Disaster Recovery at Texas Medical Center from Tropical Storm Allison

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Tropical Storm Allison formed quickly over the Gulf of Mexico in early June 2001. The storm moved ashore with relatively low wind speeds but with torrential rains. On Wednesday, June 6, the storm passed over the Houston metropolitan area, moving north-northeast. On the first pass, the storm dumped enough rain to cause moderate flooding in some sections of the city and also saturated the ground. Due to a high-pressure system over the Midwest, the storm advanced north-northeast to approximately Lufkin, Texas, then it reversed course. The storm moved southwest, arriving over the Houston metropolitan area again on Friday, June 8. The rain began mid-afternoon on June 8.

Because of the storm’s southwest direction of movement and the counterclockwise rotation of the tropical storm clouds, it appeared for some time that the storm did not move but was stationary over the Houston metropolitan area. Rain gauges recorded anywhere from two inches of rain on the far west side of the Houston area to 36 inches of rain east of downtown Houston. The amount of rain dropped from this storm system exceeded most records in the area. The storm tapered off its rainfall in the early morning hours of June 9. As the sun rose over Houston and Harris County, the massive damage and destruction that was caused by the flooding of Tropical Storm Allison became evident. The storm had left behind more than $2 billion in damage [1]. See Exhibit S3.1.

Storm Damage at the Texas Medical Center

One of the hardest hit sections of Houston was the Texas Medical Center, which is approximately 700 acres containing some forty medical facilities, including two medical schools, four nursing schools, thirteen hospitals, and two specialty hospitals. The Texas Medical Center contains only not-for-profit or state-operated institutions.

Although all the facilities were affected by the floods to some extent, the level of damage and destruction varied significantly based on their location within the Texas Medical Center. While there was ample warning that the tropical storm was passing over Houston for a second time, the intensity of the storm had not been anticipated. The facilities had been prepared for the tropical storm and possible flooding, but the high level of the floodwaters was not anticipated. The Texas Medical Center area has multiple electrical feeds from the Houston power grid. Early in the morning on June 9, floodwaters caused the multiple feed to fail, resulting in primary power loss to all the facilities.
Contrary to press reports, none of the generator units were underwater. The generators initially started on the multiple facilities and began providing emergency power to the emergency circuits.

As the early morning of June 9 wore on, the floodwaters continued to rise. Water began entering the facilities from multiple roofs, over flood barriers at the drive entrances to parking garages, over flood barriers around the perimeters of the sites, and through backed-up storm sewers. The floodwaters also moved from area to area through the tunnel systems interconnecting the buildings within the Texas Medical Center. All of these institutions have had to deal with flooding in the past, and all have occasionally experienced minor flooding due to storms. The amount of water entering the facilities overwhelmed the normal sump pumps and filled the lower levels of the facilities. As the water rose, it began to come in contact with the electrical switchgear that controls the power distribution in many of the facilities. As the switchgear was affected, the facilities began to lose emergency power. As emergency power systems failed, patient care functions became critical.

**Disaster Response**

The health care facilities began their storm emergency procedures while handling the patients. Additional staff members from many facilities were notified to respond to the institution to assist.

Facility staffs rose to the challenge and became very innovative, taking actions to preserve and save patients’ lives. By midday on June 9, most patient care issues had been stabilized. The next function became assessing damages to the facilities. Each facility took a slightly different approach in assessment and recovery; however, the following were common themes addressed by all.

The assessment phase began immediately. This phase lasted up to 10 days at some facilities due to the time frame necessary to remove the water safely from the facility and from access areas contaminated with hazardous chemicals. Along with the assessment phase was the initial recovery and *critical path evaluation* for the facilities. Each facility was affected differently by the flooding, and each facility had a different critical path to reach its recovery goals. Critical path items included emergency power for the following:

- Information management services
- Command and control areas
- Dehydration and air-conditioning units
- Temporary lighting
- Water removal systems

The early stages of the recovery also included assembling teams of consultants, contractors, and equipment suppliers to assist in damage evaluation and repairs. In the larger facilities, multiple general contractors were brought...
in and set up with construction trailers, and they functioned as an integral part of the assessment team. Consultants included mechanical, electrical, plumbing, med gases, building commissioning, fire protection, life safety, cost estimating, environmental health and safety, hygiene, asbestos, and architects. In addition to the consultants, the owners’ representatives included architects, building construction managers, and insurance adjusters.

The Army Corps of Engineers, the Federal Emergency Management Agency (FEMA), the Houston Building Department, the Houston Fire Department, and the Texas Department of Health lent their input and support throughout the recovery effort. Their support included switchgear, onboard drawing reviews, expedited inspections, expedited drawing reviews, expedited permits, and disaster recovery funding.

The recovery goals for each institution varied, but in general, getting back to providing patient care at the pre-storm levels was of paramount importance. This required drying the buildings including pumping, dehumidification, and repair of broken water mains and sewage lines due to the flood. The recovery process also included a massive cleanout of most of the facilities.

The removal of walls and other building materials covered in floodwater was not a major issue during the initial stages of the recovery. Some insurance adjusters questioned the level of demolition in some of the upper areas of the building that only experienced a couple of feet of flooding. However, in general, due to the infectious control concerns and mold concerns, a majority of the gypsum wallboard was removed in areas inundated with floods. Very little equipment that had been covered by floodwater was salvaged. However, some unusual size electrical motors and hard-to-get electrical components were refurbished for temporary use.

All the facilities approached the recovery similarly to a construction project needing a building certification prior to use. Almost every system in these facilities was affected in one way or another by the floods. Although not required by the authority having jurisdiction, recertification of the systems was conducted, including main power supply; emergency power and transfer switches; medical gas systems; water systems including deionized water systems and automatic sprinkler systems; stair pressurization systems; smoke control systems; fire detection and alarm systems; elevators; sump pumps; and foundation dewatering systems.

The floodwaters destroyed many of the support functions that needed to be rebuilt, including central sterile, labs, pharmacy, and bioengineering. These functions were critical to bring the hospitals back online. Other support areas that were damaged or lost, while critical to the research functions of the facilities, were not on the critical recovery path. Facilities such as research labs, vivariums, and engineering support shops were not included in the initial efforts to bring the facility back online. See Exhibit S3.2.

Recovery times varied from ten days to five weeks. The incident command function, although initially set up to deal with the flood, changed over time to become the project management and control functions for the recovery effort. Extensive meetings and tracking of goals and accomplishments were recorded to evaluate progress. Also, as the recovery progressed, damage assessments were re-evaluated as equipment was removed, replacement equipment delivery dates were tracked, and options and alternative solutions were constantly evaluated. Interim life safety measures were implemented that covered everything from changes in evacuation routes to completely revised fire department responses to the facilities due to the temporary emergency generator locations and other construction activities. Recovery resources, such as manpower and electri-

EXHIBIT S3.2 Flood damage at Memorial Hermann Hospital in Houston after Tropical Storm Allison. (Courtesy of AP/Wideworld Photos)
Lessons Learned

The disaster of Tropical Storm Allison is, in many ways, beyond description, due to the magnitude of its effect at the Texas Medical Center. Many of the individual stories of heroics and ingenuity might never be known. However, some of the lessons learned must be shared with all facilities to prepare them for the unthinkable. These lessons include the following:

- Maintain a good working relationship with a general contractor in the area, that is, someone who can be contacted in a moment’s notice to provide the expertise and manpower to rebuild a major portion of the facility.
- Keep extensive records of the building systems, including manufacturers, model numbers, and dates of purchase. This file should include all of the life safety equipment, all of the major comfort equipment for the building, and all of the patient-related systems, ranging from nurse call to liquid oxygen.
- Keep a list of design professionals who know health care and, preferably, are located locally. Their opinions and engineering and design support can help the facility through critical recovery issues.
- Know the facility’s insurance coverage, including limits, deductibles, and specialty clauses related to equipment loss due to floods, water, fire, and other hazards.
- Keep a working relationship with the authorities having jurisdiction, either directly through the hospital, through contractors, or through consultants. The authority having jurisdiction can be a great asset in helping navigate through the bureaucratic requirements of the recovery effort.

Conclusion

The challenges addressed during the post–flood recovery of Tropical Storm Allison were loss of fire protection systems, loss of fire detection and alarm systems, hazardous material contamination, removal of radioactive waste, removal of tons of debris, air quality control, management of combustible and flammable material, and removal and recovery of records. A single person or department cannot provide the talents needed to cover this wide range of challenges. It requires a team approach, with the facility operators managing the team and directing it toward reaching its goal.

Will a disaster like this happen at the Texas Medical Center again? Probably not. Each facility has assessed its vulnerabilities to flooding and has adjusted its building to protect it from floods and to respond to high water conditions in the area. These protections include floodwalls, flood doors to compartment the buildings, enhanced passive flood protection for the facilities, and relocation of vital equipment to above flood plain levels.

Other disasters can occur and can strike a critical blow to any facility, affecting its primary function of health care. With complete preplanning, all facilities can be prepared before the unthinkable disaster occurs.

REFERENCE