

# atmospheric pressure

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HOUSTON-AREA  
HOSPITALS  
LEARNED HOW  
PREPARED THEY  
WERE WHEN FACED  
WITH ONE OF THE  
BIGGEST STORMS  
IN A CENTURY.

■ JOHN R. PARADISE

## HEALTH-CARE SAFETY



Tropical storm Allison.

**T**ropical Storm Allison was barely a blip on weather forecasters' computer screens when the rain started to fall on Houston, Texas, on June 5, 2001. The storm had just taken shape in the Gulf of Mexico when it made landfall, so it didn't pack the high winds and storm surges usually associated with tropical storms. But it did bring rain, torrential rain, the likes of which Houston had never experienced.

When the storm finally began tracking northward up the coast later that week, the city found itself drenched but generally unscathed. The drainage ditches, retention basins, and other structures built to protect Houston's low-lying areas, including the center of the city, had held firm against the deluge—barely held, but held nonetheless.

By Friday, June 8, though, Houston's luck ran out when Allison reversed course and paid the city a return visit. When the storm clouds cleared the following Monday, parts of the city were under nearly 3 feet (1 meter) of water, its defenses overwhelmed by the rising floodwaters.

Among those hardest hit was the Texas Medical Center, the nation's largest health-care megaplex, which consists of 42 medical institutions, including 19 hospitals. The buildings, located in the heart of the low-lying downtown area, are within walking distance of one another, and most are connected by an underground tunnel system with some connected by a skywalk.

When the flood reached the medical center a few hours past midnight on Saturday, June 9, muddy water poured into several of the hospitals' basements and sub-basements, inundating their electric power stations and turning the tunnel system into a raging underground river. According to the *Houston Chronicle*, Texas Medical Center Senior Vice President Andy Icken said the flood caught the medical center off guard, not just because of Allison's quick turn-

about, but also because the floodwaters rose 4 feet (1 meter) higher than anyone imagined they would. Even the watertight aluminum barricades and metal, submarine-type doors installed in some buildings were no match for rushing water, which forced its way around the stackable barricades and ripped several of the 12-inch-thick (30-centimeter-thick) sealed doors off the walls.

With their basements flooded, numerous facilities, including Christus St. Joseph, St. Luke's Episcopal, and Methodist Hospitals, lost power, leaving them without lights, telephones, pagers, air conditioning, ventilation, and drinking water. Many even lost backup power because their emergency generators, also in the basement, were now underwater, too. Several facilities in which the emergency generators were above the flood level also found

# PREPARATION

themselves without electricity when damage to related equipment, such as transfer switches, rendered the generators useless. Hardest hit in most of the hospitals were the radiology, nuclear medicine, radiation therapy, biomedical engineering, and medical records departments.

Six facilities were forced to evacuate all or some of their patients, some of whom were on life support. With no elevators in service, staff and volunteers had to carry patients through darkened hallways down hot, airless stairwells to waiting ambulances and helicopters. At Memorial Hermann Hospital, a trauma center and one of the hospitals hardest hit by the storm, 300 volunteers helped evacuate the hospital's 540 patients, using flashlights to find their way out of the dimly lit building.

"These hospitals found themselves completely without power," says Russell Phillips, of Russell Phillips and Associates, (a Medsafe Company) based in Rochester, New York, specializing in fire protection and emergency management consulting firm, who flew to Houston a week after the flood to study the catastrophe. "They had nothing—no electricity, no water, no air conditioning, no medical oxygen—nothing. I've seen disasters before, but nothing of this magnitude, not first-hand anyway."

Phillips is chairman of the NFPA technical committee responsible for the content of Chapter 12, "Health Care Emergency Management," of NFPA 99, *Health Care Facilities*. Chapter 12 is designed to provide information that health-care facilities can use to draft emergency protocols and disaster plans.

One hospital Phillips applauded for its preparation before, and quick action during, the flood was St. Luke's Episcopal, a 26-story, 1.3-million-square-foot (120,770-square-

meter) facility. Even though the 948-bed hospital sustained \$90 million in damage when storm waters annihilated most of its utilities and basement work space, it was able to care for its patients, evacuate safely, perform the



Houston police officers look over the ruined commons at the closed Memorial Hermann Hospital in Houston June 11, 2001. The hospital was forced to close after flooding damaged the building's electrical system.

needed repairs, and reopen under its own power just 10 days after the storm subsided.

"In the early stage of a disaster like this, you need to have two things in place if you hope to be able to sustain your facility," says Charles Swanson, vice president of St. Luke's. "You need situational awareness—you've got to have a good grasp of what's going on—and you need adequate resources to deal with the situation. Without one or the other, you're

lost."

Hospitals in Houston used several disaster preparation standards in drafting their disaster plans, including the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) protocols and NFPA 99.

"JCAHO is the agency that the payers—governmental and otherwise—require us to use," says Swanson. "Without JCAHO accreditation, the hospital is simply out of

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Onlookers stand on an overpass where flood waters covered Interstate 10 in Houston, on June 9, 2001, as Tropical storm Allison swamped Southeast Texas.

business, that's why the JCAHO standards formed the nexus for our plan. But I felt this wasn't enough. That's why I turned to NFPA codes. I was able to fill in some gaps using them. I think that's one of the reasons we came out of it so well."

Even before it started to rain, Swanson was monitoring developments in the Gulf and knew that the tropical depression taking shape could cause problems for the hospital.

"When the storm backed up on us later in the week, we were as ready as we could be," he says.

Some hospitals failed to stay abreast of weather reports, says Phillips, and were caught completely by surprise when Allison reversed course.

"This was definitely unfortunate. By staying on top of the weather, hospitals like St. Luke's had a little bit of time to prepare themselves," he says.

By Friday afternoon, with Allison raging outside, Swanson says the hospital staff was reviewing emergency protocols and discussing how best to deal with the water filling the building's basement. By late Friday night, extra staff had been called in, and Swanson had briefed the director of nursing and other senior medical staff, explaining that the hospital would probably lose power sometime during the night.

"We decided that before we lost power, we should evacuate the most critical patients to an adjoining medical building," says Swanson. That building has 10 operating rooms, 20 pre-operative beds, and 20 post-operative beds available, all with cardiac monitors and oxygen stations. Medical equipment and drugs necessary to care for the patients were also carried to the building over a skywalk. Officials were confident the other building wouldn't lose power since its utility systems were on ground above the flood waters.

"We essentially transformed that building into a critical-care unit," says Swanson. "In all, we moved about 50 people over there before the hospital's power went out. The medical building never lost power."

Throughout the night, hospital staff communicated with each other using two-way radios.

"But when the batteries ran low, we had no way to recharge them," says Swanson. "We started using runners to carry messages back and forth. Communication is so vital in an emergency. You have to stay in tune with what's happening everywhere in your hospital."

Phillips agrees.

"Communication, whether you're talking about communication within the hospital or from the outside world, is critical during and

after a situation like this," he says. "People I talked to after the disaster stressed the importance of having an ample supply of handheld radios on hand. However, when radio repeaters are knocked out, like they were in Houston, the radios' range was significantly reduced. Whenever possible, repeaters should be above the high-water mark and have an uninterrupted backup power supply."

Patient safety was a prime concern for hospitals during the storm, says Swanson.

"You're in the dark, and you're trying to care for all these people," he notes. "We had the doctors constantly making rounds all night long."

The tropical storm was responsible for 20 deaths in the region.

#### In the aftermath

Riding out the storm was only the beginning of the crisis for many of the Texas Medical Center hospitals, which sustained more than \$2.03 billion in damage that night.

Once the weather cleared, damaged hospitals had to transfer patients to other facilities untouched by the flood so repair work could begin. Phillips found this process slow because the medical center had no mutual-aid protocol in place to dictate exactly where patients should go.

"Having an up-to-date plan in place would

have saved some of these hospitals a lot of time and aggravation,” says Craig Kampmier, formerly NFPA’s senior fire protection specialist for health care.

Many hospitals, including St. Luke’s and the Texas Heart Institute, also lost extra equipment, including the tools and manuals needed to repair equipment that wasn’t destroyed by the flood.

“Our entire biomedical engineering department, which is responsible for evaluating, installing, and maintaining all the patient care equipment, was underwater,” says Yadin David, a member of the NFPA 99 Technical Committee on Electrical Equipment and the Committee on Gas Delivery Equipment and director of Biomedical Engineering for St. Luke’s and Texas Children’s hospitals. Yadin is also chairman of NFPA 115, *Laser Fire Protection*.

“One of the first things we did was establish a separate facilities command center with 15 computer stations,” says Swanson. “We were very fortunate to have good relationships with top-notch contractors—builders, electricians, plumbers. Even before I got on the phone, they were at the hospital. They’d been watching the news. They knew what we needed.

“These relationships were instrumental to our quick recovery. If there are hospitals out there that don’t have strong relationships with tradesmen, establish them as soon as possible. You never know when you’re going to need them in a hurry. The contractors had the command center up and running by Monday morning. Now, we had a place from which to direct the remediation and recovery operations.”

Also in demand immediately following the disaster were filtration masks, batteries, flashlights, portable radios, cellular telephones, and portable electric generators.

“We were on the telephone right away to stores and suppliers, lining up everything we needed,” says Swanson. “We acted quickly and were able to get some of what we needed on scene in a hurry, like emergency generators and bottled water.”

Some hospitals used portable air conditioning units to keep temperature- and humidity-sensitive equipment and supplies cool and dry, as workers continued to clear away the mess and mend the damage.

The sweltering summer weather and the

lack of air conditioning also made keeping people cool and hydrated a major concern during the recovery period. Hospitals were careful to supply plenty of bottled water to patients and workers, and when bottled water ran low, soda and juice were passed out. With many of the hospitals’ kitchens damaged by the flood, these drinks had to be brought in from other places, as did food. In some cases, meals were passed hand-to-hand up many flights of stairs to waiting patients and staff.

St. Luke’s administrators met several times a day to discuss the ongoing recovery work.

“We had whiteboards all over the place, detailing the work that was being done and the status of each project,” says Swanson. “We were working as hard and fast as we could to reopen.”

Before the facilities were allowed to reopen officially, the Texas Department of Health required that they meet all life safety codes and be able to operate completely under their own power. The health department also required that the hospitals have an operational emergency backup power system in place in case their primary power sources failed.

“The speed at which each hospital was able to reopen had a lot to do with how well each had planned for a disaster like this and how well they followed through with their plans,” says Kampmier.

Swanson agrees.

“I have a worst-case disaster scenario in my head, and we’ve planned for it,” he says. “It was a tropical storm that hits the hospital, just like Allison did.

“My advice to other health-care facilities would be to think of the worst that could happen to your facility—the absolute worst—and then develop a plan, not only for surviving it but also recovering from it. Plan for the worst, and then hope for the best.”

In the flood’s aftermath, every hospital in the Texas Medical Center has taken steps to prevent such utter devastation in the event of another natural disaster. With the help of federal, state, and local grants, many have purchased satellite telephones and additional portable radios with spare batteries and have moved their emergency generators to higher ground. Some have also bought specially designed evacuation chairs to make carrying patients up and down stairs easier, while others have installed watertight doors in their

basements. Although the floodwaters tore through the submarine-type doors at some hospitals, others, such as those at Texas Children’s Hospital, held fast and protected the facility from flooding.

At least one hospital is planning to move its utilities out of the basement, a project that will cost the facility between \$15 million and \$20 million. Much of the cost associated with this move comes from the need to reinforce the floors to support the equipment, Phillips says.

Other hospitals have argued that the cost of relocating utilities is too great, considering the improbability of another such storm striking any time soon.

“At St. Luke’s, we’re building concrete walls 4 feet (1 meter) high with flood doors around our core utility rooms,” says Swanson. “To move the utilities would be very expensive, and, in any case, on our upper floors every inch of space is being used. There’s really no room.”

In addition, the hospitals have traded in their conventional sewer, storm water, drinking water, and fire protection pumps for submersible pumps and moved critical electrical switching equipment for emergency power and sprinkler systems to upper floors. Some have also connected their elevators to backup emergency power supplies.

“Experience has shown us that we can’t really predict disasters, but we’ve had enough experience now to tell us what can happen to health-care facilities during such a disaster,” says Phillips. “We’ve seen what works and what doesn’t.”

“By understanding past catastrophes, hospitals and other health-care facilities can plan for the future,” says Kampmier. “My advice is to plan for the unlikely, prepare for the impossible, be capable of responding to the inevitable, and then the event or incident will be less consequential. The proof is in the storm water.” ♦

### NFPA Technical Committee

The lessons learned from the Houston flood will be considered for inclusion in Chapter 12 of NFPA 99 when the technical committee begins its revision cycle next summer.