HURRICANE SANDY

How does a relatively “modest” hurricane / tropical storm wreak so much damage?

and

Just what does an inspection engineer need to keep in mind when examining “at risk for storm damage” properties?

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Hurricane Sandy near peak intensity on October 25, 2012

Hurricane Sandy was a hurricane that devastated portions of the Caribbean and the Mid-Atlantic and Northeastern United States during late October 2012, with lesser impacts in the Southeastern and Midwestern states and Eastern Canada. Sandy, classified as the eighteenth named storm and tenth hurricane of the 2012 Atlantic hurricane season, was a Category 2 storm at its peak intensity. While it was a Category 1 storm off the coast of the Northeastern United States, the storm became the largest Atlantic hurricane on record (as measured by diameter, with winds spanning 1,100 miles (1,800 km)).

Storm path

After Sandy exited Cuba, the structure became disorganized, and it turned to the north-northwest over the Bahamas. By October 27, Sandy was no longer fully tropical, and despite strong shear, it maintained convection due to influence from an approaching trough; the same trough turned the hurricane to the northeast. After briefly weakening to a tropical storm, Sandy re-intensified into a hurricane,[and on October 28 an eye began redeveloping. The storm moved around an upper-level low over the eastern United States and also to the southwest of a ridge over Atlantic Canada, turning it to the northwest. Sandy reached a secondary peak of 90 mph (150 km/h) on October 29, around which time it had a wind diameter of over 1,000 nautical miles (1,150 mi, 1,850 km). The convection diminished while the hurricane accelerated toward the New Jersey coast, and the hurricane was no longer tropical by 2300 UTC on October 29. An hour later at about 0000 UTC on October 30, Sandy made landfall about 5 miles (8 km) southwest of Atlantic City, with winds of 90 mph (150 km/h). The remnants weakened over western Pennsylvania, degenerating into a remnant trough on October 31.

So what caused much of the damage?

- There is no denying that Atlantic Coast damage was widespread, even some distance inland. A sampling of effects include:
- **New Jersey:** A 50-foot piece of the Atlantic City Boardwalk washed away. Half the city of Hoboken flooded; the city of 50,000 had to evacuate two of its fire stations and the city's Mayor asked for National Guard help. In the early morning of October 30, authorities in Bergen County, New Jersey, evacuated residents after a berm overflowed and flooded several communities. Police Chief of Staff Jeanne Baratta said there were up to five feet of water in the streets of Moonachie and Little Ferry. The state Office of Emergency Management said rescues were undertaken in Carlstadt. Baratta said the three towns had been "devastated" by the flood of water. At least 24 people in the state were killed. Damage in the state is estimated at $30 billion.
- **New York:** New York governor Andrew Cuomo called National Guard members to help in the state. Storm impacts in Upstate New York were much more limited than in New York City; there was some flooding and a few downed trees. Rochester area utilities reported slightly fewer than 19,000 customers without power, in seven counties. Mayor Bloomberg announced that New York City public schools would be remain closed Tuesday, October 30 and Wednesday, October 31, but they remained closed through Friday, November 2. CUNY and NYU canceled all classes and campus activities for October 30. The New York Stock Exchange was closed for trading for two days, the first weather closure of the exchange since 1985. It was also the first two-day weather closure since the Great Blizzard of 1888. The East River overflowed its banks, flooding large sections of Lower Manhattan. Battery Park had a water surge of 13.88 ft. Seven subway tunnels under the East River were flooded. The Metropolitan Transportation Authority said that the destruction caused by the storm was the worst disaster in the 108-year history of the New York City subway system. Sea water flooded the Ground Zero construction site. In addition, a four story Chelsea building's facade crumbled and collapsed, leaving the interior on full display; however, no one was hurt by the falling masonry. After receiving many complaints that holding the marathon would divert needed resources, Mayor Bloomberg announced late afternoon November 2 that the New York City Marathon had been canceled. The event was to take place on Sunday, November 4. Marathon officials had said that they did not plan to reschedule. Gas shortages throughout the region led to an effort by the U.S. federal government to bring in gasoline and set up mobile truck distribution at which people could receive up to 10 gallons of gas, free of charge. This caused lines of up to 20 blocks long and was quickly suspended. On Thursday, November 8, Mayor Bloomberg announced odd-even rationing of gasoline would be in effect beginning November 9 until further notice. On November 26, Governor Cuomo called Sandy, "more impactful" than Hurricane Katrina, and estimated costs to New York at $42 billion. The storm severely damaged or destroyed around 100,000 homes on Long Island with more than 2,000 homes deemed uninhabitable there.

The chart below is a very basic comparison between Hurricane Sandy and Hurricane Katrina over several parameters, as of November 27, 2012.

	Katrina	Sandy
Storm Type at Landfall	Category 3 hurricane, Aug. 29, 2005 (second landfall).	Post-tropical cyclone, Oct. 29, 2012.
Deaths	1,833.	More than 200 in 7 countries, including 132 on the U.S. mainland.
Buildings Damaged or Destroyed	1.2 million housing units damaged, including 126,000 “severely damaged or destroyed” — includes Hurricanes Rita (Sept. 2005) and Wilma (Oct. 2005).	N.Y.: 305,000 housing units damaged or destroyed. N.J.: estimated 72,000 buildings damaged. Conn.: 3,000 homes damaged.
Estimated Cost	$148 billion (2012 dollars) in “total damages/costs.”	$71 billion in New York and New Jersey, including $9 billion in New York for preventive work. $360 million in Connecticut.
Insured Losses	$48.7 billion (2012 dollars).	$16 billion to $22 billion.
Homes Without Power	About 3 million in at least 8 states.	8.51 million in 16 states and Washington, D.C.
FEMA Assistance	738,318 applications approved.	465,000 applications filed in N.Y. and N.J., FEMA said Tuesday.
People Displaced	Up to 600,000 families homeless a month after the storm.	Officials still compiling data.

COSTLIEST HURRICANES

	Year	Landfall	Total (in billions)*	Diameter (miles)**	Top Winds (mph)***
Katrina	2005	LA	$128	200	110
Sandy	2012	NJ	$60-70	940	94
Andrew	1992	FL	$44	90	105
Ike	2008	TX	$32	240	95
Wilma	2005	FL	$25	250	105

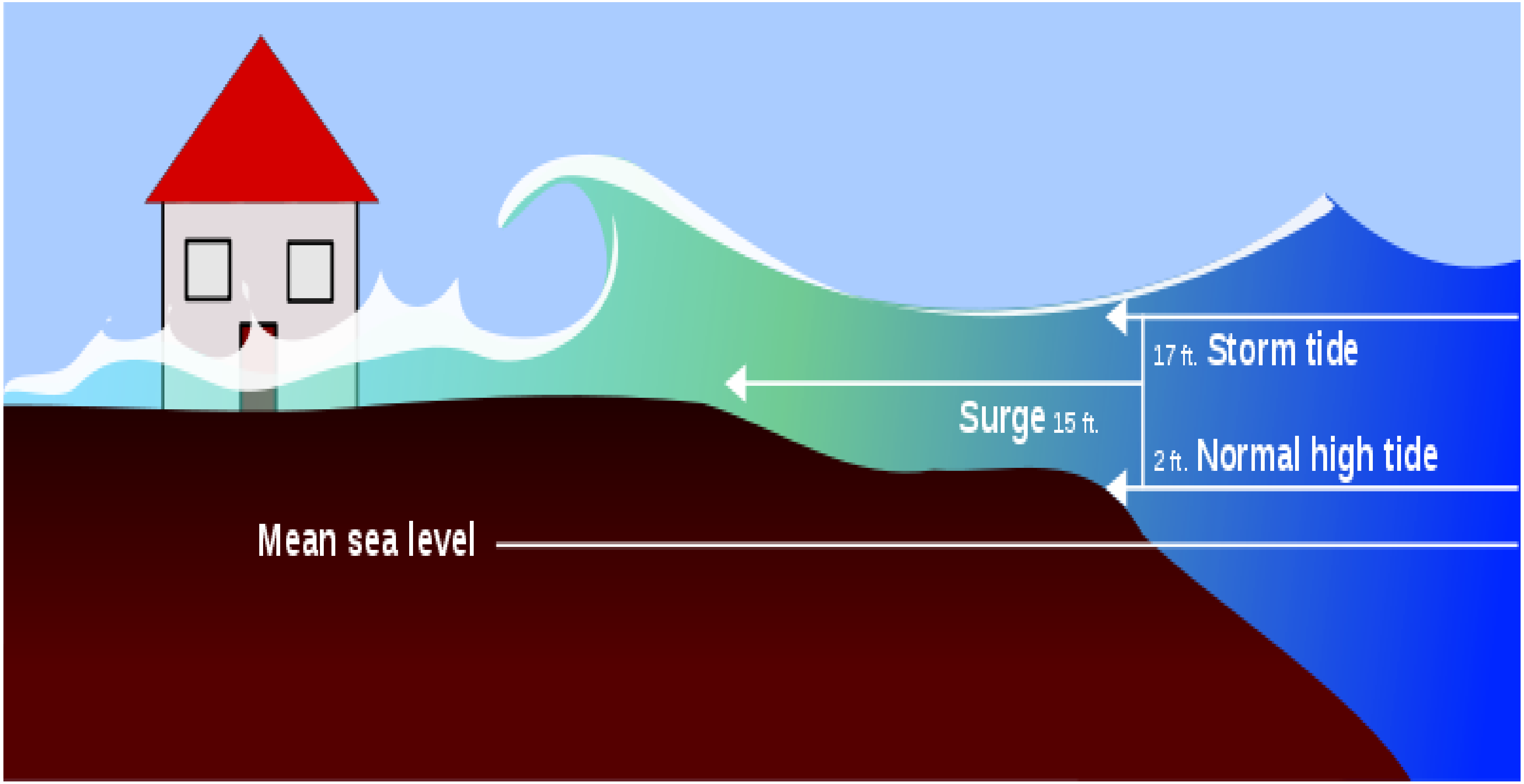
*2012 dollars

**Of tropical storm-force winds at landfall

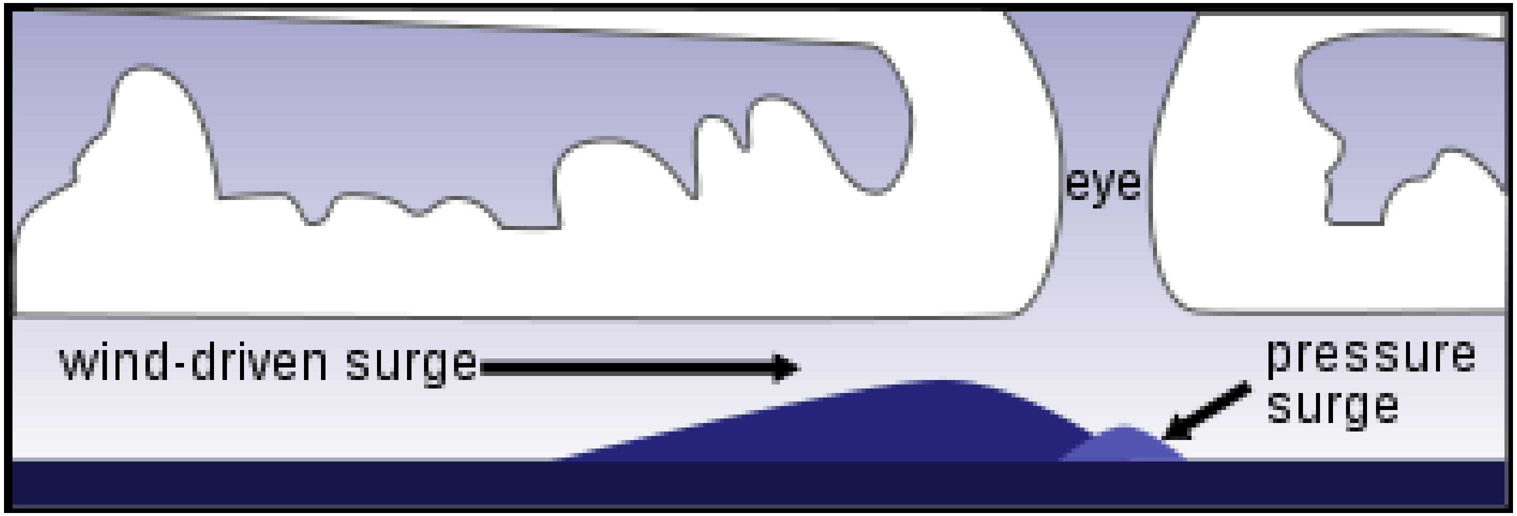
***Sustained at landfall

Flooding was the common denominator in virtually all severely damaged areas. And the damage largely related to “storm surge" effects.

- Water level is often defined as the mean elevation of the water surface when averaged over a sufficient period of time to eliminate the clearly distinguishable short period surface waves. In this presentation we are most interested in water level variations caused by:
- ***Storm Surge***, or the rise and fall of the normal water level in coastal waters due to the interaction between a storm and the underlying water surface



This offers a very schematic representation of storm surge



Schematic diagram of processes that generate storm surge

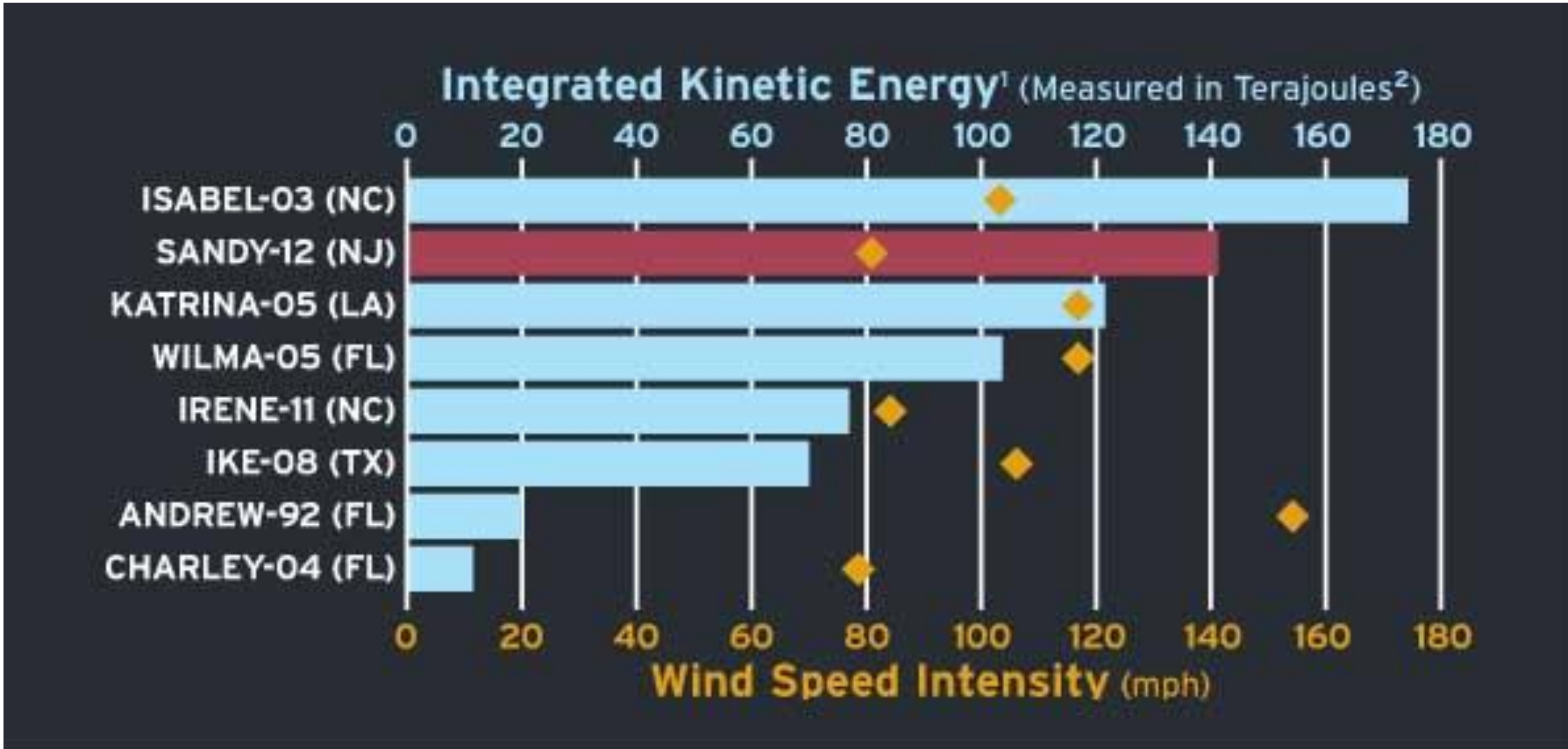
At least five processes can be involved in altering tide levels during storms: the pressure effect, the direct wind effect, the effect of the Earth's rotation, the effect of waves, and the rainfall effect. The pressure effects of a tropical cyclone will cause the water level in the open ocean to rise in regions of low atmospheric pressure and fall in regions of high atmospheric pressure. The rising water level will counteract the low atmospheric pressure such that the total pressure at some plane beneath the water surface remains constant. This effect is estimated at a 10 mm (0.39 in) increase in sea level for every millibar drop in atmospheric pressure.

A look at probable surge effects related purely to Sandy's exceedingly low barometric pressure

- Sandy had one of the lowest barometric pressures on record for a cyclone, 940 mbar
- 1 psi = 68.95 mbar
- "normal" atmospheric pressure is 14.7 psi
- (14.7 psi)(68.95 mbar/1 psi) = 1013.6 mbar
- 1013.6 – 940 = 73.6 mbar
- sea level rises .39" for each 1 mbar decrease in pressure
- (73.6 mbar)(.39"/1 mbar) = 28.7" = 2.4'
- It should be noted that this is an approximate or rule of thumb method. A considerably more refined mathematical approach is contained in Appendix D of the Army Corps of Engineers Engineering Manual EM 1110-2-1412, 15 APRIL 1986, titled Engineering and Design: Storm Surge Analysis

OVERALL STORM POWER AT LANDFALL

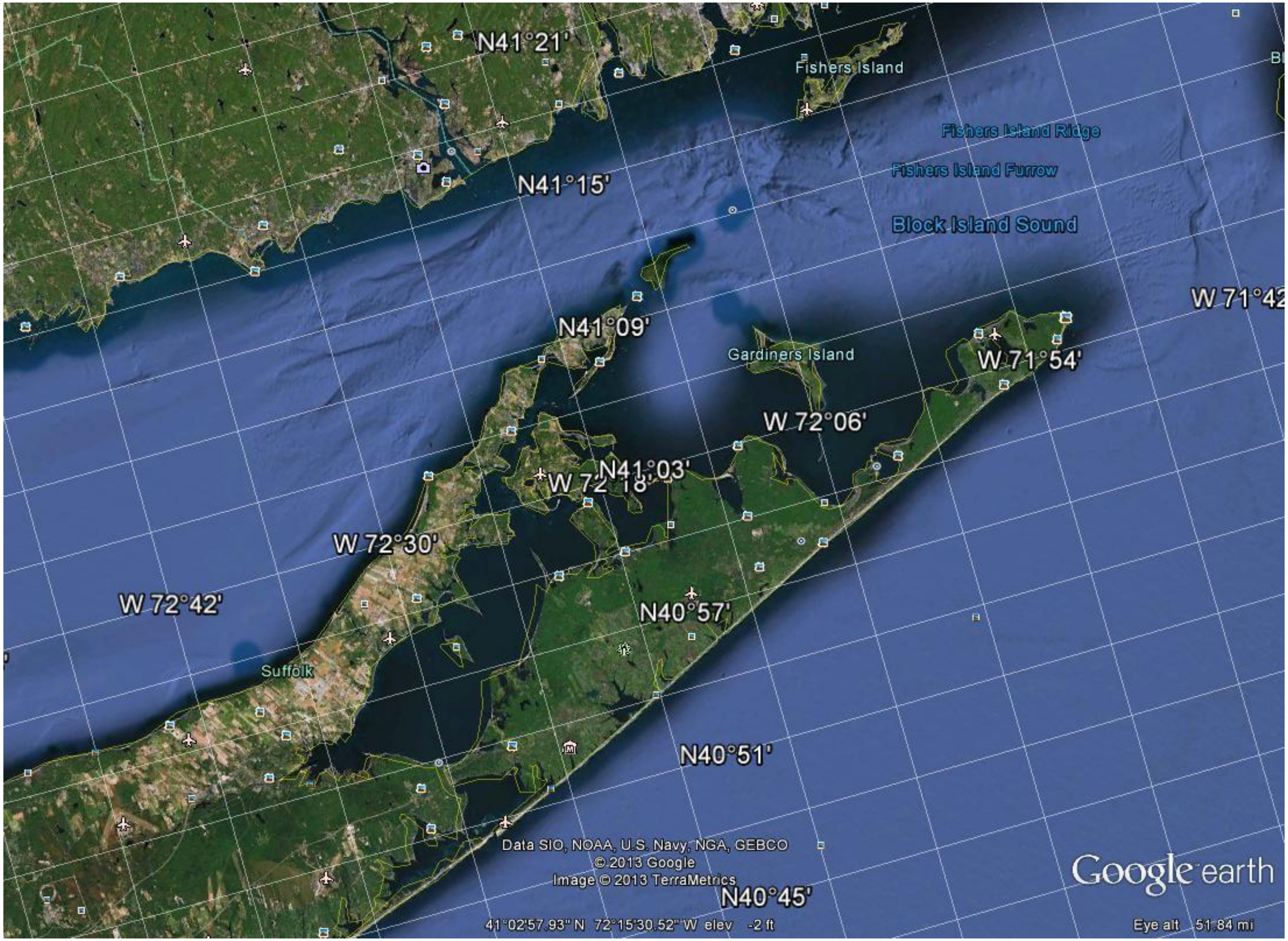
The most powerful storms are not necessarily the windiest. The energy in Sandy was equivalent to the power used by 41,440 U.S. homes in one month.



1. Energy of storm based on extent of tropical storm-force winds
2. One terajoule = 277,777 kWh = energy used by 296 homes in one month

So what kind of damage is typically produced by storm surge effects?

The next few slides depict damage that occurred from Hurricane Sandy.



Google Earth view of eastern Long Island, NY

Northeast facing home on beachfront

This home had a relatively new bulkhead in place prior to the storm.

Newly reconstructed bulkhead, post storm

A repair and replacement for the damaged bulkhead was secured relatively quickly. The end of the bulkhead closest to us had been swept away, with debris deposited on a point of land far to the right. It is doubtful this repair will be any better than what was lost.

This is the point of land discussed in the previous slide

This land feature is actually a protective spit that terminates in an inlet into a harbor in about the middle of the photo. The spit forms a barrier to the harbor to the left. Storm surge effects nearly breached this barrier beach.

Google Earth view of the affected areas from the previous slides

Waterfront home in East Marion, Long Island, NY

The rear portion of this house was virtually demolished, and much of the first floor interior was heavily damaged. The second floor was largely unaffected although the building was structurally compromised. The home was a total loss.

Shorefront behind the previously shown home

Although groins remain in place, the bulkhead behind the house was effectively washed away.

This home is immediately east of the previous

This residence, though damaged, survived the onslaught because it was built to newer and more stringent requirements in the NYS Building Code. However the back porch roof and the bulkhead were destroyed.

Another home in the same area

This home also survived the storm with minimal damage. It too was built to the more robust requirements in the NYS Building Code.

Google Earth view of the affected areas from the previous slides

Damaged home in Breezy Point, Queens (NYC)

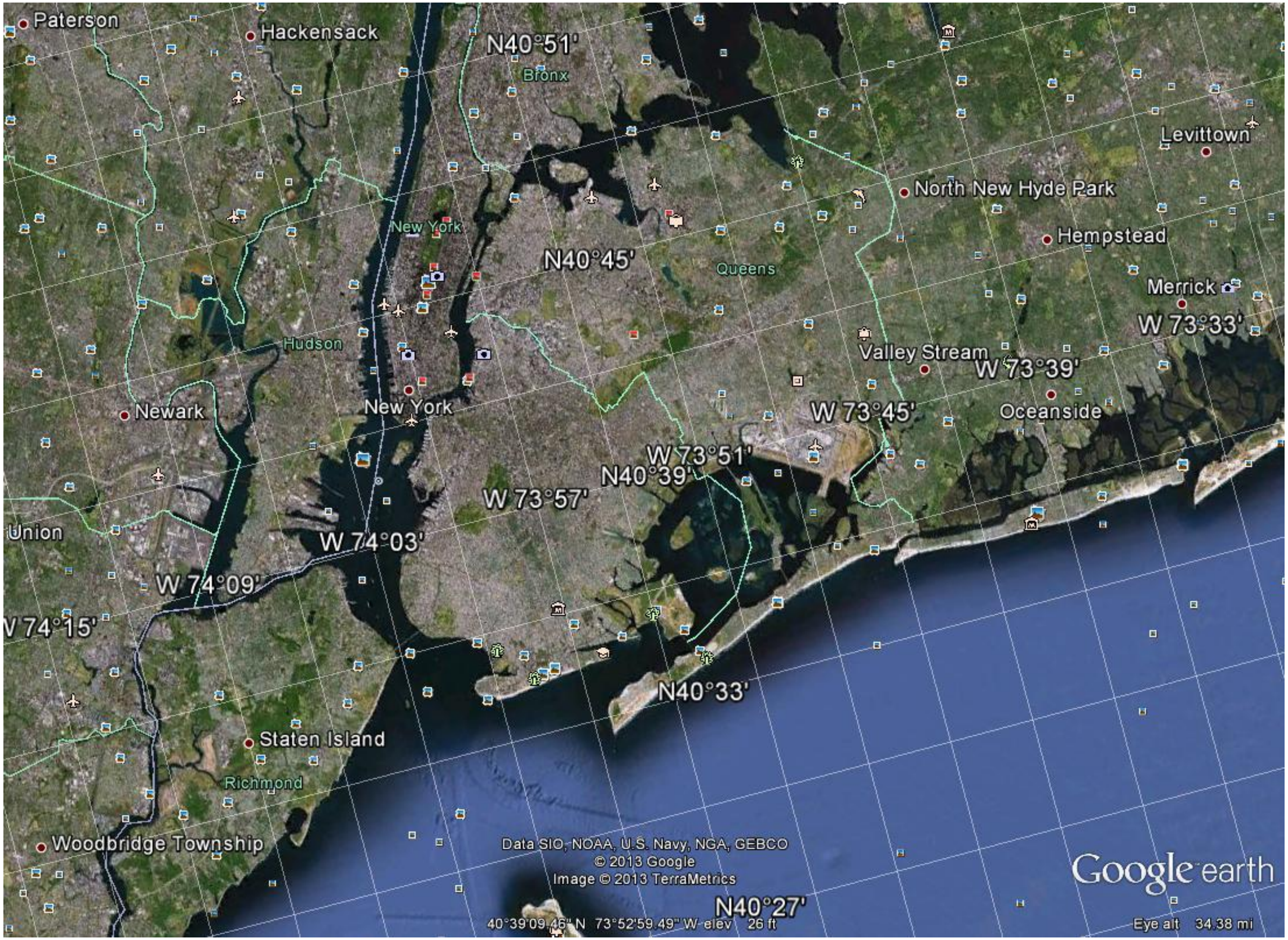
Note the displaced concrete blocks from the foundation, at the lower right.

Same house

Displacement from, and damage to, foundation is apparent. Newer code requirements address this issue.

Another view of the same residence

This photo better illustrates the pronounced movement of the building off the foundation.



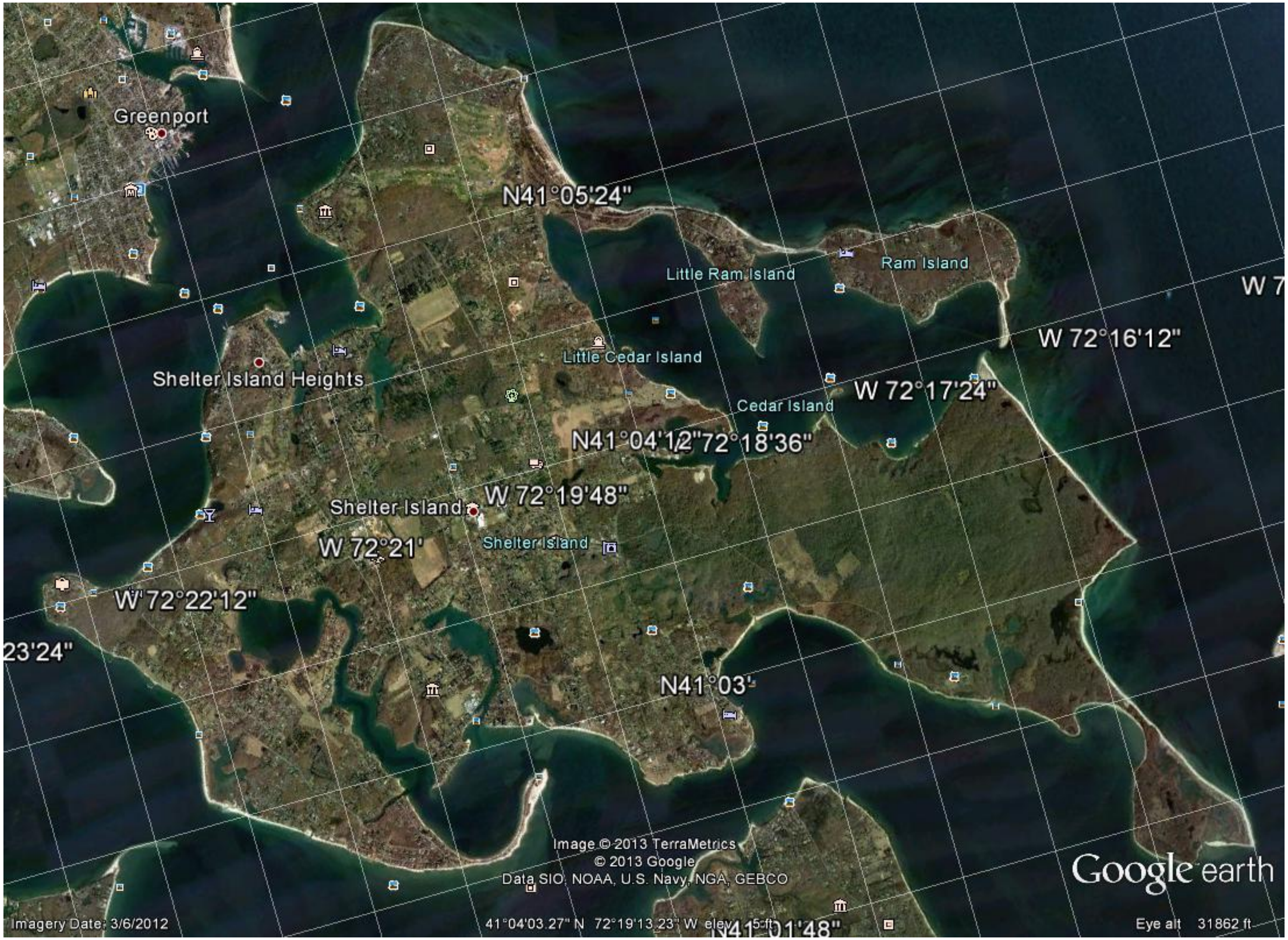
Google Earth view of the affected areas from the previous slides

Bulkhead jacked out of position, eastern Long Island

This bulkhead was completed less than a year ago. The failure involved wave action under the top cap that jacked the bulkhead out of place until the cap failed and breaking waves could now vent.

Same bulkhead, cap detail

Top cap has broken away from wave action, but not before jacking the bulkhead out of place and breaking connections to the sheet piling.



Google Earth view of the affected areas from the previous slides

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Entrance to the Brooklyn Battery Tunnel

The southern end of Manhattan is connected to Brooklyn (NYC boroughs) by the Brooklyn Battery Tunnel. The storm surge flooded the tunnel.

Bay Park Sewage Treatment Plant Damage

A Nassau County sewage treatment facility was rendered off line from the storm surge when flood waters entered the plant and devastated sewage pumps.

Now that we have an idea of the effects of storm surge, how can we plan to mitigate them?

What should we be alert for as we assess conditions at high risk properties?

- Building to an appropriate height is key
- Flood Insurance Maps can provide data for the 100 year storm event (1% chance annually)
- Flood Insurance Studies can provide data for the 500 year storm event, along with the 100 year event
- Storm surge inundation maps can help show extent and depth of flooding

Base Flood Elevation (BFE)--The elevation of surface water resulting from a flood that has a 1 percent chance of equaling or exceeding that level in any given year. The BFE is shown on the Flood Insurance Rate Map (FIRM) for zones AE, AH, A1–A30, AR, AR/A, AR/AE, AR/A1– A30, AR/AH, AR/AO, V1–V30, and VE.

High Risk Areas

In communities that participate in the NFIP, mandatory flood insurance purchase requirements apply to all of these zones:

ZONE	DESCRIPTION
A	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas; no depths or base flood elevations are shown within these zones.
AE	The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones.
A1-30	These are known as numbered A Zones (e.g., A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format).
AH	Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.
AO	River or stream flood hazard areas, and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones.
AR	Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam). Mandatory flood insurance purchase requirements will apply, but rates will not exceed the rates for unnumbered A zones if the structure is built or restored in compliance with Zone AR floodplain management regulations.
A99	Areas with a 1% annual chance of flooding that will be protected by a Federal flood control system where construction has reached specified legal requirements. No depths or base flood elevations are shown within these zones.

Further BFE information

High Risk - Coastal Areas

In communities that participate in the NFIP, mandatory flood insurance purchase requirements apply to all of these zones:

ZONE	DESCRIPTION
V	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. No base flood elevations are shown within these zones.
VE, V1 - 30	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.

V and A zone base flood elevation concepts

Northeast facing home on beachfront

Recall this previously shown slide? This residence is located in a VE zone with an elevation of 13 feet.

This is the point of land earlier discussed applicable to the previous slide

Storm surge effects must also be considered for protective barrier beaches. This barrier is also in a VE zone with an elevation of 13 feet.

Waterfront home in East Marion, Long Island, NY

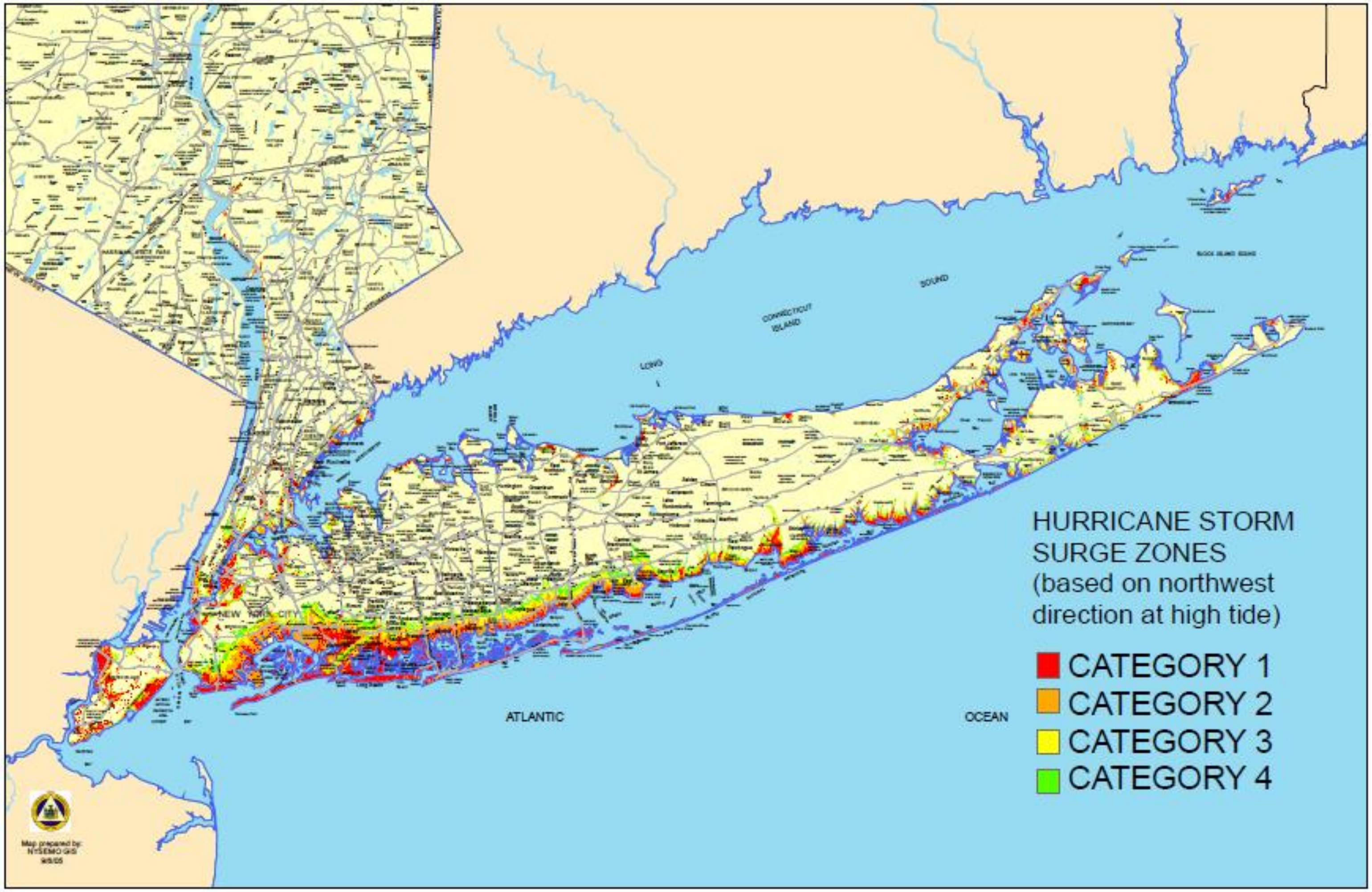
Another example of a building situated in a VE zone with elevations estimated in the range of 9 to 12 feet, and incapable of withstanding the effects.

Another home in the same area

This home, in the same VE zone with elevations estimated in the range of 9 to 12 feet, had survivability.

Bulkhead jacked out of position, eastern Long Island

Earlier we examined this slide and the resulting damage from storm surge. Now we can report that it is in a VE zone with an elevation of 10 feet.



Metro New York and Long Island Storm Surge Map

While this map illustrates anticipated surge affected areas depending on storm intensity, it does not illustrate depth of inundation.

Predicting Storm Surge, and Some Interesting Effects Associated With Surge

- Historical data can be used to “predict” or “guess” how much water levels will rise
- Theoretical approach using numerical methods to model water behavior in storm conditions
- Statistical methods based on either real data or generated data
- Various agencies model storm surge with an eye toward predicting it

Through NOAA, the National Weather Service and the National Hurricane Center (NHC) maintain surge modeling efforts. These efforts enable the NHC to:

- Keep track of notable storm surge events
- Maintain an interactive predictive map for surge along the United States coast lines
- Report storm surge vulnerability facts
- Offer the coastal inundation toolkit

Two notable storm surge effects

- The “out of phase” effect
- And what I refer to as the “build up” effect
- Each can have notable consequences and should be acknowledged when gauging the potential for storm surge damage

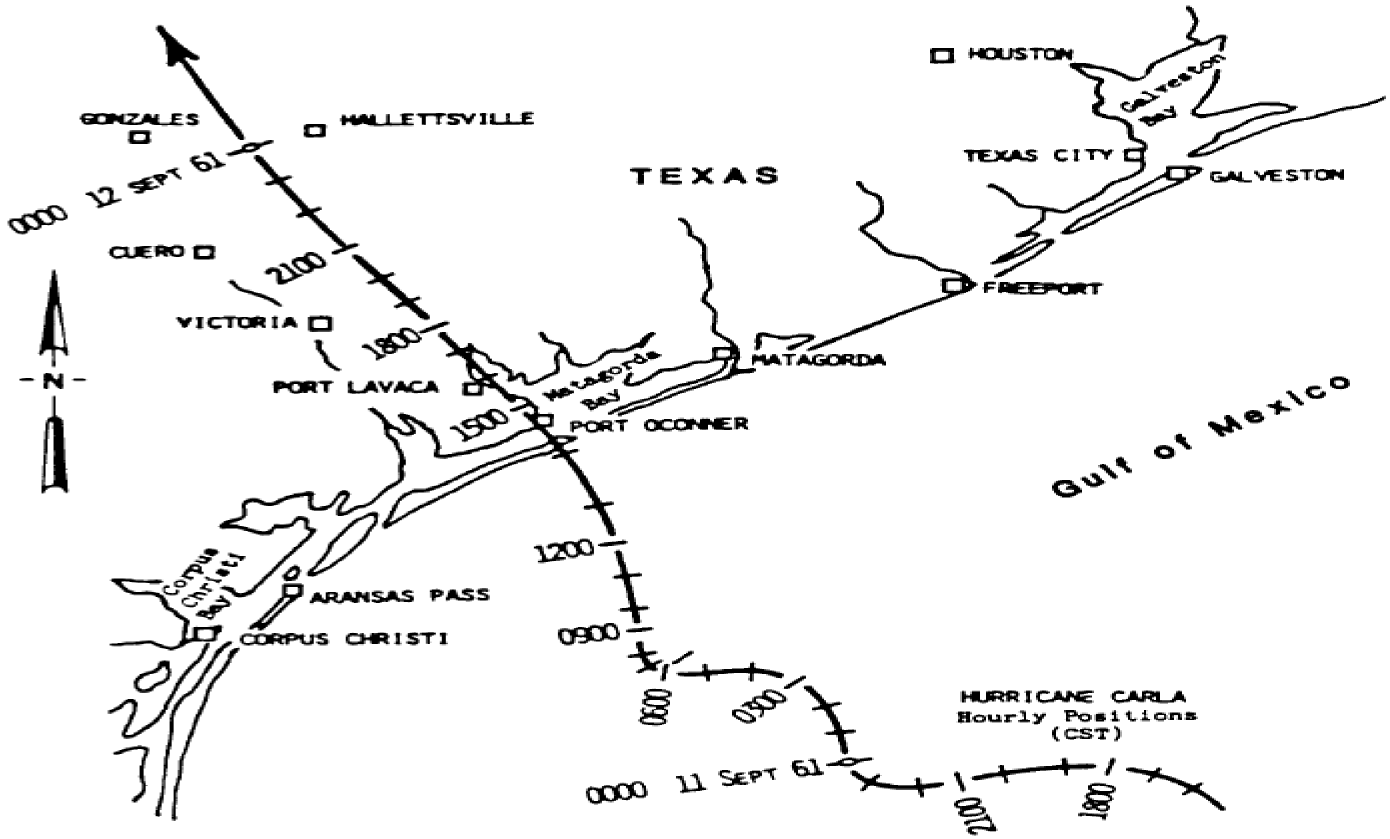
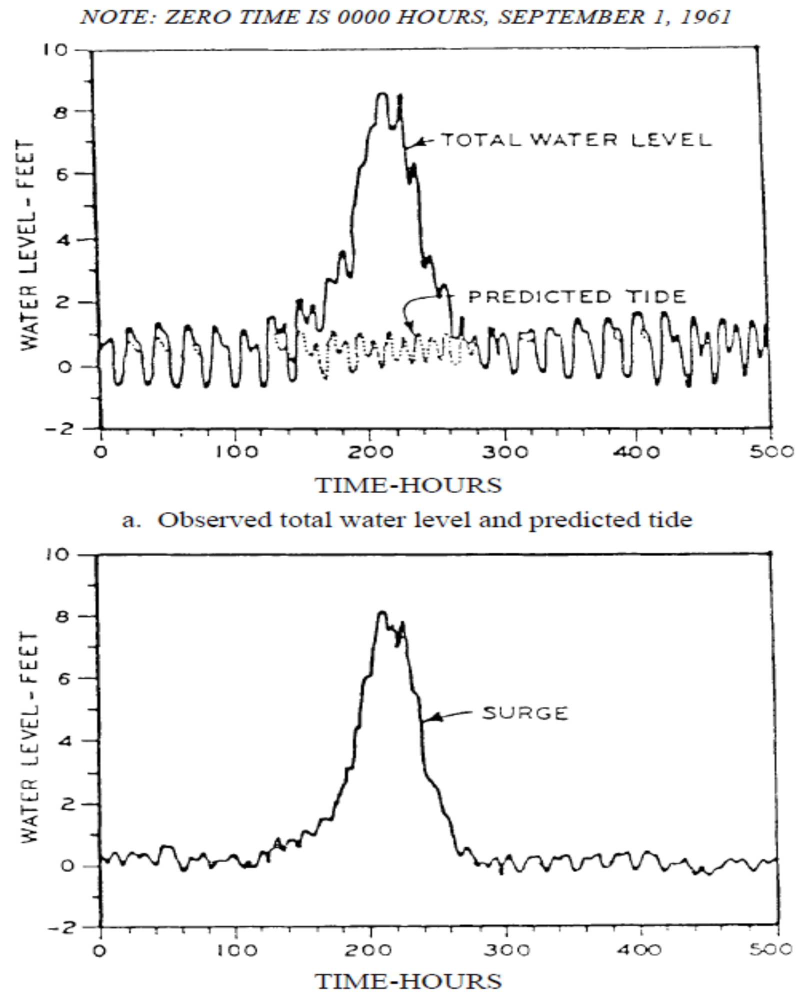


Figure 1-2. Hurricane Carla track, hourly positions, September 1961.
(based on item 31 of Appendix A)

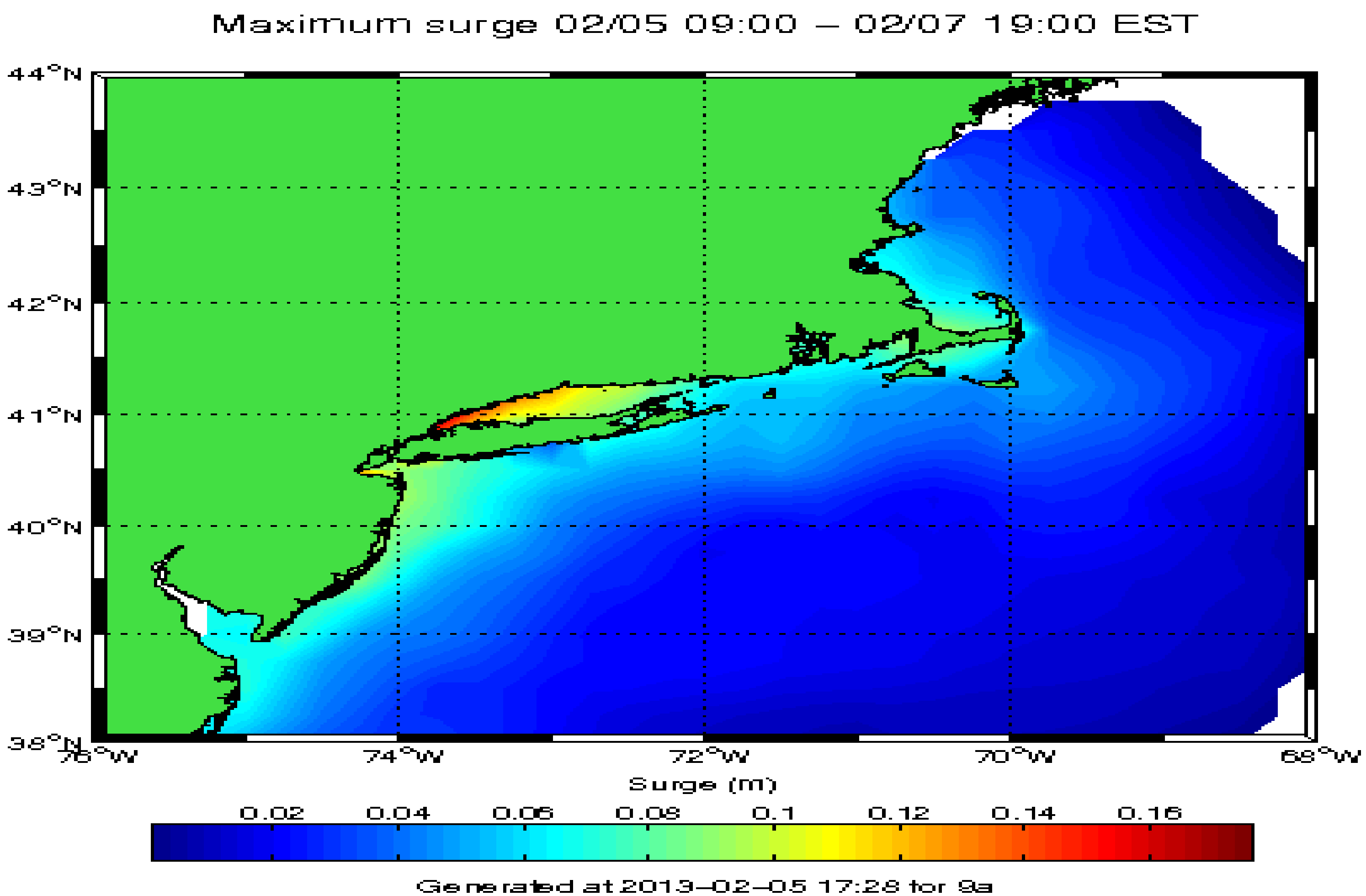
The storm made landfall around 1400 hours on 9/11, about 252 hours after the surge clock started, yet peak surge occurred at about 210 hours.



a. Observed total water level and predicted tide

b. Surge obtained by extracting predicted tide from total water level

Figure 1-3. Water level variations during Hurricane Carla (1961) at Pleasure Pier, Galveston, Texas.



SUNY Stony Brook Storm Surge Model

This slide illustrates an interesting effect that takes place regardless of severe weather.

We have spent some time considering storm surge, its causes, its effects…

We have seen a few examples of the damage created by storm surge…

We understand what resources are available for predicting storm surge…

What can we now do in examining structures to gauge their survivability?

We can try to develop or utilize generalized assessment tools. The next few slides include information as provided by the New York Property Insurance Underwriting Association as part of the NYS windstorm certification program.

NEW YORK PROPERTY INSURANCE UNDERWRITING ASSOCIATION

ELIGIBILITY REQUIREMENTS FOR WINDSTORM COVERAGE

1. INTRODUCTION

Owners of coastal property face a special risk of damage from exposure to high winds of hurricanes. After much research and analysis, NYPIUA has developed a series of standards to improve the ability of property to withstand windstorms.

These standards which have been approved by the Department of Insurance of the State of New York are attached. They are in effect for property on the barrier islands or within 1500 feet of the coast.

2. INTENT

This program has been established to permit a registered architect or engineer to inspect and evaluate a property insured for the peril of windstorm. It is expected that the architect or engineer will use professional judgment in determining whether a property complies with the standards or whether alternative good and acceptable construction practices offer equivalent protection.

The standards found in the accompanying material have been adopted from the Coastal Construction Manual published by the Federal Emergency Management Agency, the New York State Uniform Fire Prevention and Construction Code, as well as extensive professional engineering analyses.

3. REQUIRED CERTIFICATION

Failure of the named insured to submit a certification by a registered architect or engineer within 60 days of the Association's request will render the property uninsurable for the peril of windstorm. Furthermore, after ninety (90) days, failure to correct deficiencies recommended by the certifier and required by the Association will likewise render the property and its contents uninsurable for windstorm damage. Extensions beyond these time specifications will be issued for good cause.

4. DISCLAIMER

Neither compliance with these requirements nor certification by a registered architect or engineer are a guarantee of or imply any level of structural performance against any wind intensity to which such structures may be subjected; neither are they a guarantee or representation that windstorm damage will not occur. It is hoped, however, that the program will reduce the extent of such damage.

NEW YORK PROPERTY INSURANCE UNDERWRITING ASSOCIATION

INSPECTION AND CERTIFICATION FOR RESISTANCE TO WIND EFFECTS IN COASTAL HIGH HAZARD AREAS

INSTRUCTIONS

The attached Inspection and Certification of Compliance forms are to be executed by an architect or engineer registered in the State of New York, following an on-site inspection.

The accompanying Certification Guidelines for Windstorm Coverage are provided to assist those performing the required inspection to determine whether the subject property complies with good engineering practice and meets eligibility standards set by the New York Property Insurance Underwriting Association.

Architects and engineers are expected to conduct inspections within the framework set and exercise professional judgment to determine whether a property complies with the stated guidelines or alternatively, whether good and acceptable construction practices offer equivalent protection.

It is understood that older buildings will not necessarily conform to specific details and practices given in the subject “Guidelines” and as found in more recently constructed structures. The architect or engineer performing inspections will need to reflect such realities in his determination of whether acceptable wind resistance exists, and in his recommendations for correction of deficiencies.

There is no requirement that certification include any specific wind speed in which the building will withstand. In determining alternative good and acceptable practices, however, it is prudent for architects and engineers to use the effects of a 100 mph storm, particularly where site exposure or building design factors (see guidelines 10.1 “Unusual Building Design”) increase wind vulnerability. In no case shall a wind provision or requirement be used which is less than in accordance with the New York State Uniform Fire Prevention and Building Code and any other applicable building codes.[2]

Neither compliance with the NYPIUA guidelines nor certification by a registered architect or engineer are a guarantee of or imply any level of structural performance against any wind intensity to which such structures may be subjected, nor are they a guarantee or representation that windstorm damage will not occur.

New York Property Insurance Underwriting Association relinquishes all claims against persons executing certificates in good faith which cause insurance to be issued by the Association under which claims are later paid.

NEW YORK PROPERTY INSURANCE UNDERWRITING ASSOCIATION

ELIGIBILITY REQUIREMENTS FOR WINDSTORM COVERAGE

1.0 SITE

1.1 The location of each inspected property and elevations of foundation and superstructure referenced to base flood elevations (BFE) as reported in applicable National Flood Insurance Plans (NFIP) should be used to determine that structures are safe against water forces which may affect wind resistance.

1.2 Buildings whose foundations and/or superstructures are subject to instabilities due to observed serious erosion, wave action or wind effects are deemed uninsurable under the subject plan.

1.3 Seawalls, rock revetments and bulkheads meant to protect site and structure against water intrusions caused by tidal or wind surge phenomena should be of sufficient top elevation and in sound condition with regard to materials, embedment of principal elements and overall stability to adequately perform these functions.

1.4 Site development including type and placement of fill materials and accommodations for surface drainage should be adequate to support the structure and to preclude erosion and undermining of the building's foundations which might lead to reduction of wind resistance.

2.0 FOUNDATIONS

2.1 Pile foundations and pilings, unless expressly designed for such conditions, should not be unduly subjected to the action of tidal or storm surge water which may cause failure through scouring or undermining. Design of pile foundations should meet accepted engineering practice with respect to type, size, number, spacing, embedment, lateral and diagonal bracing and connection details.

2.2 Metal connectors must be in sound condition with appropriate numbers and sizes of fasteners, also in sound condition, installed on both sides of the connection.

2.3 The design ratio of pile spacing to pile diameter should not be less than (8) for individual piles. Maximum center-to-center spacing of wood piles should not be more than 12 feet under load bearing sills, beams or girders.

2.4 The adequacy of piles should be considered in the context of column action from the bottom of the structure to the stable soil level of the site including anticipated erosion.

2.5 Piles should be in sound condition, free of decay, rot, insect damage or other forms of structural deterioration. Concrete pilings should be free from serious spalling or other deterioration.

2.6 Minimum penetration for foundation piles should be to the depth necessary to provide protection from wave surge, to provide adequate bearing, and resist overturning moment. [1, 2] In this determination, grade elevation and base flood elevation (BFE) should be considered. Wood piles should be treated to minimize decay from marine animals and fungus.

2.7 Adequate pile support should be provided at ground level and by diagonal and knee bracing as required. [1, 2]

2.8 Post foundations should be sound, free of serious spalling and with adequate, sound, corrosion resistant connections to floor beams. Appropriate numbers and sizes of fasteners, also in sound condition, must be installed on both sides of these connections.

2.9 Resistance and factors of safety against sliding and overturning of all structures, including accessory buildings for which wind storm coverage is sought, should be in accordance with provisions of the New York State Uniform Fire Protection and Building Code and any other applicable local codes. [3]

3.0 ANCHORING

3.1 All components of buildings should be adequately anchored and continuously connected from the foundation to the roof to prevent collapse or permanent lateral movement under wind forces.

3.2 Overlapping plywood sheathing, bolts, threaded rods, wood tie downs, or galvanized steel wind anchors of appropriate size and number should be used to connect adjoining components of the structure such as bearing walls to roof or pilings to girders. Toenailing as a principal method of providing uplift resistance is not considered adequate. All galvanized wind anchors will be fastened with an appropriate number and size of nails as specified by the manufacturer.

3.3 Ceiling joists and rafters should be securely fastened at their intersections and to the wall below. The connection to the wall below should be made using metal hurricane straps and may be either to the top plate (in which case the top plate must also be suitably connected to the wall below) or bypass the top plate and connect directly to a wall stud below. If the spacing of rafters is 16 inches or less, it is permissible to have every other ceiling joist/rafter connected to the wall below using a metal hurricane strap. If the spacing of rafters is greater than 16 inches, every ceiling joist/rafter should be connected to the wall below using a metal hurricane strap.

3.4 Roof trusses should be securely fastened to every load bearing wall intended to support that truss. The connection to the wall below may be either to the top plate (in which case the top plate must also be suitably connected to the wall below) or connect directly to a wall stud below.

3.5 For wood frame construction, uplift loads must be resisted by a continuous load path that connects the rafters or trusses through the wall to the floor structure. Sections 3.3 and 3.4 describe suitable connections between the rafters or trusses and the wall below. If the rafters or trusses are connected to the top plate by a strap that does not extend to the stud below, the load applied to the top plate must be transferred into the wall below using one of several acceptable methods.

3.5.1 A strap may be used to connect the top plate to the top of the wall studs provided these straps are located on the same side of the top plate as the strap connecting the rafter or truss to the top plate.

3.5.2 Continuous 5/8-inch or thicker plywood sheathing may be used provided the straps connecting the rafters or trusses are installed on the same side of the top plate as the sheathing. The sheathing must overlap and be securely fastened to the top wall plate and continue down to and be securely fastened to the sill, floor beams or floor girders.

3.6 The bottom of the wall must be connected to the floor below or foundation system using an appropriate combination of anchor bolts, strapping, hold-downs or threaded rods. Threaded rods shall be terminated with plated washers and nuts that are "tool tight". When continuous threaded rods are used in multi-story construction, plate washers and nuts shall be installed at each floor level.

3.7 Fasteners and connections to floor beams and bracing should be of corrosion resistant materials and show no evidence of corrosion or other deterioration which might reduce the ability of the structure to resist wind effects.

3.8 All new fasteners and connectors including nails, bolts, steel wind anchors and truss plates (including any newly installed in existing structures to comply with these Guidelines) should be hot dipped galvanized. All connectors such as wind anchors and truss plates, with an open exposure to salt air should be hot dipped galvanized after fabrication.

3.9 Floor beam to pile connections should be bolted. Concrete post members should be connected by reinforcement if cast in place, or should be connected by bolting or welding. Where sills, beams, or girders are attached to wood piling at a notch, a minimum of two (5/8)-inch galvanized steel bolts, or two hot-dipped galvanized straps (3/16-inch by 4-inches by 18-inches) each bolted with two (1/2)-inch lag bolts per beam member, should be used. Piling should not be notched so that the cross section is reduced below 50 percent.

3.10 Floor and deck connections used to tie floor joists to floor beams/girders should be of wood with minimum dimensions of 2 by 4-inch, or metal joist anchors installed at a minimum of alternate floor joists. All floor joists should have cross bridging of 1 by 3-inch material, placed a minimum distance of 8 feet on center. Solid bridging is also acceptable.

3.11 Plywood subflooring and attic flooring should be of sufficient thickness to provide necessary stiffness and should be fastened with 8d annular or spiral thread galvanized nails.

3.12 Floor beam splices should be located over supports. Their ends and tops should not be exposed to the weather and they should be in sound and serviceable condition. Bottom plates of load bearing walls should have an anchor bolt installed within 6-inches of any end with an appropriate intermediate spacing of anchor bolts.

3.13 Alternative methods using 2 by 4-inch blocking at horizontal joints or galvanized steel rods (min. ½-inch diameter) or straps (min. 1-inch wide by 1/16-inch thick) may be used to connect from the top plate to the sill, beam or girder. [1]

3.14 Gable roofs and the corresponding gable end wall should be stabilized and strengthened as needed to resist the design wind loads on the gable end. Any outriggers should be anchored to the gable rafters or truss using hurricane straps and the end that is typically nailed to the second rafter or truss from the gable end should be anchored to that rafter or truss with a joist hanger. Gable end walls with heights greater than 4 feet may be stabilized by adding framing members of suitable size and orientation to provide adequate bending strength and strapping all the wall framing members with heights greater than 4-feet to horizontal 2 by 4-inch braces attached to the bottom edges of the rafters or truss top plates and to the top edges of the ceiling joists. These horizontal braces (or Rat Runs) should extend a distance of 8 feet toward the building interior from the gable end. [4, 5]

3.15 Collar beams should be installed between opposite sets of rafters, located within the top third of the rafters and not more than 4-feet apart. Ridge boards should be straight and sound.

3.16 Projecting members including cantilevers should be adequately supported to resist uplift wind forces and roof eave overhangs and unsupported porches should be limited to 2 feet unless subjected to engineering design. All porch columns should be securely anchored to other structural components to resist uplift and lateral forces at both ends.

4.0 ROOF SHEATHING

4.1 Plywood and other wood structural panels used as roof sheathing should be of adequate thickness and installed in accordance with good practice. Sheathing should span at least three structural members. It should be of exterior grade, and should be fastened to rafter or truss assembly in a secure manner using as a minimum 8d corrosion resistant fasteners installed at a maximum of 6-inch spacing along all supporting framing members. Sheathing boards should preferably be 1-inch nominal dimension, not over 6 inches wide and fastened with at least two 8d fasteners to every framing member they cross. [3]

4.2 Ridges, hips, valleys, eaves, vents, chimneys and other points of discontinuity in the roofing surface should be adequately secured. Corners at roof elevation normally exposed to high wind forces should have sheathing, siding, and supporting roof and wall structures firmly secured.

5.0 ROOF COVERING

5.1 The roof cover should generally be in good sound condition. If the roof cover is composed of asphalt shingles, the tabs should be securely sealed to the shingle below and the roof cover should be free of cupped, loose or cracked shingles.

5.2 If a new shingle roof cover is installed to meet the requirements of this guideline, it should be an ASTM D7158 F, G, or H rated product or one that has passed ASTM D3161 (modified to 110 mph).

5.3 Roof covering should be securely attached to the roof in accordance with manufacturer's instructions and specifications. There shall not be in excess of two installed layers of roofing shingles. Edge shingles shall be securely nailed with no raised edges. Asphalt tab shingles shall not be directly applied over a base of wood shingles or other non-continuous sheathing. Solar collectors or photo-voltaic panels shall be securely fastened to resist wind uplift.

5.4 Nails, clips, and similar attaching devices should be corrosion resistant.

5.5 Nails should extend through the roof sheathing. Thick-butt asphalt shingles should be nailed in the thick portion of the shingle. Metal drip edges should be nailed to the roof deck with nails not more than ~~10~~ 6 inches on center.

5.6 For built-up roof coverings, cant strips should be located at the angle of roof and vertical surfaces. The first layer should be not less than 30-pound felt nailed 6 inches on center along a 2-inch lap and nailed 12-inches on center both ways, in the area between laps with tin caps and 1-inch nails. Each additional sheet should be thoroughly mopped between layers.

5.7 Gravel stop and drip strips, and eave and gable drips should be no less than 26 gauge galvanized metal, 16-ounce copper or 0.024 inch aluminum, with not less than 3-inch flange on roof and nailed with not less than ¾-inch nails spaced not more than 6 inches apart.

5.8 Roll roofing should not be applied over shingle roofs. When applied in a single sheet it should be spot mopped and applied by concealed nail method with a minimum 3-inch head lap and a minimum 6-inch end lap properly cemented. Nail spacing should be not less than 4 inches on center. Nails securing roll roofing should be driven no less than ¾-inch from the edge of the sheet.

5.9 Masonry chimneys shall have no loose bricks or other components or show any mortar deterioration. Prefabricated sheet metal flue terminations shall be free of excess surface rust and must be securely attached.

5.10 Deteriorated or derelict roof antennas or satellite dish antennas must be removed from the roof.

5.11 Electrical supply conductors shall have adequate clearance and not be in contact or have the potential to come into contact with any roof or soffit metallic components.

5.12 Metal canopy roof sections shall be securely attached and supported to resist wind uplift forces. Lightweight patio and porch roofs shall be securely attached to supports that are attached to the ground or foundations that will resist uplift forces.

6.0 CLADDING

6.1 Cladding, including siding, shingles and glazing should be securely attached using appropriate sizes, numbers and spacing of corrosion resistant nails, clips, or other types of fasteners, should be installed in accordance with manufacturer's instructions and be in sound condition.

7.0 PROTECTION OF OPENINGS

7.1 Exterior glass panels, windows and doors should be in sound condition, securely installed, and capable of transferring wind loads to the supporting structure.

7.2 Glass windows or doors should be protected from windborne debris impact using a protective system that meets the requirements of ASTM E1886 and ASTM E1996 for large missile impacts or be an impact rated glass product that meets these same requirements. Anchors for any removable protective system must be permanently installed to facilitate rapid deployment of the protective system and the protective system must be labeled to indicate its location on the building and stored on site.

8.0 DECKS,PORCHES, EXTERIOR STAIRS

8.1 Decks, porches and exterior stairs should be constructed of sound and suitably dimensioned materials and should be securely attached to the building in accordance with good and acceptable practice.

8.2 Garages and other auxiliary buildings shall have functional doors, closing all large opening and having secure locking provisions that will resist the entry of strong winds capable of lifting up interior components.

8.3 No tree branches shall be in direct contact or have the potential to come into contact with siding or roofing components.

9.0 UTILITIES

9.1 Machinery and equipment servicing the building should be elevated above flood elevation, including heating, ventilating and air conditioning equipment, hot water heaters, appliances, elevator lift equipment and electrical junction and circuit breaker boxes. Electrical service should be attached to building in an approved manner and so that no undue damage to the building will result when such lines fail during windstorms.

9.2 All equipment attached to the building should be securely connected with bracing, column supports and other straps and retaining elements as necessary to resist wind effects.

10.0 UNUSUAL BUILDING DESIGNS

10.1 Buildings which in the opinion of the certifying architect or engineer are of unusual aerodynamic shape, or which have extensive quantities, expanses, or configurations of glass, or which include other design features especially vulnerable to wind effects such as vaulted ceilings and multi-story exterior walls without interior bracing, require documentation that such features have been specifically designed to resist wind forces.

REFERENCES

1. Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas (3rd ED.), FEMA 55, Federal Emergency Management Agency, June 2000.
2. Flood Resistant Design and Construction, ASCE 24-05, American Society of Civil Engineers, January 2006.
3. Residential Code of New York State 2007, New York State, Department of State, Division of Code Enforcement and Administration, 2007.
4. International Existing Building Code 2012, International Code Council (addition accepted at the Final Action Hearings in 2010).
5. 2007 Florida Building Code Existing Building, International Code Council, February 2008.

Inspection and Certification Form for Windstorm Coverage Eligibility
NEW YORK PROPERTY INSURANCE UNDERWRITING ASSOCIATION - 100 WILLIAM STREET, NEW YORK, NY 10038
(Refer to NYPIUA Certification Guidelines for Windstorm Coverage Eligibility before completing this form)

POLICY NO.

LOCATION OF PROPERTY		
APPLICANT/INSURED		
DATE BUILT	NO. OF STORIES	BUILDING DESCRIPTION = (Dwelling, Commercial), CONSTRUCTIION (Frame, Masonry, Fire Resistive), OCCUPANCY
OTHER STRUCTURES		
MAJOR EXTENSIONS AND MODIFICATIONS		

INSPECTION	Conforms to Guidelines	Does NOT Conform	Unable to Determine
1. **SITE:** First floor elevation is above Base Flood elevation and shoreline is stable. Bulkheads are sound and free of serious erosion. Comments:			
2. **FOUNDATION:** For buildings on pilings: type, number, and condition are appropriate and in sound condition. Connections to beams including all metal strapping, connectors or bolts are in accordance with acceptable practice and in sound condition. Appropriate type and number of fasteners are installed on both sides of any straps or connectors. Comments:			
For buildings supported on posts or piers: posts and piers are of adequate size and in sound condition. Connections to beams including all metal strapping, connectors or bolts are in accordance with acceptable practice and in sound condition. Appropriate type and number of fasteners are installed on both sides of any straps or connectors. Comments:			
Foundation walls are sound and free of serious cracks and spalling. Reinforcing is not exposed or corroded. Beam anchorage is adequate and in sound condition. Comments:			
Breakaway walls are appropriately designed and protective barriers are in good and serviceable condition. No utility service elements are connected to breakaway walls, and utility service elements are reasonably well protected by connection/shielding by piles or non-breakaway wall structural elements. Comments:			
3. **FLOOR BEAMS:** Material, size, spacing and condition are satisfactory. Splices are appropriately made and located. Attachment to foundation is adequate and condition of connections is free from serious corrosion or other deterioration. Any surface corrosion of straps or connectors has been treated and elements are protected by an appropriate corrosion resistant coating. Comments:			
4. **JOISTS**: Material, size, spacing and condition are satisfactory. Type and manner of connection to beams are in accord with acceptable practice. Type, size and spacing of cross-bridging are appropriate. Comments:			
5. **SUBFLOORING:** Type, fastening method and connection are adequate and in sound condition. Comments:			
6. **WALL STUDS AND PLATING:** Type, size, spacing and grade of materials are appropriate. Connections required to provide vertical load path through wall are in accordance with acceptable practice. Studs are plumb and free of serious deterioration. Comments:			
For exterior and bearing walls where metal strapping/connectors are used to connect wall studs to top plates: straps/connectors are installed at the top of each wall stud on the same side of the wall as the connectors used to anchor the trusses/rafters to the top plate. Comments:			
For walls where sheathing is used to anchor the top plate to the wall below: straps/connectors used to anchor the trusses/rafters to the top plate are installed on the same side as the sheathing. Comments:			
Connections of upper and lower floor exterior or bearing walls are accomplished using either strapping that connects studs on the upper floor to studs on the lower floor, or by sheathing of sufficient length/width to provide the connection between the floors in accordance with acceptable practice. Comments:			
Connection to bottom floor or foundation: sole plates are attached to the floor system or foundation using appropriate size and spacing of anchor bolts, mud sill straps or other acceptable anchoring devices. The stud wall above is anchored to the sole plate using sheathing connected to the sole plate or straps that connect the studs to the sole plate, or wall sheathing extends far enough below the sole plate to provide an adequate connection to the floor rim joist. Comments:			
7. **WALL SHEATHING:** Type, thickness and grade are satisfactory. Nail weight, length and spacing on edges and along studs are appropriate. Sheathing extends to or beyond the top of the top plate and the bottom of the sole plate, and the sheathing is nailed to the top plate and sole plate. Comments:			
8. **WINDOWS AND SIDING:** Type of window and glazing are satisfactory. Condition is sound, glazed areas and support dimensions are not excessive. Comments:			

INSPECTION	Conforms to Guidelines	Does NOT Conform	Unable to Determine
Protection is provided for glazing that meets the test requirements of ASTM E1886 and ASTM E1996 for the design wind speed at the site. Permanent anchors are installed for any removable protective devices and the corresponding protective devices are properly labeled for the opening and stored at the site. Comments:			
Siding and other cladding are firmly attached and in good condition. Comments:			
9. **EXTERIOR DOORS:** Type, fit and condition are adequate. Hardware is free of serious corrosion and serviceable. Comments:			
Double entry doors are fitted with anchoring hardware that provides a robust connection into the subfloor at the bottom and into the header at the top of the swing side of each door. Comments:			
10. **ROOF STRUCTURE:** Type, size, spacing and condition of rafters are in accord with acceptable practice. Type, spacing and condition of rafter connections to walls are in accord with acceptable practice. Comments:			
Size, location and condition of collar beams are satisfactory. Peak board size and condition are adequate. Comments:			
Length of eave overhang is acceptable. Length of rafter overhang is acceptable. Comment:			
Size, spacing, manner of attachment to wall, and condition of ceiling joists are acceptable. Comment:			
For gable end overhangs using lookouts: the lookouts are appropriately anchored to the gable truss or rafter using metal straps or connectors, and the end of the lookouts that butt against the second truss or rafter from the gable end is anchored to that truss or rafter using an appropriate anchor such as a joist hanger. Comments:			
11. **ROOF SHEATHING:** The type, grade, thickness and condition are adequate and the type, spacing and manner of fastening provide uplift capacities at least equal to that provided by 8d nails at 6-inch spacing along all roof structural members. Comments:			
12. **ROOF COVERING:** The type, method of attachment and condition of roof covering are appropriate and in accord with acceptable practice. Comments:			
13. **VENTS, VENTILATORS AND OTHER APPENDAGES:** Gable vents are of reasonable size, adequately framed and securely attached. Ventilators are securely attached and in good condition. Comments:			
Chimneys are stable and in good condition. Comment:			
Gutters and leaders are securely attached and in good condition. Comments:			
Vinyl and aluminum soffit materials are adequately attached to the wall and roof eave using wood framing appropriate for high wind installations. Comments:			
14. **DECKS, PORCHES, EXTERIOR STAIRS:** Design, size of members, connections to any columns and method of attachment to building are adequate. The condition of such constructions including underpinning, uplift resistance and connection to building is sound. Comments:			
15. **UTILITIES:** Water line and sewer line attachments and supports are satisfactory. Comments:			
Equipment for heating and cooling and for cooking, electrical transformers, service panels and meters are located above the Base Flood Elevation and securely fastened and supported. Comments:			

CERTIFICATION

I hereby certify that I am an Architect or Engineer registered in the State of New York and that I have inspected the structure described above and have found that except for the conditions noted below it complies with New York Property Insurance Underwriting Association Certification Guidelines for Windstorm Coverage Eligibility.

Signature:	Title:
Firm:	Date:

NY State Registration No:	Survey Cost:	Estimate of Improvement Cost:

Questions and Discussion