Hurricane Betsy flooded New Orleans with attic-high water in 1965, accelerating a massive public works effort to protect the **COURTE UNDER** Hurricane Betsy flooded New Orleans with attic-nigh water in 1965, accelerating a massive public works effort to protect the area from storm surge and flooding. But advances in computer modeling show that dangerous weak spots in the levees could result in a catastrophic flood. Erosion and subsidence make south Louisiana all the more vulnerable to hurricanes. aff graphic by Daniel Swenson/dswenson@timespicayune.com

# **REVISITING BEISY**

Betsy was one of three direct hits on the New Orleans area in the past 100 years. Almost a Category 5 storm when it sped ashore at Grand Isle, Betsy had weakened to a Category 3 an hour later when its eye was 35 miles southwest of New Orleans, battering the city with 125 mph winds. A storm surge ranging from 8 to 16 feet flooded more than 5,000 square miles of the coast, topping 8-foot levees in Chalmette, along the Mississippi River-Gulf Outlet in eastern New Orleans, and at Camp Leroy Johnson on Lake Pontchartrain. The surge also pushed through a siphon underneath a levee along the Inner Harbor Navigation Canal, flooding the 9th Ward.



## THE DAMAGE

Damage was widespread in St. Bernard Parish, eastern New Orleans and the 9th Ward, and 58 people lost their lives in Louisiana. Many drowned in their attics, where they attempted to escape floodwaters that rose 20 feet in some places in 15 minutes. About 17,600 people were injured and 250,000 evacuated. Some buildings washed off their foundations, were carried 10 miles by surge water and ended up against levees or in the middle of intersections. Several ships ran aground on the Mississippi River levees.



After Betsy left much of the 9th Ward under water, volunteers ferried people stranded on cooftops to high ground, such as the bridge over the Industrial Canal STAFF FILE PHOTO BY G.E. ARNOLD

## **THE SOLUTION**

Reinforced by public opinion resulting from Betsy, the Army Corps of Engineers gained congressional financing for a series of flood-control and levee-building projects that were already under way to protect the New Orleans area from storms similar to hurricanes that hit the city in 1915 and 1947.



The Army Corps of Engineers began building the first concrete floodwalls along the east bank of the Inner Harbor Navigation Canal, such as here between Hayne Boulevard and Dwyer Road, in 1968. STAFF FILE PHOTO

## BUT ARE WE REALLY SAFE? ...

IF GEORGES HADNTTURNED

New Orleans most recently dodged catastrophic flooding in 1998, when Hurricane Georges cut across the Gulf of Mexico on a beeline to the mouth of the Mississippi River. As half the population fled, the storm veered to the east and made landfall in Mississippi. The hurricane caused flooding in St. Bernard Parish and also pushed waves from Lake Pontchartrain up against its south shore levees, leaving many to ponder: What if?

> 5 ST CHARLES SUBMERGED Here, water in the lake would reach heights of 3-8 feet above normal, spilling into wetlands and towns in St. Charles and St. John parishes. The water would

be deepest near the river levees.

**GRAVITY'S GATEWAY** Relentless winds from the stalled hurricane

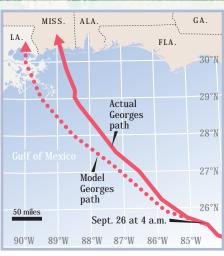
push a dome of water 14 feet above sea level at the levee. The model says that water would top low levees and floodwalls and parishes. Jefferson Parish officials say some areas would be sandbagged to 10 feet but protection would be lower near the river.

**7** FILLING THE BOWL

# computer model designed by LSU

Lac des Allemands

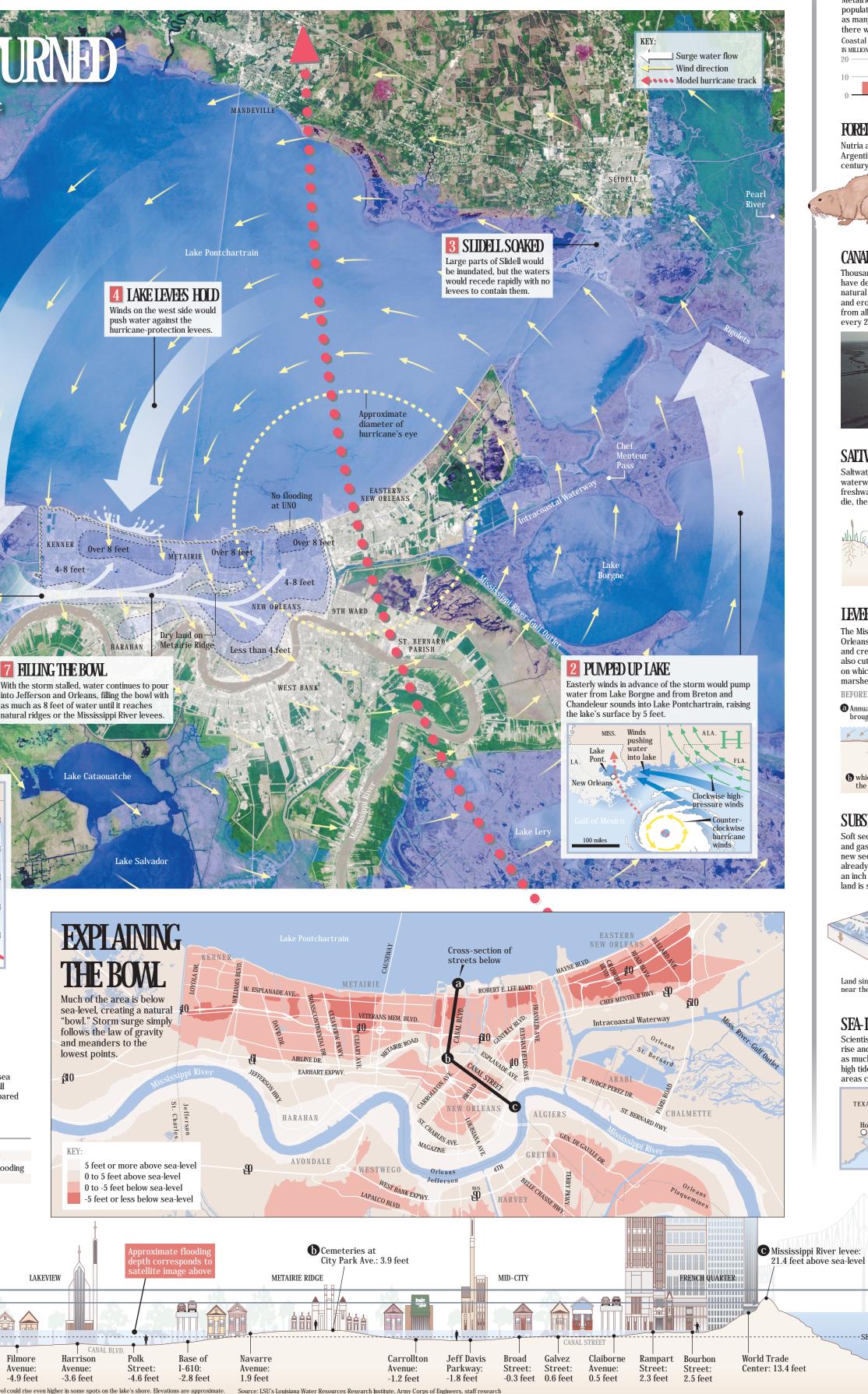
cientists Joseph Suhayda and Vibhas Aravamuthan and used by government agencies to prepare evacuation plans shows what would have happened if Georges had not turned. This scenario assumes that the storm continued on the track and intensity orecast by the National Hurricane Center on Saturday, Sept. 26, 1998, at 4 a.m. In the model, Georges intensifies to a Category 3 with 115-mph winds when it makes landfall just west of the mouth of the Mississippi. During the next two days, it moves slowly northwest, weakening to a Category 1 and stalling over eastern New Orleans. Here's what would happen.



# **UITY BELOWTHE SFA**

When a hurricane even stronger than Georges hits New Orleans, Lake Pontchartrain — a foot higher than sea level — will be the city's biggest threat. Surge water from the Gulf of Mexico, topped by towering waves, will swell the lake above levees and cause widespread flooding. A look at average surge levels by category, compared to a cross-section of the city known as "the bowl":

Hurricane	Surge and waves	
Category	at low tide*	Effect on New Orleans
•	7 feet	Lake Pontchartrain's levees stop the low-level surge
2	9 feet	Levees stop the surge, but some waves could find their way over
3	14 feet	Levees stop bulk of surge, but waves could cause considerable flooding
4	19 feet	Levees topped, causing catastrophic flooding
5	24 feet	Entire city submerged including Mississippi River levees
	Surge crashes inland with high wind-driven waves on top	a Lake Pontchartrain levee: 14.5 feet above sea-level
	5	LAKE
•	3	
Lake Pon	tchartrain	SEA-LEVEL
		Jake level:JewelRobert E. LeeFilmorebove sea levelELEVATIONSStreet:0.9 feet-3.5 feet-4.9 feet
Note: Figures co	present to maximum surge heights n	olus Lake Pontchartrain's +1 sea-level. High tides could add as much as 2 feet, and the surge level could rise ever



## WHY IS OUR COAST MORE VULNERABLE?

#### EXPANSION AND DEVELOPMENT Metairie, Kenner and Mandeville are examples of rapid

population growth along the state's coastline. Today, twice as many people and structures are in harm's way than there were 40 years ago. Coastal population of the Gulf of Mexico IN MILLIONS



Argentina for the fur trade at the beginning of the 20th century. With few natural enemies, they turned Louisiana's wetlands into their dinner table. They munch marsh grass and roots in large "eat-outs." Without roots to hold it in place, marsh soils erode and turn into open water

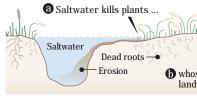
## CANALS/CHANNELS

Thousands of miles of weblike pipeline and navigation canals have destroyed some marshes and cut off others from natural water flow, opening them up to saltwater intrusion and erosion by boat traffic. Louisiana loses an acre of land from all causes, equivalent in size to three football fields, every 24 minutes



## SALTWATER INTRUSION

Saltwater from the Gulf moves inland through canals and waterways such as the Mississippi River-Gulf Outlet, killing freshwater plants that can't stand the salt. As the plants die, the soil their roots hold together is eroded away.



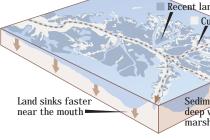
## LEVEES

The Mississippi River's springtime floods plagued New Orleans for two centuries until levees protected the city and created stable channels for sh also cut off the sediment-rich floodwaters that built the land on which the city sits, and that kept alive the coastal marshes that help protect the city from hurricanes. BEFORE LEVEES AFTER LEVEES **a** Annual floods C Levees prevent y flooding .



#### SUBSIDENCE

Soft sediment beneath Louisiana's coast is sinking, as water and gases are squeezed out by the soil's own weight and new sediment fails to replenish the loss. In New Orleans, already 6 feet below sea-level, land is sinking an average of an inch every three years. At the mouth of the Mississippi, land is sinking as quickly as 4 feet every 100 years.



SEA-LEVEL RISE Scientists say global warming is adding to existing sea-level rise and subsidence, and the Gulf of Mexico could rise by as much as 3 feet along Louisiana's coast in 100 years. At high tide and without coastal restoration, the following areas could flood:



14 feet above sea-level

SEA-LEVEL



Bounties of a few dollars a head have failed to control the invaders

**O** but the land is robbe of sediment and sinks

nent escapes int

deep water, preventing marshes from rebuilding

MISS. ALA

Average annual highwater: