THE
ARCHITECTURE
+ DESIGN
REVIEW OF HOUSTON

Cite 71

THE HURRICANE ISSUE

SUMMER 2007

$7

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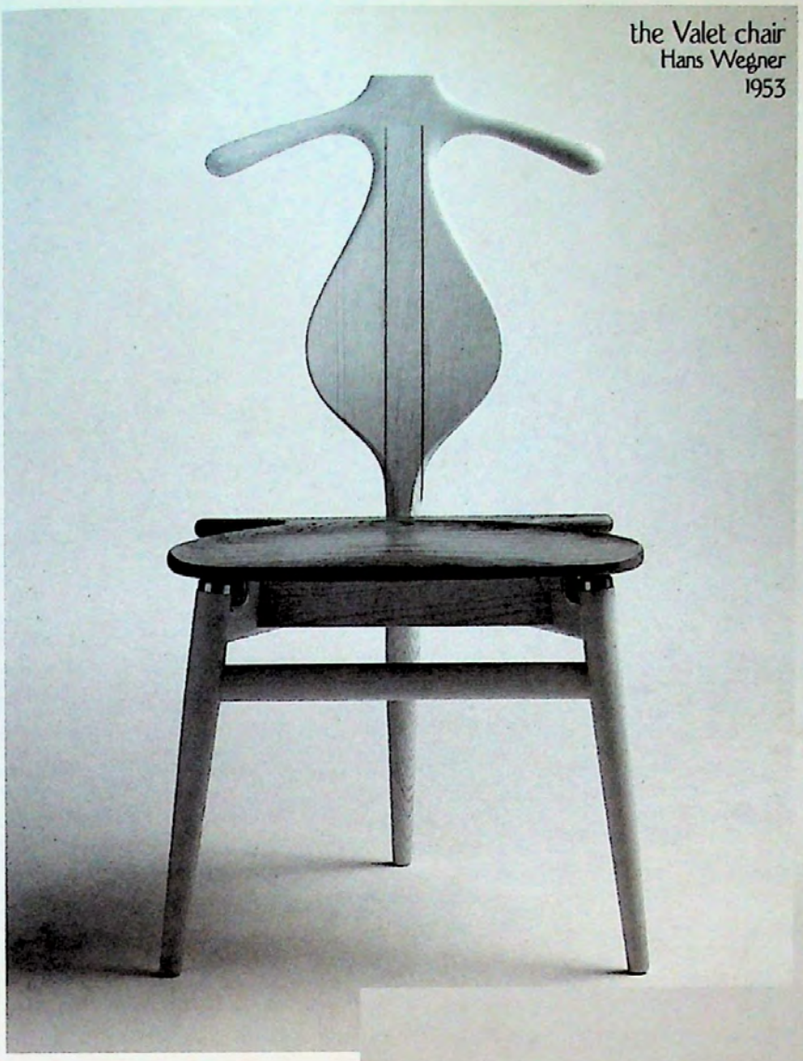

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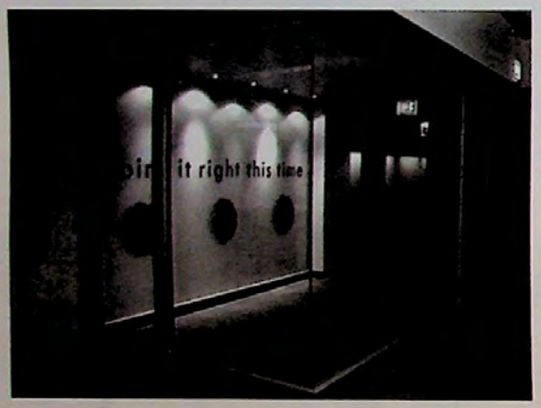

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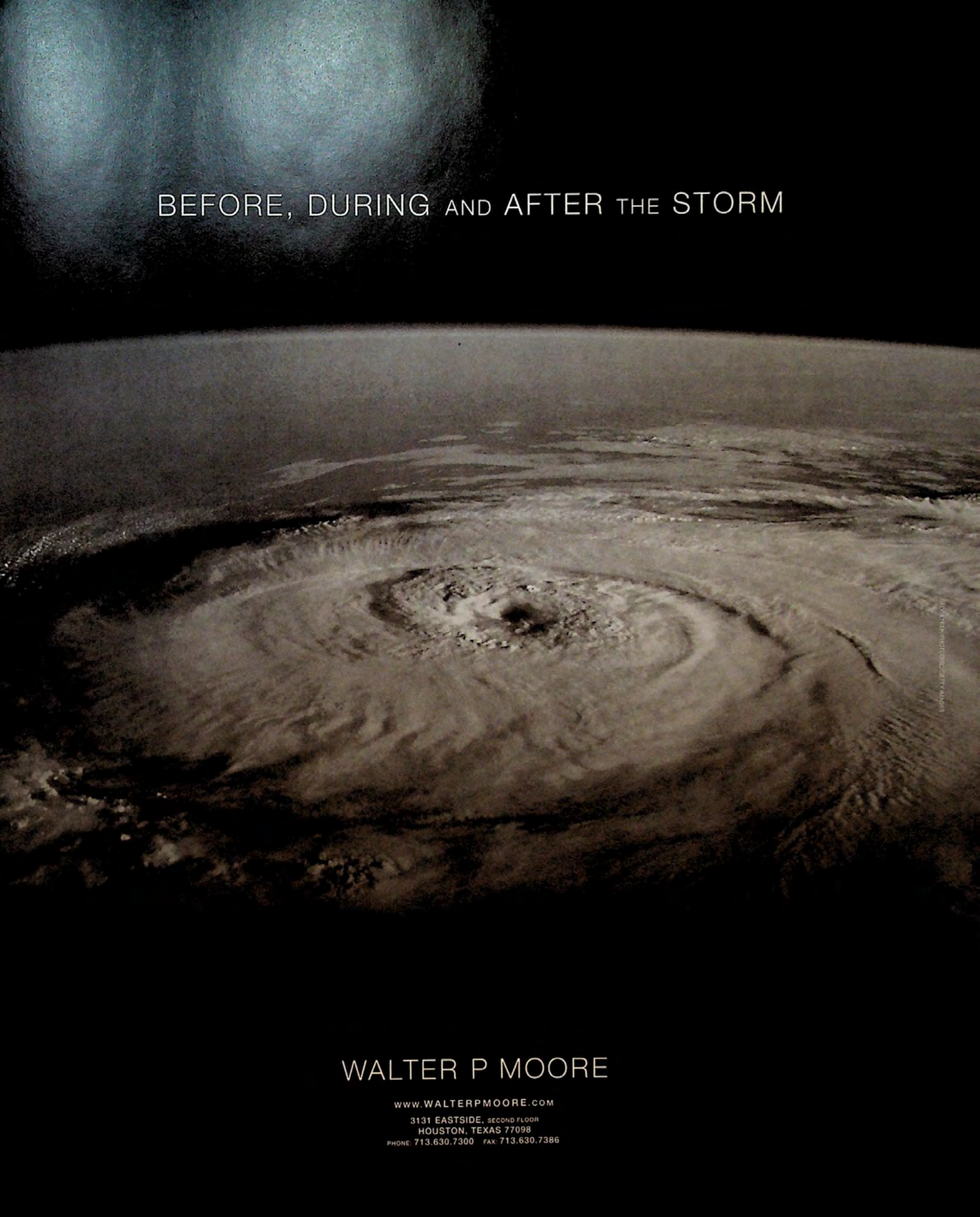

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Cite

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An architect confronts the wrecking ball and locates a failure of understanding and imagination

ON DESIGN and MEMORY

by **Thomas Colbert**

THE EXPERIENCE OF KATRINA AND THEN RITA HAD AN EERIE RESEMBLANCE TO MANY PEOPLE'S CHILDHOOD MEMORIES of Hurricane Betsy passing over New Orleans and flooding the Ninth Ward. Then there was Camille, making landfall to the east of New Orleans, washing away the city of Biloxi and leaving fully laden freighters high and dry on the beach. It's amazing how quickly these events passed from the realm of urgent public debate into anecdotal remembrance. Anecdote is usually the last resting place of shared experience, but such vignettes can also renew public awareness and discourse. They can revive history by making it personal. Hurricanes are personal. Perhaps that's why we give them names. They reach into the most intimate recesses of our lives with remarkable ease, wreaking havoc in ways that seemed unimaginable beforehand. The reality behind the statistics of risk and destruction is always personal.

The house in New Orleans that my brother and sister and I grew up in was more like the modernist designs frequently published in these pages than the shotgun homes that most people associate with Katrina, but it was our family home and it was destroyed by Katrina all the same. At the time that the house was built in the 1950s, air conditioning and suburban neighborhoods had only recently been introduced, along with plate glass and "slab on grade" foundations. The levee system was also still relatively new. It had been designed by the U. S. Army Corps of Engineers, so everyone was sure that it could be counted on. As we grew up, the canals were widened using steel sheet pilings and concrete retaining walls instead of earthen levees. No one seemed to question their design or the protection that they offered, just as no one questioned the design or the urban benefits of the interstate highway system as it was rushed to completion during the same era. There were doubters, of course. But they were regarded as alarmist eccentrics, and their voices were drowned out by the roar of construction equipment. By the time our home was built, the modern world had arrived in New Orleans with full force, bringing with it an unquestioning faith in new technologies and an enthusiastic commitment

failure to imagine design solutions. In short, it was a failure of design. The technology to prevent this disaster was available but it wasn't used wisely. The answers to the problems posed by hurricanes and coastal flooding can only be found in more robust, inclusive design thinking and in more sophisticated solutions. What the people living along the Gulf Coast need is not less technology but more sophisticated technology. What is required is not neo-traditional architecture and city planning, but better-informed designs based on the appropriate use of current technology.

This issue of *Cite* is devoted to the possible effects of a hurricane hitting the Houston-Galveston region and current governmental plans to respond to such an event. The possibility of a major storm presents largely unstudied design challenges for architects, civil engineers, planners, and environmentalists. It suggests new opportunities for creative design collaborations and for the design professions to inform public policy debate, and to not only protect, but also enrich, public life. Sustainable, survivable solutions to these challenges require the active involvement of the design professions in critical but still undebated issues.

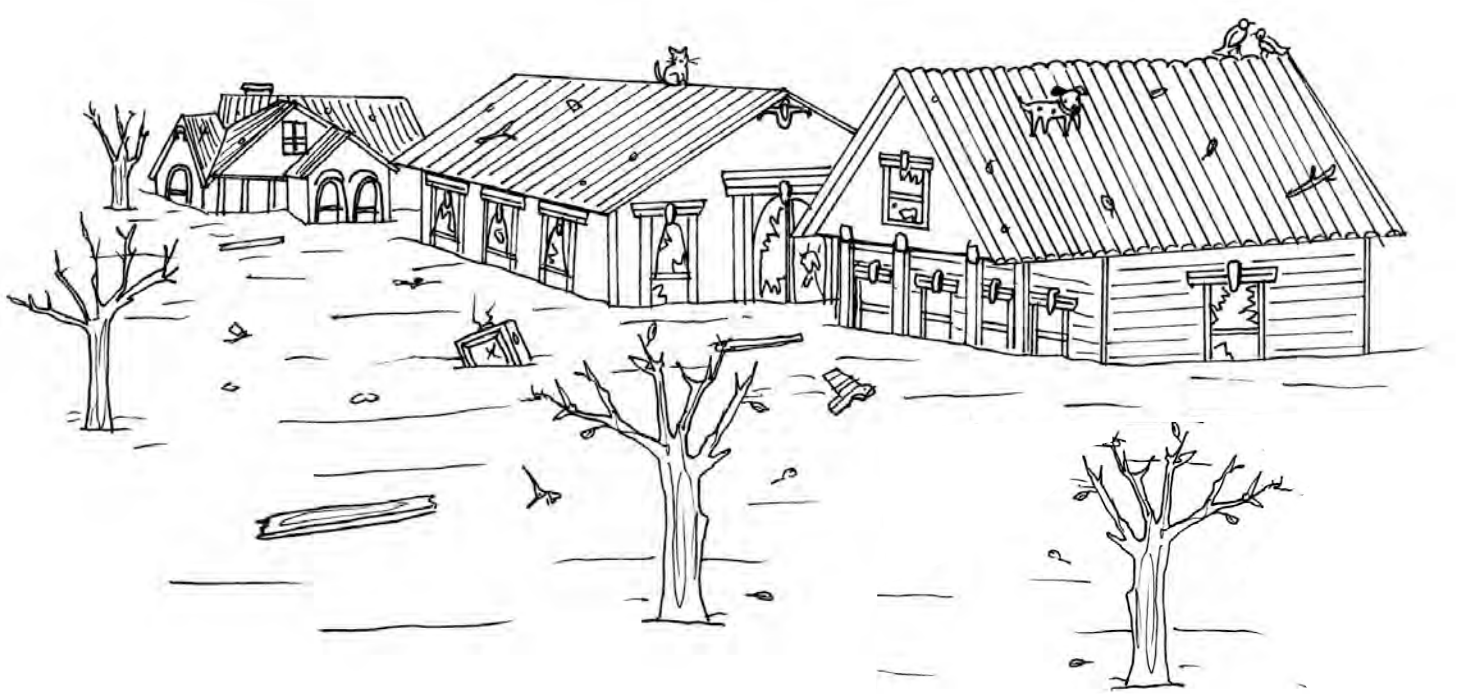
After the waters of Katrina receded, my sister and I went back to our childhood home and I saw the place differently from the way I had seen it before.

to exploring the application of those technologies in the design of buildings and neighborhoods. For those of us who were born into this world, it seemed to be the way that things had always been. No one had ever talked to us about the Great Flood of 1927, or the hundreds of storms that had gone before.

After the waters of Katrina receded, my sister and I went back to our childhood house and I saw the place differently from the way I had seen it before. Its reliance on air conditioning and on the levees appeared naïve rather than progressive. Its low slab and great planes of glass seemed more like a defiant taunt to the Indian storm god Rudra than a modernist architect's reasoned rejection of historicism. As we rummaged through the damp moldy ruins of the place looking for pieces of our history, just as so many tens of thousands of other people were doing at that time, I wondered at the seemingly irrational faith in technology that this house had been built on, and at how irrelevant "good" design seemed to be to the fate of communities.

But as the extent of the levee design failure became known, and as it became clear that wetland destruction was also a factor, I realized that blaming technology is not the answer. The failure was one of understanding and imagination. It was a failure to understand the dangers posed by hurricanes and a

COLBERT RESIDENCE, CHARLES COLBERT, FAIA.; PHOTOS: FRANK LOTZ MILLER (TOP); SHANNON STONEY (BOTTOM)



BUSINESS AS USUAL

The basic truth about hurricane insurance: The public pays

by **Michael Berryhill**
illustration **Kiersten Essenpreis**

OF ALL THE LESSONS BROUGHT HOME TO TEXAS BY HURRICANE KATRINA, perhaps the most problematic is how to prepare for such a storm financially. The simple answer would seem to be insurance, but as Katrina proved, nothing is simple about hurricane insurance. Still, there is one basic truth: Whether the damage comes from wind or flood, the taxpayers will end up shouldering the cost.

Wind damage in the 13 coastal counties of Texas is handled by the Texas Windstorm Insurance Association. The TWIA estimates it can cover a billion dollars a year in losses through its premiums and reserve funds, but if a major storm hits Harris County and the Port of Houston, the damages would far exceed a billion dollars. Half of the association's 131,000 residential policies are in Galveston County. Under current law, if damages amounted to several billion dollars, the association would assess a fee on all Texas insurance companies to make up the difference. The insurers, in turn, would be exempted from paying state taxes on their premiums, draining an estimated $450 million annually from the state budget until the benefits are paid.

The Texas Association of Independent Insurance Agents commissioned a study that concluded that if a major hurricane hit the Port of Houston, the economic damage would ripple across the entire state's economy. Consequently, the TIIA proposes that policyholders across the entire state should be assessed a premium fee to provide a cushion. Whether folks in West Texas can be persuaded to pay to insure those in East Texas remains to be seen.

While wind is important, storm surge and rain cause far more damage in most hurricane events. Insurance companies and property owners are still arguing in the courts about whether Katrina did its most virulent damage with wind or water. If their homes were destroyed by water, homeowners without federally subsidized flood insurance are out of luck. And, stunningly, many homeowners in New Orleans didn't buy the relatively cheap flood insurance—so many, in fact, that Gene Taylor, a congressman from Mississippi, introduced a bill to allow the victims of Katrina and Rita to buy flood insurance retroactively.

The congressman can perhaps be forgiven for wanting to turn the basic rules of insurance upside down, because the National Flood Insurance Program defies another basic rule of insurance, which is that the insurer should take in more in premiums than it pays out in benefits. Katrina and Rita combined to hit the federal flood insurance program for roughly $23 billion. As authorized by law, the program is borrowing from the U.S. Treasury—which is to say the taxpayers—and struggling just to pay the interest on the loans, which amounts to a billion dollars a year. The program takes in an annual premium income of about $2 billion. Insurance reformers of all political stripes have been calling for reform of the program. House Bill 1682 calls for increasing premiums 10 to 15 percent and would eliminate flood insurance for vacation homes, a provision certain to raise opposition. But no similar bill has been offered in the Senate.

While private insurers have been raising their rates all along the Gulf Coast, it's hard to feel sorry for them. In Texas last year they scored record profits of 35 percent. Stung by the insurance industry's profits and its insensitive treatment of Katrina victims, some members of Congress are talking about undoing the industry's long-held exemption from antitrust laws.

If flood insurance weren't subsidized by the government, it would probably be too expensive to buy from private insurers, who have all but given up providing it because floods are so hard to predict. The problem with the National Flood Insurance Program, which is administered by the Federal Emergency Management Agency (FEMA), is that makes it seem as though floods are predictable. Created in the 1950s by President Harry S. Truman, whose home state of Missouri was ravaged by river flooding, the program was designed to discourage people from living in floodplain. By mapping floodplains of rivers and streams and making lenders require the purchase of flood insurance by people who were living in floodplains, the legislators hoped to change building patterns. But critics of the program point out that by providing cheap insurance, the federal government has actually encouraged people to develop in areas that are at risk of flooding.

Consider the cost of insuring a modest home valued at $100,000 on the floodplain near a Texas bay. The cost of homeowner's and windstorm insurance as required by the lender is about $1,500 a year. The cost of federal flood insurance is $300 a year. Insurance companies figured out long ago that houses are much more likely to flood than to burn down; that's why they got out of the flood insurance business and have left it to the federal government.

When flood control districts draw up floodplain maps, they create a two-tier system of insurance premiums, creating the illusion for many homeowners that if they don't live in a designated floodplain, they don't need flood insurance. Terms such as "100-year floodplain" create the illusion that a house has one chance in a hundred of being flooded in any given year. The reality, as pointed out in the FEMA Web sites and those of the Harris County Flood Control District, is that during the life of a 30-year mortgage, a home has a 26 percent chance of being flooded. A "500-year flood event" sounds even more unlikely to happen, but in 1979 Tropical Storm Claudette dumped 43 inches of rain in Alvin, Texas, causing widespread flooding. In 2001 Tropical Storm Allison dropped 38 inches of rain in some parts of Harris County, causing $5 billion in damage and killing 22 people. About 65 percent of the homes damaged in the two storms were not in the floodplain. Both of these rains would be characterized as "500-year flood events"—but they came 22 years apart. The 500-year event has meaning only if the frequency of such rainfalls could be established over thousands of years.

A hurricane could flood Houston in two ways. A 30-foot storm surge would push water up the Houston Ship Channel as far as the east side of the 610 Loop, and water would likely exceed the floodplain boundaries in all of the recently re-drawn maps. If it were a particularly wet storm, it could also dump 20 inches of rain. The Harris County Flood Control District has modeled stream overflows from rain, and it has modeled storm surges from hurricanes, but significantly, it has not modeled what happens if both events happen at the same time.

After Allison hit, the Harris County Flood Control District redrew the floodplain maps with the latest laser technology. These maps put some new areas in the floodplain and removed others. The total acreage of the floodplain hasn't changed significantly. Homeowners who have been added to the floodplain had until June 18 to "grandfather" their homes into the cheaper insurance rates afforded to those not in the floodplain. That doesn't mean their rates didn't go up, but that they avoided the higher rates paid by those who live in the floodplain.

Mortgage companies require homeowners who live in the floodplain to buy federal flood insurance, but they don't require those outside the floodplain to buy it, even though the odds of being flooded are higher than of being burned out, as previously mentioned. It seems strange that lenders don't routinely require flood insurance. The Harris County Flood Control District and FEMA have conducted elaborate public relations drives to tell people in the Houston area that flooding is capricious, unpredictable, and more possible than they think. The insurance is cheap and is backed by the government. Although Harris County has more than a million residential and commercial structures, only 263,000 policies are in force.

Part of the problem lies in the illusion of safety created by the elaborate mapping and modeling of the floodplain and the use of terms such as "500-hundred-year events" and "100-year floodplain." The communications director of the Harris County Flood Control District, Fred Garcia, puts the problem for Houston much more bluntly: "As far as I'm concerned, we all live in a floodplain."

JUST A MATTER OF TIME

Present-day Galveston gambles against its own stormy history

COURTESY OF THE ROSENBERG LIBRARY, GALVESTON, TEXAS

The 1900 hurricane changed the city's physical and psychological identity; worker in a trench awaiting fill from 1906.

by **Tom Curtis**

I'VE LIVED HALF MY LIFE IN A CITY THAT SHOULDN'T BE HERE. Despite its jasmine-and-oleander-scented semi-tropical charm and its climate-adapted Victorian architecture, Galveston has one irremediable flaw: 168 years ago, it was incorporated on the shifting sands of a barrier island. The natural order of things, as coastal geologists explain, is for these slightly elevated sandbars to continuously roll over from seaward to leeward as every gust, from gentle breezes to hurricane-force winds, blows sand inland; inexorably eroding the beaches, meanwhile, are hydrologic processes ranging from daily tides and seasonal thundershowers to leviathan storm surges. These same forces rebuild the beaches and dunes farther inland, facilitating the measured migration of barrier islands towards the mainland.

Because they are in constant (if slow) motion, barrier islands are inhospitable places to site cities, or even beach houses. As the Gospel of St. Matthew recaps the age-old wisdom, only fools build houses on sand. Nature tried to teach Galveston this lesson more than a century ago, when a monster hurricane—today classified as a Category 4 on the Saffir-Simpson storm intensity scale—blindsided the island city.

On September 7, 1900, Galveston was a fast-growing metropolis of nearly 38,000 people. Perched on the northeastern edge of Galveston Island off the Upper Texas Coast, the state's fourth-largest city was a thriving port, resort, and banking and commercial center. It aspired to become the Manhattan of the Gulf, and on that day, its ambition seemed attainable. But Galveston was a disaster of biblical proportions waiting to happen. In the first decade of the 21st century, some fear that it still is.

About 8 p.m. on September 8, the eye of the then-approaching hurricane passed directly over the city—the highest ground of which was only 8.7 feet above the Gulf. The accompanying storm surge was measured at 15 feet and 20 feet at two different city locations. That surge drowned most of the 6,000 to 8,000 people in Galveston whom the hurricane is estimated to have killed. (Another 2,000 to 4,000 are thought to have drowned on the mainland.) Property damage totaled more than $17 million (in 1900 dollars); 3,600 houses and other structures in Galveston were destroyed. Overnight, Galveston earned an

unwanted distinction, dashing its aspirations for national stature and branding it with an unhappy epithet that clings to it to this day: site of the deadliest natural disaster in North American history.

The conventional scientific wisdom in 1900 was that the shallow water off Galveston's beaches would break up destructive waves and thus limit flooding. Today's weather scientists know that the height of the storm surge—the dome of water, up to 50 miles wide, that is swept ashore near where the hurricane's eye makes landfall—is inversely correlated with the water's depth, meaning that it is greatly enhanced by the shallowness of the Gulf off Galveston—a major reason for Galveston's continued vulnerability.

Both Erik Larson's 1999 best-seller *Isaac's Storm: A Man, a Time, and the Deadliest Hurricane in History* and an earlier book, John Edward Weems's *A Weekend in September*, first published in 1957, offer vivid depictions of the 1900 Storm's night of terror. Both eloquently chronicle the devastation spawned by the hurricane and detail the long and grisly aftermath. The two also discuss construction of Galveston's protective (if beach-destroying) 10-mile-long, 17-foot-high seawall, the initial phase of which was completed by the U.S. Army Corps of Engineers in 1904. They also describe the engineering feat of raising the city's grade, which gradually slopes downward from the seawall, thus draining rainwater and seawater northeast toward Galveston Bay.

But the two authors strongly differ about Galveston's subsequent safety. Larson cautions that as the 21st century approached, "meteorologists still considered Galveston one of the most likely targets for the next great hurricane disaster." Weems, on the other hand, writes reassuringly that the "massive seawall and tireless grade-raising, which still continues, make Galveston one of the best protected cities on any coast." Weems's assumption rests largely on reports of Galveston's experience with another Category 4 hurricane, said to have been nearly equal in intensity to the 1900 Storm. It went inland 50 miles southwest of the city, pummeling Galveston's beachfront with a 12-foot storm surge. The new 17-foot seawall held: Only about 50 people died on the island, and property damage reportedly totaled $5 to $8 million (1915 dollars).

"Certainly, in contrast to 1900, the city emerged relatively unscathed in 1915, and civic leaders were quick to publicize this fact to the world," independent researcher Stan Blazyk notes in his well-documented 2000 book, *A Century of Galveston Weather: People and the Elements on a Barrier Island*. He adds, "Unfortunately, this has led to a tendency to view Galveston as safe or protected from major hurricanes by the seawall, and nothing could be further from the truth. Property damage from the 1915 storm would be catastrophic by today's standards."

The odds of a catastrophe happening do seem daunting. On average, hurricanes strike the Texas coast every two and a half years. During the 20th century, 14 such "tropical cyclones" have come ashore on or near Galveston Island. Moreover, Galveston has been battered by a major hurricane—Category 3 or greater—about once every 20 years since 1900. True, fewer than 100 Galvestonians died in all the storms during the century following 1900. But there is reason to fear that this hopeful trend may be reversed in the 21st century.

Larson cautions that as the 21st century approached, "meteorologists still considered **Galveston** one of the most likely targets for the **next great hurricane disaster**."

The most recent major hurricanes afflicting Galveston were Carla, in September 1961, and Alicia, in August 1983. Carla, a Category 4 that ultimately made landfall 130 miles southwest of Galveston, killed six Galvestonians, flooded most of the city, and caused $18 million in local property damage, including destruction wrought by several tornadoes it spawned. Radar images of its monster spiral encompassing nearly the entire Gulf were terrifyingly displayed on TV screens for days before it went inland. Carla likely would have killed more people if an estimated 50,000 panicked Galvestonians hadn't fled inland ahead of the mammoth, slow-moving storm.

As the number of people living on or near the coast has mushroomed, two realities have emerged. One: Because hurricane forecasting is imperfect, people in risky locations like Galveston Island must evacuate well before it's certain they need to. Those who wait until they know for sure may not be able to get out, because rising water may obstruct escape routes or gridlocked traffic may ensnare them. Two: Galvestonians and other coastal residents often are heavily influenced in their hurricane-evacuation decision making process by their experience during the last storm.

For instance, in early August 1980, many Galvestonians and other coastal residents fled inland to escape from Hurricane Allen—then an extremely dangerous Category 5 with sustained winds clocked at 190 miles per hour. Many Allen refugees found themselves stalled on jammed freeways and later cursed weather forecasters when the storm veered south, weakened to a Category 3, and made landfall on open ranch land north of Brownsville.

That memory was still fresh in mid-August 1983, when fast-developing Hurricane Alicia struck. Barely a tenth of Galveston's population is estimated to have fled Alicia, the eye of which ultimately crossed the island's western tip. A low Category 3 at landfall, Alicia killed no one in Galveston but nevertheless ranked as the most expensive hurricane on record at that time, with more than $500 million in property damage on Galveston Island, including extensive damage to half the houses on the West End beyond the protection of the seawall and a total of $2 billion in damage throughout the region. Alicia's eye later passed over southwest Houston, and the storm uprooted trees all over town and stripped the glass skins off downtown office towers.

The next storm to threaten Galveston appeared in late September 2005. Ranked a Category 5 while swirling in the Gulf, Rita was among the most intense tropical cyclones ever observed in the Gulf, with sustained winds of 180 miles per hour gusting to 235 miles per hour. Rita arrived three weeks after Hurricane Katrina had mauled the Mississippi and Louisiana coasts. The accompanying breach of the rickety levees in New Orleans, and the chaotic federal, state, and local response, resulted in widely televised scenes illustrating a breakdown of civil society. When hurricane forecasters placed Galveston in Rita's path, the mayor ordered a mandatory evacuation. Most residents readily complied. Unfortunately, a regional plan for orderly, staged hurricane evacuations that called for the 800,000 to 1,000,000 coastal residents in the surge zones of Brazoria, Chambers, Galveston, Harris, Liberty, and Matagorda Counties to leave the area first went by the board: Thanks to the "Katrina effect," an estimated 1.5 million to 2.5 million people, many of them Houstonians who didn't need to leave, flooded onto freeways and arterial roads, turning typically three-to-five-hour trips to San Antonio, Bryan–College Station, Austin, or Dallas into hellish 24-to-36-hour ordeals. Rita, like Allen earlier, shrank to a Category 3 before landfall. While in the Gulf it took an abrupt right turn, finally barreling into the

St. Patrick's church raised for fill, from 1907.

Texas-Louisiana border. Reportedly 130 people died in the Rita evacuation, while just seven were killed by the storm itself. Despite promising better transportation planning for the next major hurricane, the 2006 report of the Houston-Galveston Area Council (HGAC) Evacuation and Response Task Force concedes: "The evacuation of the Houston-Galveston area before a Category 3 or greater hurricane presents an almost insoluble logistical problem."

With an average of one major storm striking Galveston every 20 years, the 24-year gap since Alicia suggests that Galveston today is overdue for a direct hit. And if the past is prologue, many Galvestonians, recalling their "unnecessary" flight from Rita, may decide to take their chances on the island. Even if residents merely temporize, delaying departure could prove deadly. "Rita gave us a lot of warning and drew a bead on our part of the state very early," notes Alan L. Clark, HGAC's director of transportation planning. "It provided much more lead time than we could expect from a hurricane that developed more quickly and moved inland faster." If such a storm also included drenching rains, this combination could result in thousands being stuck in traffic as waters rise, inundating vehicles and drowning their occupants.

Meteorologist Jeff Linder, a knowledgeable young staffer with the Harris County Flood Control District, describes the dangers facing those remaining in Galveston when a Category 4 or 5 hurricane strikes: A storm surge of 17 feet or greater at the coast (with destructive wave action above that) will demolish all structures within four city blocks behind the seawall, he warns. That's possible because, even as the sea level in the Gulf rises incrementally, Galveston has subsided more than two feet in the past century, meaning that the seawall is now effectively less than 15 feet high.

Beyond the seawall, West Galveston Island—22 miles of open beaches and undeveloped pastures half a century ago—is now chockablock with vacation homes and businesses. These properties are worth in the aggregate more than $1.6 billion, according to the Galveston County Central Appraisal District—four times the value of all the taxable property behind the seawall. The development of West Galveston Island, including its bay houses (some with networks of canals that during hurricane storm surges and backwashes could split the island in two) wouldn't have been possible without government programs such as federal flood insurance and the Texas Windstorm Insurance Association. These subsidized programs protect homeowners and mortgage bankers by having taxpayers elsewhere bail out those who choose to build or buy in vulnerable locations—or those who lend money to those who do. They also help support the overheated development now under way on Galveston's East Beach, where among other projects a new highrise condo has appeared and 2,000 pastel-colored homes comprising the New Urbanist development Beachtown are in the works.

As for the breakneck development on the western two-thirds of the island beyond the seawall, in May 2007 Galveston's city government declined to embrace land-use curbs suggested by the University of Texas's Bureau of Economic Geology that would have created buffer zones shielding beach foredunes, new wetlands, and a protective central ridge—all of which might spare the island from being sliced into two or more pieces by the next big storm. Instead, civic authorities decided to let west islanders read the study, pay their taxes, and take their chances: "If they want to live on the edge and risk losing it all," City Manager Steve LeBlanc told the *Galveston County Daily News*, "that's their decision."

The next Category 3, 4, or 5 storm may demonstrate whether the Galveston building codes and planning and zoning regulations enacted since Alicia are adequate. Meteorologist Linder shows two before-and-after-Hurricane-Rita slides featuring the community of Holly Beach, Louisiana, population 300. The initial scene reveals an assemblage of prosperous-looking vacation and retirement homes, with the first row of houses on the beach and, behind the vegetation line, three or four additional rows of similar residences with neatly tended yards. The post-Rita slide shows the same beach scene swept clean of everything but cement slabs where houses used to be.

COURTESY OF THE ROSENBERG LIBRARY, GALVESTON, TEXAS

URBANbuild allows Tulane University students to design and construct affordable housing for damaged New Orleans neighborhoods.

EMILIE TAYLOR

THOSE WHO FEAR THAT THE CURRENT STATE OF disaster-relief architecture in the U.S. is well represented by the Katrina Cottage and her unfortunate New Urbanist ilk will be heartened by what's happening today in the profession's training grounds. Architecture schools are adapting to and designing for crises with more sophistication and wit than their embedded colleagues. It would appear that the most devastating storm to visit the U.S. in recent years has helped architectural education to evolve. Here are three examples of how that's happening.

PROGRESSIVE ARCHITECTURE

ACCOMPLISHING GOOD HAS BECOME A MEASURE OF GOOD DESIGN

by **Julie Sinclair Eakin**

University of Texas instructor Sergio Palleroni's student team at work in New Orleans.

This church pew prototype is made of cypress collected in the ruins left by Hurricane Katrina.

Katrina Furniture Project

Some 15,000 buildings are still scheduled for demolition around New Orleans, and dumping their remains is a toxic business. "A thousand churches alone were ruined by Katrina, and it's the only institution that works there," says Sergio Palleroni, an architecture professor at the University of Texas at Austin who leads the Katrina Furniture Project. His collaborative initiative reclaims damaged but valuable lumber from demolition zones for use in making well-designed furniture. "The basic idea is to rethink our relationship with waste," he explains.

Last summer, during a six-week workshop, Palleroni partnered with the Green Project, a New Orleans-based deconstruction and salvage business, and students from UT, Art Center of Pasadena, California, and Tulane University to design and manufacture furniture prototypes as well as plan an on-site workshop measuring 3,000 square feet and accommodating 15 workers. In addition to helping restore the community's sense of purpose, one church pew at a time (he estimates 60,000 are needed), an ultimate goal is training residents to produce the designs to promote their own economic independence.

"Furniture is a great value: One dollar of material yields one hundred dollars in sales," says Palleroni. KFP's initial efforts were exhibited at the Smithsonian, the Venice Biennale, and Milan's Salon de Mobile. Design Within Reach plans to market one of the company's stepstools.

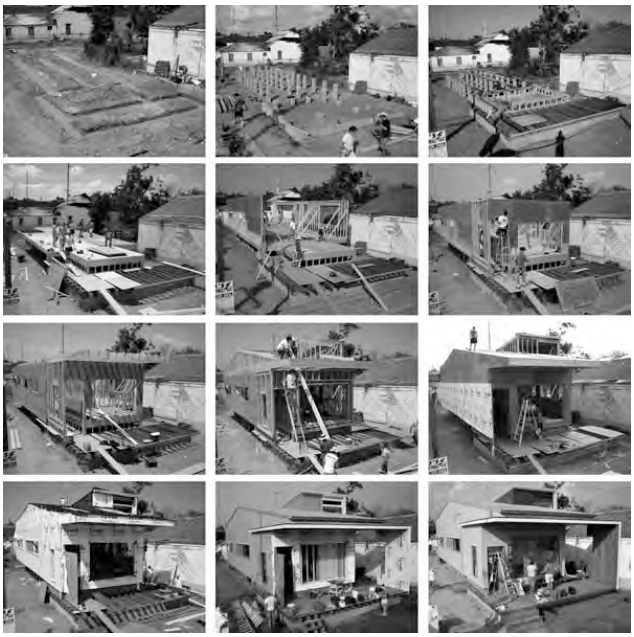
BRAD DEAL

Coastal Entanglements

Cathlyn Newell won the coveted SOM Prize and Traveling Fellowship after graduating from Rice University's School of Architecture last year, and she's currently in Scandinavia researching building techniques for severe weather conditions. Her thesis project, "Coastal Entanglements," is based on the notion that disastrous storms can be tapped for their productive energy potential. Newell calls her method "site amplification," suggesting an expansion of the definition of site by designers to also include transient aspects such as weather and natural phenomena.

Using Grand Isle, Louisiana, as a case study, Newell sought to return something to the community following its losses in Katrina. Her version of sustainability envisions a net made up of fiberglass segments that lies on the waves just beyond the shore. During storms, the net capitalizes on shifting water levels and intense wave action to collect energy via magnetic induction, storing and then later distributing electricity when it's needed. Fiberglass was the material selected because it's lightweight for easy transport, resistant to damage, and familiar to local boaters. Newell is currently seeking a backer to extend her research.

A fiberglass net constellation collects wave energy and stores it for later use.



This modified wood-frame shotgun shack is the third in a series of four prototype houses.

CATHLYN NEWELL (TOP); EMILIE TAYLOR (BOTTOM)

URBANbuild

Undergraduate and graduate architecture students at Tulane University have been helping to revitalize their city as part of Tulane City Center's URBANbuild project. "We feel there's a special urgency and poignancy to what we do now," says Emilie Taylor, a recent graduate. "Hurricane Katrina was a galvanizing event that helped give direction to the architecture school."

Taylor was project manager for an updated version of the vernacular shotgun shack completed in the Treme neighborhood in late 2006. The house is respectful of a modest budget and the local historical context while accommodating modern-day needs. (Residents need no longer troop through one another's quarters, for example, but can rely instead on an interior corridor that runs along the length of the house.) Using the common lot dimension of 30 by 90 feet, its plans are flexible enough to finesse a duplex or multigenerational home as well as a single-family dwelling. In order to satisfy its HUD grant, URBANbuild will complete four houses in as many sections of town in a two-year period.

URBANbuild partners with neighborhood nonprofits specializing in low-cost housing and is part of CITYbuild, a consortium of universities with architecture, landscape, and planning programs contributing to the rebuilding of New Orleans.

CODE BLUES

CODE.BLUES by Christof Spieler

Current measures are limited when designing buildings for **wind** and **water** emergencies

BUILDINGS ARE TYPICALLY ONLY AS HURRICANE RESISTANT AS THE LAW REQUIRES THEM TO BE.

Construction is governed by a patchwork of different codes: Cities like Houston and Sugar Land have adopted the International Building Code (IBC) and enforce it as part of their city ordinances, but those codes don't apply to areas like The Woodlands. The Texas Department of Insurance created its own building code to cover coastal counties, but it's required only for buildings that are seeking hurricane insurance. Similarly, the Federal Emergency Management Administration (FEMA) has its own guidelines that apply only to buildings in designated floodplains insured by federal flood insurance. In sum, one structure might be required to comply with three building codes, while another only blocks away might not need to meet any requirements at all.

To design a building for wind, we have to know how strongly the wind will blow. The building codes are based on a 50-year wind—the strength of wind that has a 2 percent chance of happening at that particular spot in any given year. Obviously, that's not the worst-case scenario. But safety features specified in the code add another 60 percent on top of that, which works out to anticipate a roughly 500-year wind.

The IBC provides a map of 50-year design wind speeds. Galveston is rated at 130 miles per hour, but the speed drops off rapidly inland: Downtown Houston garners a 110 estimate, IAH 100, and College Station 90. Formulas are provided to translate these speeds into pressures, with additional factors taken into account: Buildings in open areas have higher pressures than those surrounded by other buildings; pressures go up farther off the

ground; and critical facilities like hospitals, chemical plants, or buildings that could be used as shelters are designed for higher pressures. On tall or unusually shaped buildings, wind tunnel testing is used to get more accurate pressures.

Some typical pressures: A two-story building in Houston would be designed for 25 to 30 pounds per square foot of sideways load on the walls and 20 to 55 on the roof. A Galveston highrise may be designed for pressures as high as 90. These are big numbers: By comparison, the design load for a residential floor—enough to include all the people and furniture—is 40 pounds per square foot.

In our first and most simplistic view of wind loads, the big bad wolf blows over the pig's shack like a house of cards. In reality, that almost never happens in hurricanes—not because it's impossible, but rather because this is the aspect of wind design that's best understood and most thoroughly designed for. In wood construction, plywood panels nailed to the wall studs and tied to the foundation keep the building from leaning. Without the plywood, wood buildings do behave like houses of cards: In 1999, a three-story wood-framed hotel under construction in Houston collapsed in thunderstorm winds.

In commercial buildings, steel X-braces, block walls, or concrete walls brace the building. These systems are strong, small, and reliably built. They must be designed not only to hold the building up but to limit its movement, so finishes don't crack and occupants don't get seasick.

The strongest forces on a typical building in a hurricane act not on the walls but on the roof. To make design more complicated, winds suck upward on a roof, opposite to the direction of gravity loads. And once a roof fails, wind and rain get inside the building, damaging contents and often ripping off other parts of the structure. A wood roof has a myriad of potential failure points: Shingles can lift off the roof, plywood can rip off the rafters, the rafters can flex upwards, and the ends of the rafters can lift off the walls. The code prescribes measures for all of these: nailing patterns for shingles and plywood, blocking to stiffen rafters, ties at the ridge, and sheet metal hurricane clips at the eaves.

Though the materials are different, the basic wind issues with steel and concrete roofs are the same. Proprietary systems for flat roofs are lab tested and rated for uplift resistance. Welds are specified to keep roof deck and joists in place, and extra bracing is required to keep the roof from flexing upwards. Despite the code requirements, roofs remain one of the most fragile parts of a building. The basic issue is workmanship: There are hundreds of connections that can be done incorrectly, and while carpenters have a gut feel for how gravity works, they don't have that same sense for the equally strong loads that can act upward.

The most common damage to buildings in hurricanes is broken windows. Like a hole in a roof, a single broken window can lead to the complete destruction of a building as wind and rain work their way in. (Doors, especially large garage doors, are also vulnerable to being blown out). Unlike roofs, though, windows are not usually damaged by wind pressure alone. Windows break because of flying objects. Perhaps the easiest way to prevent this is with shutters or sheets of plywood. But not all building owners will be that diligent, and the usual masking-tape expedient does no good whatsoever. Window damage is also a major issue on highrises, where neither shutters nor plywood are economical. Building codes now require that all windows within one mile of the coast in hurricane-prone areas be equipped with permanent shutters or be designed to withstand impacts from flying objects. Manufacturers certify their windows for these criteria by shooting objects at them in testing labs.

The codes also address the problem of smaller amounts of debris that can break windows. During Hurricane Alicia, in1983, the Allied Bank and Interfirst Bank buildings in downtown Houston suffered considerable window damage from gravel blown off the roof of the Tenneco Building; gravel roofs are no longer permitted in hurricane zones.

There's no easier way to destroy a building than to drop a big object on it: a tree, a part of another house, even a vehicle. The resulting hole weakens the entire building. It's almost impossible to build for such an impact, and the codes do not consider it.

The greatest destruction from Hurricane Katrina wasn't from wind; it was from water. Along the Mississippi coast, the storm surge rose to the second floor of houses, with battering waves on top, and entire communities were leveled. In New Orleans, the water came more slowly, leaving buildings standing; but a building that is submerged in standing water for days will require major reconstruction.

It is essentially impossible to design a building for being submerged. No wood framing will withstand the pressure of several feet of water, let alone the pounding of waves. Neither will doors or windows. The only solution is to elevate the building on piles, with any walls between the piles designed to break away in a storm, a requirement by FEMA in flood areas. But FEMA's floodplain maps don't represent anything like the maximum possible storm surge, and they don't take waves into account. If a worst-case storm surge hits the Houston area, any building built at grade within its reach will likely be destroyed or significantly damaged. But many buildings built on piles will probably be damaged, too, from wave action. Codes offer little protection. But then, the only way to successfully resist a storm surge is probably a concrete bunker with solid steel hatches instead of doors.

Building codes have gotten significantly better as we've gained experience with each major hurricane. A building built to code will likely survive the winds of even a major storm intact, if no storm surge or falling tree is involved. Of course, not all buildings are built to code: Builders have many incentives to cut corners, and even in those places where building inspections are required, inspectors can miss things.

The biggest shortcoming in the codes, however, do not relate to new buildings at all. Older buildings were not built to current codes and lack many features we now consider essential. The first building code to consider debris impacts on windows was South Florida's in 1994, in response to Hurricane Andrew; that provision was not adopted widely until 2000. Hurricane clips were uncommon before the 1980s; in the 1960s and 1970s, engineers often did not consider wind design in one- or two-story commercial buildings.

No code requires older buildings—even essential facilities—to meet its standards, except when they are significantly modified. Thus, most of the buildings in any hurricane-prone city do not meet current codes. Of course, that does not mean they will fail. But in every storm, the greatest number of building failures tends to be in older structures. At present, the codes are sound, but they're limited.

There's no easier way to destroy a building than to drop a big object on it ... It's almost impossible to build for such an impact, and the codes do not consider it.

SECTION 6.4
METHOD 1 — SIMPLIFIED PROCEDURE

6.4.1 Scope. A building whose design wind loads are

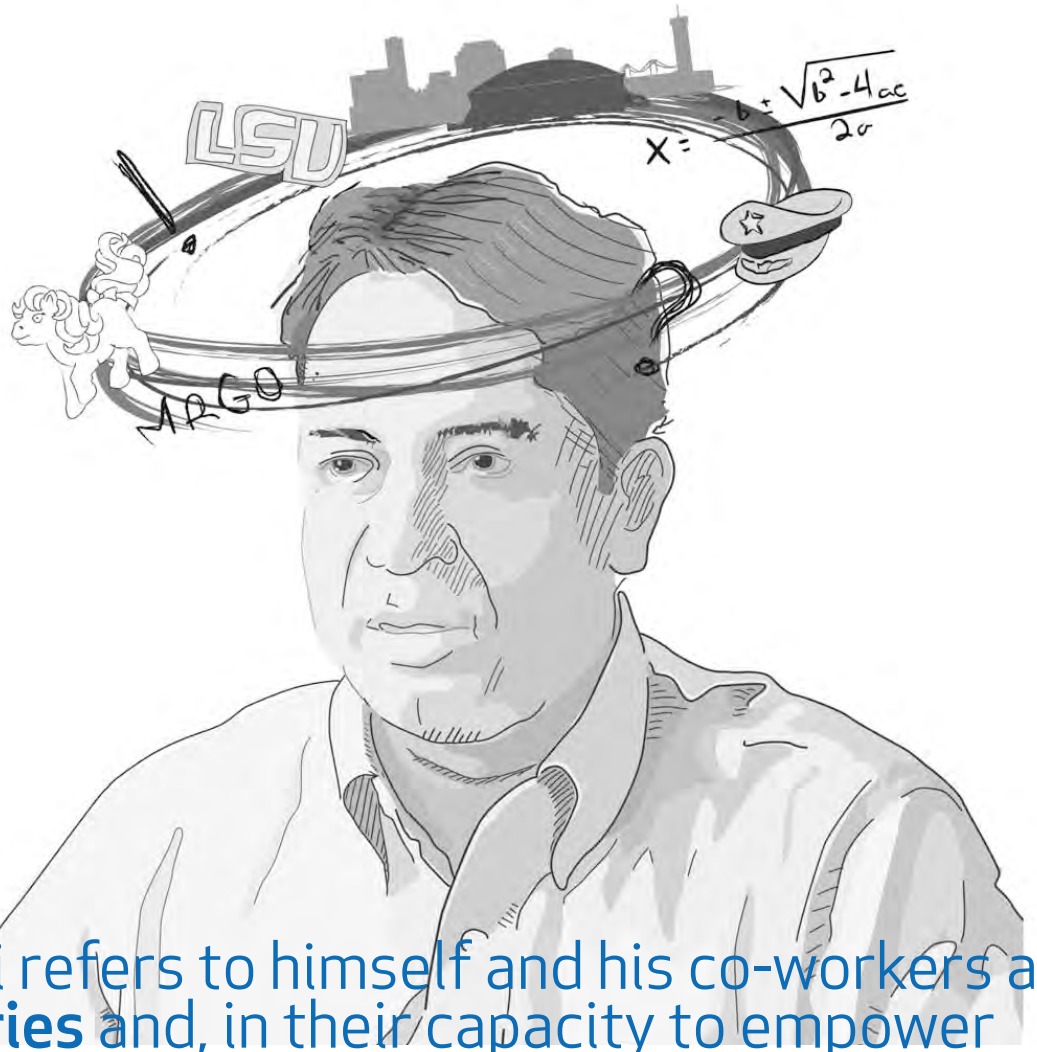
FROM MRGO TO MY LITTLE PONY, TRACKING A HURRICANE EXPERT'S FAR-REACHING RADAR

by **Julie Sinclair Eakin**

"IT WAS VERY PAINFUL TO WATCH PEOPLE GO THROUGH SUFFERING WHEN IT WAS AVOIDABLE," storm-surge expert Hassan Mashriqui remembers, as he steers a mini-van through his hometown of Baton Rouge two and a half years after Hurricane Katrina. The succulent foliage that virtually obscures the street signs here couldn't be in greater contrast to the still-barren, toxic grounds of New Orleans's Lower Ninth Ward, just 90 minutes away. "They are always one storm behind," he says of the federal government. "They won't learn until the next one." As a research scientist at the Louisiana State University Hurricane Center, Dr. Mashriqui and his colleagues were in a position to anticipate the disastrous events of August 2005.

Three months before Katrina hit, he delivered an alarming PowerPoint presentation to the Regional Planning Commission in New Orleans, detailing the potential for precisely the devastation wreaked there soon after. Mashriqui based his hydrodynamic graphics on information from the fictional hurricane model Pam, devised by Dr. Will Schafer of the National Oceanic & Atmospheric Administration in response to FEMA's 2004 request for such an experiment. Pam was designed to embody deadly characteristics: She would progress along Hurricane Betsy's track of 1965 and be slow-moving, thereby causing the most damage. The goal of the exercise was to see what would happen if the bowl of the city was filled to overtopping, just like a bathtub. Breaching the levees was not even considered.

On May 19, 2005, Mashriqui warned his listeners in New Orleans of the particular danger posed by MRGO (the Mississippi River Gulf Outlet). He predicted that the U.S. Army Corps of Engineers' 36-foot-deep navigation canal connecting Lake Pontchartrain to the Gulf of Mexico would collect storm surge in its narrow confines, where the water height would build and essentially unleash a tempest in a teapot. He called "Mr. Go" the city's Trojan horse. To considerably lessen and redirect the tremendous funneling action a moderate storm could create there, Mashriqui suggested employing a temporary obstruction, such as a barge filled with gravel, that could be sunk at the channel's entrance until a permanent solution was advanced. The following March, a prominent general in the Army Corps of Engineers dismissed Mashriqui's theory as "urban legend," and today, a lawsuit currently in the courts has the general reexamining those words. "This was not the Big One—not even close," Mashriqui told the *Washington Post* in late October 2005, when the failure of the levees and MRGO had been made pub-



TYLER BARBER

Mashriqui refers to himself and his co-workers as **missionaries** and, in their capacity to empower people (often on a voluntary basis), the term is apt.

lic, and his prediction of a storm surge amplified by 20 to 40 percent validated. Fortunately, three leaders present at his pre-Katrina lecture asked him to give the same talk to their local county officials, a decision that ultimately aided their evacuation processes during the storm.

Perhaps surprisingly for someone whose dissertation at LSU was called "Hydrodynamic and Sediment Transport Modeling of Deltaic Sediment Processes," Mashriqui is gifted at explaining complexities to the uninitiated. Take his description of storm surge: wind-driven waters that come with a storm toward the coast, the height and duration of which determine its impact. "Information is power," he repeats, like a mantra, several times during our talk. Mashriqui refers to himself and his co-workers as missionaries and, in their capacity to empower people (often working after hours on a voluntary basis), the term is apt.

Teaching future researchers is another important means of spreading the word for Mashriqui. Under his tutelage, one of his former thesis students, Stephanie Pedro, created an innocent-looking map with a collection of pink dots populating a crescent-shaped landscape. They represent those places in New Orleans, pre-Katrina, where 50 percent of the residents lived below the national poverty level; they also stand in for those without a high school education, or a vehicle. The chilling discovery, however, revealed in hindsight by Mashriqui and Pedro's statistical data, is that the map also predicted the exact location of those hardest hit during the hurricane.

As Mashriqui speaks while negotiating traffic, I reach under my leg on the van's car seat to find a tiny purple plastic horse from the animated television series "My Little Pony." It's becoming clear that the anguish this man feels over not having been able to help those storm victims resonates on multiple levels: as a civil engineer and native of Bangladesh, where tropical cyclones abound, as a scientist and educator, a father of young children, and a survivor. He acknowledges that a kind of post-traumatic stress became a mantle he and his colleagues wore following Katrina, and that several of that group sought therapy.

Mashriqui's latest work focuses on extension services, community-outreach events such as the aforementioned lectures. One of the things he intends to communicate so that people can better understand what they're facing is that contrary to what the numbers imply, a Category 5 storm isn't necessarily more perilous than a Category 4. The measurements of wind speeds in the former may actually register a tiny, fast-moving space within a storm that doesn't cover much ground. A more accurate means of indicating a storm's potential for damage is currently being developed and will undoubtedly contribute to the kind of valuable information with which Mashriqui hopes to arm his listeners.

by Jim Blackburn

BLOW- BY

AN ENVIRONMENTAL ATTORNEY DETAILS A MAJOR HURRICANE'S POTENTIAL IMPACT ON HOUSTON

-BLOW

FOR MOST OF US, IT IS DIFFICULT TO ENVISION THE POWER OF A HURRICANE. IN OUR MODERN INFORMATION-DENSE SOCIETY, PERHAPS ONE MEASURE OF AN EVENT'S POWER IS THE ABILITY TO FOCUS US ON THE MOMENT. FOR EXAMPLE, YOU REMEMBER WHERE YOU WERE WHEN HURRICANE RITA WAS HEADING FOR THE HOUSTON REGION—IN ALL LIKELIHOOD, EITHER STUCK IN TRAFFIC LEAVING TOWN OR HUNKERED DOWN AT HOME WAITING TO GET POUNDED. EITHER WAY, RITA IS INGRAINED IN OUR COMMUNITY MEMORY, AND SHE DIDN'T EVEN HIT US. THAT'S POWER.

ANOTHER TESTIMENT OF A HURRICANE'S POWER IS THE FACT that we name it, giving these events a metaphysical element. Carla hit 150 miles down the Texas coast in 1961 and is remembered by old-timers 40 years later; Beulah hit South Texas in 1967; Celia hit Corpus Christi in 1971; Alicia hit Galveston Island in 1983; and more recently there was Andrew in Florida and Katrina in New Orleans. We name these storms and fear them, like ancient angry spirits.

As residents of New Orleans and the Mississippi coast can attest, life will not be as it was once a hurricane strikes. Luckily, we in Houston have missed a direct hit from a large Category 4 or Category 5 hurricane. Although many of us have evacuated, we have always returned to relatively good conditions. But we should not delude ourselves that we are not going to be hit; it is simply a matter of time.

Have you ever considered what would happen if a large hurricane came ashore in the Houston-Galveston area? I know that many of you have been flooded and have had to live with the horror of the loss of your primary investment, the loss of security, and the feeling of invasion. But how about a storm roaring in from the Gulf with a 20-plus-foot surge tide, sustained winds of over 150 miles per hour, and perhaps 12 or more inches of rain. What happens then?

The storm of most concern to the Houston region is one that makes landfall just south of Galveston Bay. Hurricanes are large low-pressure systems with counterclockwise rotation in the northern hemisphere. As they come ashore, the more severe storm surge, wind, and rain will be on the side of the storm with the circulation moving in from water rather than from land. In our area, the dirty side is the east side.

As these circular storms make their way across the Gulf of Mexico, I pay particular attention to any that move westward in the Caribbean toward the Yucatan straits. Once a major storm enters the Gulf of Mexico, we should be ready to act, particularly those living on Galveston Island and adjacent to Galveston Bay. Time is of the essence. Those who don't get out early may not get out at all.

The modern storm of record on the Texas coast is the Category 4 Hurricane Carla. In 1961, Carla hit the Port O'Connor area on Matagorda Bay with a 22.5-foot surge tide, sustained winds of 150 miles per hour with gusts to 175, and over 16 inches of rain. In Galveston Bay, 150 miles to the north, the surge tide reached almost 15 feet in the Houston Ship Channel.

In order to better understand the impact of such a storm on the Houston region, Dr. Gordon Wells of the University of Texas Space Research Center simulated Hurricane Carla striking the Houston region. Dr. Wells named his mockup Carly and modeled it making landfall near Freeport. The following description documents the fictional storm's powerful potential as it intersects our lives.

Carly makes landfall in the early morning. By 8 a.m., her forward edge—the storm will cover hundreds of square miles—has moved ashore and the tide has risen to almost five feet above sea level. At this early stage, the damage is minimal. The major flooding is of low-lying marshlands, primarily in Galveston, Brazoria, and Chambers counties, our natural flood buffer. Large coastal streams and bayous such as Clear Creek, Oyster Creek, Double Bayou, and Dickinson Bayou are at or near flood stage as water moves upstream from the bay. Travel along Interstate 45 and State Highway 146 is disrupted at this point.

As the storm continues to move ashore, the surge tide moves farther inland. By noon it has reached an elevation of 10.6 feet. Damage is increasing and becoming widespread. All of Bolivar Peninsula and most of the West End of Galveston Island are under three or more feet of water. The southern half of Chambers County has disappeared into East Bay and much of southern Brazoria and Galveston counties are one with West Bay. Water levels are becoming a major problem in the Clear Lake area as well as in Dickinson Bayou and along the Houston Ship Channel. Areas of Galveston Island such as the Strand are not yet inundated due to the protection of the 16-foot-high seawall, although water is coming into downtown Galveston from the bay side.

By 5 p.m., the tide has reached 17.8 feet, and the eye of the hurricane has not yet moved ashore. With three-to-five-foot waves atop the surge tide, the seawall has been overtopped, and the Strand is now under water. The western shoreline of Galveston Bay—San Leon, Kemah, Seabrook, La Porte—is submerged, as is much of the Clear Lake area. Water surrounds and has moved into the Johnson Space Center. Depths of from six to seven feet are common over the southern mainland areas from Brazoria to

Chambers County. Coastal bayou flooding is now a major problem because rainfall amounts of four to six inches have already fallen and the storm surge is pushing up bayou levels, preventing runoff, and extending the flooded area well inland.

At 8 p.m., the eye has moved ashore and the surge tide has peaked at 22.4 feet. Water is several feet deep over the seawall on Galveston Island. Virtually all of the western shoreline of Galveston Bay east of IH 45 is under water. The Clear Lake–NASA area is submerged, with the tidal water extending from League City and Webster across the south side of Ellington Field to Deer Park and La Porte. The flooding extends up Dickinson Bayou and Clear Creek well beyond IH 45. The Houston Ship Channel has topped its banks on both sides, inundating portions of refineries and chemical plants all the way to Loop 610.

Now, this flooding is no bayou simply rising out of its banks due to too much water. This is a storm surge, water driven by hurricane winds. As the storm approaches, the winds build. Gale forces of 40 to 50 miles per hour start 24 hours before the eye hits. Hurricane-force winds of 75 miles per hour are felt by midmorning. For about 12 hours, the wind continues to increase, reaching a peak of sustained winds of about 150 miles per hour in a Category 4 storm and even higher in a Category 5.

The picture on the coast is ugly, and nowhere is worse than West Galveston Island. The rising tide inundates the West End, where the highest elevation is 10 to 12 feet above sea level. The beach is literally ripped up and the dunes flattened. The storm waters cut channels through the island, aided by the presence of human-made canals and excavations, many of which have been built in the last two decades. Few structures survive without serious damage on the island's West End.

Along the bay, tree limbs start popping, and shingles are blown from roofs. Anything loose becomes airborne. The sound of the wind is frightening. It just keeps on and on without stopping, only getting stronger, sounding more like machinery than nature. The water rises into and then above the coastal marshes. It comes over the docks at the edge of the bay and then extends into the yards as it also snakes its way up the coastal bayous, preempting their capacity to handle the runoff from the rainfall that started hours ago.

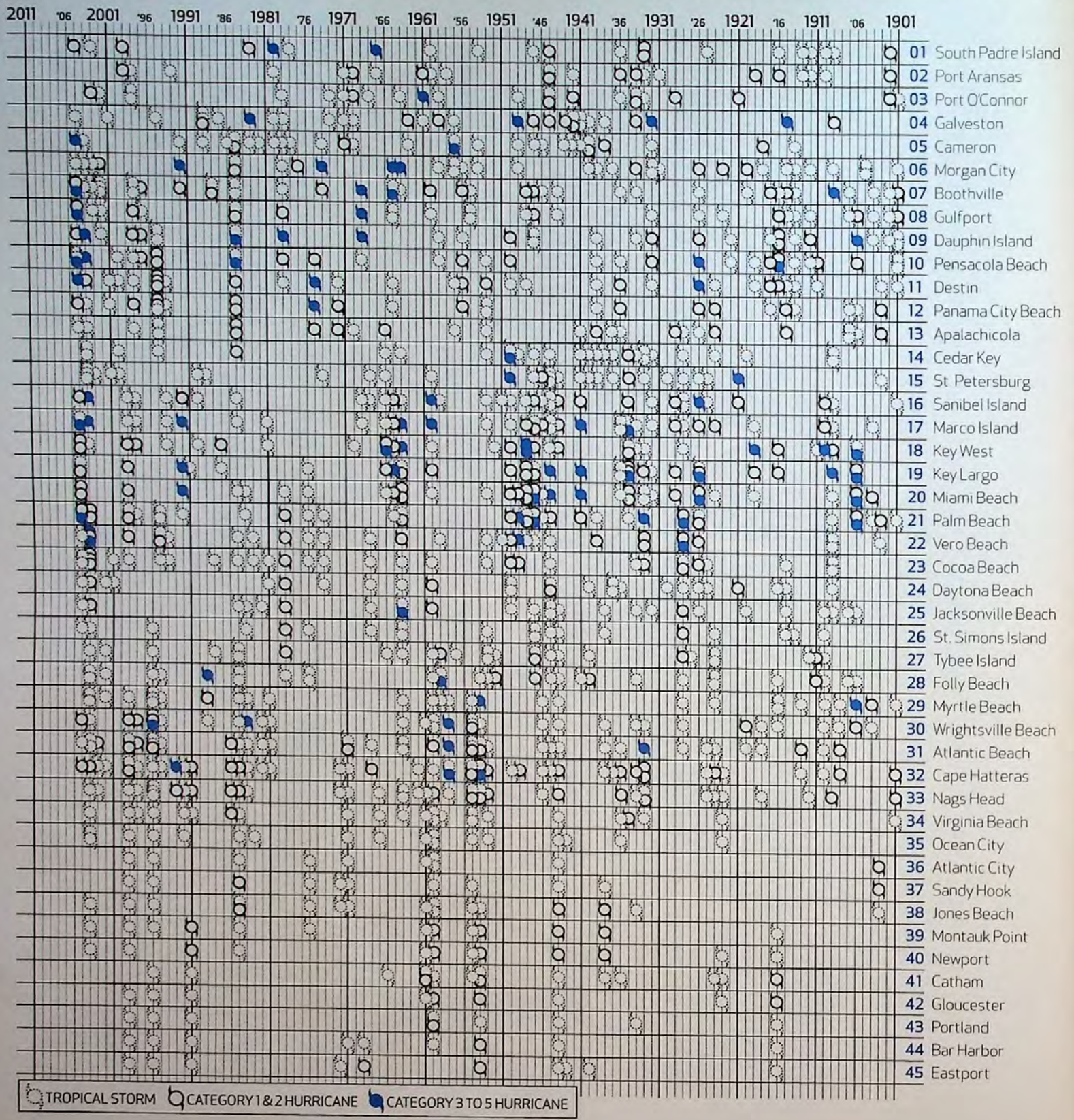
As the water rises, the wind blows whitecaps into and onto the mainland, blasting the first level of homes on the shoreline. The windblown waves are three to five feet higher than the tide itself, and they strike with relentless power. Homeowners who elevated their foundations are grateful at this time. Any structure built at ground level is subjected to hours of pounding waves. The minutes seem like hours. Crashing wave after crashing wave weakens every structure, and then, as the water and winds rise higher and higher, buildings collapse.

The first floors of most structures immediately

ANY STRUCTURE BUILT AT GROUND LEVEL WILL BE SUBJECTED TO HOURS OF POUNDING WAVES. THE MINUTES SEEM LIKE HOURS. CRASHING WAVE AFTER CRASHING WAVE WEAKENS THE STRUCTURE, AND THEN, AS THE WATER AND THE WINDS RISE EVEN HIGHER AND HIGHER, BUILDINGS COLLAPSE.

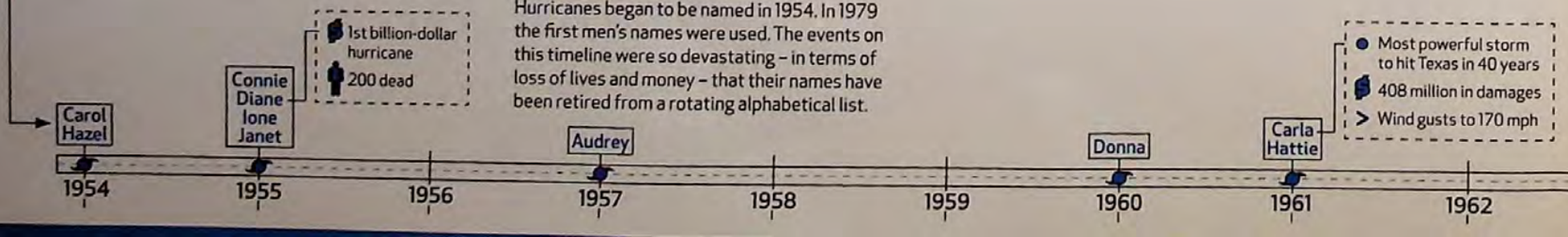
MARTHA CLAIRE TOMPKINS

COASTAL STORM HISTORY (1901 TO PRESENT)

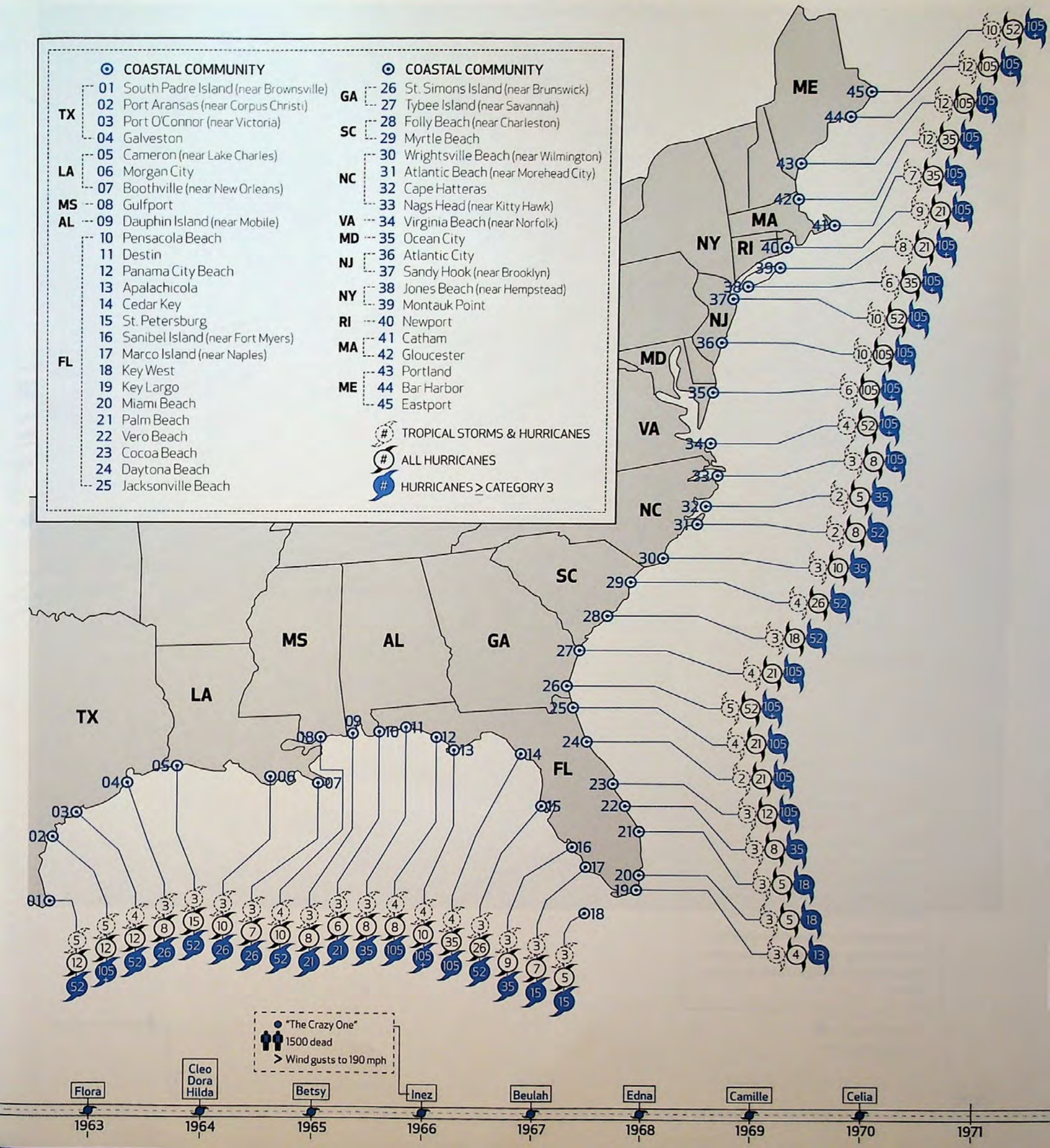


THE RETIREES

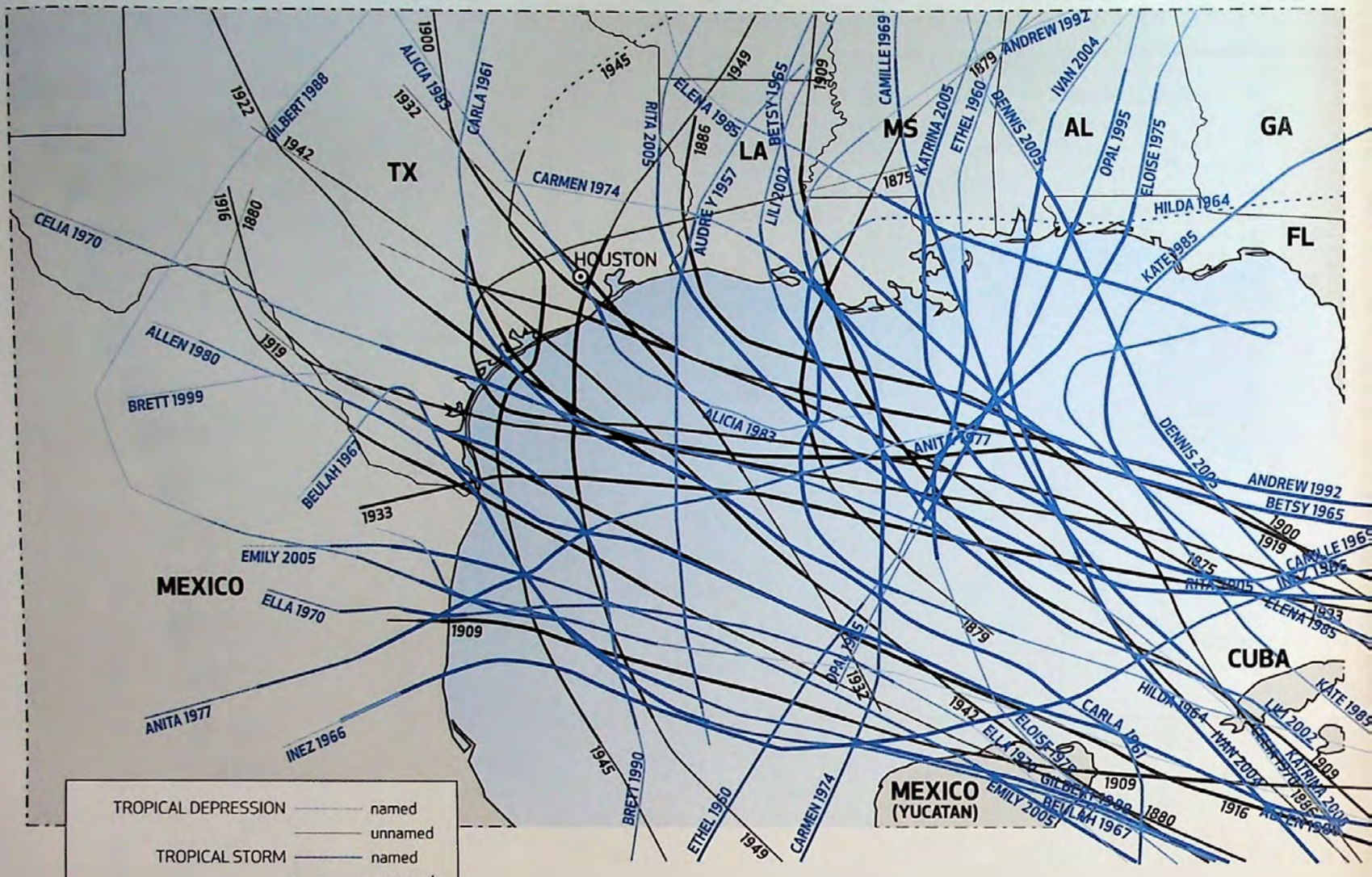
Hurricanes began to be named in 1954. In 1979 the first men's names were used. The events on this timeline were so devastating – in terms of loss of lives and money – that their names have been retired from a rotating alphabetical list.



COASTAL STORM RETURN PERIODS (1901 TO PRESENT



MAJOR AREA STORMS (CATEGORY 3 OR HIGHER)

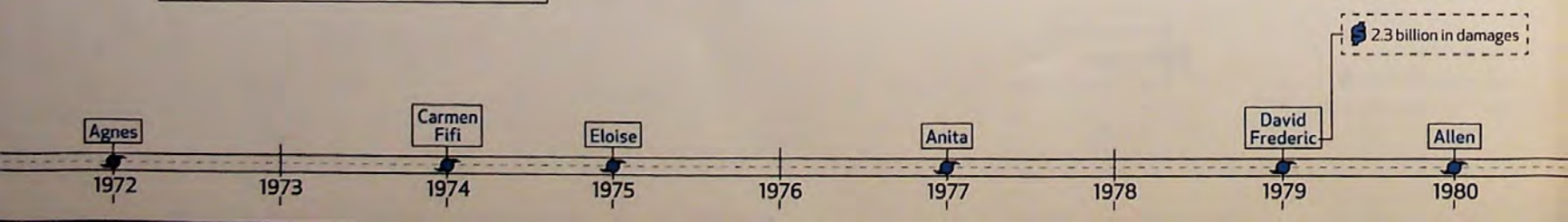


TROPICAL DEPRESSION	named
	unnamed
TROPICAL STORM	named
	unnamed
CATEGORY 1 & 2 HURRICANE	named
	unnamed
CATEGORY 3-5 HURRICANE	named
	unnamed
EXTRATROPICAL STORM	named
	unnamed

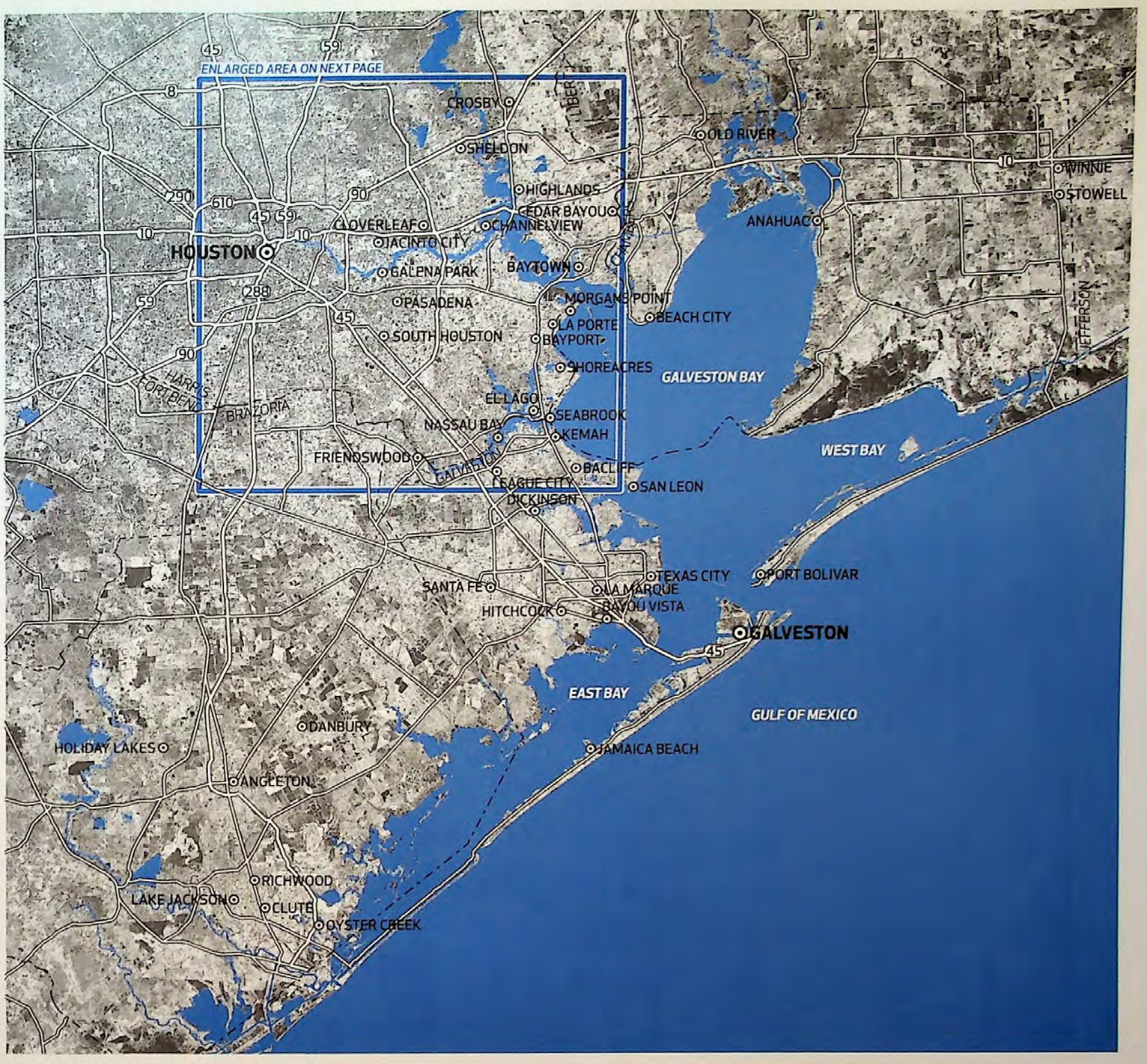
STORMS DEFINED*

Tropical Depression	< than 39 mph winds
Tropical Storm	39-73 mph winds
Category 1 Hurricane	74-95 mph winds
Category 2 Hurricane	96-110 mph winds
Category 3 Hurricane	111-130 mph winds
Category 4 Hurricane	131-155 mph winds
Category 5 Hurricane	155+ mph winds

*A new system is in the works to identify a hurricane categorizing technique that takes into account storm surge in addition to wind speeds.



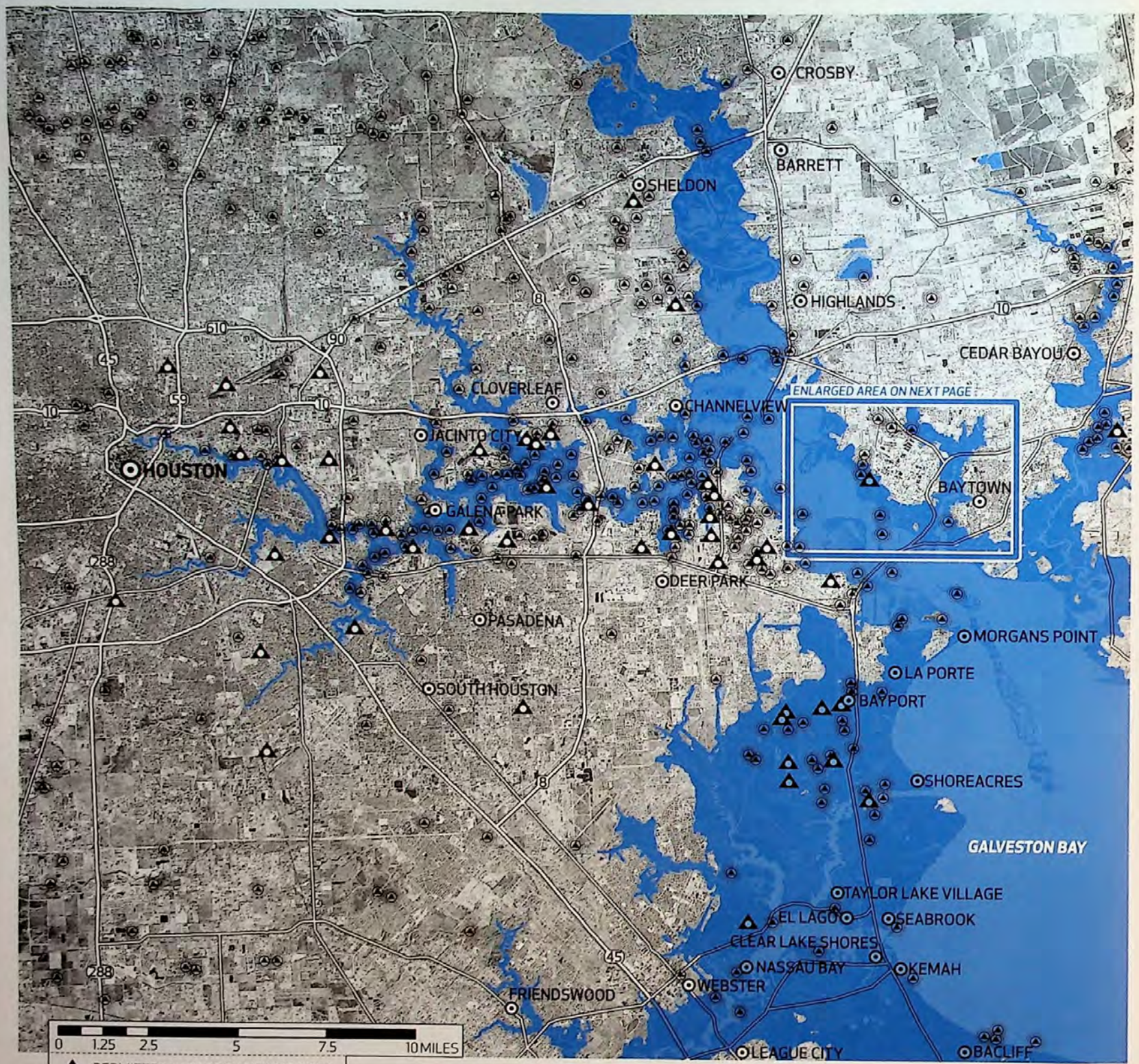
FOCUS ON HOUSTON

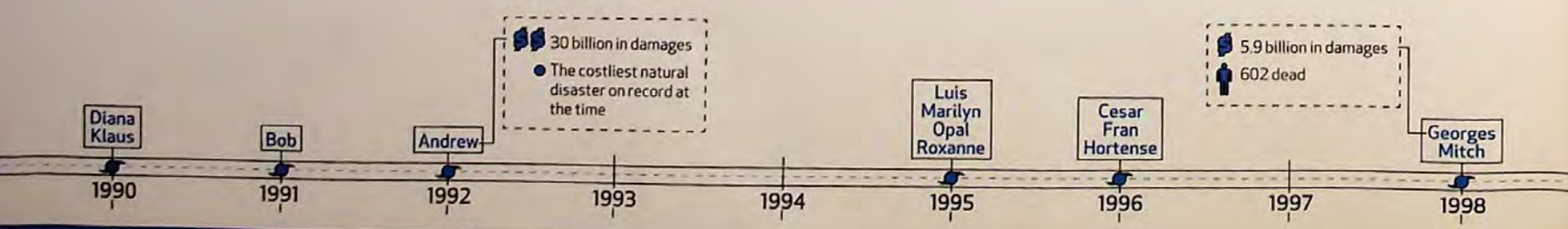


PAGES 29, 30, & 31: REDRAWN FROM DATA PROVIDED BY BRYAN CARLILE, GIS CONSULTANT PRIMARY SOURCES: DR. GORDON WELLS, UT AUSTIN; HGAC, USGS; TRANSPORTATION DEPT., RAZ 2035 PROJECTION DATA; TEXAS GENERAL LAND OFFICE

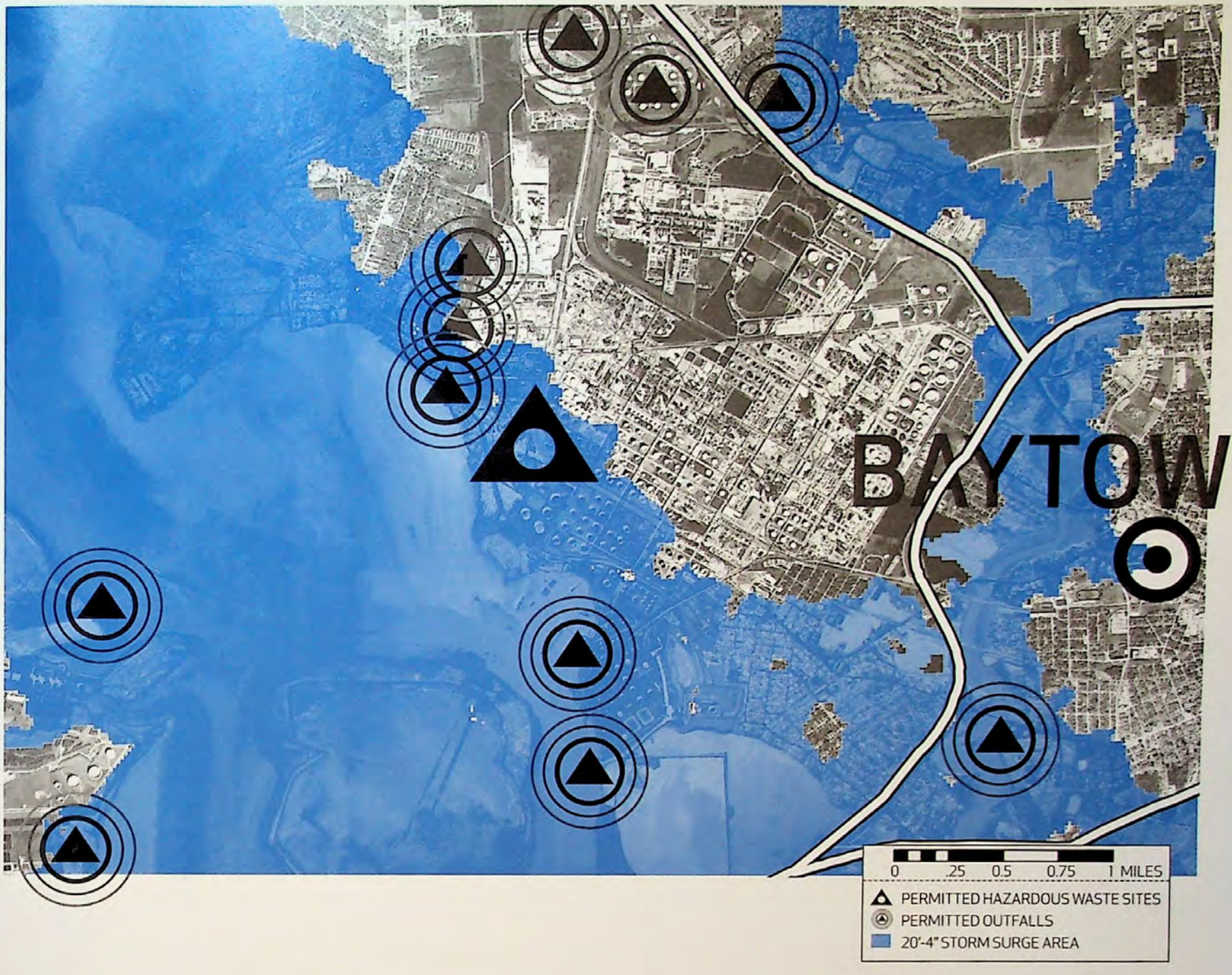
7 billion in damages
> Wind gusts of 160 mph

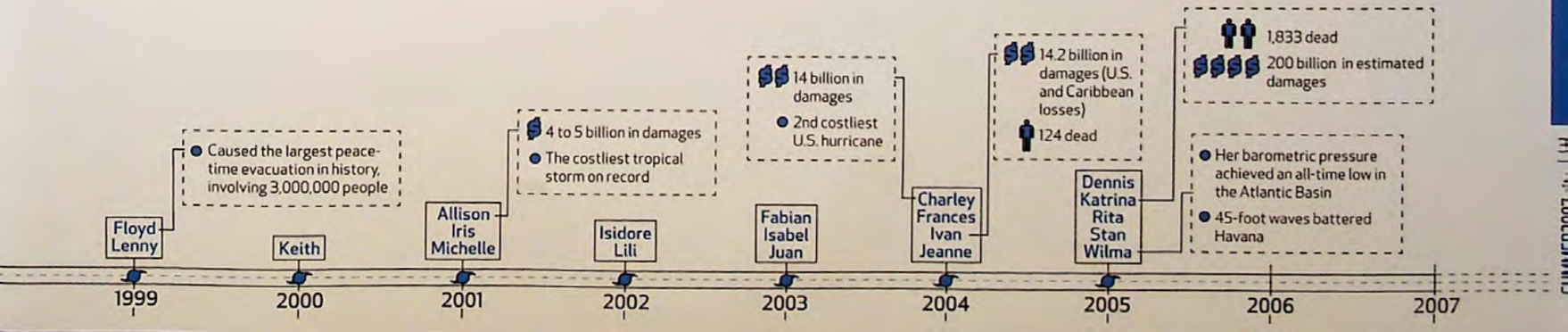
STORM SURGE 20′-4″ (HOUSTON SHIP CHANNEL)





STORM SURGE 20′-4″ (BAYTOWN)





UNDER

THE CURRENT EVACUATION PLAN, THOSE OF US LIVING INSIDE THE LOOP AND FARTHER NORTH AND WEST ARE TOLD TO REMAIN HOME AND "SHELTER IN PLACE," A FEARSOME PROSPECT AT BEST. ELECTRICITY IS LOST SOON AFTER THE STORM MOVES ASHORE ON THE COAST. CELL PHONE TOWERS BLOW DOWN. LANDLINES ARE CUT. WE MAY BE ISOLATED FOR DAYS.

adjacent to the bay are built to an elevation of 16 feet. However, as little as a hundred feet inland, the FEMA flood elevation requirements drop to 10 or 11 feet throughout the Clear Lake, Kemah, and Seabrook areas. Unlike the regulatory map, this incoming wall of water does not differentiate. It simply rises and occupies space.

As the unrelenting surge continues, the damage mounts. Smaller structures go first—the storage room or extra bedroom built at ground level, often in violation of the coastal building standards. The debris flying off one damaged building rams into an adjacent one. Rooftops blown off their roosts fly with the fury, only to be added to the floating mass atop the waves. This is not just wind-blown water but a slurry of water and demolished buildings, with an occasional boat and a few cars battering inland with the storm. As the mass moves, it stacks up against any structure in its way. The former wall of the storage room turns into a battering ram, smashing windows, piling up against foundations, adding its weight to the weight of the water that piles up with it, slamming with the next wave, ever rising, ever moving inland. Slowly but surely, a house is uprooted like a tree, ripped from its mooring in the soil and hurled into the next home inland, adding its weight to the mass of moving debris.

Along the Houston Ship Channel, industries have shut down, leaving only skeleton crews to ride out the storm. Industrial waste storage and waste disposal areas there are protected by levees built to the elevation stated on the FEMA floodplain maps. Along the Houston Ship Channel, the 100-year floodplain lies below approximately 11 or 12 feet in elevation. Dikes and levees are built to those levels.

As the storm surge goes higher than 12 feet, the levees are overtopped, and the water churns up the soil and waste, floating barrels and other materials. Although land disposal of hazardous waste is no longer allowed in the United States, a substantial volume of waste is still stored along the ship channel, awaiting incineration or transport, and there is on-site disposal of many so-called nonhazardous industrial wastes. There is also commercial product waiting to be shipped away by barge, rail, and truck, and there are no flood protection rules for its storage.

Perhaps more importantly, the refineries and petrochemical plants themselves are not required to be protected by levees. These structures are inundated as the water level rises to over 20 feet. The potential for contamination is significant, particularly if any of the storage vessels collapse from the pounding of waves and debris. The Houston-Galveston industrial complex is one of the largest in the world and includes over 2.5 percent of the world's refining capacity, as well as significant percentages of the world's production of ethylene, propylene, butadiene, and many other building blocks of the petrochemical industry. None of these facilities are required to be flood-protected.

Similar issues are associated with dredge spoil disposal sites. Galveston Bay is relatively shallow, with an average depth of ten feet or less. Industrial navigation channels such as the Houston Ship Channel require dredging, and the dredged material must be deposited in sites contained by levees, which are only to minimum flood elevations, if that. Among other things, these spoil disposal areas contain sediments contaminated with dioxin, a highly dangerous pollutant. Virtually all of the spoil disposal sites in the ship channel are ripped apart by the storm, and their sediment spread inland and then back into the bay.

The damage from the storm is not limited to the coastal areas but extends far inland, generated by both wind and flooding from rainfall. Gusts in excess of 175 miles per hour are common on the coastline and diminish slowly as the storm moves inland. Tornadoes are common. Downtown Houston is subjected to sustained winds greater than 125 miles per hour with gusts to 150. Our skyscrapers are tested as debris of all sorts flies full speed into their glass walls.

Under the current evacuation plan, those of us living inside the Loop and farther north and west are told to remain home and "shelter in place," a fearsome prospect. Electricity is lost soon after the storm moves ashore on the coast. Cell phone towers blow down. Landlines are cut. We may be isolated for days.

Inland, trees are uprooted and roofs are stressed if not ripped off. Most homes are built to withstand winds of less than 100 miles per hour, a number exceeded over much of our region, at least during gusts. Rita caused significant damage in Beaumont from trees being uprooted and falling into houses. Given the number of trees in the greater Houston area, significant wind damage can be expected.

And then there is flooding. Houston floods often; we don't need a hurricane to have a flood. Over the last 40 years we have not experienced a major hurricane with a high storm surge and high rainfall amounts. Often our flooding is limited to one portion of the region or another. Seldom do all our bayous flood during a single storm event, as they are likely to during a Category 4 hurricane. The amount of rainfall associated with a hurricane is determined by the forward speed of the system. A formula used by meteorologists divides the forward speed of the storm into 100 to determine the inches of rain during the storm. If a storm is moving forward at 15 miles per hour, then six to seven inches of rain are expected; if the storm is moving at 10 miles per hour, then 10 inches. Carla, a slow-moving storm, dumped over 16 inches of rain on Galveston.

Flooding associated with hurricane-generated rain is worsened by the storm surge. The tide moves up the streams and bayous that drain into the bay, raising the water's elevation to as much as 20 feet above sea level as it surges inland. As much as ten inches of rain may fall as the storm closes in. There is a high likelihood that the lower ends of our coastal streams and bayous such as Buffalo, Brays, Greens, Clear Creek, Dickinson, Armand, Hunting, and countless others will fill up and be unable to drain adjacent urban areas. Rainfall will pond within urban areas, unable to drain until the coastal tide falls.

FEMA, the federal agency responsible for flood mapping, assumes that a larger hurricane event with a significant surge tide will not coincide with a very large rainfall event. Therefore our flooding maps do not predict the dual circumstance. Those looking at a floodplain map should recognize that it is a minimalist representation of the reality of flooding from a strong hurricane.

The results of a hit by a Category 4 hurricane are beyond belief. Areas near the coast will look as if a bomb had leveled everything. Pictures of Kemah after Carla hit over a hundred miles down the coast shows a landscape where all of the buildings are gone. Virtually nothing was left standing on the Mississippi coast after Katrina. Holly Beach, in Louisiana, was removed from the face of the earth by Rita. Damage estimates prepared by the Governor's Division of Emergency Management indicate that the wind and storm surge damage will exceed $73 billion. Of the approximately 300,000 homes in the coastal evacuation zone, over 100,000 will have been destroyed and virtually all damaged, either by winds or floodwaters or both. The governor's office estimates that nearly two million households in the region will have been negatively impacted by the storm. One hundred twenty-four million tons of debris will be generated.

Think about it: 100,000 homes destroyed. Wiped out. No home to come back to. In the coastal evacuation zone, over 500,000 people will likely be without a home for several months. It may take that long for some of these areas to get basic electrical and water and wastewater service repaired. These people will need to be housed and fed. Where will they go? Who will care for them? For those of us living outside the evacuation zone, the prospect may not be much better. Electricity and water will likely be lost for days, if not weeks. Trees will have smashed many houses, opening them to the weather, making them uninhabitable. However, we will have "sheltered in place" because we're not encouraged or able to evacuate: There are simply too many of us for all to leave.

The bottom line is that we are not prepared to deal with the impact and aftermath of a large hurricane. The loss will be staggering. And at the time our worst fears are realized, we will be hit with the hardest question of all: What to do now? The absolute worst time to make these types of decisions is the week after a hurricane hits, yet that is what we face if we do not recognize the danger and plan for living afterward. Many of us made derisive comments about the lack of organization and planning in New Orleans. Houston, you haven't seen anything yet.

FUTURE BACK TO THE

Texas City arms itself against disaster using age-old technology

by **Bruce C. Webb**
photography **Shannon Stoney**

TEXAS CITY IS A MOSTLY TIDY, STRIP AND SUBDIVISION SORT OF PLACE OF NEARLY 50,000 NESTLED BETWEEN TWO KINDS OF IMMINENT PERIL. The one, a frenzied petrochemical-industrial enclave on the south side of town that boasts several major plants and refineries, including Valero, Marathon Ashland, Dow Chemical, and BP, has coughed up disasters more than once. Most famously, the French ship *Grandcamp*, loaded with ammonium nitrate fertilizer, exploded in the harbor in 1947, setting off a chain of dock fires and igniting a second ship, which also exploded. It took a week to put out the fires; one third of all the houses had to be condemned; 576 people were killed; and the city suffered over $61 million in damage. Remembering the *Grandcamp* disaster is the main attraction at the city's downtown historic museum. A more recent reminder of the volatility of the plants occurred in 2005, when an explosion at the BP refinery killed 15 and injured 170—the worst

A guillotine-style floodgate marks the outlet between Moses Lake and the bay.

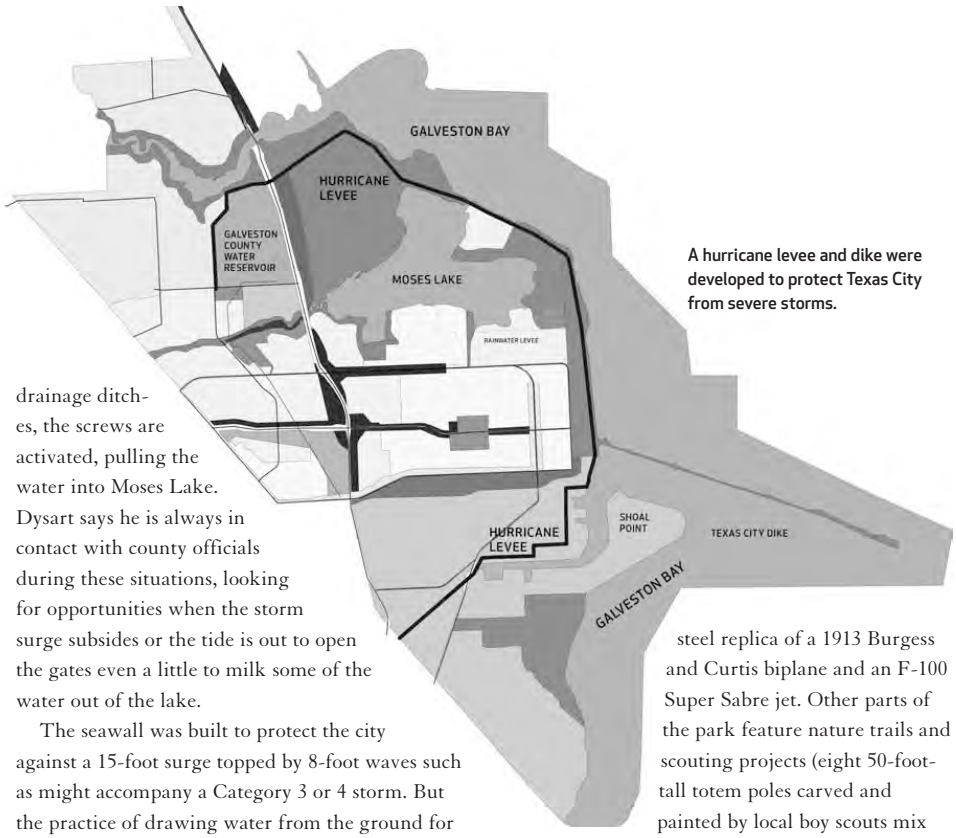
Enhanced versions of the Archimedean screw can lift 125,000 gallons of water per minute over an 11-foot barrier.

industrial accident in the United States in 16 years.

The other threat comes from the city's adjacency to the waters of Galveston Bay, a generally docile but determined body of water that is capable of occasional tantrums. To make the bay behave, the city began tinkering with some of the realities of its nature-given situation back in the early part of the century, building an extensive dike to divert the currents that swept down from Galveston across the Texas City Ship Channel, filling it with silt. The Army Corps of Engineers began building the five-mile-long appendage out into Galveston Bay in 1914 as pile construction, replacing it between 1931 and 1934 with a rubble mound. The dike was a great success; not only did it prevent the silting problem, but it also protected the ship channel from the bay's tidal action and storms, giving Texas City one of the safest ports in the country. Locals call it the world's largest fishing pier.

Texas City has always been vulnerable to hurricanes, having survived five major ones. But not until Hurricane Carla hit the city in 1961, flooding it with four feet of water, did the city begin working on improving its protection. Plans for a seawall had been on hold since 1949, but Carla was the impetus for activating them. A seawall or levee is conceptually simple: Like a child's sand construction on the beach, it is made of dredged material, earth, large rocks, and anything else that can be piled up to create a barrier to hold back or contain water. In Texas City, engineers scooped up sandy soil from the land side, creating an artificial pond locals refer to as the "blue hole" and piled it into a 17-mile-long barrier along the bay that is topped off with grass and a road called the Skyline Drive. A portion of the hurricane levee, about a mile in length, is a concrete wall.

The seawall protects the city from storm surges, but the runoff from the heavy rains that accompany coastal storms is another problem for the flat, low-lying coast. Toward that end, the city had an inner levee constructed around Moses Lake, inside the seawall, making the lake into a vast retention pond. Storm sewers and drainage ditches route water to the foot of the Moses Lake levee, and engineers have



A hurricane levee and dike were developed to protect Texas City from severe storms.

installed an enhanced version of the Archimedean screw to pull water up and over the 11-foot-high barrier. Archimedean screws, long, cylindrical, corkscrew-shaped augers, have been used from the time of the pharaohs to move water efficiently from lower to higher elevations. In Texas City the pumps are 12 feet in diameter and 60 feet long and are located at two pumping stations: three in the Gottfried Moller Rainwater Pump Station in the northeastern part of town and five at the Captain A. B. Wolvin Pump Station, which handles the drainage from the west side of town. Each screw is powered by a 650-horse power Caterpillar diesel engine and can lift approximately 125,000 gallons of water per minute.

Another part of the technical landscape, which works in tandem with the screws, is the guillotine-style floodgate at the outlet between Moses Lake and the bay. Typically open to allow boat traffic, the gate can be closed during extremely high tides or storm surges.

Ron Dysart is in charge of the pump stations. A tall, energetic man with the confident manner of someone used to getting respect, he has been at his job for 18 years. Outside his office in the Wolvin station is a banner that reads: "Whatever it takes. What we do affects everyone." Dysart's office adjoins the immaculately clean and orderly engine room where the six massive engines wait to be fired up. He says he tests them once a week to make sure they are in good working order. The pump station has the no-nonsense look of a military command post. When a weather event is predicted, Dysart and his team hunker down onsite to make sure everything operates smoothly. Usually there are three storms a year that require activating the pumps.

Since the county maintains and controls the bayside hurricane levee and floodgate, and the city the screw pumps, Dysart coordinates operations with the county manager. Anticipating a tidal surge, the county closes the tidal gate to prevent inundation of Moses Lake. As rainfall fills the city's storm sewers and drainage ditches, the screws are activated, pulling the water into Moses Lake. Dysart says he is always in contact with county officials during these situations, looking for opportunities when the storm surge subsides or the tide is out to open the gates even a little to milk some of the water out of the lake.

The seawall was built to protect the city against a 15-foot surge topped by 8-foot waves such as might accompany a Category 3 or 4 storm. But the practice of drawing water from the ground for domestic use has resulted in substantial ground subsidence, so the seawall has sunk as much as three feet from its designed elevation. (Texas City now uses only surface water from the Trinity River.) But with many possible storm scenarios, it is never entirely certain that the seawall will prove adequate protection in a large storm. Hurricane Alicia in 1983 was the last major test of the hurricane levee system: A tidal surge of ten feet with an additional four feet of waves challenged the barrier, but it held.

Except for the pumps and floodgate, everything else connected with storm protection and water control has been absorbed into the city, often by creating impressive amenities. The five-mile-long dike is a regional attraction: Shrimp boats dock along its flanks, and the shoreline is usually busy with fisherman, bird watchers, wind surfers, and kiteboarders. At the end of the dike, the 600-foot lighted pier ("family fun since 1962") stretches into the bay for 24-hour-a-day deeper-water angling.

Skyline Drive, the narrow road built on the top of the hurricane levee, takes advantage of the views out to the bay. A 50-acre linear park extends along the leeward side of the seawall, a portion of which commemorates Texas City's role as the birthplace of military aviation, with an installation of a stainless steel replica of a 1913 Burgess and Curtis biplane and an F-100 Super Sabre jet. Other parts of the park feature nature trails and scouting projects (eight 50-foot-tall totem poles carved and painted by local boy scouts mix with the trees), family play fields, and handicap-accessible recreation equipment. A replica of the Halfmoon Shoal lighthouse on Skyline Drive, similar to the one that used to be located two and a half miles off the Texas City shore, contains information on the hurricane levee, the port, and the pump drainage system. Inside the north end of the hurricane levee, just east of the storm gate, David Weekley Homes has created an infrastructure of dredged canals and mounded-earth building sites for Grand Cay Harbour, a new subdivision.

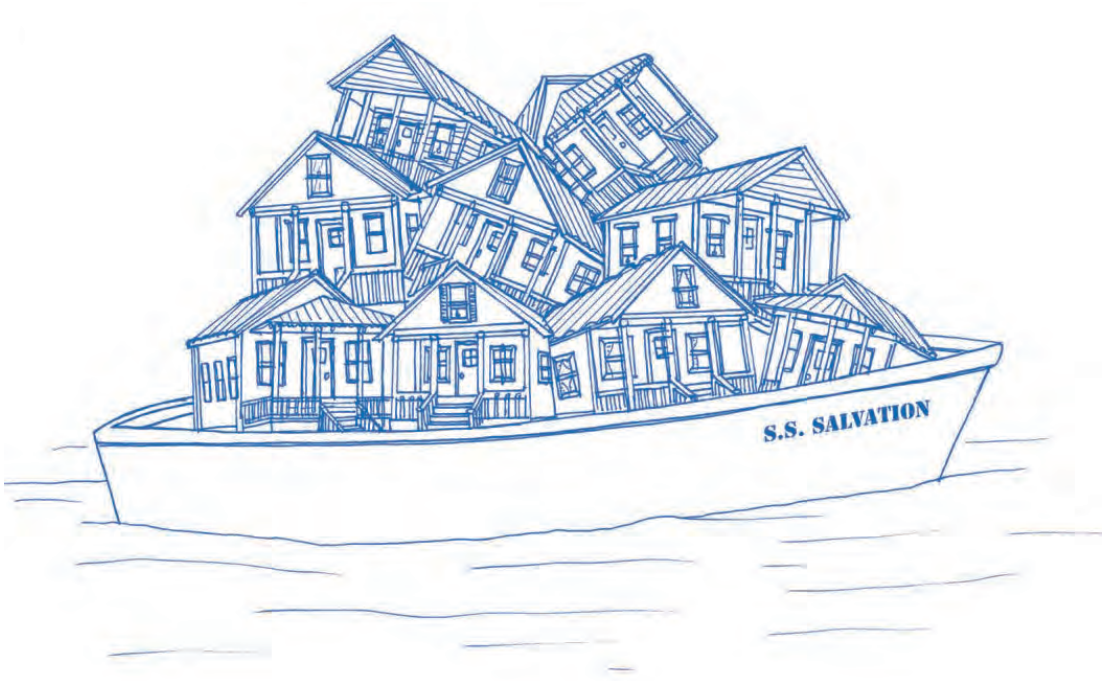
A seawall or levee is **conceptually simple:** Like a child's sand construction on the beach, it is made of dredged material, earth, large rocks, and anything else that can be piled up to create a barrier to **hold back or contain water**.

Strategies for preventing flooding involve simple physics; the principles show up in children's beach construction, as discussed above, and mechanical toys. Added together, the provisions in Texas City create a hyper-engineered landscape, where the distinctions between what is natural and what is technical are obsolete and difficult to discern. Texas City is not quite The Netherlands, where much of the land is composed of reclaimed polders protected from the sea by an extensive network of dikes and pumps. But it's cyborglike nonetheless. These well-engineered modifications, along with the chemical plants and refineries, have become the most profound markers of the local landscape.

WHAT BECOMES A LEGEND MOST?

Andrei Codrescu reflects on his New Orleans in a letter to Houstonians

by **Andrei Codrescu**
illustration **Kiersten Essenpreis**



I LIVE IN THE "SLAVE QUARTERS" OF A FRENCH QUARTER BUILDING AT THE BACK OF A COURTYARD IN WHICH STANDS A WATER-SPEWING ANGEL.

The angel has starred in photographs, movies, and extremely vivid memories. At the turn of the millennium my beautiful friend Michelle, who resembles the aquatic putto, stood nude in the fountain at the stroke of midnight and sang the Chinese national anthem—in Mandarin. How prophetic was that? This may well be the Chinese millennium, as Wal-Mart keeps reminding us.

In the hallway of the "big house," through which you reach my cobblestoned courtyard, there are my neighbor's photographs of jazz musicians who played here over the years. My neighbors gave some doozy parties in this yard: "Doc" Cheatham, the great trumpet player, played his next-to-last gig here. The musicians set up under the stairs to my pad, so I gingerly stepped over jazz greats to get upstairs.

The doorway to my tiny place is low because people were short in the 19th century and because servants' doors were humbler than their masters'. Inside, there are the mementos of artistic French Quarter living: a tree-of-life rug from Romania, paintings by friends, a variety of demons crafted for Mardi Gras past, masks, and towers of poetry books. The apartment itself starred in my novel *Wakefield*, about a guy who just wants to stay home and read, with the windows on the balcony wide open while it rains and the scents of magnolia and sweet olive drifting in. In *Wakefield*, the devil makes the guy a proposition: If you can find your "true life" in one year, I'll let you live.

Then Katrina came. No, wait, one more thing: My building is the first condo in New Orleans. When I bought it, my Realtor told me, "I don't know if this condo thing will work in the French Quarter." Since then, the area went condo all over. Most of them were snapped up by out-of-towners who found the idea of spending some time in America's most historically rich city charming and sexy. During the condoification of the old Quarter, the full-time resident population dropped by half. Grocery stores and inexpensive eateries serving residents closed down, and T-shirt shops sprouted in their stead. French Quarter real estate heated up, way above the generally hot market in America. The charm of the old buildings added greatly to their value. It didn't hurt that movie stars bought mansions and restored them, and filmmakers found New Orleans an ideal set. Just before the Storm, I had the unaccustomed (but not unpleasant) thought that not only was I living a fantasy life in America's last bohemia, but also that I had a considerable investment. One day, when I tired of intense young artistes with smoldering eyes and leather sacks full of poetry, I could retire to, let's say, Houston, and build me one of those great art houses that look like toys.

And then Katrina came. The great Jesus behind the St. Louis Cathedral saved the French Quarter by snapping the fingers of His left hand and pushing the storm off by ten miles to make landfall in Mississippi. The fingers are still missing and there is a reward out for them. I've met people who claim they know who has them. My building survived with only a few shingles ripped off the roof, but the neighborhood, like the entire city, went into a deep funk. For over a week, everyone (with the blessed exception of some river rats of the sort who like to dance when the world ends) left town. The empty streets were occupied by the U.S. Army and several states' National Guards. The soldiers marched around and around, bored, nervous, and ready for anything. But there was nothing, nothing to shoot at, nothing to do; no music, no food, no strippers.

It is now nearly two years later, dear people of Houston, one year more than the Devil gave Wakefield, and there is no sign of New Orleans finding any "true life," or even just life, the way it used to be. Many of our former residents are in your city, making your lives more interesting—or more miserable, if you believe the crime stats. At this point, I think that we should simply exchange cities. Move here, Houstonians, and bring your urban visions, if not your actual houses, with you. I'll tell you why (besides the obvious, which is that we breathe high drama and our ghosts are groovy). Since the Storm we've been descended upon by a plague of "visionaries" ready to "rebuild our city." The worst of these are the New Urbanists who'd revision us as something New Orleans–*like*, a city of new houses themed around a French Quarter "look." This vision fits well with the bigger plans of the casino industry and other tourist concerns to make the city corporate friendly, like Las Vegas and Disney. If y'all moved here and brought your well-known "no zoning" spirit, we might have something entirely different.

Here is what I propose: Eliminate all zoning regulations to allow nightclubs in any house in the city. Legalize drugs, prostitution, and street theater. Subsidize nationally and internationally any artist willing to work here.

Here is what I propose. See if you can live with this: Return all low-lying areas of New Orleans to floodplain. If anyone wants to live there, give them pontoons. Also allow water dwellings on Lake Ponchartrain and the Mississippi River. Eliminate all zoning regulations to allow any sort of business, but especially nightclubs, in any house in the city. Legalize drugs, prostitution, and street theater. Subsidize nationally and internationally any artist willing to work here; artists working in New Orleans should be exempt from local and federal taxes. Declare New Orleans a PAZ (Permanent Autonomous Zone) and an International City, to be administered lightly by every nation on earth in alphabetical order. (This last one is negotiable because I know how patriotic you are, but doesn't the rest sound good?)

by **Thomas Colbert**

Ready or Not?

AS HURRICANE SEASON PROGRESSES, A TONE OF UNCERTAINTY CLOSES IN.

WHEN KATRINA CAME ASHORE TWO YEARS AGO, New Orleans was caught flat-footed. Municipal, state, and federal governments were completely unprepared for a disaster of this magnitude. The levees had been poorly designed, the evacuation plan left out the most needy citizens, and the handling of the aftermath confirmed a lack of foresight. If such a hurricane were to hit Houston today, what would our government's response be? With the help of officials working for FEMA, Harris and Galveston counties, the City of Houston, the Houston-Galveston Area Council, and scientists at the Louisiana State University Hurricane Center, it has been possible to construct a picture of what the governmental response would be to a major hurricane hitting the Houston-Galveston metropolitan area. And it's clear that there are ways in which we are ready and others in which we are not.

great deal of disaster planning and many evacuation rehearsals have taken place since Hurricanes Katrina and then Rita battered our part of the Gulf Coast. Local and state agencies have committed substantial resources to preparing for "the big one." But much of our rapidly growing metropolis lies within the deadly tidal surge area that such a hurricane would create, and many of our existing buildings and industrial facilities were not built to withstand the winds and debris generated by a storm such as Rita. (Had it not turned away from Houston, Rita, at a Category 5 intensity, was predicted to create wind speeds of 155 miles per hour or more at the coast and throughout Harris County, and 110 miles per hour as far north as Conroe.) Progress has been made in minimizing and preventing flooding from rainwater, but many places in Houston are still not safe from the kind of rainfall that a hurricane or major tropical storm could create, especially when combined with tidal surge. With that said, significant improvements to the city's drainage system are planned and under construction, and there have been ameliorations in evacuation and disaster-response planning since Rita.

How the government responds to the threat of a hurricane varies based on the specific risks posed by a particular storm, but a provisional timetable of events has been developed.

As a hurricane crosses over the Florida Keys, its progress is monitored by state, county, and municipal emergency-management personnel. When it reaches the middle of the Gulf of Mexico, some 96 to 120 hours before landfall, the Harris County Homeland Security & Emergency Management center and other comparable agencies are activated and manned around the clock, bringing elected officials together with disaster-management staff, representatives of the utility companies, the medical community, meteorologists, and additional specialists.

Preparation for the evacuation from low-lying areas of the elderly, hospital patients, and those with special needs begins, together with a recommendation for others living in low-lying areas or in weak structures to leave. As the storm reaches 96 to 72 hours out and the infamous "cone of uncertainty" prevails, healthcare facilities must decide whether to have their staff leave or stay, and fuel is surged to evacuation routes, where it is to be distributed to needy motorists by prepositioned tanker trucks and by filling stations, which are now required to remain open. At 72 hours out, people in Evacuation Zone A (in expectation of a Category 1, 2, or higher storm) are encouraged to leave. Whether this action is voluntary or mandatory is a local jurisdictional decision by mayors and county judges. (Citizens are advised or ordered to evacuate according to their zip codes, since this information is better understood than the zone maps.) Between 72 and 36 hours out, people in Evacuation Zone B (in response to the prediction of a Category 3 or higher) are advised or ordered to depart. The government's major effort is to get people away from the tidal surge area. Galveston County's evacuation of the special needs population begins at 48 to 36 hours out and people in Evacuation Zone C (anticipating a Category 4, 5, or higher) are advised or ordered to leave. Evacuation from Galveston County is through Harris County, along I-45 North, I-10 West, State Highway 290 North, and State Highway 59 North. State Highways 59 South and I-10 East do not lead away from the coast and are not evacuation routes. The reason for the government's emphasis on evacuation is simple: Many of those who stay in lowland areas will not survive.

According to government officials and the scientific community, another storm such as Rita or Katrina would bring with it the possibility of a tidal surge of 20 to 30 feet. In such an event, along the Galveston coast there would be 10-to-15-foot waves on top of the tidal surge. Waves in Galveston Bay would reach 8 to 10 feet above tide levels, and in Clear Lake those heights are expected to be 3 to 5 feet higher than the surge tide. In some areas storm-driven tide would be rapidly flowing, and in many locations it would be filled with the debris of homes, cars, and trees. Most buildings and many bridges in the main tidal surge zones would be destroyed by the action of water and debris. The incoming surge would not only demolish houses and businesses, but would also make evacuation routes impassable.

As traffic generated by evacuating motorists increases, the contraflow system is to be activated. Since the record-breaking traffic jams associated with Rita, government officials want to ensure that municipalities along the evacuation routes and the appropriate agencies are well rehearsed and to be certain that gasoline, water, and police protection are available. The contraflow system is designed to redirect traffic at the outskirts of Houston, where the freeways narrow to two lanes going in each direction, so that all four lanes will carry outbound cars. Access ramps in the contraflow areas are to be closed if they are going the wrong direction, and supplies are to be prepositioned. Only secondary roads will be available for traffic heading into the Houston-Galveston region.

So that everyone in low-lying areas will be able to reach safety, people who live outside of the defined storm surge zones will be encouraged to stay home. Those who are worried about the vulnerability of their houses to hurricane-force winds will be asked to either evacuate or move to a more secure structure. It's not clear, though, how one can know if a home or apartment building will be safe. It is recommended that every building be evaluated by an

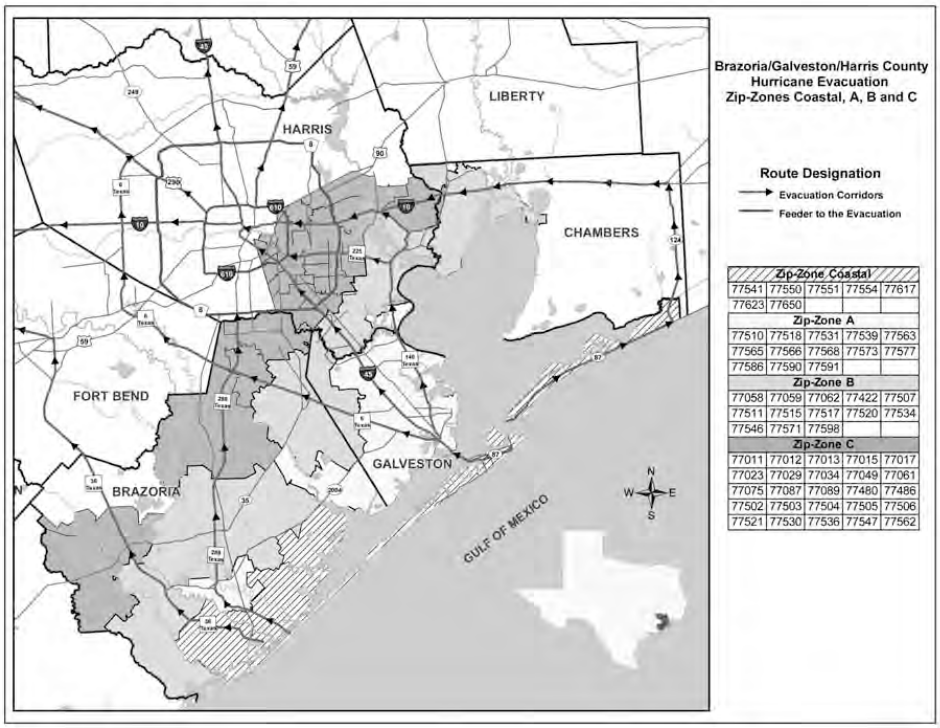
engineer to see if it meets current building-code requirements, but few structures have undergone that process, and there is debate about the adequacy of code requirements for strength. However, it must also be recognized that the number of fatalities associated with wind damage due to hurricanes is small. Andrew, a Category 5 hurricane that passed over densely populated areas of Florida in 1992, resulted in seven wind-associated casualties. Water is what usually kills people in hurricanes, particularly tidal surge waters.

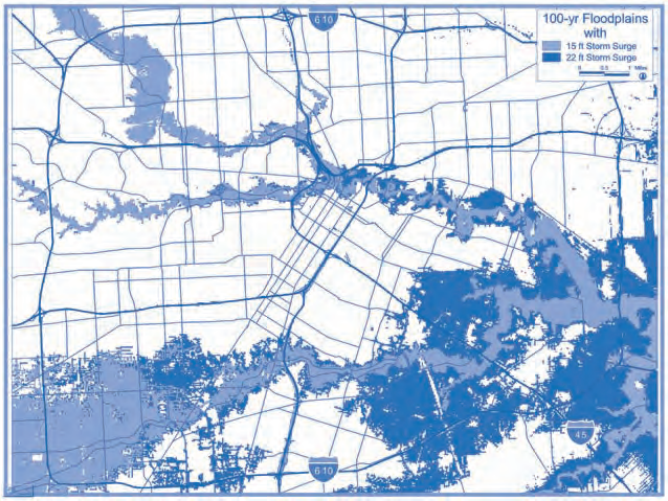
Disaster planners are pleased that during Hurricane Rita there was a 90 to 95 percent compliance rate for evacuation of low-lying areas (the normal rate is 80 percent) and the freeways were clear of traffic 12 hours before gale-force winds made landfall. But they are worried that enough lead time may not be available for the next evacuation. Hurricanes Alicia and Brett formed in the Gulf of Mexico and came ashore in under 60 hours. Katrina entered the Gulf of Mexico and hit land in only 55 hours. Other hurricanes could sprint over Florida and reach Texas in less than the 96 hours that government agencies anticipate.

While the region's hurricane evacuation plans are fundamentally dependent on the private automobile, other options do exist. Anyone in an evacuation zone who is identified as a part of the special-needs population will be picked up from neighborhood collection points. People who cannot leave their homes without assistance will be accommodated. Everyone taken in for evacuation will be given a bar code ID for tracking their progress and to make reassembly of families easier. The special-needs population automatically includes all residents of retirement homes, prisoners, and hospital patients, as well as anyone without access to transportation. All that is required to register for assistance is for locals to call 211, but, despite widespread advertising and coverage by the television and print media, only a small portion of those estimated to have special needs have requested assistance.

For those who require more protection from wind than their homes can provide, "refuges of last resort" will be opened. These places are not called shelters because the term implies that there will be cots and supplies at these locations. Refuges of last resort are merely wind-resistant structures such as school gymnasiums. They're not announced in advance because different facilities will be opened up for various kinds and levels of emergency. As soon as an evacuation is necessary, shelters will be set up in other cities to receive evacuees who were unable to arrange to stay with friends or family or at a hotel.

In preparation for all categories of hurricanes, people are advised to have previously determined several alternate routes to high ground, to maintain a fully stocked evacuation kit, and to have a prearranged family communications plan in case telephone and cell phone service breaks down. The recommended contents of an evacuation kit are daunting: three to five gallons of water per person and food for three to five days, as well as important legal and insurance documents; medical supplies, bedding, and clothing; flashlights and battery-powered radio; cash or travelers checks; a fire extinguisher; and extra supplies for children, the elderly, and pets. Before leaving home, garbage cans, lawn furniture, and other loose objects are to be brought inside homes, garage doors reinforced, and windows boarded up. During hurricane season, all residents of coastal areas are asked to keep trees trimmed and to remove weak or dead branches. Residents are advised to ask their insurance agents about storm coverage requirements, since some companies have claimed that houses damaged by Rita and Katrina were not covered because residents didn't take "reasonable precautions," including boarding up windows.





Zip-Zone Evacuation map (above); 100-Year Floodplain Storm Surge map (right).

themselves for relief and recovery efforts. Fire engines, ambulances, and construction equipment from the evacuation zones will be sent to assembly points on high ground, as will units being brought in from other regions. Utility companies will organize crews and equipment to facilitate rapid reoccupation and reconstruction of affected areas. Hospitals will gear up to receive large numbers of casualties, and other emergency workers will be required to report for duty.

Katrina taught us that first responders and other essential personnel are unlikely to report to work during a disaster if they are worried about the safety of their own families. It has therefore become a top priority of all levels of government to provide special

COURTESY OF HGAC (TOP); PHILIP BEDIENT (BOTTOM)

facilities for the families of first responders. The number of workers described as essential personnel has been expanded based on experiences gained during Katrina and Rita, so that government agencies not only have administrative staff in place but support staff available to keep offices running for extended periods of time after a disaster.

When the storm has passed, seriously affected areas are to be sealed off by the police. Hazard assessment teams will be sent in to these regions to identify toxic spills and gas releases, downed power lines, and unstable buildings and bridges, and to cordon them off. As this work progresses, fire and EMS teams will begin the search for victims and casualties. Debris management will be a critical problem. A high priority is to be given to clearing roads and bridges so that emergency personnel have access to areas from which they have been cut off and construction and utility crews and heavy equipment can be transported to critical locations. National Guard troops are to be stationed, if necessary, throughout the most damaged areas. Local Red Cross shelters will be set up to take care of the returning population. As soon as it is safe to do so, residents will be allowed to go home, but this may not be for a number of days or even months, particularly in seriously affected areas. In some cases it will not be possible at all.

The question of toxic releases is of particular importance for our region. A slow-moving Category 3 to Category 5 hurricane with winds from the south or southeast creating up to a 30-foot tidal surge would direct Gulf waters up Galveston Bay and into the Houston Ship Channel. In such a storm, rapidly flowing water and large, debris-filled waves would pass over the nation's largest petrochemical refining and storage center and the contents of those refineries and storage tanks would be driven toward the center of Houston. When the storm passes and waters recede, these chemicals and toxic soils would wash over the entire Galveston Bay and Houston Ship Channel area. It has been reported that refineries and chemical companies along the Ship Channel plan to rush their product inland by pipeline and rail car as soon as a hurricane is seen as a threat. It is not clear that they would be able to move their entire inventory in time. It is also not clear what their clean-up plans are for an event of this magnitude.

While tidal surge and high winds would cause the most damage during a major hurricane, rainwater also represents a major threat that challenges government agencies. Rainfall in the range of 10 to 12 inches is considered normal during a hurricane, with significantly more possible. As a part of the Tropical Storm Allison Recovery Project, the Harris County Flood Control District has partnered with FEMA to update flood insurance rate maps using state-of-the-art LiDAR (Light Detection and Ranging) aerial mapping technology. These maps are much more accurate than earlier versions, making flood-control planning more effective. Also inspired by Allison, which dropped 28.5 inches of rain on northwest Houston in a 12-hour period, a number of major flood-reduction projects have been initiated. These include widening and deepening bayous, excavating storm-water detention basins, and initiating a voluntary home-buyout program for residents in areas prone to flooding due to rain. Projects are under way for Brays, Sims, White Oak, Armand, Greens, and Halls bayous, as well as Goose Creek. Along Brays Bayou alone, $458 million is being spent to widen and deepen 21 miles of channel, to excavate 3.5 billion gallons of storm-water detention, and to raise 32 bridges. When completed, this project will remove 30,000 residences from the 100-year floodplain map. Approximately 2,500 homes have been bought in Harris County so that their sites can return to their natural state or be used as parks. The objective of these efforts is to reduce flood damage from rainwater.

> A Katrina-like storm hitting the Port of Houston would jeopardize over 850,000 jobs and may result in losses of more than $130 billion to the Texas economy.

Working together with the City of Houston Parks Department and the U.S. Army Corps of Engineers, the flood control district is creating a vast new metropolitan park system, one that will reduce but not remove the risk of flooding in the event of a hurricane or tropical storm. Because of the continuing risk of flooding, residents of the Houston-Galveston region are being encouraged to have flood insurance, whether or not their homes or businesses are in a floodplain; not having been flooded previously is not a future indication of safety. However, living in a flood-prone area or having to pass through one may make early evacuation necessary for individual families and neighborhoods.

Although it has been almost 25 years since a Category 3 or higher hurricane hit the Galveston-Houston area, meteorological records indicate that such storms have struck our area on a roughly predictable 17-year cycle ever since 1900. Since Carla flattened Kemah and Seabrook in 1961, the population and the number and size of refineries and chemical plants around Galveston Bay and in low-lying coastal areas have grown enormously. According to the Houston-Galveston Area Council, there are over 350,000 homes and almost a million people living within the evacuation zone area today. They estimate that this number will increase in the next 25 to 30 years to over 550,000 thousand homes and almost 1.5 million people. The Independent Insurance Agents of Texas have identified 405 chemical and refining plants in the same area. They estimate that over $130 billion dollars of losses to the Texas economy would be caused if a Katrina-like storm hit the Port of Houston, and over 850,000 jobs could be lost. Aside from the economic damage, after the Rita experience, when nothing significant happened to our region, it isn't clear who will evacuate next time.

While there are plans for the approach of "the big one" and for its immediate aftermath, what about economic reconstruction and recovery afterward? What about protection against tidal surge, by either engineering wetlands areas, the construction of levees and floodgates, or other means? There are no plans to require raising minimum floor heights throughout the flood zone, to buy out homes and factories that are most at risk of flooding, or to prevent future construction of homes in the most at-risk locations. Finally, there do not appear to be any plans to fortify existing or future chemical and refining plants against tidal surge, or to clean up the vast volume of chemical pollutants that could be released after a hurricane. A number of years ago there was a proposal by the Army Corps of Engineers to build a levee around Galveston Bay, but it didn't get very far, probably because of the high cost of construction, the low cost of flood insurance, and the perception that major storms were unlikely to have a serious impact on our area. But now we have seen the devastation that can be caused by major storm events, and have been reminded of what old-timers along the Gulf Coast have always known: It's just a matter of time.

The challenges for government are huge. The expense of dealing with these dangers leaves few politically attractive alternatives. But the scale of disaster that our region can in all probability expect should create the political will to make Houston as prepared as possible. The challenges for designers are enormous as well. How can we fortify cities and homes? How can livable cities and great architecture emerge from these challenges? The need for the design community to be involved is increasingly clear, even if the answers aren't yet apparent.

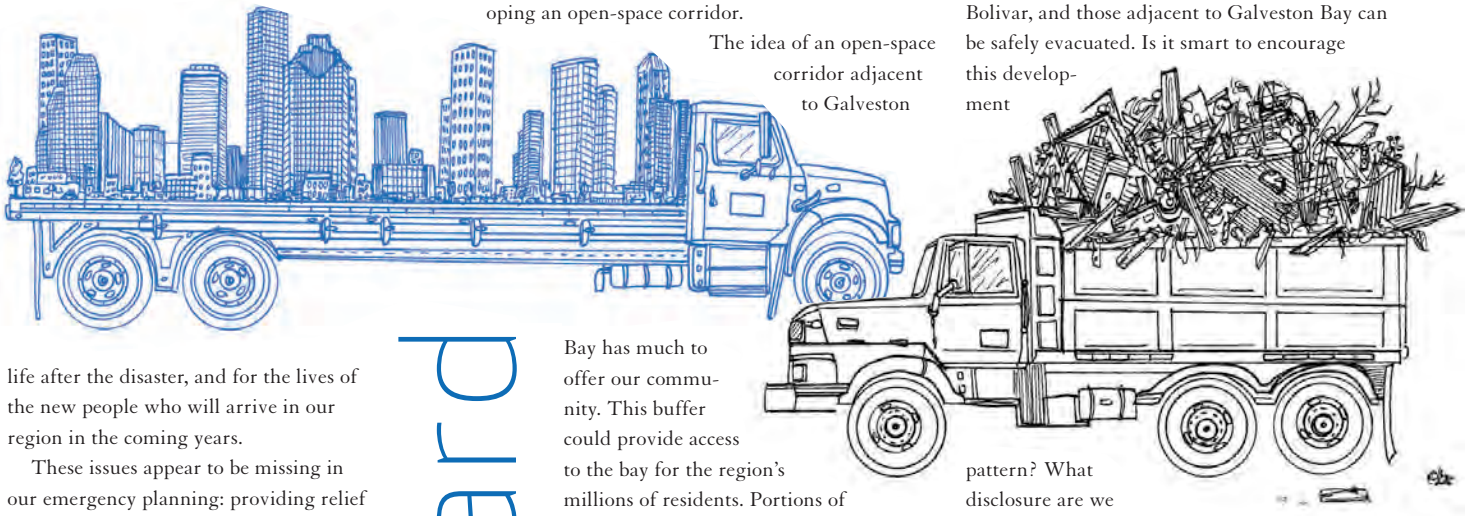
FLASH forward

WE ARE TOTALLY UNPREPARED FOR THE DESTRUCTION and chaos accompanying a major hurricane strike, shortcomings that become more obvious as the research mounts. Our discussion of preparedness is focused on evacuation; however, evacuation is only one aspect of preparedness. What's missing is the rest of the story—the part about planning for life after the disaster, and for the lives of the new people who will arrive in our region in the coming years.

These issues appear to be missing in our emergency planning: providing relief for evacuees who return to destroyed or damaged housing; developing a plan for rebuilding after the storm; determining the extent to which we allow/encourage future development in these hurricane high-risk zones; and providing for adequate floodplain mapping to give proper information for industrial and residential development.

The amount of damage that is projected from a Category 4 or 5 storm is incredible: Over 300,000 households are subject to inundation from a 20-plus-foot storm surge, of which 100,000 will be destroyed and 100,000 seriously damaged. It may take weeks to restore electricity to less damaged areas. Regions along the coast will not be habitable for months. In addition, there will be inland flood and wind damage. With a direct hit, we could have over 500,000 people with no place to live for an extended period of time. Where and how do we shelter and feed these people? How do we get our basic economy up and running?

The second issue is rebuilding. Should we really redevelop an area that is so vulnerable to hurricane damage? A viable alternative concept is to set up a fund to be used in association with flood insurance payments to buy out those who live in the most vulnerable areas, preventing rebuilding and developing an open-space corridor.



The idea of an open-space corridor adjacent to Galveston Bay has much to offer our community. This buffer could provide access to the bay for the region's millions of residents. Portions of this area could be planted with wetlands and with other types of vegetation to form a biological barrier to storm surge damage. This could be done in association with strategic engineering projects to provide a long-term reconstruction concept for the area.

But we have no plan for reconstruction after a storm, and it seems that we are simply going to redevelop in the same manner that led to such destruction and chaos in the first place. Certainly the worst time to have this discussion is after the storm has come and left 500,000 folks homeless, staring at building officials, and begging for building permits. We need community discussion about a businesslike approach to rebuilding—one that makes economic and engineering sense. Any chance at being rational depends on planning before the storm, not after it.

A third issue is population growth. Our community is expected to gain three to four million persons over the next few decades. Over 150,000 new households are projected for the coastal evacuation zone in the next 30 years. That means another 400,000 people to evacuate and another 50,000 homes likely destroyed, with substantial damage to the remainder. Based on the experience of Rita, it is reasonable to question whether the existing population of Galveston, Bolivar, and those adjacent to Galveston Bay can be safely evacuated. Is it smart to encourage this development pattern? What disclosure are we making as a community?

The final issue is the accuracy and reliability of the FEMA floodplain maps. There is no doubt that the Category 4 and 5 storm surge predicted is significantly higher than the flood elevations shown on the FEMA Flood Insurance Rate Maps, the official 100-year floodplain maps. These set the minimum elevation for new homes and businesses, and the levels of protection for hazardous waste storage and disposal and for sewage treatment plants and landfills. The maps are simply not sufficient at this time.

The maps currently used within the community routinely show flood elevations of 10 to 12 feet in areas that are likely to be inundated to depths greater than 20 feet. Reliable information about hurricanes, storm surge, and flooding is missing. We need to know whether our floodplains will be enlarged by 20-plus-foot tides combined with 10 to 12 inches of rain. The Harris County Flood Control District says that that interaction will not make any difference, but many engineers disagree. We need public accountability and answers to these and many more questions. Our lives and property depend upon it.

by Jim Blackburn
illustration Kiersten Essenpreis

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RESOURCES.SUMMER 2007.cite

After the Flood
Photographs by Robert Polidori
(Steidl, 2006; 336 pages; $90)

A Century of Galveston Weather: 1900-1999, People and the Elements on a Barrier Island
Stan Blazyk
(Eakin Press, 2004; 448 pages; $27.95)

The Great Deluge
Hurricane Katrina, New Orleans, and the Mississippi Gulf Coast
Douglas Brinkley
(William Morrow, 2006; 736 pages; $29.95)

Isaac's Storm: A Man, a Time, and the Deadliest Hurricane in History
Erik Larson
(Pelican, 2000; 385 pages; $13)

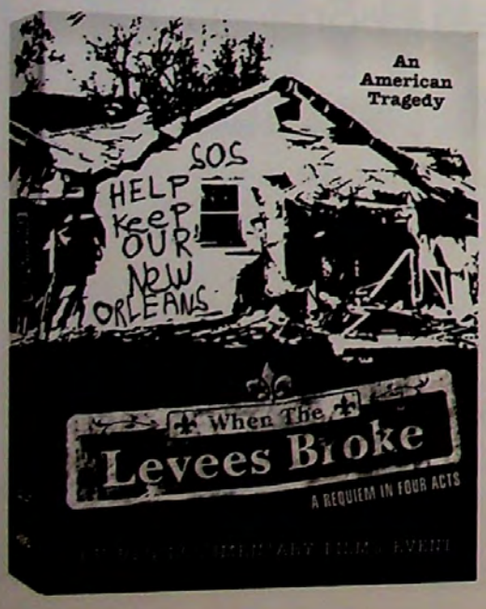
Katrinaandrita.org
Oral histories of NOLA evacuees to Houston, as told to fellow evacuees.

The Storm
What Went Wrong and Why during Hurricane Katrina—the inside story from one Louisiana scientist
Ivor van Heerden and Mike Bryan
(Viking, 2006; 320 pages; $25.95)

An Unnatural Metropolis
Wresting New Orleans from Nature
Craig E. Colten
(Louisiana State University Press, 2006; 272 pages; $18.95 paper)

A Weekend in September
John Edward Weems
(TAMU Press, 1989; 192 pages; $13.95)

When the Levees Broke:
A Requiem in Four Acts
Directed by Spike Lee
(HBO Home Video, 2006; 256 minutes; $29.98)



New Orleans native Lumar Leblanc, leader of the Soul Rebels Brass Band. From a photography exhibition at katrinaandrita.org.

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HONORED SIR,

I take up my pen, just to give you an imperfect account of one of the most dreadful hurricanes that memory or any records whatever can trace, which happened here on the 31st ultimo at night. It began about dusk, at north, and raged very violently till ten o'clock. Then ensued a sudden and unexpected interval which lasted about an hour. Meanwhile the wind was shifting round to the south west point , from whence it returned with redoubled fury and continued till nearly three in the morning. Good God! what horror and destruction - it's impossible for me to describe - or you to form any idea of it. It seemed as if a total dissolution of nature was taking place. The roaring of the sea and wind - fiery meteors flying about in the air - the prodigious glare of almost perpetual lightning - the crash of falling houses - and the ear-piercing shrieks of the distressed were sufficient to strike astonishment into Angels. A great part of the buildings throughout the island are leveled to the ground - almost all the rest very much shattered - several persons killed and numbers utterly ruined - whole families wandering about the streets, unknowing where to find a place of shelter - the sick exposed to the keenness of water and air - without a bed to lie upon - or a dry covering to their bodies - and our harbors entirely bare. In a word, misery, in its most hideous shapes, spread over the whole face of the country ....

Alexander Hamilton at 15 years, in a letter to his father. From *Virgin Islands: Our New Possessions and the British Islands,* by Theodoor De Booy and John T. Faris, 1918.

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