the U.S. Coast Guard, and the National Oceanic and Atmospheric Administration (NOAA).

The following year Congress enacted many of the elements of CEPP in the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA), also known as Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This law required states to establish State Emergency Response Commissions and Local Emergency Planning Committees to develop emergency response plans for each community. EPCRA also required facilities to make information available to the public on the hazardous chemicals they have on site. EPCRA's reporting requirements foster a valuable dialogue between industry and local communities on hazards to help citizens become more informed about the presence of hazardous chemicals that might affect public health and the environment. According to OSHA requirements, workers on site also have a right to know about the hazardous chemicals to which they could be exposed. The Tampa Bay LEPC was created in 1988 to help the public and emergency responders address hazardous materials public safety issues. The focus of the committee is on planning, regional coordination, education and awareness. Every state has an LEPC. In Florida the LEPCs are organized in conjunction with the eleven Regional Planning Councils which provide staff support with funding from the Florida Division of Emergency Management. District VIII, which incorporates the counties of Hillsborough, Manatee, Pasco and Pinellas counties and their respective jurisdictions, meets quarterly beginning in February of each year. LEPC members are appointed by the State Emergency Response Commission for Hazardous Materials (SERC), a policy board

appointed by the Governor, which administers the hazardous materials (HAZMAT) laws for the U.S. Environmental Protection Agency (EPA) at the Florida level and at the local level, through the 11 LEPCs statewide. The Chairman of the SERC is the Secretary of the Department of Community Affairs and the Alternate Chairman is the Director of the Division of Emergency Management. Membership of the LEPC represents 18 occupational categories as follows: Elected State Official, Elected Local Official, Emergency Management, Firefighting, First Aid (EMS), Health Organizations, Law Enforcement, Local Environmental, Hospital, Transportation, Broadcast media, Print Media, Community Groups (i.e. Red Cross, etc), Facility Owners, Facility Operators, Non-Elected Local Officials, Water Management District Rep (SWFWMD), and Interested Citizen.

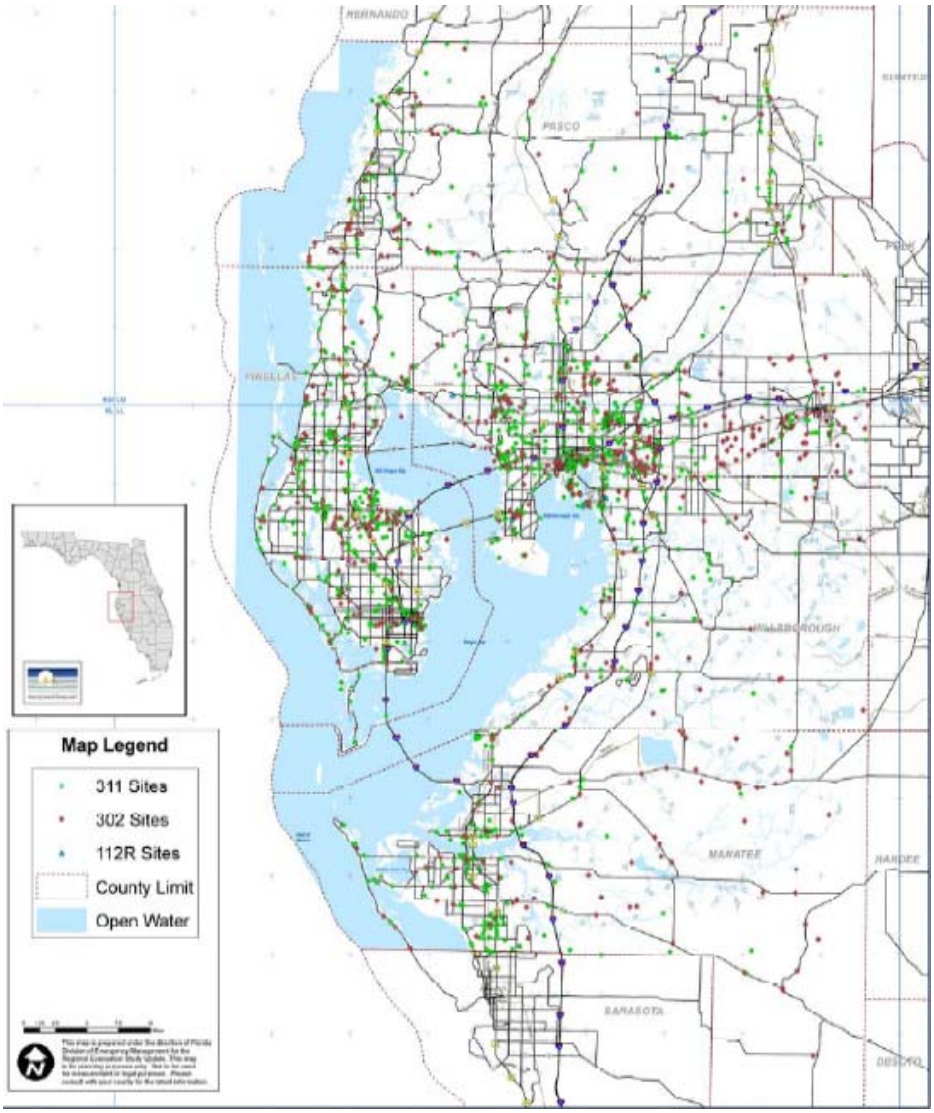
Hazards Analysis of Hazardous Materials

Any facility, public or private, that has at any given time during the year, extremely hazardous materials at or above established threshold amounts is required to report annually. It is termed a Section 302 facility (relating to the clause in EPCRA which pertains to Extremely Hazardous Substances facilities). A hazards analysis on the facility is usually performed by the county in which the facility is located. The map below shows the general location of Section 302 facilities in the region.

The hazard analysis looks at the amounts of materials present, the risk to the surrounding community, public facilities vulnerable to potential release such as schools, hospitals, etc. Evacuation routes are determined based on a vulnerable zone radius from a “worst-case” release scenario. In addition, site plans are created to show first responders exactly where the hazardous materials are stored within the facility. The data is entered in a database suite called Computer Aided Management of Emergency Operations (CAMEO). The CAMEO system is a combination of three programs which work independently or in conjunction to give hazardous materials planners and first responders the tools to plan for and respond to hazardous materials releases.

Additionally, any facility which possesses in excess of 10,000 pounds, a hazardous material for which the Occupational Safety and Health Administration (OSHA) requires the facility to keep a Material Safety Data Sheet is also required to render the annual report.

While the number of hazardous substance facilities continues to increase as awareness of the law reaches various segments of the community, EPCRA has been successful in reducing, over the years, facilities possessing extremely hazardous substances (EHSs) by encouraging that they seek alternative products which do not require reporting and thus, payment of the reporting fee. The reporting deadline each year is March 1st. Within District VIII, there are 519 Section 302 (EHS) facilities reporting in 2008 and 1501 facilities reporting under Sections 311/312.



District VIII possesses slightly less than half (48 percent) of the total Section 302 chemicals by weight and volume in the State of Florida. District VIII had the second highest number of hazardous material incidents for 2007, 323 total, this was only 15 percent of the total of 2,125 incidents statewide. This is attributed to the safety commitments of the district=s largest facilities and their outstanding safety records. It must be pointed out that many of these releases involved anhydrous ammonia and most of these from the foreign vessels delivering the ammonia. Additionally, some of the ammonia releases were from attempted thefts of anhydrous ammonia, an essential ingredient in the manufacture of methamphetamines. District VIII's reported ten top Section 302 chemicals for 2007 are as follows:

District VIII Top Ten Section 302 Chemicals

Chemical	2007 Maximum Inventory (lbs)	Percent of State-Wide Inventory
Anhydrous Ammonia	280,353,750	85.9%
Sulfuric Acid	131,053,883	32.1%
Bromomethane (Methyl Bromide)	11,307,098	9.3%
Chlorine	6,695,313	32.6%
Vanadium pentoxide	1,547,216	100% ?
Nitric acid	1,041,662	3.7%
Sulfur dioxide	524,776	19.3%
Hydrogen Peroxide	358,047	31.7%
Aldicarb	284,151	11.7%
Fenamiphos	256,232	**

Source, SERC for Hazardous Materials, *Annual Report 2008*

CAMEOfm, MARPLOT and ALOHA Update

Accidental releases involving hazardous chemicals occur frequently in the United States. Therefore, the U.S. Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA) and firefighters collaborated to develop the Computer Aided Management of Emergency Operations (CAMEO) software system more than twenty years ago. The CAMEO system is a combination of three programs which work independently or in conjunction to give hazardous materials planners and first responders the tools to plan for and respond to hazardous materials releases. As technology has advanced, numerous revisions have been made to the software. The most recent update was released in February 2006.

One of the programs, CAMEO filemaker (CAMEOfm), contains a chemical library which provides planners and responders with important information on a multitude of chemicals and chemical mixtures. The program also allows the user to create a chemical information database for individual facilities that have hazardous materials on site. CAMEOfm can automatically calculate a vulnerable zone for a simulated or actual chemical release based on specific data entered by the user. The Chemical Library was also updated with the latest Acute Exposure Guideline Levels (AEGLs). The AEGLs are Toxic Levels of Concern that can be used to predict the area in which a toxic gas concentration may be high enough to harm people. Finally, minor changes were made to the Reactivity Report that is used to predict possible reactions that might occur when two or more chemicals are mixed.

The second program, Mapping Application for Response and Planning of Local Operational Tasks (MARPLOT), is a typical Geographic Information System (GIS) with multiple layers which allow the user to view major roads, secondary roads, water bodies, railroads, and other features on selected maps. It also allows the user to plot features like chemical facilities and critical facilities (schools, hospitals, day care centers, etc.) and identify evacuation routes on the maps. MARPLOT may be used in conjunction with CAMEOfm to map a vulnerable zone around a release point and identify populations within the zone that may be affected by a chemical release. The upgraded version of MARPLOT correctly displays multiple plume footprints.

The third program, Arial Locations of Hazardous Atmospheres (ALOHA), was developed to allow the user to model dispersion of a hazardous chemical release. ALOHA gives emergency planners and responders the capability to model chemical plumes. The user chooses from a variety of criteria such as, location, date, time, atmospheric conditions, type/size of container, assorted hole sizes and shapes, source (puddle, gas pipeline etc.) to plot a footprint. In the updated version of ALOHA, users can now estimate the hazards associated with jet fires (flares), pool fires, vapor cloud explosions, Boiling Liquid Expanding Vapor Explosions (BLEVEs), and flammable regions (flashfires) as well as downwind toxic threats.

Over the years, CAMEO has become the most widely used hazardous materials emergency planning and response tool in Florida and the United States. In fact, Florida

now requires electronic submission of hazards analyses in CAMEOfm format from local emergency planners.

Potential hazards were identified in the Tampa Bay Hazardous Material Emergency Plan to consider all potential acute health hazards within the Tampa Bay LEPC area and to identify which hazards are of high priority and should be addressed in the emergency response planning process The hazards analysis for the Tampa Bay LEPC area consists of the following three components:

(1). Hazards Identification - provides specific information on situations that have the potential for causing injury to life or damage to property.

A hazards identification includes information about:

1) Chemical identities;

2) The location of facilities that use, produce, process, or store hazardous materials;

3) The type and design of chemical container or vessel;

4) The quantity of material that could be involved in an airborne release; and

5) The nature of the hazard (e.g., airborne toxic vapors or mists which are the primary focus of this guide; also other hazards such as fire, explosion, large quantities stored or processed, handling conditions) most likely to accompany hazardous materials spills or releases.

(2). Vulnerability Analysis - identifies areas in the community that may be affected or exposed, individuals in the community who may be subject to injury or death from certain specific hazardous materials, and what facilities, property, or environment may be susceptible to damage should a hazardous materials release occur. A comprehensive vulnerability analysis provides information on:

(a) The extent of the vulnerable zones (i.e., an estimation of the area that may be affected in a significant way as a result of a spill or release of a known quantity of a specific chemical under defined conditions);

(b) The population, in terms of numbers, density, and types of individuals that could be within a vulnerable zone;

(c) The private and public property that may be damaged, including essential support systems and transportation facilities and corridors; and

(d) The environment that may be affected, and the impact of a release on sensitive natural areas and endangered species.

(3). Risk Analysis - is an assessment by the community of the likelihood (probability) of an accidental release of a hazardous material and the actual consequences that might occur, based on the estimated vulnerable zones. The risk analysis is a judgment of probability and severity of consequences based on the history of previous incidents, local experience, and the best available current technological information. It provides an estimation of:

(a) The likelihood (probability) of an accidental release based on the history of current conditions and controls at the facility, consideration of any unusual environmental conditions, or the possibility of simultaneous emergency incidents;

(b) Severity of consequences of human injury that may occur, the number of possible injuries and deaths, and the associated high-risk groups; and

(c) Severity of consequences of damage to critical facilities, property, and the environment.

The hazards analyses summaries for 504 facilities in the Tampa Bay LEPC area, updated or in the process of updating for FY in 2008-09, that have reported to the State Emergency Response Commission in compliance with Sections 302 and 303 of EPCRA are provided in the *Regional Hazardous Material Emergency Response Plan.*

Emergencies involving hazardous materials can be postulated as ranging from a minor emergency with no off-site effects to a major emergency that may result in an off-site release of hazardous/toxic materials. The overall objective of chemical emergency response planning and preparedness is to minimize exposure for a spectrum of emergencies that could produce off-site levels of contamination in excess of Levels of Concern (LOCs) established by the US Environmental Protection Agency. Minimizing this exposure will reduce the consequences of an emergency to persons in the area nearby facilities that manufacture, store or process hazardous materials.

Terrorism and Domestic Security

Terrorism is the use of force or violence against persons or property in violation of the criminal laws of the United States for purposes of intimidation, coercion, or ransom. Terrorists often use threats to create fear among the public, try to convince citizens that their government is powerless to prevent terrorism, and/or get immediate publicity for their causes.

Acts of terrorism include threats of terrorism; assassinations; kidnappings; hijackings; bomb scares and bombings; cyber attacks (computer-based); and the use of chemical, biological, nuclear and radiological weapons.

High-risk targets for acts of terrorism include military and civilian government facilities, international airports, large cities, and high-profile landmarks. Terrorists might also target large public gatherings, water and food supplies, utilities, and corporate centers. Further, terrorists are capable of spreading fear by sending explosives or chemical and biological agents through the mail.

Examples of techniques employed by a terrorist attack may include explosions, biological threats, chemical threats, nuclear blast, and radiological dispersion devices. There have been no terrorist events in recent history in the Tampa Bay Region.

The Regional Domestic Security Task Forces (RDSTFs) in the state are in the process of identifying critical infrastructure and key resources (CI/KR) as defined by Department of Homeland Security (DHS) in the National Infrastructure Protection Plan (NIPP). This information will allow for county and regional profiles to be developed outlining risk versus vulnerabilities. Once complied, the region will use a tiering methodology developed by DHS and modified to support regional needs to prioritize the identified CI/KR and vulnerability assessment will be completed to support mitigation efforts. Emergency Operating Plans have been developed and validated to respond to emergency events ensuring the citizens of Florida are protected and safe when responding to emergency events.

Nuclear Power Plant Incidents

Florida is home to five commercial nuclear reactors located at three sites. Two additional reactors are located in Alabama near the State line.

- Crystal River Nuclear Power Plant (NW of CR)
- St. Lucie Nuclear Power Plant (SE of FT. Pierce)
- Turkey Point Nuclear Power Plant (S of Miami)
- Farley Nuclear Power Plant (SE of Dothan, Alabama)

The Nuclear/Radiological Incident Annex provides an organized and integrated capability for a timely, coordinated response by Federal agencies to terrorist incidents involving nuclear or radioactive materials (Incidents of National Significance), and accidents or incidents involving such material that may or may not rise to the level of an Incident of National Significance.

Tsunami

Tsunamis, also called seismic sea waves or, incorrectly, tidal waves, generally are caused by earthquakes, less commonly by submarine landslides, infrequently by submarine volcanic eruptions and very rarely by a large meteorite impact in the ocean. Submarine volcanic eruptions have the potential to produce truly awesome tsunami waves.

The possibility of a tsunami impacting the Atlantic or Gulf Coasts of Florida is considered to be remote. This is because most tsunamis are associated with major earthquakes. The Atlantic Ocean basin is not ringed by large faults as is the Pacific, which is associated both with earthquakes and tsunamis. It is thought that rare underwater landslides would pose a greater risk in the Atlantic Ocean. The Caribbean region has a history of both earthquakes and tsunamis. They do not appear to have impacted Florida's coastlines. However because of the horrific tsunami that impacted South East Asia in December 2004 and Japan in 2011and in recognition of the fact that a tsunami occurrence is possible, the Federal government has decided to expand its warning system to include the Atlantic and Gulf Coasts of the United States.

There is no history of significant tsunami activity in the region.

Although it is highly unlikely that a tsunami will impact Florida, it is not impossible. It is vital to know (and instruct children) that if the ocean suddenly recedes from the shore do not stand and stare. It is necessary immediately to run uphill or away from the shore and go to the highest location possible which may mean up the stairs of a substantial building. Everyone should be aware that no matter where in the world they are, if the sea is observed to recede from the shore, they should immediately run for high ground.