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## Final Report to the University of South Florida COAST Modeling for Broward County, Florida

For the Belmont Forum-GB Initiative Collaborative Research Initiative,  
METROPOLE: An Integrated Framework to Analyze Local Decision  
Making and Adaptive Capacity to Large-Scale Environmental Change.

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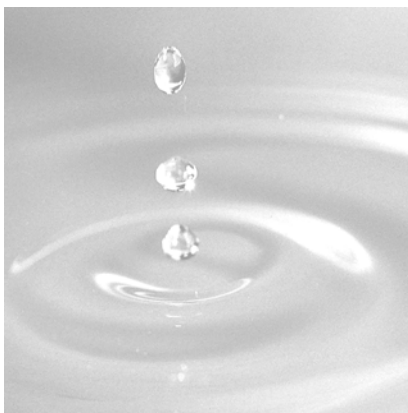
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# 1. Executive Summary

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Since 2014, the University of South Florida (USF) has led a three-country initiative for local communities to increase resiliency to the combined threats of sea level rise and storm surge. The work has been part of the G-8 Belmont Forum's METROPOLE project. Intents have included quantifying vulnerability of coastal real estate; evaluating benefits and costs of candidate adaptation actions such as floodproofing or relocation; quantifying social attitudes about effectiveness of possible adaptation actions and how the engagement methods used could help implement the adaptation actions; and comparing all results between countries. The United States component was conducted in Broward County, Florida. The vulnerability assessment highlighted potential damage to real estate in the study area; including, that by 2060 a nuisance flood would cause about \$5.2 million in damages to buildings under a high (24 in) sea level rise scenario and a Hurricane Wilma-size flood would likely cause about \$862.7 million in damages. Between 2015 and 2060 there were \$3.348 billion and \$5.257 billion in cumulative damages from all possible storms under low (9 in) and high (24 in) sea level rise scenarios respectively. Meeting attendees voted on modeling parameters for two adaptation strategies: elevating and floodproofing buildings, and offering a cash payment for owners to voluntarily leave properties that were vulnerable to sea level rise. The COAST software used in the study showed that with adaptations in place, elevating and floodproofing was the more cost-effective strategy. Meeting attendees believed Broward County should seek funding to further investigate both strategies. Social surveys revealed patterns of public support for different types of adaptation action and identified preferences for funding mechanisms.

## 2. Background

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In 2014, the University of South Florida (USF) contracted Catalysis Adaptation Partners, LLC (Catalysis) to perform a vulnerability assessment and benefit-cost analysis in a study area of Broward County, as part of the Belmont Forum's METROPOLE project. The Catalysis subconsultant team that performed the work moved to GEI Consultants, Inc. (GEI) during the project and completed the work as GEI. The team worked with a USF staff and Broward County officials to organize two public meetings to begin the project and share results. The vulnerability assessment highlighted potential damage to real estate in the study area, which included sections of Hollywood, Dania Beach and Ft. Lauderdale, Florida.

The first meeting was held on January 29, 2015 at the Garfield Community Center in Hollywood, Florida. The purpose was to educate local residents about the COastal Adaptation to Sea level rise Tool (COAST) that would be used to analyze impacts from storm surge and sea level rise and to present results from modeling those impacts in the study area. Attendees also voted on parameters to be used to model adaptation strategies to address those vulnerabilities. The second meeting occurred on March 26, 2015 at the I.T. Parker Community Center in Dania Beach, Florida. The purpose was to share results and solicit feedback from community members about which adaptation strategy they preferred. The project team also surveyed attendees to gauge whether the modeling and engagement processes changed their perceptions towards climate change adaptation, through both keypad polling and a written survey of participants conducted both before and after meetings one and two (polling results and written survey evaluation are located in Appendices).

The GEI team modeled two types of real estate damage: 1) One-time damages from nuisance floods and Hurricane Wilma-size floods under various sea level rise scenarios at particular points in time (snapshots); and 2) cumulative damages from all possible storms over a given time period made worse by various sea level rise scenarios. The project intent was that following these no-action scenarios, and using stakeholder-refined modeling parameters for two adaptation strategies (elevating and floodproofing buildings, and offering cash payments for owners to voluntarily leave properties vulnerable to sea level rise), benefit-cost analysis would help guide further conversations about possible directions in planning and finance for candidate adaptation actions.

In combination with social surveys conducted at each public meeting and inter-country comparisons as part of the larger Belmont Forum project, these results would improve collective understanding about methods for helping local communities move from inaction to action on new initiatives in climate adaptation. Surveys are provided in the Appendices for context on the overall integrated approach; survey analysis and interpretation are provided under separate cover.

Additional background on the social surveys includes that much effort has been expended in the United States on assessment of whether the public believes climate change science is credible and whether climate change is attributable to humans. With the focus through the COAST process and analysis of actual choices of credible adaptation actions and their costs and benefits, investigation of stakeholder beliefs in this study is likewise focused on actions, costs and participants' preferences for both actions and alternate means for how to fund the costs. The method for investigating these questions is a panel survey study of attending participants with a first paper and pencil survey before content of the first COAST workshop commences and a post-workshop re-survey at the close of the second workshop. Like most panel studies, this one has complex and challenging aspects; including not only attrition, but also addition of participants after the first workshop in the context of fairly open, community issue-oriented workshops that are public. These aspects are discussed in detail in a separate report on survey design, administration and analysis.

Key features of the set of surveys include measurement of a priori values using the New Ecological Paradigm (NEP) framework developed by Dunlap and Van Lier (1978) as well as demographic characteristics of participants, in which value orientations tend to be embedded, including gender, education, income, age and general political affiliations. Measurement scales and items developed specifically for this investigation then include prior hazard experience with climate-driven threats in the study areas, perceptions of risks both to self and community-wide, preferences among a set of generally applicable potential adaptation actions and also for a set of generally available methods of paying for actions in the public sector. The second post-workshop survey measures those preferences again for actions and funding alternatives as well as the specific actions modeled in the COAST process.

These panel studies, within each national site and across sites, aim to gain insights into these questions: How preferred is action on climate-sensitive coastal hazards in general and differentially across of actions and similarly among and between different funding methods? Are these preferences sensitive in any non-trivial way to basic values orientations and life conditions (as measured by demographics)? Is there any non-trivial and systematic change in these judgments among panelists between their responses before the first workshop and after the final workshop? And finally, are there any discernible patterns of similarity or divergence among the beliefs and influence of the COAST process between the three international panels of workshop participants? Preliminary results from the Broward COAST process suggest possible guidance for those seeking to design public (and other) funding of long-run adaptation strategies, as well as choosing actions.

Funding for the overall Belmont project was provided by different entities in each country. In the United States (this study) funds were provided by the National Science Foundation (NSF). In the United Kingdom funds were provided by the Natural Environment Research Council and the Economic and Social Research Council (NESC and SRC). In Brazil funds were provided by the São Paulo Research Foundation (FAPESP). GEI personnel on the project were led by Dr. Sam

Merrill, CO-Investigator for the overall USF Belmont project. GEI team members in each country included Jonathan (JT) Lockman and Alex Gray, with subconsulting assistance on social survey design and research from Dr. Jack Kartez.

## **3. Methods**

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### **3.1 Site Selection**

The University of South Florida (USF) selected a study area in Broward County, Florida that included sections of Ft. Lauderdale, Dania Beach and Hollywood (Fig. 1). Most selected properties were situated near the coast or adjacent to the Intracoastal Waterway.

### **3.2 Geographic Inputs and COAST Model Parameters**

#### ***3.2.1 Digital Elevation Model***

A Digital Elevation Model (DEM) of Broward County was created by combining multiple DEM files at 5 m resolution. These files were obtained from the University of Florida GeoPlan Center (2014) and were referenced in the North American Vertical Datum of 1988 (NAVD88) in feet.

#### ***3.2.2 Mean Higher High Water***

Mean Higher High Water (MHHW) was the base reference upon which storm surge and sea level rise were added. The NOAA tide station at the Bahia Yacht Club in Ft. Lauderdale (NOAA, 2014) reported MHHW at an elevation of 4.57 ft. The DEM for Broward County had elevations referenced in NAVD88 (ft), MHHW value was, therefore, converted to NAVD88 by subtracting 4.20 ft from 4.57 ft (Fig. 2), giving a base value of 0.37 ft. The DEM was then lowered by 0.37 ft to reflect MHHW being at zero elevation.

#### ***3.2.3 Sea Level Rise Curves***

Two sea level rise curves (Low and High) were used to calculate amounts of damage to buildings over time. These curves were derived from “A Unified Sea Level Rise Projection for Southeast Florida” (2011) (Fig. 3).

#### ***3.2.4 Storm Surge Recurrence Interval Heights***

Storm surge values that COAST used to inundate parcels each year in the multi-decade scenarios were derived from FEMA Flood Insurance Rate Maps (FIRMs) and Flood Insurance Study (FIS) reports (2014). These products provide heights for storms of various strengths, typically including 10-, 50-, and 100-year recurrence intervals (that is, storms that have a 10%, 2%, and 1% chance of occurring in any year). These heights were used to create exceedance curves for different sub-areas so that cumulative damage estimates could be calculated in a hydrologically variable, non-bathtub format. For one-time damage estimates, heights for today’s nuisance flood (1.05 ft) and Hurricane Wilma (6 ft) were used.



### **3.2.5 *Parcels and Building Types***

A parcel map layer was provided by personnel from the Broward County Property Appraiser Network. Each property in the layer contained an attribute for assessed a building and land value, use code and construction year. Because local ordinances required buildings to be elevated after 1978, construction year was used a proxy for which properties had elevated buildings. All buildings constructed since 1979 were assumed to have first floor elevations 8 ft above grade. Use codes were identified to determine whether a building was commercial or residential. These uses were then matched with depth damage functions for building types outlined by Gulf Engineers & Consultants (2006) for the US Army Corps of Engineers.

### **3.2.6 *Cost Estimates***

Costs of floodproofing and elevation actions were secured from earlier projects in collaboration with engineering firm Parsons Brinckerhoff, in a review of internet contractor websites. Costs of the voluntary buyout action were based on per-parcel market values of real estate in the study area. A 3.3% discount rate was applied for all scenarios.

### **3.2.7 *Scenarios and Timeframes***

The COAST software was used to model 14 scenarios:

- One-time damages from a nuisance flood (1.05 ft) in 2015 with no sea level rise.
- One-time damages from a nuisance flood (1.05 ft) in 2030 with low (3 in) and high (7 in) sea level rise.
- One-time damages from a nuisance flood (1.05 ft) in 2060 with low (9 in) and high (24 in) sea level rise.
- One-time damages from a Hurricane Wilma-size flood (6 ft) in 2015 with no sea level rise.
- One-time damages from a Hurricane Wilma-size flood (6 ft) in 2030 with low (3 in) and high (7 in) sea level rise.
- One-time damages from a Hurricane Wilma-size flood in 2060 with low (9 in) and high (24 in) sea level rise.
- Cumulative damages from all possible storms between 2015 and 2030 with low (3 in) and high (7 in) sea level rise.
- Cumulative damages from all possible storms between 2031 and 2060 with low (9 in) and high (24 in) sea level rise.

## 4. Vulnerability Assessment Results

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### 4.1 One-Time Damages

One-time damage estimates represented potential damages to building structures, and did not incorporate building contents. One-time damages from a nuisance flood in 2030 under low and high sea level rise scenarios were \$0.1 million and \$0.5 million respectively (Table 1). One-time damages from a nuisance flood in 2060 under low and high sea level rise scenarios were \$0.7 million and \$5.2 million respectively. Figs. 4 to 7 illustrate these damage estimates in a northern section of the study area and Figs. 8 to 11 illustrate these damage estimates in a southern section. There were no damages from a nuisance flood in 2015.

One-time damages from a Hurricane Wilma-size flood in 2030 under low and high sea level rise scenarios were \$452.1 million and \$518.4 million respectively (Table 2). One-time damages from a Hurricane Wilma-size flood in 2060 under low and high sea level rise scenarios were \$629.7 million and \$862.7 million respectively. Figs. 12 to 15 illustrate these damage estimates in a northern section of the study area and Figs. 16 to 19 illustrate these damage estimates in a southern section. The damage estimate from a Hurricane Wilma-size flood in 2015 was \$445.8 million.

### 4.2 Cumulative Damages

Cumulative damage estimates represent potential damages to building structures from all possible storms over a given time period, and does not incorporate building contents or other possible flood-related damages in the vulnerable areas. Cumulative damages between 2015 and 2030 under low and high sea level rise scenarios were \$1.009 billion and \$1.132 billion respectively (Table 3). Between 2031 and 2060, cumulative damages under low and high sea level rise scenarios were \$2.339 billion and \$4.125 billion respectively. Between 2015 and 2060, the cumulative damages under low and high sea level rise scenarios were \$3.348 billion and \$5.257 billion respectively.

Table 3 also lists the value of buildings permanently inundated by sea level rise. Between 2015 and 2030 under low and high sea level rise scenarios there were \$100 million and \$101 million (respectively) in building values permanently inundated by sea level rise. Between 2031 and 2060 under low and high sea level rise scenarios there were \$14 million and \$147 million (respectively) in building values permanently inundated by sea level rise. During 2015 to 2060 under low and high sea level rise scenarios, there were \$114 million and \$248 million (respectively) in building values permanently inundated by sea level rise.

While the results above are limited to buildings, Table 4 presents the total value of parcels (buildings and land) permanently inundated by sea level rise. This metric provides an estimate

for potential tax revenue lost from properties that might be unusable (and thus not taxable) in the future. Between 2015 and 2030, total dollar amount of buildings and land permanently inundated by sea level rise was \$345 million under low sea level rise and \$386 million under high sea level rise. Between 2031 and 2060, total dollar amount of buildings and land permanently inundated by sea level rise between was \$81 million under low sea level rise and \$405 million under high sea level rise. Combining these time-periods, total dollar amount of buildings and land permanently inundated by sea level rise between 2015 and 2060 was \$426 million under low sea level rise and \$791 million under high sea level rise. The 199 parcels permanently inundated by 2060 under the high sea level rise scenario were roughly 2.8% of the total number of parcels in the study area, representing about 8.4% of the assessed value of the study area.

## 5. Adaptation Strategies

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### 5.1 Do Nothing, Fortify, Accommodate or Strategically Relocate

Options for responding to sea level rise and storm surge are generally presented as follows:

- *Do nothing* simply involves waiting for a storm incident to happen and responding afterwards.
- Adaptation approaches that *fortify* use hard or soft structures to prevent water from reaching community assets. Such armoring can be “hard,” such as seawalls or bulkheads, or “soft” structures such as geotextile tubes, giant fabric sandbags designed to be replaced after storms.
- Adaptation approaches that *accommodate* modify community assets to reduce the impact of water, but they do not protect against sea level rise (only storm surge). Accommodation acknowledges that structures will become wet, but actions are taken to make them resilient, such as elevating structures or their critical systems.
- *Strategic relocation* involves relocating existing structures, people and land-uses away from areas at high risk or flooding to a new location to eliminate the risks of flooding, and allowing wetland, beaches and natural coastal habitats to migrate landward naturally.

### 5.2 Benefit-Cost Analysis for Two Proposed Adaptation Actions

Once an adaptation strategy or set of strategies has been identified for a community or portion of a shoreline, the COAST software can be used to evaluate whether the strategy would be a good investment from the perspective of avoided damages for the vulnerable asset modeled. This occurs through running the model with adjustments to the depth damage functions, providing a proxy estimate of cumulative damage that might be avoided if the adaptation strategy were taken. Avoided cumulative damage can then be compared to the cost of the potential strategies, creating a benefit-cost ratio. If this ratio is high (i.e., costs are low and benefits are high) the option may be a good investment and worthy of further study, such as more detailed feasibility plans, construction designs or cost estimates. Cost estimates obtained for this study use high and low estimates to bracket the range of possible benefit-cost ratios that might result in situations with varying adaptation costs. More detailed work would be needed to provide more precise engineering design, permitting, and construction cost estimates.

### 5.3 Description of the Two Actions

Audience polling at the Garfield Community Center in Hollywood, Florida on January 29, 2015 (Workshop 1) refined two adaptation strategy scenarios initially developed by the project team. The confirmed scenarios were as follows:

- Strategy 1: Elevate and Floodproofing (Figs. 20 and 21)
  - 75% of properties in FEMA V-Zones elevated to current code plus 2 ft
  - 75% of properties in FEMA A-Zones floodproofed to 8 ft

Benefits from elevating and floodproofing were first calculated with the assumption of 100% participation. We then multiplied these by 0.75 to calculate benefits from partial participation. We used this method in lieu of selecting individual buildings for elevating and floodproofing because it averages benefits across the region. Buildings in the V-Zones that were not currently elevated had their first floors raised to the Base Flood Elevation (BFE) plus 2 ft. For example, a building with a BFE of 14 ft now had a first floor elevation at 16 ft. Buildings in the A-Zone did not receive damage until the water level reached 8 ft.

- Strategy 2: Voluntary Relocation Over Time (Figs. 22 and 23)
  - 50% of property owners whose properties become permanently inundated by sea level rise between 2015 and 2030 accept cash payment today with title transferring in 2020.
  - 75% of property owners whose properties become permanently inundated by sea level rise between 2031 and 2060 accept cash payment in 2025 with title transferring in 2030.

Benefits from property owners voluntarily relocating were calculated assuming 100% participation. To reflect partial participation we then multiplied these by 0.5 for properties permanently inundated by 2030, and 0.75 for properties permanently inundated between 2031 and 2060. Again, rather than hand selecting a portion of buildings to reflect partial participation, the above method was used to create average benefits across the region.

## 6. Adaptation Strategy Benefit-Cost Analysis

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Table 5 shows results of the benefit-cost analysis for the two adaptation strategies. For the elevate and floodproof strategy, there was \$1.258 billion in avoided damages under the low sea level rise scenario and \$1.791 billion in avoided damages under the high sea level rise scenario. Cost estimates for elevating and floodproofing 75% of the buildings not elevated or floodproofed today ranged from \$57.0 million to \$116.6 million. When these costs were compared to cumulative avoided damages, benefit-cost ratios ranged from 10.78 (low sea level rise scenario and high cost estimate) to 31.41 (high sea level rise scenario and low cost estimate). These represent long-term savings in the form of damage reduction for every dollar spent today. For example under the best benefit-cost ratio, every \$1.00 spent today to elevate and floodproof buildings would save \$31.41 by 2060.

For the voluntary relocation strategy, there were \$207.6 million in avoided damages under the low sea level rise scenario and \$177.9 million in avoided damages under the high sea level rise scenario. Cost estimates for purchasing half of the properties vulnerable to sea level rise by 2030 and 75% of the properties vulnerable to sea level rise by 2060 ranged from \$350.8 million to \$526.1 million. Benefit-cost ratios from these numbers ranged from 0.34 (high cost estimate and high sea level rise scenario) to 0.59 (low cost estimate and low sea level rise scenario). All ratios were less than one, meaning the modeled action would provide no long-term savings in the form of building damage reduction alone.

## 7. Discussion

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The vulnerability assessment showed clear trends in increasing damage and the number and value of parcels permanently inundated by sea level rise over time. Even though calculations were based on assessed values for buildings and land (not market prices), this information is helpful in initial stages of resiliency planning where overall vulnerabilities need to be quantified. It enables the studied community to better understand risks if they do nothing to adapt to threats of sea level rise and storm surge, and can be used to begin discussions that might not have occurred without details about possible climate change impacts. It can also foster discussions with neighboring municipalities that might share similar vulnerabilities, perhaps leading to future partnerships for developing joint adaptation strategies.

This benefit-cost analysis could help Broward County move beyond introductory discussions about general adaptation planning. Notice that the best benefit-cost ratios for the two adaptation strategies considered were partly a result of different climate scenarios. The elevating and floodproofing strategy had higher benefit-cost ratios during high sea level rise scenarios because more damage was avoided when properties had been elevated and floodproofed. This was different from the voluntary relocation strategy, where high sea level rise scenarios were damaging buildings before titles were transferring away from the property owners. Notwithstanding these results, meeting attendees still believed Broward County should seek funding to further investigate both strategies.

While the results show that elevating and floodproofing buildings was the most cost-effective strategy, only two strategies were modeled in this study. Other strategies might yield more favorable results. Altering strategy parameters would also change the resulting ratios. For example, in the voluntary relocation strategy a building could still be damaged after someone had received compensation for it and before the title had transferred. This means shortening the amount of time between compensation and the title transfer could cause damage estimates to decrease under this strategy. In addition, the voluntary relocation strategy would not only reduce damages to buildings from storm surge but would also eliminate losses from sea level rise, unlike the elevate and floodproof strategy which only protects against storm surge. And importantly, consideration of other categories of benefit would also improve the benefit-cost ratios. These could include avoided loss-of-function costs, casualties, emergency management costs, and other categories of physical damages such as building contents, landscaping, vehicles, and site contamination (parameterization of these benefits was outside the scope of this study).

In most cases where COAST has been used, conversations about priorities and community values are generally the most meaningful and useful outcomes from the study. For example, despite the elevate and floodproof strategy clearly being the most cost effective strategy in terms of real estate loss, and the voluntary relocation strategy not appearing cost effective, keypad polling results from the second meeting (Appendix B) showed community members still find

value in the voluntary relocation strategy. Not only did participants think the County should further research this strategy, but also believed that the County should pursue funding sources to help owners move out of properties vulnerable to sea level rise.

As is apparent from these conversations, COAST results do not always play a lead role in future decision-making; rather they often calibrate discussions about future decision-making efforts with the values that participants learn are important to the community during the modeling process. Results also aid in considering general timelines for municipal adaptation action. Most adaptation strategies take years or decades to develop and implement, and decisions around those strategies require substantial public support. Benchmarking avoided damage estimates for candidate adaptation actions, and recording community sentiment about these actions, are helpful means of encouraging further efforts in response to the combined threats of extreme weather events and additional sea level rise.



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# Tables

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**Table 1. Damage estimates for a nuisance flood in 2015 with no sea level rise and in 2030 and 2060 under low and high sea level rise scenarios. Damage estimates are to building structure only (does not include contents). Figures are in today's dollars.**

<b>One-Time Damages from Nuisance Flood in Broward County, FL Study Area</b>		
<b>Year</b>	<b>Sea Level Rise</b>	<b>Damage to Buildings</b>
2015	None	\$0 million
2030	Low (3 in)	\$0.1 million
2030	High (7 in)	\$0.5 million
2060	Low (9 in)	\$0.7 million
2060	High (24 in)	\$5.2 million

**Table 2. Damage estimates for a Hurricane Wilma-size flood in 2015 with no sea level rise and in 2030 and 2060 under low and high sea level rise scenarios. Damage estimates are to building structure only (does not include contents). Figures are in today's dollars.**

<b>One-Time Damages from Hurricane Wilma-Size Flood in Broward County, FL Study Area</b>		
<b>Year</b>	<b>Sea Level Rise</b>	<b>Damage to Buildings</b>
2015	None	\$445.8 million
2030	Low (3 in)	\$452.1 million
2030	High (7 in)	\$518.4 million
2060	Low (1.09 ft)	\$629.7 million
2060	Med (2.19 ft)	\$862.7 million

**Table 3. Cumulative storm surge and sea level rise damage estimates for buildings in Broward County, FL study area between 2015 and 2030, 2031 and 2060, and 2015 and 2060. Damage estimates are to building structure only (does not include contents). Figures are in today's dollars.**

Year	Sea Level Rise	Damage to Buildings	Buildings Lost to SLR
2015-2030	Low (0 in - 3 in)	\$1.009 billion	\$100 million
2015-2030	High (0 in – 7 in)	\$1.132 billion	\$101 million
2031-2060	Low (3 in – 9 in)	\$2.339 billion	\$14 million
2031-2060	High (7 in – 24 in)	\$4.125 billion	\$147 million
2015-2060	Low (0 in – 9 in)	\$3.348 billion	\$114 million
2015-2060	High (0 in – 24 in)	\$5.257 billion	\$248 million

**Table 4. Parcels, land, buildings, and total parcel values lost to sea level rise by 2030 and 2060. Figures are in today's dollars.**

Year	Sea Level Rise	Parcels Lost to SLR	Land Value	Building Value	Total Value
2015-2030	Low (0 in - 3 in)	35	\$245 million	\$100 million	\$345 million
2015-2030	High (0 in – 7 in)	44	\$185 million	\$101 million	\$386 million
2031-2060	Low (3 in – 9 in)	18	\$67 million	\$14 million	\$81 million
2031-2060	High (7 in – 24 in)	155	\$258 million	\$147 million	\$405 million
2015-2060	Low (0 in – 9 in)	53	312 million	\$114 million	\$426 million
2015-2060	High (0 in – 24 in)	199	543 million	\$248 million	\$791 million

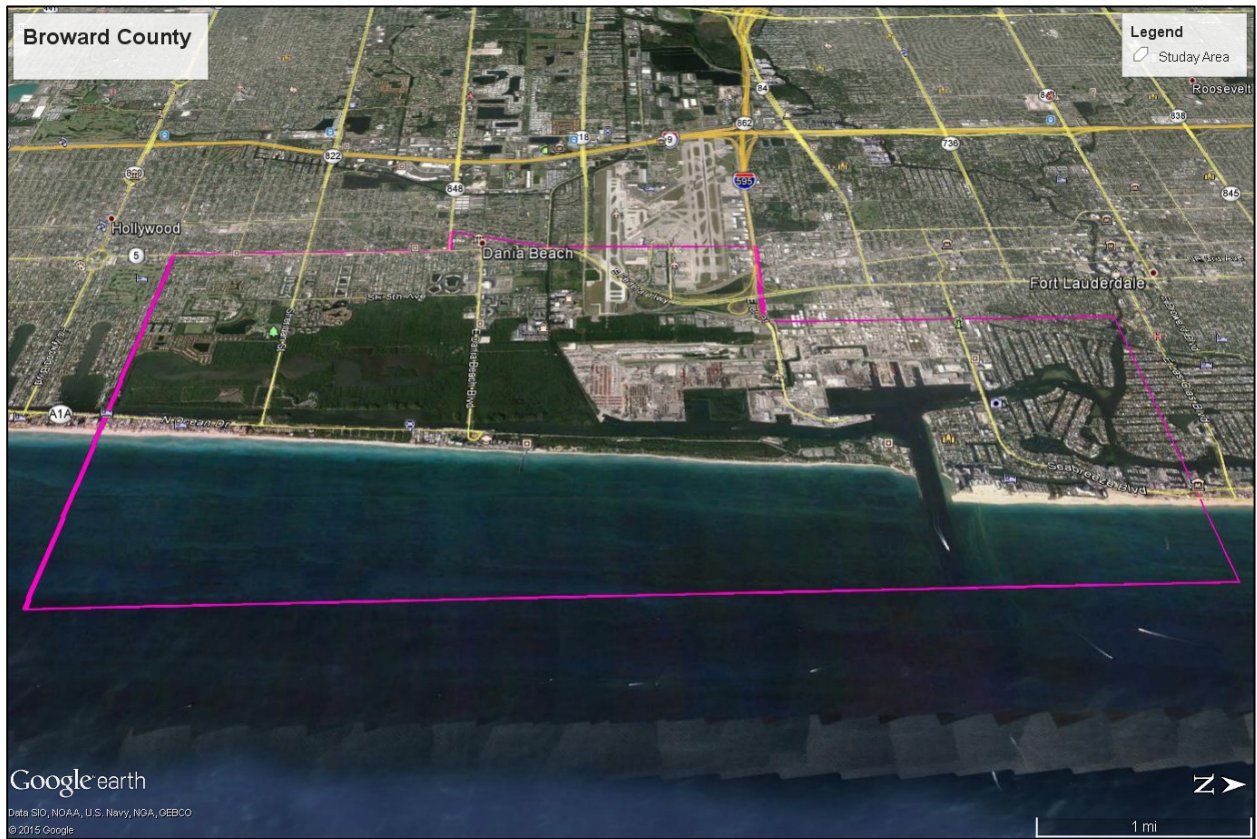
**Table 5. Benefit-cost analysis for two adaptation strategies, both with high and low costs, and under high and low sea level rise scenarios. Strategies with ratios greater than 1 are considered cost effective. Figures are in future dollars (3.3% discount rate).**

Strategy	Avoided Damages (\$ millions)		Cost Estimates (\$ millions)		Benefit-Cost Ratios (Low Cost Estimate)		Benefit-Cost Ratios (High Cost Estimate)	
	Low SLR (9 in)	High SLR (24 in)	Low	High	Low SLR (9 in)	High SLR (24 in)	Low SLR (9 in)	High SLR (24 in)
Strategy 1: Elevate & Floodproof	\$1,257.5	\$1,791.1	\$57.0	\$116.6	22.05	31.41	10.78	15.35
Strategy 2: Voluntary Relocation	\$207.6	\$177.9	\$350.8	\$526.1	0.59	0.51	0.39	0.34

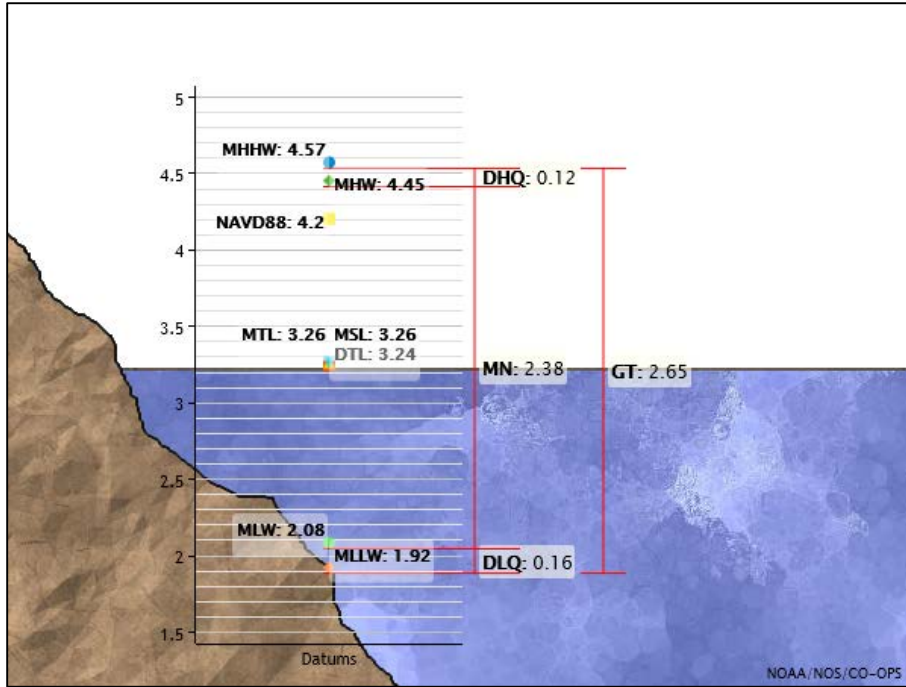
# Figures

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Fig. 1. Broward County study area.



**Fig. 2. Ft. Lauderdale Bahia Yacht Club tide gauge datum with various water level heights.**



**Fig. 3. Sea level rise curves from A Unified Sea Level Rise Projection for Southeast Florida (2011).**

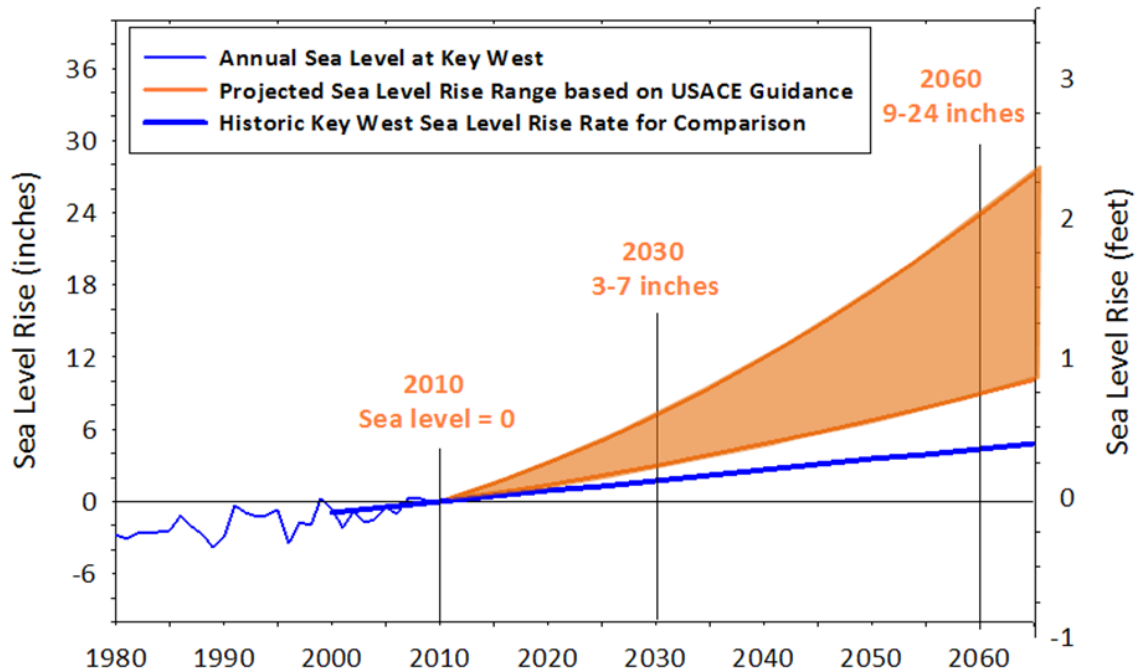




Fig. 4. One-time damage estimate for nuisance flood in 2030 with low sea level rise.



Fig. 5. One-time damage estimate for nuisance flood in 2030 with high sea level rise.





Fig. 6. One-time damage estimate for nuisance flood in 2060 with low sea level rise.



Fig. 7. One-time damage estimate for nuisance flood in 2060 with high sea level rise.

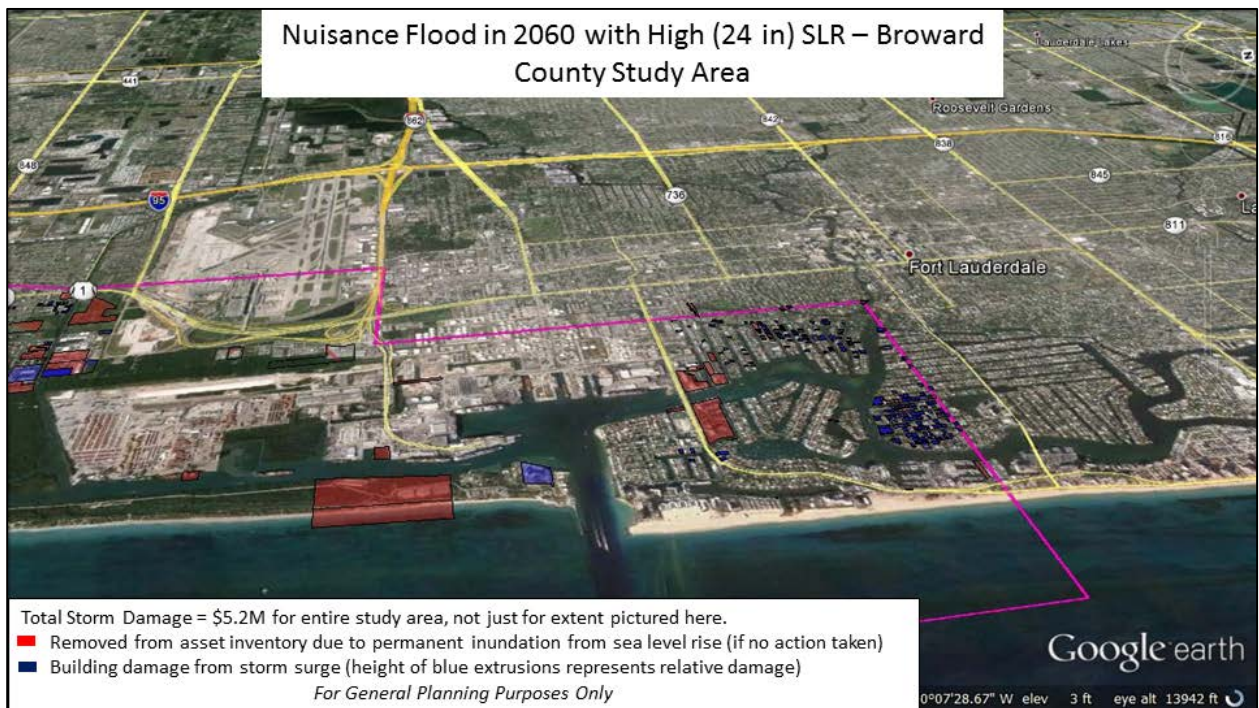




Fig. 8. One-time damage estimate for nuisance flood in 2030 with low sea level rise.



Fig. 9. One-time damage estimate for nuisance flood in 2030 with high sea level rise.





Fig. 10. One-time damage estimate for nuisance flood in 2060 with low sea level rise.



Fig. 11. One-time damage estimate for nuisance flood in 2060 with high sea level rise.

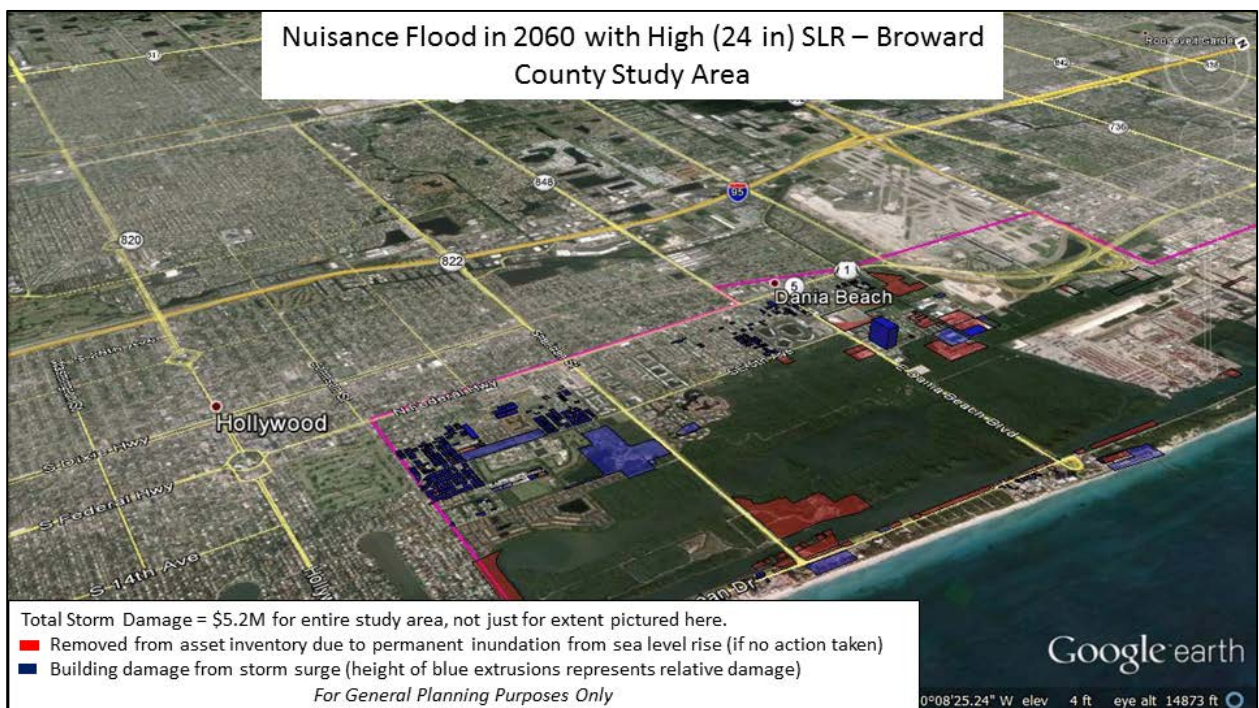




Fig. 12. One-time damage estimate for Hurricane Wilma-size flood in 2030 with low sea level rise.



Fig. 13. One-time damage estimate for Hurricane Wilma-size flood in 2030 with high sea level rise.





Fig. 14. One-time damage estimate for Hurricane Wilma-size flood in 2060 with low sea level rise.

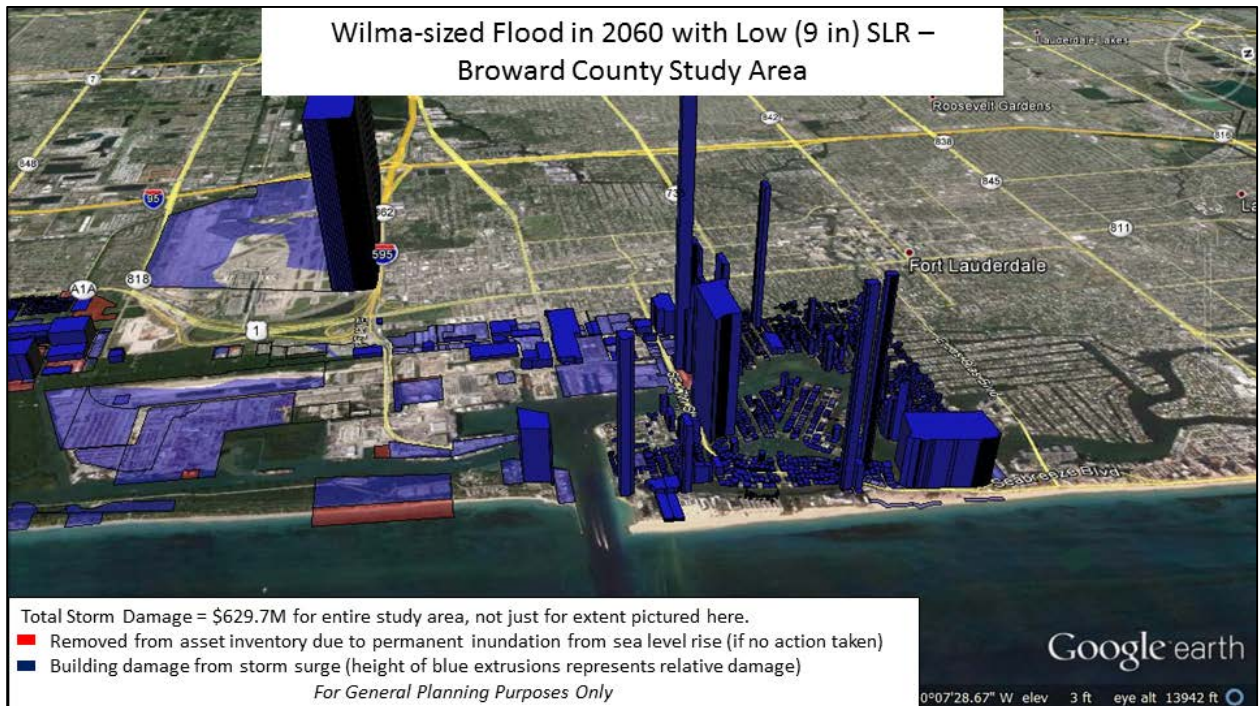


Fig. 15. One-time damage estimate for Hurricane Wilma-size flood in 2060 with high sea level rise.

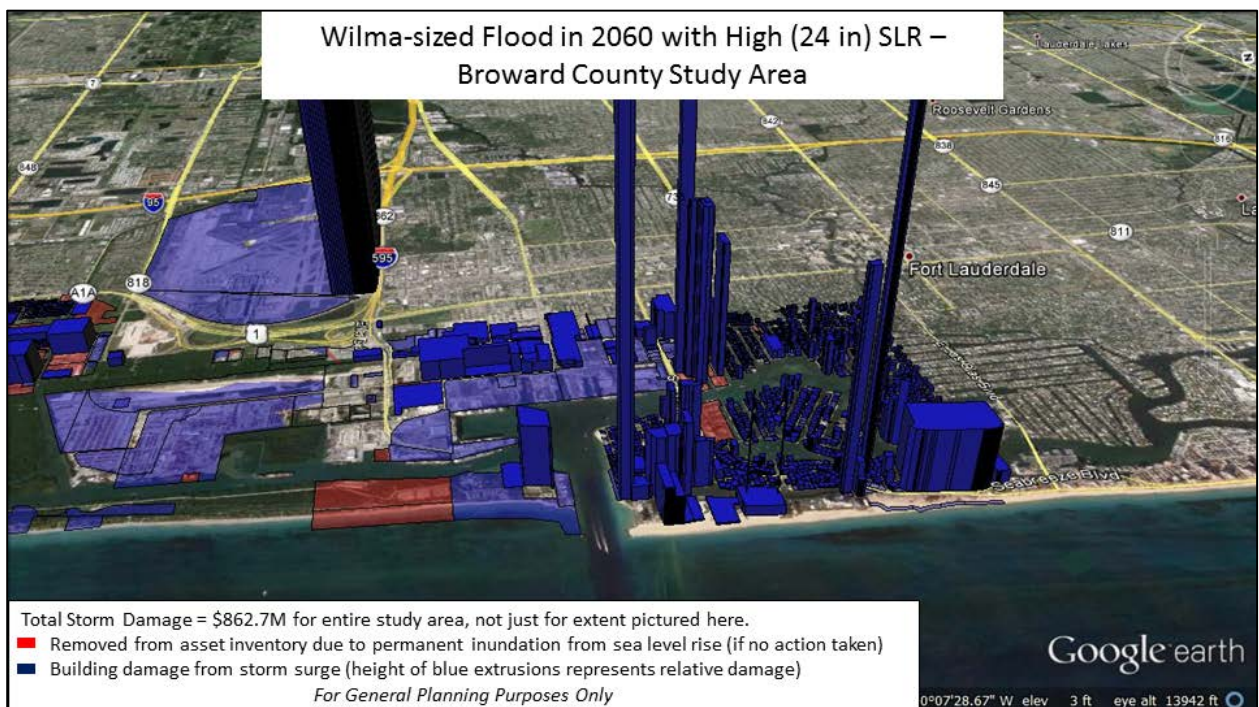
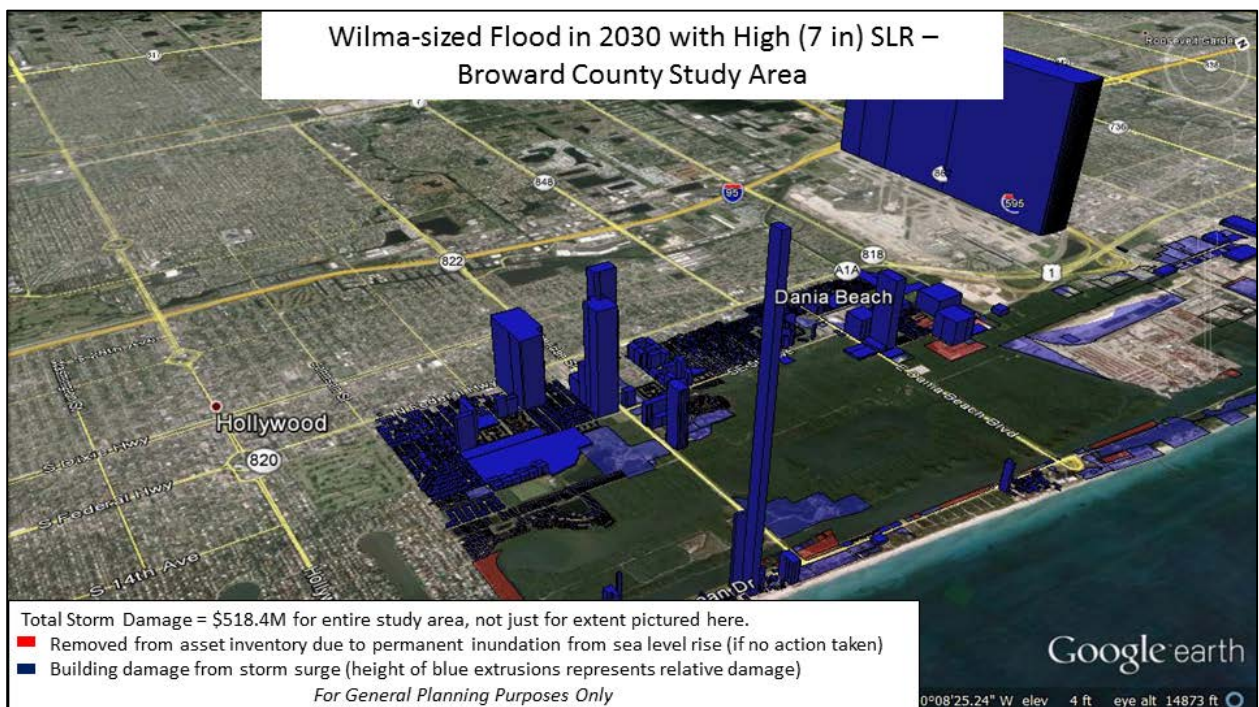




Fig. 16. One-time damage estimate for Hurricane Wilma-size flood in 2030 with low sea level rise.



Fig. 17. One-time damage estimate for Hurricane Wilma-size flood in 2030 with high sea level rise.





**Fig. 18. One-time damage estimate for Hurricane Wilma-size flood in 2060 with low sea level rise.**



**Fig. 19. One-time damage estimate for Hurricane Wilma-size flood in 2060 with high sea level rise.**

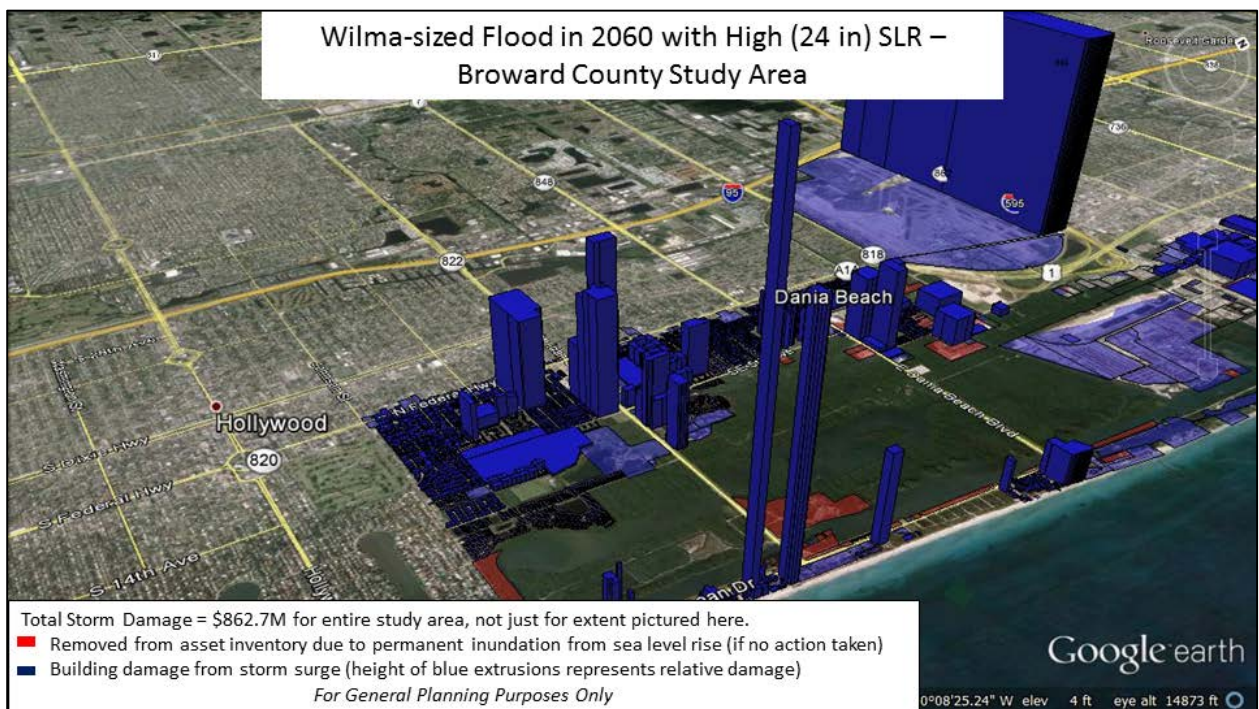




Fig. 20. Non-elevated buildings in FEMA V-Zone (red) and non-floodproofed buildings in FEMA A-Zone (green) – northern section of study area.



Fig. 21. Non-elevated buildings in FEMA V-Zone (red) and non-floodproofed buildings in FEMA A-Zone (green) – southern section of study area.





Fig. 22. Properties permanently inundated by 2030 (red) and 2060 (green) – northern section of study area.

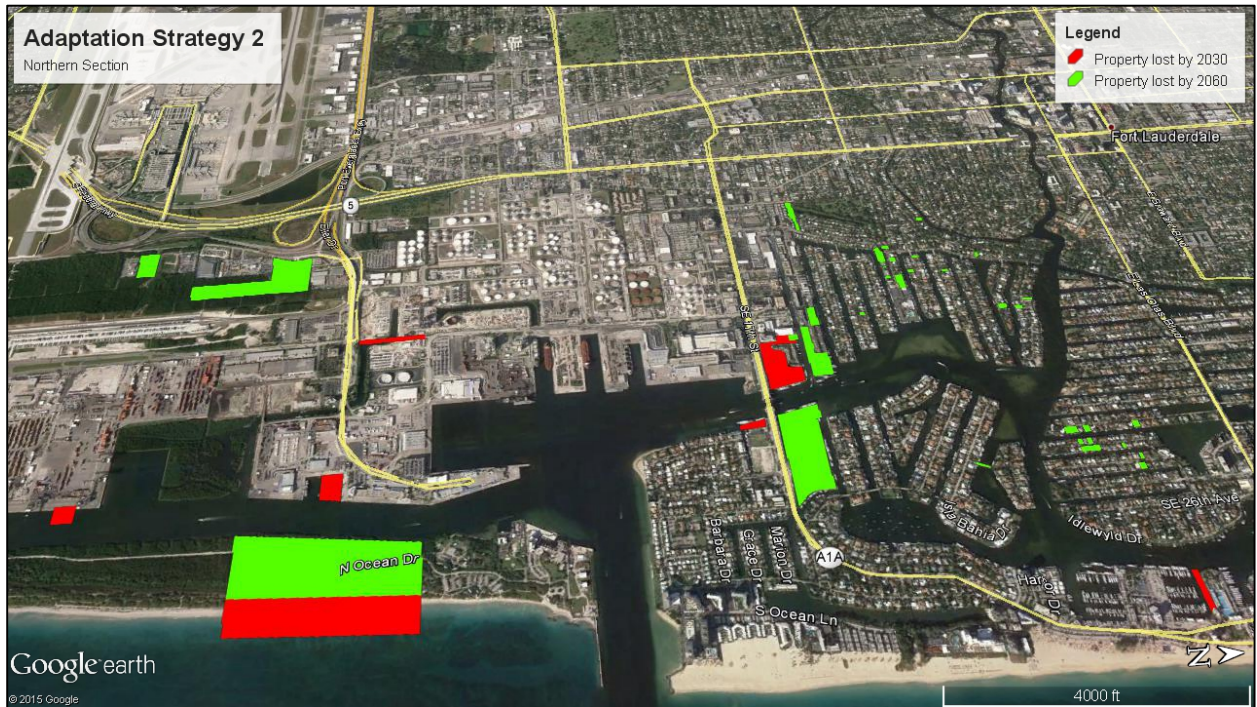


Fig. 23. Properties permanently inundated by 2030 (red) and 2060 (green) – southern section of study area.



# Appendix A

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## Meeting 1 Agenda and Keypad Polling Results

## AGENDA

### **Evaluating impacts of sea level rise and storm surge to buildings in Broward County, and structuring adaptation actions to model.**

29 January 2015

Garfield Community Center: Hollywood Beach, FL

9:00 AM to 3:15 PM

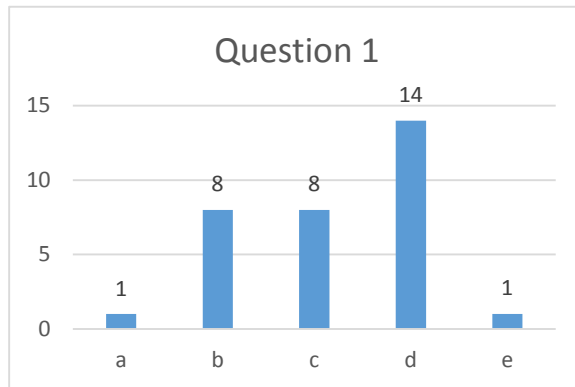
1. Welcome and introductions; Context of this workshop and recent, ongoing, and future adaptation efforts in Broward County – Samantha Danchuk, Broward County (15 min)
2. Summary of the three country Metropole Project; Administration of pre-meeting survey – CJ Reynolds, USF Metropole Project, Jack Kartez, Catalysis (45 min)
3. Overview of the COAST software and approach. How does it work and what were the inputs for this location? - JT Lockman, Catalysis (30 min)
4. 10:30 am - Break (15 min)
5. Results from “no action” COAST model of sea level rise and storm surge scenarios for the Broward County study area, Questions and Answers - JT Lockman, Catalysis (45 min)
6. 12:00 pm LUNCH (45 min)
7. Overview of possible adaptation actions and comparison of their strengths and weaknesses - JT Lockman, Catalysis (25 min)
8. Presentation of two draft adaptation actions for consideration, to help prepare the “action” scenarios to model - JT Lockman, Catalysis (25 min)
9. Breakout Group discussion at two locations to learn about and evaluate details of each draft adaptation option that will be modeled - JT Lockman, Jack Kartez, Catalysis (50 min, 25 minutes for each group on each topic at each location)
10. Keypad polling to vote on/modify details about each candidate adaptation action to model - Jack Kartez, Catalysis (25 min)
11. Decision Assessment Survey; Questions; Next Steps - Jack Kartez, Catalysis, Samantha Danchuk, Broward County (15 min)

## Meeting 1 Keypad Polling Questions

### **Floodproof and Elevate –**

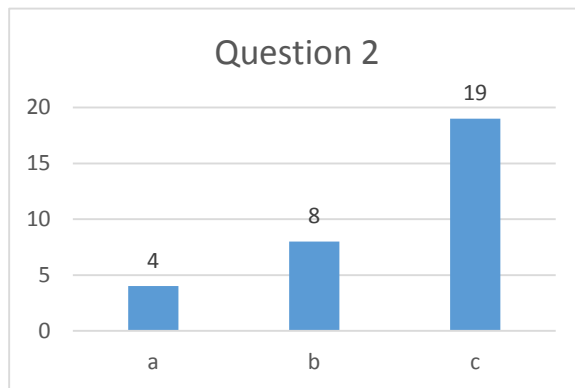
Question 1: If floodplain property owners were offered grants or subsidized loans to elevate their V-Zone properties that currently sit on grade, what percent of these eligible owners in the Broward County Study area do you think would participate?

- a) 0%
- b) 25%
- c) 50%
- d) 75%
- e) The draft input of 100%



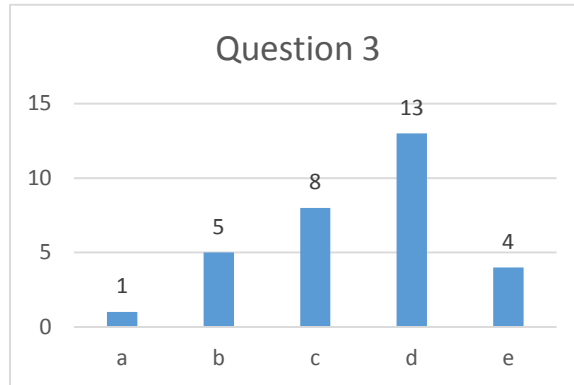
Question 2: FEMA's minimum requirement is that new buildings are required to be elevated to the 100-year flood elevation, which ranges from 5 to 13 feet across the study area. For parcels that will be elevated in the model, do you want them to be elevated up to this code or something higher?

- a) Up to current code
- b) Up to current code plus 1 foot
- c) The draft input of current code plus 2 feet



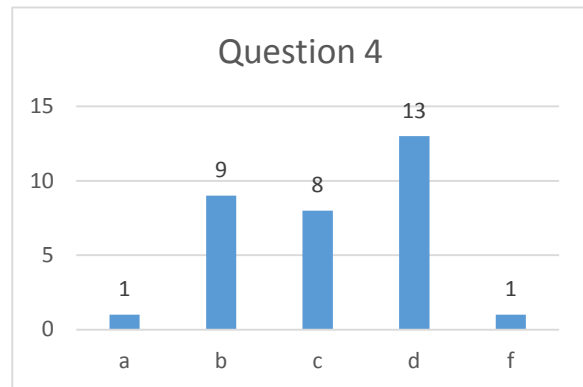
Question 3: If floodplain property owners were offered grants or subsidized loans to floodproof their A-Zone properties, what percent of these eligible owners in the Broward County Study area do you think would participate?

- a) 0%
- b) 25%
- c) 50%
- d) 75%
- e) Draft input of 100%



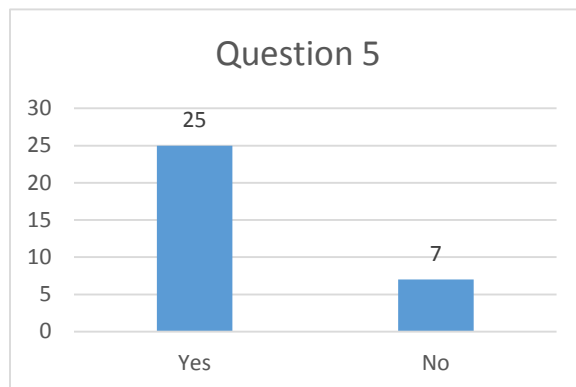
Question 4: If floodplain property owners were offered grants or subsidized loans to floodproof their A-Zone properties, to what height do you think they would install floodproofing protections?

- a) 1 foot
- b) 3 feet
- c) 6 feet
- d) The draft input of 8 feet
- e) Not applicable; I think 0% of owners would accept these offers



Question 5: Should the planning group model this action?

- a) Yes
- b) No

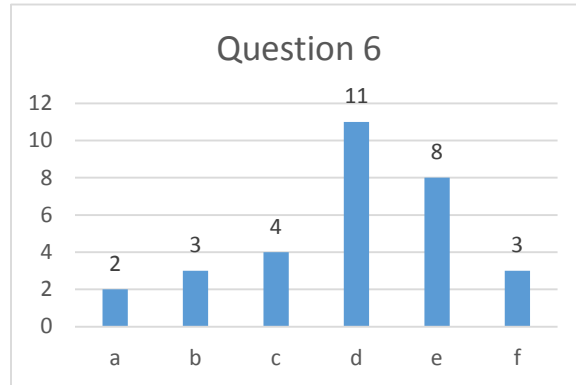




## Relocate Over Time

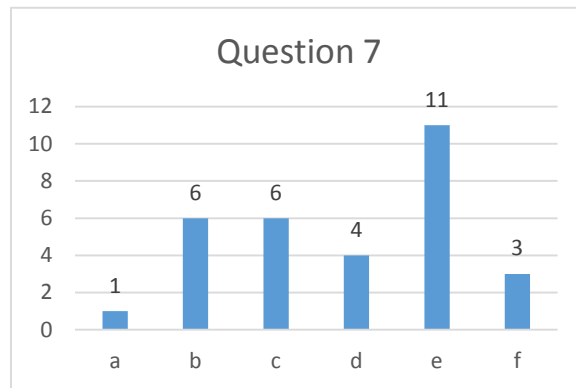
Question 6: If property owners in the Broward County Study area whose lots with buildings were identified as being inundated by sea level rise between now and 2030 could volunteer to accept a buyout, what percent of these eligible owners (illustrated in red) do you think would participate?

- a) 0%
- b) 10%
- c) 25%
- d) 50%
- e) 75%
- f) The draft input of 100%



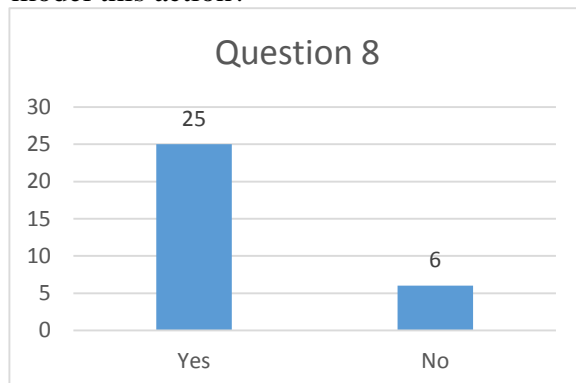
Question 7: If property owners whose lots with buildings were identified as being inundated by sea level rise between 2030 and 2060 could volunteer to accept a buyout, what percent of these eligible owners (illustrated in green) in the Broward County Study area do you think would participate?

- a) 0%
- b) 10%
- c) 25%
- d) 50%
- e) 75%
- f) The draft input of 100%



Question 8: Should the planning group model this action?

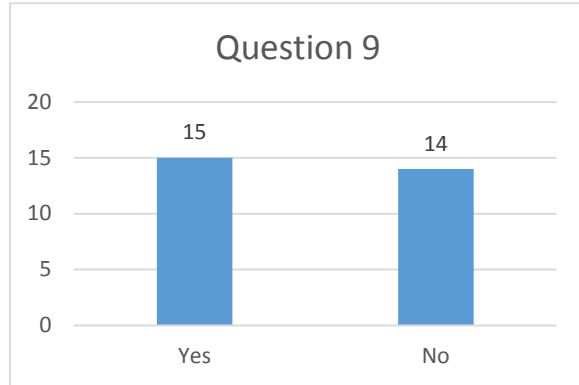
- a) Yes
- b) No



## Future Workshops

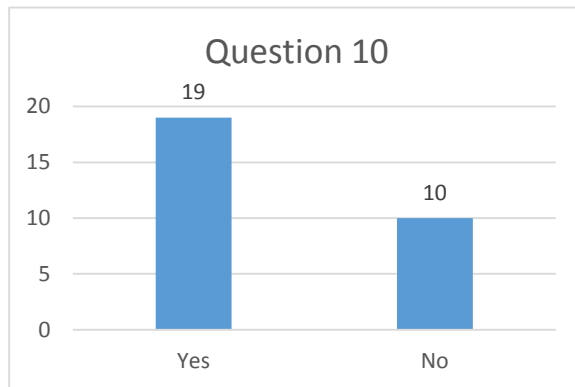
Question 9: Can you attend Workshop #2 on Monday March 16<sup>th</sup> in the morning?

- a) Yes
- b) No



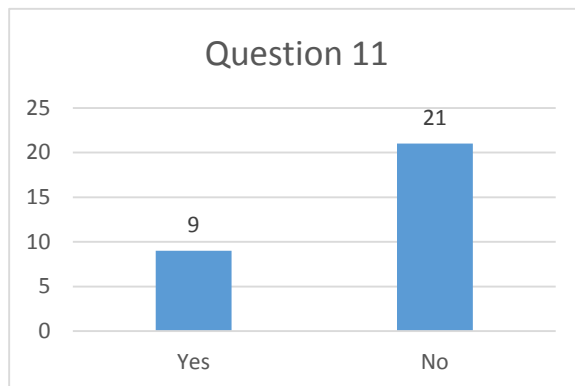
Question 10: Can you attend Workshop #2 on Monday March 16<sup>th</sup> in the afternoon?

- a) Yes
- b) No



Question 11: Can you attend Workshop #2 on Monday March 16<sup>th</sup> in the evening?

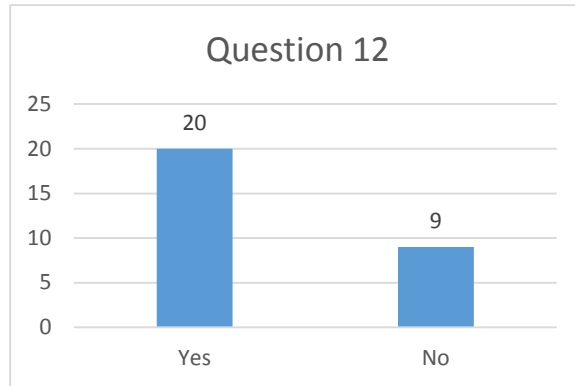
- a) Yes
- b) No





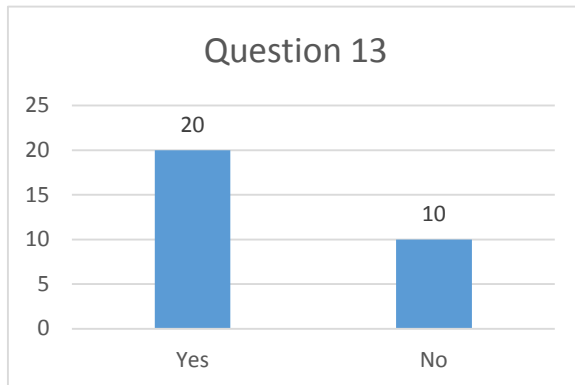
Question 12: Can you attend Workshop #2 on Thursday March 26<sup>th</sup> in the morning?

- a) Yes
- b) No



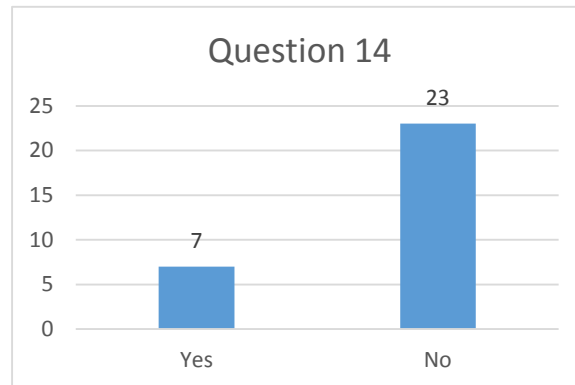
Question 13: Can you attend Workshop #2 on Thursday March 26<sup>th</sup> in the afternoon?

- a) Yes
- b) No



Question 14: Can you attend Workshop #2 on Thursday March 26<sup>th</sup> in the evening?

- a) Yes
- b) No



## **Appendix B**

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### **Meeting 2 Agenda and Keypad Polling Results**

## AGENDA

### **Planning for Sea Level Rise and Storm Surge: Modeling Costs and Benefits for Coastal Broward County**

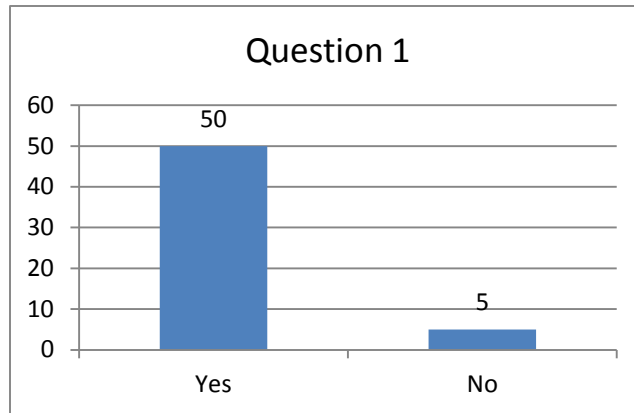
Thursday, March 26th, 2015  
I.T. Parker Community Center  
901 NE 3rd Street, Dania Beach  
9:00 am to 1:00 pm

1. Overview of Project – How Did We Get Here? (Samantha Danchuk, 10 min)
2. Pre-Meeting Survey for Metropole Project (Jack Kartez, CAP, 10 min)
3. What is the COAST Model and What Happened at the First COAST Workshop on January 29th? (J.T. Lockman, CAP, 30 min, Questions 15 min)
  - a) Vulnerability Assessment Inputs
  - b) Model Estimates of Surge Damage
  - c) Discussion of Adaptation Options, and Polling to Refine Modeling Details for Benefit Cost Analysis
4. Break (15 min)
5. Presentation of results from the COAST Model of Two Adaptation Actions – Benefits and Costs of:
  - a) Elevation and Floodproofing; and
  - b) Relocation of Properties Over Time.  
(Lockman, 30 min, Questions 15 min)
6. Discussion Groups: Benefit Cost Analysis Results (Lockman, Kartez 60 min)
7. Keypad polling to vote on attitudes and about each adaptation action, and next steps.  
(Lockman, 30 min)
8. Post-Meeting Survey of Participants for Metropole Project (Kartez, 20 min)

## Meeting 2 Keypad Polling Questions

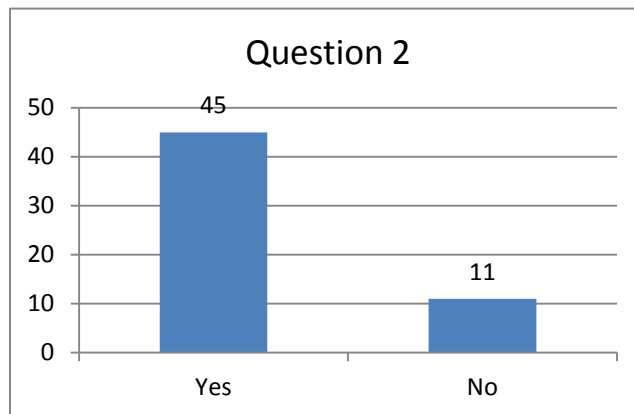
Question 1: Given the results of the COAST model do you think this action deserves further study by Broward County?

- a) Yes
- b) No



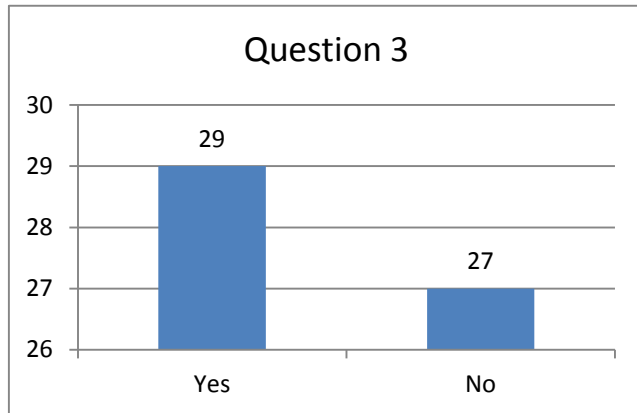
Question 2: Floodproof & Elevate: Do you think Broward County should require elevations of structures in Broward County after they are damaged by more than 50% from a storm surge event to a higher level than the current code requires? (such as the 100-yr flood height as required in most jurisdictions?)

- a) Yes
- b) No



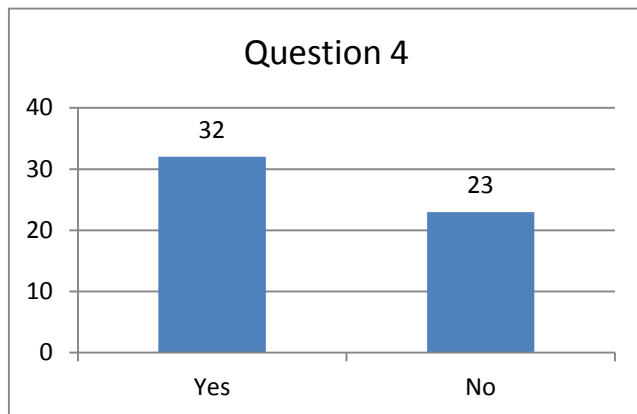
Question 3: Floodproof & Elevate: Do you think Broward County should pursue sources of funding to help private property owners elevate properties located in the FEMA V-Zones as a way to prevent storm surge damage?

- a) Yes
- b) No



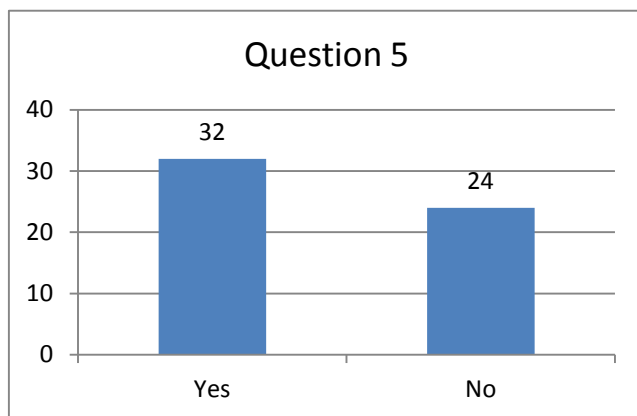
Question 4: Floodproof & Elevate: Do you think Broward County should pursue sources of funding to help private property owners elevate properties located in the FEMA A-Zones as a way to prevent storm surge damage?

- a) Yes
- b) No



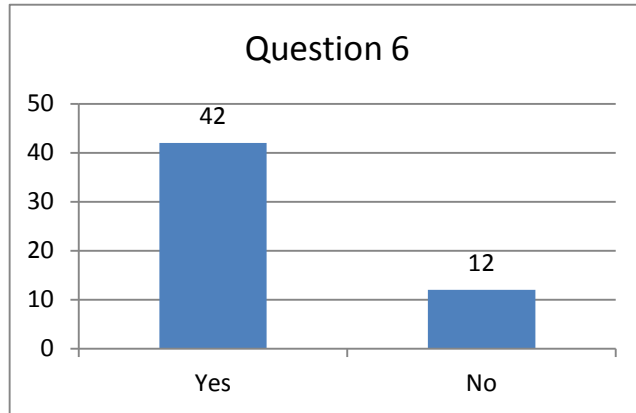
Question 5: Floodproof & Elevate: After looking at the model results and participating in the group discussions of the two actions modeled, do you prefer the “floodproof and elevate” option over “voluntary relocation?”

- a) Yes
- b) No



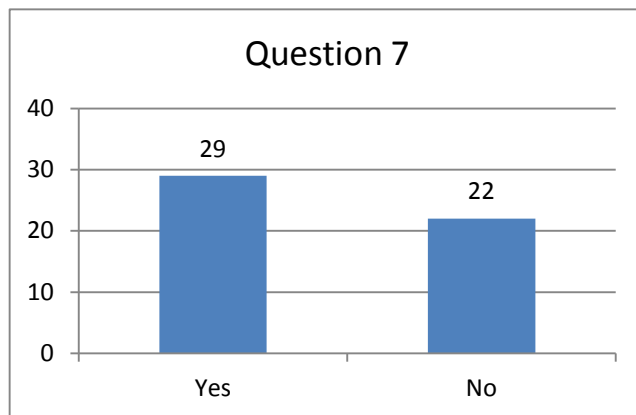
Question 6: Voluntary Relocation: Given the results of the COAST model, do you think this action deserves further study by Broward County?

- a) Yes
- b) No



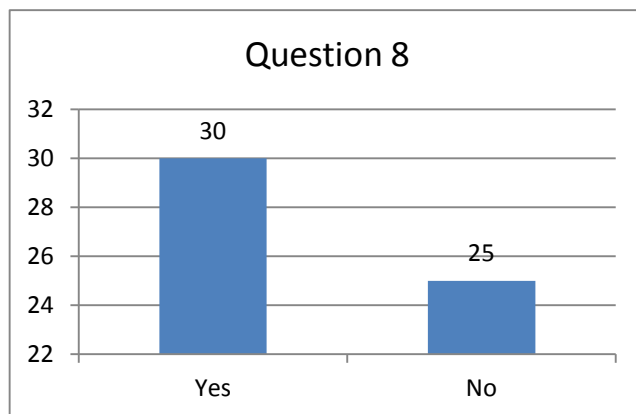
Question 7: Voluntary Relocation: Do you think Broward County should pursue sources of funding to support a voluntary rolling easement purchase program, similar to what was modeled in this study?

- a) Yes
- b) No



Question 8: Voluntary Relocation: After looking at the model results and participating in the group discussions of the two actions modeled do you prefer “voluntary relocation” option over “elevate and floodproofing?”

- a) Yes
- b) No



## **Appendix C**

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### **Pre-Survey (Meeting 1), Post-Survey (Meeting 2), and New Participant Survey (Meeting 2)**



**JANUARY 29, 2015**

Dear Community Leader:

This survey is part of an international research study called METROPOLE: An Integrated Framework to Analyze Local Decision Making and Adaptive Capacity to Large-Scale Environmental Change.

The study is led by the University of South Florida College of Marine Science, and funded by the National Science Foundation. This project is engaging stakeholders in communities in Brazil, the UK, and the US to help understand perceptions about hazards and preferences of adaptation options and funding sources in different communities.

The questions, issues and adaptation options in this survey do not necessarily reflect the views, ideas or plans of Broward County or of the participating cities.

The information derived from the surveys will be shared with you and other community leaders. All responses will be anonymous and held in strict confidence. The data will be reported in an aggregate manner.

Your perspective is very important. Thank you for filling out this survey.





**SECTION 1: YOUR EXPERIENCE WITH HAZARDS**

**1. Which of the following natural hazards that seriously and negatively affected your household or town in the past ten years have you experienced?** (Please circle either or both for each item, or No Experience).

	<b>IMPACTED MY TOWN</b>	<b>IMPACTED MY HOUSEHOLD</b>	<b>NO EXPERIENCE</b>
a. Storm surge	1	2	3
b. Extended flooding	1	2	3
c. High winds in storms	1	2	3
d. Rising sea levels	1	2	3
e. Coastal or beach erosion	1	2	3

**2) How concerned are you that the following natural hazards might seriously and negatively AFFECT YOUR TOWN in the next 10 years in terms of physical and economic damage?** Please circle one answer for each hazard. Scale: 1 = Not concerned to 5 = highly concerned, 9 = Don't Know, 0 = Not Applicable.

	1	2	3	4	5	Don't Know	Not Applicable
a. Storm surge	1	2	3	4	5	9	0
b. Extended flooding	1	2	3	4	5	9	0
c. High winds in storms	1	2	3	4	5	9	0
d. Rising sea levels	1	2	3	4	5	9	0
e. Coastal or beach erosion	1	2	3	4	5	9	0

**3) Thinking about the next 10 years, how concerned are you that these natural hazard may seriously and negatively affect YOUR PRIMARY HOUSEHOLD in terms of physical and economic damage?** Please circle one answer for each hazard. Scale: 1 = Not concerned to 5 = highly concerned, 9 = Don't Know, 0 = Not Applicable.

	1	2	3	4	5	Don't Know	Not Applicable
a. Storm surge	1	2	3	4	5	9	0
b. Extended flooding	1	2	3	4	5	9	0
c. High winds in storms	1	2	3	4	5	9	0
d. Rising sea levels	1	2	3	4	5	9	0
e. Coastal or beach erosion	1	2	3	4	5	9	0

**SECTION 2: QUESTIONS ABOUT POTENTIAL ADAPTATION ACTIONS**

**4. There are a variety of programs and actions a city or county could implement to reduce the potential for physical and economic damage caused by climate-related hazards.** Which planning activities or programs do you think your local government(s) should implement, and when. For each item, please circle a number for the timeframe.

	<b>Now</b>	<b>10 Years</b>	<b>25 Years</b>	<b>100 Years</b>	<b>Never</b>	<b>Unsure</b>
A. Build new or higher seawalls	1	2	3	4	5	6
B. Build levees and use pumps to maintain dry areas	1	2	3	4	5	6
C. Require new buildings to be elevated above minimums required by National Flood Insurance Program to reflect expected local conditions	1	2	3	4	5	6
D. Use innovative or green technology to reduce flooding due to increased rains (ex. permeable surfaces, other storm water management systems)	1	2	3	4	5	6
E. Raise the height of canal flood gates	1	2	3	4	5	6
F. Create a plan to purchase vulnerable land and structures from residents	1	2	3	4	5	6
G. Create a plan to purchase vulnerable land and structures from small businesses	1	2	3	4	5	6
H. Restrict new building in highly vulnerable locations	1	2	3	4	5	6
I. Restrict rebuilding in highly vulnerable areas after major damage has occurred	1	2	3	4	5	6
J. Elevate or harden coastal transportation infrastructure — roads, bridges	1	2	3	4	5	6
K. Relocate vulnerable public facilities such as water and wastewater treatment plants	1	2	3	4	5	6
L. Conserve existing natural areas (such as wetlands or mangroves) to protect coastal areas	1	2	3	4	5	6
M. Restore/increase amount of natural areas (such as wetlands or mangroves) to protect coastal areas	1	2	3	4	5	6
N. Nourish beaches and build dunes	1	2	3	4	5	6
O. Climate proof ongoing infrastructure improvements and development efforts	1	2	3	4	5	6
P. Move public water supply/well fields away from the coast	1	2	3	4	5	6

**SECTION 3: QUESTIONS ABOUT POSSIBLE FUNDING SOURCES**

*Like other large-scale public infrastructure projects, local governments will need to consider new funding sources to implement new hazard protection efforts. The next three questions ask your opinion about funding options.*

**5. Do you agree or disagree with the following statement: Implementing projects to reduce potential impacts of climate-related hazards in our community should be a local or regional government priority, even if it will require a slight increase in taxes or new fees?** (Please circle one answer.)

- 1. Disagree strongly
- 2. Disagree somewhat
- 3. Agree somewhat
- 4. Agree strongly

**6. Please consider the following funding options that local government and agencies could use/offer and tell us whether you think they are acceptable.** Please CIRCLE a number for each funding option. Scale: 1=Not at All Acceptable, 2=SOMEWHAT ACCEPTABLE, 3=MODERATELY ACCEPTABLE, 4=HIGHLY ACCEPTABLE, 5=TOTALLY ACCEPTABLE

	NOT	SOME WHAT	MODER ATELY	HIGHLY	TOTALLY
A. Create a new county-wide resiliency fund based on property taxes	1	2	3	4	5
B. Develop a special district assessment which applies to properties in areas designated as highly vulnerable	1	2	3	4	5
C. Issue a bond (long-term borrowing) to finance public infrastructure improvements	1	2	3	4	5
D. Create a low-interest loan program for flood proofing and elevating residences	1	2	3	4	5
E. Add a flood resiliency surcharge on the monthly water utility bill (ex: specific to storm water drain improvements)	1	2	3	4	5
F. Raise the local sales tax slightly. (options under the law are either ½ cent or 1 cent per dollar.)	1	2	3	4	5

**7. If a referendum was put on the 2016 ballot to create a Community Resiliency Bond (a long-term loan) that would generate \$100 million by 2036 to support multiple adaptation projects, how likely would you be vote for it?** (Please circle one answer.)

- 1. Would not vote for it
- 2. Somewhat likely
- 3. Moderately likely
- 4. Very Likely
- 5. Would vote for it

**SECTION 4. PERSPECTIVES ABOUT ADAPTATION AND ENVIRONMENT**

**8. Some people in your community might NOT want to support local government adaptation plans. What do you think are some the most common reasons for NOT supporting plans?** (Please CIRCLE up to 3 reasons.)

- a. Lack of knowledge/understanding of future hazards and local consequences.
- b. Adaptation actions will need funding – people are generally opposed to new fees and taxes.
- c. Climate change is a distant issue. Other social/economic issues are more important now.
- d. Distrust the media and news reports.
- e. Uncertain about scientific data – no one really knows how bad it will get.
- f. Local government doesn't have technical expertise to solve the problems.
- g. Denial. People don't want to believe their homes will be impacted/don't want to move.
- h. Businesses are concerned about the impact on real estate investments.
- i. Concerns that tourism businesses and jobs will decline.

**9. Are there other reasons why people in your community might NOT support local government adaptation plans? Please tell us your thoughts.**

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**10. People have different views about managing and adjusting to the environment around us. We want to know if you agree or disagree with the views below. Please circle one answer for EACH item. Scale: 1 = Strongly Disagree to 5= Strongly Agree.**

	Strongly disagree	Somewhat disagree	Undecided	Somewhat agree	Strongly agree
A. We are approaching the limit of the number of people the earth can support.	1	2	3	4	5
B. Humans have the right to modify the natural environment to suit their needs.	1	2	3	4	5
C. When humans interfere with nature it often produces disastrous consequences.	1	2	3	4	5
D. Human ingenuity will insure that we do not make the earth unlivable.	1	2	3	4	5
E. Humans are seriously abusing the environment.	1	2	3	4	5
F. Earth has plenty of natural resources if we just learn how to develop them.	1	2	3	4	5
G. Plants and animals have as much right as humans to exist.	1	2	3	4	5
H. The balance of nature is strong enough to cope with impacts of modern industrial nations.	1	2	3	4	5
I. Despite our special abilities, humans are still subject to the laws of nature.	1	2	3	4	5
J. The so-called "ecological crisis" facing humankind has been greatly exaggerated.	1	2	3	4	5

**SECTION 5: DEMOGRAPHIC QUESTIONS**

**11. What is your home zip code or postal code?** \_\_\_\_\_

**12. Please circle the Month and Day you were born.** (We need this to anonymously compare your responses to the second survey at the second meeting.)

Jan Feb March April May June July August  
September October November December  
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19  
20 21 22 23 24 25 26 27 28 29 30 31

**13. What is your gender?** (Please circle one.) female male transgender

**14. How old are you?** (Please circle your age group)

21-25 45-54  
26-34 55-64  
35-44 65+

**15. Do you have children or grandchildren under the age of 18 living with you?** (Please circle one.)

Yes No

**16. What is your race/ethnicity?** (Please circle one.)

Asian Indian/Native-American  
Black/African-American White/Caucasian  
Hispanic/Latino Other \_\_\_\_\_

**17. What was your total household income last year** (the income of yourself and everyone who contributes to your household and lives with you)? Please select one.

- Less than \$20,000
- \$20,000 to \$39,000
- More than \$39,000 up to \$63,000
- More than \$63,000 up to \$102,000
- More than \$102,000 up to \$150,000
- Greater than \$150,000

**18. Do you currently own a home or condo?** Yes\_\_ No\_\_

**19. In politics today, do you consider yourself a Republican, Democrat or Independent or other?** (Please circle one or write in.)

Republican Democrat Independent Other \_\_\_\_\_

**SECTION 5: DEMOGRAPHICS continued.**

**20. What is the highest level of school you have completed?** (Please choose one.)

- DID NOT FINISH HIGH SCHOOL
- HIGH SCHOOL GRADUATE OR GED
- SOME COLLEGE OR ASSOCIATE DEGREE OR TECHNICAL SCHOOL
- 4 YEAR COLLEGE DEGREE (BA, BS)
- POST-GRADUATE DEGREE

**21. Finally, which of the following describes your role in your community AT THIS MEETING?** (Please choose all that apply to you.)

- Elected official (local, state, federal)
- Appointed official (board/task force member)
- Government staff (local)
- Government staff (state, national)
- Represent environment organization
- Represent neighborhood organization
- Represent business organization
- Technical professional (engineer, planner, economist, geologist, etc.)
- Research scientist (university, institute, government)
- Business owner in the local area
- Interested citizen
- Other \_\_\_\_\_

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Thank you for completing this survey.

This information will be very helpful for developing future adaption planning efforts and community outreach and engagement programs.



**March 26, 2015**

**METROPOLE Broward County Stakeholder 2<sup>nd</sup> Survey**

Dear Community Leader:

Thanks for participating in the second Broward County workshop. This is the last survey that is part of an international research study called: METROPOLE: An Integrated Framework to Analyze Local Decision Making and Adaptive Capacity to Large-Scale Environmental Change. The study is led by the University of South Florida College of Marine Science and funded by the National Science Foundation.

The information will help us to understand local perceptions of coastal hazards and preferences for how to develop adaptation actions. The results will be shared with your community, but all individual responses will be anonymous and held in strict confidence. The data collected here will only be reported in aggregate.

The questions, issues and adaptation options in this survey do not necessarily reflect the ideas or plans of Broward County or the cities participating in the today's meeting.

Please be sure to include your zip code and birth day and month, in order for us to match your surveys.

Your perspective is very important. Thank you for filling out this survey before you leave.



**SECTION 1: Matching information**

1. What is your home zip code or postal code? \_\_\_\_\_
2. Please circle the Month and Day you were born. (We need this to anonymously compare your responses to the survey from meeting one.)

Jan Feb March April May June July August  
 September October November December  
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19  
 20 21 22 23 24 25 26 27 28 29 30 31

**SECTION 2: YOUR CURRENT VIEWS ON THE HAZARDS**

3. Thinking about the next 10 years, how concerned are you that these natural hazards may seriously and negatively AFFECT YOUR TOWN in terms of physical and economic damage? Please circle one answer for each hazard.

Scale: 1 = Not concerned to 5 = highly concerned, 9 = Don't Know, 0 = Not Applicable

	1	2	3	4	5	9	0
						Don't Know	Not Applicable
a. Storm surge	1	2	3	4	5	9	0
b. Extended flooding	1	2	3	4	5	9	0
c. High winds in storms	1	2	3	4	5	9	0
d. Rising sea levels	1	2	3	4	5	9	0
e. Coastal or beach erosion	1	2	3	4	5	9	0

4. Thinking about the next 10 years, how concerned are you that these natural hazards may seriously and negatively affect YOUR PRIMARY HOUSEHOLD in terms of physical and economic damage? Please circle one answer for each hazard.

Scale: 1 = Not concerned to 5 = highly concerned, 9 = Don't Know, 0 = Not Applicable

	1	2	3	4	5	9	0
						Don't Know	Not Applicable
a. Storm surge	1	2	3	4	5	9	0
b. Extended flooding	1	2	3	4	5	9	0
c. High winds in storms	1	2	3	4	5	9	0
d. Rising sea levels	1	2	3	4	5	9	0
e. Coastal or beach erosion	1	2	3	4	5	9	0



**SECTION 3: QUESTIONS ABOUT POTENTIAL ADAPTATION ACTIONS**

5. **There are a variety of programs and actions a city or county could implement to reduce the potential for physical and economic damage caused by climate-related hazards. Which planning activities or programs do you think your local government(s) should implement, and when?** For each item, please circle a number for the timeframe.

	Now	10 Years	25 Years	100 Years	Never	Unsure
A. Build new or higher seawalls	1	2	3	4	5	6
B. Build levees and use pumps to maintain dry areas	1	2	3	4	5	6
C. Require new buildings to be elevated above minimums required by National Flood Insurance Program to reflect expected local conditions	1	2	3	4	5	6
D. Use innovative or green technology to reduce flooding due to increased rains (ex: permeable surfaces, other storm water management systems)	1	2	3	4	5	6
E. Raise the height of canal flood gates	1	2	3	4	5	6
F. Create a plan to purchase vulnerable land and structures from residents						
G. Create a plan to purchase vulnerable land and structures from small businesses	1	2	3	4	5	6
H. Restrict new building in highly vulnerable locations	1	2	3	4	5	6
I. Restrict rebuilding in highly vulnerable areas after major damage has occurred	1	2	3	4	5	6
J. Elevate or harden coastal transportation infrastructure — roads, bridges	1	2	3	4	5	6
K. Relocate vulnerable public facilities such as water and wastewater treatment plants	1	2	3	4	5	6
L. Conserve existing natural areas (such as wetlands or mangroves) to protect coastal areas	1	2	3	4	5	6
M. Restore/increase amount of natural areas (such as wetlands or mangroves) to protect coastal areas	1	2	3	4	5	6
N. Nourish beaches and build dunes	1	2	3	4	5	6
O. Climate proof ongoing infrastructure improvements and development efforts	1	2	3	4	5	6
P. Move public water supply/well fields away from the coast	1	2	3	4	5	6

**COAST Meeting #1 Community Chosen Options**

Q. Require buildings (new and rebuilds after storms) in Broward County to be elevated to 100-year flood height plus 3 feet, to protect against a 100-year storm surge plus expected sea level rise	1	2	3	4	5	6
R. Create a plan to purchase vulnerable land and structures predicted to be permanently lost to sea level rise, from property owners in flood zones	1	2	3	4	5	6

**SECTION 4: QUESTIONS ABOUT POSSIBLE FUNDING SOURCES**

*Like other large-scale public infrastructure projects, local governments will need to consider new funding sources to implement new hazard protection efforts. The next three questions ask your opinion about funding options.*

**6. Do you agree or disagree with the following statement: Implementing projects to reduce potential impacts of climate-related hazards in our community should be a local or regional government priority, even if it will require a slight increase in taxes or new fees.** Please circle one answer.

- 1. Disagree strongly
- 2. Disagree somewhat
- 3. Agree somewhat
- 4. Agree strongly

**7. Please consider the following funding options that local government and agencies could use/offer and tell us whether you think they are acceptable.** Please CIRCLE a number for each funding option.

Scale: 1=Not at all Acceptable, 2=Somewhat Acceptable, 3=Moderately Acceptable, 4=Highly Acceptable, 5=Totally Acceptable

	NOT	SOME WHAT	MODE- RATELY	HIGHLY	TOTALLY
A. Create a new county-wide resiliency fund based on property taxes	1	2	3	4	5
B. Develop a special district assessment which applies to properties in areas designated as highly vulnerable	1	2	3	4	5
C. Issue a bond (long-term borrowing) to finance public infrastructure improvements	1	2	3	4	5
D. Create a low-interest loan program for flood proofing and elevating residences as modeled in the COAST analysis	1	2	3	4	5
E. Add a flood resiliency surcharge on the monthly water utility bill (ex: specific to storm water drain improvements)	1	2	3	4	5
F. Create a local optional surtax	1	2	3	4	5
G. Create public funding to buy out at-risk properties in the V-zone as modeled in the COAST analysis	1	2	3	4	5

**8. If a referendum was put on the 2016 ballot to create a Community Resiliency Bond (a long-term loan) that would generate \$100 million by 2036 to support multiple adaptation projects, how likely would you be to vote for it?**

Please circle one answer.

- 1. Would not vote for it
- 2. Somewhat likely
- 3. Moderately likely
- 4. Very Likely
- 5. Would vote for it

**SECTION 5. PERSPECTIVES ABOUT ADAPTATION AND ENVIRONMENT**

9. Some people in your community might NOT want to support local government adaptation plans. What do you think are some of the most common reasons for NOT supporting plans? Please CIRCLE up to 3 reasons.

- a. Lack of knowledge/understanding of future hazards and local consequences.
- b. Adaptation actions will need funding – people are generally opposed to new fees and taxes.
- c. Climate change is a distant issue. Other social/economic issues are more important now.
- d. Distrust the media and news reports.
- e. Uncertain about scientific data – no one really knows how bad it will get.
- f. Local government doesn't have technical expertise to solve the problems.
- g. Denial. People don't want to believe their homes will be impacted/don't want to move.
- h. Businesses are concerned about the impact on real estate investments.
- i. Concerns that tourism businesses and jobs will decline.
- j. None of the above

10. To keep improving the process of community exploration of adaptation choices, please tell us what you think about the information that was presented and discussed today. Please circle a number for each of the following statements on a scale of 1= Strongly disagree, 2=Somewhat disagree, 3= Neutral, 4 = Somewhat Agree, 5= Strongly Agree.

	STRONGLY DIS AGREE	SOME WHAT DISAGREE	NEUTRAL	SOME WHAT AGREE	STRONGLY AGREE
A. The technical information was presented in a clear and understandable manner.	1	2	3	4	5
B. The technical information was credible.	1	2	3	4	5
C. The cost/damage information was credible.	1	2	3	4	5
D. I am more knowledgeable about local risks and impacts of long-term hazards than before the meeting.	1	2	3	4	5
E. I am more knowledgeable about different adaptation options than before the meeting.	1	2	3	4	5
F. I think it is likely that my local government(s) will need to implement some of the adaptation options discussed.	1	2	3	4	5
G. I agree with the group's general judgments about the adaptation options in the group keypad polling.	1	2	3	4	5

11. Please tell us what reasons (i.e., factors, beliefs, information) most influenced your thoughts about supporting or not supporting the adaptation options presented at the workshop. Write your comments in the box or on the next page if needed.

12. Lastly, please help us understand what you/your organization might do with this information in the next three months. Circle ALL that apply.

1. Share information with community members at next neighborhood or homeowner association meeting.
2. Contact my local elected official to inquire about existing plans and ask that attention be given to this issue.
3. Schedule departmental or interagency meetings to discuss information and determine next steps.
4. Schedule meeting with my leadership/senior management to discuss information and determine next steps.
5. Conduct an internal review of plans and budgets.
6. Update/incorporate information into existing plans.
7. None of the above/Other\_\_\_\_\_

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Thank you for completing this survey.

This information will be very helpful for developing future adaption planning efforts and community outreach and engagement programs.



# METROPOLE

Dear first-time attendees:

Attendees at the first COAST Workshop (January 29) completed a survey on coastal hazards and possible adaptation actions. Since this is your first time attending a COAST workshop, we ask that you complete the brief background questionnaire below. This information will be used as part of an international research study called: METROPOLE: An Integrated Framework to Analyze Local Decision Making and Adaptive Capacity to Large-Scale Environmental Change. This effort is exploring new ways to encourage deliberation about coastal adaptation and provide information to local government. The purpose of this research is to help understand how adaptation choices are viewed and what approaches to funding them are preferable in this region. Our study involves your community as well as communities in Brazil and England. It is led by the College of Marine Science at the University of South Florida and supported with funding by the National Science Foundation and research agencies in England and Brazil.

Everyone here today will also help us by completing a post-workshop survey. All individual responses will be anonymous and held in strict confidence. The data will only be reported in aggregate. The results of our research will be shared with your communities.

Thank you for completing this survey as we get started today.

## BACKGROUND QUESTIONS FOR ALL PARTICIPANTS

1. Which of the following natural hazards that seriously and negatively affected your household or town in the past ten years have you experienced? (Please circle either or both for each item, or No Experience).

	IMPACTED MY TOWN	IMPACTED MY HOUSEHOLD	NO EXPERIENCE
a. Storm surge	1	2	3
b. Extended flooding	1	2	3
c. High winds in storms	1	2	3
d. Rising sea levels	1	2	3
e. Coastal or beach erosion	1	2	3

**2. People have different views about managing and adjusting to the environment around us.** We want to know if you agree or disagree with the views below. Please circle one answer for EACH item. Scale: 1 = Strongly Disagree to 5= Strongly Agree.

	STRONGLY DISAGREE	SOMEWHAT DISAGREE	UNDECIDED	SOMEWHAT AGREE	STRONGLY AGREE
A. We are approaching the limit of the number of people the earth can support.	1	2	3	4	5
B. Humans have the right to modify the natural environment to suit their needs.	1	2	3	4	5
C. When humans interfere with nature it often produces disastrous consequences.	1	2	3	4	5
D. Human ingenuity will insure that we do not make the earth unlivable.	1	2	3	4	5
E. Humans are seriously abusing the environment.	1	2	3	4	5
F. Earth has plenty of natural resources if we just learn how to develop them.	1	2	3	4	5
G. Plants and animals have as much right as humans to exist.	1	2	3	4	5
H. The balance of nature is strong enough to cope with impacts of modern industrial nations.	1	2	3	4	5
I. Despite our special abilities, humans are still subject to the laws of nature.	1	2	3	4	5
J. The so-called "ecological crisis" facing humankind has been greatly exaggerated.	1	2	3	4	5

**3. What is your home zip code or postal code? \_\_\_\_\_**

**4. Please circle the Month and Day you were born.** (We need this to anonymously match the questions here to the survey you'll complete this afternoon)

Jan Feb March April May June July August  
September October November December

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19  
20 21 22 23 24 25 26 27 28 29 30 31

**5. What is your gender?** (Please circle one.) female male transgender

**6. How old are you?** (Please circle your age group)

21-25 45-54  
26-34 55-64  
35-44 65+

**7. Do you have children or grandchildren under the age of 18 living with you?** (Please circle one.)

Yes No

8. **What is your race/ethnicity?** (Please circle one.)

Asian

Black/African-American

Hispanic/Latino

Indian/Native-American

White/Caucasian

Other \_\_\_\_\_

9. **What was your total household income last year** (the income of yourself and everyone who contributes to your household and lives with you)? Please select one.

- Less than \$20,000
- \$20,000 to \$39,000
- More than \$39,000 up to \$63,000
- More than \$63,000 up to \$102,000
- More than \$102,000 up to \$150,000
- Greater than \$150,000

10. **Do you currently own a home or condo?** Yes\_\_ No\_\_

11. **In politics today, do you consider yourself a Republican, Democrat, Independent or other?** (Please circle one or write in.)

Republican

Democrat

Independent

Other \_\_\_\_\_

12. **What is the highest level of school you have completed?** (Please choose one)

- DID NOT FINISH HIGH SCHOOL
- HIGH SCHOOL GRADUATE OR GED
- SOME COLLEGE OR ASSOCIATE DEGREE OR TECHNICAL SCHOOL
- 4 YEAR COLLEGE DEGREE (BA, BS)
- POST-GRADUATE DEGREE

13. **Finally, which of the following describes your role in your community AT THIS MEETING?** (Please choose all that apply to you.)

- Elected official (local, state, federal)
- Appointed official (board/task force member)
- Government staff (local)
- Government staff (state, national)
- Represent environmental organization
- Represent neighborhood organization
- Represent business organization
- Technical professional (engineer, planner, economist, geologist, etc.)
- Research scientist (university, institute, government)
- Business owner in the local area
- Interested citizen
- Other \_\_\_\_\_

**Thank You. Please hold on to this survey—we will collect it at the end of the workshop.**