Structure-Based Risk Assessments

Depth, Damage... Done!

Louie Greenwell, GISP, CFM
Structure-Based Risk Assessments

- Latest NFIP Reform
  - BW-12
  - HFIAA

- Local Officials
- Property Owners

FLOOD RISK
Project Examples

- **Louisville/Jefferson County, Kentucky**
  - Over 11,000 buildings
  - Categorized flood depths (high / moderate / low risk)
  - Long-term mitigation program

- **Salina, Kansas**
  - Under 1,000 buildings
  - Dataset used to communicate flood insurance rate impacts
  - Prioritize future flood mitigation efforts
Flood Risk Inventory

- Structures at risk of flooding
  - Where are they?
  - How many?
  - What’s the total value?
  - When were they built?
  - What are the potential damages?
- Not all flooding is the same
  - Depth varies (>15’ to -5’)
  - Ohio River vs interior streams
  - Combined sewer flooding
Floodprone Inventory
Estimating Flood Depths

Depth of flooding ??
Estimating Flood Depths

Depth of flooding = 2.25’

3 Steps = 1.75’

100-year Flood Elevation

First Floor

Ground

534’ - FEMA

531.75’

530’ - LiDAR
- Dozen scripts/tools
- 165 Data Fields
- 4 Main functions
  - Depth
  - Damage
  - Insurance Rate
  - Benefit/Cost
How Close is Close Enough?

- **First Floor Elevations**
  - Approximately 250 surveyed elevations
  - Calculated elevations
  - Average difference = 2 inches

- **Flood Depths**
  - Homeowner reported depths (approx. 50)
  - Surveyed high water marks
  - Calculated depths
  - Average difference = 1 inch
Slab on Grade Example

High Water Mark: 474.3
Calculated FFE: 472.8
Calculated Depth: 1.5
Reported Depth: 1.5
Basement Example

High Water Mark: 458.4
Calculated FFE: 460.0
Calculated Depth: -1.6
Reported Depth: N/A
Alternative Approaches

- Elevation Certificates
- Mobile Lidar
  - Line of sight issues
  - Data intensive
  - Cost considerations
- Field Survey
  - Labor intensive
  - Safety concerns
  - Management & coordination
Benefits

▶ Accurate
  ▶ Within 2 inches (average) of surveyed elevations
  ▶ Within 1 inch (average) of homeowner-reported flood depths

▶ Affordable
  ▶ 20 times more cost-effective than traditional survey
  ▶ Half the cost of mobile Lidar collection

▶ Available
  ▶ Dataset can be created in a few weeks
Data Requirements

- **Topography**
  - Lidar for the ground elevation
  - Terrain dataset suitable for contours

- **Flood Hazard**
  - Water surface elevations (from FEMA modernized models)
  - Cross sections with elevation attributes

- **Structure**
  - Building footprint
  - Parcel polygons with structure value / landuse class / year built / foundation type
OK .....so now what?

- **Decision Support**
  - Categorize risk (high/moderate/low)
  - Calculate damages

- **Mitigation project prioritization**
  - Group structures into smaller areas
  - Prioritize areas of highest risk
  - Rank & sort

- **Develop Alternatives**
Levels of Risk

**HIGH RISK**
- 2 feet below first floor

**MODERATE RISK**
- 1.5 feet above first floor

**LOW RISK**
- First Floor (0')
- 2 feet below first floor

**RIVER & INTERIOR STREAM FLOODING**

**COMBINED SEWER FLOODING**
### Jefferson County

<table>
<thead>
<tr>
<th>Height Above FFE</th>
<th>Combined Sewer Service Area</th>
<th>Internal Stream Flooding</th>
<th>Ohio River</th>
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<th>Ohio River</th>
<th>Jefferson County</th>
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</thead>
<tbody>
<tr>
<td>Below -2 ft</td>
<td>$2,149 $804,033,401</td>
<td>$0</td>
<td>$0</td>
<td>$119 $829,647,468</td>
<td>$0</td>
<td>$0</td>
<td>$5,047 $2,448,121,950</td>
</tr>
<tr>
<td>-2 - 0 ft</td>
<td>877 $205,713,549 $3,375,125</td>
<td>2,779 $814,441,082</td>
<td>98 $321,580,451</td>
<td>100 Year Damages</td>
<td>5,369,398</td>
<td>1,438 $901,904,831</td>
<td>$35,932,478</td>
</tr>
<tr>
<td>0.1 - 0.4 ft</td>
<td>39 $3,537,096 $509,091</td>
<td>294 $577,030,400</td>
<td>18 $7,626,213</td>
<td>100 Year Damages</td>
<td>$1,526,836</td>
<td>351 $68,893,349</td>
<td>$9,558,192</td>
</tr>
<tr>
<td>0.5 - 1 ft</td>
<td>12 $2,371,609 $462,550</td>
<td>404 $627,275,957</td>
<td>24 $6,734,344</td>
<td>100 Year Damages</td>
<td>$1,391,553</td>
<td>440 $70,941,369</td>
<td>$7,428,557</td>
</tr>
<tr>
<td>1.1 - 1.4 ft</td>
<td>9 $808,043 $267,174</td>
<td>200 $356,144,898</td>
<td>15 $4,596,319</td>
<td>100 Year Damages</td>
<td>$1,715,635</td>
<td>244 $40,992,248</td>
<td>$10,381,501</td>
</tr>
<tr>
<td>1.5 - 2 ft</td>
<td>8 $1,016,040 $356,477</td>
<td>190 $298,092,061</td>
<td>23 $12,931,203</td>
<td>100 Year Damages</td>
<td>$3,076,339</td>
<td>224 $40,990,244</td>
<td>$13,543,693</td>
</tr>
<tr>
<td>1.5 - 3 ft</td>
<td>2 $271,034 $72,304</td>
<td>149 $299,197,413</td>
<td>25 $22,462,834</td>
<td>100 Year Damages</td>
<td>$5,989,339</td>
<td>186 $51,867,281</td>
<td>$15,892,912</td>
</tr>
<tr>
<td>3.1 - 5 ft</td>
<td>2 $372,511 $124,144</td>
<td>70 $141,516,091</td>
<td>55 $11,478,285</td>
<td>100 Year Damages</td>
<td>$4,946,697</td>
<td>127 $26,366,866</td>
<td>$12,678,244</td>
</tr>
<tr>
<td>5.1 - 10 ft</td>
<td>0 $0 $0 $0</td>
<td>25 $4,319,109</td>
<td>127 $45,777,951</td>
<td>100 Year Damages</td>
<td>$21,214,855</td>
<td>152 $50,097,060</td>
<td>$25,544,318</td>
</tr>
<tr>
<td>Above 10 ft</td>
<td>0 $0 $0 $0</td>
<td>8 $1,741,195</td>
<td>147 $49,645,128</td>
<td>100 Year Damages</td>
<td>$41,581,290</td>
<td>155 $51,386,323</td>
<td>$43,083,467</td>
</tr>
<tr>
<td>Grand Total</td>
<td>3,098 $1,017,988,742</td>
<td>$5,141,065</td>
<td>7,282 $1,582,460,607</td>
<td>100 Year Damages</td>
<td>$93,847,876</td>
<td>664 $1,151,191,192</td>
<td>$85,064,900</td>
</tr>
</tbody>
</table>

### Single Family Residential

<table>
<thead>
<tr>
<th>Height Above FFE</th>
<th>Combined Sewer Service Area</th>
<th>Internal Stream Flooding</th>
<th>Ohio River</th>
<th>Jefferson County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below -2 ft</td>
<td>$1,932,826 $1,372,916</td>
<td>$0</td>
<td>$0</td>
<td>$5,047 $2,448,121,950</td>
</tr>
<tr>
<td>-2 - 0 ft</td>
<td>578 $48,108,057 $2,970,919</td>
<td>404 $304,810,447</td>
<td>69 $26,493,193</td>
<td>100 Year Damages</td>
</tr>
<tr>
<td>0.1 - 0.4 ft</td>
<td>33 $3,031,552 $485,807</td>
<td>237 $27,667,087</td>
<td>12 $5,171,848</td>
<td>100 Year Damages</td>
</tr>
<tr>
<td>0.5 - 1 ft</td>
<td>9 $1,147,416 $277,247</td>
<td>341 $32,967,034</td>
<td>19 $4,356,586</td>
<td>100 Year Damages</td>
</tr>
<tr>
<td>1.1 - 1.4 ft</td>
<td>7 $643,733 $201,793</td>
<td>165 $14,548,673</td>
<td>12 $4,063,295</td>
<td>100 Year Damages</td>
</tr>
<tr>
<td>1.5 - 2 ft</td>
<td>8 $1,016,040 $356,477</td>
<td>141 $12,867,523</td>
<td>12 $5,844,954</td>
<td>100 Year Damages</td>
</tr>
<tr>
<td>1.5 - 3 ft</td>
<td>1 $75,084 $41,992</td>
<td>118 $10,080,085</td>
<td>22 $4,751,028</td>
<td>100 Year Damages</td>
</tr>
<tr>
<td>3.1 - 5 ft</td>
<td>2 $1,016,040 $356,477</td>
<td>61 $9,444,553</td>
<td>37 $4,546,145</td>
<td>100 Year Damages</td>
</tr>
<tr>
<td>5.1 - 10 ft</td>
<td>0 $0 $0 $0</td>
<td>$25 $4,319,109</td>
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<tr>
<td>Above 10 ft</td>
<td>0 $0 $0 $0</td>
<td>8 $1,741,195</td>
<td>147 $49,645,128</td>
<td>100 Year Damages</td>
</tr>
<tr>
<td>Grand Total</td>
<td>2,229 $1,017,988,742</td>
<td>$5,141,065</td>
<td>6,180 $750,955,515</td>
<td>100 Year Damages</td>
</tr>
</tbody>
</table>

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**Combined Sewer Service Area**

- **Grand Total**: $1,034,053,841

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**Single Family Residential**

- **Grand Total**: $1,037,541,416

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**Jefferson County**

- **Combined Sewer Service Area**: $1,034,053,841

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**Ohio River**

- **Combined Sewer Service Area**: $1,037,541,416

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**Decision Support**
Grouped Project Areas (400+)
Prioritization

- Prioritization Method
  - Flood Depth (>=1.5’ or > 0’ in CSSA)
  - Value of calculated 100-year damages
  - Amount of prior flood insurance claims
  - Number of repetitive loss properties
  - Number of severe repetitive loss properties

- Each factor was ranked and normalized
- Ranks were then averaged
- Validated against recent grants & acquisition areas
High Risk Areas (100+)
Assess Mitigation Alternatives

- Assess highest risk project areas
- Identify non-structural & structural alternatives
  - Acquisition, structure elevation, flood-proofing
  - Basin, berm, floodwall, channel improvement, culvert
- Assess “most probable” alternatives
- Model the impacts (H&H analysis)
  - Challenge: not all streams have up-to-date models
- Calculate benefits
  - Challenge: FEMA benefit/cost calculations appear to be undervaluing damages when compared to recent Louisville events
Mitigation Alternative Analysis
Additional Results

- Mitigation alternatives
  - 150 conceptual structural measures (i.e. projects)
    - Flood storage basins
    - Channel improvements
  - Long-term mitigation program

- Comprehensive flood risk inventory
  - Expedited grant applications
  - Target the “right” areas
  - Can support tracking substantial damage
## Catastrophic Flood Planning

### Flood-prone Structures

<table>
<thead>
<tr>
<th>Property Class</th>
<th>Ohio River 500-yr &amp; Levee Overtop</th>
<th>Interior</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential (includes Condos)</td>
<td>65,086</td>
<td>4,038</td>
<td>69,124</td>
</tr>
<tr>
<td>Commercial</td>
<td>8,332</td>
<td>1,145</td>
<td>9,477</td>
</tr>
<tr>
<td>Industrial</td>
<td>1,599</td>
<td>86</td>
<td>1,685</td>
</tr>
<tr>
<td>Other</td>
<td>3,905</td>
<td>235</td>
<td>4,140</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>78,922</strong></td>
<td><strong>5,504</strong></td>
<td><strong>84,426</strong></td>
</tr>
<tr>
<td>Previously measured</td>
<td>(10,659)</td>
<td>(3,626)</td>
<td>(14,285)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>68,263</strong></td>
<td><strong>1,878</strong></td>
<td><strong>70,141</strong></td>
</tr>
</tbody>
</table>
Structure-Based Risk Assessments

- Flood risk inventory
- Mitigation alternatives analysis
- Risk communication
Flood Risk Communication

- Communicate “Full Risk Rate”
  - Subsidies will eventually expire
- Change the conversation
  - From “in/out” to “above/below”
  - From zones and elevations to depths and dollars
- Message varies depending on
  - Individual structure characteristics
  - Depth of flooding
  - Purchase requirements
Flood Insurance Rate Impacts

- Salina, Kansas (2015 pop. 47,700)
  - Effective study was from 1986
    - Un-modernized, Q3 product
  - New FIRM
    - SWMM model for interior drainage
    - Removed Zone A streams
  - Accredited levee protects 40% of town

- Comparisons
  - Effective vs. proposed studies
  - With vs. without federal subsidy*

* FEMA Flood Insurance Manual – November 2015
Salina Study Statistics

- 1009 structures in effective SFHA
  - 699 pre-FIRM (i.e. built before 1976)
  - 1,871 LOMAs
- 418 structures in proposed SFHA
  - 112 new structures added
  - 703 structures removed (50% would be impacted by a levee failure)
  - 306 structures “no change”
Impact Hot Spots

- Changes Since Last FIRM – only better!
- Areas of significant rate change
  - Calculations are performed for each structure
  - Impacts are aggregated
  - No individual rates or premiums are shown
- How to use this for outreach?
  - Structures newly mapped into SFHA
  - Structures removed from SFHA
  - Structures with “no change”
### Decision Support

#### Flood Depth

<table>
<thead>
<tr>
<th>Structure Status</th>
<th>Below -2 ft</th>
<th>-2 - -1.1 ft</th>
<th>-1 - 0 ft</th>
<th>0.1 - 0.4 ft</th>
<th>0.5 - 1 ft</th>
<th>1.1 - 1.4 ft</th>
<th>1.5 - 2 ft</th>
<th>2.1 - 3 ft</th>
<th>3.1 - 5 ft</th>
<th>5.1 - 10 ft</th>
<th>Above 10 ft</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newly Mapped</td>
<td>32</td>
<td>49</td>
<td>28</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>112</td>
</tr>
<tr>
<td>Status Unchanged</td>
<td>43</td>
<td>100</td>
<td>122</td>
<td>11</td>
<td>11</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>-</td>
<td>1</td>
<td>306</td>
</tr>
<tr>
<td>Grand Total</td>
<td>75</td>
<td>149</td>
<td>150</td>
<td>11</td>
<td>14</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>-</td>
<td>1</td>
<td>418</td>
</tr>
<tr>
<td><strong>Flood Depth &lt; 0 ft:</strong></td>
<td>18%</td>
<td>36%</td>
<td>36%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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#### Map of Insurance Change Grid

- **High Decrease**
- **Moderate Decrease**
- **Small Decrease**
- **Negligible Difference**
- **Small Increase**
- **Moderate Increase**
- **High Increase**

**Flood Depth**

- Below -2 ft: 89%

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**Note:** The table and map provide information about flood depth and structure status changes, with percentages indicating the distribution of flood depths across different levels.
Salina Results

- Outreach to local officials is ongoing
- Messaging is very different than before
  - Information is more substantive
  - Move the discussion towards mitigation
  - Outreach can be tailored to varied situations
    - People that no longer are required to carry a policy
    - People that are newly added
    - People that are still in, but rates are decreasing
    - People that are still in, but rates are increasing

### Flood Depth

<table>
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<th>Structure Status</th>
<th>Below -2 ft</th>
<th>2 - -1.1 ft</th>
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<td>6</td>
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<td>4</td>
<td>3</td>
<td>-</td>
<td>1</td>
<td>418</td>
</tr>
</tbody>
</table>

- Flood Depth < 0 ft: 89%

- Flood Depth < 1 ft: 36%

- Flood Depth 1 ft or more: 36%
Future Advancements
Better Risk Assessments

- Improved mitigation planning
- Improved communication
- Improved risk reduction
Questions

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LGreenwell@primeeng.com
(502) 493-6533

Thank You!