Interim Report:

Survey and Investigation of Buildings Damaged by Category III Hurricanes in FY 2016-17 – Hurricane Mathew 2016

Submitted to:

Florida Department of Business and Professional Regulation

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1 INTRODUCTION

The documentation of hurricanes making landfall in the State of Florida should include both a direct quantification of ground level wind speeds and an assessment of the resultant damage to the nearby infrastructure. Ongoing research through the Florida Coastal Monitoring Program evaluates the characteristics of near-surface wind speeds in land-falling hurricanes, but there is potential to relate these measured wind speeds to local infrastructure and close the loop in the study of wind-structure interaction. The Florida Building Commission provided partial support to University of Florida faculty, staff and students for documenting residential infrastructure performance after hurricane landfalls in Florida during FY2016-2017.

This interim report provides the original statement of work for the project. A summary of Hurricane Matthew and its impact on the Florida coastline is provided in Section 3. The impact of Hurricane Matthew led to a revised statement of work, involving social scientist from Carnegie-Mellon University, which is described in Section 4. The status of the ongoing tasks, and timeline for remaining tasks, are provided in Sections 5 and 6.

2 ORIGINAL STATEMENT OF WORK

The original statement of work for the FY2016-2017 project is provided below:

- Maintain data collection and transport equipment as necessary for measuring intensity of land-falling hurricanes and documenting damage
- Conduct one deployment training exercise (Thunderbolt Drill) in the field to ensure personnel are familiarized with wind monitoring equipment and data collection procedures
- Perform field data collection preparation to include: purchase and organize data collection and recording equipment; documenting equipment and software for database construction
- Deploy wind monitoring assets in the event of a land-falling hurricane
- Provide an initial triage assessment of damage to the residential infrastructure
- Organize a formal damage assessment effort if directed by the Program Manager

A damage assessment deployment would occur if a Saffir-Simpson Hurricane Wind Category III, IV or V storm made landfall in Florida or caused sustained wind speeds over land in Florida estimated as > 110 mph. A damage assessment deployment could also be requested by the FBC staff for a Category II hurricane.

3 HURRICANE MATTHEW (OCTOBER 2016)

The near landfall storm track of Hurricane Matthew on 9 October 2016 subjected several coastal communities along Florida's east coast to wind speeds of 70-80 mph, and although this was not a design-level event, several houses experienced wind damage as a result. A team from the Wind Hazard Damage Assessment Group at the University of Florida deployed within 18 hours to document the performance of houses in two communities of Flagler Beach and Marineland in Flagler County, FL. The UF Team surveyed nearly 100 houses, noting that approximately 20% of them suffered some roof cover and wall cladding damage, two houses had broken windows and approximately 10% had minor flashing damage and failures. The Team did not observe any structural failures. A detailed report on the survey and findings is provided in Appendix A. Figure 1 provides an aerial view identifying the locations of damaged homes in the survey region of Flagler Beach.

Figure 1: Aerial imagery of surveyed homes in Flagler Beach, FL obtained using the UAV.

A limitation of this preliminary study was that forensic observations were only done visually by investigators looking at the houses from the street or public thoroughfare, and by using a UAV-mounted high-resolution camera. As a result, no information could be collected on extent of interior damage (water damage) or whether damage was present on other building elevations that were not visible from the street. Further, since the UF Team conducted their inspections before the evacuated residents were allowed back onto the communities it was not possible to question them regarding their experience.

The two communities we surveyed represented two different styles of subdivisions that are commonly seen in Florida. The Flagler Beach community consists of mixed-age residential structures, constructed over about 70 years from 1950 through present. Many of the Flagler Beach houses are located within dense tree canopies. The houses at the second site in Marineland were built within the last 2 to 3 years. This neighborhood consists of a gated community in which all homes were relatively new (less than two years old) and they all appeared to be designed in accordance with the 2012 Florida Building Code. While we know that few homeowners take adaptive measures to enhance their resilience to high impact storm events voluntarily (Kunreuther 1996) and they are often underprepared once disaster strikes (Donahue 2014), those with recent direct experience are more open to taking such protective measures to meet future risk (Bubeck et al. 2012). Therefore, Hurricane Matthew offers a unique opportunity to evaluate and design policy and behaviorally realistic communication interventions that will most effectively encourage residents to take those adaptation measures that result in less damage to property, loss of life and longer-term disruptions to communities.

4 SUPPLEMENTAL STATEMENT OF WORK

At the request of FBC staff, the UF team proposed to follow up on the initial damage assessment by conducting interviews with members of the Flagler Beach and Marineland, FL communities instead of a more extensive assessment of physical damage. The supplemental project is entitled "*Comparison of Hurricane Matthew Damage Patterns for Two Coastal Communities and Homeowner/Occupant Survey on Risk Perceptions, Mitigation and Evacuation".* The additional project tasks include the following:

- Conduct interviews with approximately 20 homeowner/occupants to supplement the UF Team's preliminary database of exterior damage. Interviews will enable the Team to gather data interior damage, and specific information on components damages and overall economic loss (including deductibles) data for the homes that experienced damage.
- Conduct interviews of approximately 20 additional homeowner/occupants of an adjacent (undamaged) single-family residences to determine the extent of hidden damage (if any) that the UF Team was unable to observe during their preliminary damage survey.

For this additional scope of work, we have included on the team Dr. Gabrielle Wong-Parodi from Carnegie-Mellon University. Dr. Wong-Parodi focuses on applying behavioral decision research to promote environmental sustainability and community resilience, and has authored or co-authored more than 30 peer-reviewed journal publications on this topic. Her expertise in capturing community risk perceptions through open-ended interviews is perfectly suited to the objectives of this project. Dr. Wong-Parodi will train and advise the engineering team in conducting the in-person interviews, and will assist with analyzing the gathered data and placing it in proper context within the current body of knowledge available in the peer-reviewed literature.

The anticipated findings from this additional work will initiate further longitudinal studies on homeowner relationship to hurricane damage, repair and retrofit, and evacuation that will ultimately result in better policy and communication strategies that encourage residents to take adaptation measures. The outcome of such work will be decision aids such as the one created by Carnegie-Mellon University for coastal communities at risk for sea level rise. This decision aid relied upon basic research to understand the public's perceptions of sea level rise and flood risk on the US East Coast, and was shown to increase intention to prepare by providing people with realistic options for adaptation (Bruine de Bruin et al. 2014; Wong-Parodi et al. 2014).

4.1 Institutional Review Board

Any research involving human subjects is required to have approval from the Institutional Review Board (IRB). The IRBs review such research to ensure that the welfare and rights of the subjects are protected in accordance with federal regulations. The University of Florida has three IRBs, which review specific types of research from clinical trials to surveys. UF IRB 02 reviews social, behavioral, and educational research and other research involving surveys, which is most closely aligned with the current project. Descriptions of the research project objectives and personnel, the interview protocol, and the recruitment material were all submitted to UF IRB 02 through an online interface for review by the board.

On 28 March 2017, we received approval for IRB201700282 to conduct the research project under by the Dr. Ira Fischler, Chair of IRB-02. The study was granted exempt status because it poses minimal risk to the participants.

4.2 Interview Protocol and Internal Review Board Approvals

Interviewees will be recruited from homes identified with visible damage from the on-site assessment, and an adjacent (or nearby) residence. The interviews will consist of open-ended questions on topics such as the performance of the home during Hurricane Matthew, incurred damage and losses, understanding of the risk, perceptions about future preparedness, demographics, and impacts of Hurricane Matthew on emotional, physical and financial well-being. The interview protocol will include gathering information on the house itself, such as distance from the shoreline, age, roof shape, number of stories, materials, applicable building code, presence of retrofits, etc. The draft interview protocol is provided in Appendix B.

4.3 Recruitment

A recruitment flyer has been created and will be mailed to each of the targeted residents. The recruitment flyer briefly describes the research objectives of the study and invites those interested in participating to contact the research team via phone or email. Participants are offered $40 in compensation for taking part in the interview, which is expected to require an hour of the interviewee's time. The draft recruitment flyer is provided in Appendix C. As an exempt approved study, no approval stamp was placed on the consents, fliers, emails or any other recruitment document.

5 SUMMARY OF PROGRESS

- A conference call was held on January 16th with PI David O. Prevatt (University of Florida), co-PI Gabrielle Wong-Parodi (Carnegie-Mellon University) and David B. Roueche (University of Florida) to coordinate drafting of the interview protocol and submitting to the Institutional Review Board (IRB) for review at the respective institutions.
- A draft interview protocol was written under guidance of co-PI Wong-Parodi, detailing the general structure of the interview and the specific questions to be asked. The interview style utilizes open-ended questions that invite the interviewee to share their thoughts on specific topics in a conversational style.
- University of Florida faculty, staff and students involved in the process completed training requirements necessary for submitting an IRB. Carnegie-Mellon University staff already possessed the required training certifications.
- The interview protocol, including project description and recruitment documents, was submitted to the IRB for review. The protocol has been approved by the Carnegie-Mellon University IRB committee and the University of Florida IRB committee as of 28 March 2017. The confirmation letter from the University of Florida is provided in Appendix D.

6 TIMELINE FOR REMAINING TASKS

Table 1 provides the estimated timeline for the remaining tasks. We anticipate the project being completed within the project timeframe without delays.

Table 1: Timeline for remaining project tasks

Task	**Completion Date**
Mail recruitment flyers	4/14/2017
Follow-up with phone calls to coordinate interview dates and locations	4/21/2017
Conduct interviews	5/6/2017
Transcribe interview responses	5/14/2017
Analyze interview responses	6/1/2017
Draft final report	6/15/2017

7 REFERENCES

Bruine de Bruin, W., Wong-Parodi, G., and Morgan, M. G. (2014). "Public perceptions of local flood risk and the role of climate change." *Environment Systems and Decisions*, 34(4), 591-599.

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Kunreuther, H. (1996). "Mitigating disaster losses through insurance." *Journal of Risk and Uncertainty*, 12(2), 171-187.

Wong-Parodi, G., Fischhoff, B., and Strauss, B. (2014). "A method to evaluate the usability of interactive climate change impact decision aids." *Climatic Change*, 126(3-4), 485-493.

Appendix A. UF WHDAG Hurricane Matthew Damage Assessment

Background

Hurricane Matthew became the 13th named storm of 2016 in the Atlantic season on September 28th, reaching maximum wind speeds on October 1st of 160 mph, making Matthew the first Category 5 hurricane of the season, and the first since Hurricane Felix in 2007. Hurricane Matthew first made landfall in Haiti on October 4th as a Category 4 storm, and leaving widespread destruction in its wake. The storm continued through the Caribbean, affecting Cuba and The Bahamas before skirting the coast of Florida and Georgia as a Category 3 hurricane on October 7th, and finally making landfall as a Category 1 hurricane near McClellanville, South Carolina on October 8th.

Hurricane Matthew caused catastrophic damage across vast swathes of Haiti, and greatly impacted both Cuba and The Bahamas. Loss of life and property were widespread in Haiti, as sadly over 1,000 people have been reported as killed by Hurricane Matthew, and a growing humanitarian crisis is still ongoing, as the Haitian people lack access to clean water, food, and shelter, causing a significant cholera outbreak that has yet to be contained.

Matthew approached the Eastern Seaboard as a Category 3 hurricane, where the eye of the storm passed within 12 miles of Melbourne, Florida with sustained wind speeds of 130 mph on October 6th. Matthew continued to skirt the First Coast, causing historic flooding among Northeast Florida. A record storm surge of 9.88 feet was recorded in Fernandina Beach, Florida on October 7th, just 35 miles North of Jacksonville. Mandatory evacuations were ordered for many parts of Jacksonville and all areas of downtown St. Augustine and the intercoastal along the First Coast. Bridges to the intercoastal were closed after evacuations were completed and blockaded by the National Guard until the storm had moved further North on October 8th.

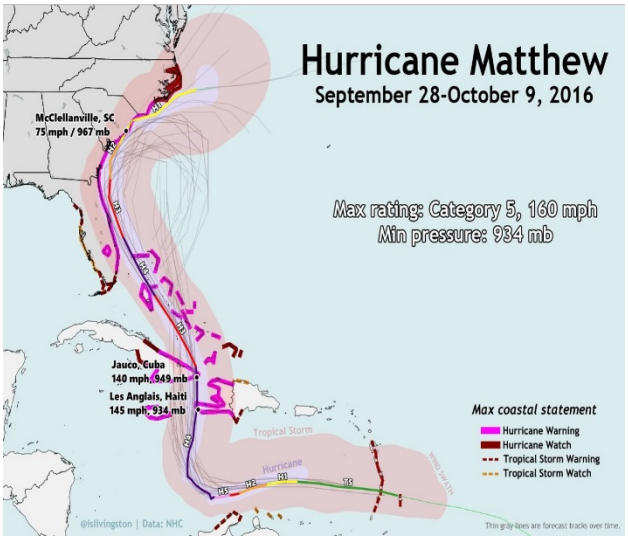


Figure A-1: Hurricane Matthew track

As Matthew continued up the coast, the storm steadily weakened as wind speeds dropped, however the downpour continued, causing erosion along hundreds of miles of beaches.

In total, flooding and significant storm surges were seen throughout Florida, Georgia, and the Carolinas. Hurricane Matthew dropped nearly 15 inches of rain in Goldsboro and Fayetteville, North Carolina as well as over a foot of rain in other areas of South Carolina and Virginia before turning out to sea on October 9th.

All told, Hurricane Matthew claimed at least 36 lives in the United States, and over 1,000 lives in total through its 10 days as a hurricane. The damage and loss of life associated with Matthew is tragic in any regard, however it should be noted that thanks to a slight eastern shift as the storm passed over the Bahamas, the storm caused much less damage than had been expected, a very welcome and thankful development for citizens along the coastline. Even though Matthew shifted slightly to the east, the estimated insured costs are still between $4 billion to $6 billion according to the consulting firm CoreLogic's report on Hurricane Matthew damages sourced from their website, www.corelogic.com, coming from both storm surge and wind damage. CoreLogic's analysis also stated that of these damages, roughly 90% would be from wind damage, whereas the other 10% would come from the storm surge. With the vast majority of losses occurring due to wind damage, it is without doubt that greater adoption of wind mitigation methods would have been able to reduce the amount of damages caused by Hurricane Matthew.

Figure A-2: Damage to A1A in Flagler Beach, FL

WHDAG Deployment Overview

On October 8th, the Wind Hazard Damage Assessment Group at the University of Florida, led by Dr. David Prevatt, left for Flagler Beach, Florida. Upon arriving, the WHDAG conducted damage assessments in two distinct areas, the 1400 block from A1A to Flagler St. in Flagler Beach, FL and a newly built community in Marineland, approximately 15 miles to the north. These two areas were distinctly different due to the age of the houses within; the Marineland subdivision was all post-2015 construction, whereas the average house in the Flagler Beach area was built between 1970 – 1990, as per the Flagler County Tax Assessors Office. The objective was to investigate regions along the Florida coast that experienced hurricane strength winds, demonstrate survey methodologies with the assistance of a UAV and the Survey123 smartphone app, and to provide a recommendation for a full assessment.

Methodology

The WHDAG utilized a new methodology for data collection in the wake of Hurricane Matthew which incorporated the latest technology in hopes to demonstrate improvements in the efficacy, reliability, and speed of data collection in the hours after a natural disaster.

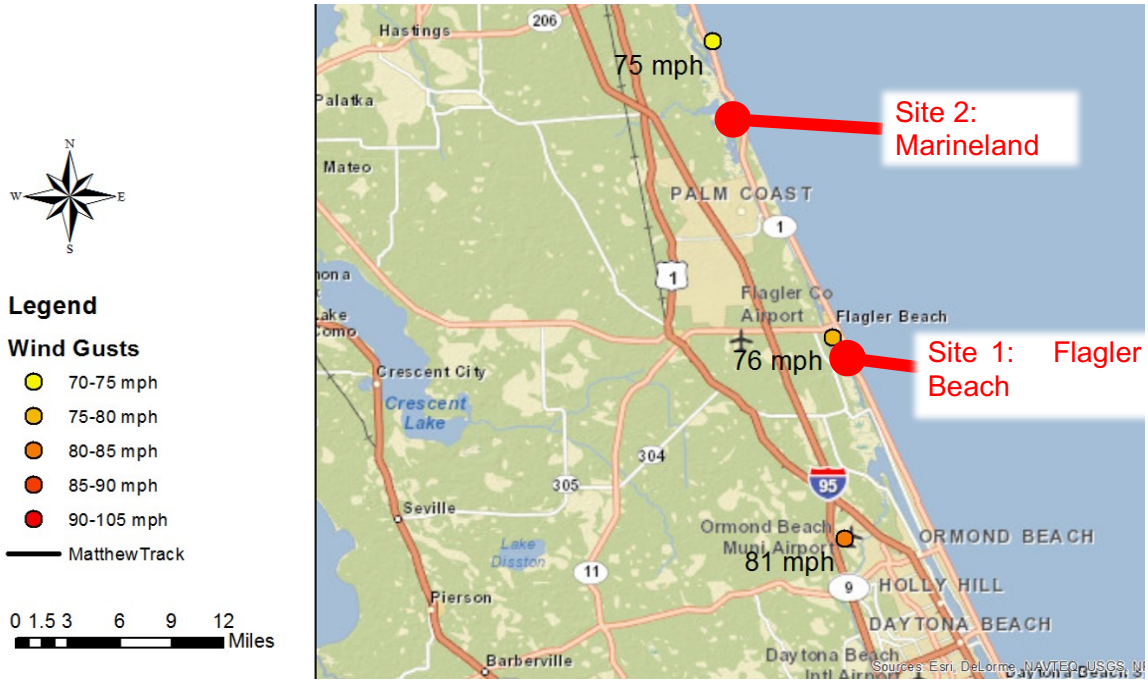
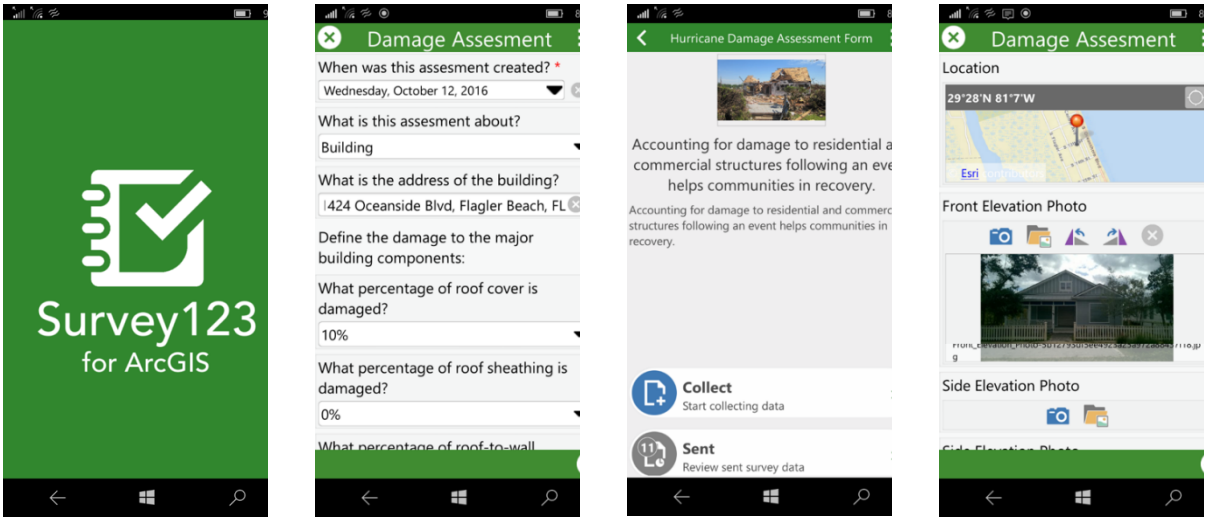


Figure A-3: Locations of Surveyed Sites with Measured Wind Speeds

Assisted by Kwasi Perry, owner and operator of UAV Survey Inc., the group used high-res aerial images alongside a novel smartphone app called Survey123 to collect data on 90

residential structures, 44 in Flagler beach, and 46 in Marineland. The UAV took 581 high resolution photos, with an imagery pixel size of 5 cm. The quad copter UAV flew at an altitude around 220 feet, with a velocity of 30 MPH. The smartphone app, named Survey123 for ArcGIS, was developed by esri™ as an "intuitive data gathering solution that makes creating, sharing, and analyzing surveys possible in just three steps." The WDHAG expected to see that utilizing the UAV along with the Survey123 app would greatly increase the quantity of data, and the quality of data, in less time than previous survey methods. This damage assessment served as a "pilot run" for this methodology, and the results gathered will be used to evaluate its performance across all aspects, from the UAV to the software used by the app, to debugging of the Survey123 app itself.

As shown in the screenshots in Figures A-4, the team deployed a survey form on the app to have 13 fields to input damages, 7 spots for photos from street level, and built in location redundancy where you can input both the street address and geotag each photo using the location feature on the smartphone.



Figures A-4: From left to right: a) Load screen b) Damage Assessment c) Survey Page d) Location/Images

For each home assessed, the user input values for damages of varying degrees to the different components of the roof and walls of the home. At the same time, the user used the camera built into the phone to snap pictures of the house from every possible elevation, and at the end was able to save the survey so it could be uploaded to a central database after the collection had ended. As seen in Figure A-5, after all the data for one site had been uploaded the user can see on a map where the geotagged locations are, and in the table in the bottom of the

image, characteristics of each individual survey. Finally, in the bottom right images of the specific house the user is interested in are shown so that the physical damage, if any, can be shown visually.

This user interface allows the user to scan the overall region of the survey and be able to quickly see the damage assessment and photos associated with any of the data points in that site. This ability highlights the power of this methodology to quickly combine inputs from multiple people in the field into a single database containing every damage assessment done in that area. From this point, it is possible to extract useful information. For example, after surveying the two sites, the data shows that 18 of 111 houses, or 16%, experienced some sort of damage, a conclusion that can be corroborated by images from the UAV and the ground survey.

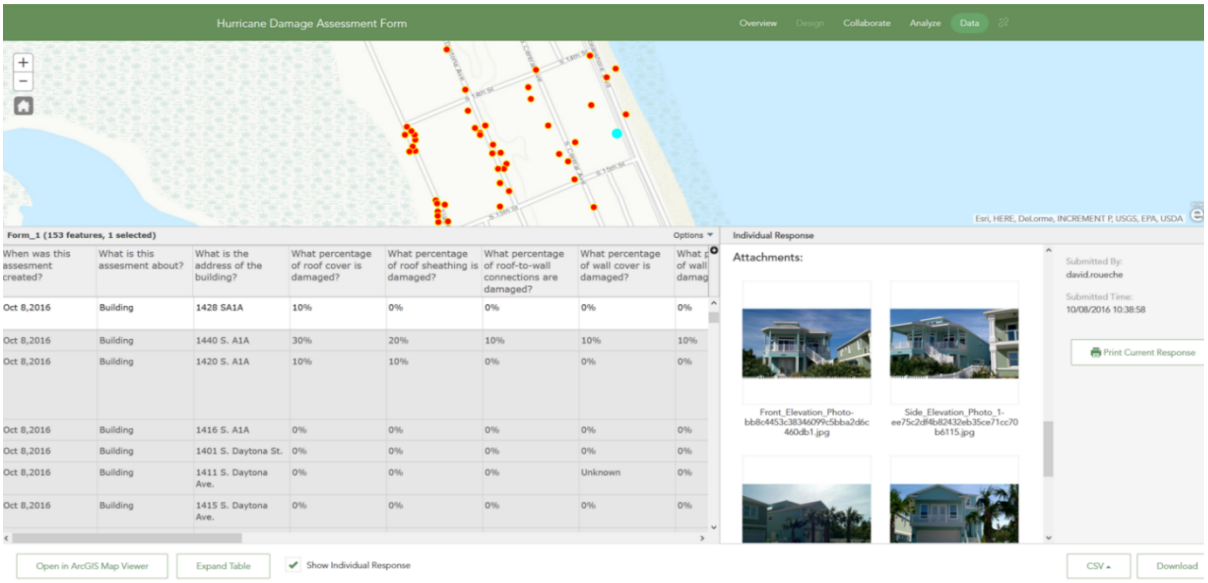


Figure A-5: ESRI Survey123 online portal for viewing and editing damage survey submissions

The UAV, combined with the Survey123 smartphone app, allowed the WHDAG to obtain a treasure trove of meaningful data that is able to be analyzed by any person in the group via the associated website that accompanies the app. Any member of the survey team has the ability to log on to the website and view all of the data that was collected, a streamlined and efficient method of sharing data amongst stakeholders. As this deployment was used as a “pilot run” for this method of data collection, after a review the WHDAG will be able to determine which functions

were the most valuable, what parts were not as useful as anticipated, and report back to the developer of the app, ESRI, any technical issues or bugs that were found during its use.

It is the hope of the WHDAG that this methodology can be refined further in the near future and then disseminated to all researchers who wish to conduct damage assessments around the world. With this technology giving researchers the ability to quickly gather data from multiple people in the field and have it all compiled into one easily accessible database, the ensuing damage assessments can be conducted more quickly, with more detail than before.

Figure A-6: Aerial photo of Site 2.
Credit: Kwasi Perry

Damage Assessment

Using the data obtained from the work in the field conducted on October 8th, the day after Hurricane Matthew passed by both sites in Flagler Beach and Marineland, the WHDAG has prepared a preliminary assessment of the damages caused by the high winds of Matthew. This data was used to support a variety of anecdotally known results that were observed directly after the hurricane passed and that have been observed at the sites of other natural disasters with high-wind damage present. After preliminary analysis of this data, the WHDAG was able to draw significant conclusions regarding the varied damage sustained by houses built in different time periods (and therefore to different building code specifications), the occurrence of shingle damage being concentrated on the North side of roofs, and finally were able to compare observed damages with damages predicted by the HAZUS-MH damage prediction model

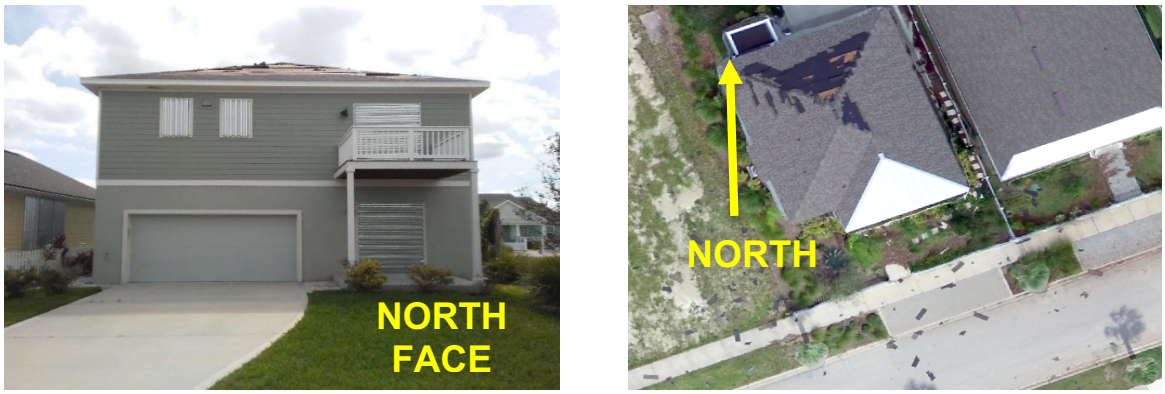


Figure A-7: 30 Sandy Beach Way. a) Ground Survey Photo b) UAV

As Hurricane Matthew moved along the coast, its outer bands rotated in a counterclockwise direction, which means the north faces of the houses bore the brunt of the damage, and to a lesser extent the north-most house on each street served as a "buffer" for the houses directly south, taking the most damage. Examples of this are shown in Figures A-8. While the houses lie in two different sites, the significant shingle damage shown in both is evidence of the hurricane strength winds coming out of the north affecting the north faces in a larger proportion than those that face other directions. Of the 15 houses that sustained shingle damage in both sites, eight had shingle damage primarily on the north face of the roof.

Figure 8: Home at 1424 S. Oceanshore Drive built in 2015. a) Photo from ground survey b) UAV aerial imagery

Concerning the relationship between the age of homes and the damage they received, as seen in Table A-1 there was a stark difference in the ages of homes in the two different sites

surveyed by the WHDAG on October 8th. The year 2001 was chosen because while the devastation caused by Hurricane Andrew in 1992 was the impetus for the development of a statewide building code, the inclusion of wind resistance in this statewide building code began in 2001.

Table A-1: Homes Built before & after 2001 (statewide wind resistance building code introduced in 2001).

	Flagler Beach (Site 1)	Marineland (Site 2)
Houses built before 2001:	55	0
Houses built after 2001:	9	46

According to a 2013 study conducted by the Environmental and Energy Study Institute (EESI), had the homes damaged by Andrew in 1992 been built to the 2004 Florida Building Code, insured damages would have been halved from $12 billion to roughly $6 billion. Seeing as 90% of the homes in the Flagler Beach site were not built after 2001, a similar reduction in damages could be expected for the homes in the site.

The data gathered in the field further supports the idea that newer houses sustain less damage from hurricane-force winds than older homes. Damage was observed to thirteen homes in Flagler Beach, and four homes in Marineland. Of the nine homes in Flagler Beach that were built after 2001, four were observed with damage. Nine, or 24%, of homes built before 2001 were observed with damage from Hurricane Matthew. Of the 46 houses surveyed in the Marineland subdivision, in which all houses were built after 2001, only 4, or 9%, sustained hurricane-related damage. It is expected that the wind speed in both sites is the same. These results are repeated in tabular form below, in Table A-2. While this preliminary assessment cannot provide definitive results, the higher proportion of damage to post-2011 homes in Flagler Beach is somewhat concerning, although more data would be needed to verify this trend. Data regarding the age of homes in Flagler Beach was found via the Flagler County Tax Assessors Office.

Table A-2: Damaged Houses Sorted by Year Built and Location

	Flagler Beach (Site 1)	Marineland (Site 2)
% of houses built before 2001 that were damaged:	24%	N/A
% of houses built after 2001 that were damaged:	44%	9%

With 80 mph gust wind speeds occurring at both sites, and a reasonable number of damaged and undamaged structures surveyed, it is possible to compare the observed damage with the expected damage given the estimated wind speeds. The HAZUS-MH Hurricane catastrophe model contains fragility curves for a large number of possible building types, including one- and two-story hip and gable roofs. These fragility curves represent the probability of experiencing certain damage levels in a structure given it experiences a specific wind speed. Here we combine the fragility curves for one- and two-story hip and gable roofs into a single compound fragility, assuming equal proportions of each. The damage state considered is defined as:

- Maximum of one broken window, door, or garage door.
- Moderate roof shingle loss ($\leq$ 15%) that can be covered to prevent additional water entering the building.
- Marks or dents on walls requiring painting or patching for repair.

Figure A-9 shows the resulting fragility curve along with the proportion of damage observed in both sites combined. The proportion of observed damage is about 10% higher than would have been expected. The proportion of homes damaged in Marineland, 9%, would be closer to the expected amounts from HAZUS. The higher proportion of damage than predicted could be attributable to any one of the following factors:

- Some of the newest homes appeared to have been just finished, and the asphalt shingles may not have had the opportunity to fully seal by the time the hurricane struck.
- The HAZUS fragility curves may not be well-suited to a large proportion of old structures, where roofs may have been in need of replacing prior to the storm.
- This area of the coast has not had a hurricane strike in decades, and any vulnerabilities in existing structures would have remained unnoticed and uncorrected until this hurricane.

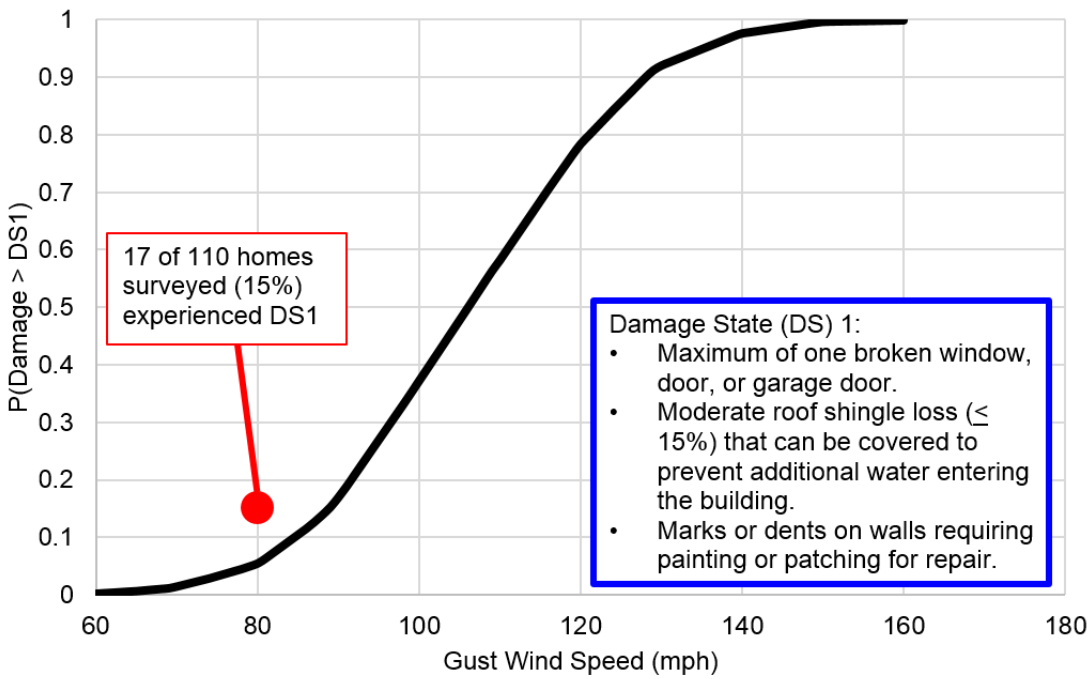


Figure A-9: Fragility curve from HAZUS-MH Hurricane for light damage (DS1)

Furthermore, while damage to homes in the area was relatively minimal, the impact of Hurricane Matthew was felt fully by a large portion of A1A in Flagler Beach. Storm surges decimated long stretches of the road, with huge chunks of asphalt dumped onto the beaches, showing the innards of the road and the barriers underneath that were constructed to support the road and to help prevent damage. When cost estimates of the impact of storms such as Hurricane Matthew are calculated, damage to infrastructure such as that shown in the image below factors in a large portion.

Figure A-10: Damage to A1A along Flagler Beach

This damage assessment serves to portray the extent of the damage caused by Hurricane Matthew along Florida's First Coast, specifically in Flagler Beach and Marineland, the two sites of the WHDAG's October 8th deployment. Thankfully, the damage sustained in these areas was much less than what could've been, the destruction of A1A notwithstanding, had Hurricane Matthew maintained its path instead of shifting slightly to the east. Hurricane force winds were still felt at both sites despite that fortunate side step and left tangible signs of its destructive force, especially on the north face of the roofs and those houses built before 1990. Flooding caused by the huge storm surge and exasperated by the high tide caused significant damage in innumerable communities up and down the coastline, however these effects were not seen in Flagler Beach nor Marineland. As the overall damage dealt by Hurricane Matthew's winds was minimal, it does not appear to be necessary to conduct a full scale damage survey of the area at this time.

Figure A-11: Aerial photo of Flagler Beach, FL. Credit: Kwasi Perry

Conclusion

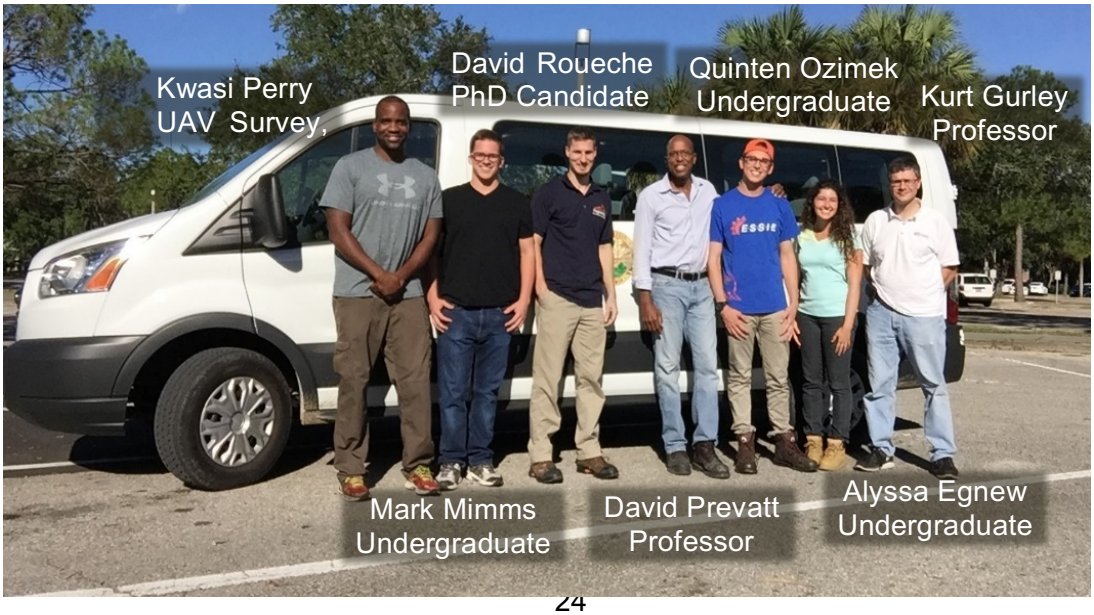
Hurricane Matthew was the largest and most catastrophic storm of the 2016 hurricane season in the Atlantic, where over a thousand people lost their lives, and countless more their homes and livelihoods. Even now Haiti, the country most affected by Matthew, is dealing with and will continue to deal with the truly tragic aftermath of the strongest hurricane since 2007. Much of the coastline from Florida to North Carolina would have also experienced severe damage if not for a slight eastward shift as Matthew pummeled The Bahamas as a Category 4 storm, and even still Matthew grazed the eastern seaboard through four states extreme flooding and high winds caused loss of life and property until making landfall as a Category 1 storm in McClellan, North Carolina and promptly dissipating as it turned out to sea. Along Florida's First Coast record flooding was recorded, and hurricane strength winds were felt from south of Flagler Beach to the north of Jacksonville, the state's largest city by land mass.

The WHDAG deployed Saturday, October 8th early in the morning with a novel data collection methodology that utilized a UAV overhead that provided high-res images that was piloted by Kwasi Perry, the owner of UAV Surveys Inc., and a smartphone app named Survey123 which allowed the group to spread out and quickly collect data on damaged residential structures that was later uploaded into one database easily accessible by all participants. A preliminary damage assessment was conducted, focusing on the majority of shingle damage occurring on

the north face of the roof, the difference in damages sustained by houses built before and after a statewide building code was introduced following Hurricane Andrew in 1992, and showcasing the HAZUS disaster model.

Figure A-12: 13 Smiling Fish Lane Damaged Soffits (Site 2)

Reiterating the substantial impact of Matthew's eastward shift, the lesser magnitude of damage was useful to wind engineers in assessing the structural sturdiness of buildings along the northeast coast of Florida, where it had been some time since a major hurricane had impacted the area. It also allowed for this "pilot run" of the data collection process outlined in the methodology to be conducted in order to assess not only the damages seen in both sites, but the effectiveness and areas of improvement in the use of the smartphone app Survey123 and the use of UAV's to provide another dimension to future damage assessments. In the future, this combination of new technologies could be used by researchers over the world to improve their own damage assessments and thus bring the scientific community nearer to a comprehensive understanding of the impacts of high strength winds during natural disasters.



Appendix B. Draft Interview Protocol

This interview will ask about your thoughts and experience with Hurricane Matthew as well as about your decisions you had to make before, during and after the event.

Your thoughts are important to us. Please answer the questions to the best of your ability. If you absolutely have no idea at all or feel uncomfortable answering a question, just let me know and we'll move on to the next question.

Do you have any questions before we begin?

Is it OK if I start recording our conversation now?

I. Hurricane Matthew experience

First, I would like to know about your experience with Hurricane Matthew. Can you tell me what happened to you? How are you doing now? How do you feel about what happened?

- *Describe anything you did to prepare your home in the days prior to the arrival of Hurricane Matthew. [Anything else? Did you get any help from friends or family members? Anyone else? If you didn't do anything, why not? How effective do you think the measures you took to protect your home were? What would you do next time? Anything else?]*
- *Describe anything you did to protect your family as Hurricane Matthew arrived? [If you stayed in place, why? If you decided to leave, why? If you decided to leave, where did you go? Why?]*
- *In what ways did your community prepare for Hurricane Matthew? [Anything else? Why?] How would you describe your community?*
- *Describe any previous experience you've had with hurricanes prior to Matthew. Can you tell me what happened to you? [Anything else?]*

II. Causes and the future

Next I would like to know what you think about possible future hurricanes. Can you tell me when you think the next hurricane might happen? When do you think it might happen? Why? Do you think that you or your family will be directly impacted? [Why or why not?] Who do you think will be directly impacted? [Why?]

- *Can you tell me if you think the chances of a hurricane are going to become more frequent? [Why or why not?] How much more (or less) frequent? Why?*
- *Can you tell me if you think that future hurricanes will be more intense? [Why or why not?] How much more (or less) intense? Why?*

- *In your own words, tell me what happens when hurricane forms, gains strength, and then dissipates. [Can you describe that in a little more detail?]*

III. Physical and financial damage

Now, I would like to ask you some specific questions about any physical and/or financial damage you experienced due to Hurricane Matthew.

- *Describe any damage that Hurricane Matthew caused to your home. Describe any financial loss you anticipate experiencing due to this damage.*
    - *Was your home insured against damage from wind? Wind-blown rain? Storm-surge? If so, what was your deductible?*
    - *If you had insurance and your house was damaged, how responsive and accommodating was your insurance company in helping you get restitution for the damage? Did you get the amount of restitution that you expected?*
- *How much damage do you think your home would sustain if it experienced 120 mph winds instead of the ~80 mph winds from Hurricane Matthew? Can you tell me more?*
- *At any point before or during the hurricane, did you think your home might become uninhabitable as a result of the hurricane?*
- *At any point before or during the hurricane did you feel your life was in danger? Why or why not?*
- *At any point during the hurricane did you experience an injury caused by the hurricane?*
- *What indirect costs did you experience due to Hurricane Matthew (e.g., hotel, evacuation, days off work without pay, etc.)?*

I would also like to know more about how much you might be willing-to-pay to avoid any damage to your home you experienced during Hurricane Matthew. How much would you be willing-to-pay if winds were much stronger than Hurricane Matthew, say if they were 120 mph?

- *Describe for me how you would prefer to pay for this? Through a tax? A rebate program? Through higher insurance premiums? Etc.?*

IV. Demographics

Finally, I would like to ask you a few questions about yourself. The answers to these questions will be kept strictly confidential, and will only be used to get a better sense of the people we talked to.

- *What is your age?*
- *Do you identify as male, female or other?*
- *What is your highest level of education?*
- *What is your household annual income?*
- *Do you own your own home or rent or live with friends and/or family without paying rent?*
- *What is the number of people living here, including yourself?*
- *Of those, how many are under the age of 18?*

- *Does anyone who is living here have any illness or other issues that makes mobility difficult?*
- *What is the language that is most often spoken in your home?*

V. Closing and debrief

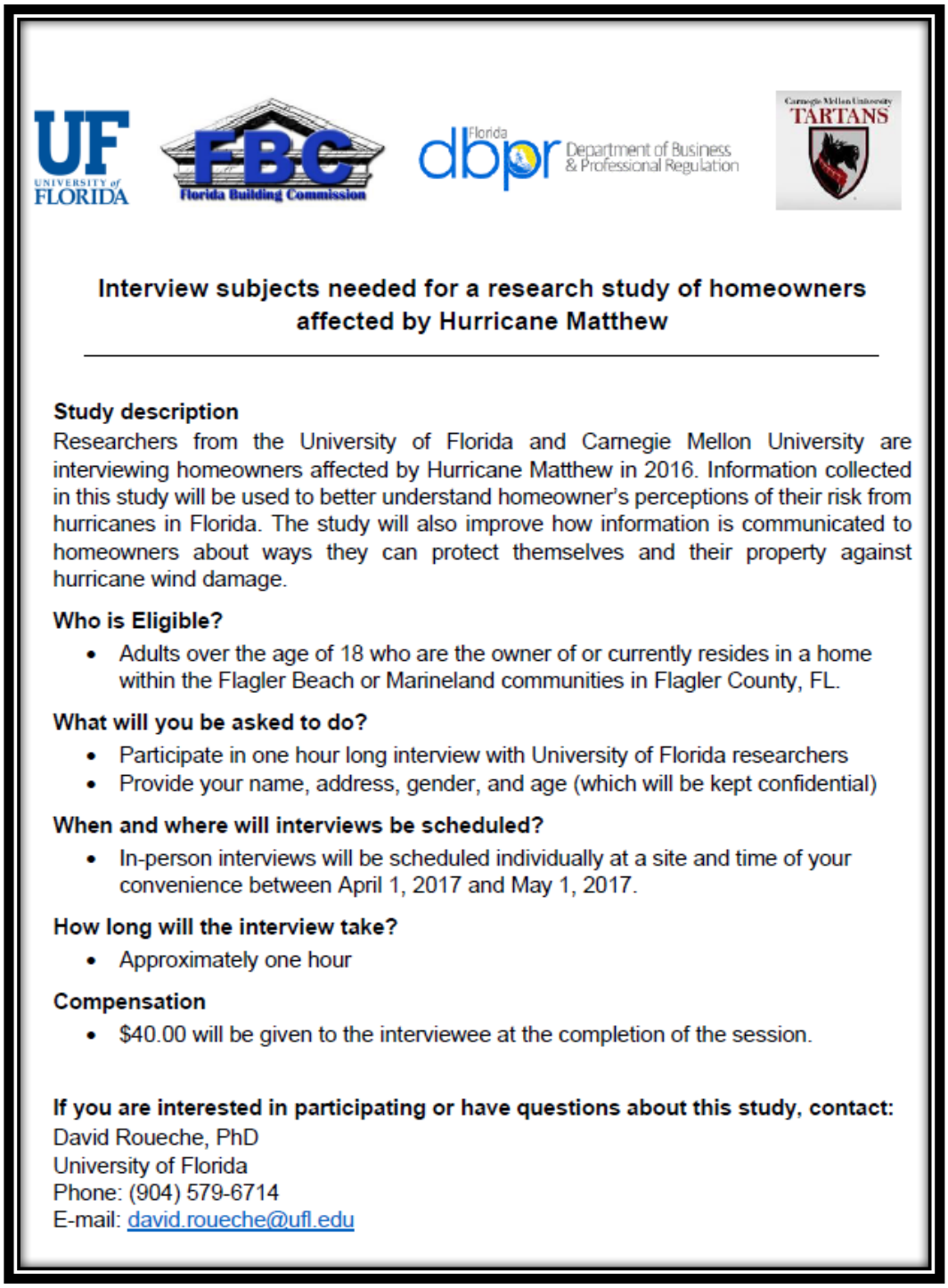
Those are all of the questions that I have today on your experience with Hurricane Matthew. Are there any questions you have for me? Is there any question I didn't ask that you wished I did? Anything else?

We are planning on interviewing residents over the next few weeks. Once the interviews are complete, we are going to transcribe all of the interviews and summarize our findings in a report. Would you be interested in getting a summary of the report?

Do you know of any neighbors who you think might be willing to talk to me?

Thank you so much for your time.

Appendix C. Recruitment Flyer



Interview subjects needed for a research study of homeowners affected by Hurricane Matthew

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Study description

Researchers from the University of Florida and Carnegie Mellon University are interviewing homeowners affected by Hurricane Matthew in 2016. Information collected in this study will be used to better understand homeowner's perceptions of their risk from hurricanes in Florida. The study will also improve how information is communicated to homeowners about ways they can protect themselves and their property against hurricane wind damage.

Who is Eligible?

- Adults over the age of 18 who are the owner of or currently resides in a home within the Flagler Beach or Marineland communities in Flagler County, FL.

What will you be asked to do?

- Participate in one hour long interview with University of Florida researchers
- Provide your name, address, gender, and age (which will be kept confidential)

When and where will interviews be scheduled?

- In-person interviews will be scheduled individually at a site and time of your convenience between April 1, 2017 and May 1, 2017.

How long will the interview take?

- Approximately one hour

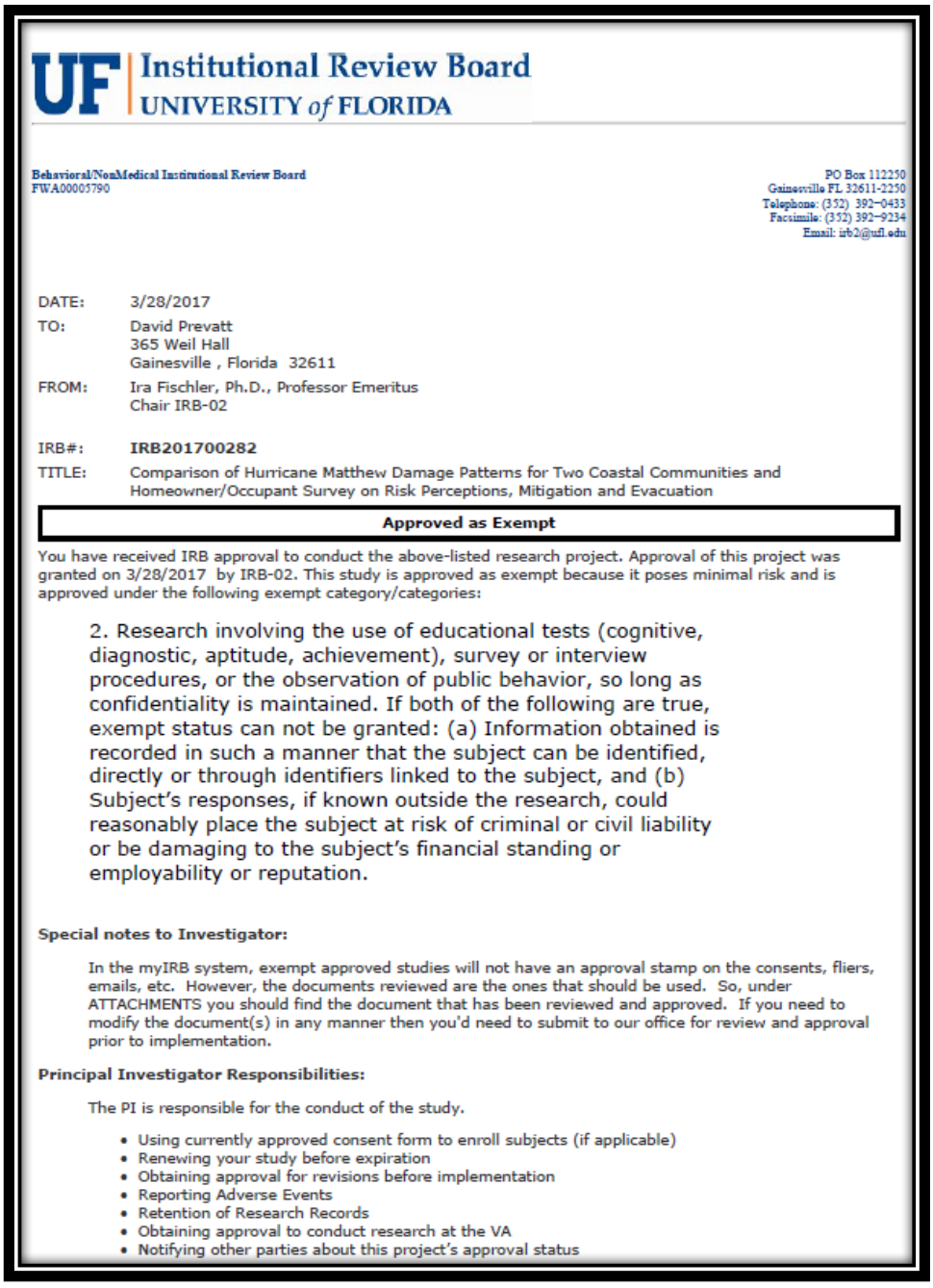
Compensation

- $40.00 will be given to the interviewee at the completion of the session.

If you are interested in participating or have questions about this study, contact:

David Roueche, PhD
University of Florida
Phone: (904) 579-6714
E-mail: david.roueche@ufl.edu

Appendix D. University of Florida IRB Exempt Approval Letter



UF Institutional Review Board
UNIVERSITY of FLORIDA

Behavioral/NonMedical Institutional Review Board
FWA00005790

PO Box 112250
Gainesville FL 32611-2250
Telephone: (352) 392-0433
Facsimile: (352) 392-9234
Email: irb2@ufl.edu

DATE: 3/28/2017

TO: David Prevatt
365 Weil Hall
Gainesville , Florida 32611

FROM: Ira Fischler, Ph.D., Professor Emeritus
Chair IRB-02

IRB#: **IRB201700282**

TITLE: Comparison of Hurricane Matthew Damage Patterns for Two Coastal Communities and Homeowner/Occupant Survey on Risk Perceptions, Mitigation and Evacuation

Approved as Exempt

You have received IRB approval to conduct the above-listed research project. Approval of this project was granted on 3/28/2017 by IRB-02. This study is approved as exempt because it poses minimal risk and is approved under the following exempt category/categories:

2. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures, or the observation of public behavior, so long as confidentiality is maintained. If both of the following are true, exempt status can not be granted: (a) Information obtained is recorded in such a manner that the subject can be identified, directly or through identifiers linked to the subject, and (b) Subject's responses, if known outside the research, could reasonably place the subject at risk of criminal or civil liability or be damaging to the subject's financial standing or employability or reputation.

Special notes to Investigator:

In the myIRB system, exempt approved studies will not have an approval stamp on the consents, fliers, emails, etc. However, the documents reviewed are the ones that should be used. So, under ATTACHMENTS you should find the document that has been reviewed and approved. If you need to modify the document(s) in any manner then you'd need to submit to our office for review and approval prior to implementation.

Principal Investigator Responsibilities:

The PI is responsible for the conduct of the study.

- Using currently approved consent form to enroll subjects (if applicable)
- Renewing your study before expiration
- Obtaining approval for revisions before implementation
- Reporting Adverse Events
- Retention of Research Records
- Obtaining approval to conduct research at the VA
- Notifying other parties about this project's approval status