Climate Change Accounting:

What Is the Cost?

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Metropolitan Waterfront Alliance

NY - NJ HARBOR Coalition

The Cost of Sandy
A Wake Up Call

Hurricane Sandy made it all too clear: the New York metropolitan region is extremely vulnerable to the impacts of climate change and increasingly intense coastal storms. The storm brought the reality of a changed world to our doorstep with a harsh and unforgiving lesson—72 deaths and almost $70 billion ($B) in damages along the East Coast, including 44 deaths and $19B in damages in New York City alone. At least 650,000 homes were destroyed and an estimated eight million were left without power, sometimes for weeks, after the storm.[1]

While post-Sandy recovery efforts have been tremendous, with almost $48B allocated nationally, and almost $20B awarded in New York and New Jersey[2] for recovery, rebuilding, and improved protection from future storms, this is simply not enough.

How much more do we need to invest to reduce risks to our critical infrastructure and vulnerable properties in coastal areas? Beyond "plenty," we can only guess. We are making a down payment on resiliency with current projects and plans, but is that down payment 10 percent or 50 percent of the cost of a safer future? Even more important, how are we to realistically secure the resources necessary to complete the deal?

As a region, and as a society, we have to tackle some basic accounting. First, we need to identify the true costs of all planned and proposed flood-risk reduction and resiliency projects, the timeframe for their implementation, and the extent of risk they would mitigate. Beyond that, and more important, what more should we do? Can we develop a comprehensive, long-range plan to substantially reduce risk for even the next 30 to 40 years, let alone to 2100 and beyond?

The world has changed—the waters continue to rise and storms will threaten. This is an existential and unprecedented challenge for coastal cities like New York. **What will it take to substantially reduce risk; what will it cost; and how will we pay for it?** This report will better define those questions, seek answers, and call for action.

This report was produced based on a review of government and academic reports, along with numerous, off-the-record discussions with leading climate change and resiliency professionals in city and federal agencies, academia, and the private sector.

1. *Blake, Eric, et al. Tropical Cyclone Report Hurricane Sandy, 2012*
2. *Recovery Accountability and Transparency Board for Hurricane Sandy Funding, 2015*

The Cost of Inaction

While Hurricane Sandy was an historic event, it was not a worst-case scenario, and it will not be the last storm to strike this region. In fact, as sea levels continue to rise and hurricane patterns change, it is likely that coastal flooding will increase in both frequency and severity. In order to make important decisions about prioritizing and funding risk-reduction measures for the region, it is necessary to understand the cost—economic and otherwise—of failing to make long-term plans.

New York City's Special Initiative for Rebuilding and Resiliency (SIRR) report indicates that if no action is taken, a storm comparable to Sandy in 2050 would cause an estimated $90B of damage in New York City, a dramatic increase from $19B in actual damages in 2012. This projection is based on modeling by the global reinsurance company Swiss Re, and accounts for projections for rising sea levels and more intense storms.[3] The Risky Business Project, co-chaired by Michael R. Bloomberg, Henry Paulson, and Tom Steyer, aims to quantify the economic risks associated with climate change over time. They report that the combination of projected sea level rise and potential changes in hurricane activity will add a **projected $11B–$22B to current average annual property losses in the northeastern U.S. by the end of the century—a two-to-four-fold increase from current levels.**[4]

Recently updated federal flood maps show that the city's 100-year flood zone has increased dramatically since the maps were last updated in 1983.[5] These revised, preliminary flood insurance rate maps (PFIRMs) show that over 400,000 New Yorkers and 85,000 buildings are located in high-risk flood areas, an increase of 183 and 120 percent, respectively.[6,7] While these updated PFIRMs give us a better idea of the risks we face today, they are created using only historical data, and therefore do not predict future flood risk due to climate change and sea level rise.

Climate and risk modeling can be used to highlight both likely and extreme scenarios to demonstrate what we might expect from future storms and coastal flooding. These models describe projected environmental conditions—global warming, increased frequency of extreme weather, and sea level rise—and the effects of these environmental conditions on our region.

Average sea levels in the northeastern U.S. have risen over a foot since 1900, higher than the average global rate. More crucially, sea level rise is accelerating. According to a recent study by the New York City Panel on Climate Change (NPCC), sea levels in New York City could rise by 11–21 inches by the 2050s, and by 22–50 inches, or even by 72 inches in the worst-case scenario, by 2100. Before accounting for possible changes in storm size or intensity, such an increase in sea levels would increase the severity of coastal flooding, causing a two- to 15-fold increase in the frequency of current 1/100-year floods by the 2080s.[8] NPCC also projects that sea level rise through 2100 will roughly double the land area affected by a 1/100-year flood, compared with current PFIRMs.

3. *City of New York, A Stronger, More Resilient New York (SIRR report), 2013*
4. *Risky Business Project, 2014*
5. *A 100-year flood, also known as a 1/100-year flood, has a one in 100, or one percent, chance of occurring in any given year.*
6. *Crain's New York Business. Feds Find Big Jump in Flood-Prone New Yorkers, 2013*
7. *Office of New York City Comptroller. On the Front Lines: $129 Billion in Property at Risk from Flood Waters, 2014*
8. *New York City Office of the Mayor. Mayor de Blasio Releases NPCC 2015 Report, Providing Climate Projections through 2100 for the First Time, 2015*

photo credit: Jason DeCrow

The Cost of Flood Risk Reduction to Date

In response to Sandy, federal, state, and local governments initiated numerous response and recovery initiatives, including many to reduce flood risk and improve resiliency. Examples of those initiatives are described here; **this list is not intended to be exhaustive and does not include all initiatives in the region**.

Federal
In response to Hurricane Sandy, Congress passed the Disaster Relief Appropriations Act ("Sandy Supplemental"), an emergency relief bill initially totaling nearly $51B, and reduced to $48B due to sequestration. Funds were allocated to all 50 states (in many cases, for natural disasters unrelated to Sandy) and 20 federal departments and agencies.

Over 90 percent was allocated to four federal agencies: Department of Homeland Security, including the Federal Emergency Management Agency; Department of Housing and Urban Development (HUD); Department of Transportation; and U.S. Army Corps of Engineers (USACE). Of the $48B total, $23.3B has been awarded, with 58 percent awarded to New York State including New York City, 27 percent to New Jersey, five percent to other Sandy-affected states, and the remaining 10 percent awarded to multi-state federal programs and states affected by other natural disasters.[9]

While approximately 80 percent of the funds have gone to programs to rebuild homes and infrastructure or provide direct assistance to those affected by the storm, approximately 20 percent has been directed toward preexisting federal programs to mitigate future disasters.[10] Major programs funded by the Sandy Supplemental to reduce flood risk and improve resiliency include HUD's Community Development Block Grant Disaster Recovery Program, the Federal Transit Administration's Public Transportation Emergency Relief Program, and USACE's Flood Risk Management Program.

USACE recently completed its North Atlantic Coast Comprehensive Study (NACCS), developing a comprehensive framework for coastal storm risk management and resilience. To implement NACCS, nine high-risk "focus areas," including New York Harbor and its tributaries, will receive further study and analysis to identify specific flood control and resiliency investments.

New York City
In December 2012, Mayor Michael Bloomberg formed SIRR to analyze Hurricane Sandy's impact on New York City's buildings, infrastructure, and people, and to recommend initiatives for rebuilding parts of the city heavily impacted by Sandy. SIRR was also charged with developing ambitious yet implementable strategies that address the city's vulnerabilities to the impacts of climate change. This undertaking was nothing short of a minor government miracle and quickly resulted in the SIRR report, a comprehensive ten-year plan.

The primary focus of the SIRR report was to survey citywide infrastructure and assess the effect of climate change and storms on the built environment. It outlines where Sandy hit the city hardest, and where it is most vulnerable to damage from future storms and sea level rise. The report analyzes previous coastal protection studies and identifies the relative merits of typical coastal resiliency measures. From this baseline, the report evaluates the performance of coastal protection during Sandy to develop a 10-year plan for coastal protection initiatives and identify potential longer-term measures. The SIRR report also provides strategic, system-wide recommendations for buildings, utilities, telecommunications, transportation, parks, water and wastewater, and other critical networks, proposing a total of 257 physical, social, and economic initiatives to address the impacts of Sandy and future climate change risks.

The report's initiatives are based on the climate change projections of NPCC. First convened in 2008, NPCC consists of leading climate change scientists, academics, and private-

9. *Recovery Accountability and Transparency Board for Hurricane Sandy Funding, 2015*
10. *Congressional Research Service. FY2013 Supplemental Funding for Disaster Relief, 2013*

sector practitioners who develop New York City-specific climate change projections to inform and support ongoing recovery and resiliency planning initiatives.

The SIRR report highlights cooperation between multiple agencies, comprehensive public outreach, and creative innovation as some of the major determining factors for future success. In 2014, Mayor Bill de Blasio established the Office of Recovery and Resiliency as the City's central management and coordination agency to oversee implementation of the SIRR report initiatives.

The SIRR report estimates a cost of $14B for implementation of its 257 initiatives, plus an additional $5.5B for resiliency-related Sandy recovery initiatives. Coastal protection measures account for $3.7B of this $19.5B total. The report outlines achievable measures that can be modified in response to funding availability, and has identified $15B in existing and expected sources, but still faces a $4.5B funding gap.

Hoboken, New Jersey

Across the Hudson River, much of Hoboken, New Jersey, lies below high tide, and as a result is highly vulnerable to flooding and storm surge. Hurricane Sandy caused over $100M in damages to private property and hundreds of millions more to public transit infrastructure.[11] In response, the City of Hoboken created the Community Resilience Plan, a comprehensive strategy to mitigate flood risk from storms and sea level rise. The City's plan includes a variety of strategies, such as green infrastructure and rain gardens in new public parks designed for stormwater retention, as well as up to three new pump stations for stormwater management capacity improvements.[12] The first phase of the "Resist, Delay, Store, Discharge" strategy ("Resist") for stormwater management was awarded $230M in HUD funding through its Rebuild by Design competition. In March 2015, United Nations Office for Disaster Risk Reduction named Hoboken as a Role Model City as part of its Making Cities Resilient campaign.[13]

With progress toward implementation, examples such as those above provide strong foundations for the near-term reduction of flood risk and improved resiliency on which longer-term efforts may be built. **However, although they provide an emphasis toward long-term planning and adaptive pathways to address flood risk, they are not multi-decade plans and only represent down payments against future impacts.**

The Cost of Flood Risk Reduction Elsewhere

How are other coastal communities responding to rising flood risks? In the Netherlands, a country where two-thirds of the population live below sea level, reducing flood risk is a national priority. In 2008 the Sustainable Coastal Development Commission, appointed by the Dutch executive government and also known as the second Delta Commission, developed the primary guide to reduce the country's risk based on worst-case climate projections through the year 2200.

The first Delta Commission was formed in the wake of devastating floods in 1953 that breached coastal defenses, killing over 1,800 people. That commission's work resulted in Delta Works, a multi-decade coastal protection project completed in 2010 that made Dutch water defenses some of the strongest in the world. The most critical protections were designed to withstand 1/10,000-year floods, which would produce catastrophe at unprecedented scale in a country in which 65 percent of GDP is generated below sea level. The United States, where hurricanes are stronger but population and economic activity is not quite as concentrated in low-lying areas, typically builds for 1/100-year floods. Nonetheless, 400,000 people and 85,000 buildings are located in the proposed 1/100-year flood zone in New York City.

Recognizing that the first Delta Works was inadequate given new projections for sea level rise, the second Delta Commission plan calls for more than $144B in new spending through 2100, to strengthen coastal defenses such as dunes and sea and river levees. The plan identifies projects to be implemented that can reduce the country's

11. *City of Hoboken. Hoboken Resiliency and Readiness Plan (presentation), 2013*
12. *City of Hoboken. Community Resilience Plan, 2013*
13. *United Nations Office for Disaster Risk Reduction. UN Recognizes Hoboken as a Model City, 2015*
14. *New York Times. Dutch Draw up Drastic Measures to Defend Coast against Rising Seas, 2008*

photo credit: Vladimir Siman

risks from higher sea levels through 2200, which may rise by as much as 13 feet.[14]
The plan will be financed through a special Delta Fund, supported by a combination of natural gas revenues and loans, supporting annual estimated project costs of $1.6B.

The political, social, and environmental differences between the U.S. and the Netherlands are substantial. However, the U.S. can learn much from the Delta Commission as an example of how to plan for—and finance—a series of long-term measures intended to provide dramatic reductions in climate change-related flood risk.

New York Harbor's Standard of Protection Compared to Other Major Ports
A 2010 study by the UK's University of Southampton and Middlesex University compared the applied standards of protection offered by coastal protections in major port cities around the world. It found that New York-Newark is nominally protected against a 1/100-year flood, but that "no comprehensive system of flood defenses exists." Risks vary considerably by location, due to factors such as topography and the potential human and economic impacts of flooding. Yet compared with other major cities such as London, Shanghai, Singapore, St. Petersburg, and Tokyo, which employ a 1/1,000 standard of protection, or Amsterdam and Rotterdam, which employ a 1/10,000 standard, **New York appears to be taking on more risk than its global counterparts**.[15]

The Cost of Flood Risk Reduction in New York Harbor: **The Big, Unanswered Question**

In the aftermath of Sandy, many strategies for protecting against the next storm emerged. Some called for large storm-surge barriers, or floodgates that could close during storms, protecting the areas inside the gates by blocking surge waters. One such proposal aimed at protecting New York City called for a set of three closure gates: at the Narrows between Brooklyn and Staten Island; on the Arthur Kill between Staten Island and New Jersey; and on the upper reaches of the East River. Others advocated for a barrier on the upper East River and a massive gate stretching from Sandy Hook, New Jersey, to the Rockaway Peninsula.

The SIRR report estimated a construction cost of $20B–$25B for these barrier systems, which did not include projected operating and maintenance costs. Other sources estimate construction costs of up to $30B. Plans for harbor-wide storm-surge barriers were ultimately not adopted by the City because they would not directly address rising sea levels, but instead reduce the risk only of storm-related flood events. Furthermore, such measures would likely be substantially beyond the scope of any source of funding currently identified. Instead, the City has opted for a series of locally tailored coastal protection measures such as small storm-surge barriers, beach nourishment, and offshore breakwaters.

15. Linham, M., et al. Costs of Adaptation to the Effects of Climate Change in the World's Large Port Cities, 2010
photo credit: BIG [Bjarke Ingels Group] Team

The cost estimates presented in the 10-year SIRR plan do not attempt to give us a comprehensive picture of the price tag of long-term resiliency. Whereas the SIRR report tells us how we can reduce flood risk and improve resiliency based on available or achievable funding, we ask the following:

- What is the full cost of investments necessary to mitigate climate change-related flood risks in the New York region?
- What is the level of risk reduction offered by such investments?

The SIRR report's $19.5B price tag for implementation of all 257 initiatives includes $3.7B for coastal protection measures. However, it does not include cost estimates for the "full-build" recommendations of its Comprehensive Coastal Protection Plan, and indicates, "…implementation of all of these tactics…would be an expensive proposition."[16] The plan also focuses on strategies implementable by the City of New York. It does not include specific initiatives related to infrastructure outside its jurisdiction, but it does call on other governmental bodies with substantial assets in New York City, such as the Metropolitan Transportation Authority and The Port Authority of New York and New Jersey, to make appropriate investments. The report also calls for certain investments to infrastructure owned by private utilities such as Consolidated Edison.

Based on the Metropolitan Waterfront Alliance's conversations with various government officials and flood control experts, there may be a loose consensus that $25B–$30B of infrastructure investments could provide adequate risk reduction during a 1/100-year flood. However, Sandy is variously described as being somewhere between a 1/250-year flood and a 1/700-year flood.[17] Under higher projections for sea level rise, by the 2080s, a flood currently rated as a 1/100-year flood, with a one percent chance of occurring in any given year, will be something closer to a 1/8-year flood, with a 12.5 percent chance of occurring in any given year.[18] **Thus $25B to $30B in near-term investments would likely provide inadequate risk reduction against another storm with the force of Sandy, with risks rising higher and higher throughout the 21st century.**

Call to Action!

The region's response to both climate change and the unprecedented challenge Sandy set before us has been tremendous, including the following examples:

- The formation of the New York City Panel on Climate Change that provides expert advice to government leaders
- The creation of the Mayor's Office of Recovery and Resiliency to oversee execution of the ten-year, 257-point SIRR plan for Sandy recovery and climate change mitigation in New York
- The recent release of New York City's OneNYC sustainability and equity plan that includes numerous resiliency initiatives
- The City of Hoboken's UN-recognized Community Resilience Plan
- USACE's NACCS and forthcoming high-risk focus area study for New York Harbor and tributaries.

We have done an excellent job with available resources, but it is not enough. New York City and New Jersey cannot address their flood risks alone; it is a national problem. Fortunately, there are recent precedents of national, cross-jurisdictional collaboration to protect and improve critical, shared waterways.

Following the recovery period in the Gulf of Mexico in the aftermath of the Deepwater Horizon oil spill, President Obama issued an executive order establishing the Gulf Coast Ecosystem Restoration Task Force in October 2010. This group, comprising representatives of five Gulf states and senior representatives of executive departments, agencies, and offices, was responsible for developing a comprehensive strategy for restoring and conserving water quality, marine habitat, and other coastal resources.[19] This strategic plan issued by the Task Force is shaping the transition from recovery to restoration, by setting measurable goals, indicators, and guidelines for intergovernmental action.[20]

16. *City of New York, A Stronger, More Resilient New York (SIRR report), 2013*
17. *New York City Mayor's Office of Recovery and Resiliency, 2015*
18. *New York City Office of the Mayor. Mayor de Blasio Releases NPCC 2015 Report, Providing Climate Projections through 2100 for the First Time, 2015*
19. *President Barack H. Obama. Executive Order 13554 Establishing the Gulf Coast Ecosystem Restoration Task Force, 2010*
20. *Gulf Coast Ecosystem Restoration Task Force. Gulf of Mexico Regional Ecosystem Restoration Strategy, 2011*

The Metropolitan Waterfront Alliance and our partners in the New York–New Jersey Harbor Coalition call for the creation of a presidential commission to develop a comprehensive capital strategy to dramatically reduce the region's flood risk through 2100.

By executive order, President Obama instructed federal agencies to collaborate on improving the health of the Chesapeake Bay watershed, long polluted and degraded, to meet the "fishable and swimmable" goals of the Clean Water Act. The order created the Federal Leadership Committee for the Chesapeake Bay, an interagency partnership charged with developing a comprehensive strategy for restoring clean water, recovering habitat, sustaining fish and wildlife, and increasing public access in the bay.[21] These efforts resulted in the Chesapeake Bay Watershed Agreement, a compact that aligns the restoration priorities of six states, the District of Columbia, and the federal government.[22]

Rising seas, more intense storms, and a substantial increase in the extent of related damages by the end of the century require us to look farther into the future. The motivation to take long-term action in the face of climate change is indisputable, and many have attempted to calculate the cost of inaction. The National Institute of Building Sciences estimates that for every $1 spent on mitigating natural hazards, $4 in future damages are avoided.[23] The Risky Business Project projects up to a quadrupling of annual property losses in the northeastern U.S. by 2100 to $22B. Further, without more substantial action to reduce our risk, analysts expect that another Sandy-like storm in 2050 would result in damages almost five times that of Sandy.[24] We cannot eliminate the threats posed by climate change without massive international cooperation, but we can invest to reduce the risks associated with future environmental calamities.

We've estimated the cost of inaction. Now it is essential that we do the opposite: **develop a comprehensive capital strategy to dramatically reduce the region's flood risk through 2100**, including determining and prioritizing the necessary infrastructure investments, ensuring appropriate accountability to execute the strategy, and securing the necessary funds.

To accomplish this and safeguard our future, **the Metropolitan Waterfront Alliance and our partners in the New York–New Jersey Harbor Coalition call for creation of a presidential commission.** The commission should include elected representatives from New York, New Jersey, and Connecticut; necessary federal, state, and local government agencies; and climate change and infrastructure experts from academia and the private sector.

The challenge to protect our city of water also presents an unprecedented opportunity to improve our coastlines and better connect with the water that surrounds us. Living shorelines and wetlands restoration can improve environmental health and water quality. Coastal improvements can make our shoreline not only safer, but more accessible and visually appealing. New waterfront parks and beaches improve opportunities for recreation and education.

We are off to a good start, but we must recognize that adapting to the realities of climate change is a costly, complex, multi-generational marathon. We are overdue for a serious conversation and accounting of what to do and how to pay for it. Our children, and their children, depend on our planning and action today.

21. *President Barack H. Obama. Executive Order: Chesapeake Bay Protection and Restoration, 2009*
22. *Chesapeake Bay Program. Chesapeake Bay Watershed Agreement, 2014*
23 *National Institute of Building Sciences Multihazard Mitigation Council. Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities, 2005*
24. *City of New York, A Stronger, More Resilient New York (SIRR report), 2013*

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