

# NYS Resiliency Institute for Storm Emergencies (NYS RISE)

## **Subtask 4.1:**

Projection of evacuation zones under  
climate change

**Led by:**

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**Mar 27, 2014 Meeting**

# Research Questions (Motivation)

**1:** What is the effect of evacuation zones on evacuation warnings, evacuation models and / or times?

**2:** How do we determine evacuation zones as a function of geography, storm, infrastructure and other factors.

**3:** What are the storm surge probability distributions at different locations under climate variability and long-term change?

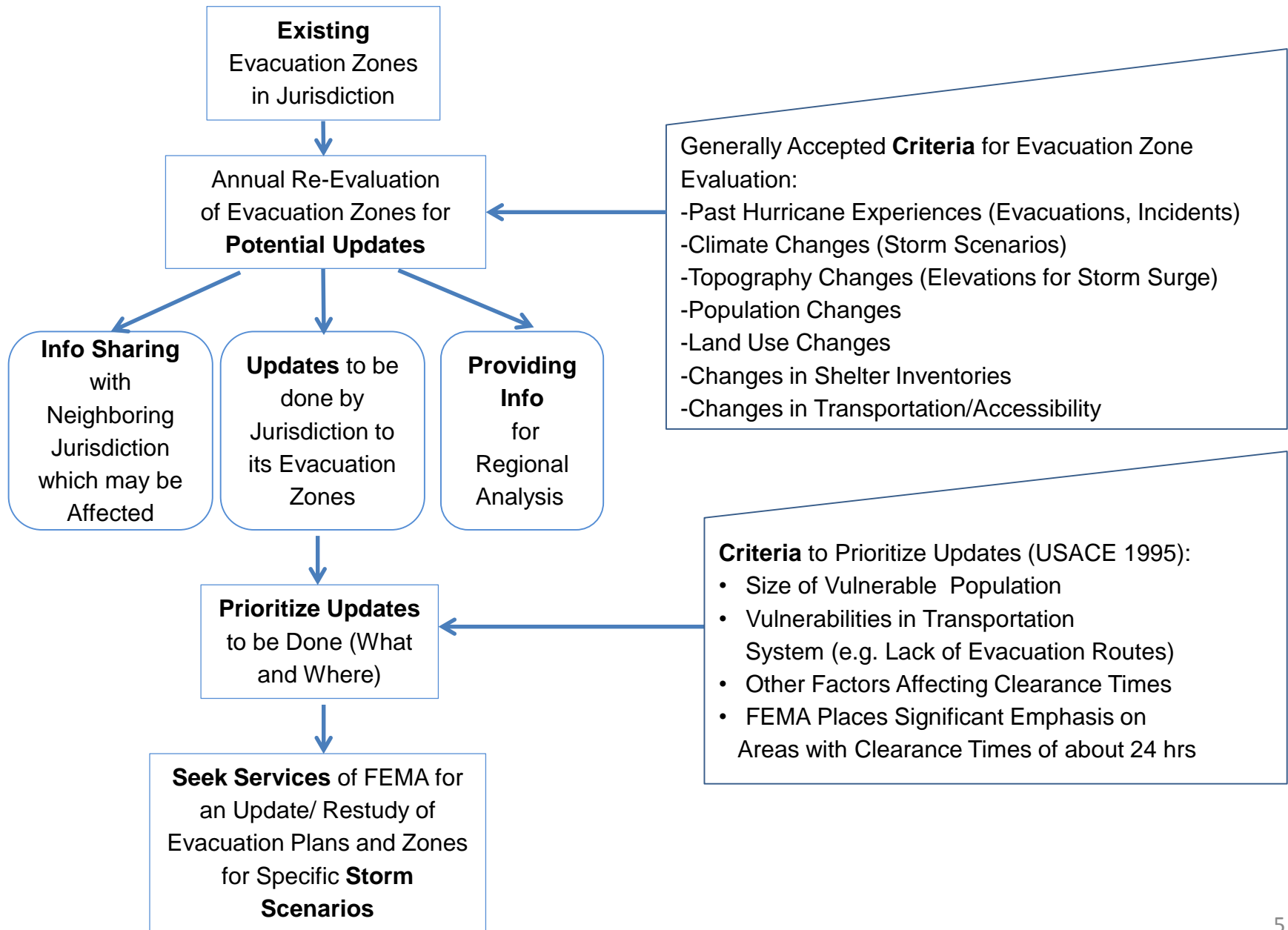
# Progress to Date

- Literature review and draft report completed
- Identification and review of relevant data done
  - flood data from SBU, Surge Models, SLOSH maps
  - real incident data during Sandy from TRANSCOM for New York City
  - Updated evacuation zones are obtained
- Data will be used in the evaluation of the existing evacuation zones, development of incident and storm prediction models to help with the development of more up-to-date evacuation zones based on specific scenarios
- Findings of this subtask to be used to update/validate the current evacuation zones based on specific scenarios

## Research Methodology: Improved Evacuation Zone Modeling

- A step by step methodology to “improve” existing zoning system based on:
  - the predictions of an accurate atmospheric model
  - network-wide infrastructure
  - socio-demographic characteristics of the study region
  - incident records of the most recent hurricanes Sandy and Irene
- SBU will use their atmospheric model to predict potential flooding / surge for a given storm scenario. They will also visualize this information using 3-D visualization techniques.
- NYU will use information from the previous step and network-wide infrastructure, socio-demographic, traffic characteristics of the study region plus the incident records from TRANSCOM to validate and improve existing zoning structure.
- NYU and SBU will develop a new / improved zoning for “different types of storms” with the idea of eventual automation of this approach.

# Research Methodology: Updating Evacuation Zones

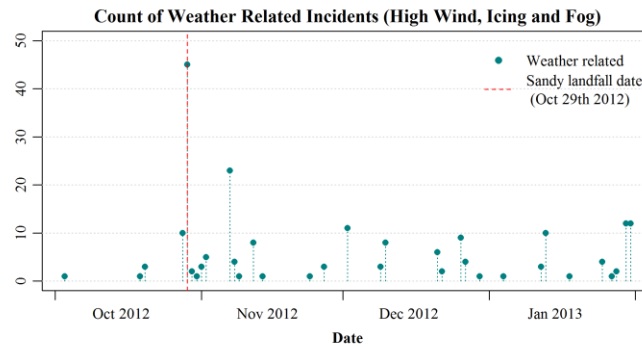
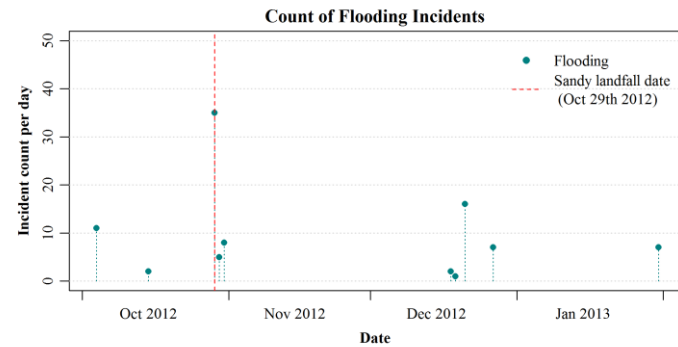
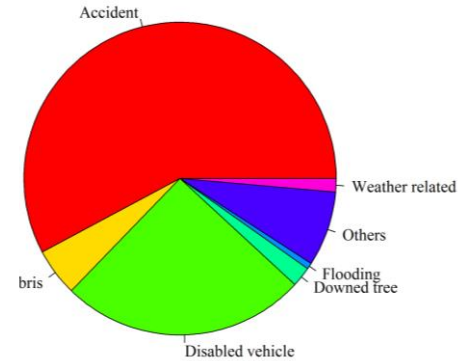
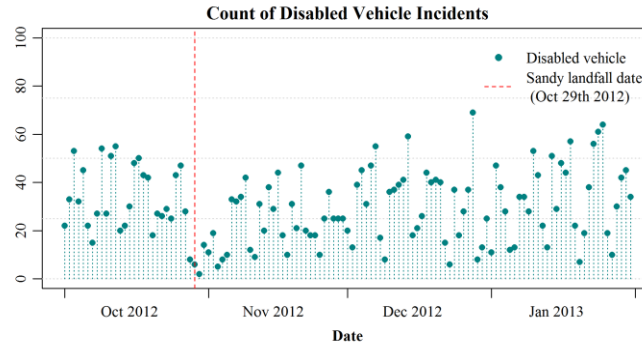
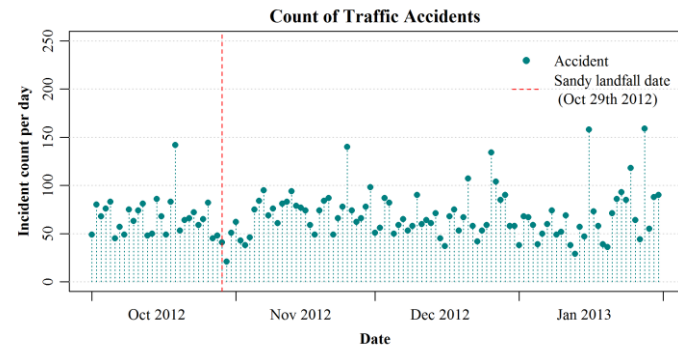


## Research Methodology: Major Criteria for Updating Evacuation Zones

In June 2013, NYC Mayor's Office announced final updates to the City's hurricane evacuation zones, criteria for which overlaps with the general criteria identified in the literature.

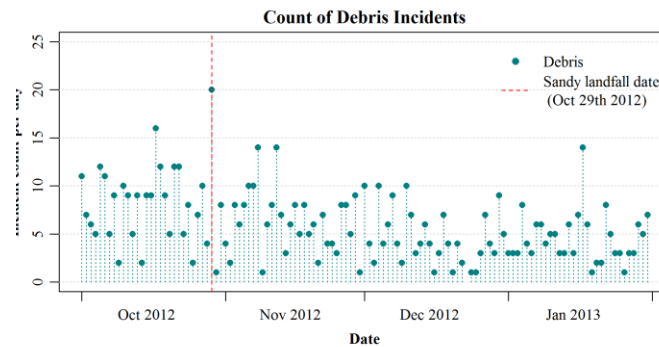
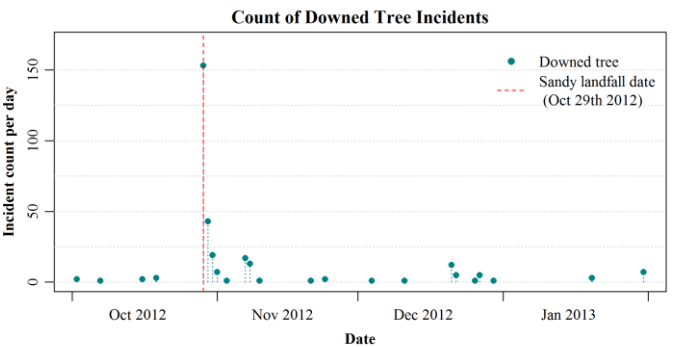
- The new Zones, 1 through 6, which will replace Zones A, B and C, now include an additional 600,000 New Yorkers not included within the boundaries of the former zones
- The new zone system was developed using the latest SLOSH maps
- The zones are based on coastal flood risk resulting from storm surge; the geography of the city's low-lying neighborhoods; accessibility of these neighborhoods by bridge and roads.
- The new hurricane evacuation zones incorporate a recently updated model from the National Weather Service, and the new model accounts for larger and slower moving storms.
- Additionally, the resolution of the model has been increased, incorporating improved elevation data, and the new evacuation zones also assume that the storm surge will coincide with high tide.

# Relevant Data and Preliminary Analysis: Sandy Traffic Incident Analysis



-Fewer accidents and disabled vehicle incidents during Sandy.

-More flooding, weather related and downed tree and debris incidents during Sandy.

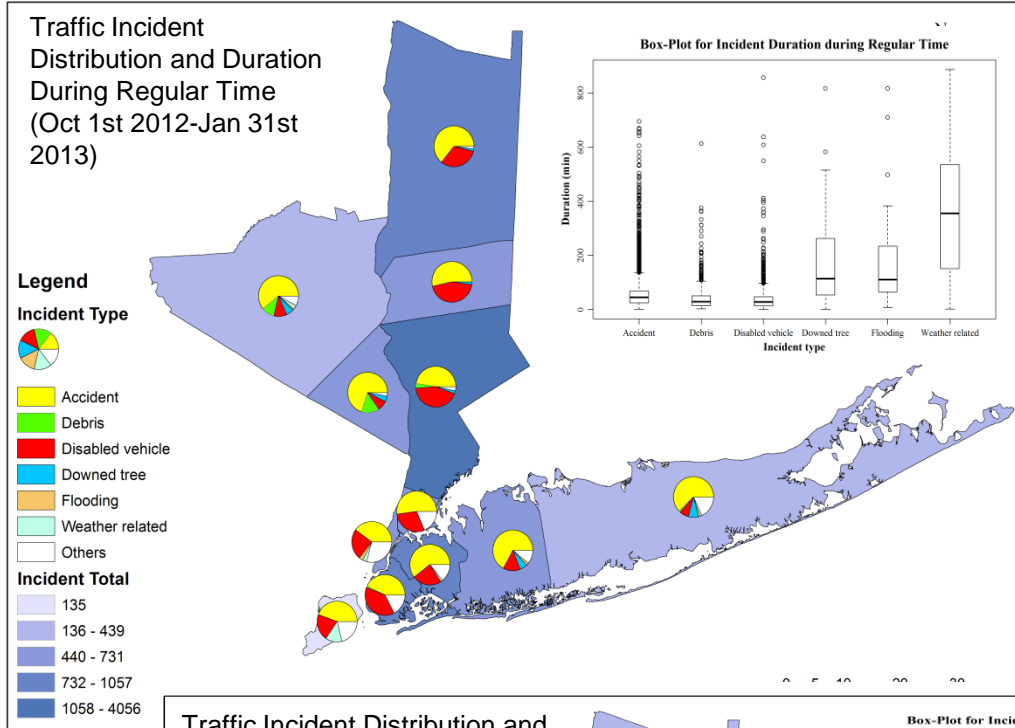


-For NYC less than 50% of flooding occurred in evacuation zones.

-There are a number of downed tree incidents in the evacuation route.

6 incident types (92% of total) were identified in NYC, LI and downstate counties

# Relevant Data and Preliminary Analysis: Traffic Incident Analysis

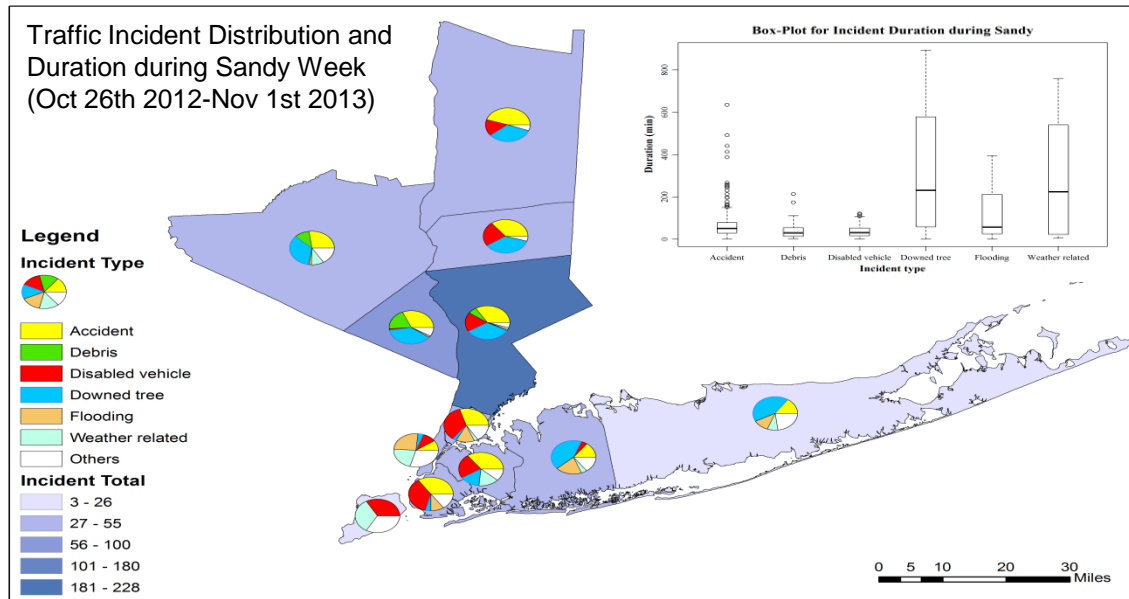


-Accidents and disabled vehicle incidents are the two main incidents in regular times

-During Sandy, more downed tree incidents occurred in LI and downstate counties

-More flooding and weather related incidents in NYC and more debris incidents in Rockland county

-Generally, the duration of incidents did not change a lot during Sandy. But the average duration of "downed tree" gets longer during Sandy.





# Next Steps

- Current Evacuation Zones will be evaluated using the major criteria identified in the literature
- Available storm, traffic and incident data will be used to assess the effectiveness of current evacuation zones under Sandy conditions
- An improved evacuation zoning scheme will be proposed for different storm scenarios and incident prediction functions

# Schedule and Milestones

## Milestones:

- **January 15:** Approval of the improved modeling approach by the sponsor
- **January 30:** Preliminary findings
- **March 15:** Submission of the draft report for review and comments for Phase 1
- **July 30 :** Submission of the draft report for review and comments for Phase 2
- **August 30:** Submission of the final draft report for Phase 2

## Project Schedule

Tasks	Dec	Jan	Feb	Marc	April	May	June	July	August
<b>Task 1:</b> Literature Review									
<b>Task 2:</b> Data Collection									
<b>Task 3:</b> Development of Improved Modeling Approach									
<b>Task 4:</b> Short-term Case Study									
<b>Task 5:</b> Generalized Evacuation Zone Methodology									
<b>Task 6:</b> Long-Term Case Studies									
<b>Task 7:</b> Final Report & Project Management									

# Appendix

# Relevant Data: NYC Latest Evacuation Zones

## New Evacuation Zones Before Sandy

### NEW YORK CITY HURRICANE EVACUATION ZONES

**How to Use This Map\***

- Determine whether you live in an evacuation zone by using the Hurricane Evacuation Zone Finder at [www.nyc.gov/hurricanezones](http://www.nyc.gov/hurricanezones), calling 311 (TTY: 212-504-4155), or consulting this map.
- If your address falls into one of the City's hurricane evacuation zones, you may have to evacuate during a hurricane.
- The City strongly encourages evacuees first to seek shelter with friends or family located outside the evacuation zones.
- If no evacuation site with friends or family, use the Finder, call 311 (TTY: 212-504-4155), or use this map to identify which evacuation center is most appropriate for you. NOTE: Not all evacuation centers are accessible by all modes of transportation. Visit the MTA website at [www.mta.info](http://www.mta.info) or call 718-330-0234 for the latest transit information.

\*Evacuation information is subject to change. For the latest information, visit [www.nyc.gov/hurricanezones](http://www.nyc.gov/hurricanezones) or call 311 (TTY: 212-504-4155).

**Hurricane Evacuation Zones**

**ZONE A**  
Residents in Zone A face the highest risk of flooding from a hurricane's storm surge. Zone A includes all low-lying coastal areas and other areas that could be affected by storm surge from ANY hurricane making landfall close to New York City.

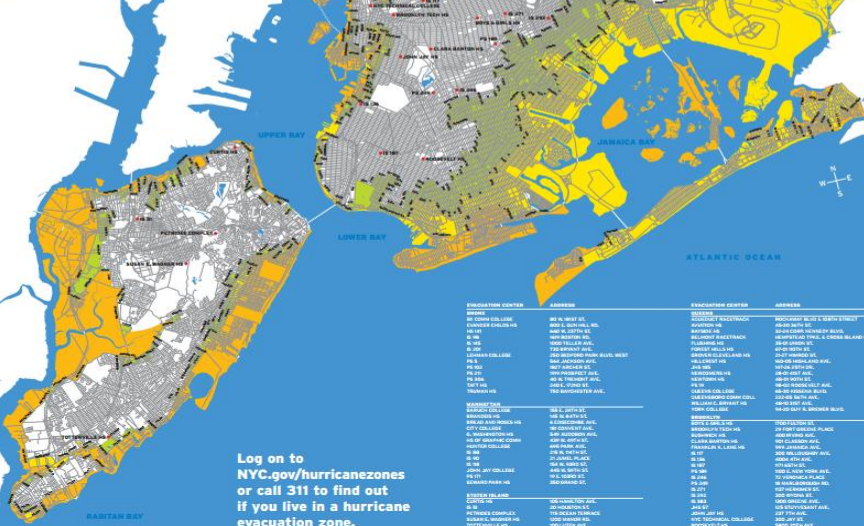
**ZONE B**  
Residents in Zone B may experience storm surge flooding from a MODERATE (Category 2 and higher) hurricane.

**ZONE C**  
Residents in Zone C may experience storm surge flooding from a MAJOR (Category 3, 4 or 5) hurricane making landfall just south of New York City. A major hurricane is unlikely to hit New York City, but not impossible.

**NO ZONE D**  
Residents who do not live in a hurricane evacuation zone face an unlikely to experience of storm surge flooding from a hurricane.

**LEGEND**

- EVACUATION CENTER
- ZONE A
- ZONE B
- ZONE C
- ZONE D



Log on to [nyc.gov/hurricanezones](http://nyc.gov/hurricanezones) or call 311 to find out if you live in a hurricane evacuation zone.

## New Evacuation Zones Post Sandy

<b>B</b>	LEHMAN COLLEGE 250 REEFING HAVEN BLVD. BRONX, NY 10465	<b>PS 210</b> 250 REEFING HAVEN BLVD. BRONX, NY 10465
<b>MS</b>	MS-HS 341 340 W. 277TH ST. BRONX, NY 10468	<b>PS 306</b> 40 W. 262ND ST. BRONX, NY 10468
<b>PS 5</b>	WILLIAM W. TAFFI HS 240 E. 172ND ST. BRONX, NY 10454	
<b>N</b>	HS OF GRAPHIC COMM 430 W. 107TH ST. BRONX, NY 10441	<b>JOHN JAY COLLEGE</b> 430 W. 107TH ST. BRONX, NY 10441
<b>HS</b>	HUNTER COLLEGE 195 PARK AVE. BRONX, NY 10471	<b>JULIA ROBINSON ED.</b> 209 W. 125TH ST. BRONX, NY 10452
<b>HS</b>	HS W. 181ST ST. 17 JAMES PLACE BRONX, NY 10460	<b>SEWARD PARK HS</b> 200 GRAND ST. BRONX, NY 10451
<b>HS</b>	HS W. 242ND ST. 18 W. 242ND ST. BRONX, NY 10462	
<b>D</b>	GRANER CLEVELAND HS 2727 BRONX ST. BRONX, NY 10469	<b>SWEENEY COLLEGE</b> 65-30 HESLERA BLVD. BRONX, NY 10471
<b>MS</b>	WELLESLEY HS 3005 HIGHL. AND AVE. BRONX, NY 10462	<b>SWEENEY-HOUSE</b> COMMUNITY COLLEGE 2005 HIGHL. AND AVE. BRONX, NY 10462
<b>JHS</b>	JHS HS 120-45 145TH AVE. BRONX, NY 10456	<b>WILLIAM C. BRYANT HS</b> 4800 145TH AVE. BRONX, NY 10456
<b>CR</b>	NEWTONS HS 180-45 145TH AVE. BRONX, NY 10456	<b>YORK COLLEGE</b> 2000 GATEWAY BLVD. BRONX, NY 10473
<b>PS 10</b>	PS 10 280 COCKEVELL AVE. BRONX, NY 10469	
<b>IS</b>	IS 036 100 W. 171ST ST. BRONX, NY 10461	<b>JOHN JAY HS</b> 100 W. 171ST ST. BRONX, NY 10461
<b>I</b>	IS 067 100 W. 171ST ST. BRONX, NY 10461	<b>NYC TECHNICAL COLLEGE</b> 100 W. 171ST ST. BRONX, NY 10461
<b>IS</b>	IS 046 100 W. 171ST ST. BRONX, NY 10461	
<b>IS</b>	IS 046 100 W. 171ST ST. BRONX, NY 10461	
<b>IS</b>	IS 271 100 W. 171ST ST. BRONX, NY 10461	
<b>IS</b>	IS 283 100 W. 171ST ST. BRONX, NY 10461	
<b>JHS</b>	JHS ST 100 W. 171ST ST. BRONX, NY 10461	<b>ROOSEVELT HS</b> 100 W. 171ST ST. BRONX, NY 10461
<b>AND</b>	PS 175 155 HUGGENT AVE. BRONX, NY 10454	<b>SUSAN E. WANDER HS</b> 155 HUGGENT AVE. BRONX, NY 10454
	PS 175 155 HUGGENT AVE. BRONX, NY 10454	

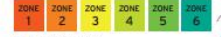
**HURRICANE ZONES OR CALL 311 TO FIND IN A HURRICANE EVACUATION ZONE.**

- If you cannot stay with friends or family, use the Finder, call 311 (TTY: 212-504-4155), or use this map to identify which evacuation center is most appropriate for you.
- Evacuees should be prepared to stay with friends or family who live outside evacuation zone boundaries.
- If you cannot stay with friends or family, use the Finder, call 311 (TTY: 212-504-4155), or use this map to identify which evacuation center is most appropriate for you.

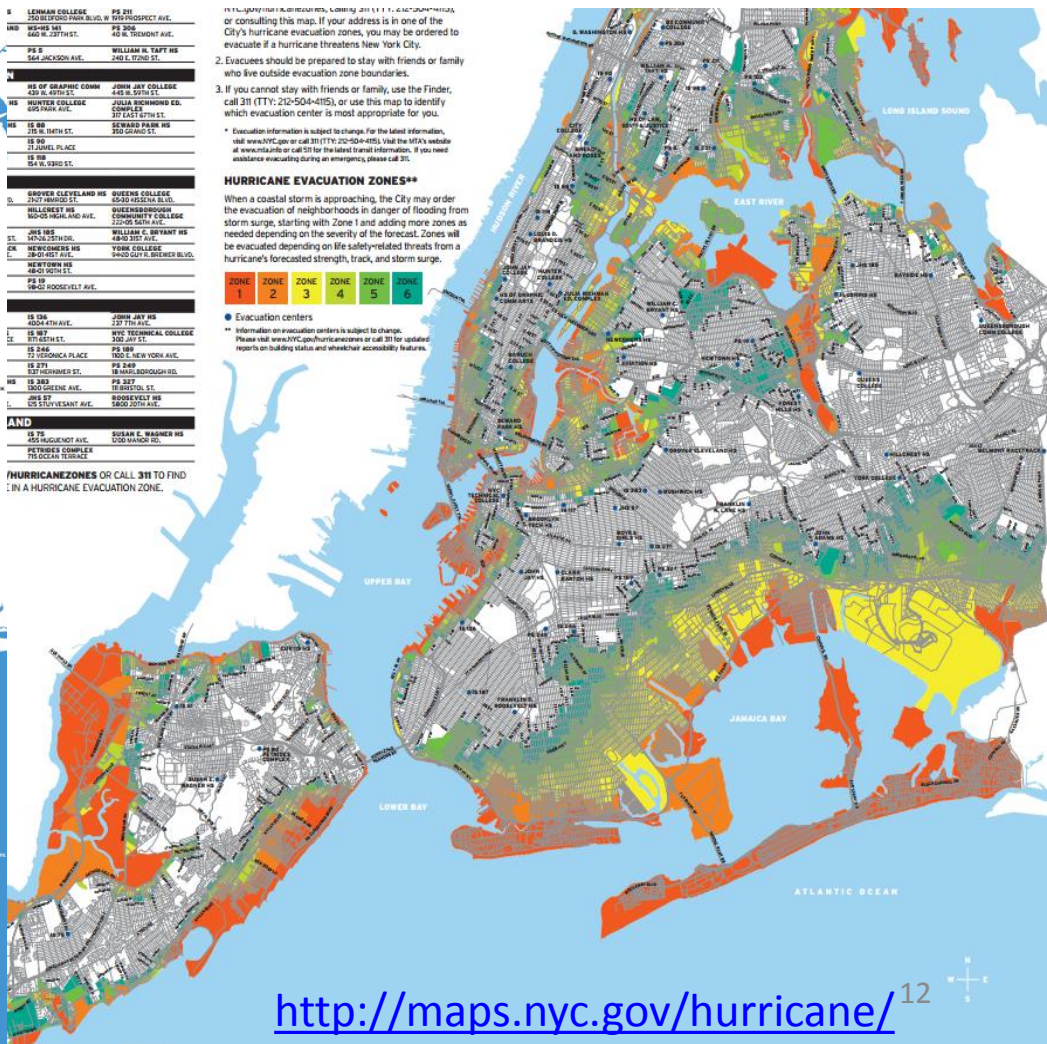
\*Evacuation information is subject to change. For the latest information, visit [www.nyc.gov](http://www.nyc.gov) or call 311 (TTY: 212-504-4155). Visit the MTA website at [www.mta.info](http://www.mta.info) or call 311 for the latest transit information. If you need assistance evacuating during an emergency, please call 311.

### HURRICANE EVACUATION ZONES\*\*

When a coastal storm is approaching, the City may order the evacuation of neighborhoods in danger of flooding from storm surge, starting with Zone 1 and adding more zones as needed depending on the severity of the forecast. Zones will be evacuated depending on life safety-related threats from a hurricane's forecasted strength, track, and storm surge.



- Evacuation centers
- Information on evacuation centers is subject to change. Please visit [www.nyc.gov/hurricanezones](http://www.nyc.gov/hurricanezones) or call 311 for additional reports on building status and wheelchair accessibility features.



<http://maps.nyc.gov/hurricane/>

# Literature Review : General Principles Considered in Planning Evacuation Zones

Principle	Literature
Hurricane evacuation zones should be areas of uniform elevation.	Meduri (2004), Wilmot and Meduri (2005)
Zones should be easily identifiable by verbal or written description.	Meduri (2004), SFRPC(2001), Wilmot and Meduri (2005)
Zones should relate to maximum potential surge flooding limits for each storm scenario.	Meduri (2004), PBS&J (2000), Wilmot and Meduri (2005)
Zones should relate well to census tracts, TAZ, or other data base units, be as homogeneous as possible in their land use.	Meduri (2004), PBS&J (2000), USACE (2001) , Wilmot and Meduri (2005)
Zonal boundaries should include identifiable features, roadways, landmarks, etc.	Meduri (2004), PBS&J (2000), USACE (2001), Wilmot and Meduri (2005)
Small EZ zones that would be isolated by surrounding surge should be avoided, and one EZ may not be established within another.	Meduri (2004), PBS&J (2000), Wilmot and Meduri (2005)
Zones should be able to be served by major evacuation routes.	Meduri (2004), PBS&J (2000), Wilmot and Meduri (2005)
Rural counties should have no more than 20 zones and counties with major urban areas should have no more than 35 zones.	USACE (2001)

# Literature Review: Major Factors in Determining and Updating Evacuation Zones

Category	Factor	Literature	Detailed Data Availability
Climate	Storm surge (critical factor)	Blakely(1997), Meduri (2004), Wilmot and Meduri (2005), National Hurricane Center Website	SLOSH and ADCIRC model
	Tide	Westerink (2008), National Hurricane Center Website	ADCIRC model
	Precipitation	Wilmot and Meduri (2005)	MM5 model
	High wind	Meduri (2004), Wilmot and Meduri (2005)	
Geographic	Natural boundary	Meduri (2004), Wilmot and Meduri (2005)	NYC Open Data
	Topography (obstacles, etc.)	Sorensen and Carnes (1992)	N/A
Socio-economic	Population traits	Chakraborty et al (2005)	Statistic Census
	Land use	Meduri (2004), Wilmot and Meduri (2005)	NYC Department of City Planning
	Building structure	Chakraborty et al (2005)	Building damage data from ESRI
	Access to resources	Chakraborty et al (2005)	
	Evacuation routes	Chakraborty et al (2005)	BPM model
	Special evacuation needs	Chakraborty et al (2005)	
	Political concerns	Sorensen and Carnes (1992)	N/A

# Relevant Data: Available GIS Data Sets

Category	GIS File	Source
Administrative District	Borough	NYC Department of City Planning
	Community	NYC Department of City Planning
	Neighborhood Tabulation Area	NYC Department of City Planning
	Census tract	NYC Department of City Planning
	Census block	NYC Department of City Planning
Road Network	Road segment	NYS Department of Transportation, NYC Department of City Planning
	Intersection	NYC Department of City Planning
Public Transit	Subway route	NY Metropolitan Transportation Authority
	Subway stop	NY Metropolitan Transportation Authority
	Bus route	NY Metropolitan Transportation Authority
	Bus stop	NY Metropolitan Transportation Authority
Bike	Bike route	NYC Department of Transportation
	Bike rack	NYC Department of Transportation
Pedestrian	Sidewalk	NYC Department of City Planning
Truck	Truck route	NYC Department of Transportation
Parking	Parking Regulation	NYS Department of Transportation
Safety & Security	Accident	NYS Department of Transportation
Land use	Land use	NYC Department of City Planning
Others	Sidewalk café	NYC Department of City Planning
	points of interest	NYC Department of City Planning
Sandy Impact	Housing damage	ESRI
	Observed flooding	ESRI
	FEMA's best available Flood Hazard Data for New Jersey and New York	<a href="http://www.region2coastal.com/sandy/table">http://www.region2coastal.com/sandy/table</a>
Geography	NYS Elevation Data	NYS GIS Clearinghouse
	LIDAR Coverage in NYS	NYS GIS Clearinghouse