



## Ice Mass & Sea Level Change Unit 5: New York City vignettes

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### Part 1: Background

With a population of nearly 20 million people and 2400 km of coastline, the NYC region is susceptible to even small changes in sea level. Over the last 100 years, sea level around New York City has risen by more than a foot. As sea levels rise, the magnitude and frequency of coastal storms increase. While it is impossible to attribute a single storm, like Hurricane Sandy, entirely to climate change, higher sea levels certainly did increase the extent and magnitude of the coastal flooding. Projections show that long-term climate changes will continue to increase the magnitude and frequency of severe storms.

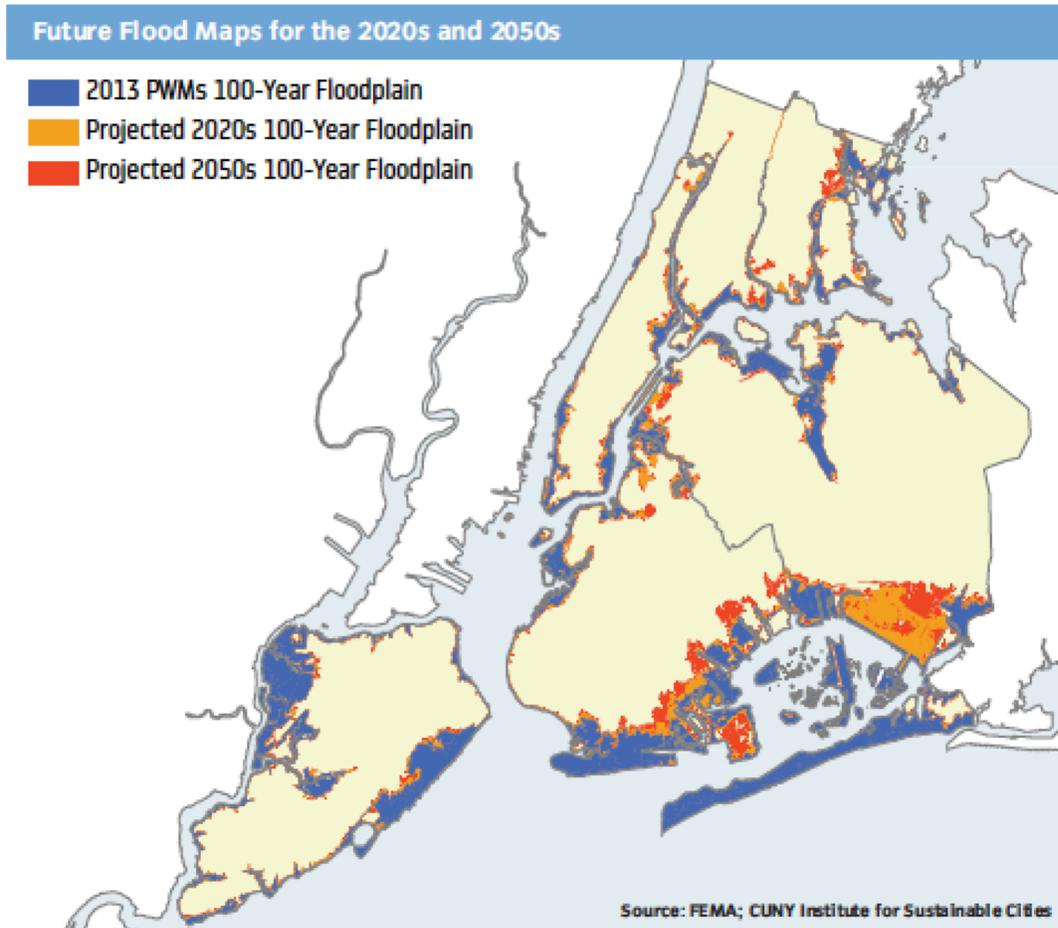
In this summary we highlight some of the damages caused when Hurricane Sandy hit the NYC region in October 2012. There were 43 deaths, 6500 patients were evacuated from nursing homes and hospitals, nearly 90,000 buildings were in the inundation zone, 1.1 million NYC children were unable to attend school for a week, nearly 2 million people were without power, 11 million travelers were affected each day, and the damages cost \$19 billion.

While most coastal regions experienced only flooding during Sandy, some ocean-facing areas reported waves over 12' high. The waves and retreating flood-waters caused extensive coastal erosion - up to 3 million cubic yards of sand.

#### A couple of notes before you get started:

1) Keep in mind that when scientists and stakeholders consider potential impacts of sea level rise, they often consider a particular area's susceptibility to a **100-year flood** event and how sea level rise could increase the probability of a 100-year flood in the area. A 100-year flood means a flood event that has a 1% chance of occurring in any given year.

2) Your work with sea level change so far has been mostly related to changes in ice mass and its influence on sea level. There are many additional factors that scientists and stakeholders must take into consideration when thinking about future sea level changes in a particular area, including, but not limited to, sea level variability from El Nino events; the shape of the coastline in a particular area; changes in ocean circulation patterns; and coastal subsidence (sinking) due to the extraction of fluids from the subsurface (groundwater and petroleum).



**Figure 1:** Future flood maps for the 2020s and 2050s. This map shows how the flood zone will increase, due to climate projections. [PlaNYC - A Stronger, More Resilient New York](#)

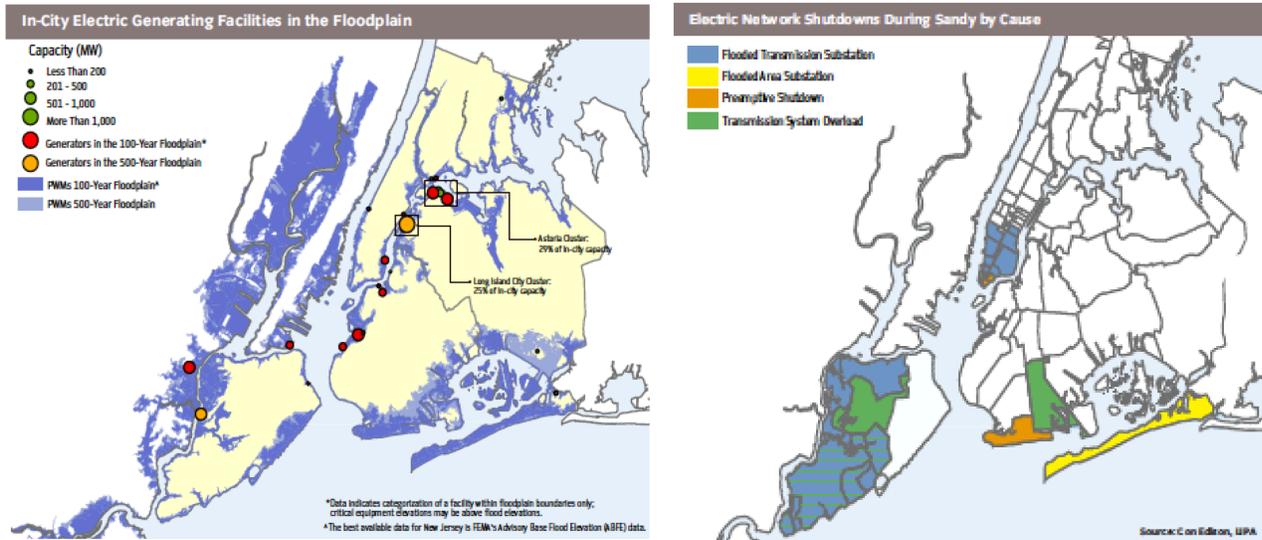
## Part 2: Vignettes

### Issue #1: Power and Waste Disposal

Most of the important electric utility infrastructure is located on the waterfront in NYC (Figure 2). Electric utilities were seriously impacted by Hurricane Sandy, causing close to 2 million people to lose power at some point.. Even with the help of thousands of utility workers from other states, it took over 2 weeks to restore power to many parts of the city.

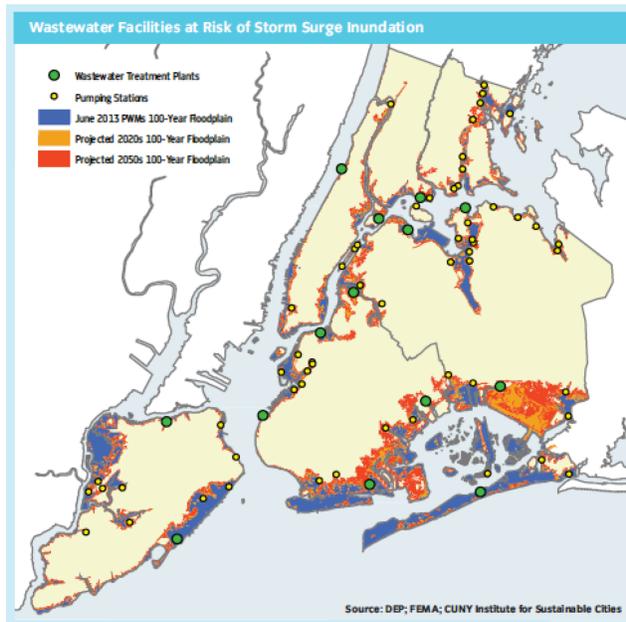
Other utility systems also experienced disruption. One steam system was unable to supply steam to 1/3 of its customers (which includes several major hospitals) because the storm inundated four plants.

It is going to be difficult to maintain the capacity of these generating stations during continuous sea level rise, and more frequent storm surges. NYC is looking into ways to better fortify these electric stations given a 1m rise in sea level.



**Figure 2:** (Left) Electric generating facilities located in the NYC floodplains. (Right) Electric generating facilities that shut down during Hurricane Sandy ([PlaNYC - A Stronger, More Resilient New York](#)).

Clean drinking water continued to flow uninterrupted to NYC during and after Sandy. However, in areas with power outages, the pumping systems in high-rise buildings stopped working.



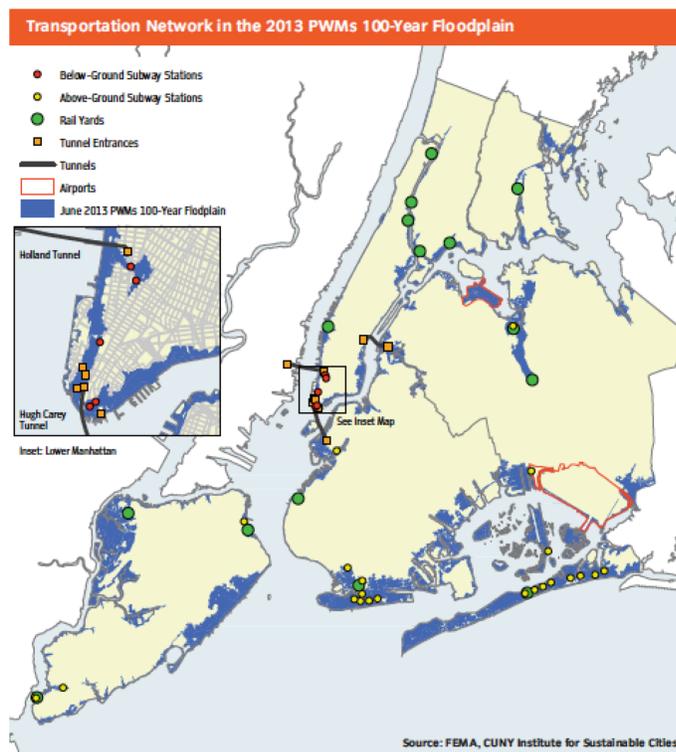
**Figure 3:** Wastewater facilities located within the floodplains ([PlaNYC - A Stronger, More Resilient New York](#)).

Sandy’s storm surge had a major impact on the city’s wastewater treatment system (Figure 3). Ten of the 14 wastewater treatment plants released partially treated or untreated sewage into local waterways. Fortunately, water quality samples showed the contamination to be minimal due to dilution from flooding.

Issue #2: Roads and railroads

During Sandy, many highways, roads, railroads and airports flooded. All six subway tunnels connecting Brooklyn and Manhattan were out of service due to flooding, along with tunnels connecting Manhattan with Queens (Figure 4). Roughly 5.4 million subway riders were stranded due to the closings. Service was also disrupted on most ferries, stranding another 80,000 commuters. Three vehicular tunnels were also closed, interrupting the commutes of 217,000 vehicles.

The loss of electrical power exacerbated the flooding because tunnels could not be pumped and subway service was slow to rebound. Major bridges reopened quickly, after winds dissipated, but over 500 miles of roads suffered significant damage. Traffic became so bad during the week after Sandy that City officials implement temporary measures to manage travel and congestion (for example, restricting single-occupant vehicles from using bridges and tunnels, and using extra buses to replace the subway loss).



**Figure 4:** Transportation network located in the floodplains ([PlaNYC - A Stronger, More Resilient New York](#)).

For weeks after Hurricane Sandy the city's gas stations shutdown or had incredibly long lines. Even gas stations located outside the area with power outages were closed. This was due to a severe breakdown in the supply chain serving NY caused by the extensive damage to the New Jersey and New York City waterfront. Marine and pipeline deliveries were halted, as were several refineries. Only 20% of stations had gas to sell after a week of the storm.

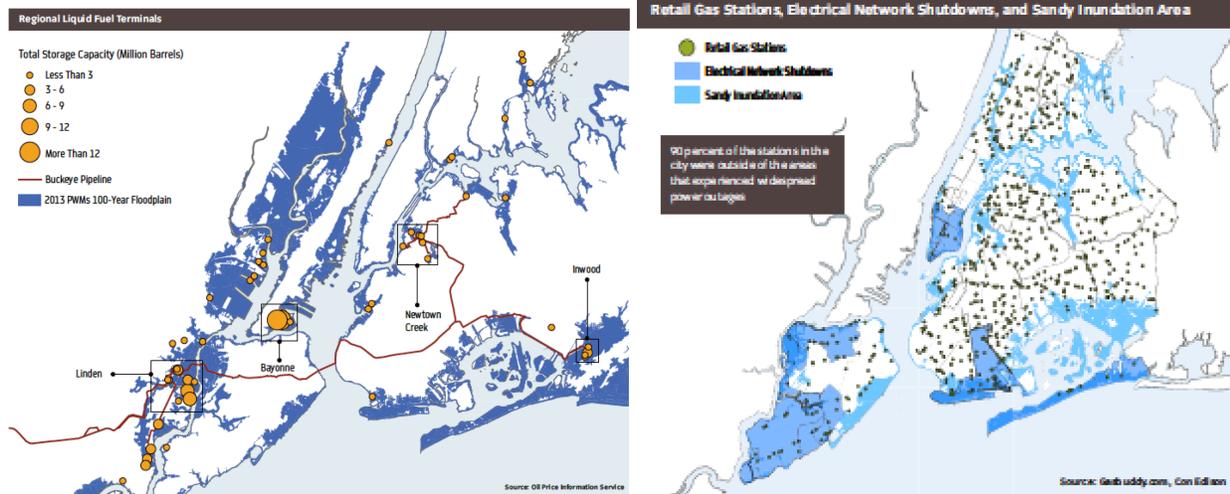


Figure 5: (Left) Liquid fuel terminals overlain on a floodplain map floodplains. (Right) Gas stations, electrical network that shut down, overlain on the Sandy inundation area ([PlaNYC - A Stronger, More Resilient New York](#)).

**Issue #3: Communications**

Sandy caused outages across phone, wireless, cable and internet services. Short-term outages, which affected the greatest number of customers, were a direct result of power loss. Flood damage at critical facilities disrupted landline and internet service for several areas for up to 11 days.

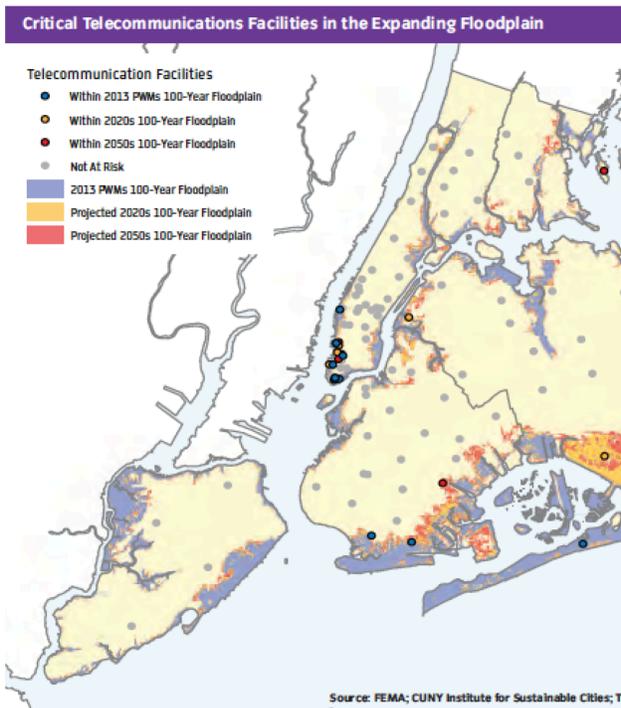
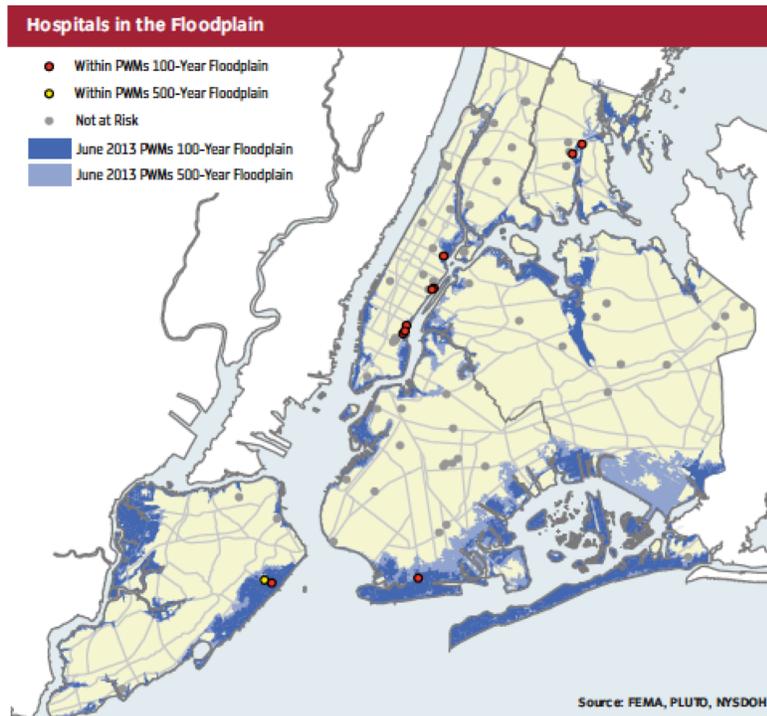


Figure 6: Critical telecommunications facilities in the expanding floodplain ([PlaNYC - A Stronger, More Resilient New York](#)).

Issue #4: Public Health

The city's healthcare system suffered disrupted service during and after the storm. Six hospitals closed requiring City and State health officials to evacuate nearly 2000 patients to other hospitals. Hospitals that remained open had to deal with many obstacles, including pumping out floodwater, repurposing lobbies as inpatient rooms, and siphoning gas from vehicles to run generators.



**Figure 7:** Critical telecommunications facilities in the expanding floodplain ([PlaNYC - A Stronger, More Resilient New York](#)).

There was also a serious initial concern that the rats that survived Sandy could spread infectious diseases throughout NYC. This proved to be overblown, but health officials actively warned citizens about other public health threats, including:

- **Contaminated flood water**
- **Compromised sewage treatment plants.**
- **Unsafe drinking water**
- **Carbon monoxide poisoning (due to unsafe generator use)**
- **Food poisoning (due to people eating spoiled food)**
- **Mold growing in flooded homes.**