Greater New Orleans
Hurricane and Storm Damage
Risk Reduction System

Mike Park
Chief
Task Force Hope
U.S. Army Corps of Engineers

February 24, 2015
New Orleans Topography

City of New Orleans Ground Elevations

From Canal St. at Mississippi River to the Lakefront at U.N.O.

- MR&T Project Design Flowline (18 feet)
- Floodwall Along Mississippi River (23 feet)
- London Avenue Canal Floodwall
- Hurricane Levee / Floodwall (14.0 feet)

Elevations in Feet NGVD

Levels:
- -20
- -10
- 0
- 10
- 20
- 30
Hurricane Katrina
Aug 29, 2005

- One of America’s largest natural disasters
- Cat 5 less than 12 hrs before landfall
- 127 MPH wind at Louisiana landfall
- Maximum surge of 28 to 30 feet along Mississippi coast
- 80 percent of the city of New Orleans flooded

Hurricane Rita
Sep 24, 2005

- Cat 4 less than 12 hrs before landfall
- 175 MPH max sustained winds in Gulf of Mexico
- 120 MPH max sustained winds at landfall
- Cat 3 strength at landfall
New Orleans
Maximum Flooding Depth

- 8 to 15 feet
- 10 to 13 feet
- 12 to 15 feet
- 9 to 11 feet

Design Failure Breach Locations
New Orleans
Levee and Floodwall Breaches

Max Flood Depth
High: 15 Ft.
Low: 0 Ft.

Breach Locations

8 to 15 feet
10 to 13 feet
12 to 15 feet
9 to 11 feet
Effects of Hurricane Katrina

Levee Erosion

Transition Erosion
Katrina Floodwall Breaches

Inner Harbor Navigational Canal

London Ave. Canal

17th St. Canal
Wave Overtopping Effects
IPET – Interagency Performance Evaluation Task Force

- Over 150 members: academia, industry, state and federal agencies
- Charged to answer 5 Questions:
  - Flood Protection System
  - Storm
  - Performance
  - Consequences
  - Risk
- Peer review by National Academy of Sciences and ASCE
- Draft report June 2006
- Final report released spring 2009
Hurricane Protection Decision Chronology

Key Decision Influences

Tyranny of Incremental Decisions

Loss of Vision for an Integrated System

Lack of Dynamic Use of New Information

Shared Sensitivity to Cost Concerns

Institutional Response

Organizational Decision-Making Issues
USACE’s Actions for Change

- Comprehensive systems approach
- Risk-informed decision making
- Communication of risk to the public
- Professional and technical expertise
HSDRRS: Our Mission and Commitment

- Repair the damages, making what was there before whole again.

- By 1 June 2011, strengthen and improve the system and provide 100-year level of risk reduction capable of withstanding the effects of a storm having a 1% chance of occurring each year.

- Current funding level $14.48 B (fully funded).
...authorized to raise, as appropriate, levee heights and otherwise enhance the existing Lake Pontchartrain and Vicinity project and the existing West Bank and Vicinity project to provide the levels of protection necessary to achieve certification required for participation in the National Flood Insurance Program...
## HSDRRS Funding Breakdown

**TOTAL APPROPRIATED FUNDS:** $14.48 B

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>$ (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SELA (Interior Drainage)</td>
<td>$1,155</td>
</tr>
<tr>
<td>WBV 100-year Level of Protection</td>
<td>$2,010</td>
</tr>
<tr>
<td>LPV 100-year Level of Protection</td>
<td>$1,690</td>
</tr>
<tr>
<td>Repair Existing System</td>
<td>$1,483</td>
</tr>
<tr>
<td>Restore to Design Height</td>
<td>$1,010</td>
</tr>
<tr>
<td>Complete Authorized System</td>
<td>$1,643</td>
</tr>
<tr>
<td>Permanent Pump Stations</td>
<td>$854</td>
</tr>
<tr>
<td>IHNC</td>
<td>$1,603</td>
</tr>
<tr>
<td>Selective Armoring</td>
<td>$414</td>
</tr>
<tr>
<td>Storm-proof Existing Pump Stations</td>
<td>$340</td>
</tr>
<tr>
<td>Incorporate non-Fed Levees in Plaquemines Parish</td>
<td>$671</td>
</tr>
<tr>
<td>Reinforce or Replace Floodwalls</td>
<td>$1,481</td>
</tr>
<tr>
<td>Other</td>
<td>$110</td>
</tr>
</tbody>
</table>
NEPA Alternative Arrangements

- **Alternative Arrangements Approved by CEQ** – to facilitate expedited construction of the 100-year level HSDRRS to abate extreme risk to life and property

- **NEPA Environmental Review** – achieved through concurrent development of multiple Individual Environmental Reports (IERs) for segments of the system in lieu of comprehensive Environmental Impact Statement (EIS)

- **Consolidated Environmental Document** – compilation of IERs into a single document assessing cumulative environmental impacts of HSDRRS
NEPA Compliance Schedule Impact

Estimated NEPA Compliance and Construction Times

Alternative Arrangements

- IER A
- LPV Polder A Construction
- IER B
- LPV Polder B Construction
- IER C
- LPV Polder C Construction
- IER D
- LPV Polder D Construction
- IER E
- LPV Polder E Construction

Traditional NEPA Procedures

- LPV EIS (~5 years)

100-yr Completion Operational Goal

~3-5 years saved in completion of 100-yr System
Total spent on achieving NEPA compliance: ~$20 million.
38 Individual Environmental Reports (IER), 22 Supplemental IERs.
Hosted 200+ public meetings.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IER A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPV Polder A Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IER B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPV Polder B Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IER C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPV Polder C Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IER D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPV Polder D Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IER E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPV Polder E Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5 Parishes
350 Miles of Levee/Floodwall
130 Miles of 100-yr Perimeter
78 Pumping Stations (Fed & Non-Fed)
Deliver the Greater New Orleans HSDRRS Mission

Challenges
- Mandate to deliver $14.6B construction program within budget and on schedule
- Form design criteria, program cost estimate, acquire funding
- Intense scrutiny / oversight
- New governances
- NEPA compliance
- Deliver a comprehensive system

Enablers
- Administration / Congressional commitment
- Fully funded program
- National / Regional Corps capabilities
- Local partners and stakeholders capabilities
- NEPA Alternate Arrangements
- Full host of acquisition strategies
- Favorable bidding climate
Hurricane Paths Considered in the Risk Analysis

- **3 HSDRRS Geometries**
  - Pre-Katrina
  - Current (1 June 07)
  - 100-year LOP (~2011)

- **152 storms**
  - 25 yr to 5,000+ yr

- **350+ features**
  - Floodwalls
  - Levees
  - Pumps Stations

→ **62,928 Hurricane Hydrographs**
HSDRRS 100YR Design Elevation Criteria

- Elevation set to higher of:
  - That required to limit wave overtopping associated with a 100-yr storm surge to 0.01 cfs/ft with 50% confidence of non-exceedance
  
  Or

  - That required to limit wave overtopping associated with a 100-yr storm surge to 0.1 cfs/ft at 90% confidence of non-exceedance
  
  Or

  - The 500-yr still water elevation with a 50% confidence of non-exceedance
A Stronger System Than Ever Before

- Developed new HSDRRS hydraulic, geotechnical and structural design criteria.
- Floodwalls and hardened structures built for 2057 hydraulic conditions
- Pre-Katrina system: 200 miles
- Post-Katrina 100-yr system: 130 miles
  →35% shorter perimeter exposed to surge

Total System Openings: 493
- Navigable Openings: 11
- Roadway Openings: 144
- Railroad Openings: 45
- Access Openings: 134
- Drainage Openings: 159
New Orleans East

Surge Barrier Tie-In
Design Improvements

T/I wall design

Before

After

Scour protection

Before

After
Interim Closure Structures

- **Orleans Ave. Canal**
- **London Ave. Canal**
- **17th St. Canal**

- All structures completed June 2006
- Provide interim 100-yr level of risk reduction
Permanent Canals Closures and Pumps

17th St. Canal

London Ave. Canal

Orleans Ave. Canal
IHNC Lake Borgne Surge Barrier

- 36 in dia steel pipe battered piles (240 ft long)
- 66 in dia spun cast concrete soldier piles (140 ft long)
- Precast and cast in place deck and parapet wall
- $1.3 B Delivery cost
- Design-Build Cost Reimbursable

- 1.8 mile span
- 150 ft sector gate and barge gate
- 54 ft vertical lift gate
Seabrook Gate Complex

- 95 ft sector gate
- Two 50 ft vertical lift flow control gates
- ~$200 M Delivery cost
- Early Contractor Involvement (ECI)
Pump Station Fronting Protection
Bayou Segnette Pump Station

Completed Safe House

- 5 new safe houses built
- 5 existing safe houses improved / hardened
West Closure Complex

- Largest drainage pump station in the world – 19,140 cfs
- Largest sector gates in US – 225 ft clear width
- Removed 26 miles of levees and floodwalls from the first line of defense
- ~$1 B Delivery cost
- Early Contractor Involvement (ECI)
West Closure Complex

Pump Station

5400 hp diesel engines drive 11 flowerpot pumps
New Orleans East Deep Soil Mixing

- Largest ever deep soil mixing application in US
- 1.7 million cubic yards of land treated
- 500,000 tons of cement used
- 5.3 mile stretch
- ECI
New Orleans East Levee

- 2 ft. thick sand blanket with 9 in. layer of gravel on top
- 1,000,000 total cubic yards of sand
Wick Drains

- Largest ever wick drain application in USA
- 250,000 wicks
- ECI
St. Bernard Floodwall, near the IHNC Tie-In

Top of Floodwall: EL +32’

Katrina Storm Surge: EL +25’

500-yr Still Water Elevation*: EL +22’

100-yr Still Water Elevation*: EL +18’

* Still water elevation does not include waves

DESIGNED FOR A 100-YR STORM SURGE EVENT
St. Bernard Floodwall

- 3 contracts
- ~$1 B
- 23 miles (2 mi completed per month at peak of construction)
- ECI
St. Bernard Floodwall Construction – Southern Reach
HSDRRS Remaining Work

- SELA Interior Drainage: $1.4 B
- Permanent Pump Stations: $850 M
- Mississippi River / HSDRRS Co-located Levees: $380 M
- Armoring: $414 M
- Environmental Mitigation: $280 M
- New Orleans to Venice / Non-Federal Levees: $1.35 B
Armoring

Wave Overtopping Testing

Turf Reinforcement Mat

Sod / Enhanced Grass
HSDRRS Environmental Mitigation

Impacts (2,295 acres)
- LPV – 1,179 acres
- WBV – 1,116 acres

Current Plan
- 3 Mitigation Bank projects
- 10 Corps constructed projects

Challenges
- Lack of in-basin mitigation bank credits for all impacted habitats
- Some Corps Constructed projects potentially require condemnation for investigation/construction

Project
Construction
Value: $190 M

Bottomland Hardwoods Wet

Swamp
Marsh
Bottomland Hardwoods Dry
In 2007, you had a 1% chance every year of flooding this deep from Hurricanes.

Notes:
- The depth map tool is a relative indicator of progress, over time, demonstrating risk reduction as a function of construction progress.
- The water surface elevations are mean values.
- The scale sensitivity of the legend is +/- 2 feet.
- The info does not depict interior drainage modeling results.
- The storm surge is characterized as the result of a probabilistic analysis of 5 to 6 storm parameters of a suite of 152 storms and not a particular event.

Assumes 50% Pumping Capacity.
With the 100-year level of protection, you have a 1% chance every year of flooding this deep from Hurricanes.

Notes:
- The depth map tool is a relative indicator of progress, over time, demonstrating risk reduction as a function of construction progress.
- The water surface elevations are mean values.
- The scale sensitivity of the legend is +/- 2 feet.
- The info does not depict interior drainage modeling results.
- The storm surge is characterized as the result of a probabilistic analysis of 5 to 6 storm parameters of a suite of 152 storms and not a particular event.

Assumes 50% Pumping Capacity.
With the 100-year level of protection, you have a 0.2% chance every year of flooding this deep from Hurricanes.

Notes:
- The depth map tool is a relative indicator of progress, over time, demonstrating risk reduction as a function of construction progress.
- The water surface elevations are mean values.
- The scale sensitivity of the legend is +/- 2 feet.
- The info does not depict interior drainage modeling results.
- The storm surge is characterized as the result of a probabilistic analysis of 5 to 6 storm parameters of a suite of 152 storms and not a particular event.

Assumes 50% Pumping Capacity.
Buying Down Risk

Initial Risk

Zoning / Building Codes

Coastal Protection and Restoration

Outreach

Evacuation Plan

Insurance

Levees / Floodwalls / Structures

Risk

Residual Risk
Discussion / Questions