18 APRIL 2017
HAMPTON DUTCH DIALOGUES

Living with Water
Back River and Newmarket Creek
Hydrologically-Based Study Areas
DUTCH DIALOGUES Virginia: Life at Sea Level
DUTCH DIALOGUES Virginia: Life at Sea Level
Looking to the Past
Historic Roads are Modern Corridors

1907

Today
Geological Foundation

Map 10: Physiography of Hampton Roads, Virginia - The Suffolk Scarp
(Data source: U.S. Geological Survey)
Hydrologically-Based Study Areas
Flood Hazard Defined

According to the USACE Norfolk Coastal Storm Risk Management Study Report:

“...a significant percentage of the city is susceptible to flooding caused by rainfall, tides, storm surge or different combinations of these three factors. Where precipitation flooding coincides with tidal flooding and/or storm surge, the existing storm drain infrastructure is incapable of conveying runoff downstream, thus exacerbating flooding. Stacking tides, or high tides that accumulate over several cycles coupled with precipitation flooding, can cause more flooding than a hurricane”
Forces of Water

- Increased Precipitation
- Surface Runoff
- Storm Surge
- Rising Tides
- Groundwater
Storm Surge and Storm Tide Threats

- Hurricanes and Nor’easters
- Coincidence of Surge and Tides
- Multiple Flood Pathways
- Low-Lying Land
- 37% of Hampton Land Area is in 100 Year FEMA Flood Hazard Zone
Storm Tide

6 of the highest tidal events occurred within the last 13 years.

Source: NOAA; Sewells Point Tide Gauge, Norfolk

Hurricane Isabel Surge

Stacked Nor’easter Tide
STORM TIDE

6 of the highest tidal events occurred within the last 13 years

Source: NOAA; Sewells Point Tide Gauge, Norfolk

Storm Tide

Hurricane Isabel Surge

Stacked Nor’easter Tide

last 20 years

NOAA/NOS/C-OPS
Observed Water Levels at 8618610, Sewells Point VA
From 2003/09/16 00:00 LST/LDT to 2003/09/21 23:59 LST/LDT

NOAA/NOS/C-OPS
Observed Water Levels at 8618610, Sewells Point VA
From 2009/11/11 00:00 LST/LDT to 2009/11/15 23:59 LST/LDT

Height in feet (NAVD)

Predictions, Verified, Preliminary — (Observed - Predicted)
### Storm Tide + Sea Level Rise at the Hague, Norfolk

<table>
<thead>
<tr>
<th>Return Interval</th>
<th>Exceedance Probability</th>
<th>Current Conditions (ft, NAVD88)</th>
<th>1.6 feet of SLR (2040s-2070s)</th>
<th>2.9 feet of SLR (2070s or later)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-year</td>
<td>100%</td>
<td>3.3</td>
<td>4.9</td>
<td>6.2</td>
</tr>
<tr>
<td>10-year</td>
<td>10%</td>
<td><strong>6.3</strong></td>
<td>7.9</td>
<td><strong>9.2</strong></td>
</tr>
<tr>
<td>20-year</td>
<td>5%</td>
<td>7.4</td>
<td><strong>9.0</strong></td>
<td>10.3</td>
</tr>
<tr>
<td>50-year</td>
<td>2%</td>
<td><strong>9.0</strong></td>
<td>10.6</td>
<td>11.9</td>
</tr>
<tr>
<td>100-year</td>
<td>1%</td>
<td>10.1</td>
<td>11.7</td>
<td>13.0</td>
</tr>
<tr>
<td>500-year</td>
<td>0.2%</td>
<td>12.7</td>
<td>14.3</td>
<td>15.6</td>
</tr>
</tbody>
</table>

Probability of damaging floods increases 2 to 5 times with Sea Level Rise:
- Today’s 10% chance floods may occur every year by the 2070’s
  - 10% → 100%
  - 5% → 10%
Storm Tide + Sea Level Rise at the Hague, Norfolk

Hours per year 2 feet above MHHW in Norfolk

<table>
<thead>
<tr>
<th>Years with most flood hours:</th>
<th>Hours per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2009 Vet-Day NorEaster</td>
<td>8</td>
</tr>
<tr>
<td>2 - 1998 Twin NorEaster</td>
<td>7</td>
</tr>
<tr>
<td>3 - 2015 Joaquin/NorEaster</td>
<td>5</td>
</tr>
<tr>
<td>4 - 2006 Thanksg NorEaster</td>
<td>2</td>
</tr>
<tr>
<td>5 - 1999 Hurricane Floyd</td>
<td>1</td>
</tr>
<tr>
<td>6 - 2012 Hurricane Sandy</td>
<td>4</td>
</tr>
<tr>
<td>7 - 1962 Ash Wed Storm</td>
<td>3</td>
</tr>
<tr>
<td>8 - 1933 Ches-Potomak Hur</td>
<td></td>
</tr>
</tbody>
</table>

Hours per year 1 Foot above MHHW Norfolk
Beach Road at High Tide
Relative Sea Level Defined

Rising Tides

- Eustatic Global Sea Level Rise:
  - Melting Glaciers
  - Thermal Expansion
  - 1.8 to 3.1 mm/year

Sinking Land

- Land Subsidence:
  - Geologic (Salisbury Embayment + Chesapeake Bay Meteorite Impact Crater)
  - Decaying Organics
  - Reclaimed Land

= Relative Sea Level

Sewell’s Point:
- +1.45 Feet/Century
- One of the largest documented rises in the world
Relative Sea Level Rise for Southeastern Virginia

Source: VIMS Relative Sea Level Rise Projections for Southeast Virginia
"Hope for the Best, Prepare for the Worst"
SLR → 30 Year Mortgage

Feet Above Sea Level

Source: VIMS Relative Sea Level Rise Projections for Southeast Virginia
SLR → Resilience Project Timeframe

Source: VIMS Relative Sea Level Rise Projections for Southeast Virginia
Shoreline Condition: 2050
2 Feet of Sea Level Rise at High Tide

380 Buildings Potentially Impacted City-Wide
Shoreline Condition: 2070
3 Feet of Sea Level Rise at High Tide

1,500 Buildings Potentially Impacted City-Wide
Shoreline Condition: 2100
5 Feet of Sea Level Rise at High Tide

7,200 Buildings Potentially Impacted City-Wide
Storm Surge: Maximum of the Maximum
Modeled Storm Surge Extent for Planning Purposes

Legend:
- Red: Category 1
- Orange: Category 2
- Green: Category 3
- Blue: Category 4
Newmarket Creek - Constrained Drainage System
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Newmarket South
Newmarket South
Street Flooding
Drainage Infrastructure can be an Integrated Asset

Dutch Dialogues Virginia - Newmarket Creek
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Dutch Dialogues Virginia - Newmarket Creek
Newmarket Creek
Newmarket Creek
Newmarket Creek, narrow creek
Newmarket Creek, residential creek
Newmarket Creek, residential creek
Newmarket Creek, residential creek
Newmarket Creek, Mercury Central
Drainage Infrastructure can be an Integrated Asset
Dutch Dialogues Virginia - Newmarket Creek
Foundation Types

- Raised/Crawl Space
- Basement
- Slab
- SLR and Flood Risk
Historic Home Raised above FEMA Flood Zone
Innovative Architectural Adaptation
Make It Right - New Orleans
Innovative Architectural Adaptation
Floating Houses - Netherlands
Retain Rain on the High Ground and Reduce Runoff

Green Infrastructure

Bioswales & Rain Gardens
Pervious Paving
Green Roof
Rainwater Collection
Retain Rain on the High Ground and Reduce Runoff
Wally Pontiff Flood Park - Metairie, Louisiana
Retain Rain on the High Ground and Reduce Runoff

Wally Pontiff Flood Park - Metairie, Louisiana
Drainage Infrastructure can be an Integrated Asset
Westersingel - Rotterdam
Develop High Ground and Transportation Corridors
Gentilly Resilience District - New Orleans
Raise Roads and Infrastructure
Resilient Bridgeport

EXISTING INDUSTRIAL

RETROFIT CONNECTIONS

PRECAST UTILITY TRENCH

EXISTING SEWER

BOSTWICK AVE

VEGETATIVE BUFFER

RAISED DEVELOPMENT

FEMA BFE
Multifunctional Flood Control
Westzeedijk - Rotterdam
Maintain Marsh and Wetlands with SLR
Living Shoreline to Reduce Erosion
Pasture Point
NO TRESPASSING
NO LAUNCHING
OF WATERCRAFT
NO FISHING
NO CRABBING
THREATS AND STRESSES

- Tidal Flooding (Lunar and Storm)
  - Frequent tidal flooding (5+ times per year)
  - Nor’easters are biggest perceived storm threat
  - Key intersections flood regularly

- Shoreline Erosion

- Emergency service access challenges after major events

- Private Streets are not maintained

- Electrical Grid stability during storms and floods (e.g. basement flooding due to loss of power to sump pump)

- Clay soils are impermeable and contribute to poor drainage

What We’ve Heard
Foxhill, Grandview, Harris Creek, Buckroe Beach, Phoebus, Ft. Monroe
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Foxhill, Grandview, Harris Creek, Buckroe Beach, Phoebus, Ft. Monroe

OPPORTUNITIES AND SOLUTIONS
- Ensure ingress/egress to flood prone areas
- Bury utilities (to improve stability)
- Bike/pedestrian connection between Buckroe and Fort Monroe
- Create incentives for parcel-size solutions (rain gardens, etc.)
- Demonstration projects on city owned property (school parking lot)
- Infiltration wells that penetrate clay layer
- Neighborhood catch basin and ditch cleaning days
- Study development limits and regulations at shoreline
- Plant more trees
- Reclaim vacant land for green space
- Allow designated areas to flood, build detention/retention areas
- Breakwaters and beach replenishment
- Monitoring and Internet apps to predict and plan for flooding
Workshop Activity

Tell us about flooding events you are experiencing.

Of these events, what are the most important to address?

Brainstorm possible actions for these priorities.