

**Hurricane Katrina – Assessing the Risks and Meeting the Challenge**  
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Hurricane Katrina focused the world's attention on the fragility of attempts to manage and develop the Mississippi River delta and protect the United States of America (US) Gulf Coast from flood disasters. As the nation struggles to address the aftermath of Katrina and her sister, Hurricane Rita, the US government has responded to the plight of flood victims by focusing on short-term recovery. It is also engaged in re-examining the advantages, limitations and risks of engineering approaches to flood protection. Our challenge is to set a rational and sound direction for future occupation and use of floodplain lands repeatedly devastated by nature's forces. Restoring the City of New Orleans after Katrina's destruction and protecting the city from future floods is at the center of the debate. In the process, the nation is closely scrutinizing the performance of government agencies and rethinking long-term flood management systems. In carrying out this review, we are examining the response of government officials to information that was available to them before, during and after the hurricane hit; and how this information was used in the performance of their mission.

### **The Disaster Called Katrina**

On August 29, 2005 Hurricane Katrina, one of the strongest storms to strike the coast of the United States (US) in the past 100 years, devastated the city of New Orleans and much of the Gulf of Mexico coastline in the states of Louisiana and Mississippi. A second major hurricane, Rita, hit the Louisiana and Texas coastlines a few weeks later. In the aftermath of these disasters the world was shocked by the level of destruction and the inability of local, state and federal agencies to effectively coordinate emergency response to the disaster. Over a million people lost their homes and jobs, and more than 1300 people lost their lives. Entire neighborhoods in New Orleans were destroyed and may never be rebuilt. Although some residents have returned to the city, the majority of displaced and relocated citizens are still temporarily or permanently scattered in communities throughout the United States. It is now estimated that cost of Katrina will exceed \$90 billion. In the aftermath of devastation and loss on this scale, flood management and emergency response policies in the US are being examined closely at all levels of government.

Katrina has generated a public policy debate in the US focusing on several key questions. Are current floodplain development policies and existing flood management systems working? What priorities have driven flood management policy decisions, and what are the social, economic and environmental consequences of those decisions? How much does the public understand about the risks that it faces in living in high-hazard areas? With one of the worlds most advanced and precise flood forecasting and warning systems, why did federal, state and local

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governments fail to implement effective emergency response plans? Finally, what needs to be done to improve flood management and emergency response systems to avoid similar disasters in the future? This paper will address some but not all of these related challenges in the context of how well available scientific information supports the policy decisions that were and are being made, and that will be made in the future.

## **The History of Flood and Hurricane Management in the Mississippi River Basin and New Orleans**

Two hundred and fifty years ago the Mississippi River Basin (Figure 1), which encompasses forty-one percent of the coterminous US, was a natural river system. Since 1718, when the first levees were built on the banks of the Mississippi at New Orleans, human activity has transformed the Mississippi River Basin into one of the most engineered river systems in the world. An extensive network of levees, dams and other structures now provide flood protection, maintain a commercial navigation system, produce energy, and impound water for municipal, industrial and agricultural uses.

Settlers, seeking to farm the fertile lands, drained vast areas of wetlands throughout the basin thus increasing the runoff and the speed in which it reached the river systems. To provide for flood protection and navigation, over the past 127 years government engineers have lined the banks of the lower Mississippi with levees, established emergency floodways to move flood waters, and built revetments and stone dikes to control the river's meandering (Figure 2). Sediment and nutrient rich flood waters that originally created the birdsfoot deltas of Louisiana (Figure 3) at the Gulf of Mexico no longer spread across the landscape and are instead channeled into the Gulf and dumped over the edge of the continental shelf. As a result of this loss of sediment and other natural and anthropogenic activities (such as oil and gas production), the Louisiana Delta is losing 65-104 square kilometers each year and the once strong storm buffering capability of the Delta is disappearing, increasing New Orleans' vulnerability to storm events.



Figure 1. The Mississippi River Basin

The US flood management systems on the lower Mississippi have provided many economic and social benefits to the region, returning more than \$18 for every dollar invested in building the system. These systems have also created serious environmental, economic and social problems in the lower basin. The combination of intensive floodplain development and the cumulative impacts of structural intervention in the river system have disrupted critical ecosystems throughout the basin. As noted, this has diminished the capacity of the river system and the delta region to provide natural protection against hurricanes and riverine flood waters.

Much of the City of New Orleans is below sea level (Figure 4). Initial settlement of the city took place on the high ground on the banks of the river. As the population grew, it moved in to lower and lower areas, formerly backswamps, drained them and protected them from flooding by levees and pumps.



Figure 2. River Control Works  
 (Clockwise from upper left: Bonne Carre Floodway; River training Dikes; Mississippi River Levees; Tributary Dam)

Since its founding, the city has been protected by levees against the flood flows of the Mississippi whose waters come from the north. Hurricane Betsy, which hit New Orleans in 1965, pointed out that the back door to New Orleans, Lake Pontchartrain, was open and that storm surges moving into the area through Lake Pontchartrain would flood the low-lying areas north and east of the original settlement. This led to federal authorization of hurricane protection and the construction, over the next 20 years, of several projects designed to protect the area against hurricane events. Since the city essentially sits inside a bowl created by the protective levees, massive pumping stations are needed to drain the city of rain water that accumulate in the city during the frequent and intense rain storms (24 hour 304 mm rainfalls have occurred) . As Katrina demonstrated, those pumps are no match for the flood waters that flow into the city when the levee system is breached. The US Army Corps of Engineers (Corps) designed and built the New Orleans levee system, but local levee boards and city and agencies operate and maintain the levees and the pumping stations.

Since 1928, the Mississippi River levees have been designed to protect New Orleans against a flood with a recurrence interval of more than 700 years; however, when the decision was made in the 1960's to move forward with hurricane protection, protection was set against a "standard-project hurricane" whose return interval was estimated to be 200-300 years. At the time, this level of protection was thought to provide protection against a Category 3 hurricane. Given that coastal areas in the Netherlands and Japan are protected against the 10,000 year event, to

many, this level of protection seemed low. For years, flood managers and flood management agencies have raised questions about the adequacy of the New Orleans levee system, arguing that the hurricane levees should be upgraded to protect the city from a Category 5 hurricane (with a recurrence interval likely to be in excess of a 1000 years). Given no information to the contrary, the public, for the most part assumed that it was being protected against the threats that it faced.



Figure 3. The Mississippi Delta



Figure 4. Cross-section of New Orleans

### Dealing with the Flood Threat

The failure of the New Orleans levee system brought the subject of flood protection to the forefront. Given New Orleans' topography, its continuing subsidence and the alarming loss of barrier islands and estuary grasslands on the Louisiana Gulf Coast, has protecting the City of New Orleans from flooding become an unrealistic goal? Even if Congress decides to improve the levee system, will the City of New Orleans rebuild districts in the lower elevation regions of the city that are most susceptible to flooding and property damage? If rebuilding is allowed, will residents be required to elevate their homes or take other measures reduce the risk and cost of property damage? The Federal Emergency Management Agency (FEMA) has recently announced that it may require all new or rebuilt structures to be elevated nearly one meter, but is this enough to deal with the threat of future levee breaches? Flood insurance is another important issue. Over 60,000 New Orleans residents carried federally subsidized flood insurance policies. The payment for claims under these policies is expected to exceed \$22 billion dollars, threatening to bankrupt the National Flood Insurance Program. Can the US afford to continue compensating home owners and businesses in floodplains for property damage that is likely to recur? Many of the most vulnerable districts in New Orleans were inhabited by low income African Americans before the flood, making social justice issues another issue in the debate over rebuilding the city. To make these decisions, officials at all levels will require sound, science-based information and policy initiatives that take into account the needs and interests of the diverse communities that have inhabited and built the city of New Orleans.

### The Mississippi Gulf Coast

The Mississippi Coast was devastated by an 8.2 meter storm surge and hurricane force winds that ripped apart buildings that fell in their paths. Those living on the coast relied on barrier islands and the profile of the coast line to slow down or dampen the effects of hurricanes. Breakwaters and storm walls have been built in some areas but are not massive in size or

extent. Some individuals have elevated their homes or businesses to reduce the impact of the surge but, as Katrina illustrated, these actions did little to protect against the big event.

### Emergency Response Systems

In the United States, first response to natural hazard emergencies is the responsibility of state governments and, as they choose to delegate authorities, of the local communities and other jurisdictions. First responders (fire, police and medical) to disaster events normally come from the local communities. On the other hand, meteorological information on storm events is developed by the federal government and passed to the public and leaders at all levels of government. Local or regional governments also may choose to pass on this information through emergency early warning systems. Following a natural disaster, the state government may use the state's resources (state agencies, the National Guard and private organizations) to react or may seek support from the federal government. FEMA is responsible for coordination of federal support, and during a disaster is able to task other government agencies to assist in this effort (Figure 5). Normally the federal government does not enter the hazard area until it is requested to do so by the state government.

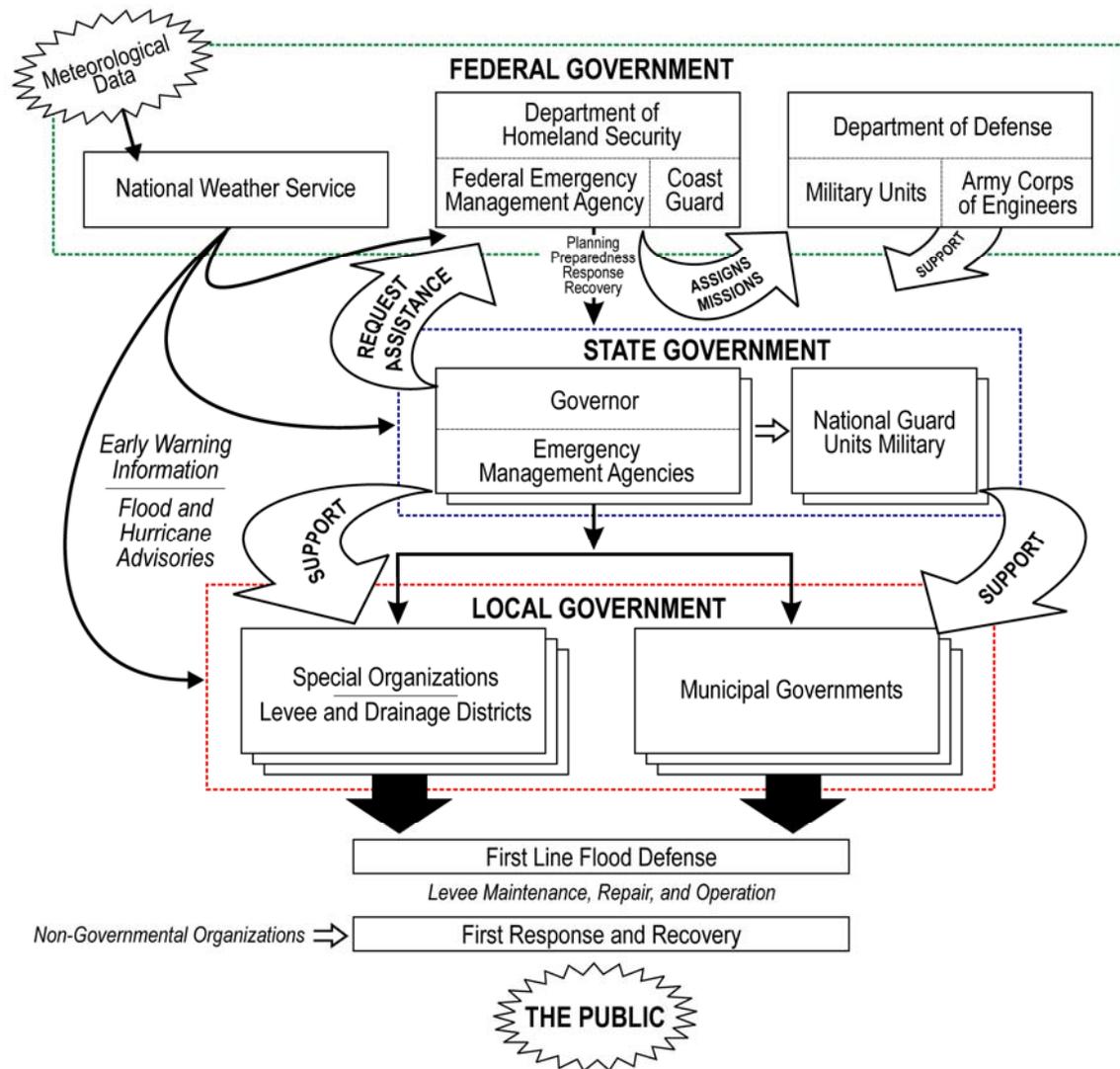


Figure 5. Organization for Disasters

At the base level in dealing with natural disasters, the federal government is responsible for collecting, analyzing, and disseminating meteorological information to governments, businesses and the public at large. It also serves as the back-up to states and local governments for immediate and short term response on the ground. In the longer term, it also acts as provider of temporary housing and critical supplies, and as financier to support extraordinary expenses connected with disasters whose destruction rises above a certain fiscal level. Outside of emergency warning and response activities, the federal government carries primary responsibility for construction of flood and hurricane damage reduction projects and operates the national flood insurance program that supports the acquisition of insurance in flood prone areas.

The nation's reaction to disasters is curious. Disasters are headline news just before and right after the event. But in only a few months, only those directly affected carry the memory on. As the disasters occur, governments at all level are involved in the immediate rescue of those who have been hardest hit. The public, once the magnitude of the event is known, is asked to support relief efforts. Then come federal support programs that seek to assist in restoration to pre-disaster conditions. Officials are there with a variety of programs designed to get people back into their homes and firms back in business. These actions are surrounded by political rhetoric that focuses on what is needed, who is going to provide it. Then the memories fade.

Emergency management operates in a cycle that begins with one emergency and cycles around to the next emergency (Figure 6). In between emergencies, those involved in disaster response are expected to learn from the current emergency and move ahead with actions (e.g. buy-outs of property) that would mitigate the impacts of future events. This is followed by planning, rehearsals and preparation of organizations and equipment that would be expected to be used when the next disaster occurs. For the many small emergencies that occur each year, this cycle has produced positive results. Communities recover from tornadoes, and small floods or even earthquakes. However, in the face of storms as large as Katrina, the system appears to have failed.

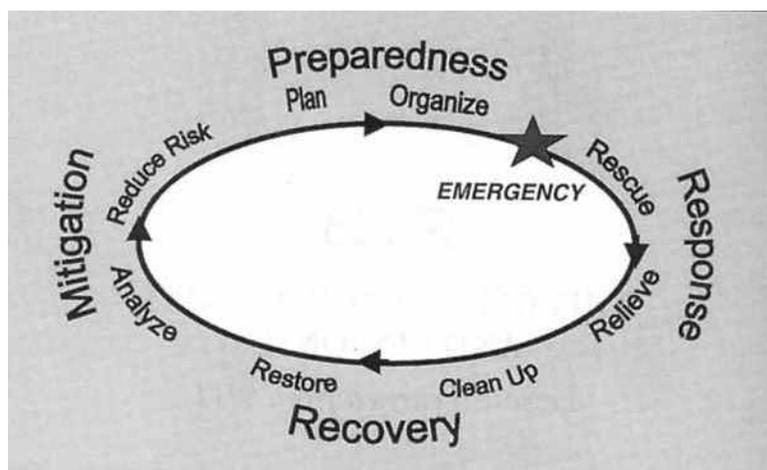


Figure 6. The Emergency Response Cycle  
(From Thomas et al 2002)

What can be learned from the Katrina disaster? Prior to Katrina there was an implicit assumption that governments at all levels had properly planned for a disaster such as Katrina and were ready to launch a response program should a hurricane occur. There was an implicit belief that governments and the public understood the threats they faced, that adequate advance warning would be given of impending threats, and that officials and the public would appropriately react to the warnings. Once the event occurred, the response effort was focused on getting people to high ground - out of endangered areas and from roof tops and other watery refuges. First responders searched for the victims and attempted to rescue those who might be still alive. Response was immediate and centered on health and safety. The first responders who carry out this work are trained to operate in this hazardous and ever changing environment and, as individuals, were very effective.

Response is followed by recovery. Recovery seeks to put the damaged communities back on their feet. Obviously, in the case of a major disaster, recovery can not be accomplished overnight or even in weeks. The efforts may take months or even years. Therefore, it is important that, as the recovery effort is launched, it moves in a direction that will eventually bring the communities to a logical and proper end state. The recovery plan must envision what a post-disaster picture might look like, taking into account well defined, long-term national goals and objectives and the nature of the threat (risk) the communities will continue to face. Long-term efforts seek to rebuild for a better future. However, the direction set for short-term recovery, often sets in concrete the direction for long term actions.

As post-Katrina response and recovery took place, it was obvious that there were significant problems. Many who were in the hurricane's path either chose to stay or had no means of transportation to evacuate. Thousands of New Orleans residents, most of them poor, simply did not know what to do when the flood came. Some went to central shelters while others remained in their own homes. Many were worried about leaving pets behind or that, if they left, their homes would not be protected since law enforcement officials also were leaving the area to ensure the safety of their own families. Hospitals and nursing homes with non-ambulatory patients remained open until all patients were finally evacuated or until they discovered that they had perished. The world watched as officials tried to bring order out of the chaos of post-Katrina New Orleans,

The failure of local, state and federal government agencies to implement an effective emergency response plan is a major issue dominating the public policy debate. Both the President and Congress commissioned studies to determine why emergency response systems failed. These reports determined that agencies at all levels of government failed to plan ahead for an orderly evacuation of the city (particularly for low income residents without transportation resources); failed to coordinate the respective roles and responsibilities of emergency response agencies; failed to establish an effective command center to direct emergency response activities; failed to adequately protect the health and welfare of tens of thousands of New Orleans residents who were abandoned in the evacuation without transportation, food, water, medicine or adequate shelter; and subjected hundreds of thousands to a chaotic relocation plan that split up families, taxed government resources and caused extensive economic hardship.

### **The Importance of Sound Information in Planning**

Good planning is essential to the successful implementation of emergency response systems and to limit the losses that will occur. It must involve all levels of government and provide these officials with information that will guide their actions. Planning for past disasters has been deemed adequate largely because the magnitude of these events has been limited. Few doing

the planning understood the force that could be generated by a major hurricane and the threat these forces were to the built environment including the flood protection structures. As a result, few anticipated the devastation that would take place with a Katrina level hurricane and few understood the plans that had been made. Plan development should include key local, state and federal agencies and the public. Planning needs to be completed before a disaster occurs and agencies need to clearly understand what the public knows about an impending threat and what it has done to mitigate this threat. While this seems like a simple proposition, as the Katrina disaster illustrates, the importance of good planning is sometimes underestimated and/or overlooked by bureaucracies. The White House review of Katrina response indicated with respect to plans that “key decision-makers at all levels simply were not familiar with them.” Therefore, they were unable to grasp the magnitude of the challenge they would face. They had the information but did not use it.

Science-based information and sound policy initiatives are critical to three aspects of disaster planning and preparation. Those in a threat area must understand the level of protection they have against natural disasters and they must be informed about the threat as it develops. They must also be adequately informed about emergency response and support systems. In the case of Katrina, it is clear that some information about the level of protection against hurricanes provided by the levee system was available to the public and to government officials, but it is also clear that the tenuous nature of the protection was not recognized by those doing the planning or those responsible for the operation and maintenance of the hurricane protection system. Information about the path and strength of the hurricane was available to the public and to the government well in advance of its arrival on shore with seemingly sufficient time to permit necessary mitigation actions such as evacuation to take place. However, many New Orleans residents were either not sufficiently informed about the need to evacuate or did not have the resources to transport themselves out of the city.

The flood insurance rate maps prepared and disseminated by the federal government clearly indicated special flood hazard areas that many areas along the Mississippi coast fall into. Unfortunately, these maps generally indicate only the area affected by a 100-year storm event and those living outside the 100-year zone may be lulled into believing that they are outside the danger zone. During Congressional hearings that followed Katrina, several Mississippi leaders expressed the view that they never knew that they were at risk even though they were near the coast. A Congressman from Mississippi proposed that since the residents had not really understood the threat, they should be allowed to retroactively purchase insurance.

While several emergency preparedness exercises had posited that a large hurricane would cause overtopping of the levees protecting New Orleans, most saw this to represent an inconvenience rather than a disaster since the period of overtopping would be limited and the expected depths of the flood waters would be relatively low. Few anticipated that the levees would breach in three locations and that when overtopping of the levees began that several of the levees would disintegrate.

## **Hurricane Warnings**

Early warning of a threat is essential to provide adequate time for emergency planners and responders to organize for the event. It allows orderly evacuation to take place from high-hazard areas, relief personnel and supplies to be moved near to the area and longer-range planning to begin. The National Weather Service began tracking Hurricane Katrina (as Tropical Depression Twelve) as it edged across the Atlantic toward Florida on August 21, 2005. Over the next week, it had jumped over Florida and was moving across the Gulf with New Orleans and the Louisiana Coast becoming a potential place for the hurricane to make landfall (Figure 7).



Figure 7, Katrina Storm Track 22-31 August 2005

By 10 PM, August 27, the National Hurricane Center had issued hurricane warnings “for the north central gulf coast from Morgan City, Louisiana eastward to the Alabama/Florida border...including the city of New Orleans and Lake Pontchartrain. A hurricane warning means that hurricane conditions are expected within the warning area within the next 24 hours. Preparations to protect life and property should be rushed to completion.” By the next day, the Center was predicting “...coastal storm surge flooding of 18 to 22 feet above normal tide levels...locally as high as 28 feet along with large and dangerous battering waves...can be expected near and to the east of where the center makes landfall.” At midnight on 29 August the forecast included “...potentially catastrophic category five hurricane Katrina...continues to approach the northern Gulf Coast...preparations to protect life and property should be rushed to completion. Katrina is expected to make landfall at either category four or five intensity. Winds affecting the upper floors of high-rise buildings will be significantly stronger than those near ground level. Some levees in the greater New Orleans area could be overtopped.”

Later than morning Katrina put its full fury into New Orleans and the Mississippi Coast. To emphasize the danger, the head of the Center, Max Mayfield, 48 hours earlier, personally called the governor of Louisiana and the Mayor of New Orleans to urge evacuation of coastal Louisiana and New Orleans. The federal Weather Service message was on every radio and television station in the region and reporters covered little else. The message about the impending hazard could not have been clearer and when the hurricane hit it did just what the weather service said it would do. Yet, many people did not evacuate and, as noted by the Senate review, “...top officials at every level of government – despite strongly worded advisories from the National Hurricane Center (NHC) and personal warnings from NHC Director Max Mayfield – did not appear to truly grasp the magnitude of the storm’s potential for destruction before it made landfall.”

In its review of Katrina activity, the White House indicated that “the Federal government’s dissemination of essential public information prior to Hurricane Katrina’s Gulf landfall is one of the positive lessons learned. The many professionals at the National Oceanic and Atmospheric Administration (NOAA) and the National Hurricane Center worked with diligence and determination in disseminating weather reports and hurricane track predictions... This includes

disseminating warnings and forecasts via NOAA Radio and the internet, which operates in conjunction with the Emergency Alert System (EAS). ***We can be certain that their efforts saved lives*** (Emphasis added).” The White House noted however that the final step in communicating to the public had not been taken, indicating that “... more could have been done by officials at all levels of government...the EAS—a mechanism for Federal, State and local officials to communicate disaster information and instructions—was not utilized by State and local officials in Louisiana, Mississippi or Alabama prior to Katrina’s landfall.”

## **Emergency Response**

Even though pre-Katrina planning indicated that disaster relief for New Orleans would be difficult, few actions were taken to prepare for the arrival of Katrina. Federal planning was based on the presumption that state and local officials would manage the first response as they have the fundamental responsibility to provide for their citizens. No one anticipated that during a major disaster, state and local governments would lose their capability to react and would have to rely on the support of the federal government. Because many officials of the affected communities left the area with their own families during the evacuation process, when the recovery began, many were not able to return to the city. Seventy percent of the New Orleans police department was impacted by the hurricane.

Emergency response requires resources – human and material – and responders need to be able to communicate with each other and the victims in order to provide efficient services. Those who have been hit by the hurricane need to learn from government officials what to do and how to deal with such new challenges as the polluted waters that were spreading across the city. When communications are disrupted, chaos reigns. According to the White House, the combination of wind and flood waters crippled 38 emergency call centers in the region, disrupted most if not all local services and shut down phone systems more than 3 million phones. 44 percent of the area’s television stations and 50 percent of the radio stations were off the air. Lacking communication, once asked to move into the area, federal officials had great difficulty determining what resources were needed and where they were needed and had even more difficulty discussing and dealing with evolving issues ranging from emergency health care to the suitability of drinking water in damaged communities. Scientists and other professionals on the “outside” had no means of providing their advisory services to those on the ground. Federal and state officials at all levels were not able to provide updates to the media and to the public and confusion reigned in and outside the affected areas. Often they were giving contradictory messages to the public and, according to the White House, were “creating confusion and feeding the perception that government sources lacked credibility.”

No one had planned for or had prepared for the extensive health care problems that arose following the hurricane. The White House reported that over 200,000 individuals with chronic ailments were cut off from access to their medications. While local hospitals and nursing homes had planned to move some patients before the hurricane and to rely on back-up power systems to permit them to care for those who remained, power outages and the flooding of the back-up systems put many of these facilities in the dark and threatened the lives of the patients. Dispersed nursing homes and homes for the elderly faced similar problems, the magnitude of which had not been anticipated. Flooding severed major transportation routes and isolated many locations. Medical records were destroyed. (In its post-Katrina review, the White House directed the Department of Health and Human Services to “foster widespread use of interoperable electronic health (EHR) records systems.”)

For the first few days after the hurricane had passed, the emergency response effort was focused simply on protecting those in shelters and finding those still in the area who were in danger from the rising waters or who might have been trapped into their homes. Bureaucratic issues slowed the request for support from beyond the regions and delayed search and rescue operations.

## **Recovery**

Recovery from a disaster requires that the disaster area first be cleaned up – removal of the debris and the rebuilding of those structures and infrastructure that had been damaged or destroyed. Even this effort requires substantial scientific input. Because of the hazardous conditions created by having homes and business under water for several weeks, the potential for disease and contamination was always present and a constant effort to monitor and evaluate conditions was necessary. Reconstruction could not begin in many areas because local officials were not prepared to make decisions about what would be built where. Advice was sought from engineers, architects and others with disaster recovery experience. In the case of New Orleans, the local officials were limited in their options until the federal government could determine the level of flood protection that it will provide for the city – a decision that may require up to two years to make.

## **The Restoration of Flood Protection**

The Mississippi Coast was devastated by an 8.2 meter storm surge and hurricane force winds. Those living on the coast relied on barrier islands and the profile of the coast line to protect them against hurricanes. Raising homes off the ground reduced the impact of the surge but did not make the homes risk-free. In the post-Katrina environment, FEMA is recommending that reconstruction that does take place be at a higher elevation and observe strict building codes. The Mississippi Gulf Coast continues to face significant challenges.

The floodwall and levee failures put 80% of New Orleans under water. Post-Katrina forensics of the hurricane protection system have revealed that because of changes in hydrology—attributed to sea level-rise and climate change and subsidence in the area, many of the 200-300 year hurricane levees actually were providing less than 100-year protection. The reasons for the levee failures have yet to be formally determined but are related to a long history of deferred maintenance, construction of the least cost, least disruptive, second choice solution, and an absence of detailed inspection along with split responsibilities. The Corps was responsible for the construction of the facilities while local governments were responsible for their maintenance and routine inspection. The Corps was criticized for designing an inadequate flood-protection system and investing limited resources in questionable navigation canal and floodplain development projects —when it allegedly should have been investing in levee upgrades. While Corps certainly plays a role, it is the US Congress and the Executive Branch of government that determine the Corps' priorities by deciding which projects the Corps is authorized to undertake and appropriating funds to carry them out. Thus, a key issue in the policy debate over the failure of federal government to adequately protect New Orleans is the failure of the Congress and the Executive to prioritize, authorize and fund adequate flood protection.

The Senate Committee noted that “the inspection and maintenance regime in place to ensure that the levees, flood walls and other structures existing to protect the residents of the greater New Orleans area was in no way commensurate with the risk posed to these persons and their property. ..Equally troubling was the revelation of serious disagreement – still unresolved

months after Katrina—among officials of several government entities over who had responsibility, and when, for key levee issues including emergency response and levee repair.”

To overcome perceived bureaucratic inertia and to set a tone of empathy, disaster recovery bypasses most existing programs and moves for ad-hoc solutions to problems that are encountered. In the face of floodplain management regulations that should slow redevelopment in known hazard areas, the approach is often, ‘rebuild what they had—get them back in their homes.’ Immediately following Katrina, many moved to immediately raise the levees around New Orleans to protect against a Category 5 hurricane, without considering that perhaps the best solution might be a combination of levees, surge gates and the important restoration of Coastal Louisiana’s storm buffer potential. The Corps was chastised for foot-dragging when it suggested that it could take several years to make such a decision. Yet, in a speech to the nation from Jackson Place in New Orleans, the President clearly stated his objective.

Protecting a city that sits lower than the water around it is not easy, but it can, and has been done. City and parish officials in New Orleans and state officials in Louisiana will have a large part in the engineering decisions to come. And the Army Corps of Engineers will work at their side to make the flood protection system stronger than it has ever been.

When there is no long-term plan or goal to guide recovery, the actions that are taken reflect the urge to appear responsive in the short term, satisfy political needs and take what might seem to be the least controversial approach. In the case of Katrina, because the US does not have any agreed-to plans for carrying out and dealing with post-hurricane and flood disasters and lacks a coherent national policy, the US may well have to deal with an ad-hoc approach in which there will be considerable rebuilding in the risk zone and little reduction in the vulnerability to future such events. There is no national or regional agreement on a comprehensive approach to water resources development in general and hazard reduction in particular. There are no plans that address how actions taken to mitigate flooding will be integrated with enhancement of other water resources uses such as navigation, water supply, environmental restoration, and water quality.

The Corps has been charged by the Congress with developing by mid-2008 a report that addresses how New Orleans and Coastal Louisiana could be protected against a Category 5 hurricane. If this effort is to be successful it will have to:

- Produce a flood damage reduction strategy that will provide a high level of protection for the people of New Orleans and key centers in the deltaic plain by building higher and stronger levees, constructing surge gates similar to the ones employed on coastal Netherlands, and restoring the coastal wetlands that protect the region from hurricanes. The solution must also consider wise use of the land along the coast and limiting redevelopment where occupancy might once again result in tragedy.
- Seek, in dealing with the ever shrinking coastline, to take advantage of natural processes to restore coastal wetlands and the environmental vitality of this incredible natural resource.
- Develop means to meet the needs of flood control and navigation while concurrently increasing the movement of sediments and fresh water from the Mississippi into the wetland areas. A recent report by a committee of the National Research Council reviews plans for restoration and suggests ways in which the program might better move ahead.

- Seek federal support to address the ongoing issues with improving the water quality of the Mississippi as well as local water quality in the Delta.
- Include in this comprehensive planning, review of the need for maintenance and upgrades to existing infrastructure –navigation, flood damage reduction, environmental, and water supply and treatment. It will be important to tie new work into structures that will be able to survive well into the 21<sup>st</sup> century.
- Develop an institutional structure, in partnership with the federal government that will prepare and oversee integrated planning and execution of the above activities, establish priorities, and develop innovative funding mechanisms.

A working group of scientists and engineers, many with close ties to coastal Louisiana, recently reviewed the challenges faced by the region and made recommendations for specific restoration activities and an integrated approach to planning.

In the interim, the Corps will, by June 2006, restore the levee system around New Orleans to its pre- Katrina condition and address the structural problems that led to the levee failures during Katrina. This will require them to repair 169 miles of levees and floodwalls (Figure 8). The post-Katrina analysis determined that much of the 350-mile levee system had been subject to settlement and that, as a result, the existing levees were not at the elevation originally authorized. Between June 2006 and fall 2007, the Corps will work on the levees to return them to their authorized elevations.

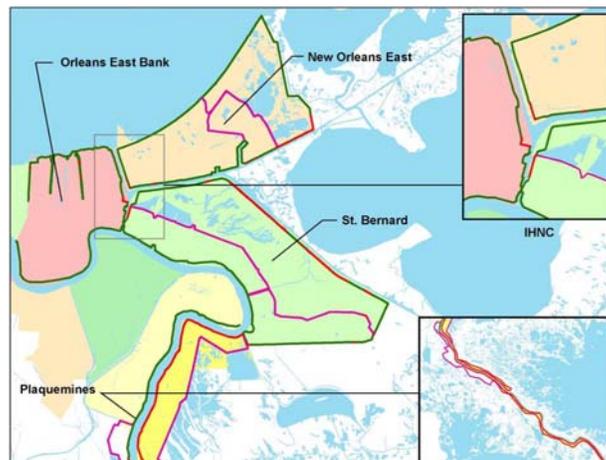


Figure 8. New Orleans Area Levees

### Why Did the System Not Work?

The White House and Senate conducted their reviews of the emergency response effort because both senior government officials and the public saw the conduct of the emergency response to Katrina as inept. The White House concluded that:

- “Only the Federal government has the resources and capabilities to respond...” to a catastrophic disaster.

- “Federal, State, and local plans were inadequate for a catastrophe that had been anticipated for years.” The US is not as prepared as it needs to be at all levels within the country for dealing with a major catastrophe. The emergency response system clearly has structural flaws for addressing catastrophic events
- “State and local authorities understood the devastation was serious but, due to the destruction of infrastructure and response capabilities, lacked the ability to communicate with each other and coordinate a response. Federal officials struggled to perform responsibilities generally conducted by State and local authorities”
- “The complete devastation of the communications infrastructure left emergency responders and citizens without a reliable network across which they could coordinate.”
- “The existing planning and operational structure for delivering critical resources and humanitarian aid clearly proved to be inadequate to the task.”
- “Federal resource managers had great difficulty determining what resources were needed, what resources were available, and where those resources were at any given point in time.”

The Senate Committee Report paralleled that of the White House and added that “ineffective leadership, poor advance planning and an unwillingness to devote sufficient resources to emergency management over the long-term doomed them [the emergency response structure] to fail when Katrina struck. Despite the understanding of the Gulf Coast’s particular vulnerability to hurricane devastation, officials braced for Katrina with full awareness of critical deficiencies in their plans and gaping holes in their resources. While Katrina’s destructive force could not be denied, state and local officials did not marshal enough of the resources at their disposal. In addition, years of short-changing federal, state and local emergency functions left them incapable of fully carrying out their missions to protect the public and care for victims.”

## **Conclusion**

Managing a complex river system and the coastal areas it creates is a difficult process. Any physical actions that alter or control the river and its estuary have far reaching economic, social and environmental impacts. The engineered Mississippi River system is among the most complex in the world and when disaster strikes the consequences can be enormous. In turn, dealing with emergency response to a catastrophic flood event can overtax the capabilities of most state and local governments. Both normal operations and emergency response must be founded on a continuous flow and sharing of information among the government officials and the public.

Hurricane Katrina has clearly pointed out the information needs of those faced with protecting those who live adjacent to major rivers and their ocean and gulf connections and providing emergency response when a disaster does occur. It also highlighted the need to have in hand well understood and developed goals and objectives to guide post-disaster activity.

By defining their information needs and developing means to disseminate this information, policy makers, resource managers and communities can improve the conduct of the water resource management and emergency response activities that they must carefully guide and nourish.

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