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Resilience Impacts of Changing Building Practices

November 12, 2018

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Building Codes

Traditional Building Codes

- Codified classification of design standards for construction.
- Based on historical conditions.

Resilient Building Codes

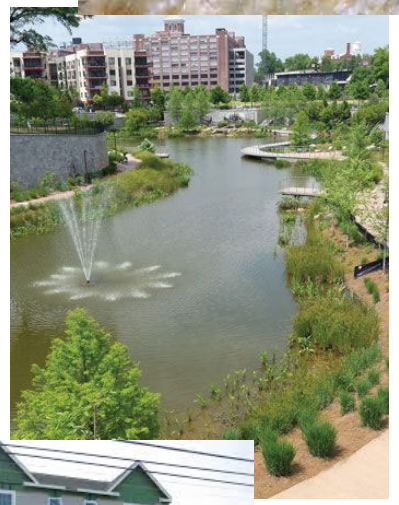
- Should be based on changing conditions in the natural environment
- Based on the life and use of the building

General Project Objectives

- Develop an approach for answering specific research questions.
- Exploratory -- to think through the practical social, political, and financial hurdles to adopting these practices.

Specific Project Objectives

- Compare current practices to phased intervention practices:
  - Flood Vents
  - Clustered Green Space Buyouts
  - Raising Structures
- Measure the return on investment (ROI) for deploying selected structural and non-structural interventions and development practices. Measurements:
  - Safety ~ property
  - Wellbeing ~ # of people displaced
  - Health ~ discontinuity of medical regimen



Scenarios

3 Storm Scenarios:

- Historic storm: 1933 Chesapeake-Potomac
- Quasi-historic storm: “Sandtrina”
- Quasi-historic storm: “Hugoswan”

Storm scenarios simulations:

- Current conditions
- 2’ SLR

Practice 1: Flood Vents

Research Questions

What is the expected reduction in damage from continued adoption of flood vents under several storm scenarios?

How do these reductions in damage translate into reduced displaced populations and health savings?

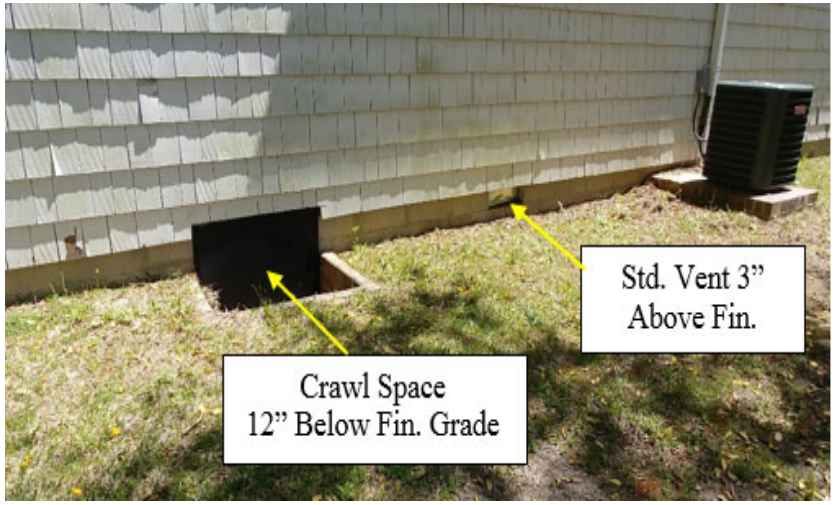
Updated HAZUS Inventory

- Refined HAZUS inventory foundation types to better reflect ground truth.
- Applied one of these to each Census block:
  - 100% Crawl
  - 100% Slab
  - 90% Slab/10% Crawl
  - 89% Crawl/11% Slab
  - 66% Crawl/34% Slab
  - 93% Crawl/5% Basement/2% Slab

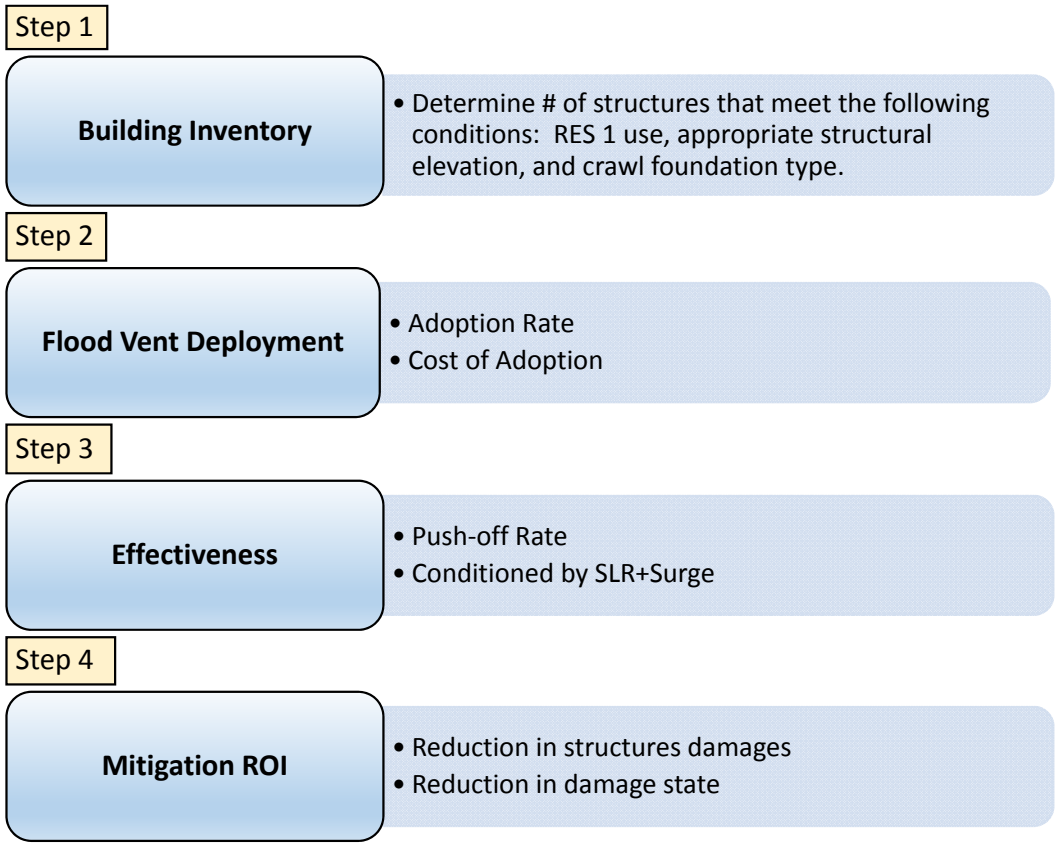
Updated to reflect actual foundation types in study area.

Mixed Category Foundations

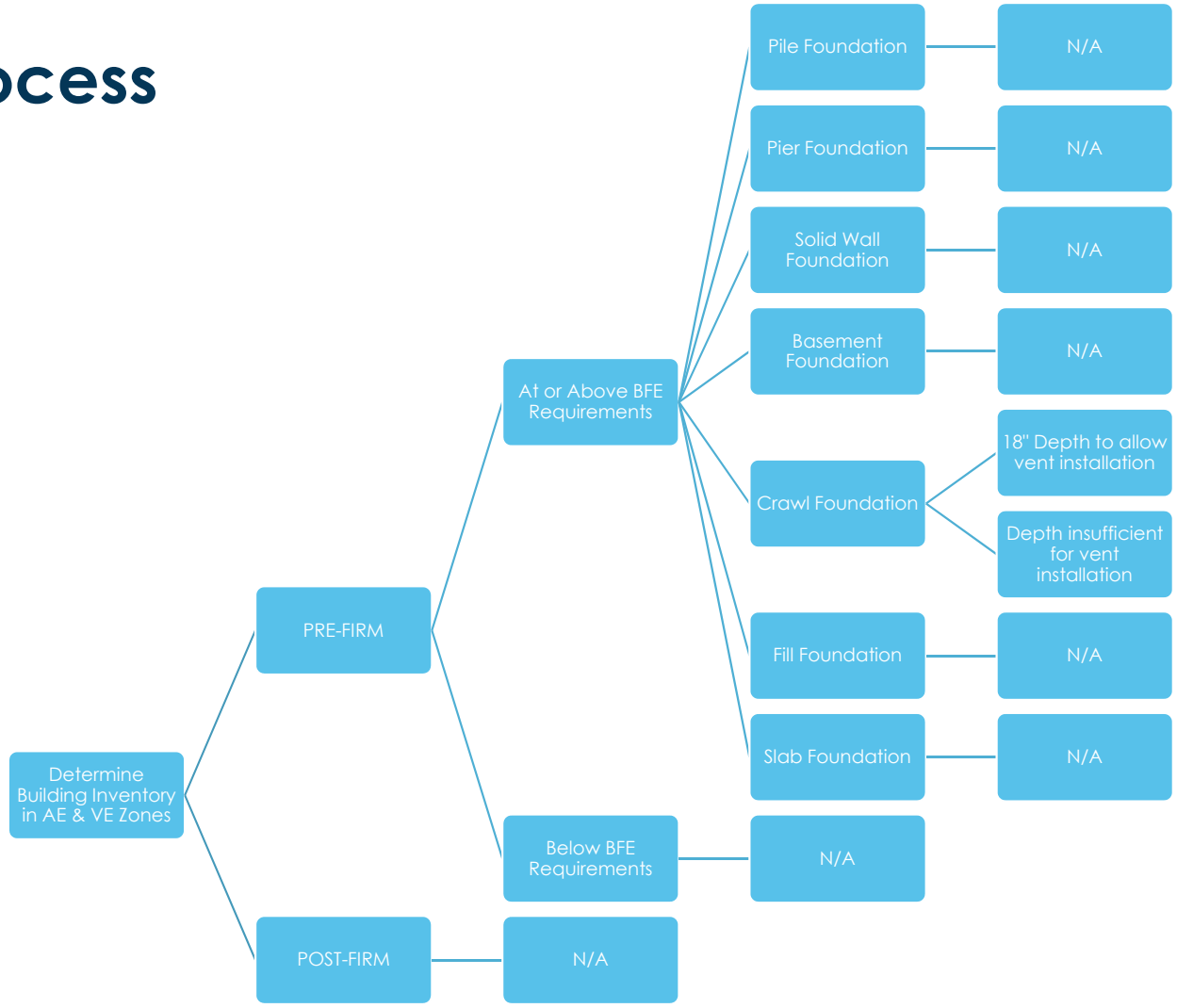
Examples…



The High Level Process



The Process



Estimated that only 7% of Portsmouth RES1 building stock meets this requirement.

Effectiveness Rate of Flood Vents

Studies have found that flood vents have an effectiveness rating of 45-55%. Problems may include:

- Type and installation
- Loose objects around structure may block or impede the effectiveness of the vents.
  - *Large Non-fixed Objects (LNFOs)*
  - *Small Non-fixed Objects (SNFOs)*

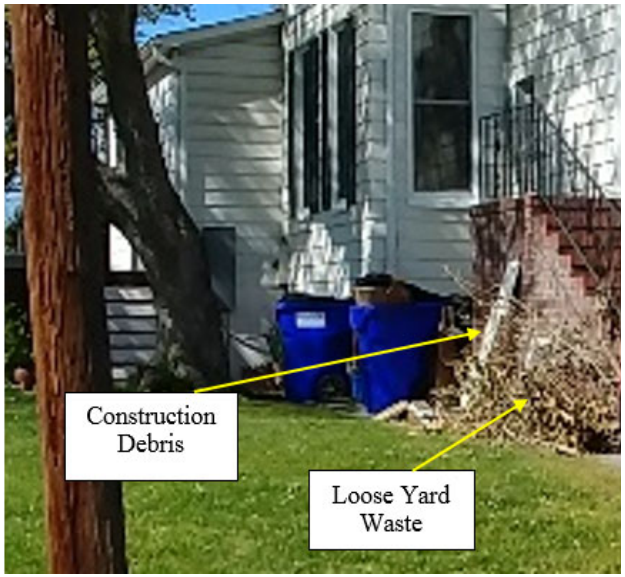
- Flood Vents within 12" of the higher of interior or exterior grade.
- Often proximate shrubs and flower beds.

LNFOs

LNFOs

Raised Structure on Relatively Small Lot, Proximity of Fencing Material

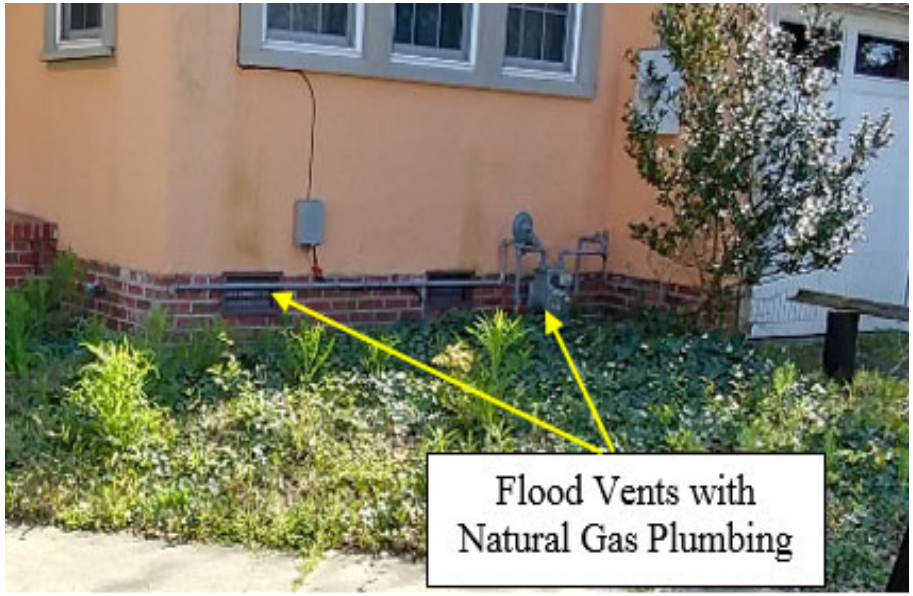
LNFOs & SNFOs


Construction Debris
Loose Yard Waste


Flower Pots Near Vents
Bagged Yard Waste


Buoyant Pine Bark Mulch

Fixed Structure Objects – Utility Services



Flood Vent Intervention

Storm	Total RES1 Bldg.	Summary of RES1 Substantial Damage	Bldg. Stock with less than Substantial Damage	% of RES1 Bldg. Stock w/ Substantial Damage
CP 1933	29,045	2,930	26,115	0.10
CP 1933 SLR	29,045	5,316	23,729	0.18
CP 1933 SLR w/Vents	29,045	4,417	24,628	0.15
Sandtrina	29,045	12,179	16,866	0.42
Sandtrina 2' SLR	29,045	12,179	16,866	0.42
Sandtrina 2' SLR w/Vents	29,045	11,280	17,765	0.39
Hugoswan	29,045	1,296	27,749	0.04
Hugoswan 2' SLR	29,045	2,215	26,830	0.08
Hugoswan 2' SLR w/Vents	29,045	1,326	27,719	0.05

Flood vent installation applies to small % of RES1 structures, but can reduce damages.

Flood Vent Takeaways

1. Foundation type and BFE limit number of potential structures.

2. Adoption rate conditioned by property value, ownership, and risk perceptions.

3. Reduction in risk is conditioned by the concept of effectiveness (45%-55%).

Practice 2: Green Space Buy Out

Research Questions

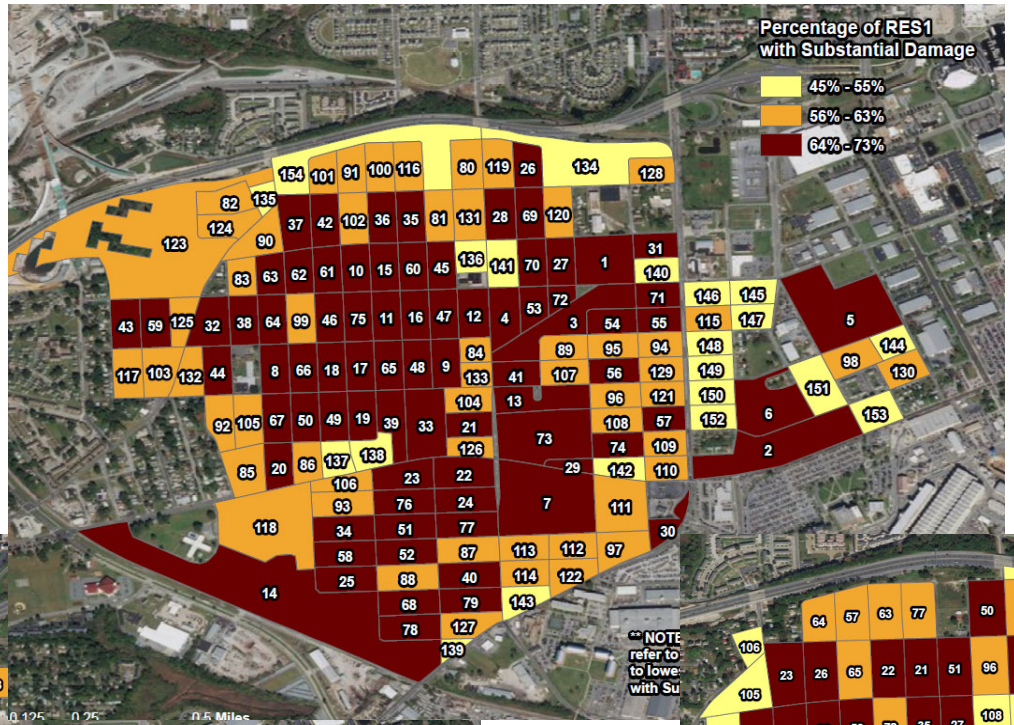
What is the expected reduction in risk stemming from the implementation of a clustered buyout program?

How does a reduction in damage translate into reduced displaced populations and health savings?

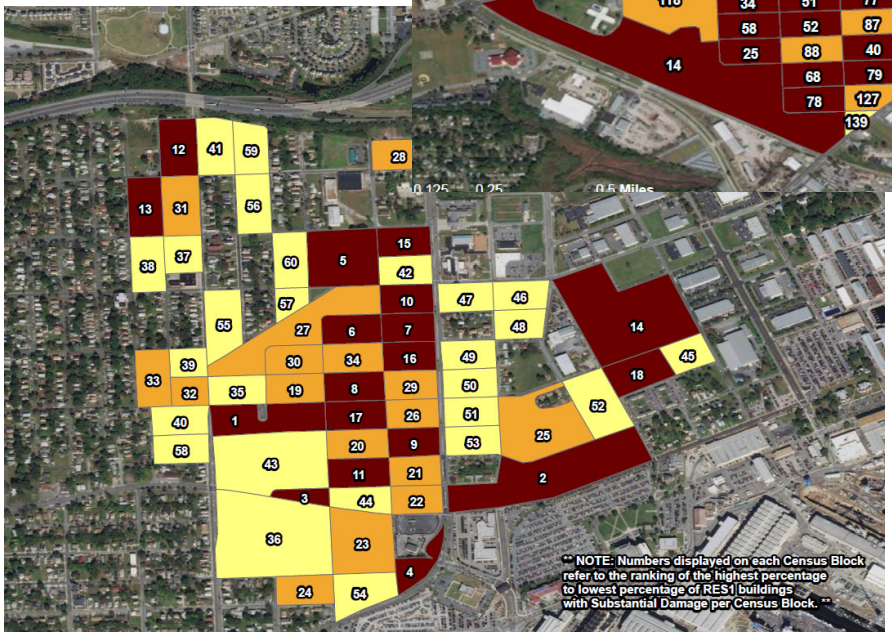
Green Space Adoption

- Run HAZUS scenarios
- Identify green space adoption areas based on substantial damage estimates
- Select residential parcels for purchase/buy-out and estimate costs
- Adjust damage estimates based on phased adoption of green space
- Report adjusted damage estimates
- Report estimated displaced populations
- Estimate health impact

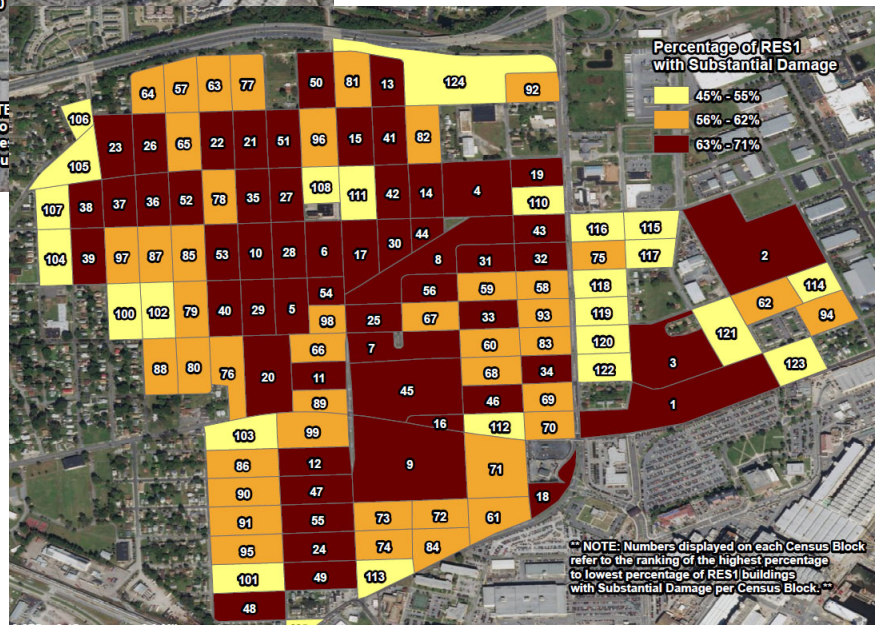
Sandtrina with SLR



Hugoswan with SLR

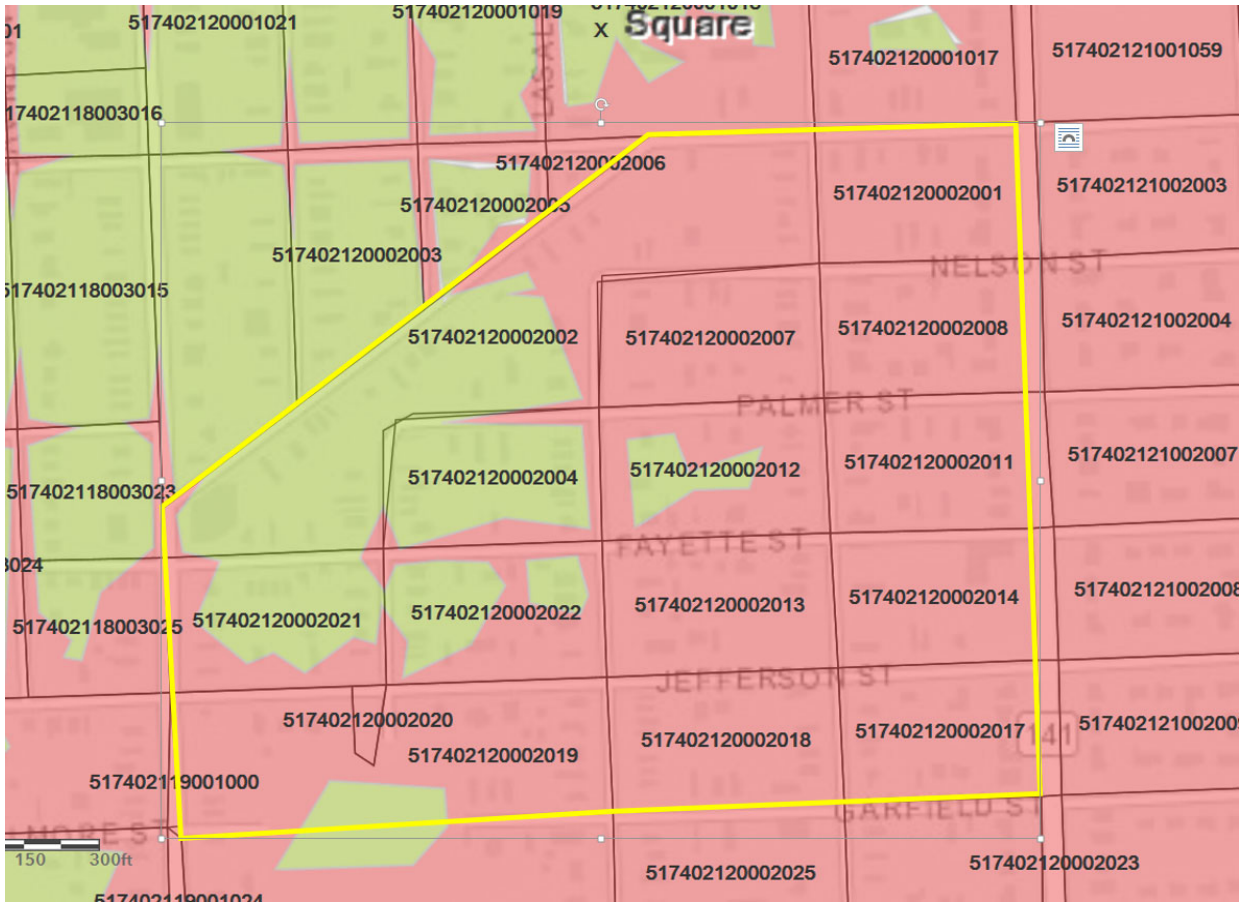


Chesapeake-Potomac with SLR

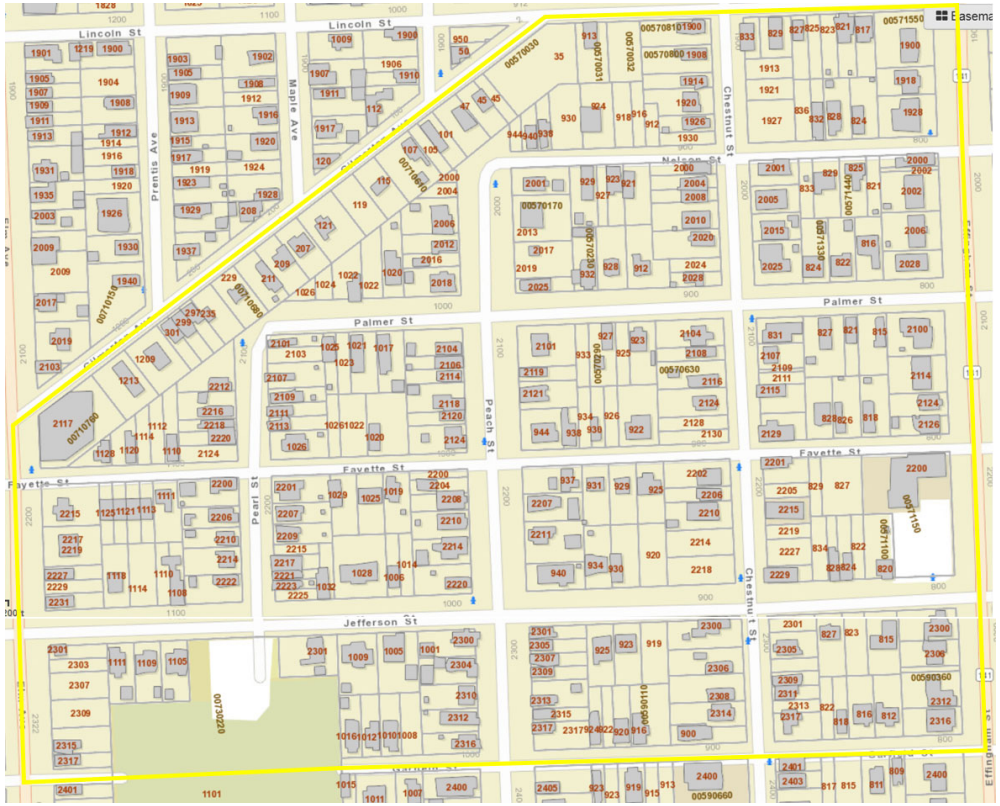


Optimized High Risk Clustered Blocks

Relationship to AE Zone



Establish Parcel Property & Structure Value



Greenspace Adoption

Greenspace Adoption

Shallow
Basin

Green Space Intervention

	Total RES1 Bldg.	Summary of RES1 Substantial Damage	Bldg. Stock with less than Substantial Damage	% of RES1 Bldg. Stock w/ Substantial Damage
Storm				
CP 1933	29,045	2,930	26,115	0.10
CP 1933 SLR	29,045	5,316	23,729	0.18
CP 1933 SLR w/Adoption of Green Space	29,045	5,100	23,945	0.18
Sandtrina	29,045	12,179	16,866	0.42
Sandtrina 2' SLR	29,045	12,179	16,866	0.42
Sandtrina 2' SLR w/Adoption of Green Space	29,045	11,963	17,082	0.41
Hugoswan	29,045	1,296	27,749	0.04
Hugoswan 2' SLR	29,045	2,215	26,830	0.08
Hugoswan 2' SLR w/Adoption of Green Space	29,045	1,999	27,046	0.07

Green space adoption reduces damages, but small (216) number of homes were evaluated for practice.

Green Space Intervention Takeaways

1. Identification of buyout properties balances multiple, often competing, constraints.
2. Advantages to clustered approach are open space and enhanced livability.
3. Open space plan may be shelf-ready after an event.
4. Additional benefits may accrue from redevelopment opportunities.

Practice 3: Raising Structure BFE

Research Questions

What is the expected reduction in risk from the implementation of new building elevation standards for single family residential construction?

How do these reductions in damage translate into reduced displaced populations and health savings?

Raising Structures

- Run HAZUS scenarios
- Identify % of new homes in study area
- Adjust damage estimates based on adoption of elevated structures
- Report adjusted damage estimates
- Report estimated change in displaced populations
- Estimate health impact

Secondary Tradeoff Issues

- Risk from height of structure
  - Risk of acute injury is greater due to stair height.
- Structure will not meet needs with onset or instantaneous mobility issues.
  - Height will not accommodate retrofitting with ramps.
- Ingress/egress of emergency responders.
- Over time, the pool of homes accessible to those with mobility impairments shrink.
- Insurance tradeoffs.

Stair System

Example…

Increased Porch Risers

Example…

Building Elevation Intervention

	Total RES1 Bldg.	Summary of RES1 Substantial Damage	Bldg. Stock with less than Substantial Damage	% of RES1 Bldg. Stock w/ Substantial Damage
Storm				
CP 1933	29,045	2,930	26,115	0.10
CP 1933 SLR	29,045	5,316	23,729	0.18
CP 1933 SLR w/ Bldg.. Elev.	32,009	542	31,467	0.02
Sandtrina	29,045	12,179	16,866	0.42
Sandtrina 2' SLR	29,045	12,179	16,866	0.42
Sandtrina 2' SLR w/ Bldg Elev.	32,009	13,444	18,565	0.42
Hugoswan	29,045	1,296	27,749	0.04
Hugoswan 2' SLR	29,045	2,215	26,830	0.08
Hugoswan 2' SLR w/ Bldg Elev.	32,009	2,087	29,922	0.07

Building elevation can reduce damages but is dependent on storm conditions.

Additional Considerations for Building Elevation

1. Building elevation can reduce damages but is dependent on storm conditions.
2. Increasing building elevation may stimulate increased development, as people perceive risk to decrease.
3. Need to better document secondary health and insurance tradeoffs.
4. Decreased pool of housing options for those with mobility limitations, elderly, and young families with children.

RESULTS

Evaluation of:

- Safety = property loss (building & content)
- Wellbeing = #of people displaced
- Health = discontinuity of medical regimen
  - A study from Katrina indicates that of storm survivors with chronic conditions, 20.6% cut back or terminated their treatment because of the disaster.

Changes in safety, health, & wellbeing

Storm	Total RES1 Bldg.	Summary of RES1 Substantial Damage	Reduction in RES1 Bldgs. with Substantial Damage	Reduction in # of People Displaced	Reduction in # of People w/ Discontinuity of Medical Treatment	Total Economic Loss (Millions)
CP 1933	29,045	2930				$1.50
CP 1933 SLR	29,045	5316				$2.51
CP 1933 SLR w/Vents	29,045	4417	899	2248	182	$2.09
CP 1933 SLR w/ Bldg. Elev.	32,009	542	4774	11935	969	$0.26
CP 1933 SLR w/Adoption of Green Space	29,045	5100	216	540	44	$2.41
Sandy	29,045	12179				$5.67
Sandy 3' SLR	29,045	12179				$5.67
Sandy 3' SLR SLR w/Vents	29,045	11280	899	2248	182	$5.25
Sandy 3' SLR w/ Bldg Elev.	32,009	13444	<1265>	<3162>	<257>	$5.77
Sandy 3' SLR w/Adoption of Green Space	29,045	11963	216	540	44	$5.57
Hugo	29,045	1296				$0.75
Hugo 3' SLR	29,045	2215				$1.26
Hugo 3' SLR w/Vents	29,045	1326	889	2223	180	$0.75
Hugo 3' SLR w/ Bldg Elev.	32,009	2087	128	321	26	$1.19
Hugo 3' SLR w/Adoption of Green Space	29,045	1999	216	540	44	$1.14

Flood Vents

All storm scenarios showed improvement in areas of safety, and wellbeing. However, vents have limited application based on foundation type and BFE.

Building Elevation

Results vary based on storm scenarios.

- CP 1933 resulted in significant improvements for safety, and wellbeing.
- Hugoswan showed slight improvement for safety, and wellbeing.
- Sandtrina was the opposite, a decrease in safety, and wellbeing.

Green Space Adoption

All storm scenarios showed improvement in areas of safety, and wellbeing, but at a much greater cost.

Return on Investment

- Single event versus cumulative return.
- Small versus modest versus catastrophic sized storms.
- ROI for high cost interventions versus low cost interventions.

Continuing and Future Work:

Continuing work:

- Reevaluate building elevation intervention to represent current rates of replacement.
- Refine health impacts.

Future direction:

- Building elevation strategy to understand storm condition dependencies.
- Green space adoption strategies considering social vulnerability indexes, ecosystem services, and water corridors.
- Redevelopment option in conjunction with green space strategies.
- Building design standards and their impact on intervention solutions.

Thank You!