Assessment of Hybrid Infrastructure Systems under Multi-Flood Hazards in Coastal Georgia

University of Georgia Institute for Resilient Infrastructure Systems | Network for Engineering with Nature

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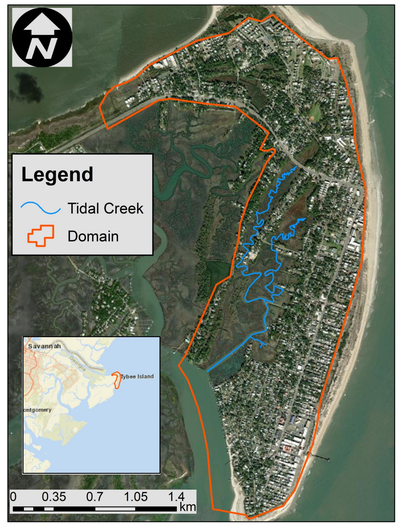
Introduction

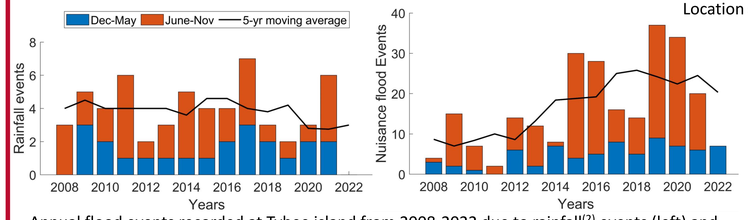
- Coastal communities faces multiple flood hazards:
  - nuisance flooding
  - extreme rainfall events
  - tropical cyclones
  - sea-level rise
- Climate change increase frequency and intensity
- Practical solutions should move towards Hybrid Infrastructure Systems (HIS)
  HIS= structural + non-structural + natural and nature-based features (NNBF)

Tybee Island (Georgia, USA)

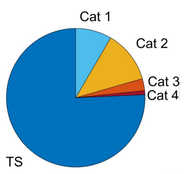
- 3,000 residents & 1 million visitors / year
- Current stormwater sewer system
  - Promotes saltwater flooding
  - Fails under a 10-yr rainfall event (190 mm in 24 hr)
- Current relative sea level trend[1]: 3.44 ± 0.26 mm/yr



Location of Tybee Island within the east coast of US

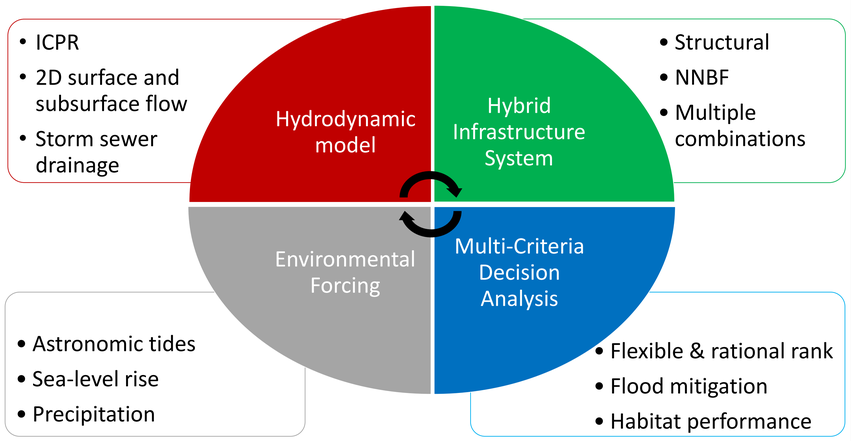


Annual flood events recorded at Tybee island from 2008-2022 due to rainfall[2] events (left) and nuisance flood[1] events (right)



Distribution of tropical cyclones [3] within 50km of GA coastline (1853-2022) based on the Saffir-Simpson Hurricane scale

Modeling Framework & Hybrid Infrastructure System



NNBF Options

- Horizontal Levee
- Rain Harvesting
- Permeable Pavers
- Pocket Park
- Curb Cut Rain Garden
- Swale
- "Pocket" Parks
- Urban Tree Canopy

Structural Options

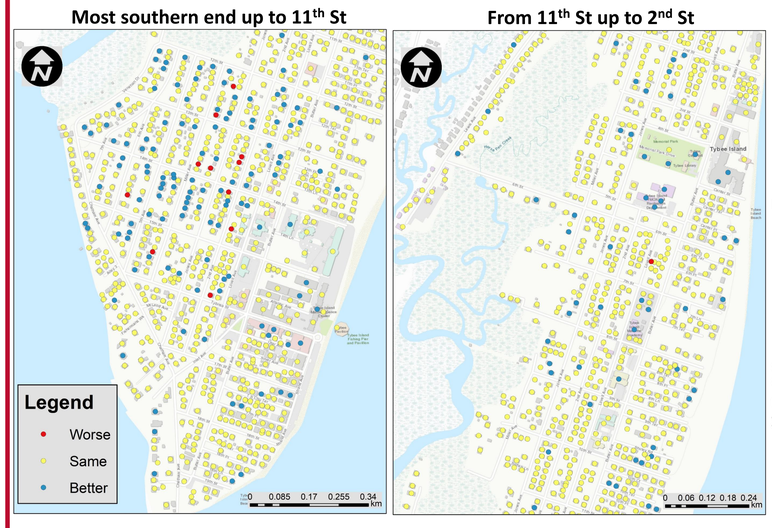
- Tidal Culvert Enlargement
- 2.28 km of additional pipes
- 50% of the existing system will have an increased diameter Backflow prevention outfalls

HIS Alternatives

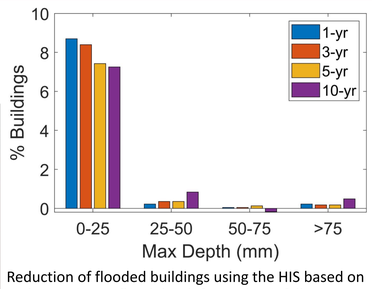
1. Public
2. Public + Commercial
3. Public + Residential
4. Public + Residential + Commercial

Location of the proposed NNBF at the south region of the island

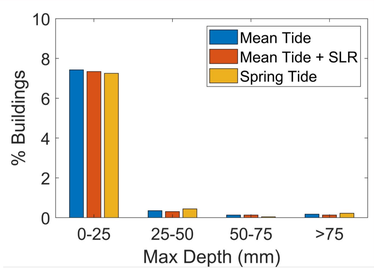
Results



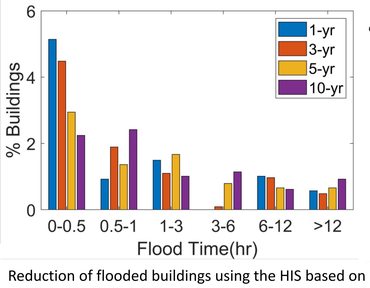
Comparison of buildings flooded (Base – HIS) for a 1-yr rainfall event using an average tide conditions
Worse = building flooded for HIS and not for Base
Better = building flooded for base and not for HIS



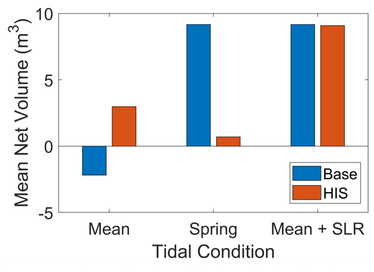
Reduction of flooded buildings using the HIS based on the maximum flood depth for each rainfall return period using an average tide conditions



Reduction of flooded buildings using the HIS based on the maximum flood depth for each coastal condition using a 5-yr rainfall event



Reduction of flooded buildings using the HIS based on the flood time (flood depth ≤ 25 mm) for each rainfall return period using an average tide conditions



Net volume (flood – ebb) through the 6th culvert averaged in time for each coastal condition using a 5-yr rainfall event

Future Work & Preliminary Conclusions

Future Work

- Simulated the different HIS alternatives under the various environmental forcings
- Execute the Multi-Criteria Decision Analysis and select the "best" HIS alternative
- Draft the 50% design of each component of the selected HIS

Preliminary Conclusions

- HIS can prolong the service life of structural features while providing many co-benefits, such as wildlife habitats enhancement, recreational opportunities, and improving urban esthetics
- HIS need to be assessed under multi-flood hazard events, especially for coastal communities

Acknowledgement & References

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1) National Oceanic and Atmospheric Administration (2022), "Fort Pulaski, GA Station (8670870)". Tides & Current dataset, [https://tidesandcurrents.noaa.gov/stationhome.html?id=8670870].
2) Community Collaborative Rain, Hail, and Snow Network (2022), "Tybee Island Station (GA-CT-37)", [https://www.cocorahs.org/].
3) National Oceanic and Atmospheric Administration (2022), "Historical Hurricane Tracks". [https://coast.noaa.gov/hurricanes/#map=4/32/-80].