Living Underwater: Hazard Mitigation Challenges from Sea Level Rise and Tidal Flooding

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AGENDA

Sea Level Rise and Tidal Flooding

• Science of climate change and sea level rise
• Studies and projections
• Historic, present, and future impacts

Hazard Mitigation Challenges

• Taking Action
• Defenses
• Retreat
• Structures/Floodproofing
• Adaption/Mitigation Example
Sea Level Rise and Tidal Flooding
Resources and Publications – Nuisance Flooding

NOAA Technical Report NOS CO-OOPS 073

Sea Level Rise and Nuisance Flood Frequency Changes around the United States

Encroaching Tides

How Sea Level Rise and Tidal Flooding Threaten U.S. East and Gulf Coast Communities over the Next 30 Years

City Dock in Annapolis, Maryland. Photo Credit: Joy McGeary.

Silver Spring, Maryland
June 2014

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

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What is Nuisance Tidal Flooding

Figure 1. Normal Variations in the Tides

Today, high tides cause frequent, minor flooding along the Potomac River. Here, the Tidal Basin overflows beneath cherry blossoms in April 2010.

Source: UOCS 2014
Increasing threat from nuisance flooding 1950-2012

Source: NOAA 2014
Example of Projected Sea Level Rise

Example of local sea-level rise projections from Climate Central. Localization is performed on top of the NCA Intermediate-Low (blue), Intermediate-High (red), and Highest (yellow) scenarios. Second order polynomials (black) are fit to each projection.

DATA SOURCE: CLIMATE CENTRAL N.D.
Tidal Flooding Today, 2030, and 2045

Projected number of minor flooding events per year for NOAA tide gauges selected for use in this study. Projections use the National Climate Assessment Intermediate-High scenario. Events that reach the minor flooding threshold initiate a Coastal Flood Advisory.

DATA SOURCE: SPANGER-SIEGFRIED, FITZPATRICK, AND DAHL 2014
Nationwide impacts and increasing flooding

Table 1. NOAA water level gauges, location, start of analysis, MSL trend, and nuisance flood level (m)

<table>
<thead>
<tr>
<th>NOAA Site</th>
<th>B.</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Analysis Start</th>
<th>MSL Trend</th>
<th>Nuisance Flood Level</th>
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<td>Boston, MA</td>
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</tbody>
</table>

To provide a physical basis for the trends in nuisance flood days, annual MSL values and their long-term trends are also shown. A yearly MSL value, which is an average of hourly water levels.

Source: NOAA 2014

Top ten U.S. areas with an increase nuisance flooding*

<table>
<thead>
<tr>
<th>Area</th>
<th>“Nuisance level”: Meters above mean higher high water mark</th>
<th>Average nuisance flood days, 1957-1963</th>
<th>Average nuisance flood days, 2007-2013</th>
<th>Percent Increase</th>
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<tr>
<td>Annapolis, Md.</td>
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<td>39.3</td>
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<td>Atlantic City, N.J.</td>
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<td>3.1</td>
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<td>Philadelphia, Pa.</td>
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<td>1.6</td>
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<td>Sandy Hook, N.J.</td>
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<td>3.3</td>
<td>23.9</td>
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<td>Port Isabel, Texas</td>
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<td>Norfolk, Va.</td>
<td>0.53</td>
<td>1.7</td>
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</table>

* More than one flood on average between 1957-1963, and for nuisance levels above 0.25 meters.
Hazard Mitigation Challenges
Why Mitigation?

MITIGATION

- Protects life
- Protects property
- Saves money

Mitigation’s Value to Society
Building Stronger and Safer

Mitigation is the effort to reduce the loss of life and property by lessening the impact of disasters. A recent study by the Multihazard Mitigation Council (MMC)* shows that each dollar spent on mitigation saves an average of $4.00.

Value to Society

Mitigation yields benefits to society and therefore:

- It creates safer communities by reducing loss of life and property;
- It enables individuals to recover more rapidly from floods and other disasters; and
- It lessens the financial impact on the Federal Treasury, States, Tribes, and communities.

FEMA’s Federal Insurance and Mitigation Administration implements numerous Congressionally-authorized programs that address the effects of natural hazards through mitigation activities.

Mitigation Creates Safer Communities

In any disaster, buildings constructed to a higher standard not only reduce property damage but can also save lives. Homes constructed to National Flood Insurance Program (NFIP) standards have 10 times more protection. A home
Savannah and Tybee Island, GA – Taking Action

Source: UOCS 2014

These historic coastal communities are taking steps to tackle tidal disruption.
Taking Action:

– Tide gate installation for sewer system to prevent seawater flooding
– Plans to retrofit bridge foundations and culverts to cope with flooding (rainfall and tidal)
– Considering plans to raise roads and building new dunes
– Also considering relocation of vulnerable infrastructure and critical facilities
Norfolk, VA – Taking Action

In this frequently flooded city, ensuring public safety and supporting national security require grappling with tidal flooding.

Source: UOCS 2014

Some coastal parks in Norfolk, such as Myrtle Park at Richmond Crescent, pictured in February 2014, face such frequent tidal flooding that the city is turning them back into wetlands.
Norfolk, VA – Taking Action

• Taking Action:
  – Residents track tide cycles in advance of extreme high tides
  – Restore wetlands (Myrtle Park at Richmond Crescent)
  – Preparing alternative evacuation routes to avoid tidal flooding
  – Requiring 3 feet of freeboard above 100-yr floodplain for new buildings
  – Replacing Norfolk Navel Shipyard piers to reduce vulnerability
  – Construction of tidal flood gates
Adaptation and mitigation options
Defend

Hard Defense

TIDAL GATE

*Diagram courtesy of Associate Professor Kristina Hill

SEAWALL

*Diagram adapted from Associate Professor Kristina Hill

PUMP STATION

Karnak Pump Station in Sutter County, CA

LEVEE

*Diagram adapted from Associate Professor Kristina Hill

London + Rotterdam have dynamic tidal gates

Seawalls can block sightlines to water

Levee alongside canal in San Joaquin Delta

CMG landscape Architecture; Living with Water Workshop 11/2014
Defend (Softly)

Soft Defense

**HORIZONTAL LEVEE**

*Diagram adapted from Associate Professor Krishna Hill*

**REEFS + BEACHES**

*Diagram courtesy of Associate Professor Krishna Hill*

Marshes reduce wave energy

Off-shore wave attenuation; reef or sand engine

CMG landscape Architecture; Living with Water Workshop 11/2014
Managed Retreat

**Demolish + Remove**

Floodplain structures are demolished + removed

**Relocate**

Homes, businesses + infrastructure relocate upland
Rebuild/Let the Water in

**Elevated Community**

**SUPER LEVEE**

*Diagram adapted from Associate Professor Kristina Hill*

Elevated land as platform for new development

**Floodable Community**

**FLOATING**

*Diagram adapted from Associate Professor Kristina Hill*

Floating buildings rise with sea levels

**STILTS**

*Diagram adapted from Associate Professor Kristina Hill*

Elevated buildings perch above ground + sea levels

**FLOODABLE**

*Diagram adapted from Associate Professor Kristina Hill*

Floodable plaza + buildings receive episodic waters

CMG landscape Architecture; Living with Water Workshop 11/2014
Example: Adaptation and mitigation in Alexandria, VA
Flood levels studied on Potomac River

- Extreme with 3 feet freeboard: 13.2 ft
- Extreme (100-year flood level): 10.2 ft
- Hurricane Isabel: 8.8 ft
- Intermediate: 8.0 ft
- Nuisance: 4.0 ft
- Mean High Water: 2.2 ft
- Mean Low Water: -0.9 ft

* NAVD 88
Alexandria Project: Elevated Pedestrian Walkway

- Potential alignment based on 10-year flooding protection
- Two sections of floodwall
- Length: 550 feet
Alexandria Project: Elevated Pedestrian Walkway

Before
Alexandria Project: Elevated Pedestrian Walkway

After
Alexandria Project: Elevated Pedestrian Walkway

Before
Alexandria Project: Elevated Pedestrian Walkway After
Alexandria Project: Flood Protection

Inundation at The Strand with Flood Elevation of 6 feet

Inundation at The Strand with protection to elevation 6 feet
Conclusions
Thank You

Questions?