Public Protection . . . Is the Current Standard Enough?

Arthur C. Miller, Ph.D., P.E

October 23, 2008
From the Mountains to the Coast

Floodplain – Georges Creek, Westernport, Maryland

Ocean City

Growing AECOM Water while making a positive difference in the environment
Levees from New Orleans to Prince George County

New Orleans Levee System

Anacostia Levee System
Annual Probability of Exceedance

The Probability of an Event being exceeded in one year.

Prob [Exceedance] = 1%

There is a One Percent Chance that this event will occur in any one year.
A percentile is the value of a variable below which a certain percent of observations fall. So the 99 percentile is the value (or score) below which 99 percent of the observations may be found.

Percentile = 1 – Prob [Exceed]
Return Period, $T_R$, is Defined as:

$$T_R = \frac{1}{\text{Prob}[\text{Exceed}]}$$

$$T_R = \frac{1}{\text{Prob}[0.01]} = 100 \text{ year}$$
## Typical Design Standards in Engineering Practice

<table>
<thead>
<tr>
<th>Type</th>
<th>Design Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stormwater Facilities</td>
<td>2 to 5 year</td>
</tr>
<tr>
<td>Culverts</td>
<td>10 to 50 year</td>
</tr>
<tr>
<td>Bridges</td>
<td>25 to 100 year</td>
</tr>
<tr>
<td>Floodplain Insurance</td>
<td>100 year</td>
</tr>
<tr>
<td>Levees</td>
<td>100 year</td>
</tr>
<tr>
<td>Dams</td>
<td>100 year to PMP</td>
</tr>
</tbody>
</table>
Risk

\[
\text{Risk} = \left(1 - \left(1 - \frac{1}{T/R}\right)^n\right)
\]

Where \(n\) is the year you want to evaluate the risk for, i.e., what is the risk of a 100-year event flood occurring within a 30 year mortgage for a home.
Risk

\[
\text{Risk} = \left(1 - \left(1 - \frac{1}{T_{100}}\right)^{30}\right)
\]

\[
\text{Risk} = 26 \%
\]
Design Standard for Levees
Growing AECOM Water while making a positive difference in the environment
NEW ORLEANS ELEVATION MAP
AREAS BELOW SEA LEVEL

Key:
- Interstates
- Roads
- Parish Boundary
- Elevation (Feet)
  - Below 6
  - 6
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7
  - 8
  - 9
  - 10
  - 11
  - 12
  - 13
  - 14
  - 15
  - 16
  - 17
  - 18
  - 19
  - 20
  - 21 - 25
  - 26 - 30
  - Above 30

Center for the Study of
PUBLIC HEALTH IMPACTS
of Hurricanes
City of New Orleans Ground Elevations

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

- **Floodwall along Mississippi River**
  - 23 FT
  - 18 FT Project Flowline
  - Avg Annual Highwater 14 FT

- **HURRICANE PROTECTION LEVEE & FLOODWALL**
  - 17.5 FT

- **SPH DESIGN ELEV 11.5 FT**

- **NORMAL LAKE 1.0 FT LEVEL**

- **ELEVATIONS IN FEET NGVD**
  - 30
  - 20
  - 10
  - 0
  - -10
  - -20

- **GENTILLY RIDGE**

- **Lake Pontchartrain**

- **New Orleans**

- **Canal St. at River**
  - St. Louis Cathedral
  - Derbigny at I-10
  - Gentilly Blvd at Allen
  - Dillard Univ Campus
  - St. Anthony at Wildair Dr
  - Wainright Dr at L.C. Simon
  - Uno Side of Wainright Dr
  - Uno

- **Mississippi River Bank**
Growing AECOM Water while making a positive difference in the environment.
Growing AECOM Water while making a positive difference in the environment.
Growing AECOM Water while making a positive difference in the environment
Growing AECOM Water while making a positive difference in the environment
Growing AECOM Water while making a positive difference in the environment
If you would expect the life of a city such as New Orleans to be a minimum of 200 years, what is the risk of a 100 year event (Category 3 Hurricane) occurring within the next 200 years?
Risk

\[
\text{Risk} = \left(1 - \left(1 - \frac{1}{T}\right)^{200}\right)
\]

Risk = 87 %
## Large Hurricanes of US

<table>
<thead>
<tr>
<th>Hurricane</th>
<th>Year</th>
<th>Location</th>
<th>Category</th>
<th>Winds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Day</td>
<td>1935</td>
<td>Florida Keys</td>
<td>5</td>
<td>200</td>
</tr>
<tr>
<td>Camille</td>
<td>1969</td>
<td>Miss.</td>
<td>5</td>
<td>190</td>
</tr>
<tr>
<td>Andrew</td>
<td>1992</td>
<td>SE FL</td>
<td>5</td>
<td>165</td>
</tr>
<tr>
<td>Charley</td>
<td>2004</td>
<td>Punta Gorda, FL</td>
<td>4</td>
<td>150</td>
</tr>
<tr>
<td>Katrina</td>
<td>2005</td>
<td>LA, MS, AL</td>
<td>4-5</td>
<td>140</td>
</tr>
</tbody>
</table>
Growing AECOM Water while making a positive difference in the environment

London Ave. Canal – North Breach

London Ave. Canal

Failure

Marsh

Pine Is. Beach Sand

Baysound
Floodwalls and levees
Levee Design

Phreatic Line

Seepage Pattern Through and Earth Embankment
Levee Design

Seepage Pattern Through and Earth Embankment

- Impermeable Core
- Toe Drain
Levee Design

Flood Wall
Levee system in New Orleans

• design of post-Betsy levees and floodwalls
  – based on rudimentary storm surge models
  – design hurricane is fast-moving category 3
    • even category 3 storm could swamp system if storm stalled over New Orleans
    • predicted that N.O. could be under as much as 20 ft water
  – 16 ft and higher levees, floodwalls
  – along Mississippi River, levees designed for the 200-year storm from inland
– New Orleans described as bowl
– as of 2003, Army Corps of Engineers reassessing levees
Problems caused by levees

• creates ecosystem problems since no flooding and limited access to the river
  – nutrients, debris, sand bars, …

• when levees fail, creates far more dramatic flood
  – housing in locations where none would be without levees

• once flooding occurs, keeps flood waters from returning to river
Predictions of 2006 disaster

- Army Corps of Engineers, LA district
- Greg Brouwer, Civil Engineering—ASCE, Vol. 73, No. 6, June 2003, pp. 46-55
- Mark Fischetti, Scientific American, October, 2001, 76-85
- Modeling efforts
  - Louisiana State University
    - Category 4 would drive surge 30 miles inland, surging water would fill Lake Pontchartrain, overflow, pour into city, flood city up to 20 ft.
  - Corps
Predictions

• flooding up to 20 ft
  – shut down city’s power, water, and sewage plants
  – pumps clogged
  – levees will hold water in the city

• American Red Cross predicted 25,000-100,000 could die

• water not the only problem
  – wind forces can rip rooftops off

• evacuation predicted to be difficult
  – 100,000 people in N.O. do not have easy access to cars
  – major evacuation routes over water
  – I-10 could be covered with water during Category 5
Compare to Netherlands

- Much of Netherlands also below sea level
- Flooding protection needed from North Sea and major rivers
Compare to Netherlands

• 1953 – North Sea storm surge at high tide destroyed the dykes, killing 1,800 people
• Rebuilt flood protection system
  – 10,000-year event for sea
  – 1,250-year event for rivers
• $620 million spent annually on maintaining the current system
Risk of 10,000 year food occurring in 200 years

\[
\text{Risk} = \left(1 - \left(1 - \frac{1}{T}\right)\right)^{200}
\]

Risk = 2 %
Netherlands

- hydraulic sea wall 130 feet high by six miles long
  - giant steel curtain that can be opened or closed, depending on the water level

- flood gates
  - 1 1/2-mile stretch of 62 gates to control the entry and exit of North Sea waters
  - close as soon as the water rises 6 feet

- large dams across rivers
Netherlands
Storm surge barrier at Rotterdam
Netherlands

- Anti-flood measures will be reviewed in all Dutch regions following Katrina disaster

- complications
  - climate change
    - sea level rise significant, 23-39 inches per century
    - most engineering design life ≈ 75-100 years
  - land sinking like New Orleans, not as fast
Growing AECOM Water while making a positive difference in the environment
Growing AECOM Water while making a positive difference in the environment
Growing AECOM Water while making a positive difference in the environment
Growing AECOM Water while making a positive difference in the environment
Growing AECOM Water while making a positive difference in the environment
Growing AECOM Water while making a positive difference in the environment
Growing AECOM Water while making a positive difference in the environment
The Current Standard

• Does the 1 percent standard effectively contribute to achieving the goals of the National Flood Insurance Program (NFIP)?

• In reality the 1 percent flood represents a range of discharge and elevation values – Uncertainty
The 1 percent standard and many supporting NFIP regulations were designed to strike a balance between promoting economic growth and preventing flood damages in the development of floodplains; however, this perceived balance might be significantly different if the economic value of the natural and beneficial functions of floodplains is considered.
The Current Standard has lead to:

- The concentration of development in land areas protected by the 1 percent flood.
- Development outside the 1 percent floodplain. (The magnitude of the property damage in the 0.2 percent floodplain may be two to three times larger than in the 1 percent floodplain)
The Current Standard

• The need for a Federal standard does not mean that one standard should limit floodplain management at the state and local levels. (States and their communities should exercise their responsibility to impose higher standards, where the health and safety of the population merits a higher standard for land use regulations)
The Current Standard

• The 1-percent standard is too low for removal of NFIP land use and insurance requirements for population centers behind levees.
• What should be the standard?
• Prob [Exceed] = ?? 0.2 (500-year)