Activity on Sea Level, Storm Surge, and Flood Risk—a New York City Case Study

Summary of activity and instruction to students: This activity uses Hurricane Sandy as a case study to examine the short-term flood risk and societal costs associated with major storms. It places these risks in the context of long-term, geologic processes, like coastal subsidence and beach erosion, and societal factors, like local development and global sea level rise from pollution-enhanced climate change. This lesson is also designed to familiarize you with concepts of topography, sea level, sea level change, and storm surge vulnerability. New York City serves as an example of a very large, concentrated population living near the ocean, with a lot of critical infrastructure at low elevations. New York City has an open data site with a lot of interesting material. Many of the activity instructions are followed by questions for you to answer (**in bold**). Write your answers on a separate sheet of paper.

Preparation: Review the Vocabulary of Storms and Storm Systems from Unit 1, paying special attention to the magnitude categories for coastal inundation and hurricanes, and pages 201–212 in Chapter 3: Risk Assessment, *Hurricane Sandy Retrospective Analysis*, for the 2014 New York City Hazard Mitigation Plan (introduced in Unit 1). **Optional**: Sea level rise simulator (examples from around the US): http://coast.noaa.gov/digitalcoast/tools/slr (Coastal resilience 2.0). It comes with an instructional video https://vimeo.com/96830721.

Materials/resources (online)
2014 New York City Hazard Mitigation Plan
Coastal resilience 2.0 Tool: http://maps.coastalresilience.org/network/
Coastal resilience 2.0 Tool Step-by-Step Guide

Part A. Navigate to the Coastal resilience 2.0 application at: http://maps.coastalresilience.org/network/. Refer to the Step-by-Step Guide, or just follow these instructions:

- Click on the pin marking New York City and then on the word “Map”. When the map appears on the screen, take a few moments to familiarize yourself with the map features, including the location names, political boundaries, roads, and natural features, like islands, rivers, and shoreline. Expand the map view frame to fill the computer screen.
- In the white box on the upper right, open the dropdown menu to select the National Geographic map view (this map has a good mix of detail and topography). Zoom in and out to see how much detail is available at highest zoom levels.
- Zoom out until you can see the entire New York City region again, including Long Island. On the left side, click on map layers, and then the "+" next to Hurricane Sandy. Click on the first box: Final FEMA Surge Area. (This layer may take a while to load - be patient.) You should see blue shading around most of the region. This is the maximum flood limit from storm surge associated with Hurricane Sandy.
- Note that most of New York City is on a series of islands. For this exercise, it's important to identify Manhattan, Long and Staten Islands. Mainland exists to the west, in New Jersey, and to the north, starting with the Bronx borough. Bridges and tunnels connect New York City’s islands to the mainland.

Leave the Sandy surge area map open and, **in new browser windows**, open (by cutting and pasting the below URLs into your browser's address) the following maps of New York City's future floodplain given current sea level rise predictions. Note, these are large interactive datasets and may take some time to load.

- The 2020 New York City 100-year flood map (includes predicted sea level rise): https://data.cityofnewyork.us/Environment/Sea-Level-Rise-Maps-2020s-100-year-Floodplain-/ezfn-5dsb
- The 2050 New York City 100-year flood map:
- https://data.cityofnewyork.us/Environment/Sea-Level-Rise-Maps-2050s-100-year-Floodplain-/hbw8-2bah
- The 2050 New York City 500-year flood map: https://data.cityofnewyork.us/Environment/Sea-Level-Rise-Maps-2050s-500-year-Floodplain-/qwca-zqw3

Once all these maps are open, flip back and forth between them until you have a feeling for their similarities and differences. It will be easier to do this if they are all on the same zoom level. It is important to note that the 2020 and 2050 flood scenarios do not include all regions that were heavily impacted by Sandy. Concentrate on the areas where all three maps show data about flooding (gray or blue shading).

1) **Where the maps overlap, which of the three scenarios, the 2020 flood, 2050 100-year flood, or the 2050 500-year flood, most closely resembles the flood from Hurricane Sandy?**

2) **Based on this evidence, how would you categorize Hurricane Sandy for in New York City:**

   a) **Less than 100-yr flood**

   b) **A 100-yr flood**

   c) **A 500-yr flood**

   d) **Greater than 500-yr flood**

Open a new window to see which areas of New York City have the highest population density: ArcGIS map of NYC population density. More detail appears as you increase zoom, to street level.

3) **Make a list of the sections of New York City (called boroughs) that flooded during Hurricane Sandy and rank them by density of people in the flood zone (1 = highest number of people affected). It might be helpful to pull up a simple map of New York City to see the borough boundaries.**

4) **The population density map is useful but doesn't provide details about the population size. Use an Internet search to find recent census data for each borough and add the population numbers next to each borough name. Examine your rankings again. If you consider all the people in the borough, and not just the ones in the flood zone, does it change your ranking of greatest number of people impacted?**

5) **One way to find out how the people of New York City were affected is to review the news reports. Search the Internet using names for each of the boroughs along with "Hurricane Sandy." Based on media reports, which boroughs do you think were hardest hit by the storm and in what way? In your response, consider the various impacted environments (i.e. called natural, social, built in the New York City Hazard Mitigation Plan).**

6)

   a) **How does coverage and description of the event by news reports compare to the *Hurricane Sandy Retrospective Analysis*? Describe what you consider as discrepancies between the reports and the official analysis.**

b) **Compare the news reports and photos with the online flood maps and the maps depicted in the *Hurricane Sandy Retrospective Analysis*. Which gives more information about risk useful for city residents? For city planners?**

7)

a) **In the 2020 and 2050 scenarios, in a 100-year flood event, which major roads could you take to go from Brooklyn to somewhere on the mainland (i.e. New Jersey, Connecticut, the Bronx or upstate New York)?**

b) **Were any of these routes open after flooding began with Hurricane Sandy? Examine access points for bridges and tunnels and the New York City Hurricane Evacuation Zone Map: http://www.nyc.gov/html/oem/downloads/pdf/hurricane_map_english.pdf. Does this map show an exit route out of the city that does not require crossing any of the evacuation zone areas?**

c) **Besides roads, consider other ways that people might try to evacuate from New York City during a flood. Which, if any, of these were accessible during or immediately after Hurricane Sandy?**

During Sandy, and for several days afterwards, un-flooded areas of New York City had no electricity or running tap water because parts of those supply systems had flooded. Examine again the population density maps, the escape routes to the mainland, and the flood zone areas.

8) If you had been in Queens or Brooklyn during the storm, would you have tried to find a way to leave immediately after the storm, or would you have stayed in place to wait for services to return? Describe the things you took into consideration for your answer.

City administrators everywhere struggle to convey information about natural hazards and risks to their residents, and many cities, like New York City, provide online access to floodplain maps. Despite this, many people still choose not to evacuate in response to flood warnings. Do a brief search for news and images of New York City during the Hurricane of 1938.

9) **If people living in New York City in 2012 had been reminded about the 1938 Hurricane, do you think more would have evacuated before Sandy? Explain your answer in a few sentences.**

10) **If you were an administrator in New York City and wanted to convey a message about potential flood risk from a future Sandy-like storm, what information would you communicate to the public? Would you use these flood maps? Would you use historical events like the 1938 Hurricane, and Sandy? In your response, consider which aspects of this activity made the greatest impact on you.**

Optional Part B. Leave the maps from Part A open in their own windows but change the Storm Surge map (http://maps.coastalresilience.org/network/) from National Geographic to Shaded Relief (elevation) using the options in the upper right box. Click the storm surge flood layer on and off a few times for comparison of flood area with elevation.

11) **Based on the topography, if the storm surge had been just 1 meter higher, which areas would have experienced the greatest amount of additional flooding?**

12) **Coastal dunes and marshes used to exist all along low-elevation river valleys and beaches in the New York City area until these lands were developed. Give a couple of examples of areas on the map where marshland probably existed prior to development.**

In the Map Layers window, leave the Hurricane Sandy Final FEMA Surge Area layer on but also click on the "+" next to Coastal Resilience (NY). Then click the "+" next to Critical Facilities.

13) **Fill in the table by clicking the individual boxes for police, fire, electric and water and, using the map, count the number of facilities in the combined area of Manhattan Island, Queens, and Brooklyn. Zoom in to street level and count the number in Sandy's storm surge area. Calculate the <u>proportion</u> and <u>percentage</u> of each type of facility affected by flooding.**

	Total	# Flooded	Proportion Flooded	Percentage Flooded

Police				
Fire				
Electric				
Drinking Water				

14) Which critical facility type suffered the greatest impact from Sandy's storm surge?

15) Think about the services offered at each facility. Which categories do you think are the most needed in a crisis like a hurricane? Write down a couple of sentences to explain why these were your choices for most-needed.