Washing away

- SPECIAL REPORT from THE TIMES-PICAYUNE -

It's only a matter of time before South Louisiana takes a direct hit from a major hurricane. Billions have been spent to protect us, but we grow more vulnerable every day.

Five-Part Series published June 23-27, 2002

For larger image and explanation of image at left, click here

DAY 1

- **IN HARM'S WAY** Levees, our best protection from flooding, may turn against us.
- **WRITTEN OFF** A new hurricane levee will protect some, but leave some coastal towns outside the walls.
- **EVOLVING DANGERS** - Scientists say we're more vulnerable than we thought.
- **GALLERIES, GRAPHICS and more**

» **Go to Part 1**

DAY 2

- **THE BIG ONE** A major hurricane could decimate the region, but flooding from even a moderate storm could kill thousands. It's just a matter of time.
- **EVACUATION** It's the best chance for survival, but it's a bumpy road, and 100,000 will be left to face the fury.
- **LOOK BACK AT GEORGES** - Stories, video and weblogs from Hurricane Georges.
- **STORM WARNING** - The weather bulletin that set off what was then the biggest evacuation in U.S. history.

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- **EXPOSURE'S COST** In the wake of Sept. 11, insurers are taking a hard look at high-risk areas and levying tough fees, a change that's already affection our economy.
- **SEEKING SHELTER** Three years after Hurricane Floyd, some North Carolina residents are still in temporary shelters.
- **BUILDING BETTER** - Changes to building codes could ensure that more of New Orleans' buildings would survive a storm.

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- **TEMPTING FATE** As the country becomes more crowded, the damage from natural disasters skyrockets in at-rist areas such as Louisiana's coast.
- **MODEL SOLUTIONS** Experts are using high-powered computers to create models that predict where flooding and storm surge dangers are worst.
- **SHIFTING TIDE** - The Army Corps of Engineers has made Louisiana habitable . . . but it's also caused many of the problems.

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DAY 5

- **COST OF SURVIVAL:** New Orleans will continue sinking and hurricanes will continue threatening us. But efforts to rebuild the areas's natural coastal protections are showing promise.

» **Go to Part 5**

HURRICANE CENTER

- **STAY INFORMED:** When tropical systems begin churning toward the United States, NOLA.com's extensive Hurricane Center provides up-to-the-minute details on everything from multiple satellite views to expert forecasts to local Doppler on demand.

» **Go to Hurricane Center**

SPECIAL EDITION — Washing away — THE TIMES-PICAYUNE

In Harm's Way

Part 1 of a Series

Water is never far from New Orleanians. Just outside the city, saltwater intrusion is destroying marshes, including this one near the Bayou Bienvenue-Florida Avenue Canal between New Orleans and St. Bernard Parish. Now that cypress trees and other vegetation have died, erosion will accelerate, further stripping the region of its natural protections against hurricanes.

(PHOTO BY ELLIS LUCIA / The Times-Picayune)

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It's only a matter of time before south Louisiana takes a direct hit from a major hurricane. Billions have been spent to protect us, but we grow more vulnerable every day.

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HISTORIC NEW ORLEANS COLLECTION

FATEFUL DECISION:
Nearly 300 years ago, Jean Baptiste le Moyne, sieur de Bienville, settled along a strip of land between the Mississippi River and the marshes south of Lake Pontchartrain. While the location would prove ideal for commerce, it left the city vulnerable to hurricanes and flooding.

IN HARM'S WAY

By John McQuaid and Mark Schleifstein
Staff writers

On the night of Aug. 10, 1856, a powerful hurricane struck Last Island off the southern tip of Terrebonne Parish. The sea rose in the darkness and trapped hundreds of summer vacationers visiting the popular resort. Wind-driven waves 8 feet high raked the island and tore it in two.

By morning, everything standing upright was broken, splintered and washed away, including all of the island's trees, its casinos, a hotel and the summer homes of wealthy New Orleans families. More than 200 people died. Many were crushed and others drowned after being struck by wreckage in the maelstrom.

LAST ISLAND'S WALTZ
As hotel guests waltzed away the night, gale winds began whipping outside. The next morning, the guests awoke to a hellish fury.
Click for photos/maps

Claire Rose Champagne's great-great-grandmother Amelie Voisin and a baby daughter were among those lost in the storm. Other family members survived and eventually abandoned Last Island — today the Isles Dernieres archipelago — for Dulac, a fishing village 30 miles inland up Bayou Grand Caillou. But there was no escape from the storms, which have followed the family inland over five generations.

In 1909, Champagne's fisherman grandfather was out at sea when another hurricane lashed the Louisiana coast with 110-mph winds that propelled a 10-foot wave of water through Dulac.

"My grandmother and (her) children were left at home and saved themselves by climbing into the attic of the house," she said. "Forty people tied ropes to the house and to two oak trees, then all stayed in the attic — women and children and some men. After the hurricane the government sent some tents for people

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to live in." Her grandfather made it back alive, but about 350 people along the coast died in the storm.

Hurricanes are a common heritage for Louisiana residents, who until the past few decades had little choice in facing a hurricane but to ride it out and pray.

Today, billions of dollars worth of levees, sea walls, pumping systems and satellite hurricane tracking provide a comforting safety margin that has saved thousands of lives.

But modern technology and engineering mask an alarming fact: In the generations since those storms menaced Champagne's ancestors, south Louisiana has been growing more vulnerable to hurricanes, not less.

Sinking land and chronic coastal erosion — in part the unintended byproducts of flood-protection efforts — have opened dangerous new avenues for even relatively weak hurricanes and tropical storms to assault areas well inland.

"There's no doubt about it," said Windell Curole, general manager of the South Lafourche Levee District, who maintains a hurricane levee that encircles Bayou Lafourche from Larose to the southern tip of Golden Meadow. "The biggest factor in hurricane risk is land loss. The Gulf of Mexico is, in effect, probably 20 miles closer to us than it was in 1965 when Hurricane Betsy hit."

These trends are the source of a complex and growing threat to everyone living in south Louisiana and to the regional economy and culture:

- The combination of sinking land and rising seas has put the Mississippi River delta as much as 3 feet lower relative to sea level than it was a century ago, and the process continues. That means hurricane floods driven inland from the Gulf have risen by corresponding amounts. Storms that once would not have had much impact can now be devastating events, and flooding penetrates to places where it rarely occurred before. The problem also is slowly eroding levee protection, cutting off evacuation routes sooner and putting dozens of communities and valuable infrastructure at risk of being wiped off the map.

- Coastal erosion has shaved barrier islands to slivers and turned marshland to open water, opening the way for hurricane winds and flooding to move inland. Hurricanes draw their strength from the sea, so they quickly weaken and begin to dissipate when they make landfall. Hurricanes moving over fragmenting marshes toward the New Orleans area can retain more strength, and their winds and large waves pack more speed and destructive power.

- Though protected by levees designed to withstand the most common storms, New Orleans is surrounded by water and is well below sea level at many points. A flood from a powerful hurricane can get trapped for weeks inside the levee system. Emergency officials concede that many of the structures in the area, including newer high-rise buildings, would not survive the winds of a major storm.

- The large size of the area at risk also makes it difficult to evacuate the million or more people who live in the area, putting tens of thousands of people at risk of dying even with improved forecasting and warnings. The American Red Cross will not put emergency shelters in the area because it does not want to put volunteers or evacuees in danger.

- The Army Corps of Engineers says the chance of New Orleans-area levees being topped is remote, but admits the estimate is based on 40-year-old calculations. An independent analysis based on updated data and computer modeling done for The Times-Picayune suggests the risk to some areas, including St. Bernard and St. Charles parishes and eastern New Orleans, may

be greater than the corps estimates. Corps officials say the agency is studying the problem with an updated model.

It all adds up to a daunting set of long-term economic, engineering and political challenges just to maintain the status quo. Higher levees, a massive coastal-restoration program and even a huge wall across New Orleans are all being proposed. Without extraordinary measures, key ports, oil and gas production, one of the nation's most important fisheries, the unique bayou culture, the historic French Quarter and more are at risk of being swept away in a catastrophic hurricane or worn down by smaller ones.

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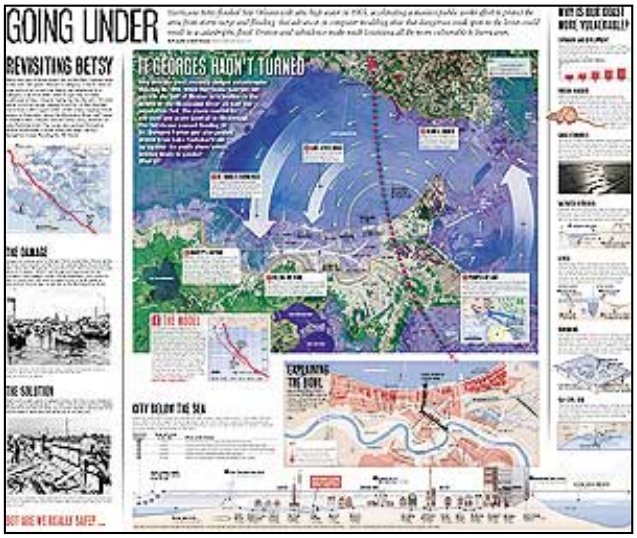

Going Under

What would have happened if Hurricane Georges hadn't turned aside at the last moment? This graphic package shows what experts say.

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LAST LINE OF DEFENSE: Hoping the levees hold

Army Corps of Engineers officials say hurricane levees in the New Orleans area will protect residents from a Category 3 hurricane moving rapidly over the area. But computer models indicate even weaker storms could find chinks in that armor.

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The Numbers Game

Each year the world's tropical waters spawn a little more than 50 cyclonic storms that earn the label of hurricane, typhoon or cyclone. The chance of one hitting New Orleans may seem low, but history says we're due.

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SPECIAL EDITION — Washing away — THE TIMES-PICAYUNE

NATURE'S ULTIMATE WEAPON

Whether they're called hurricanes, typhoons or cyclones, they are the most devastating weather events - churning masses of wind and rain that cause swaths of damage up to hundreds of miles wide at points along paths a thousand miles long.

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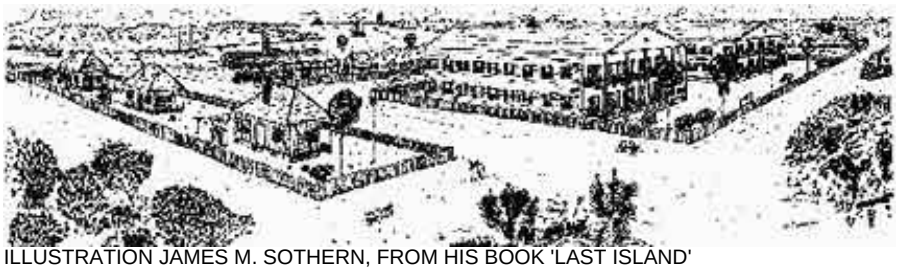
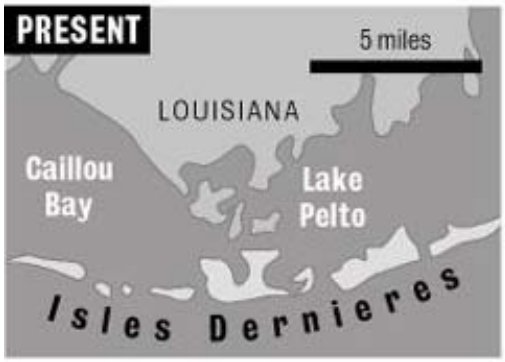


ILLUSTRATION JAMES M. SOTHERN, FROM HIS BOOK 'LAST ISLAND'



STAFF MAPS

LAST ISLAND'S WALTZ

A few years before the Civil War, one of the most legendary storms to strike the Louisiana coast destroyed Last Island. Each summer, wealthy New Orleanians would take the steamer down to the resort. On Aug. 9, 1856, as hotel guests waltzed away the night, gale winds began whipping outside. The next morning, the guests awoke to a hellish fury.

When the regularly scheduled steamer failed to arrive, vacationers realized they were trapped and that the Gulf would soon sweep over the island.

"The wind blew a perfect hurricane; every building upon the island giving way, one

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after another, until nothing remained . . . men, women and children were seen running in every direction, in search of some means of salvation," according to Mr. Duperier, an eyewitness quoted in the Aug. 14, 1856, Daily Picayune.

The 1856 hurricane claimed at least 200 lives on Last Island, today a series of islets known by the French name Isles Dernieres.

"At about 4 o'clock, the Bay and Gulf currents met and the seas washed over the whole island . . . no words could depict the awful scene," the Daily Picayune wrote after the storm.

The Isles Derniers as they appear today.
(PHOTO BY ELLIS LUCIA / The Times-Picayune)

A tiny sliver of land is all that's left to tie Isle de Jean Charles to the rest of civilization. The road was paved in the 1970s, and in the 1990s was raised by 4 feet. Today, parts of the road are often under water during high tide.
(PHOTO BY ELLIS LUCIA / The Times-Picayune)

Written Off

The Gulf is slowly swallowing Isle de Jean Charles and other south Louisiana towns. A new federal levee promises to save some but leaves others exposed to the elements that eventually will wipe them from the map. For the government, it's a question of cost vs. benefit. For residents, it's a question of survival.

By John McQuaid
Staff writer

ISLE DE JEAN CHARLES -- The road to the island is a narrow strip that runs two miles across open water, buttressed on both flanks with hewn granite boulders. Broad savannas of marsh around it have withered and dissolved, and dead cypresses reach up out of the shallows like monstrous claws. In a high tide, water laps close to the asphalt. In a storm, the road disappears.

The road is the one physical link to the rest of America for Isle de Jean Charles

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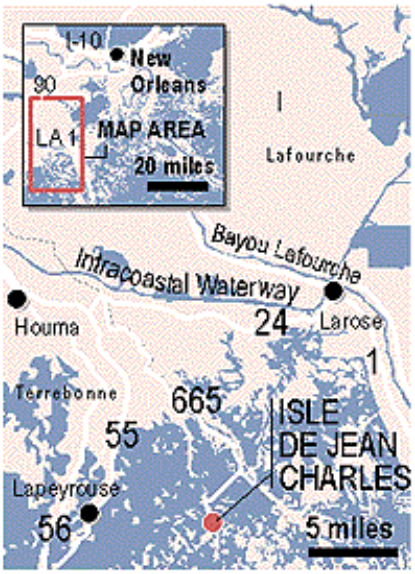
and its community of Biloxi-Chitimacha-Choctaw

Indians, whose ancestors settled the wilderness of what is now Terrebonne Parish in the early 1800s. The first settlers may have come to "hide from the white folks that wanted to kill 'em," said Chief Albert Naquin. Or, according to one legend, to stash some of Jean Lafitte's pirate treasure.



STAFF MAP

Naquin has made the road into something of a personal crusade. He saw it built 50 years ago when he was a small child and the first trucks and cars made their way onto the island via a rutted dirt track across the marsh. He saw it inlaid with crushed clamshells by the 1960s and blacktopped in the 1970s. He wheedled bureaucrats to get it raised by 4 feet and reinforced in the 1990s.

But now Naquin's efforts to keep the island's lifeline open may turn out to have been for nothing. America -- or at least the federal government — is giving up on Isle de Jean Charles. The community, along with others near the coast, will be left outside of a major federal levee project — something many residents saw as the island's last shot at long-term survival in the face of strong hurricanes.

All of the island's structures and 240 souls could be washed away by a hurricane or even a tropical storm, and its situation is worsening because of the slow, relentless onslaught of salt water from the Gulf of Mexico.

Technically speaking, it's not even an island, but a ridge rising a few feet above the marshes, 23 miles inland from Timbalier Island on the coast. But it soon will be. Water encroaches from all four points on the compass. Parts of the island road, which connects to Pointe-aux-Chenes and solid land, have already sunk 6 inches in the two years since workers finished raising and fortifying it.

Its predicament recalls how hurricanes have helped shape the history of south Louisiana, sometimes wiping out entire towns, sometimes forcing people to pick up and leave.

In 1893, for example, a hurricane obliterated the tiny Cheniere Caminada settlement near Grand Isle, killing at least half the 1,600 inhabitants. Many were buried in a mass grave that still sits next to Louisiana 1. Hundreds of Cheniere Caminada survivors moved north to Leeville. But in 1915, another hurricane destroyed Leeville, killing dozens of people and wrecking 99 of 100 buildings.

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THEN: More than 800 people died in Cheniere Caminada near Grand Isle during the unnamed hurricane of 1893. Many of the victims were buried in Lady of Lourdes cemetery along what would become Louisiana Highway 1, in a mass grave, seen in this photo thought to have been taken shortly after the tragedy. The island and the storm would later form the basis foe novel 'The Awakening' by Kate Chopin, who often visited the resort.
(CHENIERE HURRICANE CENTENNIAL)

Reminders of the storm

According to lore, Cheniere Caminada's chapel bell began pealing on its own as

TODAY: Graveyards, many holding victims of the 1893 hurricane that wiped out the tiny Cheniere Caminada settlement near Grande Isle, are slowly disappearing into the swamp. Over the years, the erosion has accelerated as saltwater intrudes and kills oaks and other vegetation, there's nothing to hold the earth together.

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an unexpected and devastating hurricane blew ashore on Oct. 1, 1893. The town's priest, Father Ferdinand Grimaud, was long remembered for his heroism, gathering up parishioners, and urging them to safety. More More than half of the resort and fishing village's 1,600 residents were killed in the storm. After the storm, many survivors moved farther inland.

TODAY: Even as the swamp devours everything in its path, new housing emerges in the distance, beyond a graveyard along Louisiana Highway 1 that is slowly disappearing.
(PHOTO BY ELLIS LUCIA / The Times-Picayune)

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Evolving Danger

Despite rising hurricane risks, the Army Corps of Engineers hasn't revised its levee designs for the New Orleans area, and some areas may be more vulnerable to floods than the Corps maintains.

By John McQuaid and Mark Schleifstein
Staff writers

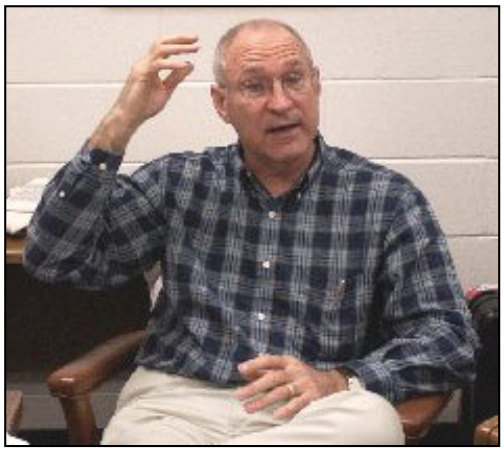
The New Orleans area's last line of defense against hurricane flooding is a 475-mile-long system of levees, locks, sea walls and floodgates averaging about 16 feet high. The Army Corps of Engineers says the system will protect the city and suburbs from a Category 3 hurricane that pushes in enough seawater to raise Lake Pontchartrain 11.5 feet above sea level -- high over the head of anyone standing on the other side of a levee.

That margin of error is critical because a storm that pushes the lake any higher can force water over the top of the levees and inundate the city. The water could quickly rise 20 feet or higher. People would drown, possibly in great numbers.

The corps doesn't know what that safety margin is anymore.

Generally speaking, the corps says the powerful, slow-moving storms capable of overwhelming the system are rare and the levees are safe. But corps engineers say their own safety estimates are out of date, and an independent analysis done for The Times-Picayune suggests some levees may provide less protection than the corps maintains.

The corps' original levee



(PHOTO BY ELLIS LUCIA / The Times-Picayune)

"The city is exposed to as much as four times the risk of hurricane flooding as it is to river

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specifications are based on calculations made in the early 1960s using the low-tech tools of the day -- manual calculators, pencils and slide rules -- and may never have been exactly right, corps officials say. Even if they were, corps officials and outside scientists say levees may provide less protection today than they were designed for because subsidence and coastal erosion have altered the landscape on which they were built.

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flooding . . . that's always been an odd issue to me. Why would the government think that water from the lake is less dangerous than water from the river?"

JOSEPH SUHAYDA
LSU engineering professor

SPECIAL EDITION — Washing away — THE TIMES-PICAYUNE

Threatening Skies

Although advanced warning systems have significantly reduced the loss of life from hurricanes, the cost in terms of destruction have jumped astronomically as coastal areas have become more developed. Here is a look at 12 notable storms that have lashed Louisiana. (Damage amounts are in current dollars. Wind speeds marked with an "*" were gusts recorded in New Orleans).

1893

UNNAMED
Landfall: Oct 1, 1893, at Grand Isle
Category: 2
Damages: $95 million
Deaths: 2,000
Winds: 100 mph
Storm surge: 15 feet

Many barrier islands were stripped of vegetation, and much of Grand Isle was destroyed. Waves at times washed over the Chandeleur Islands lighthouse, which stood 50 feet above sea level.

1893 | 1909 | 1915 | 1947 | 1957 | 1964 | 1965 | 1969 | 1985 | 1992 | Part 2 Home

STAFF GRAPHICS BY DANIEL SWENSON/ dswenson@timespicayune.com
SOURCES: Unisys Corp., National Hurricane Center, Sun-Sentinel, staff research

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NATURE, INTERRUPTED

For millennia, the Mississippi's silt-rich floodwaters built up the land. But man cut off the river from Louisiana's marshlands. Then he attacked the march itself, criscrossing it with canals and pipelines. The result: The land is sinking, the Gulf is creeping closer, and the natural barriers to a hurricane are disappearing.

GEOLOGICAL TIMELINE

See the progression of southeastern Louisiana's land formation, from the much-different geography of 5,000 years ago to the present.

View slideshow

MARSH UNDER ASSAULT

From nutria to pipelines, man, animal life and weather have taken their toll on the marshes that protect from hurricanes.

View slideshow

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The Big One

——Part 2 of a Special Report——

FILLING THE BOWL: Many New Orleanians remember how Hurricane Betsy inundated the 9th Ward, as seen in this photo. Yet under the right conditions, even a weaker storm could leave parts of New Orleans under as much as 20 feet of water for months. (FILE PHOTO BY G.E. ARNOLD / The Times-Picayune)

It's a matter of when, not if. Eventually a major hurricane will hit New Orleans head on, instead of being just a close call. It's

INSIDE PART 2

THE BIG ONE
A major hurricane could decimate the region, but flooding from even a moderate storm could kill thousands. It's just a matter of time.

LEFT BEHIND
Evacuation is the most certain route to safety, but it may be a nightmare. And 100,000 without transportation will be left behind.

happened before and it'll happen again.

Stories by John McQuaid and Mark Schleifstein
Staff writers
Graphics by Daniel Swenson
Staff artist

REVISITING GEORGES
Graphic special: A look at the track and effects of the 1998 hurricane that scared New Orleans.

THREATENING SKIES
Graphic special: A look at the 12 most notable storms that have lashed Lousiana.

SCOURGE OF SURGE
Graphic special: Explains how the dome of water that accompanies a hurricane can tower over levees and endanger residents.

LOOKING BACK AT GEORGES
A look back at the weekend New Orleans fled from Hurricane George, with stories, photos and video from The Times-Picayune and NOLA.com.

BULLETIN: FLEE
The Hurricane Warning bulletin that sent New Orleanians fleeing in what was then a record evacuation.

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Even though Hurricane Georges was considered a near miss, it made its fury known in New Orleans. The hardest hit areas were the St. Bernard Parish and along Lake Pontchartrain in eastern New Orleans where about two dozen fishing camps were destroyed by the storm in September 1998. HereBlayke Badeaux, 10, walks over a pile oflumber and debris that used to be his uncle's fishing camp.

(PHOTO BY JENNIFER ZDON / The Times-Picayune)

THE BIG ONE

A major hurricane could decimate the region, but flooding from even a moderate storm could kill thousands. It's just a matter of time.

By Mark Schleifstein and John McQuaid
Staff writers

The line of splintered planks, trash and seaweed scattered along the slope of New Orleans' lakefront levees on Hayne Boulevard in late September 1998 marked more than just the wake of Hurricane Georges. It measured the slender margin separating the city from mass destruction.

The debris, largely the remains of about 70 camps smashed by the waves of a storm surge more than 7 feet above sea level, showed that Georges, a Category 2 storm that only grazed New Orleans, had pushed waves to within a foot of the top of the levees. A stronger storm on a slightly different course -- such as the

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path Georges was on just 16 hours before landfall -- could have realized emergency officials' worst-case scenario: hundreds of billions of gallons of lake water pouring over the levees into an area averaging 5 feet below sea level with no natural means of drainage.

That would turn the city and the east bank of Jefferson Parish into a lake as much as 30 feet deep, fouled with chemicals and waste from ruined septic systems, businesses and homes. Such a flood could trap hundreds of thousands of people in buildings and in vehicles. At the same time, high winds and tornadoes would tear at everything left standing. Between 25,000 and 100,000 people would die, said John Clizbe, national vice president for disaster services with the American Red Cross.

"A catastrophic hurricane represents 10 or 15 atomic bombs in terms of the energy it releases. Think about it. New York lost two big buildings. Multiply that by 10 or 20 or 30 in the area impacted and the people lost, and we know what could happen."

Joseph Suhayda
LSU Engineer

"A catastrophic hurricane represents 10 or 15 atomic bombs in terms of the energy it releases," said Joseph Suhayda, a Louisiana State University engineer who is studying ways to limit hurricane damage in the New Orleans area. "Think about it. New York lost two big buildings. Multiply that by 10 or 20 or 30 in the area impacted and the people lost, and we know what could happen."

Hundreds of thousands would be left homeless, and it would take months to dry out the area and begin to make it livable. But there wouldn't be much for residents to come home to. The local economy would be in ruins.

The scene has been played out for years in computer models and emergency-operations simulations. Officials at the local, state and national level are convinced the risk is genuine and are devising plans for alleviating the aftermath of a disaster that could leave the city uninhabitable for six months or more. The Army Corps of Engineers has begun a study to see whether the levees should be raised to counter the threat. But officials say that right now, nothing can stop "the big one."

Like coastal Bangladesh, where typhoons killed 100,000 and 300,000 villagers, respectively, in two horrific storms in 1970 and 1991, the New Orleans area lies in a low, flat coastal area. Unlike Bangladesh, New Orleans has hurricane levees that create a bowl with the bottom dipping lower than the bottom of Lake Pontchartrain. Though providing protection from weaker storms, the levees also would trap any water that gets inside -- by breach, overtopping or torrential downpour -- in a catastrophic storm.

"Filling the bowl" is the worst potential scenario for a natural disaster in the United States, emergency officials say. The Red Cross' projected death toll dwarfs estimates of 14,000 dead from a major earthquake along the New Madrid, Mo., fault, and 4,500 dead from a similar catastrophic earthquake hitting San Francisco, the next two deadliest disasters on the agency's list.

The projected death and destruction eclipse almost any other natural disaster that people paid to think about catastrophes can dream up. And the risks are significant, especially over the long term. In a given year, for example, the corps says the risk of the lakefront levees being topped is less than 1 in 300. But over the life of a 30-year mortgage, statistically that risk approaches 9 percent.

In the past year, Federal Emergency Management Agency officials have begun working with state and local agencies to devise plans on what to do if a Category 5 hurricane strikes New Orleans.

Shortly after he took office, FEMA Director Joe Allbaugh ordered aides to examine the nation's potential major catastrophes, including the New Orleans scenario.

"Catastrophic disasters are best defined in that they totally outstrip local and state resources, which is why the federal government needs to play a role," Allbaugh said. "There are a half-dozen or so contingencies around the nation that cause me great concern, and one of them is right there in your back yard."

In concert with state and local officials, FEMA is studying evacuation procedures, postdisaster rescue strategies, temporary housing and technical issues such as how to pump out water trapped inside the levees, said Michael Lowder, chief of policy and planning in FEMA's Readiness, Response and Recovery directorate. A preliminary report should be completed in the next few months.

Louisiana emergency management officials say they lobbied the agency for years to study how to respond to New Orleans' vulnerability, finally getting attention last year.

With computer modeling of hurricanes and storm surges, disaster experts have developed a detailed picture of how a storm could push Lake Pontchartrain over the levees and into the city.

"The worst case is a hurricane moving in from due south of the city," said Suhayda, who has developed a computer simulation of the flooding from such a storm. On that track, winds on the outer edges of a huge storm system would be pushing water in Breton Sound and west of the Chandeleur Islands into the St. Bernard marshes and then Lake Pontchartrain for two days before landfall.

"Water is literally pumped into Lake Pontchartrain," Suhayda said. "It will try to flow through any gaps, and that means the Inner Harbor Navigation Canal (which is connected to Breton Sound by the Mississippi River-Gulf Outlet) and the Chef Menteur and the Rigolets passes.

"So now the lake is 5 to 8 feet higher than normal, and we're talking about a lake that's only 15 or 20 feet deep, so you're adding a third to a half as much water to the lake," Suhayda said. As the eye of the hurricane moves north, next to New Orleans but just to the east, the winds over the lake switch around to come from the north.

"As the eye impacts the Mississippi coastline, the winds are now blowing south across the lake, maybe at 50, 80, 100 mph, and all that water starts to move south," he said. "It's moving like a big army advancing toward the lake's hurricane-protection system. And then the winds themselves are generating waves, 5 to 10 feet high, on top of all that water. They'll be breaking and crashing along the sea wall."

Soon waves will start breaking over the levee.

"All of a sudden you'll start seeing flowing water. It'll look like a weir, water just pouring over the top," Suhayda said. The water will flood the lakefront, filling up low-lying areas first, and continue its march south toward the river. There would be no stopping or slowing it; pumping systems would be overwhelmed and submerged in a matter of hours.

"Another scenario is that some part of the levee would fail," Suhayda said. "It's

not something that's expected. But erosion occurs, and as levees broke, the break will get wider and wider. The water will flow through the city and stop only when it reaches the next higher thing. The most continuous barrier is the south levee, along the river. That's 25 feet high, so you'll see the water pile up on the river levee."

As the floodwaters invade and submerge neighborhoods, the wind will be blowing at speeds of at least 155 mph, accompanied by shorter gusts of as much as 200 mph, meteorologists say, enough to overturn cars, uproot trees and toss people around like dollhouse toys.

The wind will blow out windows and explode many homes, even those built to the existing 110-mph building-code standards. People seeking refuge from the floodwaters in high-rise buildings won't be very safe, recent research indicates, because wind speed in a hurricane gets greater with height. If the winds are 155 mph at ground level, scientists say, they may be 50 mph stronger 100 feet above street level.

Buildings also will have to withstand pummeling by debris picked up by water surging from the lakefront toward downtown, with larger pieces acting like battering rams.

Ninety percent of the structures in the city are likely to be destroyed by the combination of water and wind accompanying a Category 5 storm, said Robert Eichorn, former director of the New Orleans Office of Emergency Preparedness. The LSU Hurricane Center surveyed numerous large public buildings in Jefferson Parish in hopes of identifying those that might withstand such catastrophic winds. They found none.

Amid this maelstrom, the estimated 200,000 or more people left behind in an evacuation will be struggling to survive. Some will be housed at the Superdome, the designated shelter in New Orleans for people too sick or infirm to leave the city. Others will end up in last-minute emergency refuges that will offer minimal safety. But many will simply be on their own, in homes or looking for high ground.

Thousands will drown while trapped in homes or cars by rising water. Others will be washed away or crushed by debris. Survivors will end up trapped on roofs, in buildings or on high ground surrounded by water, with no means of escape and little food or fresh water, perhaps for several days.

"If you look at the World Trade Center collapsing, it'll be like that, but add water," Eichorn said. "There will be debris flying around, and you're going to be in the water with snakes, rodents, nutria and fish from the lake. It's not going to be nice."

Mobilized by FEMA, search and rescue teams from across the nation will converge on the city. Volunteer teams of doctors, nurses and emergency medical technicians that were pre-positioned in Monroe or Shreveport before the storm will move to the area, said Henry Delgado, regional emergency coordinator for the U.S. Public Health Service.

But just getting into the city will be a problem for rescuers. Approaches by road may be washed out.

"Whether or not the Airline Highway bridge across the Bonnet Carre Spillway survives, we don't know," said Jay Combe, a coastal hydraulic engineer with the corps. "The I-10 bridge (west of Kenner) is designed to withstand a surge from a Category 3 storm, but it may be that water gets under the spans, and we don't know if it will survive." Other bridges over waterways and canals throughout the city may also be washed away or made unsafe, he said. In a place where cars may be useless, small boats and helicopters will be used to move survivors to

central pickup areas, where they can be moved out of the city. Teams of disaster mortuary volunteers, meanwhile, will start collecting bodies. Other teams will bring in temporary equipment and goods, including sanitation facilities, water, ice and generators. Food, water and medical supplies will be airdropped to some areas and delivered to others.

Stranded survivors will have a dangerous wait even after the storm passes. Emergency officials worry that energized electrical wires could pose a threat of electrocution and that the floodwater could become contaminated with sewage and with toxic chemicals from industrial plants and backyard sheds. Gasoline, diesel fuel and oil leaking from underground storage tanks at service stations may also become a problem, corps officials say.

A variety of creatures -- rats, mice and nutria, poisonous snakes and alligators, fire ants, mosquitoes and abandoned cats and dogs -- will be searching for the same dry accommodations that people are using.

Contaminated food or water used for bathing, drinking and cooking could cause illnesses including salmonella, botulism, typhoid and hepatitis. Outbreaks of mosquito-borne dengue fever and encephalitis are likely, said Dr. James Diaz, director of the department of public health and preventive medicine at LSU School of Medicine in New Orleans.

"History will repeat itself," Diaz said. "My office overlooks one of the St. Louis cemeteries, where there are many graves of victims of yellow fever. Standing water in the subtropics is the breeding ground for mosquitoes."

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LEFT BEHIND

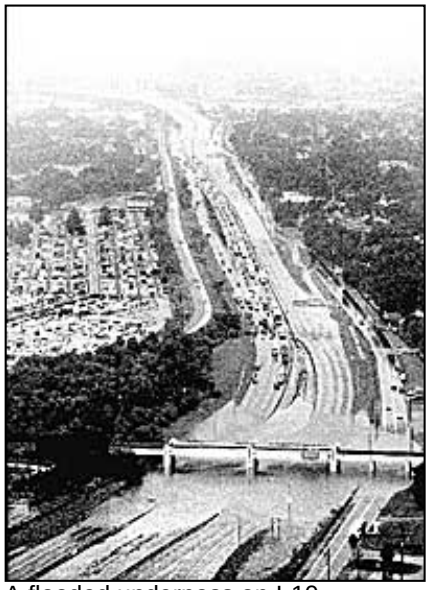
Once it's certain a major storm is about to hit, evacuation offers the best chance for survival. But for those who wait, getting out will become nearly impossible as the few routes out of town grow hopelessly clogged. And 100,000 people without transportation will be especially threatened.

By John McQuaid and Mark Schleifstein
Staff writers

Hurricane evacuations rarely go as planned. Storm tracks are hard to predict, and roads are not designed to handle the traffic flow, so huge traffic jams are a common result. In 1998 it took six hours for people leaving the New Orleans area in advance of Hurricane Georges to reach Baton Rouge, 80 miles away. The following year, Hurricane Floyd's constantly changing course spurred evacuations and bumper-to-bumper traffic on highways from Florida to North Carolina.

Moving entire populations out of harm's way is a time-consuming and unpredictable operation complicated by geography, demographics, human psychology, the limits of weather forecasting, and transportation problems that tie many cities in knots even in perfect weather.

Like every coastal area vulnerable to hurricanes, south Louisiana faces these challenges. But the Louisiana delta also has it worse than other coastal areas.



A flooded underpass on I-10 westbound near the Orleans/Jefferson parish line was a critical choke point during Tropical Storm Frances.
(FILE PHOTO BY ALEX BRANDON / The Times-Picayune)

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Because the entire region is susceptible to storm-surge flooding, hurricanes pose more danger to those left behind than in places where the coastal profile is higher.

"Evacuation is what's necessary: evacuation, evacuation, evacuation," Jefferson Parish Emergency Preparedness Director Walter Maestri said. "We anticipate that (even) with refuges of last resort in place, some 5 (percent) to 10 percent of the individuals who remain in the face of catastrophic storms are going to lose their lives."

The region's sinking coast and rising flood risk also make the task of getting people out harder than it is elsewhere. South Louisiana presents some of the most daunting evacuation problems in the United States because:

- The region's large population, including more than 1 million people in the New Orleans area, requires a 72- to 84-hour window for evacuation, well ahead of the time that forecasters can accurately predict a storm's track and strength.
- Few north-south escape routes exist to move residents away from the coast, and many of those include low-lying sections that can flood days before a hurricane makes landfall.
- Evacuees must travel more than 80 miles to reach high ground, meaning more cars on the highways for a longer time as the storm approaches.
- A large population of low-income residents do not own cars and would have to depend on an untested emergency public transportation system to evacuate them.
- Much of the area is below sea level and vulnerable to catastrophic flooding.

Based on the danger to refugees and workers, the Red Cross has decided not to operate shelters south of the Interstate 10-Interstate 12 corridor, leaving refuges of last resort that offer only minimal protection and no food or bedding.

Emergency officials say they have made improvements since Hurricane Georges, but the changes have yet to be tested under real-world conditions, and many obstacles remain.

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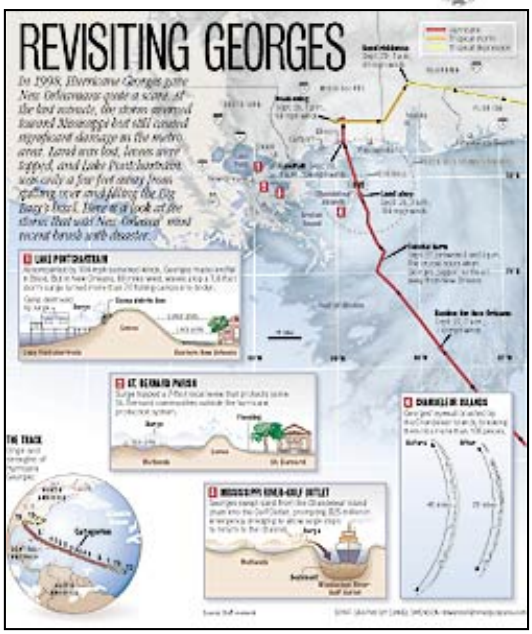

Revisiting Georges

A look back at the track and some of the damage that put a scare into the New Orleans area in 1998.

Click links below for full-size versions of this graphic. Note: this graphic originally was a five-column newspaper presentation, so these files are very large.

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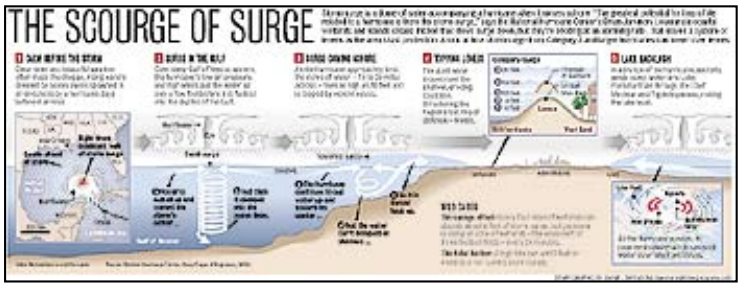

THE SCOURGE OF SURGE

Storm surge is a dome of water acompanying a hurricane when it moves ashore, which experts say has the greatest potential for loss of life. This graphic takes a look at how the storm surge from Category 3 and greater storms can tower over levees.

Click links below for full-size versions of this graphic. Note: this graphic originally was a full-page-width newspaper presentation, so these files are relatively large.

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SPECIAL EDITION — Washing away — THE TIMES-PICAYUNE

Exposure's Cost

Part 3 of a Special Report

As more people build homes in flood-prone areas, the threat of widespread damage from a major storm grows. And as the threat increases, so does the cost to protect against storms. Here, developers in eastern St. Charles Parish built 4- to 5-foot levees around the Willowdale subdivision to protect against flooding from the canals that run past this 6,000-square-foot home. The levees offer some protection, but may be offset by the additional erosion and loss of wetlands created by the new development.
(PHOTO BY ELLIS LUCIA / The Times-Picayune)

It's growing costlier to live and do business in our hurricane-prone coastal home. And as a result, **Louisiana's**

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economy is feeling the pinch from just the threat of major damage.

Three years after Hurricane Floyd, some North Carolinians still live in temporary housing.

Stories by John McQuaid and Mark Schleftein
Staff writers
Photos by Ellis Lucia
Staff photographer
Graphics by Daniel Swenson
Staff artist

EXPOSURE'S COST

Insurance companies are pulling out. Oil and gas infrastructure is threatened. Flood-prone homes may be abandoned. Louisiana's economy is feeling the pinch from the risk of hurricane damage.

By John McQuaid and Mark Schleifstein
Staff writers

When insurance bills started coming due this spring, officials in local governments and school districts were stunned. In St. Charles Parish, premiums to insure the school district's properties more than tripled, forcing officials to devise a complex scheme to buy insurance from five different companies to keep costs down.

In Jefferson Parish, most of the buildings and other property owned by the government are not currently insured at all. The parish could not find an insurance company to cover more than a third of the value of the $300 million worth of property, and the cost of doing that was a budget-busting $6 million in a total budget of $318.5

Louisiana tops the nation in the number of repeat claims for flooding, one of the reasons cited for the ever-rising cost of insurance. For areas that regularly flood, such as Irish Bayou in eastern New Orleans, seen here after Tropical Storm Frances in 1998, some residents have

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million. Officials are trying to find a cheaper alternative. But if a hurricane strikes first, taxpayers could have to foot the bill.

developed something of a post-flooding cleanup routine: clean out muck and debris, shoo out vermin, scoop up snakes and take down furniture and possessions that have been stacked up, elevated away from floodwaters. (FILE PHOTO BY RIC FRANCES / The Times-Picayune)

After the Sept. 11 terrorist attacks, insurance companies took a second look at the risks they were willing to shoulder and how much they charged for taking them on. Because of the annual hurricane threat -- and the possibility of a storm that tops levees and inundates New Orleans and surrounding suburbs -- south Louisiana is one of the riskiest places in the United States.

"A lot of it has to do with insurance companies realizing the potential liability that they have, that one incident could wipe out a company's reserves," said St. Charles school district Comptroller Jim Malone. "If they insure in St. Charles, Jefferson and Orleans, then one hurricane large enough to have a significant amount of destruction could devastate their company."

The Sept. 11 effect accentuated a trend already under way among insurance companies: to make people, businesses and governments shoulder a bigger burden in risky areas, especially coastal zones prone to hurricanes.

"If folks choose to live along the coast, there is a need to have them bear some of the responsibility and risk of living in an area that is vulnerable to such an obvious peril," said Gary Stephenson, a spokesman for State Farm Insurance Co., which writes close to a third of Louisiana private property insurance business, and which for a time stopped writing policies in the hurricane-prone area south of Interstate 10.

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SPECIAL EDITION — Washing away — THE TIMES-PICAYUNE

BUILDING BETTER

Requiring that new structures be designed to survive Category 3 and stronger hurricane winds would save lives as well as buildings, and in the long run would save homeowners money.

By Mark Schleifstein
Staff writer

Jefferson Parish officials found a disturbing flaw last year in their plans to open "refuges of last resort" for people stranded in a major hurricane: Only a few interior areas in a handful of public buildings could be trusted to withstand the 155- to 200-mph winds of a Category 5 storm.

"We were not really surprised," said Louisiana State University Hurricane Center director Marc Levitan, who oversaw an engineering assessment of the parish buildings. "Even in Florida, with their much more strict building codes, they've had serious problems with a deficit in safe shelter space."

New Orleans authorities decided to abandon similar refuge plans after concluding that up to 90 percent of the buildings in the city are vulnerable to damage from the most powerful hurricanes. Jefferson Parish is moving forward cautiously, knowing space will be limited for those left behind.

Emergency officials in both parishes say they are hoping to persuade people to evacuate rather than end up huddled in buildings that might dissolve or explode in the teeth of nature's most powerful force.

"We just don't have the structures in the metro area that are constructed to take that kind of wind," Jefferson Parish Office of Emergency Preparedness director Walter Maestri said. "Our building codes have not required us to build buildings capable of withstanding 170- to 200-mph winds, and engineers are now saying there may be even higher winds. Here the standard is 100 mph. And of course a lot of our buildings, except for the newer buildings along Poydras Street (in New Orleans), were built prior to any code being in place at all."

But experts say that must change: As Florida upgraded its building code and strengthened enforcement after Hurricane Andrew in 1992 and California has long required buildings designed to survive major earthquakes, south Louisiana needs to make changes to protect property and provide basic shelter for those caught in the path of a killer storm.

"We at least ought to be looking at hardening (making buildings more resistant to high winds) as far as public buildings are concerned," said Hucky Purpera,

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chief of the natural and technical hazards division in the Louisiana Office of Emergency Preparedness. "Every high school that's built could become a shelter, or certainly a refuge of last resort to save lives."

Authorities say protection could be greatly improved with some basic changes, including design and construction practices that would add as little as $2,000 to the cost of a new home or to retrofitting an existing one.

"For wind damage, it's relatively inexpensive to do these things, like hurricane clips and straps on beams and rafters to hold roofs on," Purpera said.

Legislative requirements

Next year the Southeast Louisiana Hurricane Task Force, which comprises city and parish emergency preparedness directors, will recommend that the Legislature consider requiring any new government buildings built south of Interstates 10 and 12 to be constructed to withstand the worst of hurricanes.

"They should be built to withstand a Category 5 hurricane, not only wind load, but from an elevation standpoint for storm surge," said Gerald Falgoust, director of the St. James Parish Office of Emergency Preparedness and former chairman of the task force committee that is recommending the strengthened building requirement. "There are things that can be done if some engineering takes place prior to a building being built."

The problems with structures considered as last-resort refuges in Jefferson Parish included wide expanses of glass that would allow wind to "blow up" a building if debris smashed through the windows, walls built without reinforcing bars necessary to withstand 150-mph to 175-mph winds, and roof beams that were too long to guarantee they wouldn't collapse in such winds, LSU's Levitan said.

In many cases, water damage to roofs and walls also made the buildings too vulnerable to the effects of winds, he said.

The state-approved building code used in Jefferson Parish requires buildings to withstand the effects of winds blowing at 100 mph for three minutes. That's the equivalent of a shorter gust of wind blowing at 120 mph. A Category 3 hurricane can be accompanied by sustained winds of 130 mph and much stronger gusts.

Falgoust said the Legislature shouldn't stop with strengthening requirements for public buildings. Building codes in the state should also be strengthened to reduce damage to private homes and businesses from such storms, he said.

Purpera agreed, saying California's building code has been strengthened several times during the past 20 years as officials learned more about how to protect buildings from the effects of earthquakes.

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SEEKING SHELTER

North Carolina officials had expected to shut down their temporary housing program after 18 months, but 33 months later, there are nearly 70 families still living in temporary housing, such as here in Princeville, N.C.
(PHOTO BY ELLIS LUCIA / The Times-Picayune)

After Hurricane Floyd inundated parts of North Carolina in 1999, thousands were left homeless. Today, nearly three years later, some people are still living in temporary trailers.

By John McQuaid
Staff writer

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ROCKY MOUNT, N.C. -- Griffin Clark's string of bad luck began when Hurricane Floyd flooded her out of her apartment in a small public housing development in Tarboro, N.C. Then an old foot injury acted up and she had to get orthopedic surgery. Unable to work for a time, she lost her job at an auto parts plant. Unable to pay the bills, she filed for bankruptcy. Amid the problems, she was unable to find a new place to live.

So for two years -- long after Floyd had become just an unpleasant memory for most people -- she stayed in a mobile home provided by the Federal Emergency Management Agency for storm refugees in Rocky Mount, about 20 miles west of Tarboro.

"It's not much, but it's home," she said, sitting on a couch and looking down at the tattered carpeting in the living room one day in November. "It's been rough being so far from my real home, my friends. I've been trying to get out, rent an apartment back in Tarboro. But there's no place to get out to."

Clark finally moved out in March, 30 months after the hurricane struck. With help from a federal relief program, she bought one of the used FEMA mobile homes on a plot in a park once used for storm refugees, now converted to private use, just outside of Tarboro.

When a disaster wrecks homes, the federal government steps in with temporary housing, considered a last resort for those who cannot find anywhere else to stay. The idea is to provide basic shelter until homes can be repaired or rebuilt. But when the damaged buildings are public housing units and rental apartments occupied by poor people, owners or agencies may be slow to rebuild. They may never come back at all. With nowhere else to go, people with few financial resources can end up in temporary housing for a very long time.

North Carolina's post-Floyd problems with poverty and temporary housing give a hint of what New Orleans could face on a much larger scale if a catastrophic storm swamps the city. North Carolina's experiences also provide a rough road map of what emergency managers here would have to do to address the needs of newly homeless residents.

Based on the North Carolina example, the state and federal governments would end up running what would be the largest public housing program in the nation's history, allocating money and other resources to maintain large trailer and mobile home parks while waiting for inexpensive, alternative housing to be rebuilt in the city. That might not take place for years, if it occurs at all.

North Carolina's temporary housing program was supposed to shut down after 18 months. But it was extended twice, and 33 months later it is still operating after a second deadline expired. Officials had whittled the numbers down to 69 families at the start of June, and they are hoping to end the program this summer.

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SPECIAL EDITION — Washing away — THE TIMES-PICAYUNE

Tempting Fate

Special Report Part 4

Hurricane Andrew left the most costly mess of any Hurricane in history, and delivering a wakeup call to emergency officials.
(NWS ARCHIVE PHOTO)

As more people settle on coasts and in other vulnerable areas, natural diasters have been getting more expensive.

INSIDE PART 4

TEMPTING FATE
The double-strike of Hurricane Andrew, the costliest hurricane in history, was a wakeup call as to the increasing cost of populating at-risk areas.

MODEL SOLUTIONS
Powerful computers are working to predict where flooding and other damage will occur during hurricanes.

MODEL OF BETSY
GRAPHIC SPECIAL: View a computerized animated SLOSH model of what might happen if Hurricane Betsy hit today.

SHIFTING TIDES
No one has been more responsible for

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keeping Louisiana habitable over the past 200 years than the Army Corps of Engineers. But the corps has also caused the most problems.

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SPECIAL EDITION — Washing away — THE TIMES-PICAYUNE

TEMPTING FATE

Hurricane Andrew left thousands homeless and billions of dollars in damage as it shredded its way across Florida and on to Louisiana.
(NWS ARCHIVE PHOTO)

Across the country, development in disaster-prone areas is accelerating in the path of hurricanes, floods, wildfires and earthquakes. It's a recipe for catastrophe.

By John McQuaid and Mark Schleifstein
Staff writers

Hurricane Andrew was a turning point in the modern history of natural disasters. In August 1992 the storm tore apart hundreds of houses in Homestead, Fla., leaving nothing but splintered beams and rubble across dozens of city blocks.

Andrew survived its first landfall, grew stronger and pummeled the small bayou communities and oil and gas rigs of Louisiana's Atchafalaya Basin.

Florida and Louisiana had seen big storms come and go. But as insurers and government officials tallied the numbers in the following days and weeks, Andrew's most significant feature emerged: It had broken all U.S. records for disaster damage. The mounting toll in cleanup costs, wrecked property and lost business eventually hit $30 billion.

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The number crunchers were shocked at first. Most had never imagined such a total was possible. But in 1994 the record was quickly shattered by an earthquake that jolted Northridge, Calif., causing losses ultimately estimated at $44 billion.

And it could have been a lot worse.

Both disasters hit relatively confined geographical areas in suburbs, sparing the large cities -- Miami and Los Angeles -- just miles away. Relatively few people died: 57 in the quake, 61 in the hurricane.

The earthquake was a moderate magnitude 6.7 on the Richter scale and lasted 15 seconds. Andrew was a powerful Category 4 storm, but it was moving fast and crossed inhabited areas of south Florida in minutes. By the time it hit a sparsely populated section of Louisiana, it had weakened considerably and was still moving fast, so it caused relatively little damage here.

Andrew and the Northridge quake opened a new era in which the United States will see such megadisasters become commonplace, emergency managers and experts say.

Because of population growth and a massive expansion of settlement into high-risk areas in the past generation, more people and more communities than ever are on the precipice of destruction. The wildfires burning across Colorado and Arizona in the past two weeks are just the latest example of this growing problem.

"History shows that the catastrophes we have had have become larger and larger," Federal Emergency Management Agency director Joe Allbaugh said. "It's due to development along the coast, increasing populations across the board. We have problems now with fires in the West. Traditionally the fire season doesn't start till summer. This time it started in January. . . . So we need to be in the business of preparing."

Development itself is making places more vulnerable to disaster. As people have tried to tame nature by building homes, redirecting water, suppressing fires and reshaping coastlines, they have disrupted or blocked natural processes. But you can't just lock nature in place, and these measures have accelerated cycles of destruction in unpredictable and dangerous ways.

"There's a tendency to see these events as chiefly the result of natural forces beyond human control," said Ted Steinberg, an environmental historian at Cleveland's Case Western Reserve University and author of "Acts of God," a book on disasters. "And obviously a tornado is a physical phenomenon. But what's disastrous about these events is that to a certain extent they're within human control because of policies we put into effect. We have a situation where natural forces lead to calamitous consequences that might otherwise be avoided."

In the wake of the Sept. 11 terrorist attacks, which helped send the federal budget spiraling into deficit, these trends raise questions about how the federal government will shoulder the costs of recovery from future natural disasters if they regularly rise into the billions. Some states and local governments are taking a more aggressive stance in disaster prevention, and emergency managers say the trend is catching on. The changes could mean more costs for the New Orleans area, which depends heavily on federal programs to protect it.

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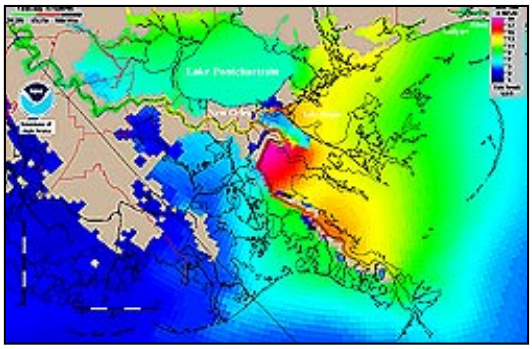
MODEL SOLUTIONS



A computerized model offers a look at the storm surge flooding across the southeastern Louisiana area if Hurricane Betsy were to hit today.

View the animation

(NOAA SCREEN CAPTURE)

Powerful computers now can predict where flooding will occur and what damage to expect. With that information, engineers can design better levees, and emergency preparedness officials can plan quicker evacuations and better relief efforts.

By John McQuaid and Mark Schleifstein
Staff writers

As Hurricane Georges shadowed the Gulf Coast 460 miles southeast of New Orleans early on a Friday morning in September 1998, Louisiana State University engineering professors Vibhas Aravamuthan and Joseph Suhayda huddled over a computer workstation in their campus office suite, sorting through terrifying scenarios of what the next few days might hold.

The National Weather Service had just issued its 5 a.m. advisory for Sept. 26, predicting that Georges, a Category 2 storm with winds of 105 mph, was expected to continue heading west-northwest at about 9 mph. The most likely track had it making landfall just to the east of New Orleans in less than 72 hours, a potentially devastating course that could flood large swaths of the metro area.

Aravamuthan plugged data on the likely track into a program running on his terminal that simulates hurricane storm surges. The professors waited for two hours as the computer crunched the numbers and finally displayed a rainbow-colored, pixelated map that showed where to expect high water. In the simulation, the flood rose and topped the levee at a low point where U.S. 61 crosses west out of Jefferson Parish, sending water pouring into protected areas. The map showed three quarters of the east bank of Jefferson and Orleans parishes ending up underwater.

Suhayda consulted with the state Office of Emergency Preparedness, the Army Corps of Engineers and officials in Jefferson Parish, who accelerated a planned

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sandbagging of the weak spot. Some corps officials decided to cancel their plans to leave the area so they could stay to monitor potential trouble spots in the levee system.

Georges ultimately veered to the east and the New Orleans area was largely spared, except for flooding in St. Bernard Parish. But the episode shows just one of the ways that computer modeling is changing and refining emergency response plans that once relied mostly on guesswork.

Mapping and modeling software have made it possible not just to forecast hurricane tracks but to predict how the storms interact with a landscape, to show where flooding and wind will strike and what damage they might do.

"It's had a huge effect," said Jay Baker, an associate professor of geology at the Florida State University who studies hurricane evacuations. "It's the foundation of all evacuation planning studies that take place now. It's night and day. It used to be a real guessing game: You evacuate from low-lying areas. Now it's modeling."

The advances in computing power let programs take many different factors -- such as land elevations, wind speeds and ocean currents -- superimpose them and predict how they will interact. Today, government agencies and private companies use an array of these.

The ultimate aim is to mimic reality as closely as possible. But different programs have different purposes. Some are complex, high-tech exercises that meticulously account for every bump in the landscape, and they can take many hours or days to run. Others, like the LSU model, can be run quickly to generate information as events unfold.

Local emergency preparedness agencies use SLOSH (Sea, Lake and Overland Surges from Hurricanes) and a related program called HurrEvac to design evacuation routes and manage evacuations as they occur. The Federal Emergency Management Agency uses a program similar to LSU's to calculate flood risk for insurance rates. The corps is using a model called AdCirc (Advanced Circulation Model for Coastal Ocean Hydrodynamics) to examine its levee designs. Insurance companies use models to estimate the risk of wind damage.

Having a way to simulate hurricane flooding is especially useful because hurricanes are relatively rare and idiosyncratic events. They move across the coast in unique ways, bringing floods, winds and rainfall along varying paths. A storm's strength is only one factor in flooding. Water heights change quickly depending on wind, the storm’s track and the obstacles encountered. So there isn’t a good historical record that would allow scientists to judge how often a place might be flooded or how the next big storm might affect a given locale.

Without modeling, government agencies would be left to trial and error: Build in response to past floods and wait for the next storm to hit to see whether they are right. With it, a modeler can draw a stretch of the coast and throw thousands of different storms at it from every possible direction to identify trouble spots.

The New Orleans area presents a unique problem for programmers. In most other places, the boundary between coast and sea is clear and the land rises above sea level relatively fast. But south Louisiana is flat with alternating areas of water and land. Much of the land, including heavily populated areas, is below sea level. Some places are surrounded by levees. The Mississippi River, smaller waterways and canals snake through the area.

"The whole way in which a storm evolves once it makes landfall is not as well-known as the behavior of storms on the open ocean," said Joannes Westerink, a University of Notre Dame engineer working on the AdCirc storm-surge model for

the corps. "Yet there is no region in the country where that is more critical than Louisiana. You have Lake Pontchartrain that is able to nail New Orleans (from the north). Surge can propagate up the river, and surge can come in from southeast. It's a complex problem."

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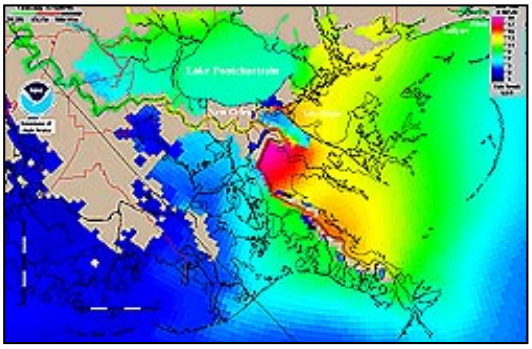

Hurricane Betsy - Animated SLOSH Model

This animation, produced by National Weather Service scientists using the SLOSH (Sea, Lake and Overland Surges from Hurricanes) Model, shows what might happen if Hurricane Betsy hit the present-day southeastern Louisiana landscape, which has higher levees than in the past. It shows flooding in eastern New Orleans and St. Bernard Parish inside hurricane levees. Experts caution that the model is somewhat speculative, and at least one other model shows that Betsy would not flood inside the levees if it hit today.

Click for 480-324pixel animation

Click for 1113x752-pixel animation

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This map shows the proposed Morganza-to-the-Gulf hurricane levee, an ambitious project that marks some changes in philosophy for the Army Corps of Engineers.

View full-sized map

SHIFTING TIDES

No one has been more responsible for keeping Louisiana habitable over the past 200 years than the Army Corps of Engineers. But the corps has also caused the most problems.

By John McQuaid and Mark Schleifstein
Staff writers

The Army Corps of Engineers says it has a big fix for the subsiding and eroding coastal areas that are threatened by increased storm-surge flooding. When completed in 15 years, it will be a cutting-edge achievement in hurricane-protection engineering: a 9- to 15-foot levee with an unusual, environmentally friendly design snaking for 72 miles across marshes and along bayous through towns from Houma to Larose.

The $680 million Morganza-to-the-Gulf of Mexico hurricane levee is part of an ambitious array of hurricane-protection projects the corps has planned or under way as it tries to hold off the rising waters of the Gulf. From big cities such as New Orleans to tiny marsh communities such as Dulac, hundreds of thousands of residents depend on the corps' engineering know-how to protect them from devastating floods.

But the levee also embodies many of the pitfalls of corps projects. Another huge structure will be built on top of sensitive marshes. Its big innovation -- a design to let water flow back and forth through gates to preserve wetlands -- is untested. And no one is yet sure how to integrate it with planned coastal restoration projects.

Hurricane risks are on the rise here because natural storm protections such as

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wetlands and barrier islands are disappearing. And for 200 years the corps -- with its propensity to build large projects that hurt marshlands -- has unintentionally contributed more to the deterioration of those protections than any other agency, public or private.

Now the corps is in charge of fixing many of the problems it created, and officials plan to use many of the same techniques they always have.

If current plans to restore the coast get a green light, the corps will have a central role in building levees, locks and floodgates and in maintaining and rebuilding wide areas of marshlands and barrier islands all at the same time. Its record raises a central question: Can the corps learn from mistakes and protect the region from hurricanes, or might it end up making a bad situation worse

Protections foster erosion

Since the early 1800s, the corps has designed, built and maintained the massive public works projects that make modern New Orleans and south Louisiana possible.

The corps created the deep-draft Mississippi River channel that helps the Port of New Orleans serve as the nation's largest handler of bulk cargo. The corps raised key levees that protect the city and development along the river from spring flooding, tropical storms and hurricanes. The corps also built and permitted the navigation channels for an expanding oil and gas industry that has underwritten the state's economy for decades.

But depending on what scientist you talk to, these projects also are responsible for a third to more than half of the erosion that has occurred along Louisiana's coast in the past 100 years, when more than 1 million acres of Louisiana's coast, mostly wetlands, have eroded -- an area the size of Rhode Island. The rate of loss grew slowly to about 14 square miles a year in the early 1940s, then increased rapidly to a high of 42 square miles in the late 1960s before slowing to between 25 and 35 square miles a year today.

As a result, the corps' own hurricane protection levees have become more vulnerable. They were built with the understanding that they would be buffered from winds and storm surge by 40 to 50 miles of protective swamp and marsh, corps and state officials say. But today the Gulf has moved north, threatening the levees and the communities they protect with higher storm surges and stronger wind-driven waves.

"The leveeing and controlling of the Mississippi River for flood protection and navigation improvements for the last 125 years is an example of the things (the corps) can do," said Clifford Smith, chief executive officer of T. Baker Smith & Co., a coastal engineering firm in Houma. "But it's also an example of how some of the problems developed in south Louisiana."

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SPECIAL EDITION — Washing away — THE TIMES-PICAYUNE

Cost of Survival

Part 5 of a Special Report

The 1900 Galveston hurricane was the deadliest in U.S. history, killing up to 8,000 residents as the violent ocean surge swept across the Texas island city with no warning.
(HISTORIC NATIONAL WEATHER SERVICE COLLECTION)

Improvements in forecasting have greatly reduced storm casualties. Now, scientists are developing techniques that could save more lives by improving hurricane warnings and evacuation

INSIDE PART 5

times critical for New Orleans.

Meanwhile, efforts to rebuild the area's natural coastal protections are showing promise.

Planning is the key to surviving a hurricane. Have a destination in mind and make arrangements for your loved ones, pets and home. Then when a storm threatens, leave.

SPECIAL EDITION — Washing away — THE TIMES-PICAYUNE

COST OF SURVIVAL

New Orleans and south Louisiana will always be vulnerable to a catastrophic hurricane, yet there are ways to make the area safer. But implementing the proposals may be prohibitively expensive.

By Mark Schleifstein and John McQuaid
Staff writers

If hurricanes haven't seriously scarred coastal Louisiana or swept it out to sea in the next 50 to 100 years, the very process of protecting the region may still end up altering it almost beyond recognition.

Based on current plans and proposals, here are some changes that coming generations may see:

- A giant wall, more than 30 feet high in places, cuts through New Orleans and across Jefferson Parish to create a "safe haven" should a storm surge from Lake Pontchartrain top the levees. The levees themselves are 10 feet or more higher than today, and some are crowned with a sea wall, blocking views of the lake. A large collapsible wall sits atop some levees, ready to be raised during hurricanes.

- At the Rigolets and Chef Menteur passes to the lake, huge floodgates stand ready to be closed if waters rise. All across the Mississippi River delta, hurricane levees crisscross marshes, surrounding dozens of towns. At key junctures on the river, large gated sluices direct fresh river water across stretches of marshland, rebuilding it with silt. Dredges have hauled sand from miles offshore to sculpt and maintain new barrier islands where only slivers exist today.

- From New Orleans to Morgan City, thousands of homes have roofs fortified to resist high winds and are equipped with steel storm shutters. Outside the levees, most homes have been raised on pilings 15 feet high or more. Main roads and highways are at similar heights.

- Some communities have built elevated shelters capable of withstanding 175-mph winds, similar to those being constructed in Bangladesh today.

- But big storms still threaten even this highly engineered landscape. In some places the Gulf of Mexico has maintained its steady progress inland and the region is starting to resemble Venice, Italy, the city of canals. Water routinely laps at the foot of levees, eroding them. In other areas, levees and walls deflect surging floodwaters into new places and to surprising heights. Engineers watch as the sea rises and the land sinks and wonder whether their ambitious fixes will ultimately amount to nothing.

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It's impossible to make a large city or a broad area like the Mississippi River delta completely disasterproof. Nature is too fierce, human structures and activities too exposed. But most emergency managers agree that south Louisiana could be much safer than it is. That will take creative engineering design and new thinking about how to disasterproof communities. It also will take plenty of money.

These innovations are collectively more ambitious than any similar engineering project anywhere in the world and will change not only the shape of the Mississippi River delta but the way people live here. Some will end up behind walls. Some on stilts. If programs don't work, many people may ultimately move away.

"We have to think big. It's the only thing that will get us anywhere," said Len Bahr, the governor's executive assistant for coastal activities.

If erosion, subsidence and sea-level rise continue on their present course, scientists say cities and towns will become man-made islands surrounded by rising Gulf waters and vulnerable to all manner of storms. That scenario strikes fear into the hearts of engineers and public officials. If water laps against levees and floodwalls, flooding becomes an almost daily threat. Transportation and other normal activities can be easily disrupted by rising water. Just maintaining the levees becomes a complex task.

"We don't want to be in a situation where there are just levees and the Gulf," said Al Naomi, an Army Corps of Engineers project manager who is leading a preliminary study on whether to significantly increase levee protection across the area. "We want something between us and the Gulf."

Several large-scale efforts to avert this "waterworld" scenario and fortify the landscape are already under way, and more are proposed, some in the realm of the fanciful and others merely ambitious.

The $14 billion, 30-year Coast 2050 plan being pushed by a governor's committee and Louisiana members of Congress seeks to rebuild the coast, primarily by diverting water and silt from the Mississippi River across marshes and rebuilding barrier islands. Its promoters say it would begin to reverse some of the losses of the past 100 years and restore natural hurricane protections.

But at best, that would provide only partial protection from hurricanes. Even if the entire coast could be restored to the way it was a century ago, large storms could still devastate the area with flooding, rain, wind and tornadoes far inland. Scientists and engineers say additional fixes are needed.

"We are not going to stop marsh loss. Subsidence is too dominant," said James Coleman, a professor of coastal studies at Louisiana State University. Coastal restoration "is a temporary fix in terms of geological time. You will see results of massive coastal restorations in our lifetime, but in the long run they are also going to go."

Naomi is looking at whether to upgrade levee protection from Morgan City to the Mississippi border to withstand Category 4 and 5 hurricanes, which can have storm surges 30 feet high. Corps officials say most current federal hurricane levees protect up to the level of a fast-moving Category 3 storm.

Though building levees and floodwalls to any height is theoretically possible -- "if we can build a 50-story building, we can build any kind of wall," Naomi said -- any realistic proposal will involve complex trade-offs. Levees can be built only so high before they either take up too much space or begin to collapse, for example. The alternative is to build more walls, but they are much more expensive and also heavier, meaning they would sink faster in relation to sea

level.

High walls also are not especially attractive. "You talk about the levees in Jefferson Parish, they're 17 to 18 feet high," Naomi said. "If you put a wall on top of that, it could be something unsightly. Do people really want that" A more aesthetically appealing alternative -- building a collapsible wall on some sections of the lakefront -- would be still more expensive, he said.

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WARNED TOO LATE: At least 8,000 people died in the Galveston hurricane in 1900 because weather officials failed to recognize the danger of the storm.
(HISTORIC NATIONAL WEATHER SERVICE COLLECTION)

ADVANCE WARNING

Improvements in forecasting have greatly reduced storm casualties. Now, scientists are developing techniques that could save more lives by improving hurricane warnings and evacuation times critical for New Orleans.

By Mark Schleifstein and John McQuaid
Staff writers

VIRGINIA KEY, FLA. -- The best example of the importance of accurate hurricane forecasting may be found in the wreckage of its worst failure.

At least 8,000 people died in Galveston, Texas, in September 1900, primarily because weather officials didn't recognize the powerful dynamics of the storm and failed to warn residents until it was too late.

The thriving Gulf Coast seaport was devastated. Homes and businesses were flattened. Bodies floated in Galveston Bay for days. Scientists were forced to re-examine their theories about the storms and the way that warnings were issued.

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Fifteen years later, U.S. Weather Bureau forecaster Isaac Cline, the man who had failed to alert Galveston, was able to warn the Louisiana coast a day before an equally strong hurricane hit New Orleans, likely saving thousands of lives.

The period after the Galveston disaster marked the beginning of a century of scientific and technological advancements in hurricane forecasting that first and foremost saved lives. During the first 30 years of the 20th century, the average annual loss of life in U.S. hurricanes was 329. During the next 40 years, the average number of deaths dropped to 70 a year, and since 1969 the average has fallen to fewer than 20.

Fifteen years after failing to alert Galveston, U.S. Weather Bureau forecaster Isaac Cline was able to warn Louisiana a day before an equally strong hurricane hit New Orleans, likely saving thousands of lives.

"Hurricane research is one of the successes of the 20th century," said Hugh Willoughby, director of the Hurricane Research Division, the nation's hurricane research think tank on Virginia Key, a small island sandwiched between Miami Beach and the Miami-Dade County mainland.

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SPECIAL EDITION Washing away THE TIMES-PICAYUNE

Coastal Resuscitation

An ambitious 30-year plan would pump new life into south Louisiana's beleaguered coast and wetlands. It may be the region's best hope for weathering major storms.

By Mark Schleifstein
Staff writer

After decades of division over who and what are most responsible for Louisiana's dissolving coastline, state officials, environmentalists, business leaders and scientists have found common ground on what they think it will take to fix the problem.

The often-combative factions are rallying around something called Coast 2050, a $14 billion, 30-year wish list of flood-control, water-diversion and coastal-restoration programs that would be the largest construction project ever undertaken. The plan is aimed at re-creating a historic mix of swamp, marshland and barrier islands by unleashing some of the natural forces that had been bottled up by levees and other flood-control projects in the past century.

That should restore some of the region's natural storm protections, scientists say, reducing inland flooding and wind damage from tropical storms and weaker hurricanes that have become common events in south Louisiana in recent years.

"In the New Orleans area, if all the Coast 2050 strategies are implemented, you stand a pretty good chance of returning to a level of protection similar to 40 years ago," said Denise Reed, a professor of coastal geomorphology at the University of New Orleans.

But even with united local support, the scope of the proposal means the next phase of the battle will be fought over federal dollars in Congress, where the outcome is anything but assured.

The state would like to tap into the process Florida established in 2000 when it got congressional approval for an $8 billion plan to restore fresh-water flow in the Everglades.

But Florida had several key advantages in the political arena, including 12 million more people and 16 more electoral votes in presidential elections than Louisiana. With a $50 billion annual operating budget, Florida also expects to be able to contribute half the costs of the program. Louisiana, with a state budget of $16 billion, would have a much harder time kicking in a substantial share.

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Florida also sold its plan during times of budget surpluses and a soaring stock market, while Louisiana is lobbying in an era of deficits and during an expensive war on terrorism.

It's a struggle, but Louisiana leaders hope they can make a case for Coast 2050 based on the straightforward argument that the sinking landscape is a direct threat to people, commercial interests, the environment and the economy -- including key fisheries and oil and gas production with national significance.

The battered coast and disappearing wetlands expose about 2 million south Louisiana residents, billions of dollars in property and key industries to increased flooding and damage from hurricanes, storms and even high tides. Officials fear the nation's energy flow could be disrupted if a hurricane takes out major pipelines or transfer facilities.

U.S. Rep. Billy Tauzin, R-Chackbay, says that should be reason enough for federal help.

"When you consider our contribution to national energy security, when we're finding out how risky it is to trust foreign sources of oil and gas, I'm not sure this is a bad time to make that argument," Tauzin said.

"If the nation continues to rely on Louisiana as the place for so much of the nation's energy requirements, the nation can't forsake our coastline at the same time," he said.

Tauzin, chairman of the House Energy and Commerce Committee, recently asked a subcommittee to create a task force comprising high-ranking officials of a variety of federal departments to oversee the wetlands-restoration plan.

But Congress already has rejected legislation that would have provided the state with money to use as its share of the construction projects.

When Sen. Mary Landrieu, D-La., proposed her Conservation and Reinvestment Act in 1998 to divvy up offshore oil revenue among states directly affected by offshore production, Louisiana would have gotten the lion's share of the money. State officials made it clear they would use most of Louisiana's share as its match for coastal-restoration projects.

The House approved a version of the bill in 2001, but it died in the Senate. Instead, Congress approved a one-year, diluted version aimed largely at financing parks and recreation.

Meanwhile, Tauzin and other members of the congressional delegation have been focusing on reshaping Coast 2050 within the confines of the federal Water Resources Development Act, the vehicle used by Florida to authorize its Everglades-restoration efforts.

Projects included in the water bill are guaranteed a line in the president's budget each year, but not the actual dollars necessary to build them.

In 2004, after a broad-based environmental impact statement is complete, the delegation will return to request authorization for the entire plan. With the authorization in hand, members of the Louisiana delegation say, the fight over money for the federal share of individual projects will begin in earnest.

"If we're successful in obtaining federal authorization in 2004 and if the state can succeed in trying to find the additional revenue necessary to be an effective cost-sharing partner, we can stay ahead of some of the wetland losses and have a pretty good chance of eventually developing a sustainable coastal system," said

Randy Hanchey, assistant secretary of the Louisiana Department of Natural Resources.

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AHEAD OF THE STORM

Planning is the key to surviving a hurricane. Have a destination in mind and make arrangements for your loved ones, pets and home. Then when a storm threatens, leave.

By Mark Schleifstein
Staff writer

New Orleans-area emergency officials have some simple advice for how to survive a catastrophic hurricane: Get out.

"At some point you have to accept some responsibility for helping yourself," said Deputy Fire Chief Terry Tullier, acting director of the New Orleans Office of Emergency Preparedness. "You have to understand that this could happen, and whether it's the second or third time you've been asked to evacuate this year . . . you have to get up and go.

"The alternative is unacceptable," he said.

For Col. Jesse St. Amant, director of the Plaquemines Parish Office of Emergency Preparedness, that means: "Every person who fails to leave is going to be a search-and-rescue mission, either a casualty, injury or death."

That's because few buildings in the area are capable of withstanding the winds from even a relatively moderate storm. The New Orleans building code only requires houses to withstand winds of 100 mph, meaning that a strong Category 2 storm, with winds between 100 and 110 mph, would heavily damage or destroy most homes.

The Red Cross has decided that operating shelters south of the Interstate 10-Interstate 12 corridor is too dangerous. Recent studies by Louisiana State University engineering experts indicate that public refuges of last resort cannot be guaranteed to withstand winds from a major hurricane.

Heavy rains or storm surge can cause sudden flooding that cuts off escape routes and could leave people stranded on rooftops or in trees for days -- if they survive the storm.

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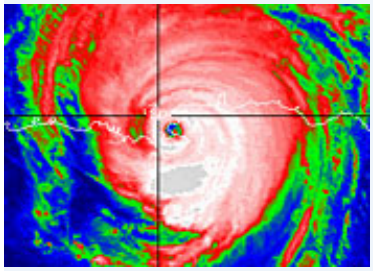

Katrina slams LA

Comes ashore as strong Cat 4 storm; significant damage reported with worst to come

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- ABC26: Jeff voluntary evacuation ignites a war of words

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- 'Zoned' storm pullout sought
- Jeff may abandon evacuation compact

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- Evacuation scramble puts contraflow system to the test
- GROUND ZERO
- N.O. has no monopoly on trouble
- No room at the inn, N.O. hotel officials say

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- **American Red Cross** - Find out what you need to do now to prepare for a severe storm.
- **National Hurricane Center** - Get the raw data on tropical storms past, present and future.
- **National Weather Center** - For local links to storm tracking information and resources.

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- **2005 Forecast:** Feds say brace for busy season
- 2005 Forecast graphic
- **Saffir-Simpson Scale:** Classification of hurricane strength and destructive power

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