1.0 INTRODUCTION

Terrebonne Parish prepared this Hazard Mitigation Plan to be better equipped for disasters before they occur. It is our hope that, with proper planning, our citizens can be more knowledgeable of things they can do to protect their property and their lives from the devastation caused by hazards like floods and hurricanes. In addition, it is our desire to objectively evaluate the hazards that occur in our Parish and, as government officials, prioritize the actions that we need to take to provide a safe place to live.

The Terrebonne Parish Consolidated Government was made aware of a Planning Grant that would assist us in preparing this plan in early 2002. The Parish applied for a Hazard Mitigation Grant Program (HMGP) grant and was awarded the grant in May 2002. We felt it was important to have the assistance of someone skilled in preparing such plans, so after receiving the grant, we hired a hazard mitigation consulting firm, Aegis Innovative Solutions, LLC (Aegis) to guide us in this process. Soon after hiring Aegis, one of the worst hurricanes to hit Louisiana in recent history came ashore in September. Hurricane Lili caused significant flooding in south Louisiana and continued her path of destruction northward. After the storm cleared, over 43 Parishes, including ours, were named as part of a Presidentially declared disaster. Once again, Terrebonne Parish faced the cleanup after the storm. In the fall of 2005, Terrebonne Parish was dramatically impacted by Hurricane Katrina in August and then heavily damaged by Hurricane Rita in September. We are continuing to assess and recover from these two storms as well as lingering impacts of Hurricane Lili.

The HMGP grants are used by the Federal Emergency Management Agency (FEMA) to help communities such as ours mitigate against future damages. Mitigation is any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards. The Louisiana Office of Homeland Security/Emergency Preparedness (LHLS/EP) used funding that was made available through FEMA from the HMGP fund created after Tropical Storm Allison in 2001, to host workshops all across Louisiana. The workshops explained the planning process that was necessary to prepare a Hazard Mitigation Plan and to meet the requirements of a new legislative act called the Disaster Mitigation Act of 2000 (DMA 2000). We learned that as a result of DMA 2000, we would not qualify for future HMGP money if we did not have a plan in place that complied with the DMA 2000 requirements.

After attending the Hazard Mitigation Planning Workshop, we had two very important reasons to prepare our Hazard Mitigation Plan – 1) to plan for disaster before it occurs to help protect our citizens from the effects of hazards, and 2) to remain eligible for future HMGP funds that could help us implement actions in our community such as elevating flood prone structures.

What follows in Section 1.0 is a description of the "scope of the plan" which addresses why we are preparing the plan, a discussion of the "authority" for preparation of the plan which addresses the Federal acts that drive the preparation of such plans, and "plan preparation and organization" which outlines how the plan was prepared and what can be found in the rest of the plan.

**Note: Although Terrebonne Parish was heavily impacted by Hurricanes Katrina and Rita in August and September of 2005, sufficient data are not available at the time of submittal of this revision to address the implications of these devastating storms. For the most part, this Plan addresses a Pre-Katrina/Rita condition. The data for these events will be included in future updates to this Plan, when a proper and complete assessment is available.*

1.1 Scope of the Plan

The Terrebonne Parish Hazard Mitigation Plan is a concerted effort on the part of the Parish to develop an all hazards, Parish-wide approach to disaster damage reduction. In order to focus on a process needed to attain a sustainable future for the community, Terrebonne Parish utilized a FEMA approved process to identify and assess all potential hazards that may affect the community and develop an action plan to address those hazards. This plan will be utilized to better articulate accurate needs for the community based on a process that involves all stakeholders including the general public, government, business and industry.

1.2 Authority

Authority for the preparation of the Hazard Mitigation Plan is derived from the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988, P.L. 93-288, as amended by the Disaster Mitigation Act of 2000, P.L. 106-390. The Disaster Mitigation Act of 2000 (The Act) requires state and local governments to develop and formally adopt natural hazard mitigation plans by November 2003 in order to be eligible to apply for Federal assistance under the HMGP. The Act was further amended to extend the planning requirement deadline to November 2004.

When the DMA 2000 was signed into law on October 30, 2000, the Robert T. Stafford Disaster Relief and Emergency Assistance Act was amended by adding a new section, 322 – Mitigation Planning. Section 322 places new emphasis on local mitigation planning. It requires local governments to develop and submit mitigation plans as a condition of receiving HMGP project grants. An Interim Final Rule for implementing Section 322 was published in the Federal Register, 44 CFR Parts 201 and 206, on February 26, 2002. The requirements for local plans, or Local Mitigation Plan Criteria, are found in part 201.6.

In addition to the plan requirement, the Act also requires communities to utilize a specific planning process developed for an all hazards approach to mitigation planning. This four step planning process is crucial to ensure that the effective planning by a community meets all the plan content criteria required by the Act. The Act requires adoption by the local governing body and specifies a stringent review process, by which states and FEMA Regional Offices will review, evaluate and approve hazard mitigation plans.

This plan was funded on May 30, 2002 by a Planning Grant from FEMA and administered by the LHLS/EP. The first draft of this Plan was submitted to LHLS/EP in

May 2004. Comments from FEMA in reference to other Hazard Mitigation Plans were received in late 2004. These comments were addressed and a revised draft was submitted to LHLS/EP in May of 2005. Based on additional comments to other Hazard Mitigation Plans, the current revision has been prepared for this December 2005 submittal to LHLS/EP.

1.3 Plan Preparation and Organization

The Parish recognized early that planning is not a product, but rather a process. And although the result of the planning process would be a plan, it would be the planning process that helps us obtain our desired outcome – a disaster resilient community. Therefore, from the beginning, we wanted to involve the community in this process.

Mr. Pat Gordon, the Terrebonne Parish Planning Director, was the primary point of contact and lead representative for the Parish.

To begin the planning process, the Parish invited members of the community with a variety of backgrounds (i.e. business, law enforcement, schools, utilities, and emergency response) to attend a project plan meeting on March 25, 2003. From this meeting, a Steering Committee was selected to continue with the planning process.

One of the Steering Committee's first tasks was to develop a mission statement that would be referred to frequently in keeping the Committee focused on our tasks:

The Hazard Mitigation Plan will establish and coordinate a roadmap of targeted projects, by identifying, evaluating and prioritizing the projects to improve the health, safety, and welfare of the citizens of Terrebonne Parish.

The Steering Committee followed the planning process outlined by FEMA as detailed in the "State and Local Mitigation Planning How-To Guides":

- Getting Started – Building Support for Mitigation Planning
- Understanding Your Risks – Identifying Hazards and Estimating Losses
- Developing a Mitigation Plan – Identifying Mitigation Measures and Implementation Strategies
- Bringing the Plan to Life – Assuring the Success of the Hazard Mitigation Plan

1.4 Local Mitigation Plan Criteria

Hazard mitigation planning is the process of determining how to reduce or eliminate the loss of life and property damage resulting from hazards such as floods and hurricanes. The primary purpose of hazard mitigation planning is to identify community policies, actions, and tools for implementation over the long term that will result in a reduction in risk and potential for future losses community-wide. This is accomplished by using a systematic process of learning about the hazards that can affect a community, setting clear goals, identifying appropriate actions, following through with an effective mitigation strategy, and keeping the plan current.

The hazard mitigation planning process, as detailed in these How-To Guides is as follows:

- Organize Resources
- Assess Risks
- Develop a Mitigation Plan
- Implement the Plan and Monitor Progress

In order to document this process, the Steering Committee chose to follow the format of the DMA 2000 Local Mitigation Plan Criteria. These criteria are required to be met in order for FEMA to approve the plan. Therefore, we have documented our responses to each plan criteria, while referring to appendices that contain supporting documentation. The purpose of this format is to enable an efficient and accurate review by FEMA.

The Local Mitigation Plan Criteria defined by the U.S. Congress in the DMA 2000 consist of the following:

- Prerequisites
- Planning Process
- Risk Assessment
- Mitigation Strategy
- Plan Maintenance Procedures

This Hazard Mitigation plan layout is as follows:

- Section 2.0 – Parish Profile
- Section 3.0 – Planning Process
- Section 4.0 – Risk Assessment
- Section 5.0 – Mitigation Strategy
- Section 6.0 – Plan Maintenance Procedures
- Section 7.0 – Action Plan

Prior to addressing the Local Mitigation Planning Criteria, we set the stage for each reader by presenting a detailed description of our Parish in Section 2.0 – Parish Profile. Then we address each of the Local Mitigation Plan Criteria in a question and answer type format in Sections 3.0 - 6.0. Finally, any effective plan must result in actions taken to implement that plan. Section 7.0 encapsulates the actions that Terrebonne Parish plans to implement in order to build a more disaster resilient Parish.

1.5 PREREQUISITES

The Local Mitigation Plan Criteria state that the plan must satisfy the related three prerequisites before the plan will be approved by the State and FEMA. If these prerequisites have not been fulfilled, the plan will not be approved.

The three prerequisites are:

- Adoption by the local governing body – Single Jurisdiction
- For multi-jurisdictional plans, each jurisdiction must adopt the plan
- For multi-jurisdictional plans, each jurisdiction must participate in the planning process.

Because our plan is not a multi-jurisdictional plan, only the first prerequisite is addressed here.

1.5.1 Adoption by the Local Governing Body – Single Jurisdiction

Requirement 201.6(c)(5):
[The local hazard mitigation plan shall include] documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County Commissioner, Tribal Council)…

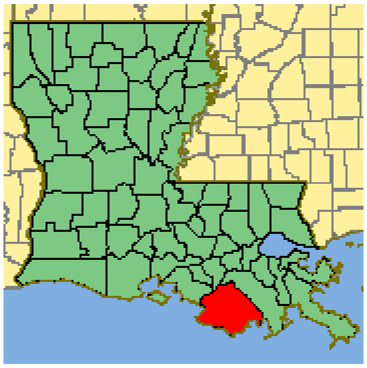
Terrebonne Parish Council will adopt this Plan by resolution. See Appendix A for a copy of a draft resolution by the Parish to adopt the Plan.

The inclusion of the adoption resolution is intended to confirm the commitment of the local community to follow through with the implementation of the plan.

2.0 PARISH PROFILE

Prior to addressing the hazards that our community faces, this plan presents a brief overview of our community, taking into account the geography, population, transportation routes, parish history, topography, climate, economics, and community assets.

2.1 Geography



Terrebonne Parish is located in the southeast portion of Louisiana, west of Lafourche Parish and southwest of New Orleans, and east of St. Mary Parish. Assumption Parish is located to the north east. Baton Rouge, along with the industrialized areas along the Mississippi River is to the north, while the Gulf of Mexico lies to the south. Terrebonne Parish is the second largest parish in Louisiana, with an area of 2,100 square miles or 1,343,995 acres; of which 1,008 square miles is land and 1,092 square miles is water.

Terrebonne Parish has no incorporated areas. Houma, which was incorporated in 1979 has an Urban Services District, which represent the "old city limits", and since that time has been consolidated with the Parish and is currently an unincorporated community. Houma is located in the northeastern section, and has the largest population in the parish, followed by Bayou Cane, which is located just north of Houma. Schriever is the most northern community in Terrebonne Parish and Gray, a farming community, is also located in the northern portion of the parish. Cocodrie is the southern most community located at the end of LA-56 where Bayou Terrebonne runs into Terrebonne Bay. Dulac, is located along the Houma Navigational Canal in the southern part of the parish, other southern communities are Montegut, Pointe-Aux-Chenes, and Chauvin.

The 2000 census reports the Terrebonne Parish population at 104,503 people with 39,928 households. Terrebonne's population from the 1990 census report was listed as 96,982 people, a population change of 7.6%. Houma's population fluctuates with an additional 3,000 people due to Nicholls State University enrollment. See Table 1 for Terrebonne's population over the last 25 years.

Table 1

Terrebonne Parish Population			
Name	**Total 2000 Population**	**Total 1990 Population**	**Total 1980 Population**
Terrebonne Parish	104,503	96,982	94,393
Houma, Urban Service District / Old City Limits	33,462	30,495	32,608
Bayou Cane, CDP	17,046	18,876	15,723
Schriever, CDP	5,880	4,958	---
Gray, CDP	4,958	4,260	---
Chauvin, CDP	3,229	3,375	3,338

Dulac, CDP	2,458	3,273	---
Montegut, CDP	1,803	---	---

Source: http://leap.nlu.edu/profiles.asp and http://factfinder.census.gov CDP: Census Designated Place

2.2 Transportation

The main transportation arteries through Terrebonne Parish are U.S. Highway 90, State Highways 20, 24, 55, 56, 57, 309, 311, 315, 316, 659, 660, 664, 665, 3040, 3052, 3087 and 3197. See Map 1, the Base Map. U.S. Highway 90 runs east/west through the southern portion of the Parish.

Some of these roadways are significant evacuation routes for Terrebonne Parish, as well as surrounding Parishes during states of emergency. Map 2 shows the location of these evacuation routes.

Southern Pacific Railroad serves Terrebonne Parish. The railroad runs east west through the northern portion of the Parish, parallel to Louisiana Highway 20. Rail rates in Louisiana for many commodities tend to be lower than those in the other states because of the competition from barge carriers. All lines handle a significant volume of containers, trailers on flat cars, and carload traffic between New Orleans and other parts of America.

Houma-Terrebonne Airport is located in Houma and can accommodate corporate and private aircraft with a 6,508 foot runway and a 5,000 foot runway. Houma-Terrebonne Airport Commission boasts an aviation/industrial complex of 1,800 acres. Ninety percent of activity at the airport is oilfield related, producing some 120 leases and a flying operation dominated by a busy helicopter oilfield support shuttle. The airport is listed in the current National Ocean Service Airport/Facility Directory, South Central Edition, and boasts a full instrument landing system. The airport offers a full range of aviation services, resulting in approximately 100,000 aircraft movements per year, placing Houma as one of the busiest airports in Louisiana.

The New Orleans International Airport services Terrebonne Parish, and is located 57 miles northeast of Houma. Every major domestic airline and several international carriers serve the New Orleans International Airport, providing one-and-two-stop service to nearly all-major domestic and international destinations. A second airport is located 83 miles to the north in Baton Rouge and is served by five commercial carriers with 31 flights daily. General aviation facilities are also available at the Baton Rouge Metro Airport and one commuter airline for shorter destinations.

The Port of Terrebonne is strategically located on the Houma Navigation Canal within one-half mile of its intersection with the Gulf Intracoastal Waterway. This location puts the port in position to take advantage of significant cargo flows and marine traffic on both waterways. The Port of Terrebonne is a shallow draft port with a depth of nine feet. The closest international waterway port is located 55 miles to the northeast at the Port of New Orleans, with a channel depth of 45 feet.

2.3 History

Terrebonne Parish was established March 22, 1822, from the southern part of Lafourche Parish. The Parish seat is Houma and was founded in 1834. Terrebonne Parish was originally named “Terre Bonne” meaning good earth. It is uncertain if Henry S. Thibodaux, one of the parishes founding fathers, used Darbonne, the name belonging to one of the first families believed to settle in Terrebonne Parish, and that the name evolved from that, or if he simply intended it to be “Terre Bonne” or “good earth”.

The first Parish seat was located north of Houma along Bayou Terrebonne, where the first courthouse and a small jailhouse were constructed. In 1829 William S. Watkins, in hopes of developing the first town in Terrebonne Parish, subdivided an area of lots in what is known today as the Bayou Cane area. He died after only a few of the lots had been sold. Even though William Watkins did not see his dreams come to full growth, the area did develop and Bayou Cane is now the second largest populated city in Terrebonne Parish. One year following Mr. Watkins death a town was developed by Hubert M. Belanger, which was originally named Newport. In the beginning there were four streets, Main, Front, Market, and Cypress. This area is now known as Bourg.

Richard H. Grinage and Hubert M. Belanger are considered, the “Fathers of Houma”, because of their generous donation of land along Bayou Terrebonne, on March 18, 1834 for the new Parish seat of Houma.

Houma, the present Parish seat, was named after the Houmas Indians. The native word "houma" means red, and the tribe's war emblem was the crawfish. Historians say the Houmas Indians originally came from Mississippi and Alabama and settled near Baton Rouge. After many conflicts with other Indian tribes, losing a war to the Tunica Indians in 1706, and to escape the encroachment of the white man, the Houmas Indians continued moving south to more remote areas. They settled in Terrebonne Parish in the mid to late eighteenth century and established a camp known as Ouiski Bayou on the high ground northwest of present-day downtown Houma. They were subsequently pushed from the highlands of the north to the coastal regions of the south by the European settlements in the late 1700's and 1800's. Evidence of the Houma Tribes can still be found in this area today.

The first settlers to enter the area, in the mid 1700’s after the Houma Indians, were French, Acadians, and French-Canadians. Most of the pioneers who came to Terrebonne migrated from the Mississippi River, down Bayou Lafourche to Bayou Terrebonne. There was an influx of the French from New Orleans to the bayou country after the Spanish domination in 1762. The district Spanish commandant granted concessions of title to not more than 630 acres of land to each newcomer to the bayou lands. While many Frenchmen came into the area prior to this, there are recorded claims by Anglo-Saxons and Spanish as well. The influx of French was so great that after organizing a parish police jury on April 6, 1822, one of the first resolutions to pass stated that all parish regulations should be recorded in both French and English. Houma was incorporated as a city by an act of legislature in 1848.

Although no major battles were fought in Terrebonne Parish, hundreds of men from Terrebonne Parish served in the Confederate Army. The Union Army did make their way to the area. The event was notable because Union soldiers were ambushed and killed. The Union commanders threatened to burn the town unless the perpetrators surrendered.

The industry in Houma at this time consisted largely of farming plantations, seafood, fur trading and logging industries. The cultivation of sugar cane was the principal agricultural industry in the parish. The first plantation was established in 1828. By 1851, Terrebonne had 110 plantations with 80 sugarhouses. The Minor family founded Southdown Plantation in 1858. Stephen Minor was the Secretary to the Spanish Governor Gayoso. Today, the home serves as the parish museum. The sugar mill itself was sold in 1979, dismantled and shipped to Guatemala where it was reassembled and is still in use today.

Canals were dug between the bayous to decrease travel time within the parish and make trade more efficient. In 1872, a railroad that linked Schriever to Houma became instrumental in increasing trade and travel within and outside the Parish. These canals are still being used even though the construction of the Intracoastal Waterway began in the early 1930's. The Intracoastal was later extended in to Lafourche Parish and to Bayou Lafourche which further increased Houma's importance as a portal city.

Houma was home to a Naval Station with a Lighter than Air Blimp during World War II. The Navy base, which was in operation from May 1943 to September 1944 used blimp squadrons to scan the coastline for enemy vessels, and was one of only two blimp stations operating on the Gulf Coast.

Terrebonne has always depended on the resources of the Gulf of Mexico for its livelihood. Oysters, shrimp, crabs and fish are a successful industry for the parish. The oysters for Terrebonne Parish have become internationally known as the finest in the world. In the great stretches of marshland surrounding Terrebonne Parish, trapping of Louisiana muskrat, mink, otter, raccoon, and nutria pelts are another form of local commerce.

By the early twentieth century, the oil industry was established in south Louisiana. The gas industry soon followed. Terrebonne became the gateway to the heaviest concentration of offshore oil service companies in the state. Houma became one of the fastest growing cities in America during the 1960's. This growth was due in part to the abundance of fertile soil, productive waters, and the natural mineral resources, which can be found throughout the Parish. In 1961, the Houma Navigational Canal was completed to provide a 30-mile link to Terrebonne Bay and the Gulf of Mexico.

During the 1980's oil industry collapse, the Houma-Terrebonne area economy also collapsed, with an unemployment rate of 25% for nearly two years; local residents and business were devastated.

The oil industry continues to be the primary source of revenue for the area; however alternative industries are emerging to fill in the gaps. Terrebonne Parish continues to account for 25% of Louisiana's seafood production. In addition, the medical industry is creating a stronghold for itself in the parish area. Tourism, too, is a popular source of commerce. Houma's new Civic Center promises to bring an influx of entertainment and convention revenue to Houma. The draw of authentic Acadian culture, diverse environment and wildlife, plantation homes, excellent food, and close proximity to New Orleans, Baton Rouge, and Lafayette make Houma – Terrebonne an excellent central location for the visitor who wishes to see all the sights and sounds of the bayou wonderland of South Louisiana.

2.4 Topography

The geography of Terrebonne varies from the north to the south. In the north, the landscape is mostly flat, used for agricultural purpose. Toward the south, around the bayous, lakes and salt marshes that characterize the coastal areas, water and low lands dominate the terrain. Of the 2,100 square miles of the Parish, nearly 1,100 square miles are accounted for by water. Elevation throughout the Parish ranges from 1-13 feet above sea level.

Approximately 95% of the total land area of Terrebonne Parish is located within FEMA's 100-year floodplain. The majority of the floodplain is found along the Gulf of Mexico, Bayou Terrebonne, Bayou Cocodrie, Bayou Black and many other bayous and waterways throughout the Parish. The floodplain is illustrated on Map 3, Repetitive Loss Areas. See Map 4 for Terrebonne Parish Land Use.

2.5 Climate

Terrebonne Parish weather is typically warm and humid. Variations in daily temperature are determined by distance from the Gulf of Mexico and, to a lesser degree, by differences in elevation. The average annual temperature for the state as a whole is 68ºF. January is the coldest month averaging 53ºF, and July the warmest, averaging 83ºF. Winter months are usually mild with cold spells of short duration. The summer months are quite warm with highs in the 90's and lows in the 70's. Prevailing winds are from the east. Average annual precipitation for the area is 84.22 inches. Terrebonne Parish is susceptible to the normal weather dangers, such as tornados and floods but, due to its proximity to the Gulf of Mexico the Parish is extremely susceptible to hurricanes. Hurricane season lasts from June 1 to November 30, with most hurricanes forming in August, September, and October.

2.6 Economics

A large labor force, excellent transportation network, abundant raw materials and land for commercial land industrial development make Terrebonne Parish an ideal prospect for business investment. The oil and gas industry continues to dominate the local industrial base, comprising a significant portion of the manufacturing workforce, whether working in oil and gas or providing related services. Other prominent industries include metal products, marine industries and commercial fishing. Terrebonne Parish is first in the State in natural gas production, third in oil, accounts for 25% of the state's seafood production, and its shipbuilding industry has benefited from the new demand for gambling boats. See Table 2 for a list of the major employers in Terrebonne Parish.

Table 2

Major Employers (> 100 Employees)		
Name	**Product or Service**	**No. of Employees**
Terrebonne Parish School Board	Education	2,665
Terrebonne General Medical Center	Medical Services	1,012
Leonard J. Chabert Medical Center	Medical Services	950
Terrebonne Consolidated Government	Government	900
Diocese of Houma-Thibodaux	Catholic Education	800
Odgen Offshore Food Services	Offshore Catering	750
Halliburton Entergy Services	Oil Field Services	649
Gulf Island Fabrication, Inc.	Steel Fabrication	560
Patterson Services	Oil Field Services	500
Wal-Mart	Discount Retailer	480
Pocahontas Food Group	Wholesale Groceries	450
J. Ray McDermott	Oil Field Services	404
Rouse Supermarket	Groceries	378
Hutco Offshore, Inc.	Offshore Contract labor	330
Saia Freight Line, Inc.	Trucking	330
Petrol Marine	Marine Transportation	300
Quality Shipyards, Inc.	Tugboats/Supply Vessels	300
Motivatit Seafood's, Inc.	Seafood/Boatbuilding	250
Sequa Engineering	Oil Drilling Tools	220
Dolphin Services	Sandblasting	200
TARC Industries	Wooden Crates/ Metal Products	200
Main Iron Works, Inc.	Tugboat/Steel Fabrication	135

Source: http://leap.nlu.edu/profiles.asp and http://www.rootsweb.com/ laaterreb/today.htm

2.7 Community Assets

The statistics for the law enforcement, fire departments, medical services, and schools are current, but they are subject to change and will be updated appropriately.

Law Enforcement – The Terrebonne Parish Sheriff's main office is located in Houma and handles all of the criminal, water patrol, civil and narcotics division operations. Terrebonne Parish Sheriff's Department has 210 deputies, and 92 motorized units.

Because of the water volume in Terrebonne Parish, a Water Patrol Division was formed, which has responded to thousand of calls from boaters across the Parish. The Terrebonne Parish Sheriff's Office operates one of only sixteen certified deputy training centers in the state. Law enforcement organizations from around the state utilize the facility for their own training. The modern Rifle Range, which is also open to the public for use five days a week, is a vital part of the continual training deputies receive. See Map 5.

Fire Departments – Terrebonne Parish has 40 fire stations with 46 full time employees, and over 430 volunteers located throughout the Parish. The equipment for the Parish includes four ladder trucks, 53 engines, and 13 rescue squad vehicles. See Map 6.

Medical Services – Terrebonne General Medical Center (TGMC), in Houma is a regional medical center with 261 licensed beds. With the opening of the new facility in 1984, TGMC has become one of the most advanced medical centers in Louisiana. The Leonard J. Chabert Medical Center operates a 201-bed facility while, as a training facility, provides clinical training and experience for 50 residents assigned on a rotational basis by the Ochsner Foundation. Bayou Oaks Hospital also provides general medical care, and along with TGMC and the Leonard J. Chabert Medical Center, is accredited through the Commission on Accreditation of Hospitals. Long-term health care is available at eight nursing homes that count 557 beds. A number of smaller hospitals, clinics and public health units are located around the Parish. Acadian Ambulance provides parish-wide ambulance service. See Map 7.

Residents have access to the large number of medical facilities located in the regional area, including Mary Byrd Perkins in Baton Rouge and Charity Hospital in New Orleans, which is one of the largest teaching hospitals in the country, the clinics of both LSU and Tulane Schools of Medicine, the prestigious Ochsner Foundation Hospital and Clinics, and numerous other public and private medical facilities. The medical care in the New Orleans region is among the finest available in the world.

Schools – There are 50 schools, including public schools and private schools in Terrebonne Parish. The Southern Association of Colleges and Secondary Schools and the Louisiana Independent School Association accredit all the public schools in Terrebonne Parish. The Terrebonne Parish School Board develops policies for the education of children in the public school system. See Map 8.

The needs of special, handicapped students are met at the TARC (Terrebonne Association for Retarded Citizens) School, TARC Industries, and TARC Residential located in Houma. A private foundation, the Terrebonne Association for Retarded Citizens, offers educational programs for these special citizens. TARC offers an early intervention program, preschool activities and a school program for children. TARC Industries offers supported work in various settings, including community placements.

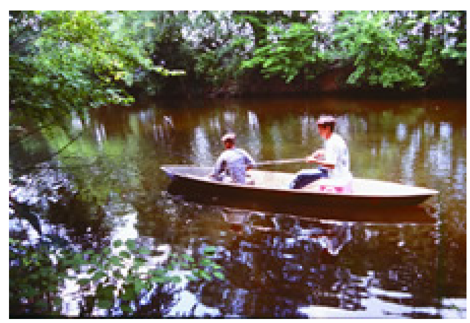
For those who chose to pursue a career in the trade and industrial sector, South Louisiana Regional-Technical Institute located in Houma, offers many programs in several exciting fields.

Nicholls State University is located in Thibodaux, 16 miles from Houma. There are 12 colleges and universities within a one-hour drive of Terrebonne Parish, and there is one vocational technical institute within Terrebonne Parish. These colleges and universities, some of which offer doctoral degrees in the arts, sciences, engineering, medical and legal fields, are nationally and internationally recognized as sponsoring extensive research activities.

<u>Distances from Houma</u>

Nicholls State University – 16 miles
Notre Dame School of Theology – 45 miles
Xavier University - 46 miles
Tulane University - 47 miles
Loyola University - 47 miles
Dillard University - 47 miles
Our Lady of Holy Cross College – 47 miles
New Orleans Baptist Theological Seminary – 48 miles
LSU Medical Center - 49 miles
Southern University at New Orleans (SUNO) - 50 miles
University of New Orleans (UNO) - 55 miles
Delgado Community College – 73 miles

Parks and Recreation – There is an abundance of outdoor recreational activities available to local residents. There are many bayous, lakes, and rivers, which offer miles of navigable waters to boaters and wonderful fishing, camping and hunting grounds for residents and visitors. There are several swamp tours within the Parish, where visitors may see various types of wildlife including alligators, rare birds, nutria and more.



Terrebonne Parish offers many programs through their Parks and Recreation Board and various recreation committees throughout the Parish. Both work to service some 20 communities throughout the Parish to provide various social and cultural activities suitable for all ages. The recreation districts provide, for the people residing in their areas: five swimming pools, 13 equipped playgrounds, six playfields, 30 tennis courts, 16 recreation facilities, 32 ball fields, three football fields and one multi-purpose field. The parish recreation program also provides one campground and park with a volleyball court, play area for children, 50 spots for tent camping and 71 trailer hook-ups at the Grand Bois Park, located on the Bourg-LaRose Highway.

Mandalay National Wildlife Refuge protects high quality freshwater marsh and cypress-tupelo swamp. It is in the Southeast Louisiana Coastal marsh in Terrebonne Parish near Houma. The area contains significant migratory bird resources including neo-tropical migrants, bald eagles, waterfowl, wading birds and shorebirds. The major management thrust will be resource protection through law enforcement, noxious weed control, and marsh restoration. Oil and gas exploration activities are ongoing within the refuge.

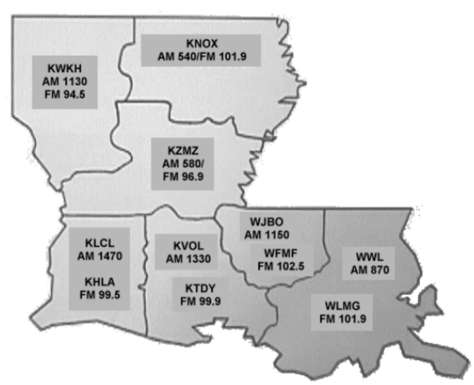
The other government-operated site in Terrebonne Parish is the Pointe-Aux-Chenes Wildlife Management Area, managed by the Louisiana Wildlife and Fisheries Department. Pointe-Aux-Chenes offers dove and waterfowl hunting, deer hunting with bow only, and plenty of great year-round fishing.

The Parish has access to the vast recreational and cultural facilities of the metropolitan New Orleans area: including the Aquarium of the Americas, the New Orleans Symphony, opera and ballet, the National Football League's New Orleans Saints, NCAA college athletics from Tulane University, University of New Orleans, Louisiana State University, and others. Boating and fishing on Lake Maurepas and Lake Pontchartrain are also major activities for visitors and residents of the Parish.

Historic buildings and other points of interest are a source of pride for residents and offer visitors a variety of things to see and do.

Parish residents are served by a main library and eight branch libraries located throughout the Parish. The main library has a total of 245,480 volumes, 329 paintings, 1,695 long-playing records, 322 microfilms, 182 magazines, 9 newspapers, 291 filmstrips, 22 (16mm) films, and 960 videocassette tapes. The main library, with its 8 branch libraries throughout the Parish, has a total annual circulation of 293,351.

Media – Communications in the area include a local newspaper, which is published six days a week, "*The Houma Courier Newspaper Corp.,"* a weekly publication of *"The Bayou Catholic,"* and a bi-weekly publication *"Tri Parish Times."*



Local radio stations include KHOM (FM), KTIB (AM 64), KCIL (FM), and KJIN (AM). Many Baton Rouge and New Orleans stations are also available.

Television stations can be received from both metropolitan areas and include all four networks (ABC, CBS, NBC and FOX), as well an independent station, locally owned and operated HTV – Martin Folse Productions, Inc. Cable service is also available in the Parish through Time Warner Cable and Charter Communications.

3.0 PLANNING PROCESS

As addressed earlier, the Steering Committee followed FEMA's hazard mitigation planning process as prescribed in the How-To Guides. This planning process assured public involvement and the participation of interested agencies and private organizations. Documentation of the planning process is addressed in this section.

3.1 Documentation of the Planning Process

IFR Requirement 201.6(c)(1):
[The plan must document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

The Terrebonne Parish Consolidated Government was made aware of a Planning Grant that would assist us in preparing this plan in early 2002. The Parish applied for a Hazard Mitigation Grant Program (HMGP) grant and was awarded the grant in May 2002. The HMGP grants are used by the Federal Emergency Management Agency (FEMA) to help communities such as ours mitigate against future damage. FEMA and LHLS/EP disperse the funds for mitigation activities.

Terrebonne Parish developed a Parish-wide Hazard Mitigation Plan which includes all of the municipalities within the Parish. There are no incorporated communities in the Parish so the Parish Council is the local governing body for all citizens. Prior to the first meeting, the project plan meeting, over 100 people were invited to participate in the planning process. Representatives from a wide cross section of the public, including each of the municipalities as well as fire, law, health care, schools, municipal and public utilities, were invited to attend. See Appendix B for a list of the people from the communities that were invited to the project plan meeting.

The project plan meeting was held on March 25, 2003. This meeting was aimed at informing the attendees of the planning process, because they would continue to meet with our consultant and guide the planning process. At this meeting, the concept of mitigation planning was explained to an audience of about 40 people and ideas on what the community felt about mitigation were discussed.

Pertinent parish and city documents were discussed and reviewed at this meeting. The specific plans are listed below along with a discussion on how they were incorporated into this Hazard Mitigation Plan.

Floodplain Ordinance – The Parish joined the National Flood Insurance Program (NFIP) and, therefore, adopted the floodplain ordinance. This ordinance was reviewed. The ordinance was used to develop most of Section 5.2.5 – Floodplain Management and Building Codes.

Emergency Operations Plan (EOP) – The EOP was used to determine which critical facilities had been previously identified. The EOP was also reviewed to determine what action items were needed to improve emergency preparedness.

Materials from the Terrebonne Parish Consolidated Government Economic Development Foundation and the Economic Development Master Plan (2002) – This information was used to obtain data and information on planned growth. This information was used in Sections 2.1 – Geography, Section 2.6 – Economics and Section 4.5 – Assessing Vulnerability – Analyzing Development Trends.

FIRM Maps – These maps were used to evaluate the risk associated with the 100 year and 500 year floods. Data from these maps were summarized in Section 4.3.1.2.

Southeast Louisiana Hurricane Preparedness Study 1994, Technical Data Report by the Federal Emergency Management Agency, Region VI, U.S. Army Corps of Engineers, New Orleans District National Weather Serves – This document was used to evaluate the Parish's vulnerability to hurricanes and to develop action items that would benefit the Parish.

Forced Drainage Master Plan (1973) - This document was used to evaluate the Parish's vulnerability to hurricanes, floods, and storm surge and to develop action items that would benefit the Parish.

Terrebonne Comprehensive Master Plan (2001) - This document was used to evaluate the Parish's vulnerability to hurricanes, floods, and storm surge and to develop action items that would benefit the Parish.

Other sources of information included: Urban Service District of Houma Zoning Regulations, Terrebonne Parish Subdivision Regulations, Regulations for Parks and Recreation, Coastal Zone Management Regulations and Building and Construction Regulations.

At the Project Plan Meeting the roster of Steering Committee members was developed. See Table 3 for a complete list of those serving on the Steering Committee.

Table 3

Terrebonne Parish, LA Hazard Mitigation Steering Committee Members		
Committee Member	**Job Title**	**Organization**
Mr. Andrew Baron	Member	Barataria-Terrebonne National Estuary Program
Mr. Patrick Gordon*	Director – Planning and Zoning	Terrebonne Parish Consolidated Government
Mr. L.P. Bordelon	Member	Terrebonne Parish School Board
Mr. Tom Bourg	Utilities Director	Terrebonne Parish Consolidated Government
Ms. Becky Cangelosi	Planning & Zoning	Terrebonne Parish Consolidated Government
Mr. Michael Deroche*	Parish Emergency Manager	Office of Emergency Preparedness
Mr. Robert Jones*	Parish Engineer	Terrebonne Parish Consolidated Government – Engineering
Mr. Tommy Lajaunie	Planning & Zoning	Terrebonne Parish Consolidated Government
Mr. Ralph D. Mitchell*	Captain	Louisiana State Police
Mr. W. Alex Ostheimer*	Chairman	Houma-Terrebonne Regional Planning Commission
Mr. Eddie Pullaro	Member	Houma-Terrebonne Regional Planning Commission
Mr. Spencer Rhodes	Chief	Montegut – Pointe-aux-Chenes Fire Department
Ms. Stephanie Shaw	Representative	American Red Cross
Mr. Stephen Smith*	Project Director	T. Baker Smith & Son, Inc.
Mr. Cyrus Theriot	Member	Harry Bourg Corporation
Mr. Clayton Voisin*	Councilman	Terrebonne Parish Council
Ms. Velma Watson*	Chair-person	TRAC
Mr. Jerome Zeringue*	Director	Terrebonne Levee & Conservation District

* Key Representatives

In order to prepare the plan, three additional meetings with the Steering Committee were held. All three of these meetings were open for the public to attend. Public notices were distributed and posted throughout the Parish. After the first meeting a press release was prepared informing the public, potential hazards and critical facilities and urging them to participate by stating when the next meeting would be held. After the second meeting a press release was prepared to keep the public involved, explaining the goals and vulnerability analysis, and urging them to participate by stating when the next meeting would be held. After the third meeting a press release was prepared to keep the public involved, explaining mitigation measures and mapping of the Parish, and informing the public of who to contact regarding the next meeting.

The press releases that were issued after the first, second, and third meetings informed the public about what was discussed during the meetings and also informed the public when the next meeting would take place, if they wanted to come and participate. Anyone from the public who wanted to be involved could have attended the meetings, joined the Steering Committee, become part of the planning process, and offer any changes or recommendations.

Our consultant, Aegis, facilitated each meeting to address the next stage in the planning process and gain input from the committee on local conditions and the Steering Committee's desires. After each meeting, Aegis researched ideas presented in the meeting and summarized their findings for presentation and input by the Steering Committee at the next meeting. This approach allowed the Steering Committee to play a valuable role in getting ideas and issues addressed in the plan. Each member of the Steering Committee was an equal member in the overall process. Everyone on the Steering Committee had an opportunity to review the draft plan, as well as the final plan. All the meetings were open discussions, where each person attending, whether a Steering Committee member or not, had the opportunity to volunteer information about the community and present ideas. Data was also collected from the respective jurisdiction representatives.

The second Steering Committee/Public Meeting on May 21, 2003, addressed critical facilities, hazard events and the risk assessment. At the third Steering Committee/Public Meeting on June 25, 2003, mitigation approaches and actions items were discussed. At the fourth Steering Committee/Public Meeting on August 27, 2003, a preliminary draft was reviewed.

The Steering Committee agreed to recommend the HMP for adoption by the local governing body pending FEMA and LHLS/EP final approval.

This plan was developed over a period of 33 months. See a copy of the sign-in sheets for each meeting in Appendix C. See Appendix D for a Summary of Meeting Attendees. See the Milestone Schedule in Appendix E. Meeting minutes for the five meetings were prepared and are found in Appendix F.

As stated earlier, in an effort to keep the public informed and to invite additional input, three press releases were issued after the first three meetings. A press release after the fourth meeting was not issued pending approval of the plan by the State and FEMA. Copies of the press releases can be found in Appendix G.

The role of the Steering Committee was to attend the planning meetings where they provided valuable information on the Parish, developed parts of the plan and reviewed the results of the research conducted by our consultant. Tasks completed by the Steering Committee include:

- Developing a mission statement for the Plan.
- Developing a list of potential hazards, such as floods and hurricanes within the Parish and municipalities.
- Assembling a list of the critical facilities, such as hospitals, police stations, and shelters within the Parish and municipalities.
- Evaluating potential losses to vulnerable assets in the Parish and municipalities.
- Establishing goals and objectives for the Parish and municipalities.
- Determining mitigation measures that would be prudent.

4.0 RISK ASSESSMENT

Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from hazards. This process involves five steps:

- Identify Hazards
- Profile Hazards
- Inventory Assets
- Estimate Losses
- Analyze Development Trends

The first step in doing a risk assessment is to identify the hazards that can affect the Parish. A hazard is any source of potential danger or adverse conditions that exist with or without the presence of people and land development. The Steering Committee identified the hazards that occur most frequently in the Parish.

The second step is to develop hazard event profiles describing how bad it can get. The Steering Committee identified the characteristics and potential consequences of the hazards that were identified in the first step.

The third step is to evaluate what assets will be affected in the Parish by the hazard events. The Steering Committee conducted an inventory of the vulnerable assets to understand what exactly could be affected by the different types of hazard events.

The fourth step is to determine how the community's assets will be affected by the hazard events. The Steering Committee estimated losses in terms of the expected losses from hazard events to people, buildings, and other important assets. Some buildings, infrastructure, or functions will be damaged more than others because of their vulnerability. Vulnerability is defined as how exposed or susceptible due to location, or construction, an asset is damaged from a hazard event.

The fifth step is to analyze developmental trends within the parish such as land uses and where the majority of growth is expected to take place so that vulnerable areas can be avoided.

4.1 Identifying Hazards

Requirement 201.6(c)(2)(i):
[The risk assessment shall include a] description of the type … of all natural hazards that can affect the jurisdiction…

Terrebonne Parish identified many hazards that affected the community in the past, and may possibly affect the Parish and municipalities in the future. These hazards are addressed individually through a widespread process that included input from the Steering Committee members (comprised of representatives from Parish/State departments and agencies, Parish and State Emergency Preparedness Offices, local businesses and local residents), public involvement, researching archived articles published or documented within the Parish pertaining to those disasters, past disaster declarations in the Parish, and a review of current FIRMs and Flood Insurance Studies.

FEMA has tracked and compiled a list of all the federally declared disasters for the State of Louisiana. Therefore, we know since 1965 this data is a complete and accurate list of all the federally declared disaster events in Terrebonne Parish.

Terrebonne Parish has been a presidential declared major disaster area on sixteen (16) different occasions since 1965. Table 4 contains a detailed account of the federally declared disaster history of Terrebonne Parish.

Table 4

Federally Declared Disasters in Terrebonne

DR #	Type	Date
208	Hurricane Betsy, Flood, Storm Surge	9/10/65
315	Hurricane/Flood	10/13/72
374	Severe Storm, Flood	4/27/73
448	Hurricane Carmen Flood, Storm Surge	9/23/74
616	Severe Storm, Flood	4/9/80
752	Hurricane Juan, Flood, Storm Surge	11/1/85
902	Severe Storm, Flood	4/15/91
904	Severe Storm, Flood	4/29/91
956	Hurricane Andrew, Flood, Storm Surge	8/25/92
1049	Severe Storm, Flood	5/8/95
1246	Hurricane Georges, Flood, Storm Surge	9/30/98
1380	Tropical Storm Allison/Flood	6/5/01
1435	Tropical Storm Isidore/Flood	9/27/02
1437	Hurricane Lili, Flood, Storm Surge	10/3/02
1603	Hurricane Katrina*	8/29/05
1607	Hurricane Rita, Flood, Storm Surge *	9/24/05

*Due to limited data available at this time, these events will be discussed in greater detail in the 5-year update.

Table 5 summarizes the hazards the Steering Committee identified as impacting the Parish. The hazards were prioritized based on a number of factors including, frequency, severity, life and death consequences, potential impact, and ultimately ranked based on what the Steering Committee determined. This Table also explains how the hazards were identified and why they were identified.

Table 5

Hazard Identification Table			
Hazard	**How Identified**	**Why Identified**	**Priority**
Hurricanes	• Input from local residents and businesses • Input from Parish and State Emergency Preparedness Offices • Review of past disaster declarations	• Caused severe debris, wind and water damage • Power and Natural gas outages throughout the parish • Water contamination • Numerous agricultural losses • Substantial costal erosion • Highway damage and closures • Evacuations • Federally declared disasters	High
Floods	• Input from local residents and businesses • Input from Parish and State Emergency Preparedness Offices • Review of past disaster declarations • Review of FIRMs and Flood Insurance Studies • Identification of NFIP repetitive loss properties in the Parish	• Major floods occurred in 1965, 1972, 1973, 1974, 1980, 1985, 1991, 1992, 1995, 1998, 2001, 2002, and 2005 • Effects from the storms caused tremendous devastation in the Parish • Numerous repetitive loss properties are located in the Parish • Federally declared disasters • Chauvin and Montegut flood-protection levee damaged during storms of 2002 and 2005	High

Storm Surge	• Input from Parish and State Office of Homeland Security/Emergency Preparedness	• Coastal erosion area classified within the Parish in June 2000 • Disappearing Barrier Islands	High
Land Subsidence	• Input from local residents and businesses • Input from Parish Planning Commission • Input from Public Works Department	• Soil erosion ongoing problem that has occurred for years	High
Thunderstorms / Lightning / High Winds	• Input from local residents and businesses • Input from Parish and State Emergency Preparedness Offices • Review of past disaster declarations	• Can be damaging to homes and businesses	High
Saltwater Intrusion	• Input from local industry • Input from the Department of Public Works	• Potential for Saltwater intrusion • Disappearing Barrier Islands	High
Expansive Soils	• Input from local residents and businesses • Input from Department of Transportation and Development	• Damages to homes foundations, ceilings, floors, and walls • Damage seen on highways and roads	Medium
Tornadoes	• Input from local residents and businesses • Input from Parish and State Office of Homeland Security / Emergency Preparedness	• Three deaths associated with the tornado and major damage to the island • Loss of residential and commercial structures • Bodily Injury, Death	Low

Hailstorms	• Input from residents and business	• Potential for hailstorms	Low
Winter Storms	• Input from local residents and business	• Potential for hard freezes and ice	Low
Drought	• Input from Parish Emergency Preparedness Offices	• Potential for agricultural loss • Drought-like conditions in 2000	Low

4.2 Profile Hazard Events

Requirement 201.6(c)(2)(i):
[The risk assessment shall include a] description of the… location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Natural hazards, the largest single contributor to catastrophic or repetitive damage to communities nationwide, evolve from atmospheric, geologic, hydrologic, and seismic events. They pose threats in all areas of the United States.

The impacts of natural hazards can be local or widespread, predictable or unpredictable. Resulting property and infrastructure damage can range from minor to major, depending on whether hazard events affect major or minor population centers. When the damage to life and property becomes real, not just potential, the event is commonly called a natural disaster.

Risk assessment provides the foundation for the rest of the mitigation planning process. It focuses attention on areas most in need by evaluating which populations and facilities are most vulnerable to natural hazards and to what extent injuries and damages may occur. It provides:

- The hazards to which the community is susceptible;
- What these hazards can do to physical, social and economic assets'
- Which areas are most vulnerable to damage from these hazards; and
- The resulting cost of damages or costs avoided through future mitigation projects.

In addition to the description of each hazard, the detailed hazard profiles will discuss:

- How likely it is that a hazard will impact the area (probability); often supported by previous occurrences, with the dates, frequency, extent and damage. When past events have not occurred, or data is missing or incomplete, probability potential is based on conditions that may cause the hazard event, i.e. dam failure, earthquake, storm surge, etc.

- How severe the hazard will be (magnitude);
- Where the hazards will affect the community (geographic extent or location); and
- Conditions in the community that may increase or reduce the effects of the hazard.

Based on the overall impact of the above considerations, the four hazards for which this plan will develop mitigation actions are floods, hurricanes, thunderstorms with lightning and high winds, and tornadoes.

4.2.1 Location

A GIS database was developed, which mapped the Parish's critical facilities, flood zones, repetitive loss areas, emergency shelters, and evacuation routes. See Maps 2, 3, 5, 6, 7, 8, 9, and 10. The Steering Committee did not feel it wise to show "hazard areas" for certain hazards that could potentially affect the entire parish. Hurricanes affect the entire Parish. See Section 4.3.1.1. Floods are most likely to occur in areas identified on FEMA's Flood Insurance Rate Maps (FIRMs). These maps are discussed in greater detail in Section 4.3.1.2. Map 2 illustrates the 100 and 500 year floodplains that are delineated on the FIRMs. Storm Surge has the potential to affect the entire Parish. See Section 4.3.1.3. Thunderstorms/Lightning/High Winds affect the entire Parish. See Section 4.3.1.4. Tornadoes affect the entire Parish. See Section 4.3.1.5. Land Subsidence has the potential to affect the entire Parish. See Section 4.3.1.6. Saltwater Intrusion has the potential to affect the entire Parish. See Section 4.3.1.7. Expansive soils have the potential to affect the entire Parish. See Section 4.3.1.8. Hailstorms affect the entire Parish. See Section 4.3.1.9. Drought affects the entire Parish. See Section 4.3.1.10. Winter Storms affect the entire Parish. See Section 4.3.1.11.

4.2.2 Previous Occurrences and Extent of Damages

The Parish reviewed Flood Insurance Rate Maps, the Flood Insurance Studies, records of past federally declared disasters, FEMA and State databases, NCDC, Steering Committee recollections, Parish OHLS/EP, and newspaper articles from the "*The Houma Courier"* describing hazard events to prepare the hazard history found below. There were data limitations in gathering an all inclusive hazard history, as the records are limited and insufficient.

The databases used were very inaccurate regarding sightings and different damage reports. We found that newspaper articles were the best source of data and this information was captured below in Table 6, Terrebonne Parish's Hazard History. Table 6, provides a detailed summary of the presidentially federally declared hazards that have historically impacted the community, including the date, location and a description of the extent of the damage.

Table 6

Terrebonne Parish's Hazard History	
Hazard Event Date & Location	**Description**
Presidential Declaration DR# 208 Hurricane Betsy September 10, 1965 Parish-Wide	• Winds of 140 mph were recorded • Chauvin subdivision flooded from Lake Boudreaux overflow • Wind and water damage to area homes and business • Sugar cane crop yield, reduced by 8 tons per acre • One fatality
Presidential Declaration DR# 315 Hurricane October 13, 1972 Parish-Wide	• Wind damage to trees and power lines • Heavy rainfall • Water damage in low-lying areas
Presidential Declaration DR# 374 Severe Storm, Flood April 27, 1973 Parish-Wide	• Six inches of rain fell • Atchafalaya River rose 6-8 inches causing flooding in low lying Gibson and Schriever • Some areas on Hwy 24 from Houma to Thibodaux, completely inundated • Several residence and businesses were flooded
Presidential Declaration DR# 448 Hurricane Carmen September 23, 1974 Parish-Wide	• Severe loss of sugarcane crops • Winds splintered power-lines and uprooted trees • Three people were injured in auto accident as a downed tree was blown across West Main • Many communities without electrical power • Evacuation of elderly persons surrounding the Houma Highrise • 5,000 residents evacuated to shelters in Houma • Chauvin, Montegut, Grand Caillous, Pointe-Aux-Chenes, Isle de Jean Charles and other southern towns suffered tidal flooding • Chauvin Brothers store was inundated by tidal flooding

Presidential Declaration DR# 616 Severe Storm, Flood April 9, 1980 Parish-Wide	• Five inches of rainfall recorded in Houma • Several homes and businesses flooded • Tunnel Boulevard at Levron St., closed due to flooding • Parkway Circle inundated by flood waters • Fifteen automobile accidents recorded within 24 hours
Presidential Declaration DR# 752 Hurricane Juan November 1, 1985 Parish-Wide	• 6,000 acres of sugarcane crop and soy bean crop devastated • Rainfall in Houma totaled 11.43 inches for 4 days • Extensive damage to Parish levees • Tidal surges in the Little Caillou-Chauvin area pushed water up to 9 feet above the road • Some areas water above 9 feet; Cocodrie at 14 feet • At least 5 feet of water in Montegut • Hundreds of homes and businesses flooded • Rooftop rescues in Dulac • Rescues for the Parish totaling over 200 • Dumas Auditorium, Oaklawn Junior High School, East Park Recreation Center, Ellender Memorial School, and Upper Little Caillou School were opened as evacuation centers, supplying shelter to over 1200 parish residents • Montegut Recreation Center was opened after the water receded • Parish-Wide school closures • 7,500 Bell South telephone lines were affected
Presidential Declaration DR# 902 Severe Storm, Flood April 15, 1991 Parish-Wide	• Road closures, including Hollywood Road near St. Louis Canal Road, Isle de Jean Charles Road and various areas in Dulac, Dularge and Montegut • Lake Houmas Inn inundated with rainwater
Presidential Declaration DR# 904 Flood April 29, 1991 Parish-Wide	• Flooding in low-lying areas • Numerous road closures • Large amount of rainfall

Presidential Declaration DR# 956 Hurricane Andrew August 25, 1992 Parish-Wide	• Agricultural losses, including 25 percent of the Parish's sugarcane crop • Leonard J. Chabert Medical Center evacuated or discharged 70 patients, after receiving over $1 million in damages • High winds knocked down trees and power lines • Many consumers without electricity • Bayou Black Elementary School sustained damage to the roof exposing two classrooms to rain • Several hundred homes were inundated • Floodwaters covered 6 miles of highway in Pointe-aux-Chenes • Montegut Fire Station lost their roof • Water in Chauvin, Dulac, Montegut, Isle de Jean Charles, and Dularge
Presidential Declaration DR# 1049 Rain/Storm, Flood May 8, 1995 Parish-Wide	• Water plant in Gray recorded 7.3 inches of rain • Gray had road closures including Vine, Patrick, Mulberry and Joyce streets • The hardest-hit areas were North Project Road, St. George Road, St. Anne Drive, Honeysuckle Drive, Brunet Street, Deer Run Drive, Horseshoe Road and all of Cortez, Patrick and LeBlanc Subdivisions • Ten homes in the Schriever area were flooded
Tropical Storm Frances September 10, 1998 Parish-Wide	• Six homes and over 15 businesses flooded in Chauvin • Tornado in Montegut knocked down trees and damaged the roof of the American Legion Hall • Bourg gym opened for evacuees • Numerous flooded roads • Many 50-foot power poles were knocked down • Lightning struck approximately 20 transformers • More than 10,000 customers without electricity

Presidential Declaration DR# 1246 Hurricane Georges September 30, 1998 Parish-Wide	• Snapped tree limbs • More than 3,500 customers without electrical power • Winds as high as 172 mph were measured • Storm surge flooding of 4 to 8 feet • Flooding in Isle de Jean Charles – water in some homes
Presidential Declaration DR# 1380 Flood/Tropical Storm Allison June 5, 2001 Parish-Wide	• Oyster beds near Houma Navigation Canal closed because contaminant levels were twice the acceptable level • Winds snapped trees and downed power lines • 2,500 customers, primarily in Broadmoor and East Park areas, were without power • Schriever was inundated with nearly 30 inches of rain, up to 35 inches in surrounding areas • Major flooding damaged or destroyed over 131 homes • 25,000 residences displaced because of high water • U.S. 90 east and west, La. 1 north to the Sunshine Bridge and to I-10, and La. 20 to the Gramercy-Wallace Bridge and to I-10, Terrebonne's current evacuation routes all were closed at one time during Tropical Storm Allison
Presidential Declaration DR# 1435 Flood, Tropical Storm Isidore September 27, 2002 Parish-Wide	• More than 15 inches of rain fell in two hours • Numerous roads were closed • Between 100 and 200 homes and businesses were flooded in the metropolitan and downtown area • Gusts of over 50 mph were recorded
Presidential Declaration DR# 1437 Hurricane Lili October 3, 2002 Parish-Wide	• Montegut drainage levee and numerous other levees damaged • More than fifty percent of the Parish residents and business were without electricity during Hurricane Lili, and over 7,400 remained without power the following morning • Consolidated Waterworks District No. 1 ordered a voluntary boil order advisory, due to flooding

	• Thirty-five percent of the sugarcane crops destroyed • Winds over 78 mph and in some areas were higher • Strong wind gusts downed large trees • Strongest effects were felt in the southern portion of the Parish • Levees in Montegut and Dulac were breeched due to storm surge • Over 300 homes Parish-wide were declared substantially damaged
Tropical Storm Bill Flood/Storm Surge June 30, 2003	• Sustained winds were measured at 60 mph • Levee in Montegut was breeched due to storm surge • Over 40 homes were flooded in an area from Chauvin to Dulac, Montegut, and Pointe Aux Chene.
Tropical Storm Matthew Flood/Storm Surge October 8, 2004	• Sustained winds were measured at 40 mph • Rainfall amounts generally ranged from 5 to 10 inches with a few locations in Terrebonne reporting amounts up to 13 to 16 inches • The storm surge was 2 to 4 feet above normal, but locally higher in some locations. • Over 20 homes sustained damage from heavy rain and storm surge in an area from Chauvin to Dulac, Montegut, and Pointe Aux Chene. • Many roads were closed due to storm tide flooding in Lower Terrebonne**.**
Hurricane Rita Flood/Storm Surge September 24, 2005	• A data deficiency exists and new information on this event will be included in the plan update.

Additional data on the extent of damage caused by these hazards were obtained using data from the NCDC. Estimated dollar amount of damages from the NCDC is summarized in Table 7.

Table 7

Estimated Dollar Losses Per Year			
	Estimated Damage from NCDC $	**Time Period**	**Projected Yearly Losses $**
Hurricanes	See Note (1)	10 years	See Note (1)
Floods	$1,415,000	10 years	$141,500
Storm Surge	See Note (1)	10 years	See Note (1)
Thunderstorms / Lightning / High Winds	$1,407,000	40 years	$35,175
Tornadoes	$12,595,000	42 years	$298,524
Land Subsidence	See Note (2)	See Note (2)	See Note (2)
Saltwater Intrusion	See Note (2)	See Note (2)	See Note (2)
Expansive Soils	See Note (2)	See Note (2)	See Note (2)
Hailstorms	See Note (3)	40 years	See Note (3)
Drought	See Note (1)	10 years	See Note (1)
Winter Storms	See Note (1)	10 years	See Note (1)
		Total	**$475,199**

(1) Although many events have occurred, NCDC did not list any events.
(2) NCDC does not track data statistics for these hazards.
(3) Although NCDC contains eleven hail storm events in Terrebonne Parish, no losses were reported.

Again, a variety of sources were searched including, local newspapers, the NCDC database, and the Parish OHLS/EP records. Also, archives in the form of microfilm were reviewed. All of the sources used were found to have data limitations in gathering an all inclusive hazard history, as the records are limited and insufficient.

4.2.3 Probability of Future Events

The statistical probability of a hazard event for Terrebonne Parish is not known, but a qualitative probability of its occurrence can be provided. Probability is defined as highly likely, likely, possible, or unlikely for the given hazard to occur. Highly likely was given the parameters of 75% to 100% that the hazard would occur each year. Likely was given the parameters of 35% to 74% that the hazard would occur each year. Possible was given the parameters of 10% to 34% that the hazard would occur each year. Unlikely was given the parameters of 0% to 9% that the hazard would occur each year. See Table 8 below for a summary of probability of reoccurrence found in Sections 4.3.1.1 though 4.3.1.11 in greater detail.

Table 8

Probability of Reoccurrence	
Hazard	**Probability**
Hurricanes	Highly Likely (11 Federally declared events)
Floods	Highly Likely (15 Federally declared events)
Storm Surge	Highly Likely (7 Federally declared events)
Thunderstorms / Lightning / High Winds	Highly Likely (5 Federally declared events)
Tornadoes	Likely
Land Subsidence	Likely
Saltwater Intrusion	Likely
Expansive Soils	Likely
Hailstorms	Possible
Drought	Possible
Winter Storms	Possible

For all of the hazard rankings, a profile of each hazard is discussed in Section 4.3.1.1 through 4.3.1.11. All unlikely hazards, such as Earthquakes, are omitted from the plan discussions, based on the initial risk assessment of possible hazards.

4.3 Assessing Vulnerability: Identifying Assets

Requirement 201.6(c)(2) (ii)(A):
[The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community. The plan should describe vulnerability in terms of: § ***The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas…***

4.3.1 Hazard Summary

As previously stated in Section 4.2, of the eleven hazards discussed in this plan there are five hazards that will be profiled and have proposed mitigation actions presented. These natural hazards were selected based on an assessment of the overall impact (geographic extent, magnitude, probability, and exacerbating or mitigating conditions) affecting Terrebonne Parish. These hazards that pose the greatest potential for a negative impact are hurricanes, floods, storm surge, tornadoes, and thunderstorms with lighting and high winds. Specific mitigation measures have been included to protect buildings, people, infrastructure, and critical facilities for the aforementioned hazards. There are six other hazards that will be discussed and profiled in this plan, but no mitigation action items for those hazards will be pursued at this time.

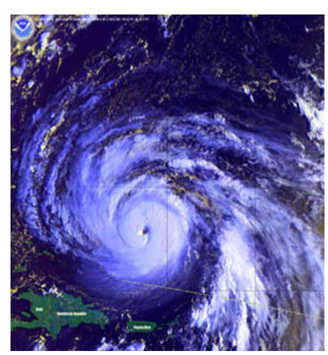
Rankings by the Steering Committee were used along with the current available data from the NCDC, the Hazard History of Terrebonne Parish and priorities set by the State Hazard Mitigation Plan; in order to eliminate low priority hazards and determine which hazards would be profiled and which hazards would have mitigation action items. Table 9 shows what hazards were eliminated based on the available criteria.

Table 9

Documentation and Elimination of Hazards						
Hazard Type	**NCDC Data Available**	**Query Results computed Highly Likely**	**High Priority by Steering Committee**	**Federally Declared Disasters**	**High Profile Area in State HMP**	**Hazards Identified (Action Items in Bold)**
Avalanche						
Coastal Erosion (see Saltwater Intrusion)						
Dam Failure (see Flood)						
Drought						X
Earthquake						
Expansive Soils						X
Extreme Heat						
Flood	X	X	X	X	X	**X**
Hailstorm	X					X
Hurricane		X	X	X	X	**X**
Land Subsidence			X			X
Landslide						
Winter Storm						X
Tornado	X					X
Tsunami						
Volcano						
Wildfire						
Saltwater Intrusion			X			X
Thunderstorms /Lightning / High Winds	X	X	X	X	X	**X**
Storm Surge		X	X	X	X	**X**

The natural hazards are discussed below in the order of their priority**.**

4.3.1.1 Hurricanes



Hurricanes, tropical storms, and typhoons, collectively known as tropical cyclones, are among the most devastating naturally occurring hazards in the United States. They present flooding, storm surge, and high wind hazards to the communities that they impact. Flooding was discussed in this plan in Section 4.3.1.2 and the high wind hazard associated with hurricanes is discussed below. Storm surge was identified by the community as a concern and will be discussed further in Section 4.3.1.3.

Hazard Identification

A hurricane is defined as a low-pressure area of closed circulation winds that originates over tropical waters. A hurricane begins as a tropical depression with wind speeds below 39 mph. As it intensifies, it may develop into a tropical storm, with further development producing a hurricane. See Table 10 for the classification of hurricanes.

Table 10

Classification of Hurricanes	
Stage of Development	**Criteria**
Tropical Depression (development)	Maximum sustained surface wind speed is < 39 mph
Tropical Storm	Maximum sustained surface wind speed ranges from 39 - <74 mph
Hurricane	Maximum sustained surface wind speed is at least 74 mph
Tropical Depression (dissipation)	Decaying stages of a cyclone in which maximum sustained surface wind speed has dropped below 39 mph

The distinguishing feature of a hurricane is the eye around which winds rotate. The eye, the storm's core, is an area of low barometric pressure that is generally 10 to 30 nautical miles in diameter. The surrounding storm may be 100 to 500 miles in diameter.

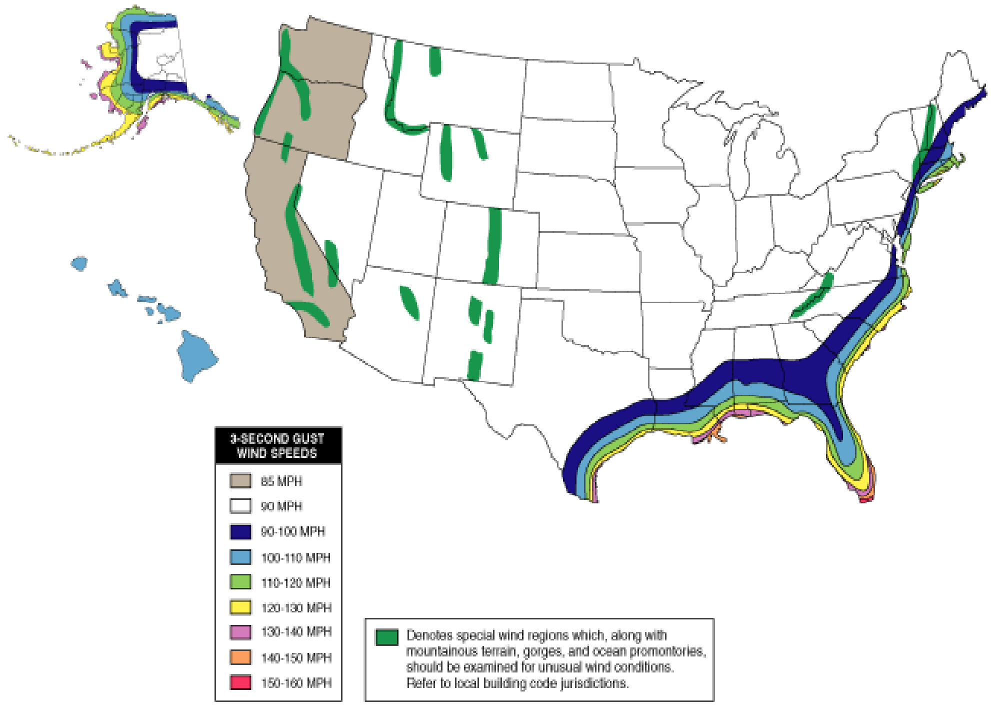
The Saffir / Simpson Hurricane Scale is used to classify storms by numbered categories (Table 11). Hurricanes are classified as Categories 1 through 5 based on central pressure, wind speed, storm surge height, and damage potential.

Table 11

Saffir / Simpson Hurricane Scale				
Storm Category	**Central Pressure**	**Sustained Winds**	**Storm Surge**	**Potential Damage**
1	> 980 mbar	74 - 95 mph	4 – 5 ft	Minimal
2	965 – 979 mbar	96 - 110 mph	6 – 8 ft	Moderate
3	945 – 964 mbar	111 – 130 mph	9 – 12 ft	Extensive
4	920 – 944 mbar	131 – 155 mph	13 – 18 ft	Extreme
5	< 920 mbar	> 155 mph	> 18 ft	Catastrophic

The hurricane season lasts from June through November, when sea and surface temperatures peak. The majority of hurricane activity occurs during August and September.

For the period 1886 – 1994, an average of five hurricanes per year has occurred in the North Atlantic basin. This region is particularly vulnerable because hurricanes occur



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frequently, the areas are prone to storm surge and coastal riverine flooding, and the population has climbed to an estimated 36 million people.

According to the National Weather Service's Tropical Prediction Center, from 1900 to 1996, Louisiana experienced 12 direct hits from major hurricanes (Category 3, 4, and 5). During the same time period, Louisiana experienced 13 direct hits from other hurricanes (Category 1 and 2). Based on the above data, Louisiana has experienced a direct hit from a hurricane every four years.

High winds are capable of imposing large lateral (horizontal) and uplift (vertical) forces on buildings. Residential buildings can suffer extensive wind damage when they are improperly designed and constructed and when wind speeds exceed design levels. The effects of high winds on a building will depend on several factors:

- Wind speed (sustained and gusts) and duration of high winds
- Height of building above the ground
- Exposure or shielding of the building (by topography, vegetation, or other buildings) relative to wind direction
- Strength of the structural frame, connections, and envelope (walls and roof)
- Shape of building and building components
- Number, size, location, and strength of openings (windows, doors, vents)
- Presence and strength of shutters or opening protection
- Type, quantity, velocity of windborne debris

Proper design and construction of residential structures, particularly those close to water or near the coast, demand that every factor mentioned above be addressed.

Failure to do so may result in building damage or destruction by wind. See Appendix H for recommended Stability System Design Tables for wind loads.

Risk Assessment

The various hazard components and risks associated with hurricanes come from storm surge, rainfall, and wind. Flooding hazards are discussed later in this plan. High winds impact utilities and transportation, can result in loss of life due to downbursts and tornadoes, creates tremendous amounts of debris, and causes agricultural losses and building damage.

The following are areas that have been impacted in Terrebonne Parish during hurricanes or tropical storms:

- Heavy debris located on local streets in Houma and marsh grass and flooding located on key evacuation routes in lower Terrebonne
- Flooding due to storm surge along Highways 182, 665, 55, 56, 57, and 315.
- Flooding at the 680 repetitive loss structure locations

There are other needs in the Parish that are not geographically specific, as those indicated above, such as increasing public awareness and education, adopting the International Building Codes, creating new subdivision guidelines, implementing a public notification system, and promoting flood insurance. These issues are addressed in the Parish's Action Plan found in Section 7.0.

Probability and Frequency

As seen on Table 8, the probability of hurricanes occurring each year in Terrebonne Parish is highly likely, with a percentage range of 75% to 100%. NCDC's data indicates that there have been no hurricane events in Terrebonne Parish since 1950. However, the information compiled in NCDC is not a complete dataset and is often changing. Even though the database originated in 1950, each dataset (hazard) actually begins recording data in different years. Therefore, to ensure the most accurate probability analysis, we investigated further sources such as the "*The Houma Courier*" newspaper and the Louisiana Office of State Climatology. Based on this analysis, Terrebonne Parish has experienced ten hurricane and tropical storms over the last seven years yielding over a 100% reoccurrence rate. Reoccurrence rates calculated at over 100% are assumed to be 100%.

The frequency of occurrence of hurricanes can be determined by the number of landfall events over a given time period. The frequencies of landfall events are measured from historical data for specific geographic areas of the United States. Florida had the greatest number of direct hits by hurricanes from 1900 through 2000, with 55, with Texas 36, Louisiana 25, North Carolina 23, South Carolina 14, and Rhode Island 14 ranked in order behind Florida.

Exposure - Location

Hurricanes present one of the greatest potentials for substantial loss of life, property damage, and economic impact because more than 36 million U.S. residents live in the coastal counties from Texas to Maine that have the greatest exposure to hurricanes.

The highest population growth rates in the United States have been in Gulf and Atlantic coastal counties. These areas have experienced an estimated 15 percent increase in population, more than 5 million people, from 1980 to 1993.

For the period from 1988 to 1990, the value of insured residential and commercial property has increased an estimated 65 percent.

Estimated damages from major hurricanes that Louisiana has faced are summarized below:

- Hurricane Carla in 1961 damages in Louisiana reached $25 million
- Hurricane Hilda in 1964 damages in Louisiana and southern Mississippi totaled $53 million
- Hurricane Betsy in 1965 damages throughout Southeast Louisiana totaled $1.4 billion
- Hurricane Carmen in 1974 damages in Louisiana reached $150 million
- Hurricane Danny in 1985 damages were estimated to be near $14 million
- Damages from Danny, Elena, and Juan across Louisiana totaled $2.5 billion in 1985
- Hurricane Andrew in 1992 reached a billion dollars of damages in Louisiana
- Hurricane Frances in 1998 over $10 million in damage was experienced across Southwest Louisiana and Extreme Southeast Texas
- Tropical Storm Isidore in 2002 causing over $200 million in damages, made landfall on the Louisiana coast as a strong tropical storm.
- Hurricane Lili made landfall on the central Louisiana coast as a category one hurricane in 2002 causing $170 million in damages.

Therefore it is estimated that when a hurricane strikes Louisiana over $552 million in damages would be seen based on previous storms the State has faced and the damages the hurricanes caused.

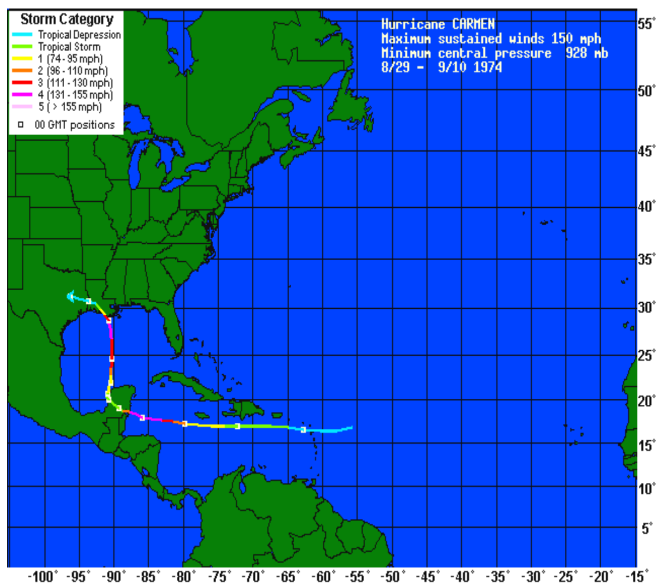
The entire Parish can be affected by a hurricane.

Consequences – Extent and Previous Occurrences

Half of the most costly hurricanes occurred in the past 25 years. Three recent tropical cyclonic events reveal consequences in densely populated areas: Hurricane Andrew (1992), Tropical Storm Alberto (1994), Tropical Storm Allison (2001), and Hurricane Lili (2002). Hurricane Andrew resulted in total damages estimated at $25 billion for southeastern Florida and southeastern Louisiana. Tropical Storm Allison, which caused widespread flooding in Texas, Louisiana and several other Gulf and Atlantic coast states was the single most costly event in NFIP history, resulting in $1.1 billion in flood insurance claims paid to policyholders---$90 million in Louisiana alone.

As shown in Table 4, of the sixteen federally declared disasters in Terrebonne Parish, eleven were due to hurricanes or tropical storms. Brief summaries of the storm events follow.

In September of 1965, Hurricane Betsy made landfall and caused extensive damage to Terrebonne Parish. An estimated one million dollars of damage occurred. The winds were measured up to 140 mph. Many people were injured and one fatality due to the effects from the storm.

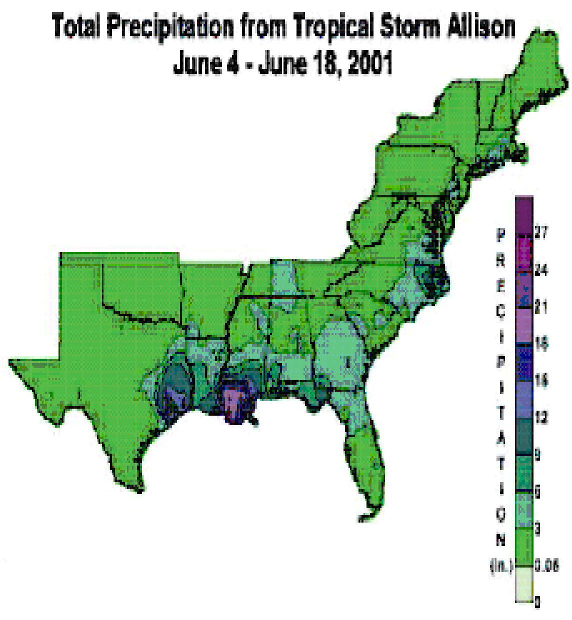


In September of 1974, Hurricane Carmen moved inland just east of Vermilion Bay near Pointe Aux Fer after crossing the Gulf of Mexico as a major hurricane. Winds reached 110 mph at the Bayou Boeuf oil rig near Amelia. Damage was mostly due to the sugar crop and offshore oil installations. Two tornadoes were spawned on the morning of September 8th. Tides of 4-6 feet above mean sea level went ashore along the coasts of St. Mary, Terrebonne, Lafourche, Jefferson, and Plaquemines Parishes. Total damages from the hurricane reached $150 million. Three deaths were indirectly associated with Carmen.

In November of 1985, Hurricane Juan spawned rain for five days. Over 69 homes and business flooded. Numerous roads were flooded. Juan looped across Southern Louisiana for several days in late October 1985. Ten inches of rain fell across Southwest Louisiana, with pockets of over 15 inches. Storm surges were 8 feet at Cocodrie. LA 1 south of Leeville and LA 3090 near Port Fourchon were destroyed. Three bridges were washed out near Lacombe on LA 434. Levees were overtopped in Lockport, Marrero, Westwego, and Myrtle Grove; this added to the already serious flooding. Two hundred cattle were drowned in Terrebonne Parish. Grand Isle was under 4 feet of sea water; 1200 residents were trapped on the island as the storm surge cut off any evacuation attempts early on. Offshore, things were far worse. An oil rig, 35 miles south of Leeville, collapsed then smashed into a neighboring rig while in 20 foot seas and hurricane force winds late on the 27th. The ship Miss Agnes sank during a rescue operation 60 miles south of Morgan City that day. The rig A.M. Howard capsized early on the 29th. The boat Kiwi sank while in the Atchafalaya Bay. This all led to nine lives being lost offshore. Total damages exceeded $300 million and 12 people died in all. Damages from Danny, Elena, and Juan across Louisiana totaled $2.5 billion and 19 people perished.

In August of 1992 Hurricane Andrew hit Terrebonne Parish with winds of 75 miles per hour. Virtually every road in the Parish contained debris. Over 28,000 customers were without power. Floodwaters covered six miles of highway in Pointe-Aux-Chenes. Fallen trees, power lines and high water blocked many streets and roads. Seven people died and 94 were injured across Southern Louisiana during Andrew. The totals of rainfall exceeded 12 inches. The storm surge moved inland from Lake Borgne westward to the Vermilion Bay with the highest surge reported was at 6.48 feet at Bayou Dupre. An F3 tornado struck LaPlace and stayed on the ground until reaching Reserve in St. John the Baptist Parish, which caused 2 of the deaths. Around 1 1/2 million people evacuated across Southern Louisiana with damages estimated near 1 billion dollars in Louisiana.

In September of 1998 Hurricane Georges forced the residents of the Parish to evacuate. The winds were measured at 30-40 miles per hour. Many homes and power lines were damaged from the winds. The hurricane struck the Mississippi coast at Category 2 intensity. Winds gusted to 55 mph at New Orleans Lakefront Airport and the pressure fell to 29.37". Storm surges above seven feet overflowed some of the land surrounding Lake Pontchartrain and Lake Borgne and a storm surge of 8.9 feet was noted at Northeast Gardene Bay, east of Pointe a la Hache. A large number of fishing camps were damaged or destroyed along Lake Pontchartrain. Two died from Georges in Louisiana.



In June 2001 Tropical Storm Allison poured more than 20 inches of rain on the Parish. The area around Schriever was heavily impacted by flood waters. Outer rain bands on the eastern periphery of the circulation of Tropical Storm Allison, which moved slowly across southeast Texas, affected southeast Louisiana beginning late on June 5th, producing heavy rainfall over much of southeast Louisiana. The areas from Baton Rouge extending south to Thibodaux were particularly hard hit on June 6th and June 7th. By early June 8th, many locations had received 10 to 18 inches of rain. Periods of torrential rain overwhelmed local drainage and created severe ponding of water which flooded numerous roadways and low lying areas, with many houses and some businesses flooded.

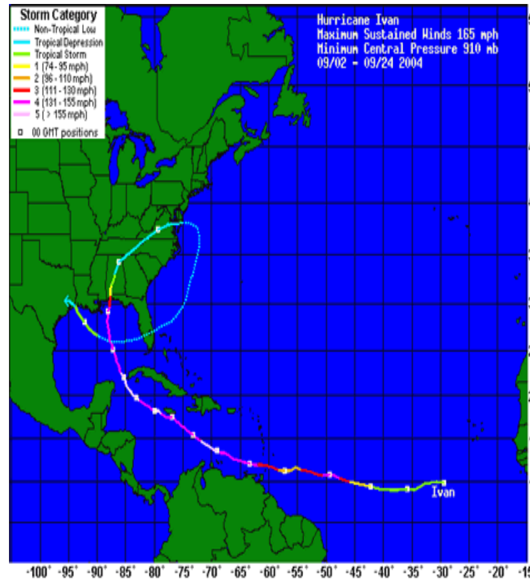
Northern Lafourche Parish was particularly hard hit by flash flooding and severe ponding of water, with hundreds of houses flooded. Another round of heavy rainfall developed on June 10 and June 11 as the remnant circulation of Tropical Storm Allison moved over southeast Louisiana and intensified. The circulation system strengthened and produced torrential rainfall in many locations of extreme southeast Louisiana. Rainfall of 5 to 10 inches fell overnight from Lafourche and Terrebonne Parishes northeastward across the New Orleans area. By the end of the event on June 11th, storm total rainfall of 15 to 25 inches was common with some location reporting up nearly 30 inches near Thibodaux. Moderate to major river flooding occurred on the lower portions of the Amite and Comite Rivers with the highest waters levels observed since 1983.

In September 2002 Tropical Storm Isidore moved steadily north across southeast Louisiana and by the afternoon of September 26 was located in central Mississippi downgraded to a tropical depression. Tropical Storm Isidore had a large circulation with tropical storm force winds extending several hundreds of miles from its center. Prior to moving onto the Yucatan Peninsula earlier in the week and weakening, Isidore was classified as a major hurricane. Swells from the distant hurricane resulted in rip tides along the northern Gulf of Mexico, with a 41 year old man drowning on the afternoon of Sunday, Sept 22, 2002 at Port Fourchon, Lafourche Parish. The large circulation caused a significant storm surge over a large area for a tropical storm. Tide levels were 4 to 6 feet above normal across much of southeast Louisiana from Grand Isle eastward to the Pearl River. Storm surge flooding occurred outside of the hurricane protection levees across Lafourche, Jefferson, Plaquemine, St. Bernard, Terrebonne, and Orleans Parishes, inundating roadways and flooding some non-elevated structures. Rain bands associated with Tropical Storm Isidore produced heavy rainfall in a wide area prior to and shortly after landfall. Portions of Terrebonne and Lafourche Parishes were also hard hit during the early morning of Thursday, September 26, 2002 with homes flooded when heavy rainfall overwhelmed drainage. Between 200 and 300 homes and businesses were reported flooded in Terrebonne Parish. Storm rainfall totals of 10 to 15 inches were common across southeast Louisiana. Most areas recorded sustained winds of 35 to 45 mph with some gusts to 50 mph in squalls. The highest wind speeds were observed near the coast or tidal lakes. Grand Isle, on the coast, recorded the highest wind gust of 71 mph. A tornado touched down near Golden Meadow, Lafourche Parish, where a couple of sheriff's office patrol cars were damaged along with several storage buildings. The Louisiana Office of Homeland Security/Emergency Preparedness reported approximately 2500 people sought refuge in approximately 40 shelters in the state. As of late November 2002, the Louisiana State Insurance Department reported that insurance industry has indicated that Tropical Storm Isidore had resulted in $105 million in insured losses. Approximately 166,200 claims had been filed with private insurance companies.

In October of 2002, Hurricane Lili made landfall along the west shore of Vermilion Bay in South Central Louisiana as a Category 2 hurricane. More than 40 roads were closed due to high water in the Parish. About 10,700 customers were without power and downed trees and power lines were wide spread throughout the Parish. The hurricane continued to moved north northwest across south central Louisiana before turning northeast across the northern portion of the state. Due to the rapid weakening, no sustained hurricane force winds were measured in southeast Louisiana. However, storm surge was significant across the southeast Louisiana coastal areas and tidal lakes. Storm surge tides were 3 to 5 feet above normal across much of coastal southeast Louisiana except 4 to 7 feet above normal across south Lafourche and Terrebonne Parishes, closer to the location where the hurricane made landfall. Storm surge caused the most damage in Terrebonne Parish where many communities situated along bayous in the southern portion of the Parish received considerable flooding. Storm surge also overtopped or breached several locally built drainage levees during the morning hours of October 4th. Particularly hard hit was the community of Montegut where many homes were flooded several feet deep. Over a thousand homes and businesses in Terrebonne Parish sustained some type of water damage due to storm surge. Storm surge flooding was also reported in southern Lafourche Parish where areas outside of the Larose-Golden Meadow were inundated by storm surge flooding. Grand Isle also was hit with considerable storm surge and beach erosion. Considerable flooding of roadways and low lying structures was reported in many areas in coastal southeast Louisiana outside of the hurricane protection levees. Along Lake Pontchartrain and Maurepas, low lying roadways and structures were also flooded, many having been flooded a week earlier due to Tropical Storm Isidore. No sustained hurricane force winds were measured across southeast Louisiana. Strong wind gusts downed trees and large tree branches across much of southeast Louisiana. Property damage occurred when the trees and tree limbs fell onto houses and automobiles. Several short-lived tornadoes touched down producing only minor property damage. Heavy rainfall was not widespread, in part due to the rapid movement of the hurricane away from the area. Flash flooding occurred in only a couple of areas.

In June of 2003, Tropical Storm Bill developed in the southern Gulf of Mexico and made landfall on southeastern Louisiana south of Houma with sustained winds of 60 mph. The storm continued to move northeast across southeast Louisiana. The lowest pressure recorded in southeast Louisiana was 995.4 mb at the Louisiana Universities Marine Consortium (LUMCON) facility near Cocodrie. Storm surge of three to five feet above normal was common along coastal southeast Louisiana. Sustained winds of 35 to 45 mph were common across the area. Storm total rainfall was six to 10 inches. River flooding developed during the first five days of July. Thousands of homes in Louisiana lost power during the storm. The collective damages of Tropical Storm Bill were $44 million in property damage in the parishes of Jefferson, Livingston, Lafourche, Orleans, Plaquemine, St. Bernard, St. Charles, St. John the Baptist, St. Tammany, Tangipahoa, and Washington. Three tornadoes as a result from Tropical Storm Bill caused further damages.

In September of 2004, Hurricane Ivan grazed southeastern Louisiana. Hurricane Ivan passed within 70 miles (to the east) of the mouth of the Mississippi River, and within 125 miles of the city of New Orleans. Southwest Pass at the mouth of the Mississippi River recorded the highest winds in the State with a peak gust of 89 mph, and sustained



winds of 79 mph. In stunning development, Hurricane Ivan, which made landfall on September 16, 2004, took a trip as far north as Pennsylvania. Then a portion of the storm fractured, moved back into the Gulf of Mexico, via Florida, and reformed into a tropical storm off of the Louisiana coast on September 23, 2004. The storm packed winds as high as 60 mph, but weakened some before making landfall near the Louisiana-Texas border. Highly scattered, and locally heavy, rainfall was prevalent from 23-25 September, due the combination of Ivan and an approaching cold front, which stalled in northern Louisiana on September 25, 2004. A one-day maximum rainfall of 6.72 inches was recorded. Several other locations recorded between two and four inches in a day.

In October of 2004 - Tropical Storm Mathew developed in the southern Gulf of Mexico and made landfall on southeastern Louisiana east of Houma with sustained winds of 40 mph. Rainfall amounts generally ranged from 5 to 10 inches with a few locations in Terrebonne reporting amounts up to 13 to 16 inches. The storm surge was 2 to 4 feet above normal, but locally higher in some locations. The greatest damage occurred in Lower Terrebonne Parish where at estimated 20 homes sustained damage from heavy rain and storm surge in an area from Chauvin to Dulac, Montegut, and Pointe Aux Chene. Many roads were closed due to storm tide flooding in Lower Terrebonne.

Another potential problem that arises when a hurricane is predicted to make landfall, as was seen in some of the above events, is evacuation of residents. If the evacuation routes are not sufficient or if there are not enough routes, this can cause major delays in moving people quickly out of the hazard area.

Of the sixteen federally declared disasters addressed in Section 4.1, eleven were from tropical storms or hurricanes.

Mitigation Approaches

Mitigation opportunities for hurricane winds are similar to mitigation measures for other wind hazards. Attention to the type of structure used in hurricane-prone areas may yield benefits, particularly by avoiding highly susceptible manufactured or mobile homes.

The greatest protection is afforded by quality construction and reinforcement of walls, floors, and ceilings. Proper anchoring of walls to foundations and roofs to walls is essential for a building to withstand certain wind speeds. Code adoption by local jurisdictions, compliance by builders, and local government inspection of new homes could reduce the risk of destruction in tornado-prone areas.

Loss of life and injuries may be reduced if more individuals seek shelter in basements, small interior rooms, or hallways, and avoid rooms and buildings with large roof spans. An interior room or closet has less chance of collapse or failure than other areas.

In recent years, mitigation of loss of life from hurricanes has included public awareness campaigns to educate residents about storm preparedness, and development of evacuation plans and actual evacuation of high-risk areas during emergencies.

Mitigation of building damage has been most successful where strict building codes for high-wind influence areas and designated special flood hazard areas have been adopted and enforced by local governments, and complied with by builders.

For the most part, buildings constructed prior to adoption of building codes remain more susceptible to damage. Some retrofit projects, for example specially designed shutters and windows for public schools, are expected to reduce future damage.

Post-disaster mitigation efforts include relocation, elevation of structures, improved open-space preservation, and land-use planning within high-risk areas.
Specific mitigation measures recommended by the Steering Committee to address this hazard are provided in Appendix I, Terrebonne Parish Mitigation Measures.

4.3.1.2 Floods

Hundreds of floods occur each year in the United States, including overbank flooding of rivers and streams and shoreline inundation along lakes and coasts. Flooding typically results from large-scale weather systems generating prolonged rainfall. Flooding in Terrebonne Parish can be the result of the following weather events: hurricanes, thunderstorms, or winter storms.

Hazard Identification

Flooding is defined as the accumulation of water within a water body and the overflow of excess water onto adjacent floodplain lands. The floodplain is the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that is susceptible to flooding.

According to the Federal Interagency Floodplain Management Task Force, flooding in the United States can be separated into several types:

- Riverine flooding, including overflow from a river channel, flash floods, alluvial fan floods;
- Local drainage or high groundwater levels;
- Fluctuating lake levels;
- Coastal flooding, including storm surges
- Debris flows

- Subsidence

Riverine Flooding

Overbank flooding of rivers and streams is the most common type of flood event. Riverine floodplains range from narrow, confined channels in the steep valleys of hilly and mountainous areas, and wide, flat areas in the Plains states and low-lying coastal regions.

In relatively flat floodplains, areas may remain inundated for days or even weeks, but floodwaters are typically slow moving and relatively shallow, and may accumulate over long periods of time.

Flooding in large rivers usually results from large-scale weather systems that generate prolonged rainfall over wide areas.

Flash Floods

Flash floods are characterized by a rapid rise in water level, high velocity, and large amounts of debris. They are capable of tearing out trees, undermining buildings and bridges and scouring new channels. Major factors in flash flooding are the high intensity and short duration of rainfall and the steepness of watershed and stream gradients.

Local Drainage or High Groundwater Levels

Locally heavy precipitation may produce flooding in areas other than delineated floodplains or along recognizable drainage channels. If local conditions cannot accommodate intense precipitation through a combination of infiltration and surface runoff (“sheet flow”), water may accumulate (“pond”) and cause flooding problems.

Fluctuating Lake Levels

Water levels in U.S. lakes can fluctuate on a short-term, seasonal basis or on a long-term basis over periods of months or years. Heavy seasonal rainfall can cause high lake levels for short periods of time. Not only does this cause the lake levels to rise, but it prevents natural drainage and causes flooding. An example of this is Lakes Maurepas and Pontchartrain, as well as Lac des Allemands.

Dam and Levee Failure

A secondary hazard to Floods is Dam and Levee Failure. Dams are water storage, control, or diversion barriers that impound water upstream in reservoirs. Dam failure is a collapse or breach in the structure. While most dams have storage volumes small enough that failures have little or no repercussions, dams with large storage volumes can cause significant flooding downstream. In Louisiana there are 365 dams included in the U.S. Army Corp of Engineers National Inventory of Dams, however, none of which are located in Terrebonne Parish.

Levees are flood control barriers constructed of earth, concrete, or other materials. Levee failure involves the overtopping, breach, or collapse of the levee. Levee failure is especially destructive to nearby development during flood and hurricane events. The southern half of Louisiana is protected by levees on the Mississippi River and Tributaries Project under the authority of the New Orleans District of the USACE.

There are an extensive number of levees in the Parish which are owned, inspected and maintained by Terrebonne Parish. These levees are designed as drainage levees but serve as a limited and proven to be unreliable protection against storm surge.

The Morganza to the Gulf Hurricane Protection System for Terrebonne Parish is under environmental assessment review and construction initiation could still be years away. Dedicated local funds are available for this project and State and Federal funds are expected but unpredictable. The Terrebonne Levee and Conservation District and Terrebonne Parish Consolidated Government will explore and implement options to accelerate the construction which is estimated at 16 years, but without hurricane protection levees in place, the Parish remains extremely vulnerable to hurricanes and storm surge.

Due to the recent events of Hurricanes Katrina and Rita, significant personal injury and property damage has occurred in Terrebonne Parish due to levee failure and/or storm surge, but due to the current data deficiency, a proper analysis will be conducted during the required Plan update.

Risk Assessment

The National Flood Insurance Program (NFIP) was authorized by the U.S. Congress with the enactment of the National Flood Insurance Act of 1968. Under the NFIP, flood insurance is made available at rates that are intended to be affordable in return for community adoption of ordinances to regulate development in mapped flood hazard areas.

The 100-year or 1-percent-annual-chance event was selected as the national standard that defines the degree of risk and damage worth protecting against without imposing excessive cost on property owners.
The 1-percent-annual-chance flood and the associated Special Flood Hazard Area (SFHA) have been widely adopted as the common design and national regulatory standard in the United States.

The following are areas that have been impacted in Terrebonne Parish during flood events:

- Heavy rains have caused flooding in the 1-1A and 2-1B forced drainage districts, as well as in the communities of, Chauvin, East Houma, Grand Caillou, and Roberta Grove and Fred Lebeouf Subdivisions.
- Flooding due to storm surge along State Highways 182, 665, 55, 56, 57, and 315.
- Flooding at the 680 repetitive loss structure locations

There are other needs in the Parish that are not geographically specific, as those indicated above, such as increasing public awareness and education, adopting the International Building Codes, improving the CRS rating, the FIRM maps need updating, creating new subdivision guidelines, implementing a public notification system, and promoting flood insurance. These issues are addressed in the Parish's Action Plan found in Section 7.0.

Probability and Frequency

The water depths and areas inundated by the 100-year flood are determined through the use of hydraulic models that reflect topographic characteristics.

Computed water surface elevations are combined with topographic mapping data to develop flood hazard maps, termed Flood Insurance Rate Maps (FIRMs).

The FIRM illustrates:

- Areas inundated by the 1-percent-annual-chance flood where water surface elevations or water depths are computed by hydraulic models (Zone AE);
- Areas inundated by the 1-percent-annual-chance flood for which flood elevations are not determined by hydraulic models (Zone A)
- Floodway areas (cross-hatched areas);
- Elevations of the 1-percent-annual-chance flood, also known as base flood elevations;
- Areas outside the 500-year flood or 0.2-percent-annual-chance flood (Zone X); and
- Locations of cross sections used to develop the hydraulic model.

As seen on Table 8, the probability of floods reoccurring each year in Terrebonne Parish is highly likely, with a percentage range of 75% to 100%. NCDC's data indicates that there have been 9 flood events in Terrebonne Parish since 1994, yielding an 82% reoccurrence rate.

FIRMs provide information on areas subject to flooding. They are used to guide future development away from flood-prone areas and to regulate development that is proposed to occur within such areas. FIRMs are used by insurance agents to assign flood insurance rates.

Exposure - Location

Floods occur in all 50 states and the U.S. territories. FEMA indicated that the states with the most land area subject to flooding by the 1-percent-annual-chance flood are Texas, Louisiana, Florida, and Arkansas. In terms of percentage of a state's total land area, the states with the most flood-prone lands are Louisiana, Florida, Arkansas, and Mississippi.

The Federal Insurance Administration reported at the end of 1994, 18,561 of over 20,000 flood-prone communities were participating in the NFIP and administering floodplain management ordinances. In those communities, over 2.8 million flood insurance policies were in effect, providing financial protection in the event of flood damage. The NFIP reports that after Tropical Storm Allison in June of 2001, over 30,251 claims were paid out resulting in over a billion dollars worth of claims.

Currently, 1,926 structures located within Terrebonne Parish have flood insurance policies with the NFIP and pay annual premiums totaling approximately $649,890. The total coverage value of these policies is approximately $194 million. Since 1978, NFIP policies within Terrebonne Parish have filed 411 insurance claims for a total loss value of approximately $3.2 million. This data is summarized in Table 12.

Table 12

Flood Insurance Statistics for Terrebonne Parish					
Name	No. of Insured Structures	Total Insurance Coverage Value	No. of Insurance Claims Filed Since 1978	Annual Premiums Paid	Total Loss Value
Terrebonne Parish	8,131	$782,774,000	5,733	$3,208,719	$80,011,462.58
Houma, Urban Service District	2,790	$324,522,800	590	$901,935	$5,526,664.49

*OPEN – Loss listed as currently open
Source: National Flood Insurance Program (as of December 31, 2002)

See Map 2 for the 100–year and 500–year floodplains as determined by FEMA. The shaded area for the floodplains indicates the areas that are prone to experience flooding problems. One can see that the highest land is adjacent to the Mississippi River, which is in a 500–year floodplain and approximately 95% of the total land area of Terrebonne Parish is located within FEMA's 100-year floodplain. These are the areas of the Parish that are at risk for flooding.

Repetitive Flood Losses

The analysis of structure vulnerability in the Parish can be classified into two categories: known flood-susceptible structures and suspected flood-susceptible structures. Known flood-susceptible structures are those appearing on the NFIP repetitive loss list as structures that have sustained flood damage twice or more. See Map 3, Repetitive Loss Areas and Appendix J, for a list of the Repetitive Loss Structures in Terrebonne Parish. Suspected flood-susceptible structures are those located within the SFHA or within an area of poor interior drainage having a high probability of flooding. Suspected flood-susceptible structures are recommended for further research through an inventory of the floodplain in the Parish. Terrebonne Parish has 624 repetitive loss structures, and the Urban Service District of Houma has 56 more.

As part of the process to reduce or eliminate repetitive flooding to structures across the United States, FEMA has developed an official Repetitive Loss Strategy. The purpose behind the national strategy is to identify, catalog, and propose mitigation measures to reduce flood losses to the relatively few number of structures that absorb the majority of the premium dollars from the national flood insurance fund.

Nationwide there are approximately 10,000 residential and commercial structures insured through the National Flood Insurance Program that are identified as possessing a significant number of insurance claims. Many of these structures have suffered extensive flooding and filed claims that equal or exceed the value of the property. Of these 10,000 structures nationwide, the State of Louisiana has 3,038 within its jurisdiction as of July 2003. Of these “target” structures, Terrebonne Parish has 39.

Through the use of GIS mapping analysis of known flood-susceptible structures within the Parish, a series of definable repetitive loss areas emerge. The repetitive loss areas are illustrated on Map 3.

Flood Insurance Studies

Terrebonne Parish had a Flood Insurance Study (FIS) Wave Height Analysis conducted in November of 1984. The Urban Service District of Houma had its own Flood Insurance Study conducted in November of 1980. The information from these FIS’s is summarized below.

Terrebonne Parish Flood Insurance Study Summary

Due to Terrebonne Parish’s location on the Gulf of Mexico, a wave height analysis was performed to include the effects of the wave action from the Gulf of Mexico. The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is based on three concepts. The first is that wave crest elevation is 70 percent of the total wave height plus the still water level. The second major concept is that wave height may be diminished of energy due to the presence of obstructions such as sand dunes, dikes and seawalls, levees, buildings, and vegetation. The third major concept is that wave height can be regenerated in open areas due to the transfer of wind energy to the water. The results of the Computed Wave Heights are found under Storm Surge Section 4.3.1.3.

> The prevalence of land subsidence and erosion in Terrebonne Parish complicates the determination of the expected depth of flooding. Major flooding is known to have occurred in Terrebonne Parish in 1965, 1972, 1973, 1974, 1980, 1985, 1991, 1992, 1995, 1998, 2001, 2002, and 2005.
> Source: Flood Insurance Study, Wave Height Analysis, Terrebonne Parish, Louisiana, Unincorporated Areas, November 1, 1984

Houma Flood Insurance Study Summary

Houma is located in south Louisiana in the northeastern portion of Terrebonne Parish. The total land area within the city limits is about 10.2 square miles. It is situated approximately 55 miles southwest of New Orleans.

The Gulf Intracoastal Waterway passes through the center of Houma and crosses Bayous Terrebonne, Black, and LaCarpe within the corporate limits, thereby effectively joining these natural water ways with the Houma Navigational Canal, which extends south to the Gulf of Mexico.

Two natural waterways originate in Houma. Bayou Grand Caillou, which flows south to the Gulf of Mexico and drains 0.8 square miles at the corporate boundary. Bayou Chauvin flows south to Lake Boudreaux and has a drainage area of 5 square miles.

About 70 percent of the city has been developed. Much of the undeveloped land area lies in the lower floodplain of Bayou Chauvin and is vulnerable to high tides from the Gulf of Mexico. Houma is a principal trade center for southeast Louisiana. It also has sugar cane and seafood processing plants, offshore oil production service industries, and boat repair facilities.

The climate in Houma is strongly influenced by the Gulf of Mexico, giving it a semi-tropical marine character. The greatest rainfall events can arise from tropical storms moving inland. Summers are long with an average temperature of 82^{o}F. Winters are relatively short with an average temperature of 56^{o}F with occasional temperatures below freezing. Snowfall is very infrequent. Annual average precipitation is 65 inches.

Principal Flood Problems

The past history of flooding within Houma indicates that flooding may occur during any season of the year, but would most likely occur during the spring and fall months, when the strong southerly winds and tropical storms cause high tides in the Gulf of Mexico.

The low lying areas of Houma are subject to periodic flooding caused by hurricanes and tropical storms, or by rainfall runoff aggravated by high tides in the Gulf of Mexico.

Areas that are protected by natural or artificial barriers from tide induced flooding would experience occasional ponding type flooding from local runoff that is in excess of outlet capacities. Localized flooding may also occur along the floodplains of Bayous Grand Caillou and Chauvin.

Major flooding is known to have occurred in Houma in 1965, 1972, 1973, 1974, 1980, 1985, 1991, 1992, 1995, 1998, 2001, 2002 and 2005.

Flood Protection Measures

In 1970, the Terrebonne Police Jury created parish-wide forced drainage districts. Under this authority, numerous individual drainage projects were proposed. Many projects were completed and others are in the process of being completed. Each of the projects provides for pumped drainage of developed or developing areas, with a low lying portion of each protected area designated for temporary storage of excess runoff. Most of the projects take advantage of existing barriers to protect against outside flood sources while others require protective levees to become fully effective.

Non-structural measures of flood protection are also being utilized to aid in prevention of future flood damage. These are in the form of land use regulations adopted from the Code of Federal Regulations which control building within the area that have a high risk of flooding.
Source: Flood Insurance Study, City of Houma, Louisiana, Terrebonne Parish, Revised November 19, 1980.

Public Works Drainage Activities

The Parish Office of Public Works is responsible for all drainage in the Parish. The Public Works budget and man-hour efforts are directed towards the following type of tasks:

- Clean out culverts with a vacuum truck
- Weed control and clean ditches/canals
- Five grade-all crews
- Sandbagging & delivery

In addition, the Parish Office of Public Works continually maintains ditches and canals throughout the Parish by means of a Work Order System. The Parish has an active culvert and drainage permit program.

Consequences – Extent and Previous Occurrences

Reasonably good information is available for the significant floods that have caused serious loss of life or major property damage. As shown in Table 4, of the sixteen federally declared disasters in Terrebonne Parish, fifteen were due to flooding. Details of the flood events follow:

- April 27, 1973 – Low lying Gibson and Schriever were flooded. Several residences and businesses were flooded.
- April 9, 1980 – Five inches of rain fell in Houma. Several residences and businesses were flooded. Parkway Circle was inundated by flood waters.
- April 15, 1991 – Ditches and canals were unable to handle all the water and overflowed. Many homes and cars were flooded. Numerous roads were closed.
- April 29, 1991 – Numerous roads were closed. Over 10 inches of rain fell in a brief time.
- May 8, 1995 – Over seven inches of rain fell. Homes in Shriever were flooded. Many subdivisions suffered from flooding. Numerous roads were flooded.
- June 5, 2001 – Winds snapped trees and downed power lines. Many people lost power. Some areas of the Parish received 35 inches of rain. 25,000 residents displaced due to the flooding. Oyster beds were closed due to contamination.
- October 8, 2004 - Rainfall amounts generally ranged from 5 to 10 inches with a few locations in Terrebonne reporting amounts up to 13 to 16 inches. The storm surge was 2 to 4 feet above normal, but locally higher in some locations. The greatest damage occurred in Lower Terrebonne Parish where at estimated 20 homes sustained damage from heavy rain and storm surge in an area from Chauvin to Dulac, Montegut, and Pointe Aux Chene. Many roads were closed due to storm tide flooding in Lower Terrebonne**.**

Interpretation of flood loss data is difficult, and estimates are not necessarily comparable due to differences in reporting flood loss and in adjusting dollar amounts to reflect changes in monetary values, as well as other problems in coordinating data sources (e.g., federal versus non-federal outlays).

The most comprehensive source of annual flood loss data is prepared by the NWS. Since 1902, the NWS has compiled annual estimates of the number of lives lost and flood damage, excluding losses to agriculture. Despite known problems with the NWS data, they provide the most complete and consistent information over the longest period of record.

For the period 1916 to 1989, there has been a definite increase in flood damage. With adjustment for population and inflation, the average annual damage was $902 million for the 1916 to 1950 period, and $2.15 billion for the 1951 to 1985 period. In other words, annual flood damage was almost 2.5 times more during the later period.

The National Climatic Data Center (NCDC) records 9 flood events in Terrebonne Parish from 1950 to 2002. These events occurred in 1994, 1995, 1997, 1998, 1999, 2001 and 2004. Highlights of some of these events are noted as follows:

- April 12, 1994 – Torrential rain fell during the early afternoon over north Terrebonne Parish. Rainfall reports indicated between four and six inches of rain fell in less than 3 hours time. The high rainfall rates overwhelmed local drainage capacity causing widespread street flooding. Water entered a few houses and a municipal building in Houma.

- July 29, 1995 - Strong winds caused tides to average two to four feet above normal causing minor flooding in low lying coastal areas.

- April 5, 1997 - Sustained onshore winds of 25 to 30 mph caused coastal flooding in several communities in south Terrebonne Parish. The communities of Pointe-Aux-Chenes, Montegut and the area along the lower Little Caillou were especially affected with three inches of water in a dozen houses and several businesses. Six inches of water entered several houses in Isle de Jean Charles. About a half a foot of water covered Louisiana Highway 665.

- January 6, 1998 - Heavy rainfall of three to six inches occurred during the night and morning hours across southeast Louisiana. Many parishes experienced flooding of rural secondary roadways, and street flooding occurred in many communities. Substantial flooding occurred in several areas where the heavy rain overwhelmed the drainage capacity. In Terrebonne Parish, several houses and businesses were flooded.

- June 26, 1999 - An area of thunderstorms persisted over portions of extreme southeast Louisiana during the day and evening hours producing 6 to 12 inches of rain across Terrebonne Parish. The highest rainfall total was just southeast of Thibodaux where 11.13 inches of rain was recorded. The intense rainfall rates overwhelmed local drainage producing flooding. The most severe damage occurred in the north portions of Terrebonne where many roadways were flooded, and 100 houses were flooded. Water depth in the houses ranged from a few inches to up to a foot or more. Communities hard hit by flooding included Thibodaux, Raceland, Lockport, and Schriever.

- June 6-11, 2001 - The areas from Baton Rouge extending south to Thibadaux were particularly hard hit on June 6th and June 7th. By early June 8th, many locations had received 10 to 18 inches of rain. Periods of torrential rain overwhelmed local drainage and created severe ponding of water which flooded numerous roadways and low lying areas, with many houses and some businesses flooded. By the end of the event on June 11th, storm total rainfall of 15 to 25 inches was common with some location reporting up nearly 30 inches near Thibodaux.

- October 8, 2004 - Rainfall amounts generally ranged from 5 to 10 inches with a few locations in Terrebonne reporting amounts up to 13 to 16 inches. The storm surge was 2 to 4 feet above normal, but locally higher in some locations. The greatest damage occurred in Lower Terrebonne Parish where at estimated 20 homes sustained damage from heavy rain and storm surge in an area from Chauvin to Dulac, Montegut, and Pointe Aux Chene. Many roads were closed due to storm tide flooding in Lower Terrebonne**.**

Of the sixteen federally declared disasters addressed in Section 4.1, fifteen were from flood events.

Mitigation Approaches

A Federal Interagency Floodplain Management Task Force report described four basic strategies for floodplain management: modify susceptibility to flood damage and disruption; modify flooding; modify the impacts of flooding; and manage natural and cultural resources.

Modify Susceptibility to Flood Damage and Disruption

- Demolition and relocation of properties in flood-prone areas
- Floodplain regulations, building codes, and participation in CRS
- Flood proofing and elevation-in-place
- Disaster preparedness and response plans
- Flood forecasting and warning systems

Modify Flooding

- Construction of dams and reservoirs
- Construction of dikes, levees, and floodwalls
- Channel alterations
- High flow diversions and spillways

Modify the Impacts of Flooding

- Information and education
- Flood insurance
- Tax adjustments
- Flood emergency measures
- Disaster assistance
- Post-flood recovery

Manage Natural and Cultural Resources

- Preservation and restoration strategies
- Regulations to protect floodplain natural and cultural resources
- Information and education

In order for any of these basic floodplain strategies to be effective the Parish must have an accurate Repetitive Flood Loss List which will enable them to identify where there greatest flood problem areas are located. This can be accomplished by annually reviewing and correcting the Repetitive Flood Loss List and submitting corrections to FEMA.

The Terrebonne Parish Consolidated Government (TPCG) completed a Forced Drainage Master Plan in 1973 and since that time, many of the projects proposed in that plan have been constructed, providing additional protection to the citizens of Terrebonne Parish. TPCG will continue to implement that plan with consideration of projected development trends, existing forced drainage improvements and the new Hurricane Protection System.

Specific mitigation measures recommended by the Steering Committee to address this hazard are provided in Appendix I, Terrebonne Parish Mitigation Measures.

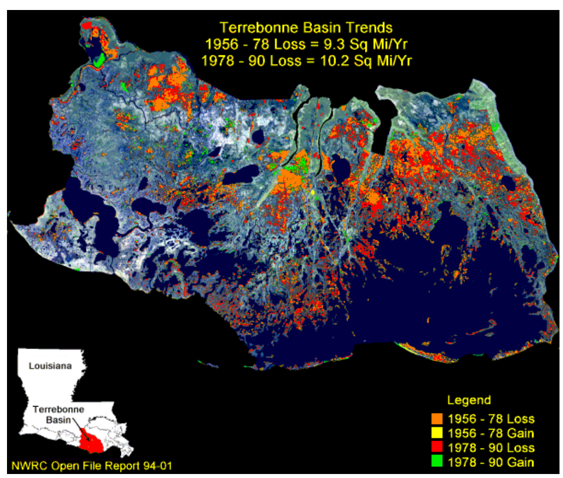
4.3.1.3 Storm Surge

Storm surges from the Gulf of Mexico are responsible for coastal flooding and erosion. Coastal erosion affects every coastal state in the United States, but it is the storm surge hazard associated with hurricanes and other severe storms that is of most concern to Terrebonne Parish. Storm surge is primarily caused by hurricanes located in the Gulf of Mexico moving towards the Parish. However, storm surge can be felt in the Parish from other hurricanes that directly impact Texas, Mississippi, or Alabama.

Hazard Identification

Storm surges occur when the water level of a tidally influenced body of water increases above the normal high tide. Storm surges occur with coastal storms caused by massive low pressure systems with cyclonic flows that are typical of hurricanes.

Changes in the earth's surface also contribute to the effects of surges. Rising seas and erosion have led to the deterioration of the state's barrier islands and marsh, important shields against storm surge. Furthermore, erosion has caused the entire delta to sink, meaning homes, businesses and highways are becoming more susceptible to surges. New Orleans actually has pumps to keep rising seawaters from inundating the entire city, but they would hold little power in the face of a powerful hurricane.



Source: http://www.lacoast.gov/

Several factors allow surges to travel so far inland. A combination of relatively flat terrain and an extensive system of bayous and tidal lakes allow the surge to flow easily northward. Shallow water off the coast also adds to the problem, contributing to a higher storm surge than would occur in a location that has deeper coastal water.

Because of our coastal marshes and barrier islands, Louisiana's commercial and recreational fisheries are among the most abundant in America, providing 25 to 35 percent of the nation's total catch. Louisiana is first in the annual harvest of oysters, crabs and menhaden, and is a top producer of shrimp. Some of the best recreational saltwater fishing in North America exists off Louisiana's coast. The reason for this abundance is that our coastal marshes provide the nursery for young fish and shellfish.

Wetlands create friction and reduce high winds when hurricanes hit. They also absorb hurricane storm surges. Scientists estimate that every 2.7 miles of wetlands absorbs one foot of storm surge. The 3.5 million acres of wetlands that line Louisiana's coast today have storm protection values of $728 million to $3.1 billion.

Storm surges inundate coastal floodplains by tidal elevation rise in inland bays and ports, and backwater flooding through coastal river mouths. Severe winds associated with low pressure systems cause increase in tide levels and water surface elevations. Storm systems also generate large waves that run up and flood coastal areas. The combined effects create storm surges that affect the beach, marsh, and low lying floodplains. Shallow offshore depths can cause storm driven waves and tides to pile up against the shoreline and inside bays. See Table 13 for factors that can influence the severity of coastal storms.

Table 13

Factors that Influence the Severity of Coastal Storms	
Factor	**Effect**
Wind Velocity	The higher the wind velocity the greater the damage.
Storm Surge Height	The higher the storm surge the greater the damage.
Coastal Shape	Concave shoreline sections sustain more damage because the water is driven into a confined area by the advancing storm, thus increasing storm surge height and storm surge flooding.
Storm Center Velocity	Then slower the storm moves, the greater damage. The worst possible situation is a storm that stalls along a coast, through several high tides.
Nature of Coast	Damage is most severe on low lying island barrier shorelines because they are easily over washed by wave action.
Previous Storm Damage	A coast weakened by even a minor previous storm will be subject to greater damage in a subsequent storm.
Human Activity	With increased development, property damage increase and more floating debris becomes available to knock down other structures.

Due to Terrebonne Parish's location on the Gulf of Mexico, a wave height analysis was performed to include the effects of the wave action from the Gulf of Mexico. The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is based on three concepts. The first is that wave crest elevation is 70 percent of the total wave height plus the still water level. The second major concept is that wave height may be diminished of energy due to the presence of obstructions such as sand dunes, dikes and seawalls, levees, buildings, and vegetation. The third major concept is that wave height can be regenerated in open areas due to the transfer of wind energy to the water.

Results of the Computed Wave Heights

Transects 1-2

These transects start at Point au Fer Island and run north to the Intracoastal Waterway. The maximum wave crest elevation at the shoreline is 15 – 16 feet. The wave crest elevation progresses inland through brackish water marshes and over various lakes and spoil banks. The marshes are predominantly brackish and freshwater due to the influence of freshwater from the Atchafalaya River. The reduction in wave crest elevations results in primarily from the spoil banks and energy dissipation through the marshes. Areas of wave regeneration occur on open bodies of water such as Lost Lake, Lake Mechant and Caillou Lake.

Transects 3 - 4

These transects start at Isles Dernieres where the maximum wave crest is 16 feet and progress inland. These barrier islands provide a buffering effect. Waves regenerate across Lake Pelto before proceeding inland over saline, brackish and freshwater marshes. Reduction in wave crest elevation results primarily from spoil banks and energy dissipation through the marshes. Areas of wave regeneration occur on open bodies of water such as Lake Boudreaux. Wave crest elevations range from 8 – 12 feet on Bayou Petit Caillou and Bayou Grand Caillou. These wave heights are reduced to less than three feet after reaching vegetation and development.

Transect 5

Waves generated in the Gulf of Mexico propagate through Terrebonne Bay and Lake Barre at which point the wave crest elevation is reduced to 15 feet. The wave progresses inland over saline, brackish and freshwater marshes. Reduction in wave crest elevation results primarily from spoil banks and energy dissipation through the marshes. The transect progresses to the Lafourche Parish line where surge and wave crest elevation are equal to seven feet.

Transect 6

The transect starts at Timbalier Island where the maximum wave crest is 16 feet. Initial degeneration of wave occurs at the island resulting in a wave crest elevation of 13 feet behind island. Waves regenerate over Terrebonne Bay and Lake Felicity before proceeding inland over saline and brackish marshes. Transect proceeds to the Parish limits at Bayou Pointe au Chien where the wave crest elevation is 12 feet.

Risk Assessment

The following are areas that have been impacted in Terrebonne Parish during storm surge events:

- The areas in the Parish located outside of the drainage levee systems are often extensively impacted from storm surge.
- Many homes are flooded in Lower Terrebonne Parish from storm surge breaching drainage levees.
- There are many forced drainage areas in the Parish that can be overwhelmed from a storm surge.

There are other needs in the Parish that are not geographically specific, as those indicated above, such as increasing public awareness and education, creating drainage plans, and improving the CRS rating. These issues are addressed in the Parish's Action Plan found in Section 7.0.

Probability and Frequency

The storm surge levels associated with coastal storms with extreme tides and waves have been analyzed by FEMA Flood Insurance Studies. This information has been used to identify the coastal high hazard areas in addition to those influenced by tropical cyclone flooding. The most common reference to a return period for storm surges has been the elevation of the coastal flood has a 1-percent chance of being equaled or exceeded in any given year, also known as the 100-year flood.

In the contiguous United States, Louisiana contains 42% of the brackish and saline marshes, and 15% of the fresh and intermediate marshes, which amounts to 28% of the total coastal marsh acreage. Louisiana has lost 1,900 square miles of land since the 1930's. Currently Louisiana accounts for 90% of the coastal marsh loss in the lower 48 states. Between 1990 and 2000 wetland loss was approximately 24 square miles per year, which is one football field lost every 38 minutes. The loss over the next 50 years with current restoration efforts is expected to be 500 square miles. Based on a 1990 habitat analysis, there are nearly 3.4 million acres of wetlands in coastal Louisiana including 568,550 acres of swamps, 907, 700 acres of fresh marsh, 365,100 acres of intermediate marsh, 767,700 acres of brackish marsh, and 404,200 acres of saline marsh.

Approximately half the Nation's original wetland habitats have been lost over the past 200 years. In part, this has been a result of the natural evolutionary processes, but human activities, such as dredging wetlands for canals or draining and filling for agriculture, grazing, or development, shares a large part of the responsibility for marsh habitat alteration and destruction. The State's wetlands extend as much as 81 miles inland and along the coast for about 186 miles. Not all the wetlands are receding; in fact some wetlands are stable, and others are growing. But, at the present net rate of wetlands loss, Louisiana will have lost this crucial habitat in about 200 years. Considerable effort has been expended, and will continue to be expended, on understanding the processes that control wetlands evolution.

As seen on Table 8, the probability of storm surges occurring each year in Terrebonne Parish is highly likely, with a percentage range of 75% to 100%. NCDC's data indicates that there has been only one storm surge event in Terrebonne Parish since 1998. However, the information compiled in NCDC is not a complete dataset and is often changing. Even though the database originated in 1950, each dataset (hazard) actually begins recording data in different years. Therefore, to ensure the most accurate probability analysis, we investigated further sources such as the "*The Houma Courier*" newspaper and the Louisiana Office of State Climatology.

Based on this analysis, we know that Terrebonne Parish has experienced four significant storm surge events, over the last five years yielding an 80% reoccurrence rate.

Exposure - Location

The area most likely to be impacted by storm surge is the water and marsh wetlands in the southern and western portions of the Parish. According to Map 4, Parish Land Use, and Table 24, the marsh wetlands, water bodies, and environmental sensitive areas make up approximately 92% of the Parish. Therefore, this is the specific area that would be affected in the Parish.

Although, the marsh wetlands are the most likely area that would be affected by storm surges the entire Parish could feel the effects from a storm surge along the coast due to the Parish's location below sea level and the large number of water bodies in the Parish. If the water body levels are already high and then there is a storm surge, the water will back up into the cities because it does not have anywhere to flow out.

Increased coastal zone development and the estimated 45 million residents in these regions place a high number of people and structures at risk. Dense development of many water front areas increases the number at risk because open space buffers along the water front are not typically preserved. The duration of a storm is the most influential factor affecting surges and exposure of people and property. Storm surge can result in street and building flooding in coastal communities. The waves accompanying an event can impact structures with sufficient force to destroy walls and undermine foundations, causing collapse.

Louisiana's cities and coastal communities are at great risk as the wetlands and barrier islands disappear, leaving people with no buffer from storm surges and the force of high winds. Miles of hurricane protection levees will be exposed to open water conditions, forcing widespread relocation and abandonment of coastal communities.

At the foot of the Mississippi's 19,000-mile river system lie the six deep-water ports of southern Louisiana. These outlets handle more than 500 million tons of cargo annually, which accounts for approximately 27% of all waterborne commerce in the United States. Five of the top fifteen largest ports in the United States are in Louisiana. Continued wetlands loss and erosion will ultimately expose several of these ports to open water, rendering them vulnerable to severe damage from hurricanes and tropical storms. Losing these ports would paralyze not only Louisiana but also the rest of the nation.

The area shown is part of the Isles Dernieres in central Louisiana. Sustained winds in excess of 135 miles per hour accompanied Hurricane Andrew as it passed across the western end of these barrier islands. The upper photograph was taken in July 1992 before Hurricane Andrew. The lower photograph was taken several days after the passage of Hurricane Andrew in August 1992.

The state's wetlands and barrier islands protect this internationally important port system, as well as navigation channels, waterways and anchorages from winds and waves. At present land loss rates, more than 155 miles of waterways will be exposed to open water in 50 years, leaving this key port system at risk.

The long-term impacts of wetland loss relate to many species of fish and shellfish that depend on these habitats, translating into economic losses that affect the entire region and the nation. Nearly all Louisiana commercial species use the marsh at some stage of their life cycle, and fisheries loss will be proportional to marsh loss. In 2001 Louisiana commercial landings exceeded 1.1 billion pounds worth a dockside value of $342.7 million, which accounts for approximately 27% of the total catch weight in the contiguous United States. By the year 2050, the annual loss of commercial fisheries will be nearly $550 million. For recreational fisheries, the total loss will be close to $200 million a year.

Human activities during the past century have drastically affected the wetlands. Natural processes alone are not responsible for the degradation and loss of wetlands in the Mississippi River delta plain. The seasonal flooding that previously provided sediments critical to the healthy growth of wetlands has been virtually eliminated by construction of massive levees that channel the river for nearly 2000 kilometers; sediment carried by the river is now discharged far from the coast, thereby depriving wetlands of vital sediment. In addition, throughout the wetlands, an extensive system of dredged canals and flood-control structures, constructed to facilitate hydrocarbon exploration and production as well as commercial and recreational boat traffic, has enabled salt water from the Gulf of Mexico to intrude brackish and freshwater wetlands. Moreover, forced drainage of the wetlands to accommodate development and agriculture also contribute to wetlands deterioration and loss.

Consequences – Extent and Previous Occurrences

Storm surges in Louisiana are deeper and travel further inland than in other Gulf Coast states, according to experts. The most dangerous part of a hurricane, storm surge, causes nine out of every ten hurricane-related deaths, according to the National Weather Service.

Louisiana's surges have covered paths up to 50 miles wide, and, in the case of Hurricane Camille, 25 feet deep. Storm surge models that are run, show that surge-related flooding could travel up to 18 feet inland, reaching the north shore of Lake Pontchartrain, just north of New Orleans.

The level of surge in a particular area is also determined by the slope of the continental shelf. A shallow slope off the coast, like what is found off the coast of Louisiana, will allow a greater surge to inundate coastal communities.

Storm surges are particularly damaging when they occur at the time of a high tide, combining the effects of the surge and the tide. This increases the difficulty of predicting the magnitude of a storm surge since it requires weather forecasts to be accurate to within a few hours.

The greatest recorded storm surge, in the United States, was generated by Hurricane Camille, which produced a storm surge exceeded 16 feet by 50 miles wide along the Mississippi Gulf Coastline, with a peak surge over 25 feet above the Mean Tide, in the area of Gulfport, Mississippi.

Hurricane Carmen in September of 1974 brought 14 foot tides along the coast. Hurricane Andrew in August of 1992 brought storm surge over six feet. Tropical Storm Frances in early September of 1998 had storm surges of two to four feet. Hurricane Georges in September of 1998 had storm surges of approximately seven feet. Tropical Storm Isidore in September of 2002 had storm surges of between four and six feet. Tropical Storm Bill in June of 2003 had storm surges of between three and five feet. Tropical Storm Matthew in October of 2004 had storm surges caused by the storm's persistent easterly winds.

Barrier islands fronting the Mississippi River delta plain act as a buffer to reduce the effects of ocean waves and currents on associated estuaries and wetlands. These warm shallow waters also serve to reduce the wind speeds of hurricanes. Hurricane

Lili, for example, went from a Category 4 to a Category 2 as it encountered Louisiana coastal waters. However, Louisiana's barrier islands are eroding, however, at a rate of up to 20 meters per year; so fast that, according to recent USGS estimates, several will disappear by the end of the century. As the barrier islands disintegrate, the vast system of sheltered wetlands along Louisiana's delta plains are exposed to the full force and effects of open marine processes such as wave action, salinity intrusion, storm surge, tidal currents, and sediment transport that combine to accelerate wetlands deterioration.

The National Climatic Data Center (NCDC) records only 1 flood event from storm surge in Terrebonne Parish from 1950 to 2005.; however, other data indicates that storm surge events occurred in 1965, 1974, 1985, 1992, 1998, 2002, 2003, 2004, and 2005. Highlights of some of these events are noted below:

- In September of 1965, Hurricane Betsy made landfall and caused extensive damage to Terrebonne Parish. An estimated one million dollars of damage occurred. The winds were measured up to 140 mph. Many people were injured and one fatality due to the effects from the storm.

- In September of 1974, Hurricane Carmen moved inland just east of Vermilion Bay near Pointe Aux Fer after crossing the Gulf of Mexico as a major hurricane. Tides of 4-6 feet above mean sea level went ashore along the coasts of St. Mary, Terrebonne, Lafourche, Jefferson, and Plaquemines Parishes. Total damages from the hurricane reached $150 million. Three deaths were indirectly associated with Carmen.

- In November of 1985, Hurricane Juan spawned rain for five days. Over 69 homes and business flooded. Numerous roads were flooded. Storm surges were 8 feet at Cocodrie. LA 1 south of Leeville and LA 3090 near Port Fourchon were destroyed. Three bridges were washed out near Lacombe on LA 434. Levees were overtopped in Lockport, Marrero, Westwego, and Myrtle Grove; this added to the already serious flooding. Grand Isle was under 4 feet of sea water; 1200 residents were trapped on the island as the storm surge cut off any evacuation attempts early on. Total damages exceeded $300 million and 12 people died in all.

- In August of 1992 Hurricane Andrew hit Terrebonne Parish with winds of 75 miles per hour. Floodwaters covered six miles of highway in Pointe-Aux-Chenes. Seven people died and 94 were injured across Southern Louisiana during Andrew. The totals of rainfall exceeded 12 inches. The storm surge moved inland from Lake Borgne westward to the Vermilion Bay with the highest surge reported was at 6.48 feet at Bayou Dupre.

- In September of 1998 Hurricane Georges forced the residents of the Parish to evacuate. Storm surges above seven feet overflowed some of the land surrounding Lake Pontchartrain and Lake Borgne and a storm surge of 8.9 feet was noted at Northeast Gardene Bay, east of Pointe a la Hache. Two died from Georges in Louisiana.

- In October of 2002, Hurricane Lili made landfall along the west shore of Vermilion Bay in South Central Louisiana as a Category 2 hurricane. More than 40 roads were closed due to high water in the Parish. Storm surge was significant across the southeast Louisiana coastal areas and tidal lakes. Storm surge tides were 3 to 5 feet above normal across much of coastal southeast Louisiana except 4 to 7 feet above normal across south Lafourche and Terrebonne Parishes, closer to the location where the hurricane made landfall. Storm surge caused the most damage in Terrebonne Parish where many communities situated along bayous in the southern portion of the Parish received considerable flooding. Storm surge also overtopped or breached several locally built drainage levees during the morning hours of October 4th. Particularly hard hit was the community of Montegut where many homes were flooded several feet deep. Over a thousand homes and businesses in Terrebonne Parish sustained some type of water damage due to storm surge. Storm surge flooding was also reported in southern Lafourche Parish where areas outside of the Larose-Golden Meadow were inundated by storm surge flooding. Grand Isle also was hit with considerable storm surge and beach erosion. Considerable flooding of roadways and low lying structures was reported in many areas in coastal southeast Louisiana outside of the hurricane protection levees.

- In June of 2003, Tropical Storm Bill developed in the southern Gulf of Mexico and made landfall on southeastern Louisiana south of Houma with sustained winds of 60 mph. Storm surge of three to five feet above normal was common along coastal southeast Louisiana. River flooding developed during the first five days of July.

- In October of 2004 - Tropical Storm Mathew developed in the southern Gulf of Mexico and made landfall on southeastern Louisiana east of Houma with sustained winds of 40 mph. The storm surge was 2 to 4 feet above normal, but locally higher in some locations. The greatest damage occurred in Lower Terrebonne Parish where at estimated 20 homes sustained damage from heavy rain and storm surge in an area from Chauvin to Dulac, Montegut, and Pointe Aux Chene. Many roads were closed due to storm tide flooding in Lower Terrebonne**.**

- In August and September of 2005 - Due to the recent events of Hurricanes Katrina and Rita, significant personal injury and property damage has occurred in Terrebonne Parish due to levee failure and/or storm surge, but due to the current data deficiency, a proper analysis will be conducted during the required Plan update.

Of the sixteen federally declared disasters addressed in Section 4.1, seven were from storm surge events.

Mitigation Approaches

Several coastal restoration and freshwater diversion projects have been completed in South Louisiana over the last 15 years. These projects have included Barataria Bay Shoreline Protection, Barataria Bay Marsh Creation, the Davis Pond Freshwater Diversion Project, and the Grand Terre Island Vegetation Planting/Barrier island Restoration. But Terrebonne Parish will remain extremely vulnerable to storm surge events until the Morganza to the Gulf Hurricane Protection System is completed.

The Morganza to the Gulf Hurricane Protection System for Terrebonne Parish is under environmental assessment review and construction initiation could still be years away. Dedicated local funds are available for this project and State and Federal funds are expected but unpredictable. The Terrebonne Levee and Conservation District and Terrebonne Parish Consolidated Government will explore and implement options to accelerate the construction which is estimated at 16 years, but without hurricane protection levees in place, the Parish remains extremely vulnerable to hurricanes and storm surge.

Methods to mitigate wetlands loss are costly and politically sensitive, affecting communities, agriculture, and industry. A variety of ideas have been put forward as partial solutions to the dramatic loss of barrier islands and wetlands along the Louisiana coast. Most ideas include soft engineering solutions such as coastal restoration through barrier island re-nourishment. Dredged materials could be distributed onto wetlands. Other ideas include a strategic retreat by creating new navigation channels allowing the delta plains, such as the modern Mississippi River Delta, to erode and proceed through their normal cycles. Such solutions could affect small communities, agricultural interests, and the petroleum industry. Hard engineering solutions, such as building sea walls and breakwaters, are also possible; however, these solutions are not only expensive but have produced mixed results at best.

Consensus on deciding the most cost-effective solutions to wetlands loss should be based on a thorough understanding of the geologic framework and physical processes that drive the barrier island-wetland system.

Many questions remain about the environment in which barrier islands evolve and wetland areas evolve and mature. A variety of coordinated studies, such as sediment budget, storm events, wave action, and sea-level fluctuations, are showing how nature intended the barrier island/wetland system to work, and can guide planners to augment the natural evolution of this system rather than operate contrary to nature. Present data collection activities are being included in models that simulate natural processes for future diversions of the Mississippi River, sea-level rise, subsidence of coastal areas, and beach nourishment. Other studies examine ways in which fine-grained sediments can be introduced into wetlands to replace sediments lost by diversion of the river; the aggravating effects of wave action as determined by moving offshore sands to onshore areas; sources of sand for nourishment activities such as sand from Ship Shoal, some 25 kilometers offshore; and whether sediment can best be removed from the ends, the top, or the sides of the shoal. In general, human attempts to engineer coastal areas have had limited success.

Specific mitigation measures recommended by the Steering Committee to address this hazard are provided in Appendix I, Terrebonne Parish Mitigation Measures.

4.3.1.4 Thunderstorms, Lightning and High Winds

The NWS estimates that over 100,000 thunderstorms occur each year on the U.S. mainland. Approximately 10 percent are classified as “severe”. Thunderstorms can produce deadly and damaging tornadoes, hailstorms, intense downburst and microburst winds, lightning, and flash floods.

Hazard Identification

Thunderstorm and lightning events are generated by atmospheric imbalance and turbulence due to a combination of conditions:

- Unstable warm air rising rapidly into the atmosphere;
- Sufficient moisture to form clouds and rain; and
- Upward lift of air currents caused by colliding weather fronts (cold and warm), sea breezes, or mountains.

Lightning, which occurs during all thunderstorms, can strike anywhere. Generated by the buildup of charged ions in a thundercloud, the discharge of a lightning bolt interacts with the best conducting object or surface on the ground. The air in the channel of a lightning strike reaches temperatures higher than 50,000 degrees F. The rapid heating and cooling of the air near the channel causes a shock wave, which produces thunder.

Wind is defined as the motion of air relative to the earth’s surface. In the mainland United States the mean annual wind speed is reported to be eight to 12 mph, with frequent speeds of 50 mph and occasional wind speeds greater than 70 mph. High winds can result from thunderstorm inflow and outflow, or downburst winds when the storm cloud collapses, and can result from strong frontal systems, or gradient winds from high or low pressure systems moving across the state. High winds are speeds reaching 50 mph or greater, either sustaining or gusting. A downburst wind is defined as a strong downdraft resulting in an outward burst of damaging winds on or near the ground. Downburst winds can produce damage similar to a strong tornado. Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder. A downdraft wind is defined as a small-scale column of air that rapidly sinks toward the ground, usually accompanied by precipitation as in a shower or thunderstorm. A downburst is the result of a strong downdraft.

High winds associated with hurricanes were discussed in Section 4.3.1.1. High winds associated with tornadoes are discussed in Section 4.3.1.5 and high winds associated with winter storms are discussed in Section 4.3.1.11.

The NWS classifies a thunderstorm as severe if its winds reach or exceed 58 mph, it produces a tornado, or it drops surface hail at least 0.75 inches in diameter. Individual thunderstorms affect relatively small geographic areas. The average thunderstorm system is approximately 15 miles in diameter and typically lasts less than 30 minutes at a single location. However, weather-monitoring reports indicate that thunderstorm systems can travel intact for distances in excess of 600 miles.

Risk Assessment

Dangerous and damaging aspects of a severe thunderstorm, other than tornadoes and hail, are lightning strikes, flash flooding, and the winds associated with downbursts and microbursts.
The impacts of thunderstorms with lighting and high wind events in Terrebonne Parish occur throughout the Parish. The needs of the Parish with respect to this hazard are best addressed by increasing public awareness and education, adopting the International Building Codes, creating new subdivision guidelines, and implementing a public notification system. These issues are addressed in the Parish's Action Plan found in Section 7.0.

Probability and Frequency

The probability of a severe thunderstorm occurring in a specific region depends on certain atmospheric and climatic conditions. Duration and frequency can be used as indicators of potential severity. The geographic areas with a high density of lightning strikes are at a greater risk for damage or potential loss of life during a thunder event.

South Florida has the greatest number of thunderstorms, with an annual average of 100 to 130, and an average duration of 80 to 100 minutes. Louisiana has an annual average of 100 – 110 thunderstorms lasting from 90 to 100 minutes.

The lightning hazard component of thunderstorms is measured as the mean annual ground flash density (flashes per square kilometer). Review of data shows that the central Florida region has over 18 flashes/km^2, the highest density in the U.S. mainland. Louisiana has from 8 to 12 flashes/km^2.

As seen on Table 8, the probability of thunderstorms, lightning and high wind events reoccurring each year in Terrebonne Parish is highly likely, with a percentage range of 75% to 100%. NCDC's data indicates that there have been 89 thunderstorms with lightning and high wind events in Terrebonne Parish since 1950, yielding over a 100% reoccurrence rate.

Exposure - Location

People and property in virtually the entire United States are exposed to damage, injury, and loss of life from thunderstorms and related hazards such as lightning, severe windstorms, hail, tornadoes, and flash floods.

Thunderstorms, lightning and high wind events affect Terrebonne Parish equally and uniformly and the entire Parish is at risk from thunderstorms, lightning and high wind events.

Consequences – Extent and Previous Occurrences

The National Oceanic and Atmospheric Administration (NOAA) reports that thunderstorm associated high winds were responsible for 23 fatalities in 1993 and associated lightning strikes caused 43 deaths. For the same year, damage from thunderstorm winds amounted to $348.7 million, while lightning caused $32.5 million in damage.

According to the NCDC, 89 thunderstorm and high wind events were reported in Terrebonne Parish between 1950 and 2005. Those events reportedly caused over $1,204,000 in property damage and 24 injuries. Most reports addressed downed power lines and trees as well as damage to mobile homes. Significant events are summarized below:

- November 11, 1995 – It was reported that a fence blew down; power lines were down and minor structural damage to houses due to downed tree limbs. A downed oak tree demolished an automobile. The total in property damage was approximately $20,000.
- January 14, 1998 – Thunderstorm winds downed utility poles, destroyed a shed and tore off the roof of a mobile home. A tree fell on top of a garage and damaged an automobile. Property damage was reported to be approximately $10,000.
- January 2, 1999 - Thunderstorm winds tore the roof off the administration building of a vocational-technical high school, damaged the roofs on four other campus buildings, and overturned a delivery truck. Property damage was estimated to be $350,000.

According to NOAA, from 1963 to 1993, the average loss of life due to lightning was 89 per year, with an additional 300 persons injured each year. In Louisiana, in 2000, lightning was responsible for 3 deaths (two while playing golf and one was from an unknown cause). Most lightning-related deaths and injuries occurred when people were outdoors during summer afternoons and evenings. NOAA also reports that two wind related fatalities occurred Louisiana in 2000.

According to the NCDC, three lightning events were reported in Terrebonne Parish between 1950 and 2002. Although many more lightning events occurred, they were not reported to the NCDC. Significant events are summarized below:

- July 24, 1999 - A lightning strike killed two men while fishing in a 15 foot aluminum boat on Muskrat Bayou.
- September 8, 1999 - A lightning strike set off a fire involving nine tanks of an oil and salt water mixture at the Houma Salt Water Disposal Facility. The fire consumed an estimated 26,460 gallons of crude oil. Property damage was estimated to be $500,000.

Flash flooding from thunderstorms causes more than 140 fatalities nationwide each year and is the primary cause of death from thunderstorm events. Most fatalities occur when people become trapped in automobiles. Flooding is addressed further in Section 4.3.1.2.

Of the sixteen federally declared disasters addressed in Section 4.1, five were from severe storms or rainstorms with flooding.

Mitigation Approaches

There is no clearly defined mitigation approaches designed specifically for thunderstorms that are separate from the associated hazard phenomena. Mitigation measures for tornadoes, hailstorms, windstorms and flash flooding can be expected to achieve a reduction in damage caused by or associated with thunderstorms. Proven techniques are available to reduce lightning damage by grounding techniques for buildings.

Specific mitigation measures recommended by the Steering Committee to address this hazard are provided in Appendix I, Terrebonne Parish Mitigation Measures.

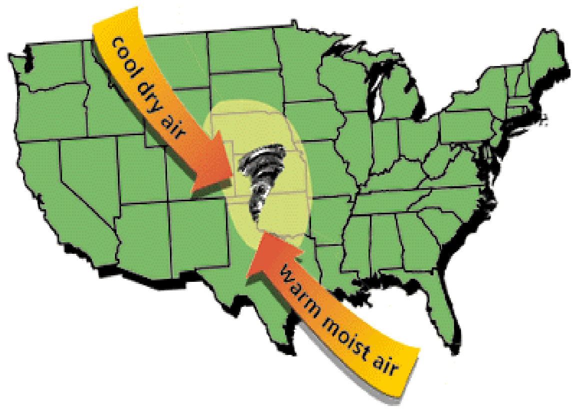
4.3.1.5 Tornadoes

In the United States, approximately 1,000 tornadoes each year are spawned by severe thunderstorms. Although most tornadoes remain aloft, those that touch ground are forces of destruction.

Hazard Identification

A tornado is a rapidly rotating vortex or funnel of air extending ground ward from a cumulonimbus cloud. Most of the time, vortices remain suspended in the atmosphere. When the lower tip of a vortex touches earth, the tornado becomes a force of destruction. Approximately 1,000 tornadoes are spawned by severe thunderstorms each year.

Tornado damage severity is measured by the Fujita Tornado Scale. The Fujita Scale assigns numerical values based on wind speeds and categorizes tornadoes from 0 to 5. The letter "F" often precedes the numerical value. Tornadoes are related to larger vortex formations, and therefore often form in convective cells such as thunderstorms or in the right forward quadrant of a hurricane, far from the hurricane eye.



The path width of a single tornado generally is less than 0.6 miles. The path length of a single tornado can range from a few hundred yards to miles. A tornado typically moves at speeds between 30 and 125 mph and can generate internal winds exceeding 300 mph. However, the life span of a tornado rarely is longer than 30 minutes. See Table 14 for Fujita Tornado Measurement Scale.

Table 14

Fujita Tornado Measurement Scale				
Category	**Wind Speed**	**Examples of Possible Damage**	**Number in Louisiana**	**% of LA Tornadoes**
F0	Gale (40-72 mph)	Light damage. Some damage to chimneys; break branches of trees; push over shallow rooted trees; damage to sign boards.	321	22%
F1	Moderate (73-112 mph)	Moderate damage. Peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads.	698	48%
F2	Significant (113-157 mph)	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.	292	20%
F3	Severe (158-206 mph)	Severe damage. Roofs and some walls torn off well constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.	132	9%
F4	Devastating (207-260 mph)	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.	18	1%
F5	Incredible (261-318 mph)	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile sized missiles fly through air in excess of 100 yards; trees debarked; incredible phenomena will occur.	2	0%

High winds are capable of imposing large lateral (horizontal) and uplift (vertical) forces on buildings. Residential buildings can suffer extensive wind damage when they are improperly designed and constructed and when wind speeds exceed design levels. The effects of high winds on a building will depend on several factors:

- Wind speed (sustained and gusts) and duration of high winds
- Height of building above the ground
- Exposure or shielding of the building (by topography, vegetation, or other buildings) relative to wind direction
- Strength of the structural frame, connections, and envelope (walls and roof)
- Shape of building and building components
- Number, size, location, and strength of openings (windows, doors, vents)
- Presence and strength of shutters or opening protection
- Type, quantity, velocity of windborne debris

Proper design and construction of residential structures, particularly those close to water or near the coast, demand that every factor mentioned above be addressed. Failure to do so may result in building damage or destruction by wind. See Appendix H for recommended Stability System Design Tables for wind loads.

Risk Assessment

A tornado watch is issued for a specific location when thunderstorms capable of producing tornadoes are recognized and arrival is expected in a few hours. A tornado warning is issued when tornadoes are spotted or when Doppler radar identifies a distinctive "hook-shaped" area within a local partition of a thunderstorm line that is likely to form a tornado.

The impacts of tornado events in Terrebonne Parish occur throughout the Parish. The needs of the Parish with respect to this hazard are best addressed by increasing public awareness and education, adopting the International Building Codes, creating new subdivision guidelines, and implementing a public notification system. These issues are addressed in the Parish's Action Plan found in Section 7.0.

Probability and Frequency

From 1953 to 1993, Texas experienced the highest average annual number of tornadoes with 128, followed by Oklahoma (52), Kansas (47), Florida (46), and Nebraska (38). Louisiana has more than 25, but less than Nebraska's 38. In Louisiana, peak tornado occurrence is in March through May, and in November.

As seen on Table 8, the probability of tornadoes reoccurring each year in Terrebonne Parish is likely, with a percentage range of 35% to 74%. NCDC's data indicates that there have been 27 tornadoes, including waterspouts, in Terrebonne Parish since 1950, yielding a 49% reoccurrence rate.

Exposure - Location

An area covering portions of Texas, Oklahoma, Arkansas, Missouri, and Kansas is known as Tornado Alley, where the average annual number of tornadoes is the highest in the United States. Cold air from the north collides with warm air from the Gulf of Mexico, creating a temperature differential on the order of 20 – 30 degrees C. Most tornadoes in this area occur in the spring.

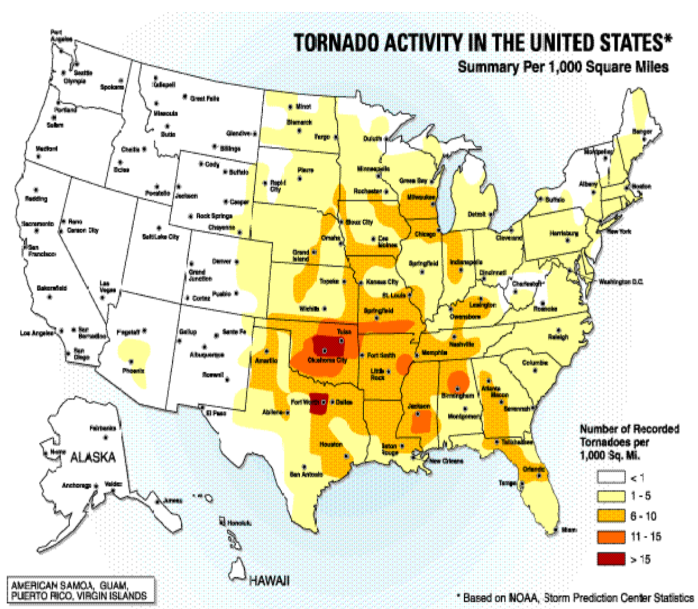
People living in manufactured or mobile homes are most exposed to damage from tornadoes. Even if anchored, mobile homes do not withstand high wind speeds as well as permanent, site-built structures.

Tornadoes affect Terrebonne Parish equally and uniformly and the entire Parish is at risk from tornadoes.

Consequences – Extent and Previous Occurrences

Tornadoes have been known to lift and move objects weighing more than 300 tons a distance of 30 feet, toss homes more than 300 feet from their foundations, and siphon millions of tons of water from water bodies. Tornadoes generate a tremendous amount of debris, which often becomes airborne shrapnel that causes additional damage and often causing public utilities failure. Tornadoes are almost always accompanied by heavy precipitation.

Between 1975 and 1995, 106 major Federal disaster declarations included impacts caused by tornadoes. The States with the greatest number of tornado-related disasters were: Mississippi (14); Alabama and Illinois (9 each); Oklahoma (8); Wisconsin (7); Ohio (6); and Missouri, Minnesota, Louisiana, Georgia, and Arkansas (5 each).



See Table 15 for Louisiana's ranking nationwide for tornadoes. Table 14 lists how Louisiana ranks in the nation for number of tornadoes, fatalities and injuries caused by tornado events, and accumulated dollar damages. Louisiana ranks within the top 20 states in the nation for all four categories, as seen by the ranking, indicating that it has a relatively high probability for occurrences and damages.

Table 15

Louisiana Rankings for Tornadoes, Fatalities, Injuries, and Damages from 1950 – 1994							
Tornadoes		**Fatalities**		**Injuries**		**Damages**	
Rank	**Number**	**Rank**	**Number**	**Rank**	**Number**	**Rank**	**Dollar**
11	1086	13	134	16	2169	15	$593,237,248

Terrebonne Parish has not had any federally declared disasters due to a tornado. The National Climatic Data Center reports 27 tornadoes occurring in Terrebonne Parish between 1950 and 2002. Those tornadoes caused 47 injuries and two deaths, and an estimated $12.56 million in property damage. See Table 14 for Louisiana's ranking nationwide for tornadoes.

The tornadoes reported to the NCDC for Terrebonne Parish ranged in severity from an F0 to an F3 on March 21, 1957. The F3 tornado caused 2 injuries, and an estimated $25,000 in property damage. It caused a path of destruction that was 100 yards wide and was on the ground for two miles. Of the 27 tornadoes, ten were an F0, fourteen were an F1, two were an F2, and one was an F3. Significant events are detailed as follows:

- March 21, 1957 – A tornado (F3) touched down with damage 100 yards wide for 2 miles with $25K in damage reported.
- January 2, 1999 - A tornado (F1) touched down in Schriever where 35 residences were damaged, including 5 brick homes that were severely damaged**.** The tornado was on the ground for one mile and was 50 yards wide with $700K in damage reported.
- On March 15, 2000 an F2 touched down in Houma injuring 36 people and damaging 212 structures, including homes and businesses. Property damage was estimated to be $10.0 million. The tornado was on the ground for three miles and was 40 yards wide.

Mitigation Approaches

Mitigation opportunities for tornado winds are similar to mitigation measures for other wind hazards. Attention to the type of structure used in tornado-prone areas may yield benefits, particularly by avoiding highly susceptible manufactured or mobile homes.

The greatest protection is afforded by quality construction and reinforcement of walls, floors, and ceilings. Proper anchoring of walls to foundations and roofs to walls is essential for a building to withstand certain wind speeds. Code adoption by local jurisdictions, compliance by builders, and local government inspection of new homes could reduce the risk of destruction in tornado-prone areas.

Loss of life and injuries may be reduced if more individuals seek shelter in basements, small interior rooms, or hallways, and avoid rooms and buildings with large roof spans. An interior room or closet has less chance of collapse or failure than other areas.

Specific mitigation measures recommended by the Steering Committee to address this hazard are provided in Appendix I, Terrebonne Parish Mitigation Measures.

4.3.1.6 Land Subsidence

Land subsidence, the loss of surface elevation due to the removal of subsurface support, ranges from broad, regional lowering of the land surface to localized collapse.

Hazard Identification

Subsidence is caused by a diverse set of human activities and natural processes. Different types of subsidence are address below:

- Collapse into Voids – Collapse of surficial materials into underground voids is the most dramatic form of subsidence. Most of the subsidence-related voids in the United States were created by coal mining.

- Sediment Compaction – Sediment compaction typically causes broad regional subsidence. Rates of subsidence usually are low, ranging from a few millimeters to centimeters per year, but total subsidence may reach several meters over decades. Another type of sediment compaction occurs naturally as older sediment is buried by younger sediment. Natural subsidence is occurring most rapidly in the Mississippi River Delta area of southern Louisiana where approximately 1,500 square miles of land are subsiding. Estimating average rates of subsidence range from 0.3 to 0.4 inches per century. Maximum rates measured by geodetic surveys are approximately 0.5 inches per year.

- Drainage of Organic Soils – Drainage of organic soils, particularly peat and muck, induces a series of processes that reduces the volume of soil. These processes include biological oxidation, compaction, and desiccation. Biological oxidation usually dominates in warm climates. The principal areas of organic soil subsidence in the United States are in the greater New Orleans, LA area.

- Tides and heavy storms in the Gulf are eroding Louisiana's marshy coastline at an alarming rate. Coastlines in southern Terrebonne Parish are sinking or eroding away with incoming water eating at the marshes and wetlands that buffer and drain the higher drier land. This can be seen around the mouth of the Houma Navigation Canal. Parts of Louisiana's coastal evacuation routes are indeed vulnerable to storm flooding. One such place is on Louisiana Highways 90 and 24.

Risk Assessment

Probability and Frequency

Land subsidence occurs slowly and continuously over time or on abrupt occasions, as in the case of sudden formation of sinkholes. Procedures for determining the probability or frequency of land subsidence have not been recommended. Terrebonne Parish has the highest land subsidence rate in Louisiana.

All states with low-lying coasts are vulnerable to accelerated sea-level rise, but Louisiana's coast is much more so because of the subsidence of the Mississippi River delta. Until humans intervened, the surface elevation of the broad delta complex had kept pace with rising sea level for several thousand years, largely because the river built delta lobes and nourished wetland vegetation. The rates of natural subsidence and sea-level rise along the Louisiana coast have been exacerbated by human modifications, primarily levees which have isolated the Mississippi River from a delta complex that depends on an annual flooding cycle. These modifications cut off the delta-building process of the river.

Louisiana's coastal system, specifically Terrebonne Parish, has also been heavily impacted by channels dug for navigation and mineral extraction, which have allowed high-salinity Gulf waters to migrate inland. Over a million acres of coastal land have been lost since the 1930s, and between 25 and 35 square miles continue to be lost each year. Louisiana's coastal ecosystems are threatened with systemic collapse.

Louisiana is clearly the state most at risk from further sea-level rise. Absent major intervention, a continuation of current trends is projected to cause loss of more than 400,000 acres over the next 50 years. This is a conservative estimate; since it presumes a continuation of what has been observed over the past 50 years, without factoring in acceleration of sea-level rise from climate change. (Source: "Danger & Opportunity: Implications of Climate Change for Louisiana; A Report for the Louisiana State Legislature to fulfill House Concurrent Resolution 74, May 1999).

As seen on Table 8, the probability of land subsidence reoccurring each year in Terrebonne Parish is likely, with a percentage range of 35% to 74%. NCDC does not track land subsidence data, but because of the soil types found in Terrebonne Parish, we expect land subsidence to likely reoccur. The soils closer to the Mississippi River have lower organic content and are better suited for construction. The organic content of the soils increases with distance to the south, away from the Mississippi River. Those soils with high organic content have higher subsidence potentials, if drained, because of their greater compatibility and water content.

Exposure - Location

Exposure of people and property is a function of the type and duration of subsidence. And extent of the area affected.

- Collapse into Voids – Collapse of surficial materials into underground voids is most commonly associated with coal mining. Coal is found in 37 states and mined underground in 22 states.

- Sediment Compaction – Sediment compaction subsidence is caused by pumping groundwater and petroleum. More than 30 areas in seven states have experienced land subsidence of this type. Groundwater withdrawal in Houston, TX, caused some coastal areas to subside more than 6 feet.

- Drainage of Organic Soils – Approximately 3,600 square miles of land underlain by organic soil has subsided because of drainage of organic soils. An even larger area is susceptible to subsidence. Approximately 39,000 square miles of the conterminous United States are covered by peat and muck soils and more than 10,000 square miles of organic wetlands are in Standard Metropolitan Statistical Areas.

- Several benchmarks in Terrebonne Parish have been found to be lower than what they are marked and satellite imagery was used to confirm this.

In Terrebonne Parish, soil subsidence has caused extensive damage to roads, and drainage systems, which can cause increased flooding. Due to continued heavy rains one would expect to see ongoing problems from expansive soils in the future, a high probability.

Land subsidence affects Terrebonne Parish equally and uniformly and the entire Parish is at risk from land subsidence.

Consequences – Extent and Previous Occurrences

The average annual damage from all types of subsidence is estimated conservatively to be at least $125 million. Cities where cumulative damage from subsidence exceeds

$100 million include Long Beach, CA, Houston, TX; and New Orleans, LA. Most of the subsidence in the Parish is due to subtraction of subsurface oil products.

- Collapse into Voids – The cumulative costs of damage from subsidence caused by underground mining are most significant in Pennsylvania and Louisiana.

- Sediment Compaction – Losses from natural compaction, particularly in the Mississippi River Delta, are difficult to estimate because of the uncertain value of coastal wetlands. Increased flooding potential is the principal impact because affected areas commonly are low lying and naturally subject to flooding. Annual revenue losses are possibly on the order of millions of dollars. Even areas with humid climates have incurred significant costs. For example, collapsible soils added more than $2.5 million in mitigation costs to interstate highway construction in Louisiana. The states with the highest damage caused from subsidence are California and Louisiana.
- Drainage of Organic Soils – Costs associated with structural damage due to differential subsidence caused by drainage of organic soils appear to be high. Approximately $30 million was spent in New Orleans to repair damage and; maintain property. Increased flooding is the most serious problems associated with organic soil subsidence. The cumulative damage caused by drainage of organic soils exceeds $100 million in California, Louisiana, and Florida.

See Table 16 below for the types of soils that are found in Terrebonne Parish, what the land subsidence rates are for each, and how many acres there are for each of those soil types. Subsidence is the settlement of organic soils or of saturated mineral soils of very low density. Subsidence generally results from either desiccation and shrinkage, or oxidation of organic material, or both, following drainage. Subsidence takes place gradually, usually over a period of several years. The table shows the expected initial subsidence, which usually is a result of drainage, and total subsidence, which results from a combination of factors.

Table 16

Soil Subsidence Rates for Terrebonne Parish

Soil Name	Soil Symbol	Subsidence Rate Initial *In*	Subsidence Rate Total *In*	Number of Acres
Allemands Muck, Drained	Ae	8-25	16-51	6,292
Aquents	AQ			280
Allemands Muck	AR	8-25	16-51	5,141
Barbary Muck	BB	3-12	6-15	9,404
Clovelly Muck	CE	8-20	16-51	28
Cancienne Silt Loam	Cm			10,178
Cancienne and Gramercy Silty Clay Loam	Co			5,282
Cancienne and Carville	CR			5
Cancienne and Schriever	CS			1,102

Dumps	Dp			291
Felicity Loamy Fine Sand, Occasionally Flooded	FA			1,027
Felicity Loamy Fine Sand, Frequently Flooded	FE			1
Harahan Clay	Ha	2-5	4-10	7,620
Kenner Muck, Drained	Ka	15-30	51	10,555
Kenner Muck	KE	15-30	51	21,834
Lafitte – Clovelly	LA	15-30	51	49,065
Larose Muck	LR	2-8	5-15	583
Arents and Aquents	LV			587
Scatlake Muck	SC		6-12	5,198
Schriever Silty Clay Loam	Sh			4,015
Schriever Clay	Sk			16,664
Timbalier and Scatlake	TM	25-45	51-60	3,861
Udorthents	Ud			4
Vacherie Silt Loam	VA			2,124
Water, Large	W			216,491
Westwego Clay	Ww	3-8	6-20	9,768

Absence of an entry indicates that the feature is not a concern or that data was not estimated at this time.
Source: http://soildatamart.nrcs.usda.gov/Default.aspx

Other sources, such as newspaper archives were used to determine previous occurrences and extent for land subsidence, and the Steering Committee could not provide any additional information about specific land subsidence sites. An attempt was made to retrieve past events information including dates, damage and location, but due to data limitations this data is not available. This hazard will be pursued further in the next update.

Any of these types of land subsidence: collapse into voids, sediment compaction, and drainage of organic soils, must be considered when determining the integrity of future hurricane protection levee systems.

Mitigation Approaches

The many causes and forms of land subsidence have let to a variety of mitigation efforts. Because of the diverse impacts, mitigation measures generally are designed for specific situations and address problems in areas that are already developed or proposed for development.

- Public Information Programs – an informed public can minimize exposure to financial loss and personal injury.

- Mapping Programs – Mapping programs are an important element in efforts to identify and manage subsidence.

- Regulation of Resource and Land Development – Prevention and Control – Regulation of the activities that cause subsidence is the most direct approach to mitigation of damage.

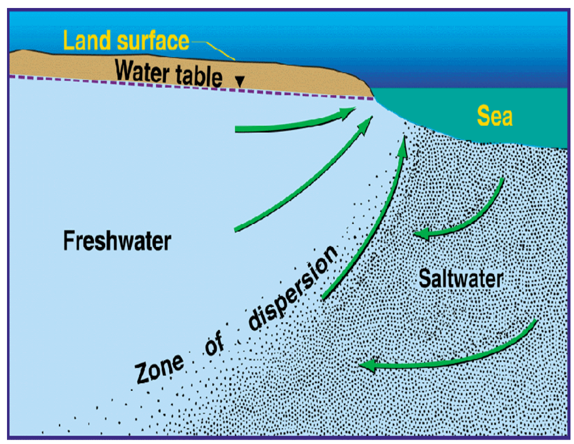
- Land-Use Management and Building Codes – Techniques include land-use planning and codes, specialized building codes, official maps, and constraints on public utilities.

Other mitigation efforts considered by the steering committee were acquisition, relocation, and dedication of open space to vulnerable areas. The Parish has completed over forty (40) home acquisitions and dedications of open space to vulnerable areas since 2001. These efforts were evaluated using the STAPLEE criteria, but without Federal funding support, and were found unfeasible due to financial constraints by the Parish. Therefore, in order to continue to meet the demand for these open space projects, the Parish must have Federal funding support.

Based on these considerations, it was determined that no additional mitigation actions will be pursued for land subsidence at this time. The risk of this hazard to the community will be reassessed during the five year update process.

4.3.1.7 Saltwater Intrusion

A large portion of the world's population (about 70%) dwells in coastal zones. In the last half-century, population and economic growth have greatly increased freshwater demands. The lack of good management schemes for coastal water resources has led to the over-exploitation of groundwater in many parts of the world. The encroachment of seawater into coastal aquifers has become a common problem. Increasing population in these areas and resulting ground water consumption has added to the problem as the saltwater intrusion moves further inland in response to pumping. The idea is to promote integrated approaches that can bridge monitoring, modeling, and management aspects.



Ground-water flow patterns and the zone of dispersion in an idealized, homogeneous coastal aquifer.

Hazard Identification

Saltwater intrusion refers to the movement of salty water into freshwater aquifers or to the encroachment of saline water into freshwater estuaries. However, saline ground water can occur naturally in inland aquifers as well as in coastal areas, and has similar implications upon ground water use. Saltwater intrusion has been a major ground water resource problem in coastal environments for decades. Saltwater intrusion is defined as the introduction, accumulation, or formation of saline water in a water of lesser salinity. The processes involved in these intrusions can result from natural phenomena or human-influenced activities, particularly dredging, and may assume a variety of specific forms.

Under natural conditions, the seaward movement of freshwater prevents saltwater from encroaching coastal aquifers, and the interface between freshwater and saltwater is maintained near the coast or far below land surface. This interface is actually a diffuse zone in which freshwater and saltwater mix, and is referred to as the zone of dispersion (or transition zone). Ground-water pumping can reduce freshwater flow toward coastal discharge areas and cause saltwater to be drawn toward the freshwater zones of the aquifer. Saltwater intrusion decreases freshwater storage in the aquifers, and, in extreme cases, can result in the abandonment of supply wells. Saltwater intrusion occurs by many mechanisms, including lateral encroachment from coastal waters and vertical upconing near discharging wells. Freshwater and saltwater mix in the zone of dispersion by the processes of diffusion and mechanical dispersion. A circulation of saltwater from the sea to the zone of dispersion and then back to the sea is induced by mixing within this zone.

Saltwater intrusion occurs in the coastal areas of Louisiana. This intrusion is into streams discharging into the Gulf as well as into marsh areas and subsequently into freshwater streams. The U.S. Army Corps of Engineers has constructed navigable barriers in some of the major streams to control saltwater intrusion. Saltwater barriers have been constructed in the Calcasieu and Mermentau River Basins.

Four saltwater intrusion conditions which are of concern are:

- The periodic intrusion into the City of Houma water supply
- The periodic intrusion into the Mississippi River during extremely low flow conditions, which may affect the New Orleans water supply
- Intrusion into marsh areas which affects the propagation of fish and wildlife
- Intrusion into brackish, intermediate, or fresh marshes with organic soils, which adversely affects the plant communities and significantly increases soil erosion.

Louisiana coastal surface intrusion occurs as the result of upstream movement of coastal saltwater in the gulf bays and estuaries into fresh or slightly saline streams, rivers, creeks, drainage ditches, and marsh areas in the coastal zone. Man-made canals can greatly increase salt water movement into fresher areas. Small amounts of saltwater may advance upstream of saltwater barriers during navigation periods.

Louisiana's 3.2 million acres of coastal marshlands are some of the most productive soil, water, and plant resources existing in the nation. However, it also has the highest resource degradation rate of any area in the nation. Saltwater intrusion is one of the major causes of marshlands loss. Intrusion of saltwater causes the loss of fresh and intermediate vegetation, which results in rapid erosion of marsh soils and the ultimate conversion to open water. The degree of mixing between freshwater and saltwater will depend in such things as freshwater discharge, tidal magnitudes, and stream-estuary geometry.

The Mississippi River Delta is classified as a stratified (salt wedge) estuary because the relatively large freshwater flows ride over the denser saltwater layer which intrudes landward along the channel bottom. Near the interface between the layers, some of the saltwater becomes entrained in the seaward-moving freshwater.

Other Louisiana estuaries that are remnants of former Mississippi River Deltas are generally classified as well-mixed because the tidal flows are much greater than the headwater flows. Salinity is only mildly variable with depth except in deep passes and inlets which may be partially or highly stratified. Deep navigation channels near the coastline tend to be highly stratified, in contrast to adjacent shallow water, which remain well-mixed except very near the channel where partially-mixed conditions may exist.

The concern about saltwater intrusion arises from the environmental damage or water use impairment that may result because of the presence of salts in ground or surface waters. Excessive salt concentrations can render water unfit for consumption by humans and animals as well as impair the growth of plants. Agricultural and industrial uses of water can also be impaired by high salinity levels. However, what is considered to be excessive salinity is determined by the uses to be made of the water and the availability of water from other sources. Uses include water for human consumption, consumption by livestock and other animals, industrial use, irrigation, and propagation of fish and wildlife. When no freshwater is available, slightly saline waters may be viewed as having acceptable quality for some purposes.

The U.S. Public Health Service has established allowable maximum concentrations for water for human consumption as 250 mg/1 of chlorides and 250 mg/1 of sulfates. Excessive salt intake can produce minor to serious effects. Allowable salinity levels for industrial waters vary widely. High salinity levels in industrial waters cause impaired use because of such factors as scaling and corrosion, incompatibility with intended physiochemical reactions in process waters, and unacceptable introduction of salts into foods and drinks in food processing industries.

Salinity levels can have a significant impact on plant growth and health. Salt tolerances of plants depend on a variety of conditions ranging from plant type to climatology of the area to amounts and manner of application of irrigation waters. Two primary Louisiana crops, rice and sorghum, have been found to have a medium tolerance to salt. Salinity levels can also result in the modification of the physiochemical environment of fish, as well as other aquatic fauna and flora, resulting in ecological damage.

There are a number of other possible effects of saltwater contamination, as indicated by the following:

- Synergistic enhancement of the toxicity of other toxic chemicals dissolved in water may occur.
- Saturation levels of dissolved oxygen decrease with increasing salinity, thus potentially accentuating poor dissolved oxygen conditions in streams.
- Permeability of soils can be altered, thus altering aquifer recharge conditions.

- Excessive salt build-ups on shores of salty waters may decrease aesthetic qualities.
- Reduction of game fish species may reduce recreational value.
- Reduced commercial values of lands adjacent to salty surface waters may result.
- Large costs may be incurred in the treatment of saline water in order to make it usable.
- Increasing salinity may force the use of alternate sources of water which, in turn, may have adverse consequences.

The U.S. Army Corps of Engineers routinely monitors the salt levels in the lower Calcasieu and the lower Mississippi River. In addition, they collect data on salinity levels in other streams in the coastal areas.
Source: http://nonpoint.deq.state.la.us/assess29.html

Risk Assessment

Probability and Frequency

Natural salinity levels in the Terrebonne Basin range from fresh (no salt) to brackish (a mix of salt and fresh water). Excess salinity can kill vegetation, and lead to wetland erosion. Long-term behavior of the saltwater interface in response to changes in population and water use can be predicted through the application of modeling. When seawater is in dynamic equilibrium with freshwater within coastal aquifers, modeling provides a remarkably good first approximation of the extent of the saltwater intrusion.

The Terrebonne Basin is an abandoned delta complex, characterized by a thick section of unconsolidated sediments that are undergoing dewatering and compaction, contributing to high subsidence, and a network of old distributary ridges extending southward from Houma. The southern end of the basin is defined by a series of narrow, low-lying barrier islands (the Isles Dernieres and Timbalier chains), separated from the mainland marshes by a series of wide, shallow lakes and bays (Lake Pelto, Terrebonne Bay, Timbalier Bay).

The Terrebonne Basin is bordered by Bayou Lafourche on the east, the Atchafalaya Basin floodway on the west, and the Gulf of Mexico on the south. The Terrebonne Basin is divided into four subbasins--Timbalier, Penchant, Verret, and Fields. The basin includes all of Terrebonne Parish, and parts of Lafourche, Assumption, St. Martin, St. Mary, Iberville, and Ascension parishes.

The Verret and Penchant Sub-basins receive fresh water from the Atchafalaya River and Bay, while the Fields Sub-basin gets fresh water primarily from rainfall. The Timbalier Sub-basin gets fresh water from rainfall and from Atchafalaya River inflow via the Houma Navigation Canal (HNC) and Grand Bayou Canal.

The Terrebonne Basin supports about 155,000 acres of swamp and almost 574,000 acres of marsh, grading from fresh marsh inland to brackish and saline marsh near the bays and the gulf. The Verret Sub-basin contains most of the cypress swamp (118,000 acres) in the Terrebonne Basin. The northern Penchant Sub-basin supports extensive fresh marsh (about 166,000 acres), including a predominance of flotant marsh, with 98,000 acres of intermediate and brackish marsh in the Lost Lake-Jug Lake area and about 17,000 acres of saline marsh to the south. Fresh marsh is also dominant in the Fields Sub-basin (approximately 23,000 acres). The Timbalier Sub-basin grades from fresh marsh in the northern part of the sub-basin to saline marsh near the bays, but is dominated by brackish (71,000 acres) and saline (153,000 acres) marsh types.

As seen on Table 8, the probability of salt water intrusion reoccurring each year in Terrebonne Parish is likely, with a percentage range of 35% to 74%. NCDC does not track salt water intrusion data, but because of the many bayous, coulees, rivers, and bays found in the Parish and because it is a coastal Parish, we expect salt water intrusion to likely reoccur. The probability of saltwater intrusion in the Terrebonne Basin is relatively high, unless structural changes are made and management systems are put in place to continue appropriate abatement techniques.

Exposure - Location

In the late 1950's, the Mississippi River-Gulf Outlet shipping channel (MRGO) was dredged. As a result, massive amounts of saltwater entered the Lake Pontchartrain Basin system, killing vegetation and causing erosion of wetlands. Over 5000 acres of productive coastal wetlands have been lost in the Lake Pontchartrain Basin due to saltwater intrusion from the MRGO.

If pumpage from a coastal aquifer exceeds the natural flow to the sea, saltwater will continue to move inland until it reaches the pumping wells.

Of the four sub-basins, only the Fields Sub-basin experiences problems which are local and relatively minor. The Timbalier Sub-basin experiences substantial subsidence and is essentially isolated from major freshwater and sediment inputs. Marsh loss rates are high due to the resulting sediment deficit, saltwater intrusion along the Houma Navigation Canal and other canals, historic oil and gas activity, and natural deterioration of barrier islands, which contributes to the inland invasion of marine tidal processes (including erosion and saltwater intrusion). The sub-basin is rapidly converting to an open estuary.

In recent years, the Penchant and Verret Sub-basins have experienced significant freshwater impacts from the Atchafalaya River. Historic wetlands loss resulting from subsidence, saltwater intrusion, and oil and gas activity appears to have moderated, but areas of cypress swamp (Verret) and flotant marsh (Penchant) are experiencing stress from high water levels in the Penchant Sub-basin, the use of freshwater and sediment resources is not being maximized.

The Terrebonne Basin covers approximately 1,712,500 acres of southern Louisiana, including about 728,700 acres of wetlands. About 96% of the wetlands in the Terrebonne Basin are privately owned. Recently a 4,618-care Mandalay National Wildlife Refuge was established and located in the Lake Hatch area of central Terrebonne Basin. State-owned land is represented by wildlife management areas (WMA's) and refuges covering about 28,244 acres in the southeastern basin.

The U.S. Army Corps of Engineers has constructed and maintains navigation channels in the Terrebonne Basin, which cross sensitive wetland areas. Vessel traffic in the channels is a major source of erosion in wetland areas. These channels also provide an avenue for saltwater intrusion into fragile wetland areas, thereby changing the salinity and nature of these wetlands and leading to deterioration and conversion to open water.

Subsidence occurs at different rates throughout the inactive deltaic plain as unconsolidated sediment dewaters and compacts. Subsidence in the Terrebonne Basin is among the highest in Louisiana at 0.42 inches/year. As subsidence occurs, flooding in wetlands increases, contributing to marsh loss. Subsidence also impacts the Terrebonne Basin's barrier island chains (Isles Dernieres and Timbalier Islands) that potentially provide protection to fragile inland wetlands. These islands absorb the impact of wave action from the Gulf of Mexico and potentially inhibit erosion of inland shorelines. As these islands shrink from subsidence, inland wetlands may become more vulnerable to the erosive forces of the Gulf of Mexico. Hurricane Andrew in 1992 had a severe impact on these islands.

An abundant supply of fresh water and sediment is an important component to the health of wetlands in the Terrebonne Basin. These resources are supplied to the northern and western areas of the basin by the Atchafalaya River. The formation of the deep organic soils of this basin is a result of vegetative deposition, typically below ground with very limited mineral matter. The primary source of fresh water to the Timbalier sub-basin is precipitation, which averages 65 inches/year in this area. On average, precipitation is greater than evaporation;

however, in the summer months evaporation exceeds precipitation. Sediment input into the southeast Terrebonne Basin occurs only when the Atchafalaya River stage is high and river waters flow down the Houma Navigation Canal. These inputs are small relative to the substantial influence of saltwater intrusion and high subsidence rates in the area. Overall, the southern basin has the most limited freshwater resources and sediment influx in the entire inactive deltaic plain. The absence of overflows from the riverine sources accounts for these freshwater and sediment deficits.

Consequences – Extent and Previous Occurrences

The hydrology of the Terrebonne Basin has been severely influenced by construction of canals and levees. As a result saltwater intrusion has occurred and has led to erosion and ultimate conversion of many areas from fresh marsh to salt marsh or open bodies of water. Barrier islands have also been impacted by erosion. As these islands have absorbed the wave energy of the Gulf of Mexico, they have continued to erode away.

Since 1932, the Terrebonne Basin has lost approximately 20% of its wetlands. Current loss rates range from approximately 4,500 to 6,500 acres/year. This loss amounts to up to 130,000 acres during the next 20 years. One-third of the Terrebonne Basin's remaining wetlands would be lost to open water by the year 2040. Losses would be concentrated in the lower basin, where Timbalier Bay could become open to the Gulf of Mexico and the existing shoreline could retreat as much as 10 miles north.

Project implementation in the Terrebonne Basin to date has focused on rebuilding barrier islands and creating, protecting, and restoring wetlands in localized areas. Since no projects have been completed in the Terrebonne Basin, there are no results of project performance. Once completed, almost 7,000 acres are anticipated to directly benefit from wetland creation, restoration, and protection through CWPPRA. Additional indirect benefits may include mainland marsh protection resulting from the CWPPRA barrier island projects.
Source: http://www.lacoast.gov/cwppra/projects/terrebonne/index.asp

With no action, the Timbalier Subbasin will become 75 percent (or more) open water, with the shore reaching as far north as the suburbs of Houma. In the Penchant Sub-basin, losses will likely be concentrated in the northern and central sectors, further exposing areas of open water and broken marsh. The inefficient use of Atchafalaya fresh water and sediments will continue to squander this significant resource. With continued high marsh losses, biological productivity and diversity will decrease. With loss of critical habitat for commercially and recreationally important fish, shellfish, and furbearers, as well as for endangered species, fish and wildlife dependent economic activities will decline. Flooding problems will increasingly impact economic activities throughout the Terrebonne Basin, leading to grave consequences for the oil and gas industry and for other human infrastructure.

Mitigation Approaches

This critical problem of saltwater intrusion requires proper management to protect the ground water resources. Four basic components are necessary to properly manage the ground water resources against saltwater intrusion. These four components include:

- Measurement: The existing conditions must be characterized so that there is an adequate understanding of both the hydrogeologic conditions and a reasonably detailed spatial characterization of the saltwater interface.

- Monitoring: A monitoring program must be established that will monitor conditions and provide a reasonably accurate assessment of the changes in the saltwater interface with time. This can be accomplished by accurately selecting the location of monitoring wells and providing a sufficient screen length to monitor the changes in the saltwater interface.
- Modeling: There must be a means of assessing and modeling to provide predictive long-term behavior of the saltwater interface in response to changes in population, water use, rainfall, and other actions which impact ground water.

- Modification: The predictive results must be utilized to modify the pumping and control runoff or consider re-injection of waste water to maintain the freshwater head to prevent the further encroachment of saltwater.

Various strategies may be employed to retard saltwater movement including:

- Limiting pumping and time share pumping from a number of wells. A redesign of the well field may be necessary in some cases

- Re-injection of waste water near the saltwater interface to aid in maintaining a sufficient head of fresh water.

These four tasks; measurement, monitoring, modeling and modification must be accomplished on a cost effective basis with a strong emphasis on a systems approach to tie all of the components together. The information needs to be utilized and acted on in a timely and intelligent manner to effectively protect the ground water resource. When properly done this approach can assure island and coastal communities of maximum utilization of their ground water resources at a minimal long term cost.
Source: http://www.technos-inc.com/TECHSALT.HTM

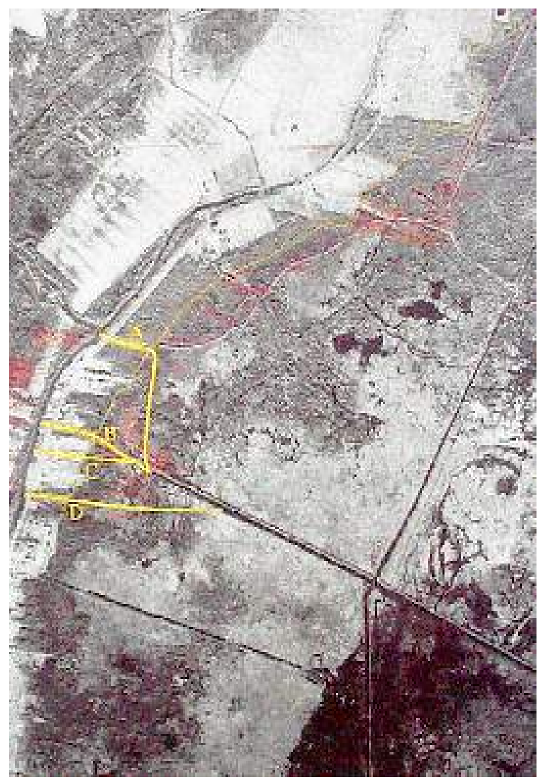
In the Timbalier Subbasin, protection and restoration of the barrier islands (Isles Dernieres and Timbalier Islands) requires immediate and extensive action, because these landforms provide protection for mainland marshes, and destruction of many of the islands is imminent. Interior marshes will also be protected through a hydrologic restoration zone which will be developed in the vicinity of the independently proposed Terrebonne Parish Comprehensive Hurricane Protection system. In this zone, fresh water and sediment will be used along with marsh protection and passive hydrologic restoration structures to enhance and restore overland and sinuous channel flow. A related action in the Timbalier Subbasin is a proposed barrier to saltwater intrusion in the Houma Navigation Canal.

In the Penchant Subbasin, Atchafalaya River fresh water, sediment, and nutrients will be better utilized through hydrologic restoration to protect marshes and reduce loss rates. To the extent possible, actions will restore historic flow patterns and conveyance channels and improve the distribution of sediment-laden water. These actions in Timbalier and Penchant are considered critical for short-term implementation. At least one major diversion would be built from the Atchafalaya River to bring fresh water and sediment into the subbasin. This is contingent upon adequate addressing of flood problems in the subbasin.

Because these actions will not cover all areas of concern, a supporting short-term strategy is to consider site-specific, small-scale projects in all subbasins where there is a critical need for wetlands protection or restoration, or a significant opportunity for wetlands creation. In the short term, demonstration and pilot projects must also be conducted to develop or test methods and approaches needed for implementing long-term strategies.

In the Timbalier Subbasin, long-term restoration depends on cost-effective importation of sediment by diversions or dedicated dredging, which makes demonstration of sediment extraction, transport, and placement technologies a priority. In addition, the possibility of diverting Mississippi River water and sediment into Bayou Lafourche as a conduit to the Timbalier Subbasin (as well as to the Barataria Basin) must be evaluated.

In the Verret Subbasin, pumping to lower water levels is required to protect the swamp forests. This is a long-term strategy, because significant planning activities must precede its implementation. In addition, this action cannot occur until provisions are made for managing outfalls in ways which will not exacerbate flooding in the Penchant Subbasin.



Source: http://www.lacoast.gov/reports/index.htm

In summary, the Terrebonne Basin Plan includes both a short-term and a long-term phase. The short-term phase focuses on immediate actions needed to protect vulnerable marshes from the proximal causes of loss in the Terrebonne Basin (saltwater intrusion, erosion, and other consequences of significant hydrologic modifications) using a combination of restoration techniques (especially hydrologic restoration and small-scale marsh creation) in the most critical areas or key locations, and barrier island protection. Successful implementation of short-term strategies will reduce rates of wetlands loss, and will provide the foundation for longer-term strategies. The long-term phase focuses on wetlands gains through sediment diversion and import, with the intent of encouraging development of a sustainable wetland ecosystem. Long-term strategies are critical to addressing the primary problem of sediment starvation associated with high subsidence and loss of fluvial inputs, and to achieving no net loss of wetlands in the basin.

In the Penchant Subbasin, implementation of the short-term phase of the selected plan, including both critical and supporting projects, will avert or offset approximately 55 percent of the predicted loss. After hydrologic restoration is in place and flood control problems are addressed, the long-term strategy of diverting substantial amounts of Atchafalaya River water and sediment into the subbasin can be implemented, conceivably leading to no net loss of wetlands.

The Lake Boudreaux Basin Freshwater Introduction Project located in Terrebonne Parish is funded through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) with the United States Fish and Wildlife Service (USFWS) acting as the Federal sponsor and the Louisiana Department of Natural Resources/Coastal Restoration Division (LDNR) acting as the local sponsor. The project purpose is to seasonally divert freshwater from the Houma Navigation Canal into the upper reaches of Lake Boudreaux to reduce saltwater intrusion and promote and nourish vegetative diversity within the project area. The project's general boundaries are shown in the picture to the right. The project is divided into two parts; the Terrebonne Parish Consolidated Government (TPCG) Forced Drainage System and the Lake Boudreaux Freshwater Introduction System. The project is located in Terrebonne Parish approximately 5 miles southwest of Chauvin. The area is suffering from a lack of freshwater, which is insufficient to reduce the negative effects of saltwater intrusion.

Project plans are to: enlarge 6,700 feet of Bayou Pelto to 100 feet wide by 8 feet deep; dredge 3,200 feet of outfall channel to 100 feet wide by 8 feet deep; install a major water control structure in the outfall canal consisting of seven 8-foot-wide by 8-foot deep sluice gates, build a bridge for Louisiana Highway 57 over the outfall canal; construct approximately six small water management structures; and provide flood protection for developed areas extending north of Canebrake Subdivision to the Grand Caillou Elementary School.

The Terrebonne Parish Consolidated Government (TPCG) forced drainage system will consist of a levee approximately 20,000 feet in length (pending acquisition of land rights) located between Canebrake Subdivision and St. Louis Canal, and a new pump station. The levee will be divided into two separate drainage systems by a conveyance channel as described in Lake Boudreaux Freshwater Introduction System. The levee system south of the conveyance channel will be tied into the Canebrake Subdivision levee with effluent being discharged from the Suzie Canal Extension Pump Station being built by the TPCG. Effluent from the levee system north of the conveyance channel to the St. Louis Canal will be discharged through the new pump station located approximately at the midway point.

The goal of the Lake Boudreaux Freshwater System is to reduce the deterioration and loss of coastal marshes north of Lake Boudreaux through the introduction of freshwater, sediments and nutrients from the Houma Navigation Canal (HNC), improving basin hydrology, lowering saltwater intrusion, and reducing tidal fluctuations in the Lake Boudreaux basin. To accomplish this, Bayou Pelto will be dredged from the HNC to Bayou Grand Caillou and if needed, dredging will continue east and north of the Koch Pipeline. A conveyance channel will be dug from Bayou Grand Caillou north and parallel to the Koch pipeline into the Lake Boudreaux marsh. An automated water control structure will be constructed near Highway 57 along with several water management structures at key locations in the basin to maintain target flows and water levels.

To introduce freshwater into the Lake Boudreaux basin the following tasks are required:

- Hydrologic modeling of the Lake Boudreaux Basin will require a substantial amount of surveys. The hydrographic surveys will determine shoreline and depths of lakes, streams, bayous, and other bodies of water for the purpose of hydraulic modeling.
- Design, construction and dredging of Bayou Pelto from the HNC proceeding eastward approximately 6,400 feet to the intersection of Bayou Pelto and Bayou Grand Caillou. From there, dredging will continue east through a conveyance channel to the intersection of the North-South Pipeline Canal.
- Design, construction and excavation of a conveyance channel from Bayou Grand Caillou parallel to the Koch Pipeline Canal will penetrate east into the Lake Boudreaux marsh.
- Design and construction of a fixed two-lane concrete bridge with shoulders on Highway 57 to span the conveyance canal.
- Design and construction of an automated water control structure in the conveyance channel near the fixed concrete bridge as required by the hydrologic model. The structure will provide for maximum freshwater inflow, prevent freshwater back flow loss, and preclude saltwater intrusion.

- Design and construction of two water management structures, as required by the hydrologic model. The first structure will be located in a pipeline canal north of Bayou Butler and the second along Bayou La Carpe.

A preliminary survey conducted in January 2003 of landowners potentially affected by the construction of the proposed conveyance channel has indicated that they would generally accept project construction provided there was sufficient compensation for impacts to property usage and values. If land rights for the preferred conveyance channel route cannot be obtained, the conveyance channel will be re-located to properties where landowners have already voiced approval.

Installation of additional water level monitoring stations and elevation surveys of existing and proposed monitoring stations are underway. The resulting data will enable engineers to more accurately estimate the project's freshwater introduction rates and the project-induced water level rise in the receiving area and in Bayou Grand Caillou. Successful implementation of short-term strategies will reduce rates of wetlands loss, and will provide the foundation for longer-term strategies. The long-term phase focuses on wetlands gains through sediment diversion and import, with the intent of encouraging development of a sustainable wetland ecosystem. Long-term strategies are critical to addressing the primary problem of sediment starvation associated with high subsidence and loss of fluvial inputs, and to achieving no net loss of wetlands in the Basins.

Based on these considerations, it was determined that there are no existing cost effective mitigation actions for salt water intrusion; therefore, no additional mitigation actions will be pursued at this time. The risk of this hazard to the community will be reassessed during the five year update process.

4.3.1.8 Expansive Soils

Soils and soft rock that tend to swell or shrink due to changes in moisture content are commonly known as expansive soils. Changes in soil volume present a hazard primarily to structures built on top of expansive soils. The most extensive damage occurs to highways and streets.

Hazard Identification

“Clay” is defined as a natural, earthy, fine-grained material that develops plasticity when mixed with a limited amount of water. A swelling clay is a clay that is capable of absorbing large quantities of water, thus increasing greatly in volume.

Variations in moisture content and volume changes are greatest in clays found in regions of moderate to high precipitation, where prolonged periods of drought are followed by long periods of rainfall. It is in these regions, which include many of the

Southern, Central, and Western States, that swelling of clays resulting from climatic fluctuations cause the most severe engineering problems.

Risk Assessment

Probability and Frequency

The risk associated with expansive soils is related to swelling potential in a qualitative manner: high, moderate to slight, and little to no swelling potential.

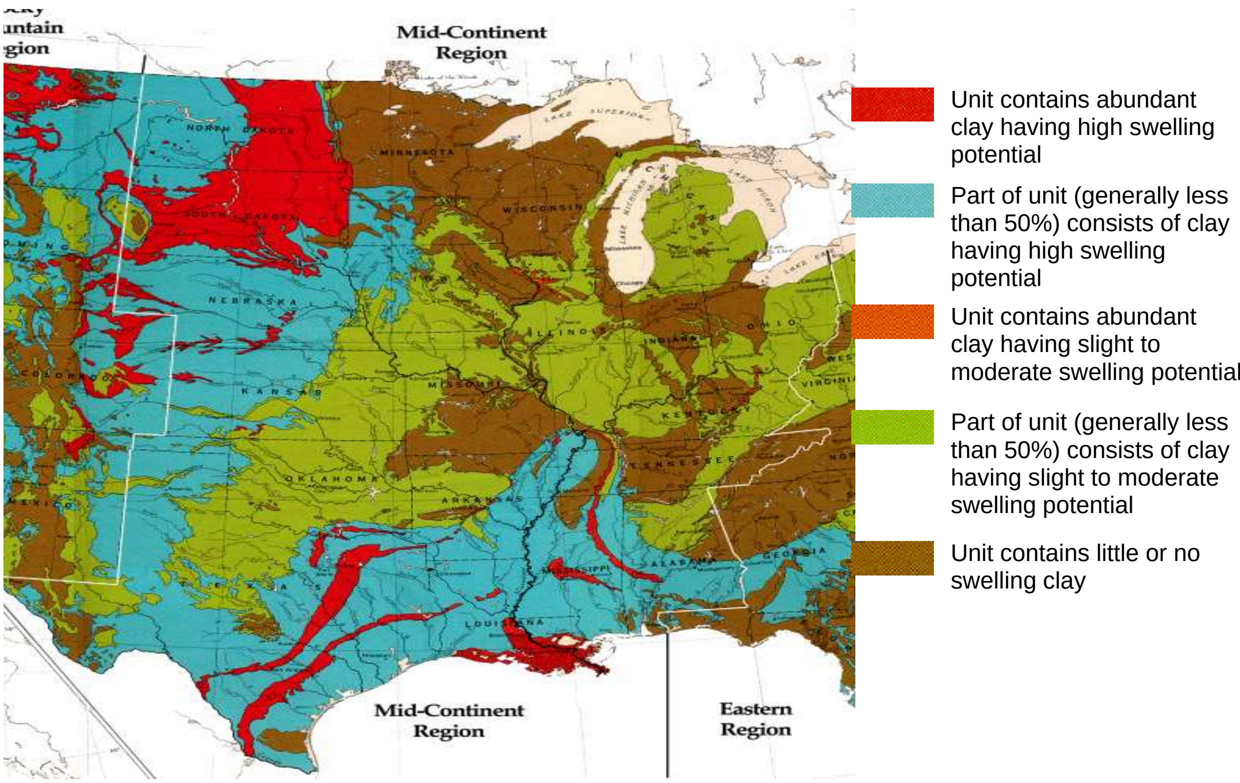
As seen on Table 8, the probability of expansive soils reoccurring each year in Terrebonne Parish is likely, with a percentage range of 35% to 74%. NCDC's does not track expansive soils data, but because of the soil types found in Terrebonne Parish, we expect expansive soils to likely reoccur. Many of the soil types found in Terrebonne Parish contain large amounts of clay.

Based on the map on the next page the entire Parish soil type is composed of abundant clay having high selling potential. Therefore one would expect expansive soils to be an ongoing problem with in the parish.

Exposure - Location

The availability of data on expansive soils varies greatly. In or near metropolitan centers and at dam sites, abundant information on the amount of clay generally is available. However, for large areas of the United States, little information is reported other than field observations of the physical characteristics of clay of a particular stratigraphic unit. Therefore, fixed criteria for determining the swelling potential have not been devised. However, one method that was devised in 1989 was based mostly on numerous published descriptions of the physical and mineralogical properties of clays. Using this classification system, one sees that the southeastern portion of Louisiana, primarily along the Mississippi River from about East Baton Rouge Parish to the mouth of the Mississippi River, is abundant with high swelling potential clays.

Clays in the Quaternary alluvium of the lower Mississippi River valley in Louisiana are reported to be of the "montmorillonite type". Clayey soils of the alluvial valley have high "shrink-swell capacity," and foundation problems in the area are associated with changing water levels and the instability of clayey soils. Foundation failures in alluvial deposits of the Mississippi River valley are common.



These maps are sourced from the U.S. Geological Survey publication "Swelling Clays Map Of The Conterminous United States" by W.W. Olive, A.F. Chleborad, C.W. Frahme, Julius Schlocker, R.R. Schneider, and R.L Shuster; 1989

In the Mid-continent region, swelling clays that have caused the greatest amount of damage are contained in stratigraphic sequences ranging in age from Cretaceous to Quaternary, and are exposed in an area extending along the Gulf Coast from east-central Texas to Alabama. In this area, clay deposits with high swelling potential are thick, numerous, and extensive, and climatic conditions are conducive to large volume changes.

The entire Parish is at risk from expansive soils. Expansive soils affect Terrebonne Parish equally and uniformly.

Consequences – Extent and Previous Occurrences

Clay, as a basic soil, consists of mineral soil particles that are less than 0.002 millimeter in diameter. The estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt and clay affects the physical behavior of a soil. Particle size is important for determination of soil hydrologic qualities and for soil classification. The amount and kind of clay can affect the fertility and physical condition of the soil and the ability of the soil to adsorb and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

See Table 17 below for the types of soils found in Terrebonne Parish, what percentage of each types contain clay, the shrink –swell potential, and how many acres there are for each of those soil types. Clay, as a basic soil, consists of mineral soil particles that are less than 0.002 millimeter in diameter. The estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt and clay affects the physical behavior of a soil. Particle size is important for determination of soil hydrologic qualities and for soil classification. The amount and kind of clay can affect the fertility and physical condition of the soil and the ability of the soil to adsorb and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Linear extensibility is used to determine the shrink-swell potential of soils. It refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod and oven dryness. The amount and type of clay minerals in the soil influence volume change. The shrink swell potential is also affected by the size of each clay particle. Shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots.

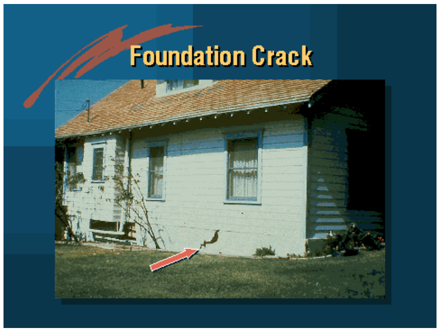
Table 17

Soil Expansion Potential for Terrebonne Parish				
Soil Name	**Soil Symbol**	**Clay Percentage**	**Shrink – Swell Potential**	**Number of Acres**
Allemands Muck, Drained	Ae	60-95	High	6,292
Aquents	AQ			280
Allemands Muck	AR	60-95	Low	5,141
Barbary Muck	BB	45-90	High	9,404
Clovelly Muck	CE	50-90	Low	28
Cancienne Silt Loam	Cm	14-27	Moderate	10,178
Cancienne and Gramercy Silty Clay Loam	Co	27-39	Moderate	5,282
Cancienne and Carville	CR	27-39	Moderate	5
Cancienne and Schriever	CS	14-27	Moderate	1,102
Dumps	Dp			291
Felicity Loamy Fine Sand, Occasionally Flooded	FA	3-10	Low	1,027
Felicity Loamy Fine Sand,	FE	5-27	Moderate	1

Frequently Flooded				
Harahan Clay	Ha	50-95	Very High	7,620
Kenner Muck, Drained	Ka		Low	10,555
Kenner Muck	KE	45-85	Low	21,834
Lafitte – Clovelly	LA	30-85	Low	49,065
Larose Muck	LR	50-80	Low	583
Arents and Aquents	LV			587
Scatlake Muck	SC	27-60	Moderate	5,198
Schriever Silty Clay Loam	Sh	27-35	High	4,015
Schriever Clay	Sk	40-60	High	16,664
Timbalier and Scatlake	TM	50-80	Moderate	3,861
Udorthents	Ud			4
Vacherie Silt Loam	VA	10-18	Low	2,124
Water, Large	W			216,491
Westwego Clay	Ww	50-95	High	9,768

Absence of an entry indicates that the feature is not a concern or that data was not estimated at this time.
Source: http://soildatamart.nrcs.usda.gov/Default.aspx

Most engineering problems caused by volume changes in swelling clays result from human activities that modify the local environment. They commonly involve swelling clays beneath areas covered by buildings and slabs or layers of concrete and asphalt, such as those used in construction of highways, canal linings, walkways, and airport runways. The most obvious manifestations of damage to buildings are sticking doors, uneven floors, and cracked foundations, floors, walls, ceilings, and windows.



In Terrebonne Parish, expansive soils have caused extensive damage to building foundations, walls and ceilings in the past. Due to continued heavy rains, followed by lack of rain for a long period of time, one would expect to see ongoing problems from expansive soils in the future.

Other sources, such as newspaper archives were used to determine previous occurrences and extent for expansive soils, and the Steering Committee could not provide any additional information about specific expansive soil sites. An attempt was made to retrieve past events information including dates, damage and location, but due to data limitations this data is not available. This hazard will be pursued further in the next update.

Mitigation Approaches

The best means to prevent or reduce damage from expansive soils is avoidance. However, as in Terrebonne Parish, that is often not possible. When such is the case, engineering practices are necessary. The most commonly applied engineered practices are removal of the soil, application of heavy loads, preventing access to water, presetting, and stabilization.

Terrebonne Parish recognizes expansive soils as a hazard. The parish implements building codes which provide some measure of mitigation for this hazard. Other mitigation efforts considered by the steering committee were based on applied engineering practices which consisted of the removal of the soil, application of heavy loads, preventing access to water, presetting, and stabilization. These efforts were evaluated using the STAPLEE criteria and were found unfeasible for the reasons listed below.

- The removal of the expansive soil is not an option in many areas of the Parish due to its extensive nature, significant depth, and widespread location. Such activities would not be economical.
- The other engineering principles although may be feasible on a small scale, i.e. a new construction site, they are not feasible to apply Parish - wide, except through the use of building codes, which are currently being implemented.

Based on these considerations, it was determined that no additional mitigation actions will be pursued for expansive soils at this time. The risk of this hazard to the community will be reassessed during the five year update process.

4.3.1.9 Hailstorms

Hazard Identification

A hailstorm is an outgrowth of a severe thunderstorm in which balls of irregularly shaped lumps of ice greater than 0.75 inches in diameter fall with rain. The size of hailstones is a direct function of the severity and size of the storm.

Risk Assessment

Hailstorms occur more frequently during the late spring and early summer, when the jet stream migrates northward across the Great Plains. This period has extreme temperature changes from the ground surface upward into the jet stream, which produces the strong updraft winds needed for hail formation.

Probability and Frequency

Data on the probability and frequency of occurrence of hailstorms is limited, with little recent research. What data that is available shows that only a localized area along the border of northern Colorado and southern Wyoming experiences hailstorms 8 or more days each year. Outside of the coastal regions, most of the United States experiences hailstorms at least 2 or more days each year.

As seen on Table 8, the probability of hailstorms reoccurring each year in Terrebonne Parish is possible, with a percentage range of 10% to 34%. NCDC's data indicates that there have been 11 hailstorms in Terrebonne Parish since

1964. Therefore, the data yields a 27% reoccurrence rate. See Table 18 below for a summary of the varying size of hail and number of events that Terrebonne Parish has experienced.

Table 18

Hail Size Summary	
Size of Hail	**Number of Events**
.75 inches	5
1.75 inches	6

Therefore, the most common size hailstorm event that Terrebonne Parish has experienced is 1.75 inches, with 55% of hail events 1.75 inches in size. The size of the hail is a direct function of the severity and size of the storm. The duration of each storm varies but rarely longer than a couple of hours.

Exposure - Location

Peak periods for hailstorms, late spring and early summer coincided with the Midwest's peak agricultural seasons for crops such as wheat, corn, barley, oats, rye, tobacco, and fruit trees. Long-stemmed vegetation is particularly vulnerable to damage by hail impacts and winds. Severe hailstorms also cause considerable damage to buildings and automobiles, but rarely result in loss of life.

The land area affected by individual hail events is not much smaller than that of a parent thunderstorm, an average of 15 miles in diameter around the center of a storm.

Hailstorms affect Terrebonne Parish equally and uniformly and the entire Parish is at risk from hailstorms.

Consequences – Extent and Previous Occurrences

The development of hailstorms from thunderstorm events causes nearly $1 billion in property and crop damage each year.

The NCDC recorded 12 hail events in Terrebonne Parish from 1950 to 2005. These events produced hail ranging from 0.75 inches in diameter to 1.75 inches in diameter. On March 18, 2000, Houma received damage caused by golf ball size hail. Roofs and automobiles were damaged by the hail. No Federally-declared disasters from hail have occurred in the parish.

Significant events are summarized below:

- On October 1, 1997, the Terrebonne Sheriff's Office reported that hail up to the size of quarters fell.
- On March 6, 1998 – Fire department personnel near Bayou Blue reported large hail. In addition heavy rain of 2.5 inches fell in 1 to 2 hours.
- On March 18, 2000 - Golf ball size hail fell on the west side of Houma.

No federally declared disasters from hail have occurred in the Parish.

Mitigation Approaches

Terrebonne Parish recognizes hail storms as a hazard and currently participates in ongoing efforts to mitigate its effects. To the extent practicable, early warning notification and building codes are implemented. No other mitigation measures were identified by the Steering Committee.

Based on these considerations, it was determined that no additional mitigation actions will be pursued for hailstorms at this time. The risk of this hazard to the community will be reassessed during the five year update process.

4.3.1.10 Drought

Drought originates from a deficiency of precipitation over an extended period of time, occurring any time of the year, resulting in a water shortage for some activity, group, or environmental sector. Its impact is far reaching; including potential for forest fires, destruction of agricultural crops, and reduction of surface and subsurface water supplies.

Hazard Identification

Drought should not be viewed as merely a physical phenomenon or natural event. Its impacts on society result from the interplay between a natural event (less precipitation than expected resulting from natural climatic variability) and the demand people place on water supply. Human beings often exacerbate the impact of drought. Recent droughts in both developing and developed countries and the resulting economic and environmental impacts and personal hardships have underscored the vulnerability of all societies to this “natural” hazard.

Risk Assessment

Probability and Frequency

The probability of a drought occurring in a specific region depends on certain atmospheric and climatic conditions. Duration and frequency can be used as indicators of potential severity.

As seen on Table 8, the probability of a drought event reoccurring each year in Terrebonne Parish is possible, with a percentage range of 10% to 34%. NCDC recorded no droughts in Terrebonne Parish from 1950 to 2005, although drought-like conditions did occur in Terrebonne Parish in the summer of 2000, yielding a 20% reoccurrence rate over the last five years.

Exposure - Location

Droughts may occur anywhere in the United States. Effects seen in different regions vary depending on normal meteorological conditions such as precipitation and temperature, as well as geological conditions such as soil type and subsurface water levels.

Drought events affect Terrebonne Parish equally and uniformly and the entire Parish is at risk from drought events.

Consequences – Extent and Consequences

Drought produces a complex web of impacts that spans many sectors of the economy and reaches well beyond the area experiencing physical drought. This complexity exists because water is integral to our ability to produce goods and provide services. Impacts are commonly referred to as direct or indirect. Reduced crop, rangeland, and forest productivity; increased fire hazard; reduced water levels; increased livestock and wildlife mortality rates; and damage to wildlife and fish habitat are a few examples of direct impacts. The consequences of these impacts illustrate indirect impacts. For example, a reduction in crop, rangeland, and forest productivity may result in reduced income for farmers and agribusiness, increased prices for food and timber, unemployment, reduced tax revenues because of reduced expenditures, increased crime, foreclosures on bank loans to farmers and businesses, migration, and disaster relief programs.

In 2000, heat was the number one killer out of all hazards reported to the National Weather Service, with 158 fatalities. Seniors are most at risk from heat. In 2000, individuals between the ages of 50 and 89 accounted for 73% of the year’s fatalities. The National Weather Service reported twelve (12) deaths in Louisiana in 2000. All twelve (12) were reported as occurring in a permanent home without air conditioning or adequate ventilation. One death was reported in Terrebonne Parish.

From 1998 to 2001, Terrebonne Parish experienced severe drought conditions. Area rivers and lakes fell to well below normal levels with water users urged to conserve. Agriculture and forestry were especially hard hit. Crops were the hardest hit with rice, sugarcane, hay, and potatoes, totaling over half of the total dollar loss.

The NCDC recorded no droughts in Terrebonne Parish from 1950 to 2005, although drought-like conditions did occur in the summer of 2000. The significant event is summarized below:

- Summer of 2000 - Only 38.10" of rain was recorded, which is 23" below normal for the year of 2000. It was the 2nd driest year of record since 1946. The Parish experienced many grass fires which resulted in agricultural and forestry losses. The Parish passed a no burning ordinance, which banned the burning trash.

No federally declared disasters for drought have occurred in Terrebonne Parish.

Drought can cause extensive damage to commercial and residential structures' foundations, framing and walls, agricultural crops, roads, bridges, pipelines, utilities and railroads.

Mitigation Approaches

Terrebonne Parish recognizes drought as a hazard and currently participates in ongoing efforts to mitigate its effects. The parish conducts public education activities. Other mitigation efforts considered by the steering committee included technical assistance and a drought contingency plan. These efforts were evaluated using the STAPLEE criteria and were found unfeasible for the reasons listed below:

- It was determined by the Steering Committee that technical assistance is already provided by the County Agent and Agricultural Extension Services. Therefore, no additional assistance is deemed necessary at this time.
- Because drought predominantly affects agricultural resources the Steering Committee felt that drought planning is best conducted by agricultural agents and not the Parish.

Based on these considerations, it was determined that no additional mitigation actions will be pursued for drought at this time. The risk of this hazard to the community will be reassessed during the five year update process.

4.3.1.11 Winter Storms

Winter storms are known to spawn other natural hazards, such as coastal flooding and erosion, severe thunderstorms, tornadoes, high winds, and severe ice.

Hazard Identification

Winter storms typically form along a front generally following the meandering path of the jet stream. These storms, called mid-latitude cyclones or extra-tropical cyclones, differ from hurricanes, in that they move from west to east as opposed to east to west. These weather patterns carry cold air from Canada and the Rockies into the southern U.S. The origins of the weather patterns that cause winter storms in Louisiana are affected by differences in temperature and pressure, moisture availability, and wind direction as well as weather systems in the Atlantic Ocean and Gulf of Mexico.

The National Oceanic and Atmospheric Administration (NOAA) describes the jet streams that carry storm systems across the United States as narrow bands of strong wind in the upper atmosphere that follow the boundaries between hot and cold air masses. These boundaries are most pronounced during the winter months, when the jet streams travel to their southernmost position over the U.S. and surrounding water.

In the last 11 winters, no region in the United States has escaped flooding during the winter months. The Southeastern and Gulf Coast states (regularly hit by autumn hurricanes) experience damaging floods in the winter months, too. No region is immune. Global warming threatens to disrupt weather patterns around the world and may increase the frequency of winter flooding.

Many winter depressions give rise to exceptionally heavy rain and widespread flooding. Conditions worsen as the temperature drops, rain turns to ice, and accumulation of ice begins to occur.

Another weather phenomenon, El Niño, can have a significant effect on precipitation in the United States. Named by Peruvian fishermen who noticed the periodic appearance of warming surface temperatures in the Pacific Ocean around Christmas, El Niño is now understood to be the warm phase of a temperature oscillation in the Pacific Basin's water and atmosphere. The cool phase of the oscillation is nicknamed La Niña. During the warm phase, heat and moisture are released into the upper atmosphere, creating precipitation. El Niño alters the course of the jet stream - pushing it farther south than usual.

See Table 19 for the Yearly National Flood Insurance Program (NFIP) Losses from Associated with winter storms.

Table 19

Yearly NFIP Losses from Winter Flood Events			
Winter Dates	**State**	**Number of Claims**	**Claim Payments in Millions**
1992 – 1993	LA	1,799	$22.8
1993 – 1994	LA	260	$1.8

1994 – 1995	LA, TX	131	$1.2
1995 – 1996	LA	327	$4.0
1996 – 1997	LA, TX	438	$5.0
1997 – 1998	LA	1,265	$7.0
1998 – 1999	LA	474	$6.6
2000 – 2001	Region VI	121	$1.4
2001 – 2002	Region VI	278	$2.6
2002 – 2003	LA	105	$1.0

Region VI is Louisiana, Arkansas, New Mexico, Oklahoma, and Texas.
Source: Watermark 2004, Number 1

See Table 20 for NFIP Flood Losses in the months of December, January, and February.

Table 20

NFIP Winter Flood Losses (December, January, and February) December 1, 1992 through February 28, 2003		
	Number of Claims	**Claim Payment**
Total in Louisiana	4,506	$45,665,279
Occupancy		
Occupancy Single Family	4,002	$38,992,188
Occupancy 2 – 4 Family	170	$1,667,101
Other Residential	68	$1,080,013
Non - Residential	266	$3,925,977
Zone		
A	3,143	$33,562,161
V	30	$278,803
B, C, and X	1,258	$11,099,108
Other Zone	75	$725,207

Zone A: Areas of 100-year flood; base flood elevations and flood hazard factors not determined Zone V: Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined Zone B, C, and X: Areas between limits of the 100-year flood and 500-year flood; or areas protected by levees from base flood or areas of minimal flooding Source: Watermark 2004, Number 1

According to the NOAA, El Niño winters tend to be wetter than normal in the Southeastern United States, as well, and contribute to flooding along the Gulf Coast. Storms that spin up in the Gulf of Mexico typically track northeast on the southern jet stream, bringing rain as well as ice and even snow to the Gulf states.

Risk Assessment

Probability and Frequency

Freezing temperatures occurring over an extended period of time in Louisiana often result in water pipe breakage, decreases in water pressure, and disruption of water service. The weight of accumulated ice can result in load forces that can cause power lines to break and damage to infrastructure. High winds associated with winter storms also lead to extensive damage. Although severe winter storms do not occur on an annual basis, they can produce widespread devastation.

While Louisiana is far less likely to have heavy snow and ice accumulation than most other states in the U.S., winter weather is expected to occur at least once each winter. According to data from the National Climatic Data Center, Louisiana is in the lowest category of probable snow depth, 0 – 25 cm snow depth with a 5% chance of being equaled or exceeded in any given year. Louisiana winter storms that have had severe consequences for the State, have generally delivered between one and three inches of ice accumulations.

As seen on Table 8, the probability of winter storms reoccurring each year in Terrebonne Parish is possible, with a percentage range of 10% to 34%. NCDC recorded no winter storms in Terrebonne Parish from 1950 to 2005, although winter storm conditions did occur in Terrebonne Parish in the winter of 1989 and 2004, yielding a 13% reoccurrence rate, over the last 16 years.

Exposure - Location

Nearly the entire United States is considered at risk for severe winter storms. When these storms occur in the South, unprotected pipes are especially vulnerable. Disruption in water service and decreases in water pressure cause a cascading problem for emergency responders. Heavily populated areas are particularly impacted when severe winter storms disrupt communication and power due to downed lines from high winds and icing. Debris associated with heavy icing may impact utility systems and transportation routes.

Because severe winter storms are relatively rare in Louisiana, occurrences tend to be very disruptive to transportation and commerce. Trees, cars, roads, and other surfaces develop a coating or glaze of ice making even small accumulations of ice an extreme hazard to motorists and pedestrians. The most prevalent impacts of heavy accumulations of ice are slippery roads and walkways, collapsed roofs from fallen trees, telephone poles and lines, electrical wires, and communication towers. As a result of severe winter storms, telecommunications and power can be disrupted for days.

Winter storms affect Terrebonne Parish equally and uniformly and the entire Parish is at risk from winter storms.

Consequences – Extent and Previous Occurrences

Louisiana has had several overwhelming bouts of winter weather. In February 1994, a severe winter storm spread freezing rain across the northern third of the State. Ice accumulations of two to three inches thick combined with gusty winds snapped power lines, power poles, and trees. Over 100,000 persons were without electrical power for several days, and more than 256,000 acres of forest were damaged by icing. The State suffered an estimated $13.5 million in damages.

Winter storms within a two-week period in December 2000 caused similar damage, causing over 250,000 persons to be without power, primarily in north Louisiana. With millions of dollars in damages and one death attributed to the storms, eight Parishes within Louisiana received presidential disaster declarations.

The NCDC recorded no winter storms in Terrebonne Parish from 1950 to 2005, although winter storm conditions did occur in the winter of 1989 and 2004. The significant events are summarized below:

- December 23, 1989 - Sleet, snow and freezing rain caused various road and bridge closures. Over half of the infrastructures were closed and since the two high rise bridges do not have freeze protection, the only access across the Intercoastal Waterway was the Pontoon bridge at Bayou Blue.

- December 25, 2004 - A mixture of sleet and snow fell off and on during much of Christmas day resulting in a dusting to one half inch of accumulation across much of east central and southeast Louisiana. The heaviest sleet and snow accumulation occurred south of New Orleans where one half to one inch was observed. While amounts were not heavy, accumulation of winter precipitation in extreme southeast Louisiana is very unusual and resulted in considerable transportation problems. Many bridges, overpasses, and other elevated roadways become icy which resulted in some traffic accidents, and many of the elevated roadways were closed due to icing. New Orleans Armstrong International Airport was also closed for several hours due to icing conditions

Other sources, such as newspaper archives were used to determine previous occurrences and extent for winter storms, and the Steering Committee could not provide any additional information about specific winter storm events. There were data limitations and this data was not available.

According to Table 4, Federally Declared Disasters, Terrebonne Parish has not had any serious winter storms. Since Terrebonne Parish is located in southern Louisiana, it is not affected as significantly by winter storms. We have experienced very few occurrences of winter storms.

Mitigation Approaches

Terrebonne Parish recognizes winter storms as a hazard and currently participates in ongoing efforts to mitigate its effects. The parish currently implements building codes, maintains generators, utilizes response resources, i.e. salt and sand, and coordinates with local utility companies to maintain the tree line along the utility lines. No other mitigation measures were identified by the Steering Committee.

Based on these considerations, it was determined that no additional mitigation actions will be pursued for winter storms at this time. The risk of this hazard to the community will be reassessed during the five year update process.

4.3.2 Vulnerability of Structures and Critical Facilities within the Parish

In order to inventory assets in the parish, the Steering Committee used the method described in FEMA's How to Guide entitled, "Understanding Your Risks; Identifying Hazards and Estimating Losses." This method calls for using HAZUS 99 software to determine the total number and value of buildings and people in both the entire Parish and in the hazard area. This information was compiled and is found in the Parish-wide Asset Inventory Worksheet located in Appendix K.

Table 21 below provides an estimate of the percent of the Parish that could be impacted by a hazard at any one time.

Table 21

Estimated Percent of Parish That Could Be Impacted By Hazards At Any One Time	
Hurricanes	50%
Floods	85%
Storm Surge	50%
Thunderstorms/Lightning/High Winds	60%
Tornadoes	40%
Land Subsidence	45%
Saltwater intrusion	35%
Expansive Soils	45%
Hailstorms	25%
Drought	0% - Impact Negligible on structures
Winter Storms	25%

Table 22 is a summary of Appendix K. The structure count and dollar worth of those structures, parish-wide, were taken from HAZUS. Then, based off the percentage of potential damage from Table 21, a dollar amount of damage Parish–wide was determined. See Table 22 for the potential dollar losses to the Parish from each hazard based on the percentages found in Table 21. The potential losses include residential properties, commercial, religious/non-profit, government, and educational facilities. It is unlikely that a hazard would occur that would adversely affect all of them at the same time, but the potential for this level of damage exists.

Table 22

Potential Dollar Losses to Terrebonne Parish					
Hazards	Potential Losses				
	Residential	Commercial	Religious / Non-Profit	Government	Education
Hurricanes	$2,269,528,481	$473,136,454	$63,268,101	$15,873,4080	$158,826,850
Floods	$3,858,198,417	$804,331,972	$107,555,772	$26,984,794	$270,005,645
Storm Surge	$2,269,528,481	$473,136,454	$63,268,101	$15,873,408	$158,826,850
Thunderstorm /Lightning/ High Winds	$2,739,155,653	$423,002,790	$74,984,416	$11,453,580	$190,592,220
Tornadoes	$1,815,622,784	$378,509,163	$50,614,481	$12,698,726	$127,061,480
Land Subsidence	$2,042,575,632	$425,822,809	$56,941,291	$14,286,067	$142,944,165
Saltwater Intrusion	$1,588,669,936	$331,195,518	$44,287,671	$11,111,386	$111,178,795
Expansive Soils	$2,042,575,632	$425,822,809	$56,941,291	$14,286,067	$142,944,165
Hailstorms	$1,134,764,240	$236,568,227	$31,634,051	$7,936,704	$79,413,425
Drought	$0	$0	$0	$0	$0
Winter Storms	$1,361,717,088	$283,881,872	$37,960,861	$9,524,045	$95,296,110

4.3.3 Critical Facilities

After completing the Parish-wide assessment of vulnerable assets, the Steering Committee focused its analysis on those facilities that were determined to be "critical". A critical facility is defined as a facility in either the public or private sector that provides essential products and services to the general public, is otherwise necessary to preserve the welfare and quality of life in the parish, or fulfills important public safety, emergency response, and/or disaster recovery functions. The critical facilities in the parish include police and fire stations, schools, public utilities, and municipal buildings.

See Appendix L for a detailed complete list of critical facilities. The critical facilities listed in Appendix L are all of the facilities that could be identified by the community after intensive surveying of Internet sources and community representatives. They are indicated on Maps 5, 6, 7, 8, 9, and 10.

4.3.4 Vulnerable Priority Critical Facilities

The Steering Committee further identified "priority" critical facilities as those critical facilities that are vulnerable to a hazard, if they could benefit from some type of mitigation measure, and if the loss of the facility would significantly impact the community's ability to recover from a hazard event. In addition, potential mitigation projects for each vulnerable priority critical facility are found in Appendix M.

To map the parish's critical facilities and to determine which are the most likely to be affected by hazards, the parish contractors used GIS software. The primary hazards of concern to the Parish are hurricanes, floods, storm surge, and thunderstorms with lightning and high winds. The analysis revealed the following:

- Terrebonne General Hospital is located next to a waterway and it could suffer from damages if an event occurred on the canal.
- Chabert Hospital is located next to a waterway and it could suffer from damages if an event occurred on the canal.
- North and South Sewage Treatment Plants provide a major service which could be damaged by flooding. The electrical systems serving these plants are not elevated.
- Houma and Schriever Water Treatment Plants provide a major service which could be damaged by flooding.
- Shelters are a refuge of last resort and use the Civic Center and area schools.
- The 911 Building provides a critical function and is subject to flooding.
- OEC Building provides a critical function and is subject to flooding.
- Houma Police Station is close to the Intracoastal Waterway and it could suffer from damages if an event occurred on the canal.
- Terrebonne Parish Sheriff's Department is close to the Intracoastal Waterway and it could suffer from damages if an event occurred on the canal.
- Public Works Yard stores all the response equipment and is subject to flooding.
- Pump Stations are subject to flooding.
- Publicly Owned Utilities provide power generation and gas distribution.

See Maps 2, 5, 6, 7, 8, 9, and 10 for maps of floodplains and critical facilities. See Appendix L for a list of the critical facilities.

4.3.5 Population

The U.S. Census Bureau reports that there are 31,723 housing units in Terrebonne Parish. Much of the Parish growth is situated in North and East Terrebonne. See Table 23 for Terrebonne Parish's population.

Table 23

Terrebonne Parish Population

Name	Total 2000 Population	Total 1990 Population	Total 1980 Population
Terrebonne Parish	104,503	96,982	94,393
Houma, USD	33,462	30,495	32,608
Bayou Cane, CDP	17,046	18,876	15,723
Schriever, CDP	5,880	4,958	---
Gray, CDP	4,958	4,260	---

Chauvin, CDP	3,229	3,375	3,338
Dulac, CDP	2,458	3,273	---
Montegut, CDP	1,803	---	---

Source: http://leap.ulm.edu/profiles.asp and http://factfinder.census.gov USD: Urban Service District CDP: Census Designated Place

4.4 Assessing Vulnerability: Estimating Potential Losses

Requirement 201.6(c)(2)(ii)(B):
[The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph I(2)(i)(A) of this section and a description of the methodology used to prepare the estimate…

In order to estimate the potential dollar losses to vulnerable structures, the Steering Committee used the process outlined in the FEMA How-To Guide entitled, “Understanding Your Risks; Identifying Hazards and Estimating Losses”. This process calls for completing two worksheets: the Vulnerable Asset Inventory Worksheet and the Loss Estimate Worksheet.

In the asset inventory, 13 vulnerable critical facilities were identified. Loss estimate worksheets were completed for each hazard and included the vulnerable critical facilities that might be affected by that hazard. The purpose of providing the vulnerable critical facilities was to generate a list of the most needed projects for retrofitting critical facilities, which is a state priority. This exercise was an attempt to perform a preliminary cost-benefit analysis to determine what mitigation projects would be cost beneficial. It was not the intent of the Steering Committee to make gross assumptions to estimate total losses. Gross losses are based on the Parish-wide asset inventory.

Vulnerable Asset Inventory Worksheet – To complete this worksheet, information is collected on each facility that was identified as vulnerable. This information will be used to calculate the estimated losses on the next worksheet. See Appendix N for Assets Inventory. A description of each data element on the spreadsheet and its source is follows.

Size of Building – squared footage is gained from a site visit
Replacement Value – expressed in cost per square foot and reflects the present day cost of labor and materials to construct a similar building
Contents Value – based on the type of facility and then multiplying it by the replacement value
Function Use or Value **–** represents the value of a building’s use or function that would be lost if it were damaged or closed, if available, the Annual Operating Budget of the priority critical facility is used for this element
Displacement Cost **–** average time in days that the building’s occupants typically must operate from a temporary location while repairs are made to the original building due to a hazard event
Occupancy or Capacity – how many people the structure is designed to hold or service

Loss Estimate Worksheet – After obtaining the above information for each vulnerable facility, an estimated loss for each hazard event is calculated to arrive at a total loss (in dollars) to the community for each type of hazard. In order to arrive at a total loss, four components are examined:

Structure Loss **–** determined by taking the structure's replacement value and multiplying it by the percent damage
Contents Loss **–** determined by taking the contents loss and multiplying it by the percent damage
Structure Use Loss – daily average operating cost multiplied by the functional downtime, which is the average time in days during which a business or service is unable to provide its services due to a hazard event
Function Loss **-** daily average operating cost multiplied by the displacement time, which is the average time in days that the building's occupants typically must operate from a temporary location while repairs are made to the original building due to a hazard event

The four categories of loss are then summed to arrive at the total loss for the hazard examined.
The total potential loss for all structures in Terrebonne Parish is approximately $5.96 billion, as seen in Appendix K. The potential loss includes residential properties, commercial, religious/non-profit, government, and educational facilities. It is unlikely that a hazard would occur that would adversely affect all of them at the same time, but the potential for damage exists.

The loss estimation was performed for each hazard, taking into account the possibility that a vulnerable critical facility may be affected by a hazard and the estimated percentage of damage due to that hazard. As indicated on the Loss Estimation worksheets found in Appendix O, the following are the total estimated losses for the vulnerable priority critical facilities and for each hazard:

- Hurricanes - $2,980,633,294
- Floods - $3439,188,659
- Storm Surge - $2,980,633,294
- Thunderstorms / Lightning / High Winds - $3,576,759,952
- Tornadoes - $2,384,506,635
- Land Subsidence - $2,682,569,964
- Saltwater Intrusion - $2,086,443,305
- Expansive Soils - $2682,569,964
- Hailstorms - $1,490,316,647
- Drought - $1,192,253,317
- Winter Storms – $1,788,379,976

Each hazard has a unique set of characteristics that can produce different effects and impact the community differently depending on the magnitude, duration, and intensity. Furthermore, the same hazard events will affect different parts of the parish in different ways, based on geography, development, population distribution, and age of buildings.

Existing disaster data are limited for use in predicting potential losses. Although the FEMA How-to-Guide provides guidance on estimating potential losses for floods, no guidance is given for the other hazards. To complete the loss estimate worksheets, the 13 vulnerable critical facilities that the Steering Committee identified were used to complete a potential dollar loss per hazard event based on educated assumptions.

4.5 Assessing Vulnerability: Analyzing Development Trends

Requirement 201.6(c)(2) (ii)(c):
[The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

The majority of Parish growth is expected to take place near Houma in the northern portion of the Parish. The remainder of the parish is not expected to undergo development pressure, and the parish does not anticipate any significant changes in land use. In addition, as seen on Table 23, Terrebonne Parish's population has changed much since 1980. There has been a total change of 10,110 people since the 1980 census, including Houma, as well as the other unincorporated areas of the Parish. Development trends, especially on the eastern and southern end of the Parish are putting some pressure on the natural areas of the Parish. There are vast areas of marshland and estuarine areas leading to the Gulf of Mexico that will remain undeveloped.

In summary, the Parish and CDP areas are growing slowly. See Appendix L, for a list of the Parish and communities identified critical facilities. See Appendix K, for the Parish-wide Asset Inventory Worksheet, which determined the total number and value of buildings. The Urban Service District of Houma has existing zoning maps and in 2001, the Parish adopted a comprehensive land use plan, which helps identify new proposed buildings, infrastructure, and critical facilities. Therefore, there are data sources in place for determining the type and number of future buildings, infrastructure, and critical facilities, as well as any planned development. Based on the population growth one would expect to see minimum infrastructure growth in Terrebonne Parish and in the CDP communities.

As evidenced from Table 24, Terrebonne Parish Land Use, waterways and wetlands account for over 92%. Vacant/Open Land accounts for about 4% and Residential, Agricultural and all other areas total less than 4% combined. Also, see Map 4 illustrating Terrebonne Parish Land Use.

Table 24

Future Land Use

Terrebonne Parish, Louisiana

Land Use #	Land Use Name	Year 2002		Year 2020		Percent Change
		Acreage	Percentage	Acreage	Percentage	
1	Single Family Residential	13004.12	1.1%	15445.04	1.4%	0.21%
2	Multi-Family Residential (Low Density)	94.76	0.0%	136.22	0.0%	0.00%
3	Multi-Family Residential (High Density)	224.13	0.0%	238.83	0.0%	0.00%
4	Mobile Homes	1727.75	0.2%	2503.72	0.2%	0.07%
5	Mobile Home Parks	406.44	0.0%	405.92	0.0%	0.00%
6	Commercial	1947.63	0.2%	3430.94	0.3%	0.13%
7	Office	121.59	0.0%	147.31	0.0%	0.00%
8	Medical Office	35.40	0.0%	44.06	0.0%	0.00%
9	Home Occupations	19.32	0.0%	19.32	0.0%	0.00%
10	Public Services	4212.03	0.4%	4203.56	0.4%	[illegible]
11	Industrial	3506.39	0.3%	4917.84	0.4%	0.12%
12	Agricultural	26341.99	2.3%	24051.73	2.1%	-0.20%
13	Vacant/Open Land	41240.55	3.6%	37699.18	3.3%	-0.31%
14	Environmentally Sensitive Areas	1048949.78	91.8%	1048113.08	91.7%	-0.07%
15	Wellheads	281.85	0.0%	281.85	0.0%	0.00%
16	Camps	327.56	0.0%	585.48	0.1%	0.02%

	Year 2002	Year 2020
Tota Area with Land Use Classification	1142441.29	1142224.08
Other (Waterways & Streets	8890.11	9107.32
Development Zone Acreag	1151331.40	1151331.40

Source: Terrebonne Comprehensive Master Plan, Volume 1 2-23

Due to Terrebonne Parish's location in south Louisiana, it is susceptible to hurricanes, floods, and storm surge. According to Table 5 in Section 4.1, Terrebonne Parish has experienced at least 11 hurricane or tropical storm events and 15 flooding events. Each flood and hurricane event caused extensive damage to homes, businesses, crops, roads, marshes, levees, culverts, and bridges.

Approximately 95% of the total land area of Terrebonne Parish is located within FEMA's 100-year floodplain. The floodplain is illustrated on Map 3, Repetitive Loss Areas.

5.0 MITIGATION STRATEGY

The Hazard Mitigation Steering Committee (see Appendix D) met on numerous occasions to discuss possible mitigative measures that could reduce the effects from disasters. Because hurricanes, floods, storm surge and thunderstorms with lightning and high winds are the predominate hazards in the Parish, they were the focus of the discussions. From these discussions, an Action Plan (Section 7.0) was prepared which identifies specific actions to achieve identified goals, an appropriate lead person for each action, a schedule for accomplishment, and an estimate of cost, and suggested funding sources.

5.1 Local Hazard Mitigation Goals

Requirement 201.6(c)(3) (i):
[The hazard mitigation strategy shall include: a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.

The Hazard Mitigation Steering Committee met on May 21, 2003 to analyze the results of the risk assessment. The goals listed were determined to be those that would have the greatest benefit in hazard reduction to the Parish. The committee established four goals with action items listed in each goal. An Action Plan (Section 7.0) was prepared which identifies specific actions to achieve identified goals, an appropriate lead person for each action, a schedule for accomplishment and suggested funding sources. The inclusion of any specific action item in this document does not commit the Parish to implementation. Each item will be considered in terms of the available staff and funding resources. Certain items may require regulatory changes or other decisions that must be implemented through standard processes, such as changing regulations. This plan is intended to offer priorities based on an examination of hazards. See the complete Action Plan in Section 7.0, where the action items for each are defined.

The goals were established by asking the Steering Committee members what they wanted to make a priority in their plan. The risk assessment consisted of identifying the hazards that affect the parish and the critical facilities that are vulnerable to the hazards. The goals are related to the risk assessment in that they address ways to reduce the impact of the identified hazards on the identified critical facilities. All of the hazards identified in Section 4.1, Table 4 are addressed in the Action Plan. All of these action items and goals established will help Terrebonne Parish and the municipalities within the Parish.

Goals identified by the Steering Committee include:

- Identify and pursue preventative measures that will reduce future damages from hazards.
- Enhance public awareness and understanding of disaster preparedness.
- Reduce repetitive flood losses in the Parish and municipalities.

- Facilitate sound development in the Parish and municipalities so as to reduce or eliminate the potential impact of hazards.

Many of the action items hinge on funding becoming available; therefore, these activities will be accomplished with outside funding. Most of them cannot be completed without outside funds. The details of the Action Plan serve to deal with changing priorities, administration transitions, and unpredictable funding and still allow for adoption of the plan by Parish and local governments.

5.2 Identification and Analysis of Mitigation Measures

Requirement 201.6(c)(3) (ii):
[The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

Terrebonne Parish has identified several hazard mitigation projects that would benefit the Parish. These were identified in the Steering Committee meetings, which include input from representatives from governmental organizations, local business, and private citizens. These are addressed in detail below and summarized on the Mitigation Measures Table in Appendix I. As seen in Appendix I, many of the mitigation measure projects described below are applicable to more than one of the hazards the Parish faces.

Alternatives that will benefit the residents of flood-prone structures will be considered and evaluated according to the necessary level of protection and the benefit cost ratio. It is important to analyze each possible alternative to ensure the result will not adversely affect surrounding structures.

5.2.1 Retrofitting of Structures

The retrofitting of structures prone to periodic flooding is an effective mitigation technique to reduce the flood loss of property. Retrofitting techniques include the elevation of both slab-on-grade and pier-on-beam structures, dry flood proofing, and wet flood proofing, and installation of generators and hurricane shutters.

Almost any type and size of structure can be elevated so that the lowest floor is above the Base Flood Elevation (BFE). A Project identified by the Steering Committee (see the Action Plan in Section 7.0) follows:

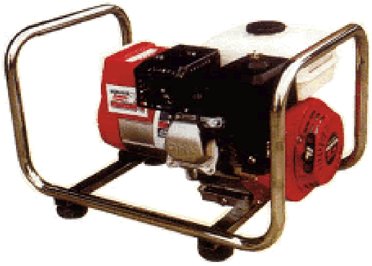
- Pursue elevation / acquisition / floodproofing projects and structural solutions to flooding by pursuing funding opportunities for the 29 repetitive loss structures.

Dry flood proofing techniques include the building of floodwalls adjacent to existing walls, the installation of special doors to seal out floodwaters, and special backflow valves for water and sewer lines. Wet flood proofing includes low cost mitigation measures such as raising air conditioners, heat pumps, and hot water heaters on platforms above the BFE.

Elevating and flood proofing structures can eliminate many problems experienced from hurricanes and floods.

Another cost effective retrofitting technique includes the installation of generators. By preserving power with generators during and after severe storms many critical facilities may continue to provide necessary services to the community. A Project identified by the Steering Committee (see the Action Plan in Section 7.0) follows:

- Add securely attached and elevated, back up power supply/generators at the Central Fire Department Station in Chauvin Montegut Middle School, the Houma Police Department, the Terrebonne Parish Civic Center, the Terrebonne Parish Public Works building, and the Terrebonne Parish Emergency Operations Center.



A project that was identified by the steering committee, but was deemed not feasible at this time, follows:

- Adding generators to all critical facilities.

The installation of generators serves to assist the communities with problems experienced from floods, hurricanes, thunderstorms with lightning and high winds and tornadoes.

By installing hurricane shutters, the exterior integrity is maintained by protecting the interior of the structure.

Hardening and installing hurricane shutters serves mainly to assist with problems experienced from floods, hurricanes, thunderstorms with lightning and high winds and tornadoes.

A Project identified by the Steering Committee (see the Action Plan in Section 7.0) follows:

- Harden the Terrebonne Parish Emergency Operations Center, Terrebonne General Medical Center, Chabert Medical Center, the TPCG Generating Station and the two Consolidated Waterworks Treatment Plans by adding roof tie-downs and additional storm protection features.

Another retrofitting technique would be to bury electric power lines to avoid tree limbs falling on them or from wind damage resulting in a break in service to the consumer.

A project that was identified by the steering committee, but was deemed not feasible at this time, follows:

- Encouraging electrical providers and new subdivision developments to consider installing underground utilities.

Burying electric power lines serves to assist the communities with problems experienced from hurricanes, floods, storm surge and thunderstorms with lightning and high winds and tornadoes.

Projects that were identified by the steering committee, but were deemed not feasible at this time, are as follows:

- Replace all school windows with shatterproof windows.
- Install hurricane shutters on all critical facilities.

5.2.2 Acquisition of Structures

The acquisition or "buyout" option is the most effective mitigation technique to reduce the loss of property due to flooding. The owners of repetitive flood loss structures sell their structure to the community on a cost share basis for the fair market value of the structure prior to the last flood event. The structure is removed/demolished and a deed restriction is placed on the property for perpetuity, thus eliminating the structure from future flood damage. This approach is most effective when flood prone structures located within the same vicinity are grouped together and acquired. The remaining property can be converted into usable recreational space with minor structure restrictions. A project identified by the steering committee (see the Action Plan in Section 7.0) follows:

- Acquire qualifying structures from the repetitive flood loss and target lists.

Acquiring structures that have repetitively flooded serves mainly to assist with problems experienced from hurricanes and floods.

5.2.3 Drainage

Improving the drainage capacity around roads and low-lying areas is a time-tested technique to mitigate flood damage. Maintenance of drainage canals and laterals is essential to maximize their efficiency and continued long term effectiveness.

The geography of Terrebonne varies from the north to the south. In the western part of the Parish, the landscape is mostly flat, used for agricultural purpose. Toward the south, around the bayous, lakes and salt marshes that characterize the coastal areas, water and low lands dominate the terrain. Of the 2,100 square miles of the parish, nearly 1,100 square miles are accounted for by water.

Terrebonne Parish is located entirely within the Mississippi River Delta Basin. The parish is low lying with highest elevations 10 feet along some of the natural ridges and bayous. Primary flooding problems in the Parish are from land subsidence, tidal flooding, and deterioration of the marshes. Many of the present drainage channels have become inadequate for the additional runoff resulting from increasing development. The western half of the Parish is influenced by backwater from the Atchafalaya River.

St. Louis Canal, an area of approximately 1,350 acres is subject flooding from heavy rainfall. This problem may be compounded by high Gulf tides and strong southerly winds which hinder interior drainage. As many as 900 homes are potentially affected by flooding in this area. St. Louis Canal has become inadequate in size due to siltation and vegetative growth and can no longer effectively drain this area.

Bayou Dularge drains approximately 4,500 acres and experiences flooding of roads, yards, and some structures during the last 12 years. The communities of Crozier, Sunset, and Theriot are included in this flood problem area. The causes of flooding along Bayou du Large include high tides and southerly winds which inhibit pumping of the drainage canals.

Bayou Dulac drains about 160 acres of land. Half of the land is developed for residential use and the remaining half is open fields. About 200 homes have periodically flooded. The extent of flooding has increased in recent years. Land has subsided to the extent that water is overflowing drainage canals during high tidal stages. The deterioration of the adjacent marshes which previously provided some buffer to tidal surges has added to the flooding problem.

Lower Bayou LaCache is bordered on the east by LA Highway 55 along Bayou Terrebonne. 1,825 acres of the Lower Bayou LaCache area reportedly is affected by flood waters. Development has occurred on the alluvial ridges along bayous Terrebonne and Petite Caillou. About 200 homes are affected by the high water and an unrecorded number are reported tom have flooded. The flooding also reduces the yields from 400 acres of sugarcane and 200 acres if soybean fields. High water in adjacent marsh areas, rainfall, southerly winds, tidal influence, land subsidence, and marsh deterioration are all considered contributing factors to the flooding problem here.
Bayou Pointe Aux Chene drains approximately 175 acres of land which is subject to flooding several times a year. About 60 homes are affected by the flooding in this area.

Houma is bisected by the Intracoastal Waterway and Bayou Terrebonne. Flooding problems within the city are due to a combination of high tides, severe rainfall, and drainage systems that have become inadequate to serve the additional demand associated with the recent urban growth. Four separate flood problem areas in Houma exist at Tunnel Boulevard, Summerfield/Southdown, Bayou Chauvin, and Boudreaux Ditch.

Tunnel Boulevard is subject to flooding from a 3 to 5 year frequency rainfall. Columbus Street has become impassable on a number of occasions and traffic has been rerouted. There are about 15 – 20 homes and several businesses that flood frequently in this area. Sections of LA Highway 3040 have been closed to standing water and several streets have been topped with water. There are approximately another 50 homes in this area that have experienced flooding in the past.

An area of 136 acres south of LA Highway 311 and west of LA Highway 661 is the Summerfield/Southdown area and has flooded three times recently. About 50 homes are affected. This is an area that is continuing to be developed and has undergone considerable change in land use patterns. The drainage channel that does exist is no longer adequate to effectively accommodate the increased rate of runoff resulting form the additional development.

The area south of Bayou Terrebonne and north of LA Highway 57 is known as Bayou Chauvin or Grand Caillou Road. This area has experienced flooding problems about once every two years. The present drainage channel drains into a forced drainage reservoir. The channel becomes full of water and ponding occurs from the excess runoff until the channel's water level has subsided.

Boudreaux Ditch area is primarily a residential area which experiences street flooding from a storm of two year frequency. High tides in the Intracoastal Waterway compounded by severe rainfall enhance the possibility of flooding. The main problem in this area is inadequate capacity of the channel. The Parish began paving Boudreaux Ditch and the flooding problems declined since the work began.
Source: Flood Control in Louisiana, 1986. Prepared by: Gulf South Research Institute

Projects identified by the Steering Committee (see the Action Plan in Section 7.0) are as follows:

- Develop a master drainage plan which incorporates the Master Forced Drainage Plan of 1973, in order to evaluate drainage projects at major drainage laterals to determine best method of increasing drainage capacity and accelerate the completion of the Morganza to the Gulf Hurricane Protection Levee through bonding of existing sales taxes. Implement recommended projects resulting from the drainage plan.
- Investigate and implement localized interior drainage projects at Lower Bayouside Drive, Savanne Road, Ringo Crocke to Hudson Canal, LA 311 at Hollywood Road, Parish Road 15 at Mandalay, and Susie Canal at Ashland South, which are repetitive loss areas, and reduce its flood potential.

A project identified by the Steering Committee, but was deemed not feasible at this time, follows:

- Elevate flood prone areas of critical evacuation routes.

Maintaining and improving drainage serves to assist the communities with problems experienced from hurricanes, floods, storm surge and thunderstorms with lightning and high winds.

5.2.4 Public Awareness

Insurance industry and emergency management research has demonstrated that awareness of hazards is not enough. People must know how to prepare for, respond to, and take preventive measures against threats from natural hazards. This research has also shown that a properly run local information program is more effective than national advertising or public campaigns.

Although concerted local and statewide efforts to inform the public exist, lives and property continue to be threatened when segments of the population remain uninformed or chose to ignore the information available. Educating the public of these life and property saving techniques must remain a high priority item at the local, State, and Federal level.

Projects identified by the steering committee (see the Action Plan in Section 7.0) are as follows:

- Promote the purchase of flood insurance.
- Distribute information regarding flood hazards, SFHA's and mitigation measures.
- Sponsor a Multi-Hazard Awareness Week.

Public education serves to assist the communities with problems experienced from floods, hurricanes, thunderstorms with lightning and high winds and tornadoes.

Terrebonne Parish joined the Community Rating System (CRS) on October 1, 1992. The Parish is currently a Class 8 within the CRS and receives a 10% discount on their Flood Insurance. As a result of being part of the CRS, the Parish is actively pursuing public outreach programs. One of the requirements of CRS is an annual outreach project; the Parish conducts a Repetitive Loss Outreach Program. This program focuses on repetitive loss areas within the Parish and consists of three main components. The first is to advise the home owners that they live in a repetitive loss area and could be subject to flooding. The second is to give the home owner appropriate property protection measure guidelines. The third is to make the homeowner aware of the basic facts about Flood Insurance.

5.2.5 Floodplain Management and Building Codes

Improved floodplain management, including land use planning, zoning, and enforcement at the local level can reduce flood related damages. The use of the

National Flood Insurance Program (NFIP) is critical to the reduction of future flood damage costs to the taxpayer. The Louisiana Department of Transportation and Development (DOTD) is the primary agency responsible for the administration of the NFIP for the State of Louisiana.

Terrebonne Parish joined the NFIP on November 20, 1970, (see Table 25). The Parish developed a Floodplain Damage Prevention Ordinance, as part of their Parish regulations, which addresses methods and practices to minimize flood damage to new and substantial home improvement projects, as well as addressing zoning and sub-division regulations.

Table 25

National Flood Insurance Program	
Name	**Date Joined NFIP**
Terrebonne Parish	November 20, 1970

Within floodplain management as a whole, the education process must play an important role. An effective education program should be implemented to show citizens the importance of building codes and ordinances and how cost effective they could be in reducing future damages.

Projects identified by the steering committee (see the Action Plan in Section 7.0) are as follows:

- Review the existing floodplain ordinance and evaluate ways to improve the Parish's Community Rating System.
- Adopt additional residential and commercial building regulations.
- Develop additional subdivision guidelines to help reduce flooding.

Floodplain management and building codes serve to assist the communities with problems experienced from floods, hurricanes, thunderstorms with lightning and high winds and tornadoes.

5.2.6 Early Warning

With sufficient warning of a flood, a community and its residents can take protective measures such as moving personal property, cars, and people out of harms way. When a flood threat recognition system is combined with an emergency response plan that addresses the community's flood problems, considerable flood damage can be prevented. This system must be coupled to warning the general public, carrying out appropriate tasks, and coordinating the flood response plan with operators of critical facilities. A comprehensive education and outreach program is critical to the success of early warning systems so that the general public, operators of critical facilities, and emergency response personnel will know what actions to take when warning is disseminated.

Within Terrebonne Parish's Emergency Operations Plan a Public Alert System is detailed. The activation of this system and timely release of emergency information to the public by all available media is vitally important.

Early warning systems serve to assist the communities with problems experienced from hurricanes, floods, thunderstorms with lightning and high winds and tornadoes.

5.3 Implementation of Mitigation Measures

Requirement 201.6(c)(3)(iii):
[The mitigation strategy section shall include] an action plan describing how the actions identified in section (c)(3) (ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

An Action Plan (Section 7.0) was prepared which identifies specific actions to achieve identified goals, an appropriate lead person for each action, a schedule for accomplishment and suggested funding sources. The inclusion of any specific action item in this document does not commit the Parish to implementation. Each item will be considered in terms of the available staff and funding resources. Certain items may require regulatory changes or other decisions that must be implemented through standard processes, such as changing regulations. The goals were established by asking the Steering Committee members what they wanted to make a priority in their plan. The risk assessment consisted of identifying the hazards that affect the parish and the critical facilities that are vulnerable to the hazards. This plan is intended to offer priorities based on an examination of hazards. The goals are related to the risk assessment in that they address ways to reduce the impact of the identified hazards on the identified critical facilities. The top four hazards in Section 4.1, Table 4 are addressed in the Action Plan. All of these action items and goals established will help Terrebonne Parish. See Section 5.1 of this plan.

Benefit-cost analysis (BCA) compares the benefits of mitigation measures to the costs, and is a technique used for evaluating the cost-effectiveness of mitigation measures. FEMA requires a BCA for all mitigation projects that receive FEMA funding.

The Steering Committee discussed the potential costs associated with each type of mitigation measure identified in Appendix I, and decided that any project could be cost effective if it's scope were properly tailored to the situation. For example, one of the most effective mitigation measures identified for repetitively flooded structures is elevation. It may not be cost effective to elevate every single repetitively flooded structure in the parish, but it certainly would be cost effective to elevate those that cause the largest drain to the National Flood Insurance Program (NFIP).

After discussing the possible costs of the various mitigation measures, and discovering that FEMA's "How-To" guide entitled, "Using Benefit-Cost Analysis in Mitigation Planning (FEMA 386-5) is not yet available, the Steering Committee decided that instead of working on developing a very generic BCA at this time for projects that may not ever be authorized, we would wait until a project was determined to be feasible. For example, the Parish is not financially capable of elevating any repetitively flooded structures without Federal Grant assistance. Therefore, elevation projects are not always feasible. However, at the time that grants become available [Hazard Mitigation Grant Program (HMGP grants) after disasters or Flood Mitigation Assistance (FMA) grants annually], the Parish will collect detailed information on each structure that is interested in participating in the grant program and collect a BCA to rank the structures to determine which should receive funding first. An estimated cost to implement the action item was, however, provided in the action plan.

The method that the Steering Committee chose to help them consider potential action items in a systematic way was the **S**ocial, **T**echnical, **A**dministrative, **P**olitical, **L**egal, **E**conomic, and **E**nvironmental (STAPLEE) Method. This method helps the Steering Committee to weigh the pros and cons of different alternative actions for each of the identified actions and objectives. See Table 26 for the STAPLEE Methodology.

Table 26

STAPLEE Methodology

STAPLEE	Criteria Explanation
S – Social	Mitigation actions are acceptable to the community if they do not adversely affect a particular segment of the population, do not cause relocation of lower income people, and if they are compatible with the community's social and cultural values.
T – Technical	Mitigation actions are technically most effective if they provide long-term reduction of losses and have minimal secondary adverse impacts.
A – Administrative	Mitigation actions are easier to implement if the jurisdiction has the necessary staffing and funding.
P – Political	Mitigation actions can truly be successful if all stakeholders have been offered an opportunity to participate in the planning process and if there is public support for the action.
L – Legal	It is critical that the jurisdiction or implementing agency have the legal authority to implement and enforce a mitigation action.
E – Economic	Budget constraints can significantly deter the implementation of mitigation actions. Hence, it is important to evaluate whether an action is cost-effective, as determined by a cost benefit review, and possible to fund.
E - Environmental	Sustainable mitigation actions that do not have an adverse effect on the environment, that comply with Federal, State, and local environmental regulations, and that are consistent with the community's environmental goals, have mitigation benefits while being environmentally sound.

The Steering Committee members prioritized the actions using the STAPLEE criteria, a planning tool used to evaluate alternative actions.

See the Action Plan found in Section 7.0. Each Steering Committee member had an equal number of votes to use toward the action items that met the criteria the best, based on their knowledge. The mitigation action items with highest priority were the most cost effective and most compatible with the communities' social and cultural values. The bottom line for determining if a project would work was if it was cost effective.

The Steering Committee defined High, Medium, and Low priorities in the Action Plan to be as follows:

- High: Meets five of the seven STAPLEE criteria
- Medium: Meets four of the seven STAPLEE criteria
- Low: Meets three of the seven STAPLEE criteria

The process of identifying the priority ratings was an informal process and whether or not the project will be cost effective was the driving factor.

The action plan found in Section 7.0 is current as of submission of the HMP but upon actual project initiation each aspect will have to be reevaluated based on the STAPLEE criteria to be sure that it is still an effective project.

5.4 Multi – Jurisdictional Mitigation Strategy

Requirement 201.6(c)(3) (iv):
For multi – jurisdictional plans, there must be identifiable action items specific to the jurisdiction requesting FEMA approval or credit of the plan.

Within Terrebonne Parish, there are several municipalities; however, they are not individually incorporated. Parish – wide strategies for hazard mitigation within Terrebonne Parish and the municipalities were identified to reduce damage to vulnerable areas. The Steering Committee identified goals and action items which are addressed in the Action Plan in Section 7.0.

6.0 PLAN MAINTENANCE PROCEDURES

The Steering Committee will be involved in the process of monitoring, evaluating, and documenting the plan's progress. Part of the plan maintenance process should include a system by which local governing bodies incorporate the Hazard Mitigation Plan into the Parish's comprehensive or capital improvement plans. This process provides for continued public participation through the diverse resources of the parish to help in achieving the goals and action items of the plan.

6.1 Monitoring, Evaluating, and Updating the Plan

Requirement 201.6(c)(4) (i):
[The plan maintenance process shall include a section describing the] method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.

Terrebonne Parish has developed a method to ensure that a regular review and update of the Hazard Mitigation Plan occurs. This will be the responsibility of the Steering Committee which consists of representatives from governmental organizations, local businesses, and private citizens, who will be involved in the process of monitoring, evaluating and updating the plan.

Review and revision of the HMP will be directed by the Terrebonne Parish Planning and Zoning Director who is listed on the Edits and Revisions page.

Although the people filling the positions may change from year to year, each city will have a representative on the Steering Committee. The future Steering Committee will continue to be comprised of the same job functions as currently evident in the Steering Committee. However, the decision of specific job duties will be left to the Terrebonne Parish Planning and Zoning Director to be assigned as deemed appropriate.

Progress on the mitigation action items will be monitored and evaluated by the Terrebonne Parish Planning and Zoning Director. The Lead Manager for each action item will complete an annual Progress Report and submit them to the Terrebonne Parish Planning and Zoning Director for review. See Appendix P for a blank copy of the Annual Progress Report. This Progress Report is designed to monitor the state of the projects and evaluate the success of each mitigation item. The report lists each action item and answers several very important questions, such as has the project begun? If not, why not? The status of project; is it complete? If so, did it eliminate the problem? Are there changes needed to better implement the mitigation actions? and so on. These questions serve to address the progress being made on each of the mitigation actions items.

Completed reports will also be kept in this appendix of the plan. The Terrebonne Parish Planning and Zoning Director will consult with the Lead Manager for details involving each mitigation item.

If during this process of reviewing the Annual Progress Report, the Terrebonne Parish Planning and Zoning Director determines that the Steering Committee should be reconvened for discussion, he has the option of doing so. He will use the following criteria to determine if a meeting needs to be held:

- Are there any changes in mitigation plan requirements for funding programs?
- Are any changes or revision required to the Mitigation Action Items? (i.e. Have any action items been completed? Are there any new specific mitigation action items? Are there any changes to the mitigation plan requirements? Have any new specific mitigation action items been identified?)
- Does a review of the Progress Reports indicate any changes are necessary?
- Are there any changes within the Steering Committee membership?

Although not required, FEMA recommends an annual meeting of the Steering Committee. If the Terrebonne Parish Planning and Zoning Director determines that this annual meeting needs to be conducted, he is responsible for contacting committee members, organizing the meeting and providing public noticing for the meeting to solicit public input.

In addition to monitoring the progress of plan projects, the plan is required to be evaluated, then revised or updated at least every five years from the date of FEMA approval. If a disaster occurs or as action items are completed, the plan will be reviewed, revised, and updated sooner than the required five years, using the process outlined in this section.

The Steering Committee will be reconvened approximately one year before the five-year deadline and begin evaluating the Hazard Mitigation Plan. The above criteria and the following key topics and questions below will be addressed at the meeting.

- ID Hazard – Are there new hazards that affect your community? Has a disaster occurred?
- Profile Hazard Events – Are additional maps or new hazard studies available? Have chances of future events changed? Have recent and future development in the community been checked for their effect on hazard areas?
- Inventory Assets – Have inventories of existing structures in hazard areas been updated? Are there any new special high risk populations? Is future land development accounted for in the inventories?
- Estimate Losses – Have losses been updated to account for recent changes?

If the answer to any of the above questions is a “Yes”, then the HMP will be updated accordingly.

The HMP review and update will be accomplished by reviewing each goal and action item to determine their relevance to changing situations in the Parish and in each municipality, as well as changes to State or Federal policy, and to ensure that they are addressing current and expected conditions. The Steering Committee will also review the risk assessment portion and determine if this information should be updated or modified. If no changes are necessary, the State Hazard Mitigation Officer will be given a justification for this determination.

The Steering Committee will work together as a team, with each member sharing responsibility for completing the evaluation and updates. Each member of the Steering Committee is an equal member of the process. It will be the responsibility of the representative from each community to ensure that their section of this plan is updated to meet the required deadline.

The Terrebonne Parish Planning and Zoning Director is responsible for including all changes into the HMP after the Steering Committee has met and decided on the changes. All necessary revisions will be completed at least three months prior to the end of the five year period to allow the Steering Committee time to review the updated plan. During the revision process, the Terrebonne Parish Planning and Zoning Director will send a status report (meeting minutes) to the Parish Council after each Steering Committee meeting. Any required revisions will be implemented into existing plans, as applicable, within six months following the review process. This process will be repeated for each five year review of the plan.

After the plan update is completed, the final plan will be submitted to the LHLS/EP's Hazard Mitigation Officer for review and then on to FEMA for review and approval to remain eligible for continued HMGP funding.

FEMA, LA DOTD, and LHLS/EP have the authority to evaluate the progress of existing mitigation plans to determine if the plan is fulfilling program requirements.

**Note: Although Terrebonne Parish was impacted by Hurricanes Katrina and Rita in August and September of 2005, sufficient data are not available at the time of submittal of this revision to address the implications of these devastating storms. For the most part, this Plan addresses a Pre-Katrina/Rita condition. The data for these events will be included in future updates to this Plan, when a proper and complete assessment is available.*

6.2 Implementation through Existing Programs

Requirement 201.6 (c)(4) (ii):
[The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate…

The project requirements from the Hazard Mitigation Plan shall be incorporated into other planning mechanisms, as applicable, during the routine re-evaluation and update of the other existing Parish plans. This HMP plan will be made available to each committee leader responsible for updating these other plans. In addition, any changes or updates to the flood plain ordinances, Emergency Operations Plan, Terrebonne Parish Consolidated Government Economic Development Foundation and the Economic Development Master Plan (2002), FIRMs, the Southeast Louisiana Hurricane

Preparedness Study 1994, Forced Drainage Master Plan (1973), Terrebonne Comprehensive Master Plan (2001), Urban Service District of Houma Zoning Regulations, Terrebonne Parish Subdivision Regulations, Regulations for Parks and Recreation, Coastal Zone Management Regulations and Building and Construction Regulations will be reflected in this HMP during its update. As seen on Table 24, the Parish is a member of the NFIP and has Floodplain Management Ordinances. When the Parish updates their Floodplain Ordinances, the requirements from this HMP will be included in the newly revised Floodplain Ordinance. This HMP plan will be made available to each committee leader responsible for revising their Floodplain Ordinance.

Terrebonne Parish Council governs the Parish and has the final decision on what projects are worked on and how and when they will be accomplished. The action items in the Parish Action Plan fall under their jurisdiction and they will delegate the tasks of the action items. Therefore the Council will coordinate with the Terrebonne Parish Planning and Zoning Director and Lead Manager of each mitigation item to accomplish the goals and action items. The Lead Manager will follow any current procedures the Parish has while completing the action items. The Annual Progress Report and status reports (meeting minutes) will be submitted to the Parish Council, which will reflect progress on each item and on the Hazard Mitigation Plan.

The action items found in Section 7.0 will be implemented through the defined political process of the Parish. The annual budget, as required by law, is the driving factor in determining what projects are accomplished. The lead manager for each action item will submit the corresponding project for consideration to the Council members. Then each Council member submits projects for consideration in the annual budget. They will use this HMP as a guide to help them determine what projects will be submitted into the annual budget for completion. Outlined within each budget are projects that the Parish would like to complete. The Council then will hold budget hearings to determine what projects in the budget will and can be funded. All other projects are then removed and must be resubmitted during the following year's budget hearings.

6.3 Continued Public Involvement

Requirement 201.6(c)(4) (iii):
[The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.

Terrebonne Parish is dedicated to involving the public directly in the reshaping and updating of the Hazard Mitigation Plan. The Steering Committee members are involved in the process of the review and update of the plan, which is to be conducted every five years. Although they represent the public to some extent, the public will be able to directly comment on and provide feedback about the plan and its updates. Before the Steering Committee is reconvened for any meeting, a public notice will be issued for anyone in the general population who would like to participate in the process of HMP review and update. A public notice will be displayed in prominent locations within the main governmental buildings in Terrebonne Parish. Those who opt to participate in this process will have an opportunity to express their concerns, opinions, or ideas about the plan.

Copies of the plan will be catalogued and kept on hand at all of the Parish public libraries. The existence and location of these copies will be publicized in "*The Houma Courier*". The Terrebonne Parish Planning and Zoning Director will be responsible for keeping track of public comments on the plan. All public comments will be reviewed and incorporated in the HMP at the five year update if appropriate. If an annual meeting of the Steering Committee is held, than the public comments will be reviewed and incorporated at this time, if appropriate. See the Edits and Revisions page at the beginning of this document for who to contact with recommendations, edits, and changes to this plan. The review, changes, and update that is made during the review, every five years, will also be publicized in "*The Houma Courier*".

7.0 ACTION PLAN

The Hazard Mitigation Steering Committee established an Action Plan, which identifies specific actions to achieve identified goals, an appropriate lead person for each action, an estimated cost, and a schedule for accomplishment and suggested funding. The Action Plan encapsulates what Terrebonne Parish plans to implement in order to build a more disaster resilient Parish.