Katrina in Your Rearview Mirror

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ARCADIS
Infrastructure, environment, buildings
Discussion

- Background
- The setting
- What went wrong?
- Lessons learned
- Recommendations
Background
We saw it coming

“... If a lingering category 3 storm – or a stronger storm, say category 4 or 5 – were to hit the city, much of New Orleans could find itself under more than 20 ft (6 m) of water...”

THE CREEPING STORM

During the past 60 years the U.S. Army Corps of Engineers has spent hundreds of millions of dollars constructing a barrier around the low-lying city of New Orleans to protect it from hurricanes, but is this system really high enough? And can any defense ultimately protect a city that is perpetually sinking? In some areas at a rate of half an inch per year? By Greg Brown

Civil Engineering, June 2003
Katrina caught us

- Ill prepared
- Hesitant, unwilling, or unable to evacuate
- With inadequate defenses
Hurricane Katrina – August 29, 2005

In New Orleans and southeast Louisiana

- >1100 people killed, >130 missing
- Flooding covered 80 percent of the city to depths of 10+ feet (3+ m)
- 400,000 people fled
- 125,000 jobs lost
- >$100 billion in damages to residences, businesses, and infrastructure
- Entire communities destroyed
Chapter 2

The Lessons of Katrina:
What Went Wrong and Why

Lawrence H. Roth

Abstract

The U.S. Army Corps of Engineers assessed the disastrous hurricane season of August 2005. New Orleans, and with it the consequences of an inadequate disaster protection system, came under intense scrutiny. The efforts to understand the problems and to assign blame were unwieldy and uncoordinated, and the poor results on the ground were on everyone's doorstep. This study was initiated to determine what lessons we learned for better protection; what went wrong; and (3) what has changed in the past five years.

Introduction

I am pleased to present the final report of the Performance Evaluation of the New Orleans Hurricane Protection System. The Interagency Performance Evaluation Task Force was established in the aftermath of Hurricane Katrina to assess the performance of the U.S. Army Corps of Engineers, New Orleans District in the protection of New Orleans. The Task Force was charged with assessing the performance of the hurricane protection system from Hurricane Katrina. The report is based on a review of the performance of the hurricane protection system during Hurricane Katrina. The report is intended to be a comprehensive review of the performance of the hurricane protection system during Hurricane Katrina. The report is intended to be a comprehensive review of the performance of the hurricane protection system during Hurricane Katrina.
10 lessons

There was a failure to:

1. Think globally, act locally
2. Absorb new knowledge
3. Understand, manage, and communicate risk
4. Build quality in
5. Build resilience in
10 lessons

There was a failure to:

6. Provide redundancy
7. Use a systems approach
8. Say, “The buck stops here!”
9. Account for interfaces
10. Follow the money
The Setting
New Orleans – 1849

- Cypress Swamp and Swamp Forest
- FRENCH QUARTER
Levee

The HPS

- Begun in 1965
- Scheduled for completion in 2015
- 350 miles in length
- 12-15 feet above MSL

T-Wall

- 284 miles of federal levees
- 66 miles of non-federal levees
- 56 miles of I-wall
- 2 miles of T-wall

I-Wall

- 56 miles of I-wall
- 2 miles of T-wall
Raising the height of an earth levee

- Existing Levee
- New I-Wall
- Required New Levee Height
- Existing Homes and Buildings
Hurricane Katrina

Map showing the impact areas of Hurricane Katrina, including locations such as Mississippi, Alabama, Florida, Texas, Cuba, and Yucatan.
Wind vectors
Storm surge
What Went Wrong
The catastrophe was born out of a failure to recognize

- How fragile the levees were
- How devastating the consequences would be
Katrina simply overwhelmed the HPS

- The storm exceeded the design, but the constructed project did not meet the design intent
- 169 miles of damaged levees
- 50 breaches, which increased flooding by at least 300 percent
With breaching

No breaching, overtopping only
Two direct causes of breaching

1. Uncontrolled overtopping and ensuing erosion led to catastrophic failure of levees and floodwalls
Katrina’s surge in East Orleans
Four I-walls collapsed before water reached design levels

- Designs failed to account for:
  - Variability in soil strength
  - Wall deformations
  - Critical water pressure
THE WATER-FILLED GAP
The design hurricane

► U.S. Congress: “Design for the most severe storm that is considered reasonably characteristic of a region.”
► The Corps used the “storm of record” (1900-1959) – 101 mph (U.S. Weather Bureau used 101-111 mph)
► No probabilistic basis was used
► Never updated despite new information from NOAA
► Katrina was 127 mph – what should be the “design hurricane”?
Contributing causes

► The management of the HPS was chaotic and dysfunctional
  ■ Multiplicity of jurisdictions
  ■ No one person or entity was in charge
► Questionable land use decisions allowed building homes up to 10 feet (3 m) below sea level
► Broader protection strategies were blocked by court orders and local opposition
► Pressure at all levels to cut costs ended up compromising safety
► Construction was piecemeal over 40 years leaving some sections too low, or incomplete
► Numerous penetrations were left “open” during the storm
Contributing causes

► Most levees were >2 feet too low
  ■ The vertical datum was inaccurate and never updated
  ■ Regional subsidence was ignored
► The margin of safety was too low at each step of the way
► There was no independent review
► The pumping system, designed for rainfall events, was useless
► Risk was never quantified, communicated, or taken into account in a rigorous way
► The HPS was a system in name only – it was never designed nor operated as a system
► By omission or commission, the HPS was not considered a critical life-safety system
The HPS was severely compromised by

- Questionable engineering decisions
- Inadequate and dysfunctional interfaces between organizations
- A political culture that:
  - Did not understand the potential for catastrophe
  - Was unwilling to pay the price
  - Put life-threatening risk on the back burner
Lessons Learned Observed?
The Standard Project Hurricane was never updated
Datum was not corrected
Subsidence was not considered

Account for issues beyond the bounds of a project

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Typically varies 1.5 to 2.5 feet
Risks were seriously underestimated
Designs pushed the envelope at each stage
Designs were not sufficiently conservative to deal with unknowns

Use rigorous, risk-based approaches to compare alternatives and manage consequences
Failure to build quality in

- Rigorous internal QA-QC procedures were not followed
- External peer review was not used

Embed appropriate margins of safety into the design process, and ensure design standards are met.
So, learned or observed?

…while some progress has been made, in general the flood challenge continues to receive scant attention, and much remains to be accomplished to safeguard the well-being of the people and property at risk…

Task Committee on Flood Safety Policies and Practices

EDITED BY Robert Traver, Ph.D., P.E.
“…If the devastating impacts of [Superstorm] Sandy and the losses sustained in floods and hurricanes since Katrina were used as the measure of progress, the nation has failed to heed the call.”
Are we thinking globally and acting locally?

- Climate change and population growth exacerbate flood risk
- 100-year flood plain could increase by 45 percent by 2100
- Future generations could face insurmountable challenges
Are we building quality in?

Recommendations

- Develop and adopt national safety standards
- Develop a national levee safety training program
The *International Levee Safety Handbook* aims to be a single, go-to source on good practices for levee design, operation, and maintenance.
Reasons for optimism

► Changing from paradigm of controlling floods to managing risk
► Recognizing absolute protection is not possible
► Improving effective communication of risk

Ongoing Problem: Too many people believe absolute protection is possible, which encourages development in flood-prone areas.
Amid drought, thousands of Californians cancel their flood insurance

HIGHLIGHTS

Since 2012, active federal flood insurance policies in California fell by 30,000, or 12 percent
Despite this progress...

► Much of our flood infrastructure is in marginal condition
► There is no plan for systematic improvement
► Resources are squeezed at all levels

Flood Risk Management

Call for a National Strategy

Task Committee on Flood Safety Policies and Practices

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Robert Traver, Ph.D., P.E.
Recommendations
Critical infrastructure systems “must hold paramount the safety, health, and welfare of the public it serves”

- Exercise sound leadership
- Use a systems approach
- Adapt to change
- Understand, manage, and communicate risk
Reduce the nation’s exposure and vulnerability to floods and hurricanes

- Develop national funding strategy for infrastructure maintenance and renewal
- Promulgate national strategy for floodplain management
- Fund the National Flood Vulnerability Study (2007 WRDA)
- Support pilot projects that demonstrate resilience and use of natural systems
Reduce the nation’s exposure and vulnerability to floods and hurricanes

- Develop strategies that balance structural and non-structural solutions
- Include effects of climate change and population growth
- Include both safety and ecosystem values in decision-making
- Implement a robust communications program to inform the public about flood risks and needed actions
Questions