The HurricaneRiskCalculator™

Working toward Enhancing Our Nation's Readiness, Responsiveness, and Resilience to Hurricanes through Probabilistic Risk Frameworks for Evacuation Decision Support

Eighth Symposium on Building a Weather-Ready Nation: Enhancing Our Nation's Readiness, Responsiveness, and Resilience to High Impact Weather Events

Session 5: Hurricane Studies and Other Tropical Programmatic Achievements
Talk 5.5

JONATHAN L. VIGH and Coauthors (next page)

NCAR RESEARCH APPLICATIONS LABORATORY

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Structural Engineering

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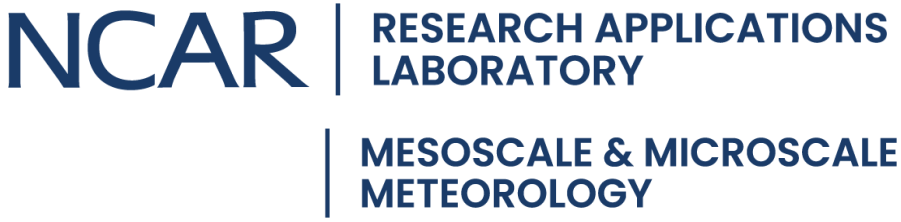
Our partners



Shadow Evacuation

- In Hurricane Irma, 6.8 million people are estimated to have evacuated
- Only about 5% went to state-designated shelters
- Most evacuated out-of-state
- 3 million of these were not from evacuation zones
  - although some were from low-lying areas, mobile/RV parks, etc. that were told to leave
- People who are not in mandatory evacuation zones but who evacuate are known as **"shadow evacuees"**

Source: Andrew Sussman (FLDEM)

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Risks of Evacuation

- Shadow evacuees consume valuable resources such as fuel and lead to much higher congestion rates on the roads
  - This can discourage those who need to evacuate from doing so

- Shadow evacuees subject themselves and their families to risk of death from traffic accidents
  - In the U.S. from 2000-2005, fatalities from traffic accidents occur at a rate of 1.5 per 100 million vehicle-miles travelled
  - Having 6.8 million people drive 1000 miles round-trip at 3 persons per vehicle, could be expected to lead to ~32 deaths
  - On a per-person basis, this is a 1 in 200,000 chance of death
  - Marginally safer than going sky diving once (1 in 153,000 chance)
  - In Hurricane Rita (2005), the fatality rate of participating in the evacuation was 1 in ~23,000
    - 80 deaths out of 2.5 million evacuees

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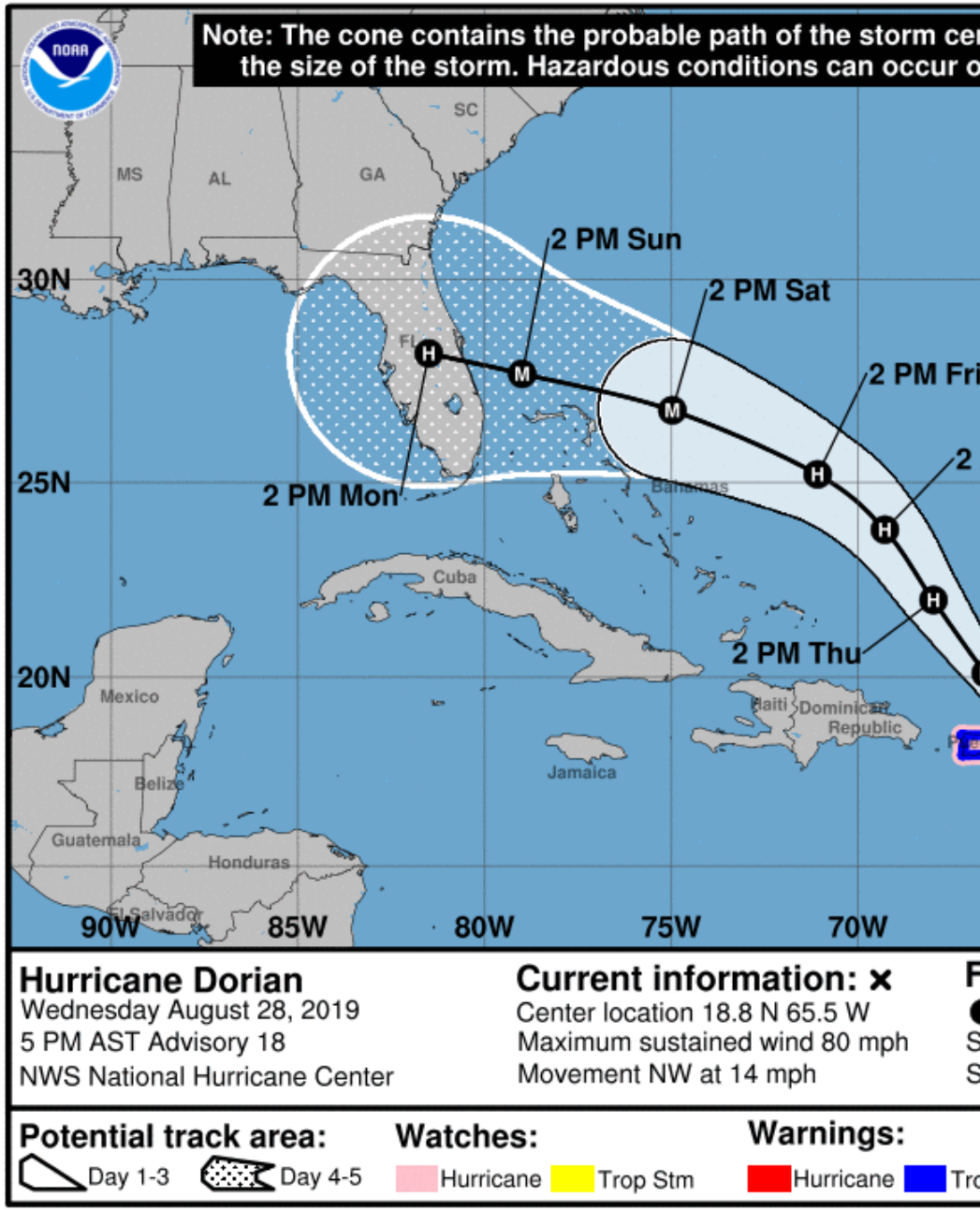
What do people really need to know?



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What do people really need to know?

the exact track

what the size of the cone is

the maximum intensity of the storm

how many inches of rain will fall

They need specific, localized, tailored information on impacts:

storm surge

wind

inland flooding

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Some specific things people need to know

Is it safe to stay in my house?

When will the winds/floods/surge arrive?

How high?

How much damage will my house experience?

How long will the power be out?

When should I put up my storm shutters?

The answers depend on each person's specific vulnerability and situation

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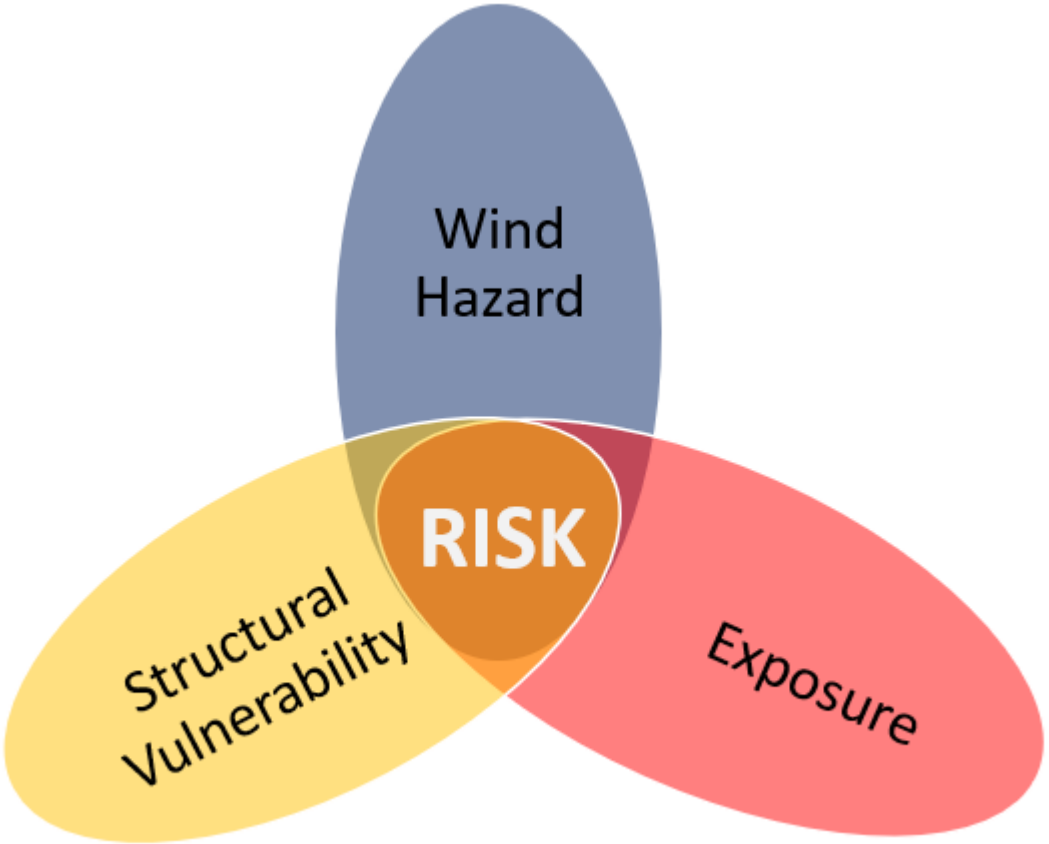
Probabilistic Risk Framework

- Probabilistic hazard information
- State-dependent uncertainty
- Probability density function for all relevant wind speed thresholds

Lin et al. “A Probabilistic, Large-Ensemble Approach to Tropical Cyclone Forecasting”

- Structural characteristics
- Vulnerability of surrounding structures
- Presence of large trees, etc.



- Physical dwelling
- Contents
- Opportunity cost of lost time
- Lives of family members
- Livelihood

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Hurricane Risk Calculator Concept

NCAR

Approach

- Intersect modeled wind hazard at user's specific location with the structural vulnerability of their dwelling
  - Key wind thresholds:
    - tree damage/power outages
    - minor damage (e.g, fences, outbuildings)
    - major structural damage
    - complete failure of structure
- Calculate probability of each consequence
- Translate into a format that is both understandable and actionable for the user
  - "shelter-in-place" vs. "evacuate to local shelter"
  - "put up storm shutters by 3 PM tomorrow"
- Disseminate directly to user through decision support tools and alerts via a mobile app

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Assessing Vulnerability

- Vulnerability is assessed through a ~20 question survey about characteristics of the home and additional behavioral questions

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1

Stories

A one-story home has only one level defined as the ground floor. A one-story home with a loft of any area with a living space between the ceiling of the ground floor and the roof is considered two stories.

One story house

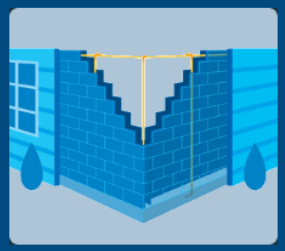
Two or more stories

2

Wall Types

A trick to determining your wall type is to look at the windows from the outside of the home. Frame windows are typically mounted flush with the wall and with masonry walls the windows are typically inset.

Frame



Reinforced Masonry

Standard Masonry

3

Shutters

Hurricane shutters are used to prevent windows from being broken by flying objects during a storm. For a shutter to be rated as a hurricane shutter it must meet Miami-Dade TAS 201, 202, and 203, SSTD 12, or ASTM E 1886 & 1996 standards. Most shutters will have a stamp or be etched identifying it as impact rated.

Hurricane Rated

Non-Rated

No Shutters

4

Roof Shape

The type and shape of your home's roof can influence how well the roof will withstand high winds. A hipped roof slopes upward from all sides of the building and its aerodynamic shape helps it perform better. A gabled roof has two slopes that come together to form a ridge or peak at the top, making each end look like the letter A.

Gable Roof

Hipped Roof

Hipped & Gabled

5

Garage Door

The best method to determine your garage door type is to look for a proof of compliance sticker (typically yellow or white). It will identify the type of door. If your door does not have a label on it you may be able to identify from the number of bracings.

Wind Resistant

Standard Door

None

6

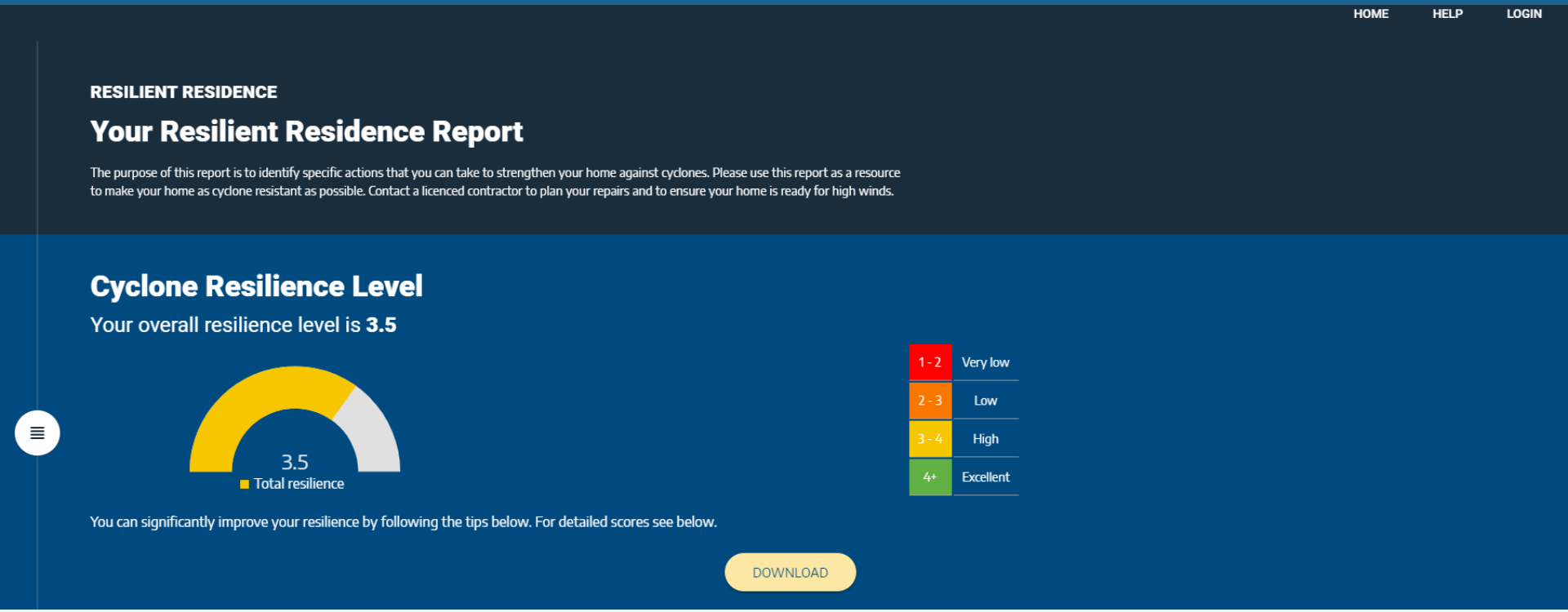
Roof to Wall Connections

Your home's ability to resist the extreme force of wind is only as strong as its weakest link. To determine your type of connections, go into the attic and look along where the sloping roof meets the floor of the attic. If the insulation is thick on the floor of your attic, you might need to move it aside to see your roof-to-wall connections. Sometimes you can see the reflection of the straps or clips with the use of a flashlight.

Toe-Nail

Metal Straps

Metal Clips



- The HurricaneRiskCalculator™ will incorporate the ResilientResidence vulnerability information provided by homeowners
- Probabilistic fragility models are also under development

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How to Communicate Risk

Original idea: Use likely condition of house after storm, following earthquake structure assessment conventions

Potential damage for the structure is displayed in a 3-category scale:

- **safety during the storm**
- **habitability after the storm:**

▶ **Green tag condition is likely**: no significant structural damage is expected

▶ **Yellow tag condition is likely**: some structural damage possible; some loss to contents is likely; structure may not be habitable after storm

▶ **Red tag condition is likely**: significant damage is likely up to a total loss of the structure and its contents; structure could lose its ability to protect life and safety of occupants

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Risk of Damage

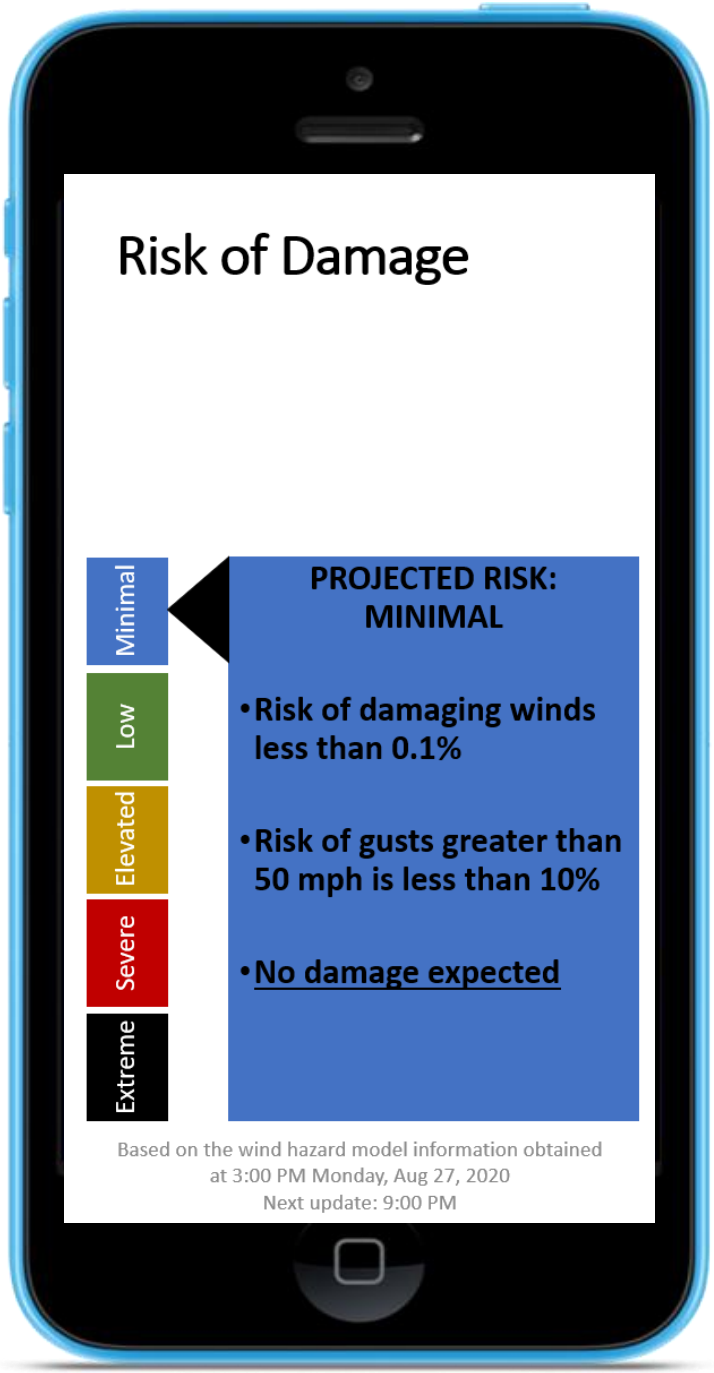
Area for user-specific disclaimers, reminders
- Currently only wind risks are provided
- Any official evacuation orders supersede any advice from this app
- Notice if user is < 40 feet above sea level

Minimal
Low
Elevated
Severe
Extreme

PROJECTED RISK: MINIMAL

- **Risk of damaging winds less than 0.1%**
- **Risk of gusts greater than 50 mph is less than 10%**
- **No damage expected**

Based on the wind hazard model information obtained
at 3:00 PM Monday, Aug 27, 2020
Next update: 9:00 PM



Risk of Damage

Minimal
Low
Elevated
Severe
Extreme

PROJECTED RISK:
LOW

- **Minor damage to out-buildings/fences possible**
- **Structure expected to be habitable after storm**
- **Little to no significant structural damage expected**

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Risk of Damage

Minimal
Low
Elevated
Severe
Extreme

PROJECTED RISK:
ELEVATED

- **Winds are expected to approach within 20% of the design windspeed for your area**
- **Damage to out-buildings/fences is *likely***
- **Structure may be uninhabitable after storm due to water damage or loss of services**
- **<u>Structural damage is possible</u>**

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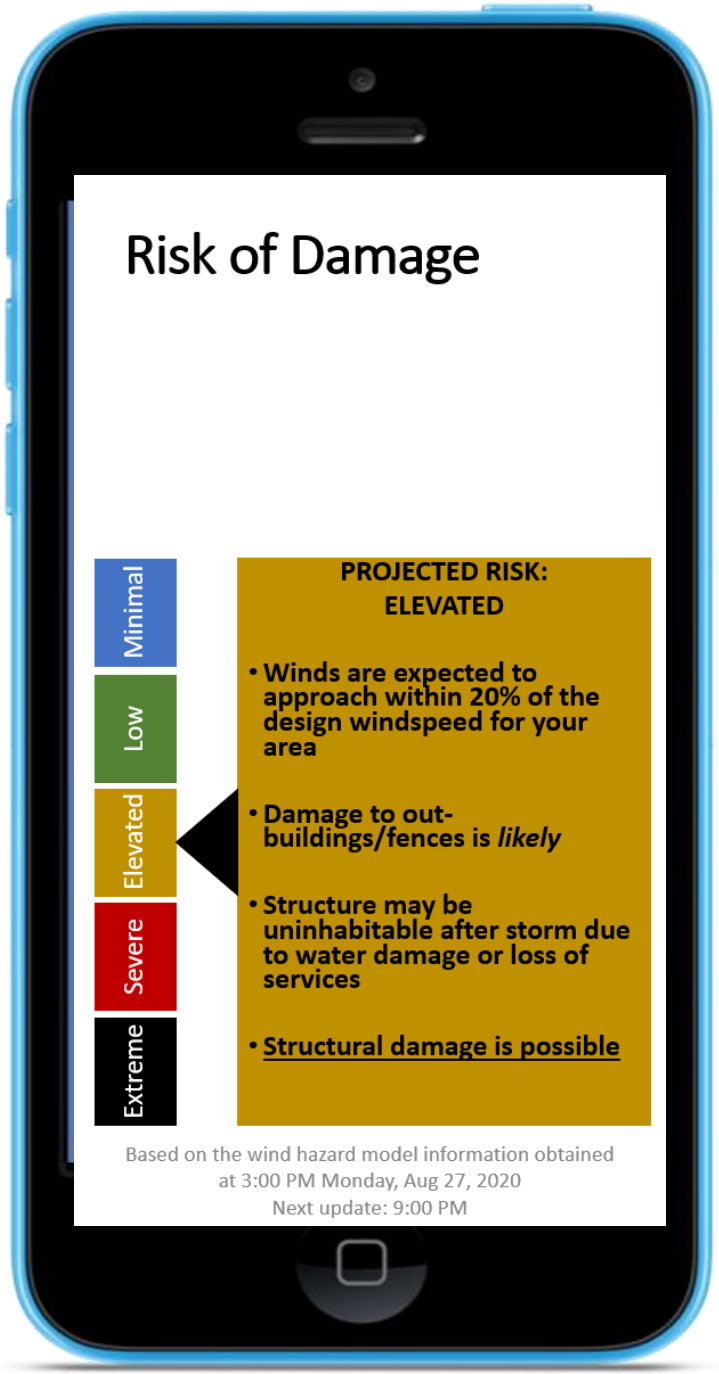
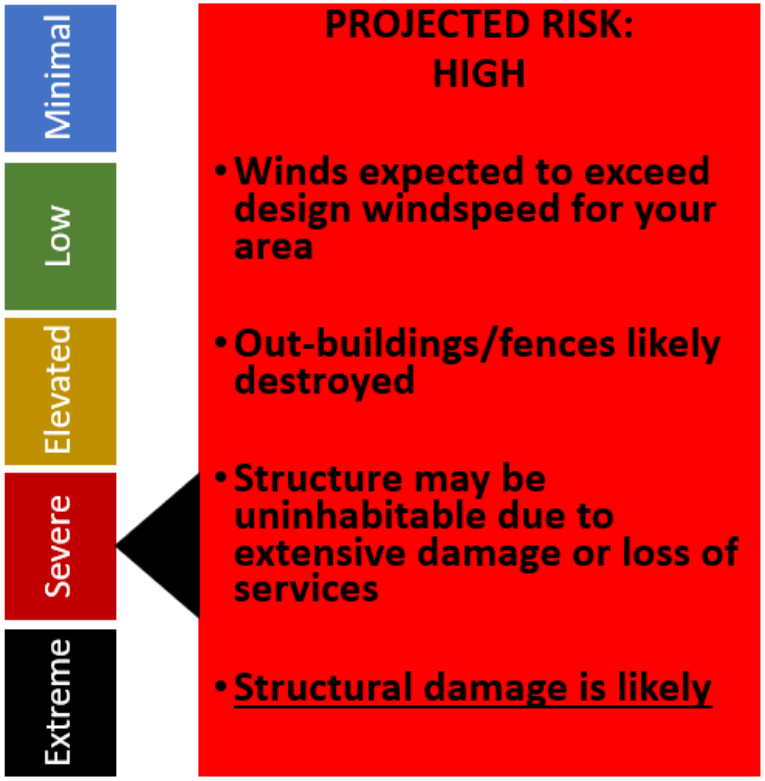


Risk of Damage



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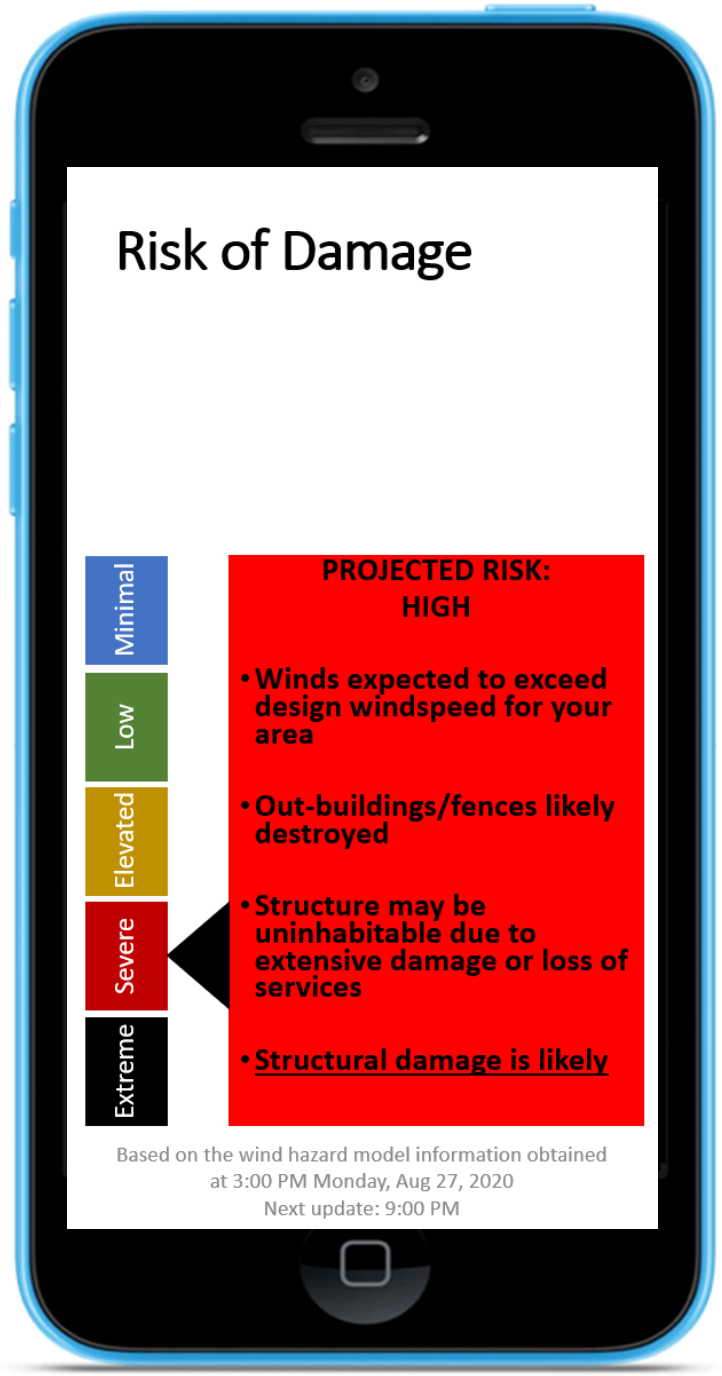
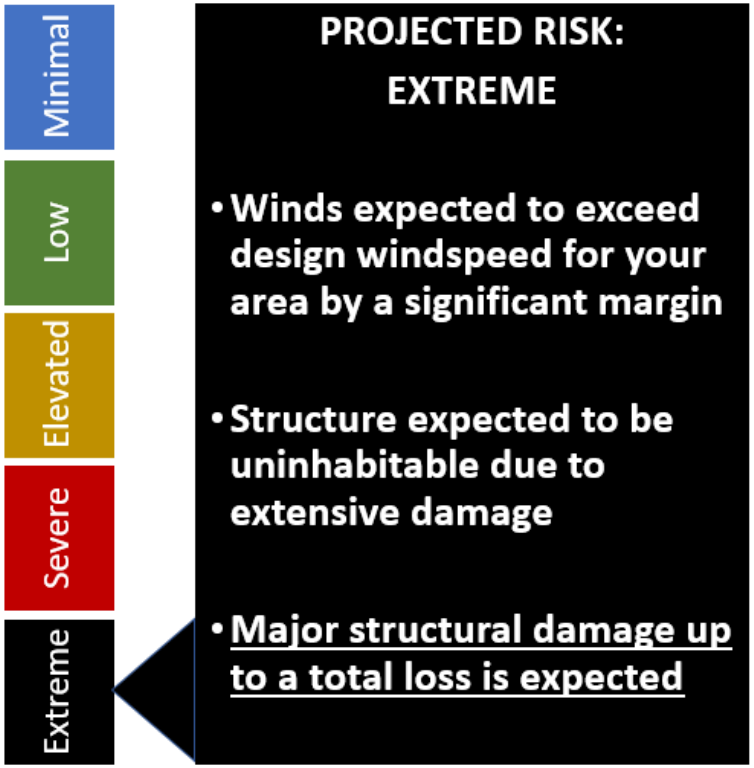


Risk of Damage



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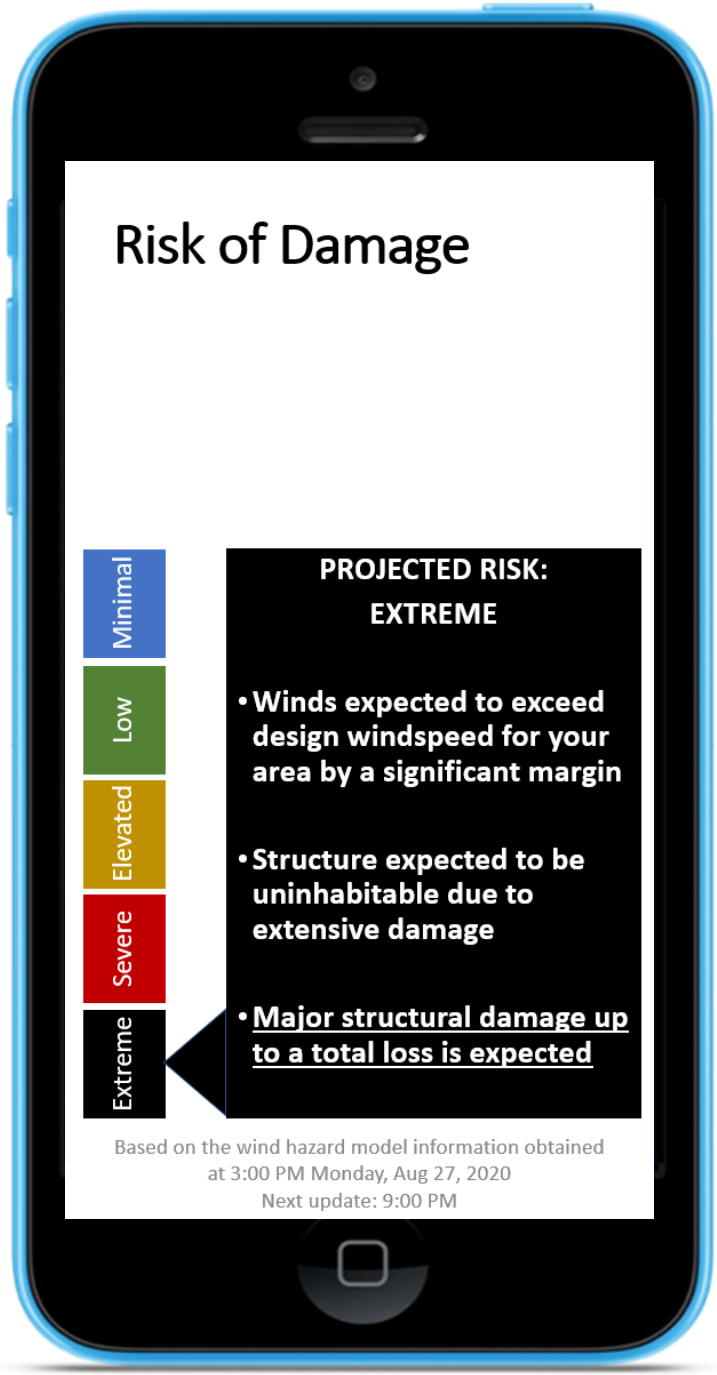

Risk of Power Outage

Minimal
Low
Elevated
Severe
Extreme

PROJECTED RISK: MINIMAL

- **Less than 2% chance of a power outage exceeding one hour**
- **Minimal risk of significant power outages**

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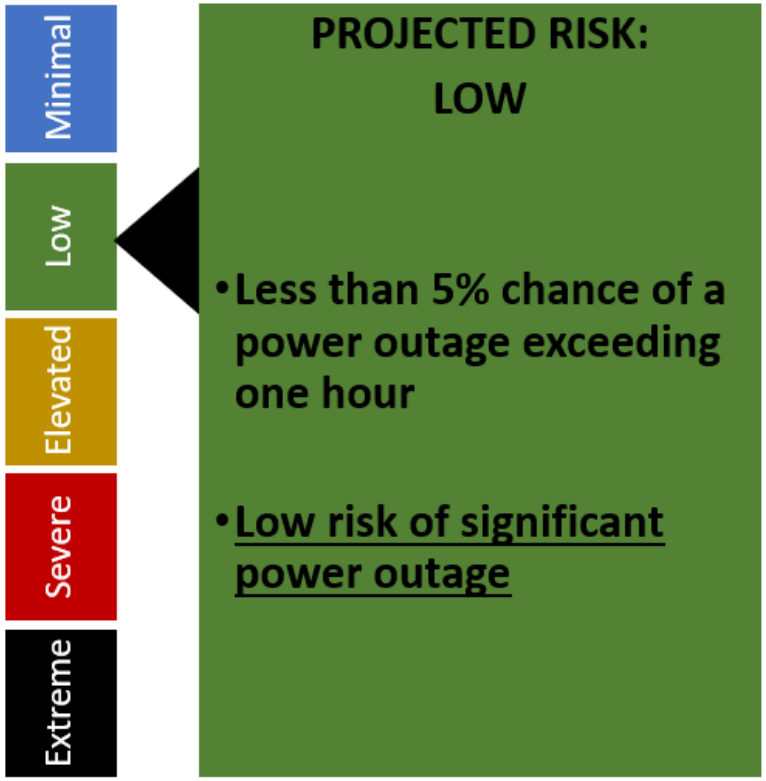
Risk of Power Outage



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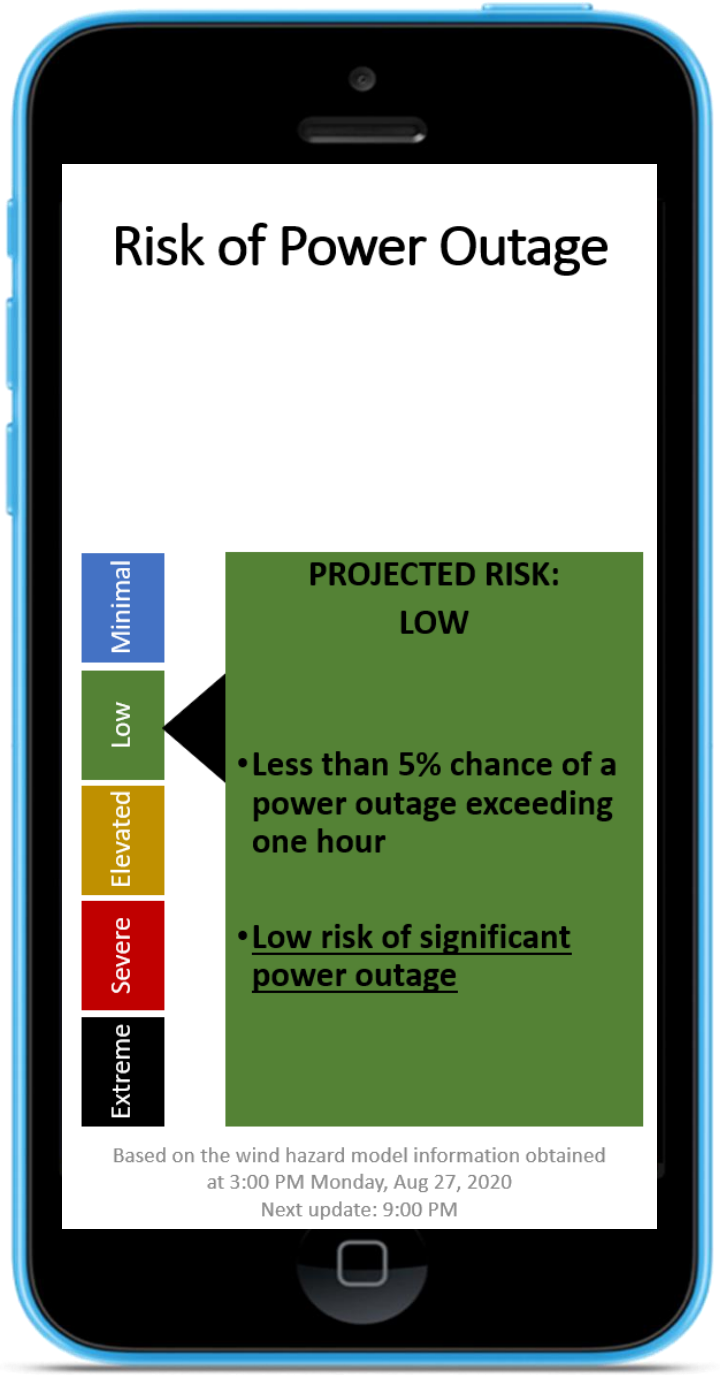
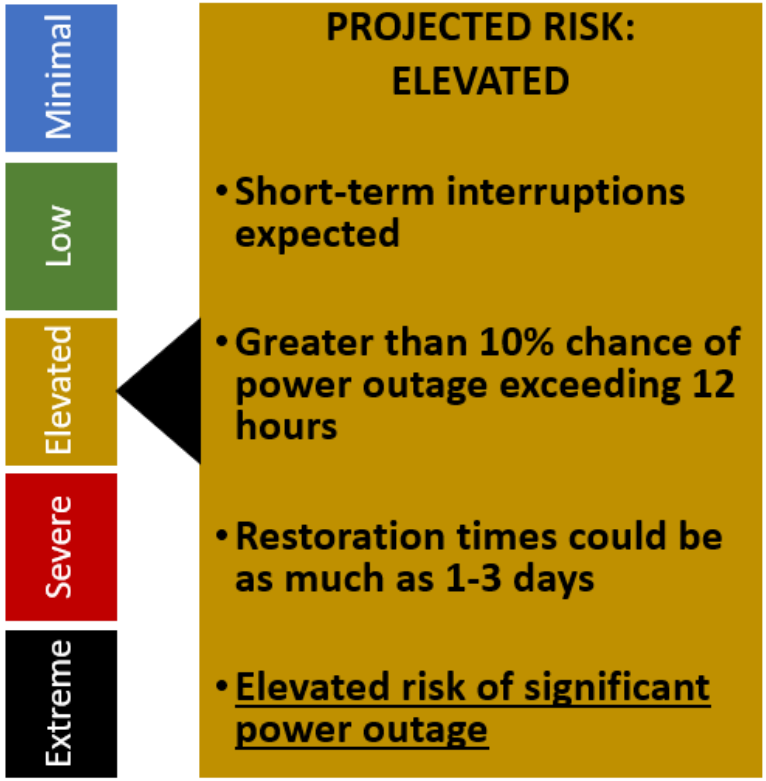


Risk of Power Outage



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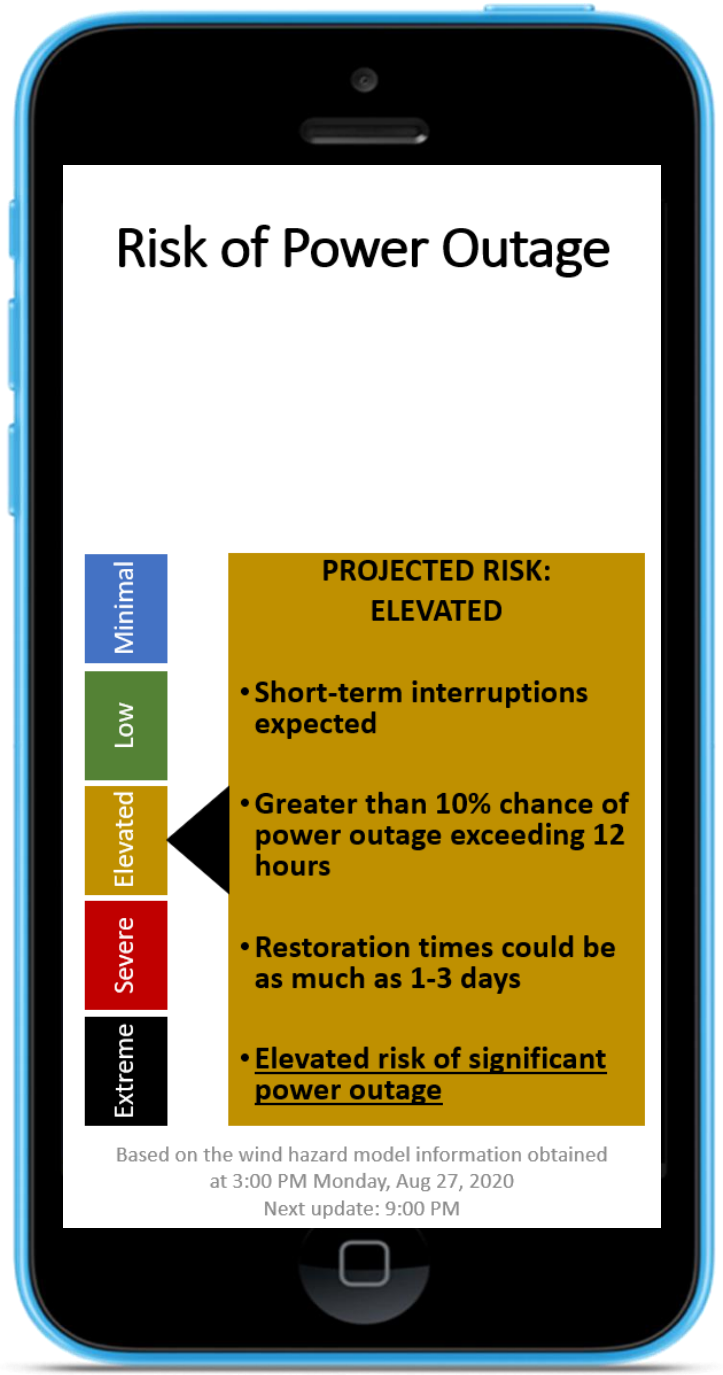

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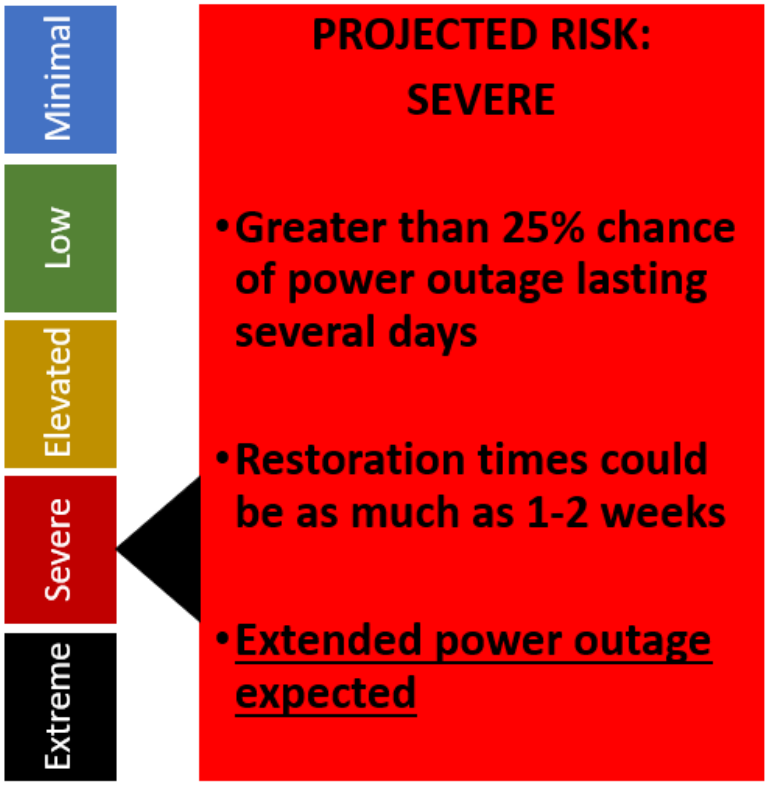

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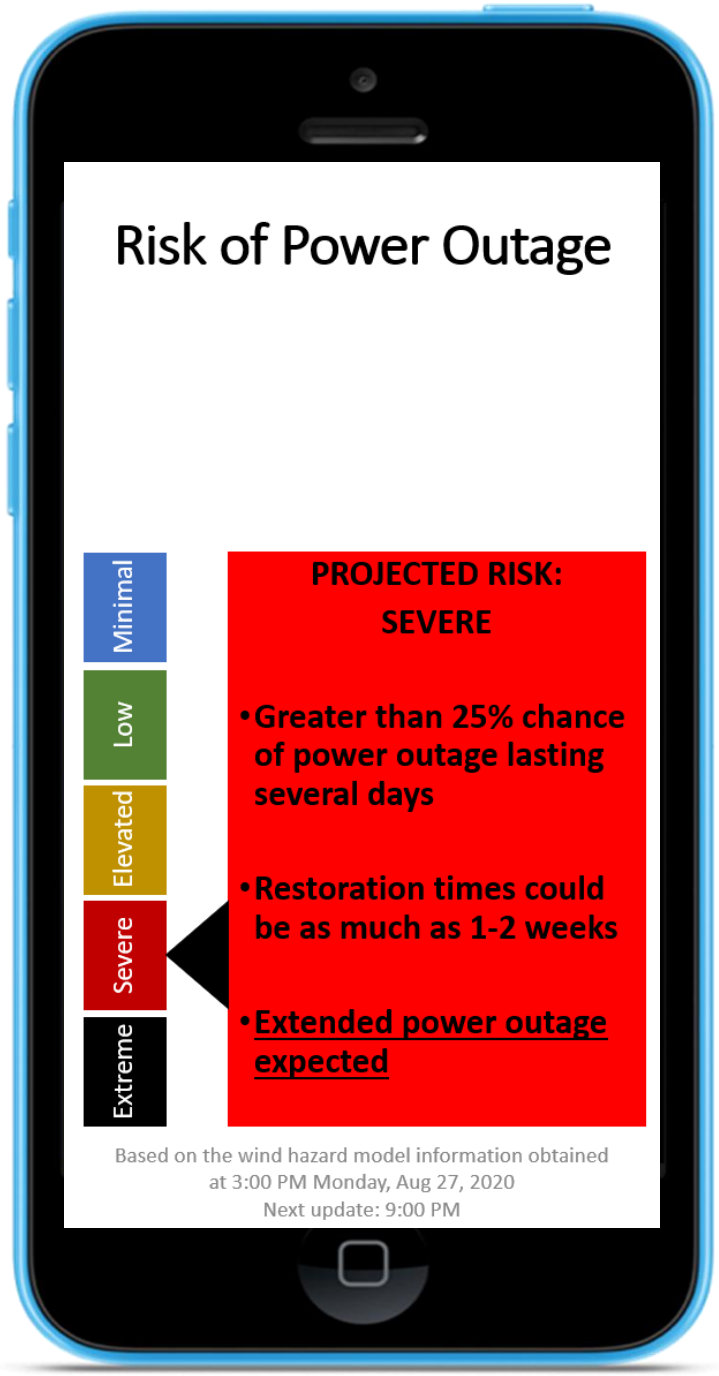

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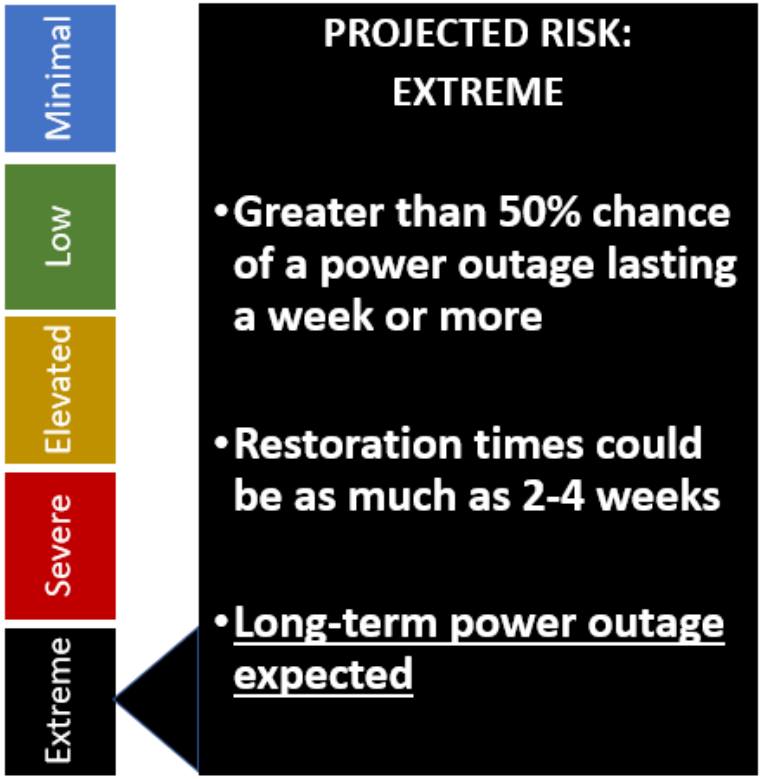

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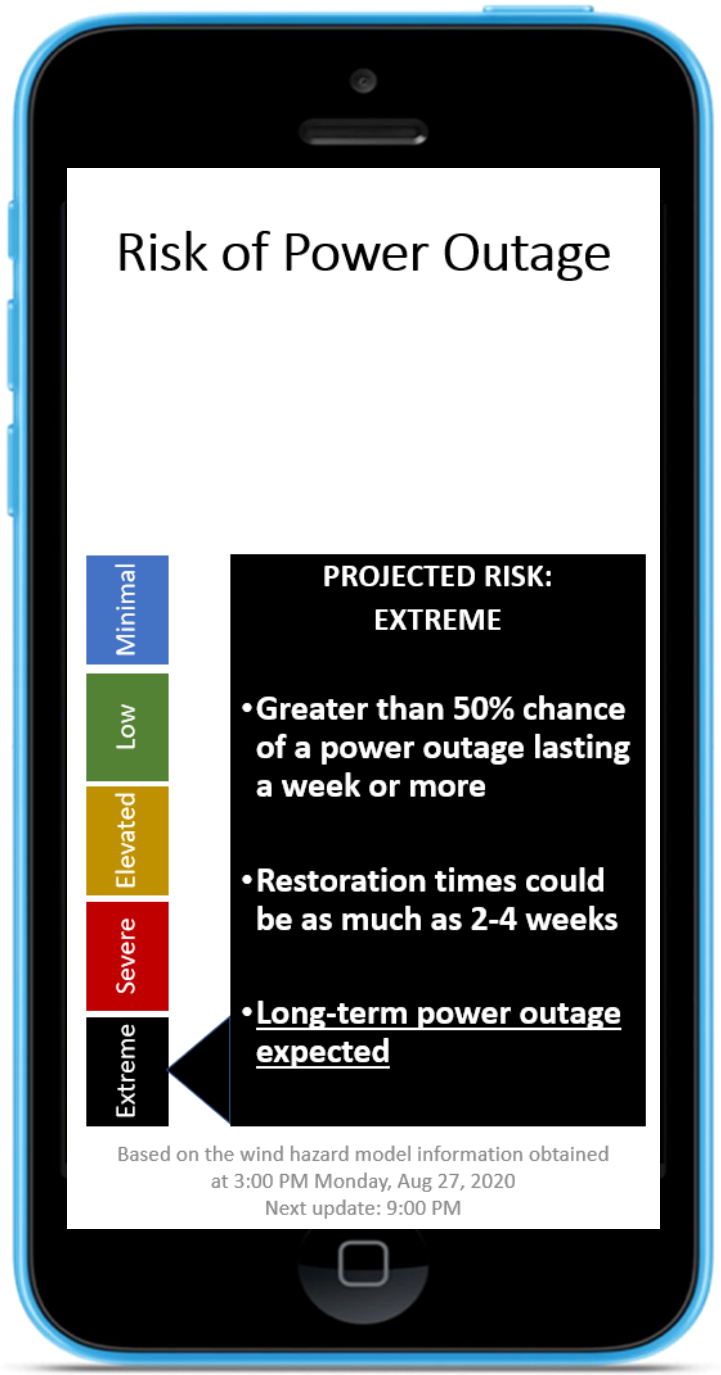
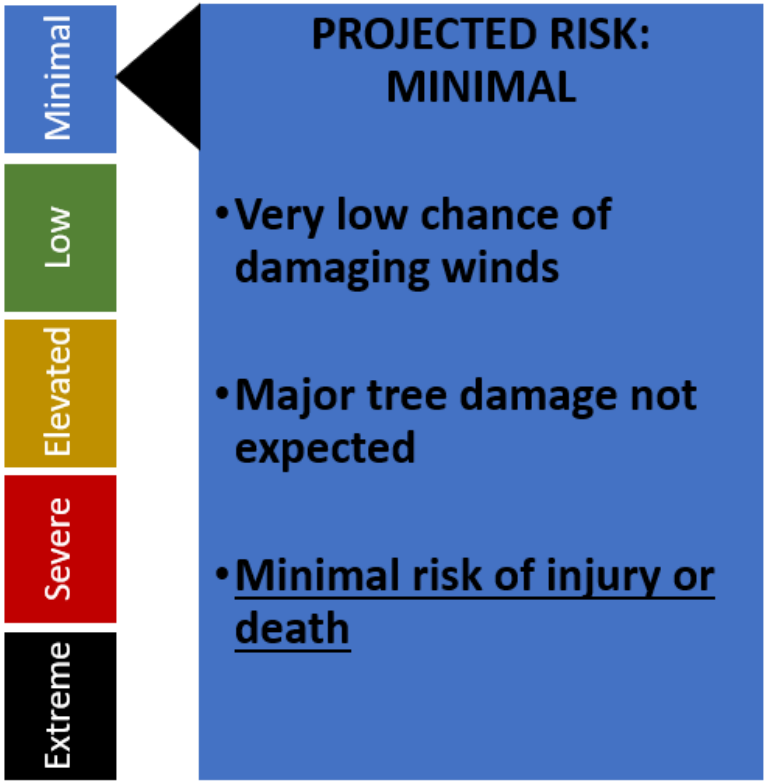


Risk of Injury & Death



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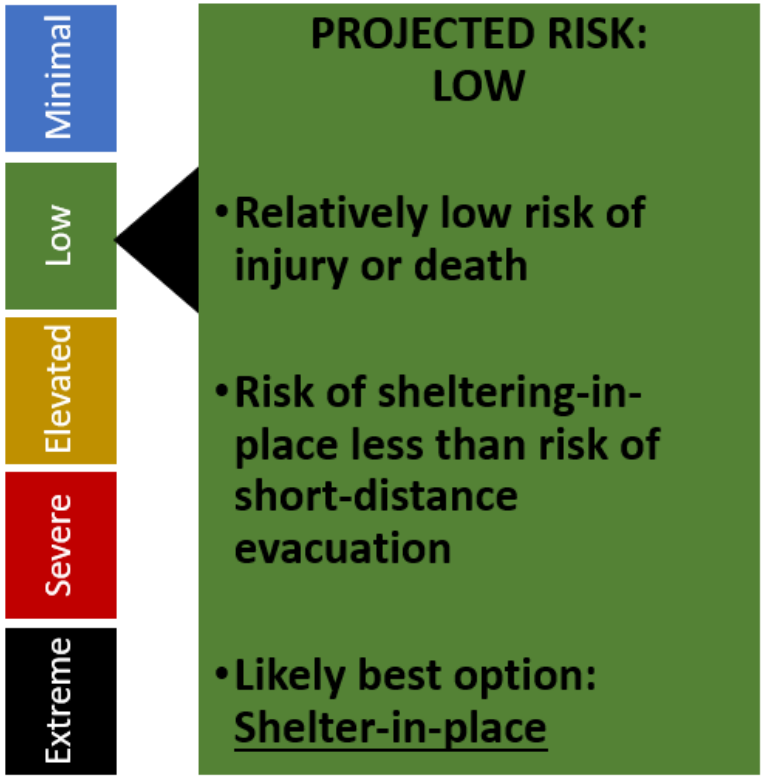

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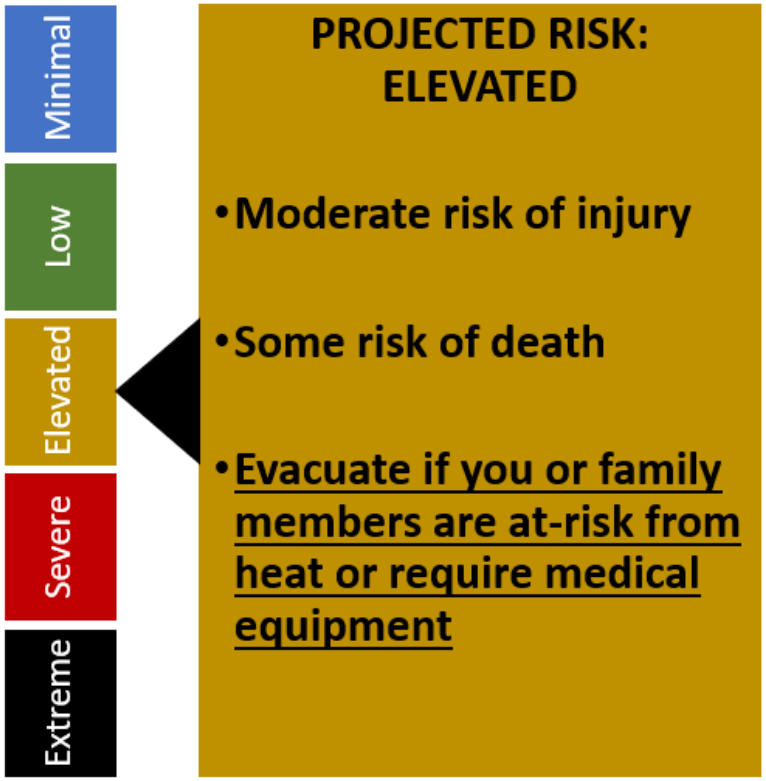

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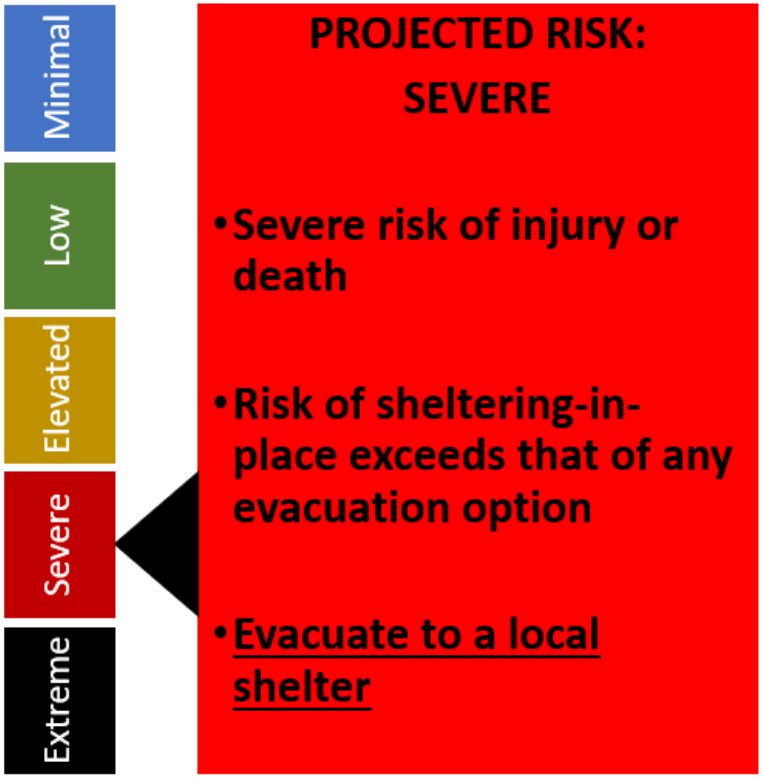

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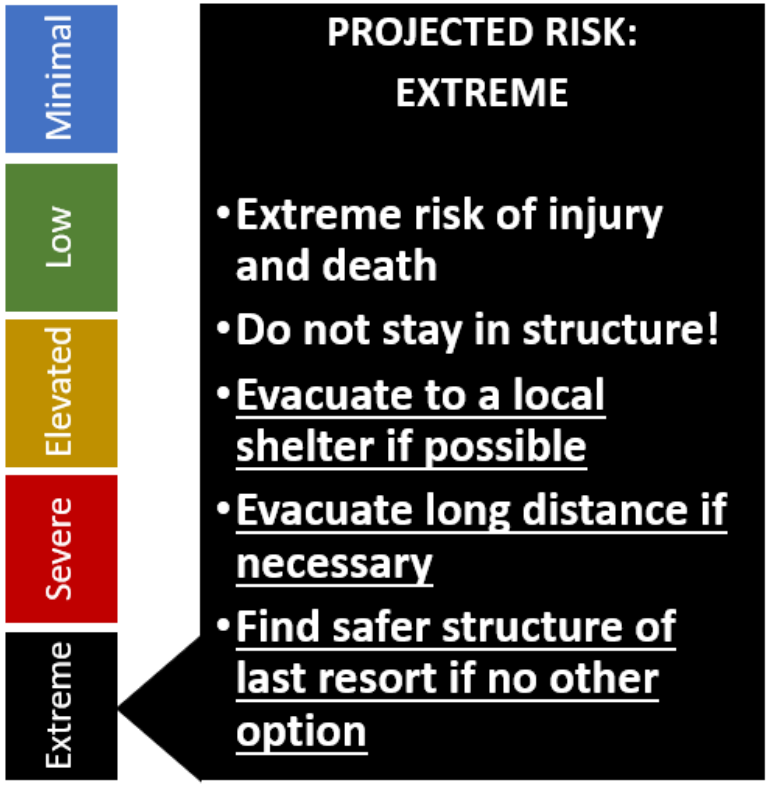

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Projected financial costs

Costs depend in part on what window protection your house will have

Please indicate what window protection will be in place by 4:00 PM tomorrow

Note: Conditions will likely be too dangerous to install protection after that time

no protection | plywood | hurricane shutters | impact-rated windows

Projected costs also depend on whether you home is insured with windstorm or hurricane coverage and what your deductible is

Your indicated coverage is the following (use buttons to edit values)

You indicate that you have homeowners insurance with hurricane/windstorm coverage | 5% hurricane deductible

Finally, projected costs depend on your rebuilding cost

Your indicated rebuilding cost is $320,000 rebuilding cost

Calculated results

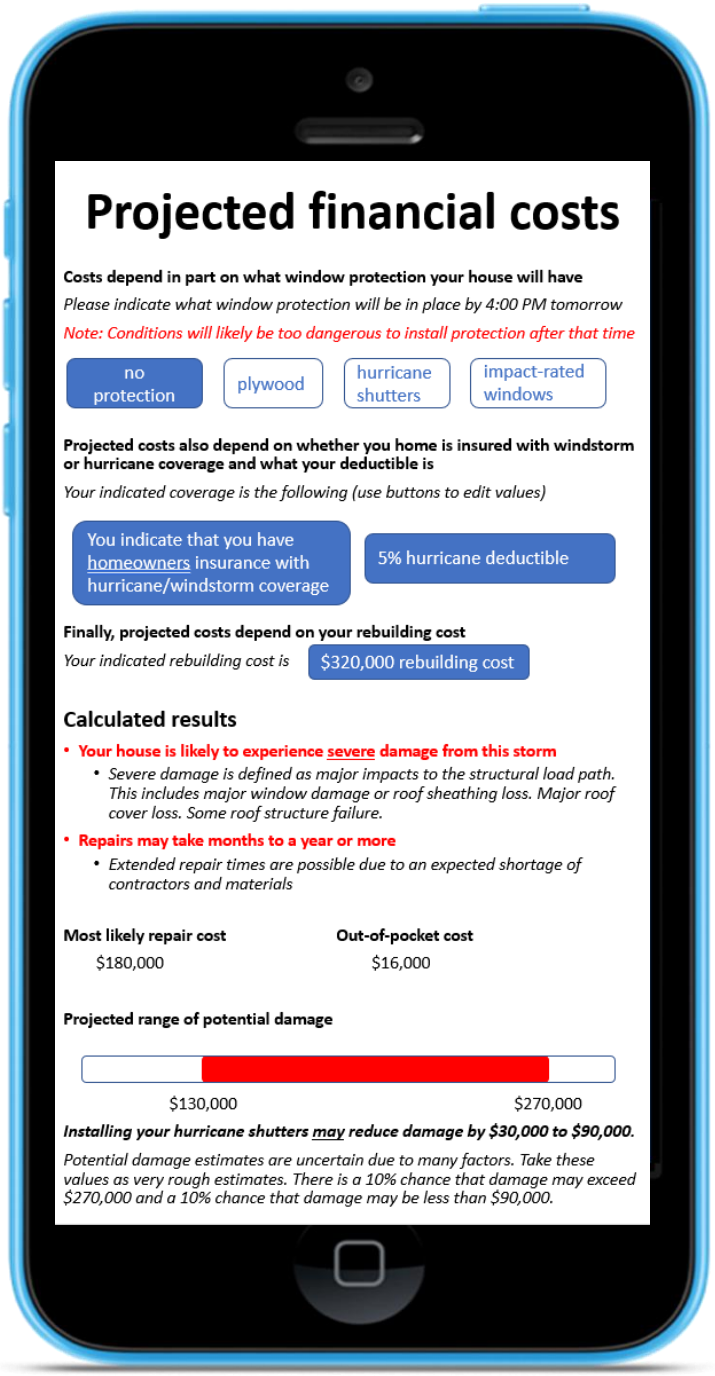
- **Your house is likely to experience severe damage from this storm**
  - *Severe damage is defined as major impacts to the structural load path. This includes major window damage or roof sheathing loss. Major roof cover loss. Some roof structure failure.*
- **Repairs may take months to a year or more**
  - *Extended repair times are possible due to an expected shortage of contractors and materials*

Most likely repair cost	Out-of-pocket cost
$180,000	$16,000

Projected range of potential damage

Installing your hurricane shutters may reduce damage by $30,000 to $90,000.

Potential damage estimates are uncertain due to many factors. Take these values as very rough estimates. There is a 10% chance that damage may exceed $270,000 and a 10% chance that damage may be less than $90,000.



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Most likely repair cost

$140,000

Out-of-pocket cost

$16,000

Projected range of potential damage

$100,000 $200,000

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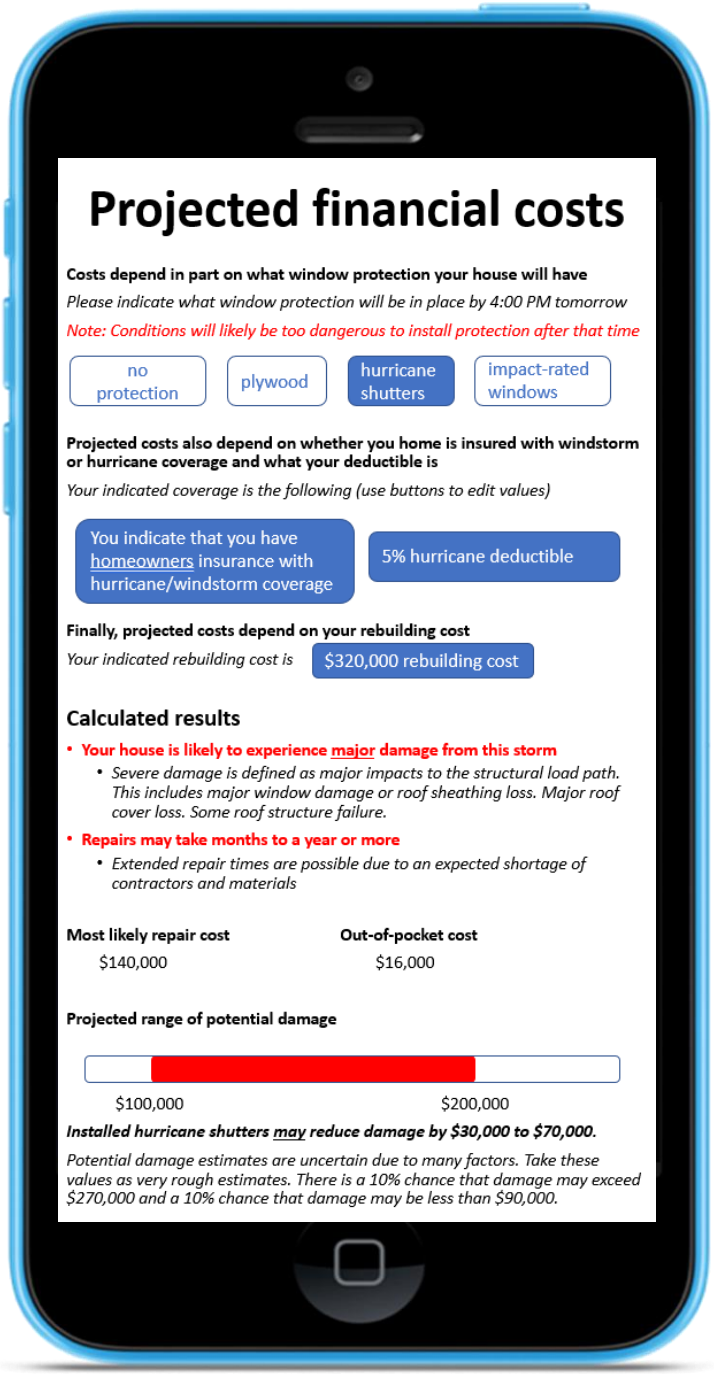


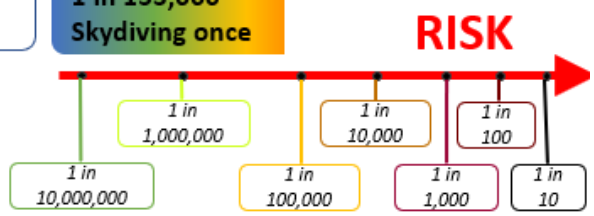
Compare Risks

Estimates of the risk of death are highly uncertain due to many factors, including some of which cannot be included in the above analysis.

Choose risk output: Risk of death | Risk of injury

Use the buttons below to add or edit any options you would like to compare:

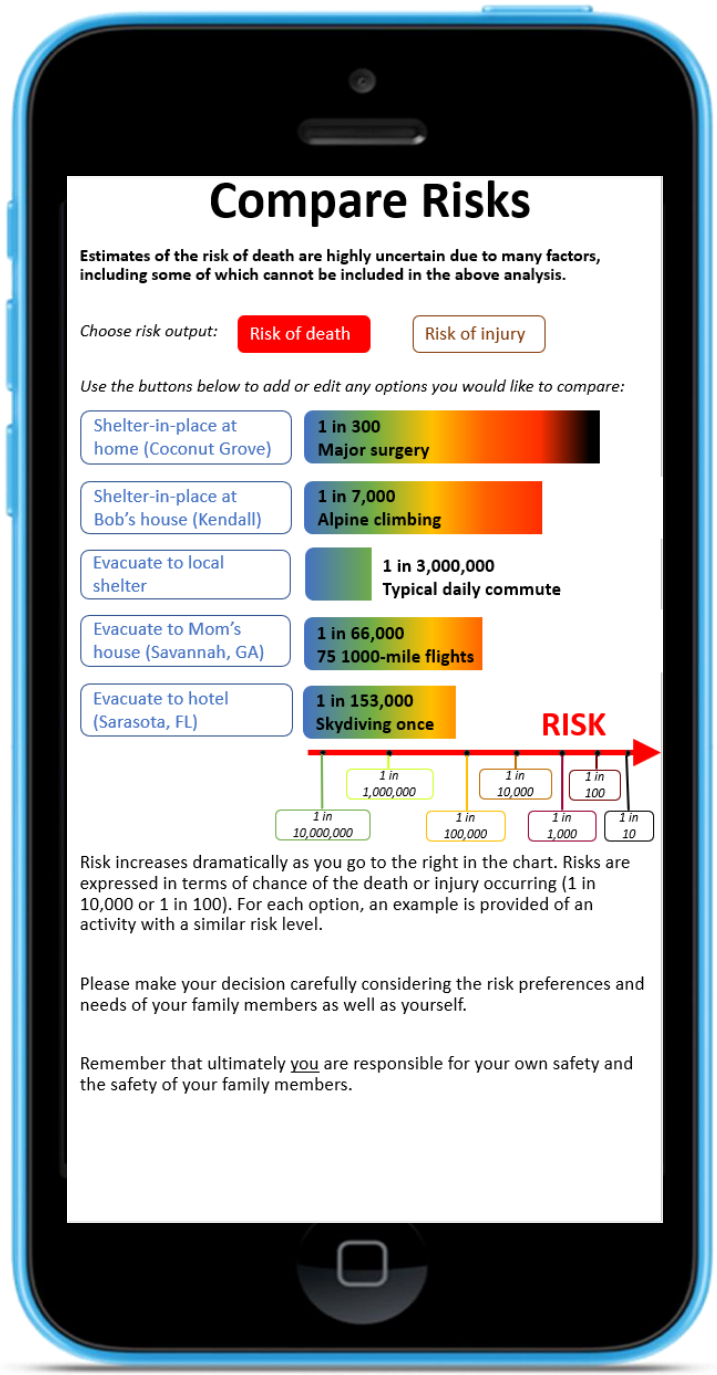
- Shelter-in-place at home (Coconut Grove) — 1 in 300, Major surgery
- Shelter-in-place at Bob's house (Kendall) — 1 in 7,000, Alpine climbing
- Evacuate to local shelter — 1 in 3,000,000, Typical daily commute
- Evacuate to Mom's house (Savannah, GA) — 1 in 66,000, 75 1000-mile flights
- Evacuate to hotel (Sarasota, FL) — 1 in 153,000, Skydiving once



Risk increases dramatically as you go to the right in the chart. Risks are expressed in terms of chance of the death or injury occurring (1 in 10,000 or 1 in 100). For each option, an example is provided of an activity with a similar risk level.

Please make your decision carefully considering the risk preferences and needs of your family members as well as yourself.

Remember that ultimately you are responsible for your own safety and the safety of your family members.



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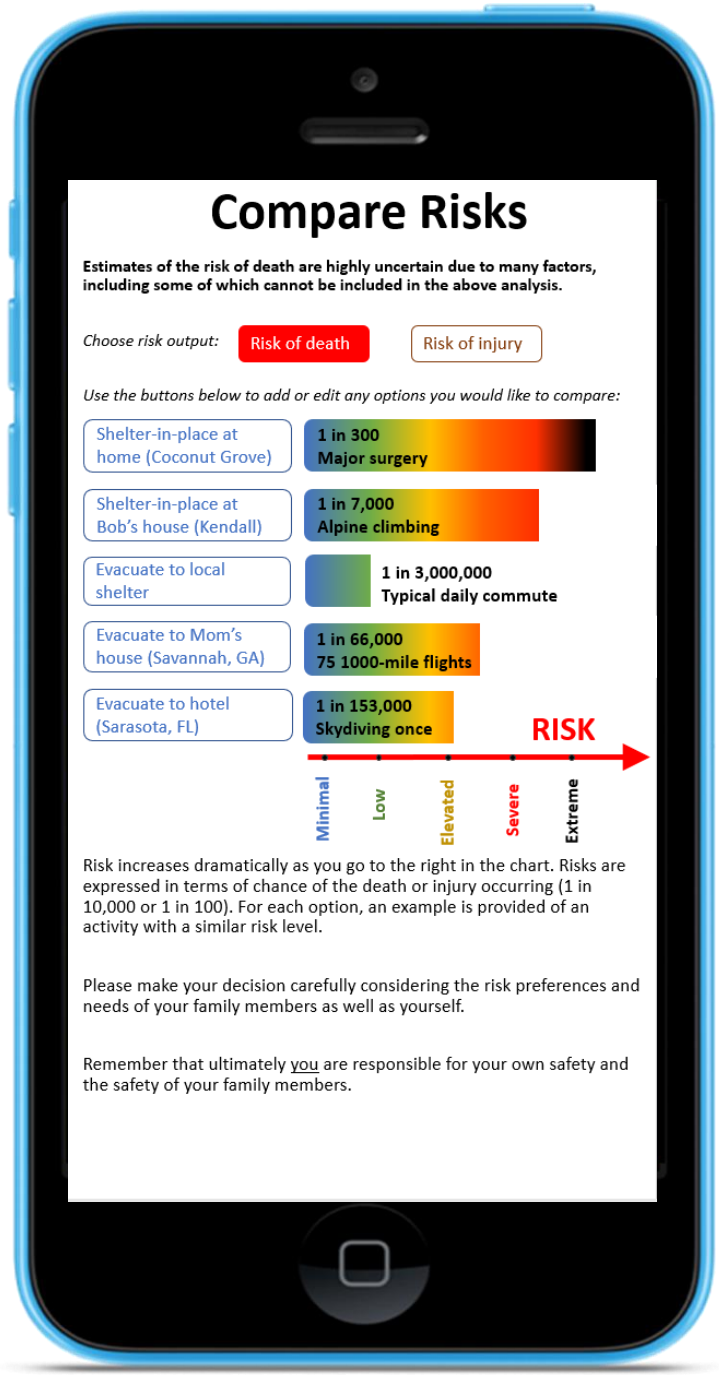
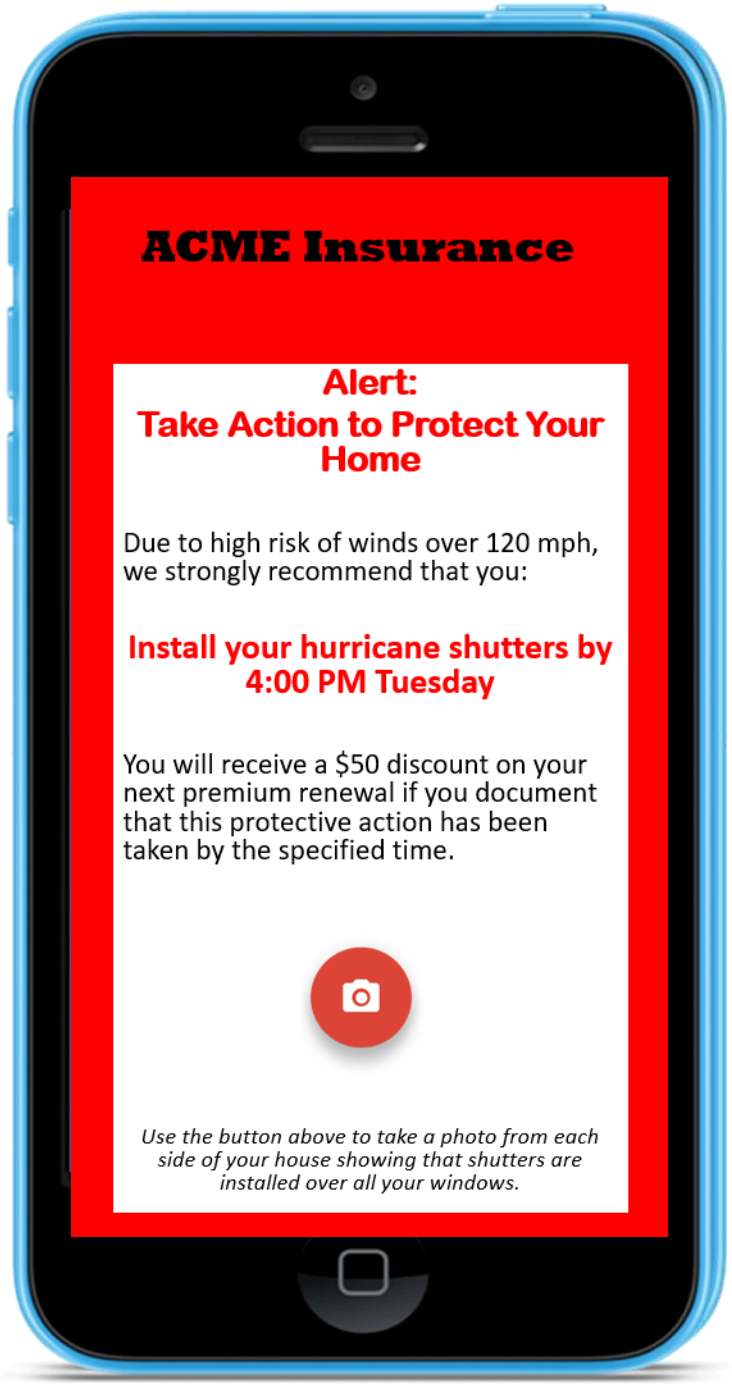
Evacuate to Mom's house (Savannah, GA)	1 in 66,000 75 1000-mile flights
Evacuate to hotel (Sarasota, FL)	1 in 153,000 Skydiving once

Risk increases dramatically as you go to the right in the chart. Risks are expressed in terms of chance of the death or injury occurring (1 in 10,000 or 1 in 100). For each option, an example is provided of an activity with a similar risk level.

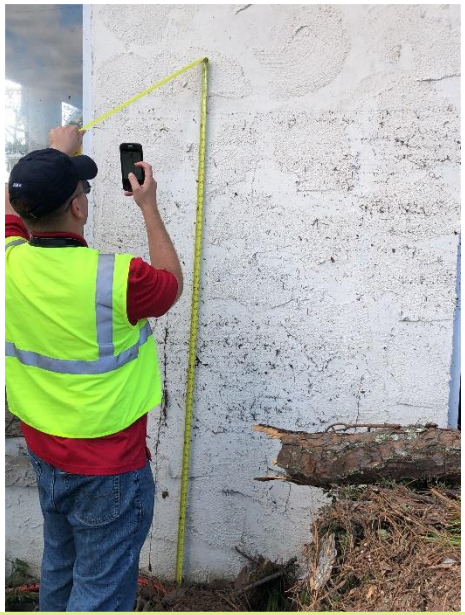
Please make your decision carefully considering the risk preferences and needs of your family members as well as yourself.

Remember that ultimately you are responsible for your own safety and the safety of your family members.




ACME Insurance
Alert:
Take Action to Protect Your Home
Due to high risk of winds over 120 mph, we strongly recommend that you:
Install your hurricane shutters by 4:00 PM Tuesday
You will receive a $50 discount on your next premium renewal if you document that this protective action has been taken by the specified time.
Use the button above to take a photo from each side of your house showing that shutters are installed over all your windows.

Next: Evaluate the capability of the deterministic HRC approach to provide accurate and useful information about structural damage potential



- Run HRC retrospectively for sites that experienced wind impacts in past hurricanes
- Compare predicted damage states to actual damage states assessed from on-the-ground damage surveys
- Evaluate how well predicted damage states correlate to ability of structures to protect life and safety

Damage Assessment Data

Hurricane Michael, 2018 (NSF StEER Team)

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- Structural Vulnerability Team
- Wind Modeling Team
- Technical Development Team
- User Design / User Experience Team (COMET)
- Hazard Communication (Social Science) Team
- Verification Team
- Human Vulnerability Team
- Utilities Modeling Team
- Storm Surge Modeling Team
- Emergency Management Team

The Researcher Collective is open to all researchers who would like to contribute
To join, e-mail riskcalculator@ucar.edu

Ways to Partner with Us

The HurricaneRiskCalculator™ will be beta-testing 2020

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I will be at the UCAR Booth from 9:00 – 11:00 AM Thursday

Please stop by

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