ft.
17

16'7" Projected Year 2080 Flood Height with Sea Level Rise

16

POST– SANDY

15

14'5" Projected Year 2050 Flood Height with Sea Level Rise

14

14' Post-Sandy Advisory Base Flood Elevation with Residential Freeboard

13

13' 2012 Sandy Surge Level

12

12' Post-Sandy Advisory Base Flood Elevation

INITIATIVE

11

10

9

8'10.8" Pre-Sandy Base Flood Elevation

8

8' Nominal Ground Level

7

Building Better, Building Smarter: Opportunities for Design and Development

6

5

4

May 2013

3

2

1

0

0' Sea level datum NAVD 88

ft.

16'7" Projected Year 2080 Flood Height with Sea Level Rise

14'5" Projected Year 2050 Flood Height with Sea Level Rise

"Climate Change Adaptation in New York City: Building a Risk Management Response: New York City Panel on Climate Change 2010," *Annals of the New York Academy of Sciences Volume* 1196, 41-62. New York, May 2010.

14' Post-Sandy Advisory Base Flood Elevation with Residential Freeboard

Mayor Bloomberg Announces New Measures to Allow Home and Property Owners Rebuilding after Hurricane Sandy to Meet Updated Flood Standards, January 31 2013 http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2013a%2Fpr044-13.html&cc=unused1978&rc=1194&ndi=1

13' 2012 Sandy Surge Level

"NYC Storm Surge Map," Center for the Advanced Research of Spatial Information, Hunter College, City University of New York, 2012. http://www.carsilab.org/sandy

12' Post-Sandy Advisory Base Flood Elevation

(see source for **14'**)

8'10.8" Pre-Sandy Base Flood Elevation

Federal Emergency Management Agency. "Advisory Base Flood Elevation Information, Region 2 Coastal Analysis and Mapping." 2013. http://www.region2coastal.com/sandy/table

8' Nominal Ground Level

Federal Emergency Management Agency. Ground level at example site (111 Beach 222nd Street, Breezy Point, Queens), "Advisory Base Flood Elevation Information, Region 2 Coastal Analysis and Mapping." 2013. http://www.region2coastal.com/sandy/table

0' Sea level datum NAVD 88

Wikipedia. "North American Vertical Datum of 1988," last modified April 10, 2013. http://en.wikipedia.org/wiki/North_American_Vertical_Datum_of_1988

Cover Image credit: NASA/NOAA

POST–SANDY INITIATIVE

16'7" Projected Year 2080 Flood Height with Sea Level Rise

14'5" Projected Year 2050 Flood Height with Sea Level Rise

14' Post-Sandy Advisory Base Flood Elevation with Residential Freeboard

13' 2012 Sandy Surge Level

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8'10.8" Pre-Sandy Base Flood Elevation

8' Nominal Ground Level

Building Better, Building Smarter: Opportunities for Design and Development

May 2013

0' Sea level datum NAVD 88

Preface

In response to Superstorm Sandy, the American Institute of Architects New York (AIANY) has spearheaded a collaborative initiative investigating issues and outlining options and opportunities to address the short-, intermediate-, and long-term impacts of the storm and the escalating effects of climate change on New York City. The impetus for this work grew in part from an informal partnership that had developed between the AIANY Design for Risk and Reconstruction Committee (DfRR) and the NYC Department of City Planning (DCP). Starting well in advance of Hurricane Sandy, these two groups had collaborated on multidisciplinary design explorations related to climate change. In addition, the DfRR Committee and AIANY undertook a number of other pre- and post-Sandy initiatives, including training and organization of FEMA neighborhood assessment programs and coordination of initiatives with the NYC Office of Emergency Management (OEM), the Dean's Roundtable, related area design schools, and relevant AIA National programs. After the devastation of the storm, this relationship expanded to include a larger set of collaborators, the Post-Sandy Initiative, which prepared this summary.

This Initiative includes relevant committee members from AIANY and volunteer representatives from other AIA chapters and sister organizations who share the commitment to recovery and belief that planning and design are a crucial component of rational decision-making. Numerous other agencies, panels, and organizations have been working in parallel with this Initiative, including those convened by the Mayor's Office, the City Council, the Governor's Office, the Municipal Art Society, the Regional Plan Association, Pratt Institute, and many others. We intend our work to complement and support these efforts, especially those with ties to the most affected populations.

The Initiative has four overarching objectives:

First, to prepare a multifaceted report illuminating options and opportunities based on the best information available in a short amount of time. The report is intended to provide policymakers with additional tools as we forge ahead in response to Sandy.

Second, to mount an exhibition of this open-ended information so that it can be shared, discussed, and debated by design professionals, stakeholders, and recovery leaders.

Third, to initiate public symposia and ongoing programs in the four areas covered in the report, providing a framework for continued focus on Sandy recovery.

Fourth, to undertake continuing advocacy with relevant public, private, and institutional stakeholders, expanding the response to Sandy into efforts for a more resilient future.

In the wake of Sandy, it is evident that we need to learn from other cities and regions that have suffered similar weather events. These precedents serve as best practices on which we can rely as we begin to build back better and smarter. We support research into resilient measures of building, which can secure our regional future and become, in turn, best practices that can be helpful to other areas at risk.

As delineated in the following pages, participants have defined a variety of short-, medium-, and long-term responses in four key areas—Transportation & Infrastructure, Housing, Critical & Commercial Buildings, and Waterfront—that will feed into these larger public, private, and institutional efforts. Following the release of this report, we will continue these fruitful collaborations and advocate for ensuring the health, safety, wellbeing, and quality of life of our magnificent city and region. Building Better. Building Smarter.

Collaborating Organizations:

American Council of Engineering Companies (ACEC New York)

American Society of Landscape Architects New York Chapter (ASLA-NY)

Citizens Housing & Planning Council (CHPC)

New York State Association for Affordable Housing (NYSAFAH)

American Planning Association New York Metro Chapter (APA-NYM)

Regional Plan Association (RPA)

Structural Engineers Association of New York (SEAoNY)

For more information on AIANY's Design for Risk and Reconstruction Committee (DfRR) please refer to www.designforrisk.com

Executive Summary

Superstorm Sandy revealed that we have created a defenseless built environment:

1. Land-use patterns encourage fragile dwelling units and critical facilities in the most vulnerable locations.
2. Transportation and utility systems fail in the face of extreme weather events.
3. Stormwater management and development policies now in effect actually increase the impact of runoff.
4. Existing buildings are barriers to sustainability, squandering power and producing greenhouse gases.

The overarching long-term objective is **resilience**, which can best be achieved by modifying buildings, transportation and infrastructure networks, and land-use patterns.

- This will require consensus on standards and where they apply—what constitutes "harm's way," based on updated predictions of flood zones, storm surges, and sea-level rise, and how these assumptions may shift or increase in coming years.
- It will also take careful analysis of many possible strategies—examining relative costs and benefits in the context of likely useful lifespans.
- There is no universal solution. Design approaches should be site-specific and respond to local programmatic needs.

A great deal of work has been published and is underway on responding immediately after disasters. As architects, planners, and designers, our focus has been, instead, in an area where we can make the most meaningful contribution: design approaches to new construction and rehabilitation to help limit the effects of future storms on our built environment, and processes to help us coordinate our efforts to provide critical services, including regional transportation, immediately after a major storm.

Building back better and smarter—moderating past mistakes through careful planning, becoming more energy independent, and requiring sustainable design and construction practices—will help reverse the vulnerability we have inherited from centuries of misguided development.

TRANSPORTATION & INFRASTRUCTURE

Regional coordination and planning for redundancy can ensure that our transportation and infrastructure networks will operate before, during, and after severe weather events.

These aging systems were not built to withstand today's rising sea levels and severe storms. Identifying their vulnerabilities and planning for their reinforcement is an urgent priority, demanding interagency collaboration, public education and commitment, and solutions that contribute to the design quality of the City and region.

Key concepts and findings

Planning for Redundancy: Transportation and infrastructure networks are interdependent. Multiple and alternative power sources can keep them functioning during severe weather events. Robust, multiple-system communication plans can alert the public to evolving conditions.

Planning for Resiliency: Reinforcing vulnerable structures and repositioning critical equipment can protect vital infrastructure systems. Sensitively-designed elements can also serve as urban amenities. Replacement of those systems that were heavily damaged by Superstorm Sandy should maximize long-term sustainability.

Planning Smart: We have identified case studies that reveal three distinct strategic approaches—defensive, adaptive, and passive. **Defensive** infrastructure can demand burdensome long-term funding and management; for each particular situation, scenario-planning exercises and other research are needed to suggest whether hard infrastructure (with a constructed resiliency) or simpler, softer solutions will best protect the community. **Adaptive** efforts reduce disruption of natural ecosystems, and focus on green infrastructure approaches. **Passive** solutions accept that protecting investments is impractical in a particular situation, and focus on moving or providing alternative systems. For all strategies, solutions must contribute to the amelioration of service gaps and improved design quality of the public realm.

Opportunities and next steps

- Assess the infrastructure and transportation systems at greatest risk, and identify strategies for their redundancy and resiliency.
- Educate the public about challenges ahead to ensure realistic expectations and support for required expenditures.
- Improve interagency and interstate communications for holistic planning before the fact and regional coordination during extreme events, including emergency wayfinding strategies to inform residents about alternative backup plans for transportation, power, fuel, and locations for assistance.
- Recognize that infrastructure failures in New York City can have catastrophic international impacts. The funding required to strengthen our infrastructure should be leveraged through all parties that benefit from preventing expanding economic disorder.

HOUSING

Multi-family buildings fared much better than one- and two-family dwellings. Yet local and national regulations related to housing in flood zones do not address the conditions of a dense urban place like New York City.

Superstorm Sandy revealed the need for new strategies to address evacuating residents who will be displaced in future disasters, and their security and comfort if sheltering in place is necessary. The existing housing stock must be retrofitted to become more resilient. Standards for new housing must ensure that it can be safe, accessible, and attractive.

Key concepts and findings

Housing displaced people in extreme events requires knowledge of available units, a centralized intake process, and a set of tools including appropriate waivers, qualifying processes, model lease agreements, and allocation of subsidies.

Non-profit housing providers need support with post-disaster training to address residents' needs, especially in flood-prone neighborhoods.

Gaps in current floodproofing guidelines and regulations—at both local and federal levels—must take into account the character of dense urban environments.

Multi-unit housing stock in flood zones, even where damaged, remains largely sound. With strategic modifications, the useful life of most of these buildings can be extended well into the future.

Broader planning implications should be addressed, such as whether exceptions to allow multi-family housing in downzoned coastal areas could increase community resiliency.

Opportunities and next steps

FEMA and National Flood Insurance Program literature is largely focused on one- and two-family housing. It is our conclusion that a FEMA multi-family design guide is very much needed.

Zoning regulations should be adjusted, in light of predicted higher flood levels, to recognize the amount of space needed by required ramps, elevators, and lifts in multi-family buildings, and to provide for the relaxation of height restrictions in order to accommodate higher-elevation ground floors.

In low-income rental buildings and supportive and senior housing, where residents may not be able to individually evacuate, safe rooms and expanded programs should be provided to allow congregation, roll call, and rescue during emergency conditions.

Multi-family housing should be engineered with building systems that protect against HVAC shutdowns, provide for alternative power during outages, and ensure a quick return to normal.

CRITICAL & COMMERCIAL BUILDINGS

The challenges of adapting the vast inventory of existing critical buildings to withstand the effects of extreme climate events are distinct from the relatively easier task of designing new structures for resiliency.

Critical facilities like hospitals, police stations, and data centers must be able to withstand the effects of a disaster and remain in operation without evacuation. Other buildings in vulnerable locations may be evacuated, but should be designed to survive without structural failure. Building owners have a responsibility to protect occupants, protect structures and contents from damage, and ensure that buildings can operate during and after the event.

Key concepts and findings

Owners of all commercial and institutional buildings—existing, in construction, or planned—should begin now to:

- Conduct vulnerability assessments of their buildings in anticipation of the likely effects of extreme climate events.
- Identify technical standards and technologies that will allow their buildings to successfully withstand these events.
- Update plans to keep buildings operational during disasters and to quickly recover functionality afterwards.
- Create implementation plans to put in place remedial actions indicated by the three preceding steps.

Opportunities and next steps

Disaster-resistant building design strategies, technologies, and materials that already exist or are being developed elsewhere should be examined and adapted here.

We should move toward replacing existing critical buildings in harm's way that cannot be hardened, with exceptions for buildings of historic or cultural significance.

We need regional protective systems that can enhance, or eliminate the need for, individual building responses.

The challenges that hurricane conditions and floods pose for buildings, in particular those in densely populated areas, should be brought to the attention of the many scientific, governmental, and professional organizations currently exploring the potential impacts of climate change. Dialogue will lead to better simulation models of water and wind behavior on built structures, a new national reference code for building construction, and zoning and planning approaches that bring patterns of development into line with present and emerging knowledge about disaster-prone areas.

WATERFRONT

The future of New York as a waterfront city depends on respecting our changing environment and building on the unifying strength of our dynamic harbor and waterways in creative ways.

Superstorm Sandy has given us a new perspective on New York City's diverse waterfront and watershed—comprising ocean, riverine, and estuarine systems within a broader context of interactive water flow. Floods and storm surges are part of natural cycles, although their frequency, intensity, and impact on our city are increasing. Within this ecological context, an array of opportunities exists that can integrate diverse land-uses—public access, parks, housing, commercial districts, and working waterfronts—and accommodate the climatic events we must now anticipate.

Key concepts and findings

More scientific research will help us to understand the interactions between urban waterfront and human ecologies. We need a dynamic and innovative approach to waterfront projects, allowing for experimentation and novel resiliency strategies.

Interdisciplinary collaborations, organizational structures, and funding mechanisms could promote robust collaborations among pure and applied disciplines—linking the design community, the scientific research community, and the regulatory community.

There is always more than one solution. New York City has 520 miles of shoreline, with varying geomorphology, hydrology, land-uses, and habitat types. Planning and design of waterfronts should embrace unique, site-specific attributes.

For instance, we need to set priorities for current and future funding for the alternatives being identified and discussed by the City's post-Sandy task force, the Special Initiative for Rebuilding and Resiliency (SIRR).

There is always more than one solution. New York City has 520 miles of shoreline, with varying geomorphology, hydrology, land-uses, and habitat types. Planning and design of waterfronts should embrace unique, site-specific attributes. For instance, we need to set priorities for current and future funding for the alternatives being identified and discussed by the City's post-Sandy task force, the Special Initiative for Rebuilding and Resiliency (SIRR), the Department of City Planning's year-long Urban Waterfront Adaptive Strategies Study, and NYS 2100 Commission. These include nourishing beaches and expanding dunes, reinserting wetlands, raising bulkheads, adding tide gates and revetments, building breakwaters, installing passive and deployable floodwalls, constructing seawalls and surge barriers, and conceiving of dual-use or multi-purpose levees.

Redundancy and modularity should be built into flood protection and stormwater management systems in densely-populated areas.

All members of waterfront communities should be included in the planning and implementation processes via community outreach and communication.

Opportunities and next steps

We need a ground-up, incremental approach to waterfront resiliency, partnering with local communities to generate sensitively formulated solutions, and arming property owners with a menu of strategies. From government we need agility and flexibility in regulations, and funding that affects the planning and design of waterfront solutions in the context of a collaborative, problem-solving approach.

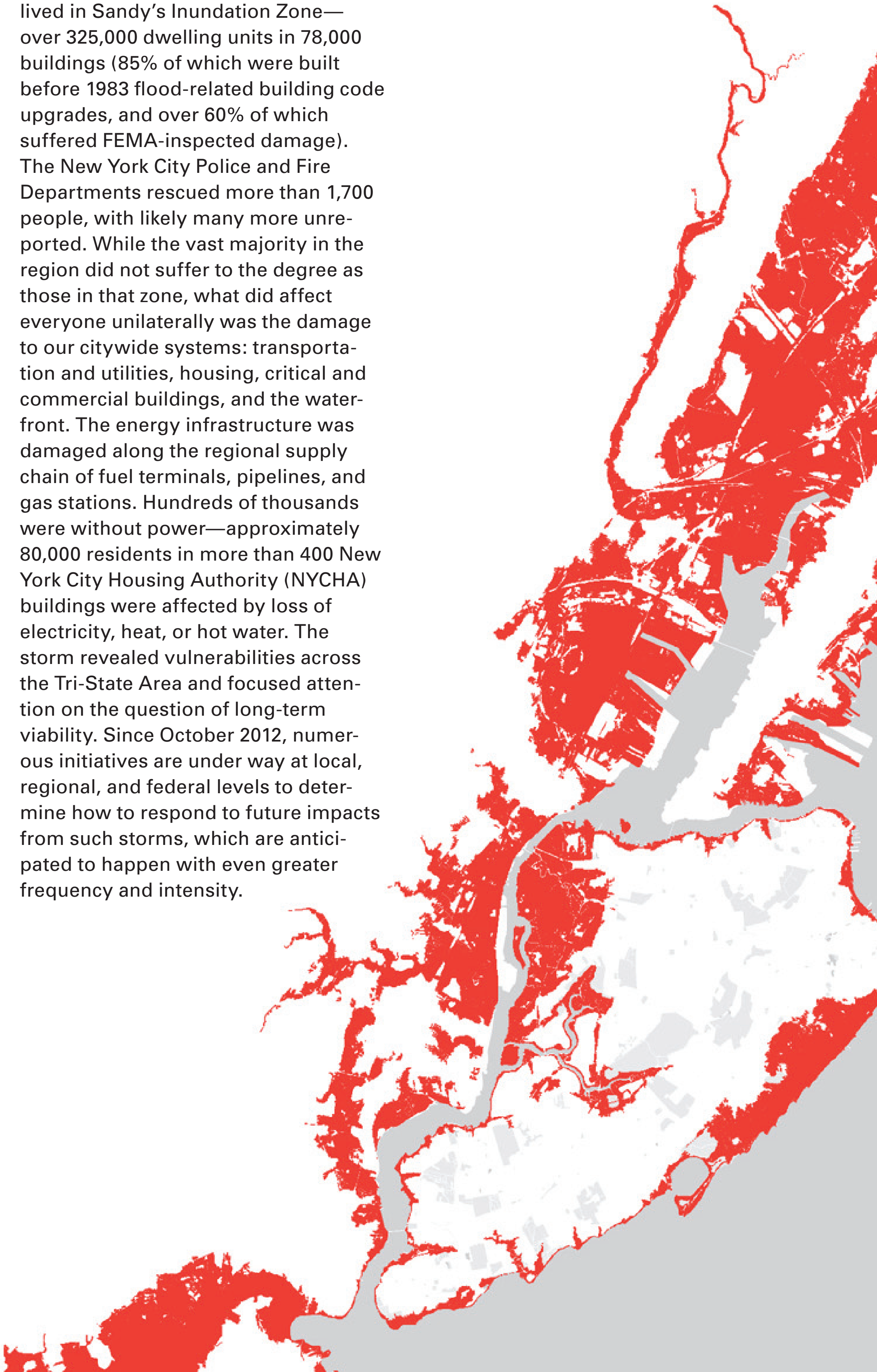
We propose Waterfront Labs to investigate strategies that could mitigate storm surge, prevent erosion, and soften the impact of rising tides. Experiments would focus on both predictable and unpredictable events, and take into account the different natural typologies found in the New York City region. The Waterfront Lab will make an important contribution by bringing New York City to the forefront of innovative waterfront resiliency planning and design.

INTRODUCTION

The cover of this report graphically quantifies Sandy's impact—and future potential implications—in terms of comparative feet and inches. Sandy's regional inundation levels are shown in the adjacent map.

As we now understand, many of the most acute impacts of Superstorm Sandy resulted from the confluence of several unique circumstances: an off-shore hurricane that entered the New Jersey / New York City / Long Island region at full bore; a fast-rising storm surge that came and went quickly; one of the highest tides of the year combined with a full moon; a Nor'Easter, and a disturbance in the jet stream that caused the storm's turn west into New Jersey. We need to learn from Sandy in order to address other different but equally threatening factors that may emerge from the next storms. For example, Hurricane Irene in 2011 caused flooding resulting from intense rainfall, rather than the storm-surge-driven flooding seen during Sandy. Wind damage from Sandy was limited to the area of first landfall, although tree damage and resulting power outages were major issues in adjacent inland areas. Obviously it is difficult to predict the factors and results associated with any storm.

Superstorm Sandy resulted in large numbers of people losing their homes, livelihoods, and in some instances, their lives. More than 10% of the City's population (almost 850,000 people) lived in Sandy's Inundation Zone—over 325,000 dwelling units in 78,000 buildings (85% of which were built before 1983 flood-related building code upgrades, and over 60% of which suffered FEMA-inspected damage). The New York City Police and Fire Departments rescued more than 1,700 people, with likely many more unreported. While the vast majority in the region did not suffer to the degree as those in that zone, what did affect everyone unilaterally was the damage to our citywide systems: transportation and utilities, housing, critical and commercial buildings, and the waterfront. The energy infrastructure was damaged along the regional supply chain of fuel terminals, pipelines, and gas stations. Hundreds of thousands were without power—approximately 80,000 residents in more than 400 New York City Housing Authority (NYCHA) buildings were affected by loss of electricity, heat, or hot water. The storm revealed vulnerabilities across the Tri-State Area and focused attention on the question of long-term viability. Since October 2012, numerous initiatives are under way at local, regional, and federal levels to determine how to respond to future impacts from such storms, which are anticipated to happen with even greater frequency and intensity.



Source: MOTF Inundation Model Date: April 3, 2013
© 2013 ESRI, DeLorme, NAVTEQ

Sandy's unexpected power and breadth created a need for realistic standards to protect communities in the way of future storms—which may be even more powerful in terms of wind, rain, and potential damage. This unprecedented challenge, complicated by estimates of rising sea levels and increasing frequency of events, will define how we plan and regenerate the inundated areas and the regional context.

Even as people and buildings suffered terrible direct impacts, the City and region as a whole suffered massive indirect impacts of the storm. Adverse effects to economic vitality, communications infrastructure, and connectivity networks were widespread.

The initial step in any disaster is **response**, preserving life and critical property in the midst and immediate aftermath of the event (ideally preceded by effective pre-planning for evacuation and staging of needed resources). This is followed by **recovery**, returning to as much normalcy as possible, in turn followed by organized and deliberate rebuilding. The overarching long-term objective is **resilience**—modifying buildings and land-use patterns over time, and infrastructure where significant investment prevents physical relocation, and waterfront edges that transition between the shore and upland areas—hardening and/or softening as relevant to mitigate the impact of future events.

In order to deal with these challenges, Mayor Michael Bloomberg's Special Initiative for Rebuilding and Resiliency (SIRR) program is engaged in preparing an integrated strategy to address how we rebuild New York City to be more resilient in the wake of Hurricane Sandy, but with a long-term focus. The City will use its first allocation of federal Community Development Block Grant (CDBG) funds to support recovery from Sandy and to build in resilience to the challenges of climate change, including programs to build and support housing, businesses, infrastructure, and other city services. This process, undertaken through the coordination of numerous governmental agencies and multidisciplinary advisors, relies heavily on community outreach to define issues and priorities. As planning and design professionals, our intent is to support that process through our parallel volunteer efforts.

But as we step back from the immediate shock and imperative response to emergency conditions, we must recognize that much of the problem lies in our own culpability as a client society—the way we have helped over the years to create a susceptible built environment:

- Land-use patterns that encourage fragile dwelling units and critical facilities in the most vulnerable locations;
- Transportation and utility systems that fail more and more frequently in the face of natural events;
- Stormwater management and development policies that increase rather than decrease the impact of runoff;
- Existing buildings that are barriers to sustainability—and that, in NYC, use 94% of electrical production and produce 75% of greenhouse gas emissions.

Overall, sea levels are rising and extreme storm events are becoming more frequent, both because of natural cycles and the worsening impact of human-induced climate change. By building back better and smarter—moderating our past poor decisions through careful planning, becoming more energy-independent, and setting in motion new, sustainable design and construction practices—we can begin to mitigate or reverse the effects of centuries of misguided development policies.

The Post-Sandy Initiative

The Post-Sandy Initiative, the collaboration that produced this summary report, is structured as the planning and design community's response to this challenge. Initiated by the American Institute of Architects New York (AIANY) in the weeks that followed the storm and in collaboration with a wide range of other professional organizations and concerned individuals, it has been supported by the participation of a variety of local, regional, state, and national public agency participants. At publication time, still only months after Sandy swept through our region, this report is a slice in time of our efforts as of April 2013—a definition of issues, an analysis of options and opportunities, and the establishment of a framework for next steps. As our community continues to explore these issues and develop ideas for building better and building smarter, progress reports will be issued online at www.postsandyinitiative.org

Unlike many of the areas devastated by comparable American storms, New York City is a major urban region whose vitality and resiliency depends on a complex web of interconnected systems. With more than 8 million residents, 6 million commuters each day, and 50 million annual visitors, New York City is the largest regional economy in the United States, and the second largest city economy in the world after Tokyo. New York is a cultural capital and home to hundreds of museums, performing arts venues, and historic sites; and more than 600,000 students are enrolled at the City's 110 higher education institutions, a larger number than the entire population of Boston.

Through the Post-Sandy Initiative's working groups, it quickly became clear that "one size does not fit all"—the imposition of national or other standards, often based on rural, suburban, or small-city situations, may not always be applicable to our high-density environment, and falls short in addressing our complex, interconnected social and economic culture. A series of complementary initiatives, many based on experience from outside the United States, is required to affect meaningful change.

As part of this Initiative, many professionals have given their time to explore important issues about Sandy and the response to date, both in terms of shorter-term recovery efforts and longer-term resiliency considerations. It is clear that we can, and need to, do better in the face of future extreme weather events. Key areas for further discussion include:

During a major storm event:

- Dealing with governmental/OEM and FEMA evacuation mandates in the face of concerns such as public housing constraints, property owner reluctance, and public safety considerations;

- Ensure that evacuees have places to go out of harm's way, and reliable means to get there;
- Reinforce and protecting building systems, infrastructure function, and ability to provide police and fire protection.

Short-term recovery:

- Assess the damage to property and community;
- Provide equitable public support in the face of varying insurance coverage;
- Justify and balance rapid-recovery efforts and costs with follow-up repairs;
- Define the standards for remediation, and resulting costs, in terms of medium-and long-term benefits;
- Understand the implications of insurance rates based on those standards, and their impact on property owners of various incomes.

Medium-term remediation:

- Define workable standards for both relatively easier new construction and significantly more difficult existing repair and reconstruction;
- Develop approaches for rebuilding based on sustainability and resource conservation;
- Establish clear standards from amongst differing expectations on the rate of climate change and sea-level rise predictions;
- Deal with social inequity, community, and economic issues of long-term settlement in areas that are now in harm's way;
- Create equitable (and appropriately funded) programs for purchase of destroyed or damaged homes and transference into open space.

Long-term resilience:

- Analyze long-term infrastructure and waterfront investments despite a lack of definitive new scientific standards for flood zones and sea-level rise;
- Evaluate how to finance premiums for design and construction based on short-term cost but long-term benefit without affecting immediate alternative needs or choices;
- Advocate planning and design solutions that reduce carbon emissions and our reliance on fossil fuels, as well as work with anticipated future water levels.

There are two major determining factors in defining resilience:

- Achieve consensus among the responsible parties (FEMA, the states, the City, and other municipalities, insurance companies) as to standards— what constitutes "harm's way." This definition will necessarily be based on predictions of sea-level rise, possible storm surges, and recommended allowances for "freeboard" above those flood levels—and how they are predicted to increase over a series of benchmarks throughout the coming century and beyond.
- Careful cost-benefit analyses that take into account funding cycles and the benefits of funds at the users' end, present value, and alternative uses of funds.

The overarching long-term objective is resilience—modifying buildings and land-use patterns over time, infrastructure where significant investment prevents physical relocation, and waterfront edges that transition between the shore and upland areas — hardening and/or softening as relevant to mitigate the impact of future events.

As the planning and design community, we are one voice in these critical issues. But our expertise and perspective are invaluable components of the solution. Architects, landscape architects, planners, and engineers must be at the table as policies and standards are developed to mitigate or reduce the risk of catastrophic damage from the next storm. We must apply our experience to those issues that speak to the physical, social, and environmental implications of possible decisions. More value and emphasis must be placed on long-range comprehensive planning under the initiative of elected leaders. Systems and resources must be organized so that short-term decisions are aligned with long-term health, safety, and sound investment.

We framed this Post-Sandy Initiative in terms of design implications and applied design thinking. A set of working groups examined key aspects of the built environment in detail, through collaboration, research, workshops, and design charrettes. We have examined these topics in terms of short-, medium-, and long-term time frames, and at a range of scales, from individual buildings to neighborhood contexts, the surrounding city, and the region as a whole.

The following chapters summarize issues, options, and opportunities identified by four of these working groups—Transportation & Infrastructure, Housing, Critical & Commercial Buildings, and Waterfront. The valuable work of a fifth working group—Zoning & Codes—has been incorporated throughout the text. Each of these reports is supplemented online by additional material delving into specific areas of concern and concepts for building better and building smarter at www.postsandyinitiative.org

TRANSPORTATION & INFRASTRUCTURE

Regional coordination and planning for redundancy can ensure that our transportation and infrastructure networks will operate before, during, and after severe weather events.

Public transportation entities such as the Metropolitan Transportation Authority (MTA), NJ TRANSIT, the Port Authority of New York & New Jersey (PANYNJ), and Amtrak are all re-examining Sandy's impacts and developing short- and long-term responses to climate change within the context of restricted budgets and smaller workforces.

City agencies responsible for infrastructure—sewer, water, and stormwater drainage—are examining failures and planning for future needs. Power utility providers such as ConEdison, LIPA, and PSE&G are developing new strategies. Advocacy groups such as the Municipal Art Society (MAS), the Regional Plan Association (RPA), and the Rudin Center for Transportation have served in multiple roles, from educating the public through public dialogues and white papers, to lobbying for funding and improved communication among infrastructure and transportation providers. It is critical to understand all of these ongoing efforts while working across disciplines that cross municipal and state lines.

Interagency collaboration and a well-developed communications plan established jointly by various transportation and infrastructure agencies that serve the City and region can strengthen the framework for future multi-modal redundancy and resiliency.

KEY CONCEPTS AND FINDINGS

As noted in Governor Andrew Cuomo's NYS 2100 Commission report, "Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure" (November 2012), New York State's recent ClimAID projections show that higher temperatures and sea-level rise are extremely likely for New York State through the end of the century, and that by 2100, experts project sea levels to rise in New York City and Long Island by as much as six feet under certain scenarios. Given our aging transportation and infrastructure, those statistics make identifying the weaknesses in our systems of utmost urgency. The following strategies are our recommendations for responding to the new anticipated norm.

Once in operation, New York City's CitiBike program will provide alternative transportation for some residents. Photo credit: CitiBike / NYC Bikeshare

Planning for Redundancy

Planned redundancy provides a more flexible infrastructure. As many of our transportation and infrastructure networks are interdependent, losing one often causes the loss of others. Working towards providing appropriate backup power systems along with alternative power sources, such as solar, wind, or geothermal, will make grid dependency less critical. Policies that encourage redundancy would promote these actions.

Developing a robust communications network and plan will allow transportation agencies to alert the public about station closings and alternate transportation routes, prior to and immediately after severe storm events.

Planning for Resiliency

There are currently available physical solutions that can protect our transportation and infrastructure networks against flooding. Sensitively designed, these barriers can also serve as urban amenities. By reinforcing vulnerable structures, we can fortify them to withstand these "new normal" events. These actions should be supported by policies that address strengthening existing structures with ongoing repair programs, as detailed in Section 3 on critical and commercial buildings. Placing new electrical equipment above anticipated flood levels and replacing damaged equipment with new equipment designed to work in a harsh salt-water environment are examples of strategies that could be implemented as part of an overall plan.

As we move from short-term recovery to long-term planning for redundancy and resiliency, we need to plan smart so we can build smart.

Planning Smart

Smart planning in the new ecosystem involves looking at transportation and infrastructure systems in new ways. It begins with an intermodal interagency process of regional cooperation, communication, and coordination for standard operations, regular outages, and extreme weather situations.

Temporary flood barriers were constructed prior to the storm at vulnerable entrances. Photo credit: Flickr / MTA Photos Photostream

It includes recognizing the efficiency of having tunnels act as drains for our cities, and considering the different ways that systems can function during severe storms, and how that differs from how they perform during a non-event.

Providing uninterrupted services at vital facilities such as hospitals, firehouses, and shelters should be prioritized as part of an overall infrastructure network. Planning smart means examining existing and new infrastructure comprehensively with a clear understanding of specific risks that vary based on location. Building better will mean coordinating systems between agencies serving the same region, and acknowledging that often a replacement in-kind is not an adequate solution.

To plan smart, we need to enhance our guidelines and standards for resiliency and redundancy by integrating the following best practices:

New Infrastructure
The Inner Harbor Navigation Canal Surge Barrier in New Orleans (the only one like it to date in the United States), London's Thames Barrier, and the Delta Works in the Netherlands are examples of climate change-responsive infrastructure solutions that are less than 30 years old. These structures typically need to be funded from design through construction and maintenance. As an example, sewage treatment failures in extreme storm events may require long-term funding of a hardened system to mitigate such problems in future storms. We recognize that in our region, these new types of infrastructure will need to be developed and maintained by a new public institution, or added to the responsibilities of an existing one.

Scenario-planning exercises in different communities, similar to what is being demonstrated as part of Mayor Bloomberg's citywide Special Initiative for Rebuilding and Resiliency (SIRR), can further inform how soft solutions or hard infrastructure can protect communities from severe storms like Sandy, and how they may either detract from or enhance those communities' quality of life.

Reduce Impact to the Ecosystems
New York City already has one of the lowest carbon footprints per capita in the country. As we develop these recommendations, we must continue to reduce this footprint and reinforce our city's approach to sustainability, ensuring that our redundancy recommendations reduce negative environmental impacts as well. The use of permeable paving materials and water retention systems that reduce the demands on sewer systems are two such viable possibilities. Another is to encourage less energy-dependent transportation modes, such as bicycle and pedestrian networks and technologies, as part of the overall regional transportation system.

It will also be important to look at areas and communities that may have been underserved in terms of a broader adoption of green infrastructure measures, and how that, in fact, may minimize flooding in the future.

G-Cans Project, Tokyo, Japan

One of the world's largest underground flood-water diversion facilities was designed to protect Toyko from flooding during typhoon season and heavy rains.

Urban Design Quality
Part of building for a resilient future is protecting our communities from problems resulting from climate change, and doing so in a way that uses natural as well as engineered measures to improve both redundancy and resiliency. Neither measure should, however, exclude maintaining the quality of the built and natural environment. Therefore, it is critical to solve these technical challenges in a way that does not lose sight of the human condition. Solutions must generate positive interventions from architectural and urban design perspectives. We must not forgo the vitality of our built environment, and in cases where communities may have been underserved aesthetically, address infrastructure and transportation needs as an opportunity for both urban and economic enhancement.

Responses Prior to Catastrophic Events
Having plans in place for catastrophic events, and communicating them to the public, is a low-cost initiative that pays dividends. Procedures to close transportation systems in order to safeguard transportation and infrastructure networks (including relocating mobile equipment to higher ground, installing temporary flood barriers, etc.), and requiring mandatory evacuations of vulnerable areas must be developed. This would increase safety and security during a storm. The MTA and the City of New York taught this lesson to millions. A regional process for communicating station, road, and line closures to the public prior to severe weather events—and providing clear information about alternative routes—should be developed and employed, as mentioned above.

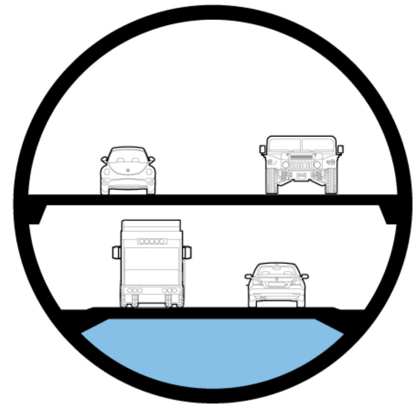
Responses to Catastrophic Events After the Fact
The recovery after Superstorm Sandy was uneven, and for many residents, not knowing when essential services would be restored was more difficult to accept than the event itself. Implementation of the strategies summarized previously, in particular the redundant and resilient systems, will help to mitigate future similar challenges.

Additionally, local outreach facilitators should be trained to educate communities about their various transportation options. Key information points can be established in advance so that in the event of a broad-based Internet shutdown, data on current and planned operations are accessible throughout the City. Details on alternative transportation systems, including bike routes and ferries, should be well distributed. Workforce development programs can help to lessen post-catastrophic isolation.

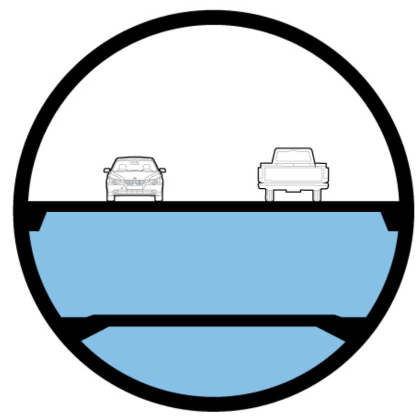
There remains much that can be done. Our institutions need to treat the "catastrophic" as "expected" and prepare accordingly. Doing so may change the "catastrophic" to merely "inconvenient."

POLICY CONSIDERATIONS AND REGULATORY IMPLICATIONS

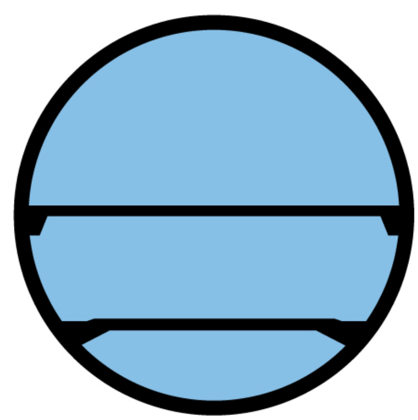
Transportation and infrastructure, when compared to other aspects of the built environment, are far more developed, controlled, and managed by public agencies. Responsive programs will necessarily be filtered through government programs and regulatory modifications. This includes agencies such as the Federal Emergency Management Agency (FEMA), the Federal Transportation Administration (FTA), the Federal Aviation Administration (FAA), the Environmental Protection Agency (EPA),



MODE 1
Normal Conditions
2 Roadways Open



MODE 2
Moderate Storms
1 Roadway Open



MODE 3
Heavy Storms
0 Roadways Open

SMART Tunnel, Kuala Lumpur, Malaysia

The SMART tunnel is six miles long and consists of two tubes, each carrying two traffic lanes, situated one above the other. The tunnel is used to manage severe flooding during monsoon season. Its mechanical and electrical equipment can handle submersion to a depth of 65 feet during flooding.

Thames Barrier, Thames River, London, UK

Designed by Rendel, Palmer and Tritton to prevent flooding from high tides and North Sea storm surges, the Thames Barrier is located downstream from central London. It needs to be raised (closed) only during high tide; at ebb tide it can be lowered to release the water that backs up behind it. Photo credit: Bikeworldtravel / Shutterstock.com

the Federal Highway Administration (FHWA), and the Federal Railroad Administration (FRA).

To fund the responses to climate change, sea-level rise, and potentially catastrophic natural events, we must demand a new paradigm of investment. With federal support in place for a considerable amount of repair work, how can we refocus the discussion on longer-term capital needs? And where will the money come from?

OPPORTUNITIES AND NEXT STEPS

We must maintain a sense of immediacy. Keeping awareness of these issues front and center needs to continue and be brought to the transportation and infrastructure conversation if we are going to evolve these ideas into tangible next steps.

When it comes to transportation and infrastructure, the responses will come from the public, with advocacy groups helping to inform decision makers. This starts with education. The public must be educated about the challenges ahead so that their expectations are realistically maintained within the context of this new reality. Cooperative efforts need to continue on a regional level. This begins with shared knowledge, including lessons learned, followed by the development of coordinated common standards and guidelines. Therefore, we need to improve interagency and interstate communications so that we are planning holistically and not in geographic vacuums. We must advocate for methods of sharing information, we must advocate for methods of sharing information, especially during a crisis. This should include emergency way-finding strategies to inform residents about alternative backup plans for transportation, power, fuel and locations for assistance.

Ultimately it is about risk management. How do we (stakeholders, the public, decision makers, government, and advocacy groups) navigate through this

MuseumPark, Rotterdam, The Netherlands

Underground parking garage designed by Paul de Ruiter Architects accommodates 1,150 cars and a 10-million-liter water reservoir, when necessary. Photo credit: Pieter Kers historical moment in the Northeast? If we are to continue living and working here, we need to recognize all these issues, and then manage the associated risks. Superstorm Sandy forced us to recognize the fragility of our position, with millions of people from New Jersey to New England affected. Now we have to manage it. We need to begin to assess the transportation and infrastructure systems that are at greatest risk, and then identify and prioritize strategies for redundancy and resiliency in the near and long term.

It is clear that we need to expend the resources that can manage these risks. The challenge will be for the public to accept these expenditures as part of a new standard, and for the agencies that are their guardians to strengthen interagency communications during severe climatic events.

New York City, as a global city, is linked inextricably with the rest of the world. That global interdependency means that minimizing the health and responsiveness of our transportation and infrastructure networks can result in catastrophic impacts throughout the world. The funding necessary to manage risks and sustain the continued strength of the region should be leveraged through all parties that benefit from this truly vital region.

STRATEGIC APPROACHES

Case studies from around the country and the world reveal three distinct strategic approaches: Defensive, Adaptive, and Passive.

A **defensive** approach implies that the subject is being attacked and must be protected. A boundary is employed like a fortress to resist the elements. These defensive approaches offer varying degrees of effectiveness, resiliency, and environmental impact, and require ongoing operations and maintenance programs.

An **adaptive** approach implies a balance between the need to protect and the acceptance of the overwhelming forces of nature. We adapt by altering the subject to live in symbiosis with the threat. If we embrace adaptive as co-existence, then solutions will become more apparent in adapting to the new normal.

A **passive** approach implies recognition that the forces of climate change have or will have such a great impact that they have won. We accept their overwhelming power completely, and the solution is to live with and embrace the threat.

Sidewalk Gratings, Queens, NY, USA

MTA commissioned raised sidewalk gratings to mitigate local flood-waters at existing subway ventilation structures. Rogers Marvel's adaptive approach serves as a bench, adding a streetscape amenity.
Photo credit: David Sundberg/Esto

HOUSING

Local and national regulations related to housing in flood zones do not address the conditions of a dense urban place like New York City.

The Post-Sandy Housing Working Group's focus was to learn what happened during Sandy and why, and to use these lessons to:

- Encourage the development of new strategies to address the evacuation and temporary rehousing of those displaced by future disasters;
- Make existing housing stock more resilient;
- Ensure that future housing is built in a way that is safe, resilient, and beautiful.

An analysis by NYU's Furman Center for Real Estate and Urban Policy and the NYC Department of City Planning revealed a few clear patterns about what worked and what did not work in residential construction.

Buildings built to modern floodproofing standards fared much better structurally than older buildings. 84% of the buildings in the flood zones were built before 1983, when New York City incorporated floodproofing requirements into the Building Code. 94% of the red-tagged buildings (i.e., those requiring repair before occupants can re-enter) were built before this date. 98% of the destroyed buildings were built before this date. Retrofitting existing housing stock and rebuilding new housing to higher, more stringent standards will require changes to the multilayered regulatory climate currently governing floodproofing issues. Also needed are creative approaches to ensuring that these changes result in safer, more resilient, and beautiful buildings and communities.

Multi-family buildings fared much better than one- and two-family buildings. 90% of the red-tagged buildings were one- and two-family buildings, even though they made up less than 30% of the floor area of all red-tagged buildings. Local and national regulations related to the design and construction of housing in flood zones have yet to take into account issues related to floodproofing in the country's densest urban environments. As building owners have moved on from immediate post-disaster recovery efforts and take the next steps to make their buildings more resilient in a post-Sandy world, the need for more attention to the future floodproofing needs of multifamily buildings has become clear.

The work by CHPC, NYSAFAH, and AIANY after Sandy revealed several issues related to displacement and rebuilding. These include: the need for organizational structures for non-profit housing providers to work together after such disasters; the potential for alternate solutions to the trailers and other temporary housing deployed after Sandy; and the need for protections that allow design professionals to play a constructive role in addressing emergency situations (the Good Samaritan Law). CHPC has recently employed a full-time Fellow who has established Zone A New York, Inc., a non-profit organization working on the ground building capacity and charged with addressing many of the key priority items outlined by the Housing Working Group.

The Post-Sandy Housing Working Group is a partnership of six professional organizations:

American Institute of Architects New York (AIANY)

American Society of Landscape Architects New York Chapter (ASLA-NY)

American Planning Association New York Metro Chapter (APA-NYM)

The New York City Bar Association, Committee on Land-use and Zoning

Structural Engineers Association of New York (SEAoNY)

American Council of Engineering Companies of New York (ACEC New York)

These organizations were joined by four housing policy organizations:

Citizens Housing and Planning Council (CHPC)

New York University (NYU), Furman Center for Real Estate and Urban Policy

New York State Association for Affordable Housing (NYSAFAH)

Regional Plan Association (RPA)

The Working Group also benefited from the participation and support of a number of public agencies including the New York City Department of City Planning (DCP), the New York City Department of Buildings (DOB), the Mayor's Office of Housing Recovery Operations, the Mayor's Office of Emergency Management (OEM), the New York City Housing Authority (NYCHA), and observers from the Federal Emergency Management Agency (FEMA).

KEY CONCEPTS AND FINDINGS

Five months after Sandy, the short term has already come and gone. The Housing Working Group accordingly focused on mid- and long-term recommendations, particularly the most important needs and priorities. We identified six priority areas for the design community's attention.

Post-disaster measures to house people displaced from their homes

NYSAFAH's experience coordinating the use of vacant apartments for temporary housing for people displaced by Sandy showed that there are alternatives to mobile homes or other temporary housing. However, the currently low vacancy rate and issues of supply vs. demand complicated this. Learning from Sandy, they recommended the following ideas to prepare for future disasters:

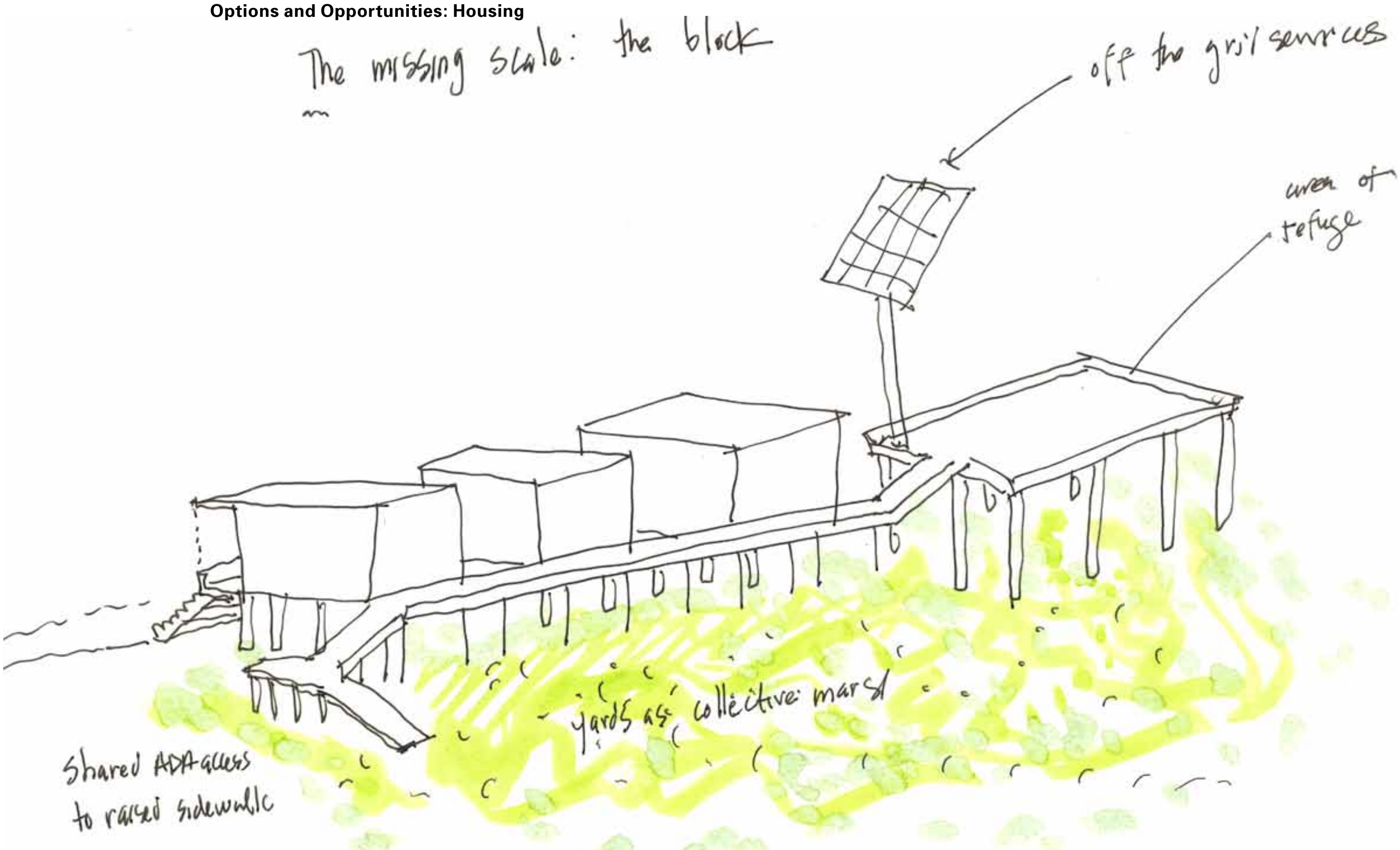
- Develop an outreach strategy to communicate with building owners on available vacant units;
- Develop a centralized intake process for applications and referrals for displaced households;
- Identify waivers necessary for the rehousing process;
- Identify and craft a model third-party lease agreement for households seeking temporary housing;
- Adopt an expedited qualifying process for displaced households applying for permanent affordable housing;
- Advocate for allocation of disaster-related Section 8 vouchers for households below 30% AMI.

As for the regulatory requirements for design and construction of buildings, many of these are affected by overlapping regulations that make sense in normal times, but are not set up to deal with issues of housing after disasters such as Sandy.

Capacity building

The period after Sandy revealed an absence of organizational structures to support the efforts of non-profit housing providers trying to work together. Two key priority areas were identified:

- Establishing programs in post-disaster training for non-profit leadership;
- Establishing a new citywide non-profit organization charged with addressing the needs of residents living in Zones A and V neighborhoods.



Interventions for single-family bungalow housing stock were explored through charrettes.

Changes to the existing patchwork quilt of floodproofing regulations

The NYC Zoning Resolution, NYC Building Code, FEMA design standards, and federal accessibility guidelines all address floodproofing issues to some extent. However, as may be expected, these regulations are not fully coordinated. Through a multidisciplinary Post-Sandy Housing Charrette, the Working Group generated a series of recommendations for addressing gaps both within and between each of the set regulations pertaining to floodproofing.

Retrofitting existing multi-unit housing stock

New York is a growing city with limited land. In most cases, multi-family buildings in the flood zone were heavily damaged, but by and large remain structurally sound. These buildings, particularly those owned by the New York City Housing Authority (NYCHA), represent a significant portion of the City's low-income housing inventory and would be exceedingly costly to replace. With strategic modifications, the useful life of most of this stock can be extended well into the future.

Create a body of literature to guide the future floodproofing needs of multi-family buildings, available in various languages

Local and national regulations related to the design and construction of housing in flood zones have not fully taken into account what is required for floodproofing in dense urban environments.

Study the broader planning implications

The specific focus of the Housing Working Group was the scale of the individual residential building. During the course of our work, however, many questions regarding larger planning and policy decisions were raised:

Given the likelihood of rising sea levels, for instance, should building codes require that buildings in the City's coastal zones be designed for higher flood levels than currently projected?

Should recent downzonings in coastal areas be reexamined to understand whether allowing exceptions for multi-family housing could increase the resiliency of these communities?

How can other equally threatening factors that may emerge from the next storm, including flooding resulting from intense rainfall and wind, be addressed?

It is the hope of the Housing Working Group that its work and recommendations will be considered and used by the responsible agencies. It should be stressed that the conclusions and recommendations in this report do not represent the policies or recommendations of any one of these individual groups or agencies.

POLICY CONSIDERATIONS AND REGULATORY IMPLICATIONS

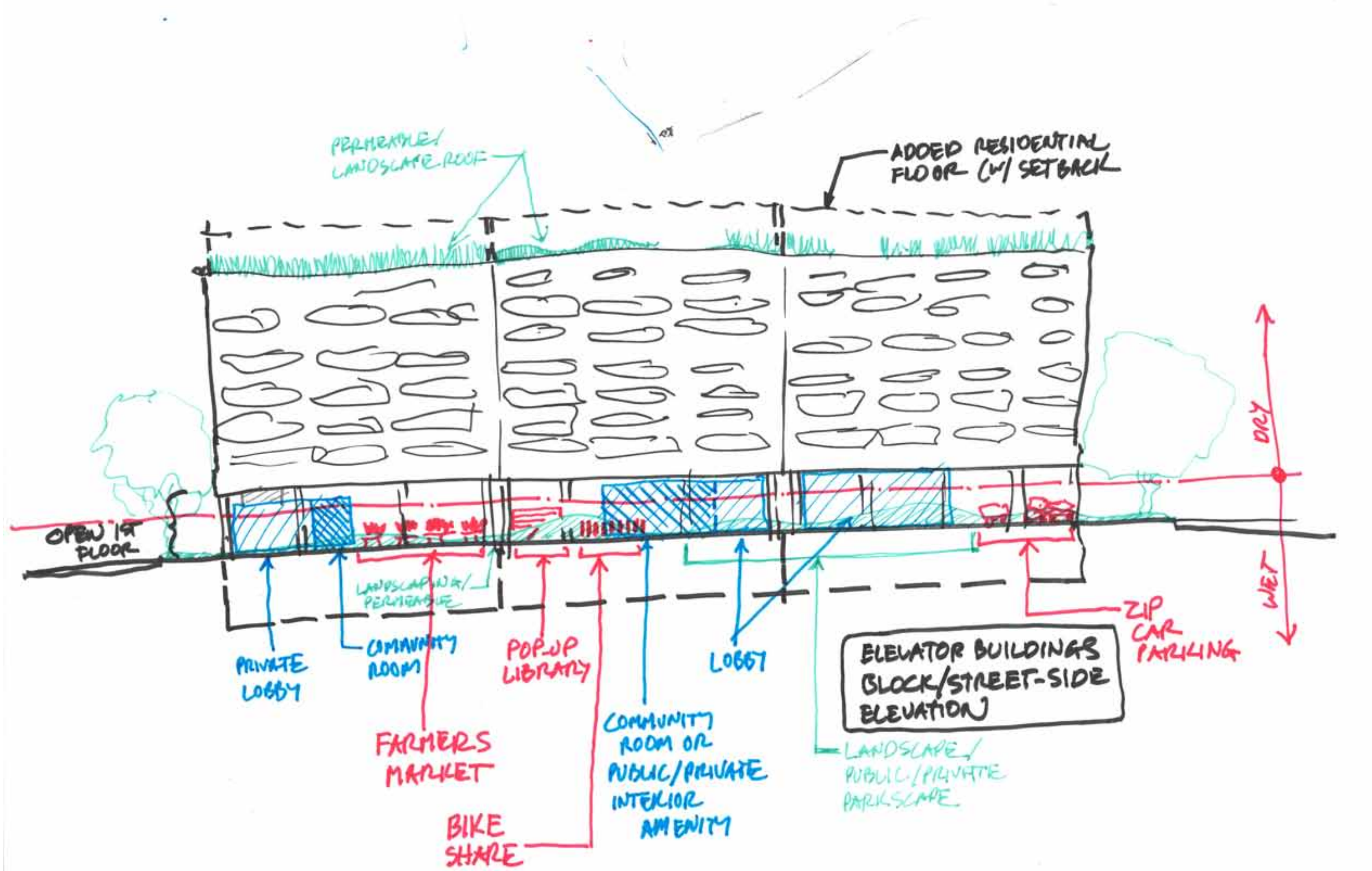
Local and national regulations governing the design and construction of housing in flood zones have not fully taken into account what is required for floodproofing in the densest urban environment in the country. The New York City Zoning Resolution, the New York City Building Code, FEMA design standards, and federal ADA guidelines all address flooding issues to some degree. However, these regulations are not fully coordinated, so a requirement stated in one may be in conflict with another. As a result of the multidisciplinary charrette held in February 2013, the Working Group generated several recommendations, which will need to be verified and modified based on specific neighborhood characters, building types, and site conditions.

NYC Building Code

- Permit handicapped lifts in flood zones;
- Wet floodproofed buildings should have an emergency exit at the first floor above flood elevation;
- As an alternative to floodproofing individual buildings, allow block-wide or neighborhood-wide floodproofing.

NYC Zoning Resolution

- Once a Design Flood Elevation of three feet is reached in a residential building, its first residential floor should be allowed to be raised to ten feet, without maximum building height penalty, so as to create a full-height floor at grade. This would allow a full-height lobby and elevator, providing an accessible common entrance at grade for all residents, and use for storage or parking or community space.
- In an existing building, if the ground floor cannot be used, expansion should be permitted horizontally or vertically, where possible, to make up for lost habitable space.
- Make alignment provisions in contextual districts more flexible. In some cases they currently prevent setting a building far enough from the property line to have a ramp composed of a flood-dampening landscape or permeable paving in front of the building.
- Where a building may have to be set back from the street line to accommodate flood zone-related steps and ramps, rear yard requirements should be reduced.
- Study of more flexible zoning envelopes should be undertaken so that moving more of the mechanical spaces above the flood zone is encouraged.
- Allow electric rooms to be floor-area deductible.
- Permit mechanical equipment in rear yards above flood elevation.
- Rezoning should allow for greater density in return for greater landscape buffer zones in the flood zone.



Once raised, ground floor planes can be activated by retail and community facilities.

- Stairs with natural light should be deductible, as is already encouraged in quality housing zoning for corridors in buildings in contextual districts.

FEMA

- Dry floodproofing of lobbies, currently permitted for mixed-use residential only, should be allowed for all multi-family buildings.
- Evacuation in place—FEMA's objective is to evacuate flood areas before floods occur, and to minimize the risks, especially to first responders. This may not always be possible in a dense urban environment such as New York. It is important in a flood event that those who do not follow government orders, for whatever reason, have a way to get out of their buildings and to safety during a flood.

Accessibility Regulations

- Entrances and ramps that lead to the interior of the primary lobby should be permitted.

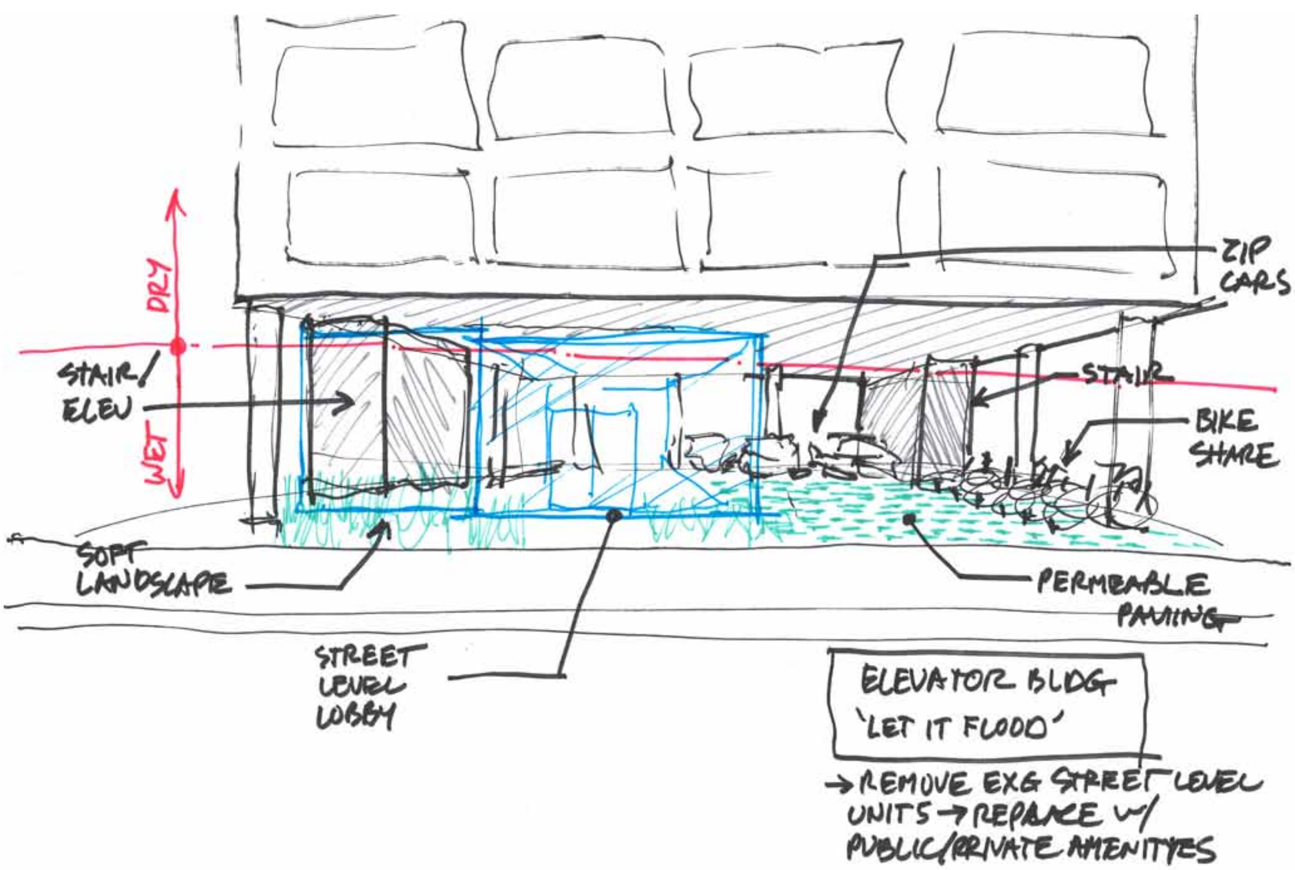
Changes in National Flood Insurance Policies

The National Flood Insurance Program (NFIP) was recently changed so that rates for buildings that meet floodproofing requirements will be significantly lower than rates for buildings that do not. This will mean that many building owners who cannot afford to meet the requirements will not be able to afford flood insurance. This is particularly true of one- and two-family and attached row houses within the flood zones, where modifying the buildings may be as costly as building new. Therefore, many buildings will not get insurance and cannot be upgraded to current floodproofing standards. This creates potential risks and costs for the City and other levels of government when the next catastrophic storm hits.

For existing buildings in the new or expanded flood zones, particularly one- and two-family detached and attached homes, renewing insurance will require much more robust floodproofing measures. These measures are likely to be costly. Efforts should be made to develop more affordable floodproofing options such as active barrier installations. Techniques to collectively fund and maintain such systems, which would decrease costs to individual homeowners, are used successfully in places like Prague in the Czech Republic and should be studied.

Other Issues

- Illegal basement apartments in buildings in the flood zone. While there is no definitive count of how many exist, there are vast numbers of such units that cannot be re-inhabited. This will be a hardship for displaced renters and owners who are dependent on this income.
- Dealing with the regulatory impediments to short-term rental of vacant housing units (see Appendix posted on www.postsandyinitiative.org)
- A Good Samaritan law for design professionals.

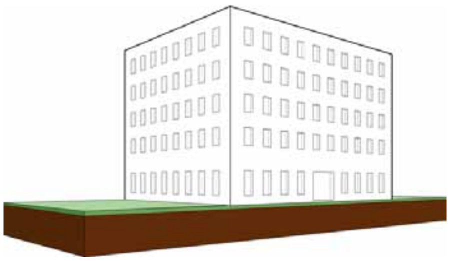


Options are being explored that combine wet-proofing and dry-proofing.

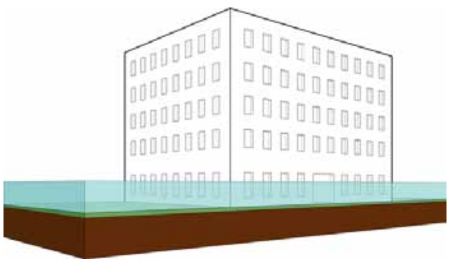
Rising Ground Floors

Credit: Curtis+Ginsberg Architects

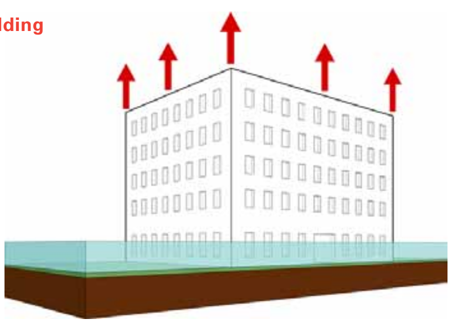
1. The Building



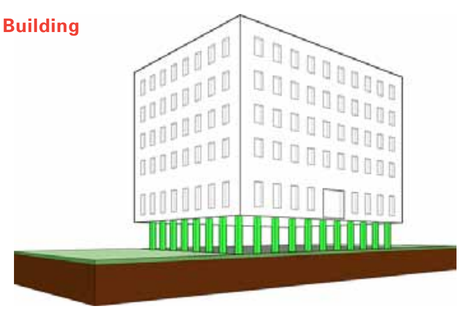
2. The Problem



3. Raise the Building



4. Support the Building

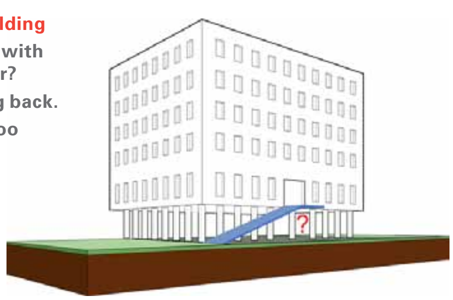


5. Enter the Building

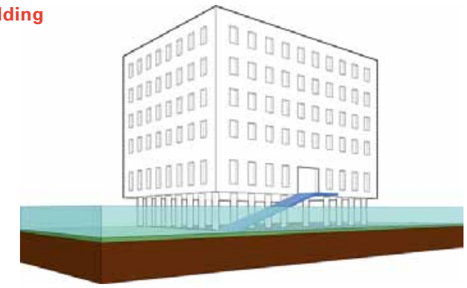
What do we do with the ground floor?

Pushes building back.

Ramp may be too long to fit.



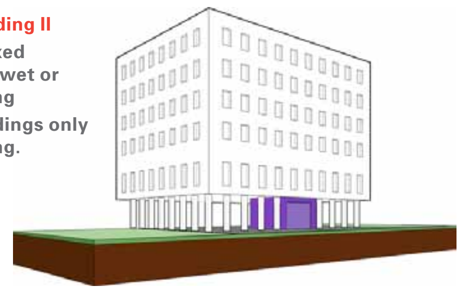
6. Enter the Building



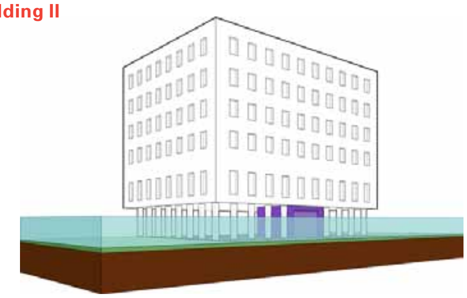
7. Enter the Building II

Permitted in mixed buildings either wet or dry flood proofing

Residential buildings only wet floodproofing.



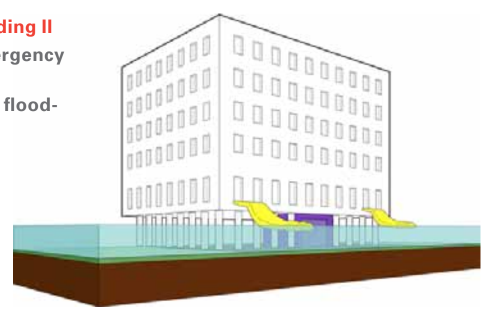
8. Enter the Building II



9. Enter the Building II

Do we need emergency exit for floods?

Required for dry flood-proofing.

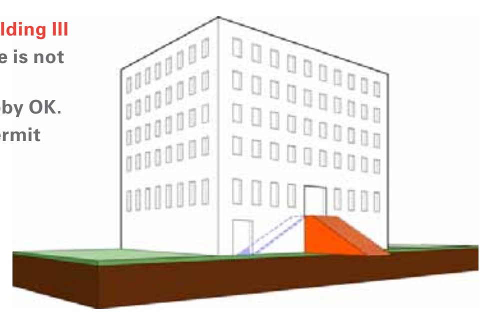


10. Enter the Building III

Primary entrance is not accessible.

If Ramp is in Lobby OK.

NYC does not permit lifts.



The Broader Context

Although the charge of the Working Group was to focus on individual residential buildings, many questions regarding larger planning and policy decisions were raised. Should the building code require that buildings in the City's coastal zones be designed for higher flood levels than currently projected? Or, if possible, should we find ways to return vacant or irrevocably damaged sites to soft-edge conditions (a program initiated by New York State on Staten Island)? Newly published projections on sea-level rise should be closely studied in conjunction with the now updated FEMA flood maps. Regulations could, for instance, permit or encourage floodproofing in the 500-year flood zone.

Over the last twenty years, many low-density areas of the City have been downzoned. For a variety of reasons described elsewhere in this chapter, multifamily buildings are more resilient and easier to retrofit to incorporate floodproof features. In addition, efficiencies of scale allow emergency systems that facilitate faster reoccupations of multifamily buildings in flood areas. In coastal areas, these downzoned areas should be reexamined.

OPPORTUNITIES AND NEXT STEPS

FEMA Multifamily Manual

Existing FEMA literature had tremendous value in getting the Working Group up to speed. However, regarding residential construction, the current FEMA and National Flood Insurance Program (NFIP) literature are largely focused on one- and two-family housing and fail to cover many issues related to multifamily housing. The Housing Working Group has identified several areas where we believe that we can be of help to FEMA in outlining, and perhaps helping to author, a FEMA multifamily design guide.

Design of Areas Below Base Flood Elevations

Careful design of spaces below the base flood elevation (BFE) is important for all types of housing. It would be expected that only water- and mold-resistant materials be used below the BFE no matter the housing type. Multifamily housing structures, however, often differ from one- and two-family buildings. Based on height, longevity, and combustibility concerns, multifamily housing typically incorporates robust materials such as masonry and concrete. During Sandy, it became clear that these structures performed better than the wood framing typical of one- and two-family homes.

When flood elevations rise, minimum required elevations for residential spaces rise, and with these increased elevations come the vertical conveyances needed to get people to those elevations. In one- and two- family housing, where accessibility rules do not apply or are often less stringent, stairs can be used for elevations too high for ramps. Because of a multitude of accessibility regulations, multifamily housing typically must incorporate ramps, elevators, and lifts. Zoning regulations should be adjusted to recognize the amount of space these features occupy. For instance, as BFEs exceed three feet above grade, we recommend that first-floor residential be permitted to be raised to ten feet without maximum building height penalty, so that a full-height lobby can be accessed at grade and dry- or wet-floodproofed as required for common access to an elevator.

On-Site Evacuation and Areas of Refuge

When it comes to occupants' life safety at the time of an impending storm, evacuation is the best policy, regardless of housing type. Yet several external factors combine to make evacuation from multifamily housing more difficult, placing rapid post-storm re-occupation of homes more critical. Multifamily housing often occurs in dense, urban communities that are transit-dependent, like New York City. But as Sandy has shown, mass transportation may be affected by or limited during an emergency, and mass evacuations can lead to congestion and a reduction in mobility.

Two types of specialized multifamily housing present particular challenges to evacuation, and underscore the need to address the issue of those who may not be able to leave their homes. First, low-income rental buildings, where residents may not possess cars, or the resources to move to temporary housing. Secondly, supportive and senior housing where residents may be attached to their permanent homes because of medical or disability concerns and cannot easily transport themselves elsewhere. To address these situations, the Working Group recommends identifying a safe room (most likely, a community room) that can be used for congregating, roll call, and rescue during emergency conditions.

Building Systems

Multifamily housing should be engineered with building systems that protect against building shutdowns during emergencies and ensure a quick return to normal or standby functions post-event. One example is reliance in municipal utility-provided electricity. One- and two-family home operators may opt to partially power their homes with oil-fueled generators. This is not an option for multifamily housing.

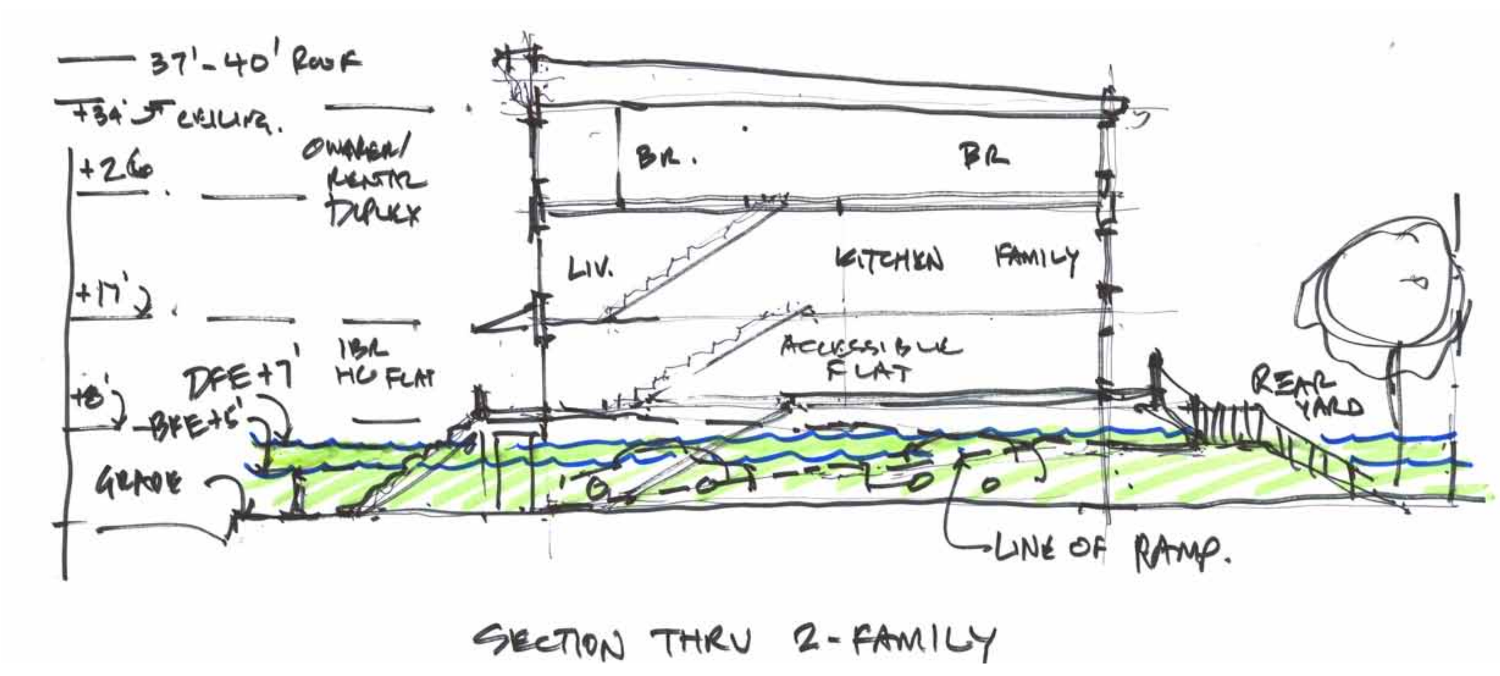
Mid-rise multifamily housing is, however, a good candidate for the use of emergency generators wired to a transfer switch with emergency power circuits. In high-rise construction, in fact, the Building Code requires this. In New York City, more and more buildings are installing city-piped natural gas-fueled generators; this trend may have broader policy implications given the fact that the City gas supply has not been interrupted during major storms.

We believe there are additional opportunities for emergency generators to be used for cogeneration. Cogeneration, in which heat entropy generated in the process of creating electric power is captured for heating and domestic hot water, is most efficient in multifamily housing, particularly in projects of 100 or more units. With cogeneration's transfer switch and emergency circuitry also comes the opportunity to wire renewable power sources, such as photovoltaic panels and wind turbines, into the building for safe use during power outages. This would allow fire pumps, elevators, emergency lighting, refrigerators, and even a convenience outlet in each apartment to remain operational. It would also provide for heat and hot water to remain available via cogeneration. Finally, high-performance building envelopes, which are increasingly required and more likely to be financed for multifamily housing projects, could contribute to the efficiency of backup systems.

Best Practices

The Housing Working Group contacted AIA, ASLA, and APA chapters around the country, asking for best practices in floodproof design. We developed a form to collect information in an organized and comparative format listing project location, housing type, flood elevation data, design strategies, flood-based regulatory actions, lessons learned/recommendations, and project graphics. All of these documents are catalogued and appear in the online appendix. These materials include methods for installing removable dry-flood barriers to existing buildings as used in Coney Island, and the Pontilly Neighborhoods Association's work in New Orleans, where landscape architects used flood mitigation techniques to absorb and re-channel floodwaters. Future research will collect examples from overseas as well as other cities in the United States.

When flood elevations rise, minimum required elevations for residential spaces rise and with these increased elevations come the vertical conveyances needed to get people to those elevations.



Section through two-family house illustrating adaptation for ramped accessibility and the addition of a new top floor.

CRITICAL & COMMERCIAL BUILDINGS

The challenges of adapting the vast inventory of existing critical buildings to withstand the effects of extreme climate events are distinct from the relatively easier task of designing new structures for resiliency.

With substantial parts of the New York City metro area's power grid down and with Superstorm Sandy's floodwaters disabling emergency power, at least 4 major NYC hospitals (Bellevue, Coney Island, Manhattan VA, and NYU Langone) were forced to evacuate all patients and to completely shut down. Coler at the north end of Roosevelt Island transferred some patients to its sister Goldwater at the south. The same level of vulnerability took down four major data centers supporting the telecommunications networks in Lower Manhattan. A police station was abandoned when it flooded and a wall collapsed. In Brooklyn and Queens, 29 nursing homes were severely damaged; despite receiving instructions to shelter their populations in place, they were unprepared to endure the storm and its desolating aftermath. Individual buildings, as well as city- and region-wide systems, were also unready. They still are.

Building owners have a four-fold responsibility when climate-driven disasters strike:

- Protecting occupants and users from death, injury, and suffering;
- Avoiding the evacuation of occupants if possible;
- Protecting buildings and their contents from damage;
- Ensuring that buildings can operate during and after the event.

Current building technologies offer the ability to construct new buildings and retrofit existing ones to better withstand the anticipated impacts of climate change. However, the challenges of adapting the vast inventory of existing buildings to those standards are distinct from the relatively easier task of designing new structures for resiliency. There exists a vast body of technical standards that can be put in place, or adapted for the local situation as it is coming to be understood. But a sobering aspect of the new paradigm is the rapid increase in dangerous conditions, such as rising sea levels and more powerful storms, as well as the ever-deepening science of the likely effects of climate change. Building standards and disaster planning will need to be revisited and updated frequently.

New York City during the lower Manhattan blackout, after Superstorm Sandy.
Photo credit: Vanni Archive

The Critical & Commercial Buildings Working Group consisted of 18 professionals, representing the main disciplines of the design profession including architects, planners, mechanical engineers, structural engineers, and hospital administrators. The group conducted six evening workshops over the course of two months. The Working Group incorporated five sub-groups: Vulnerability Assessment, Structural/Façade, Building Infrastructure, Operational Planning, and Implementation. Each sub-group produced a report on its assigned topic, which was incorporated into the final report.

KEY CONCEPTS AND FINDINGS

Owners of all commercial and institutional buildings—existing, in construction or planned—can begin now on a four-part process to meet their responsibilities in response to climate disasters. Owners should:

- Conduct vulnerability assessments of their buildings in anticipation of the likely effects of extreme climate events;
- Identify the specific technical standards their buildings must meet, and the technologies and products available to do so;
- Update operational plans to keep their buildings working during disasters, and to quickly recover functionality afterwards;
- Create implementation plans to put in place the remedial actions indicated by the three preceding steps.

Assessing Vulnerability

First, the specific impacts buildings might experience during climate-driven disasters should be determined. The potential effects on a given location can be inferred from published flood-zone and wind maps, as well as historical and modeled future weather data. As noted in the Introduction, however, the increasing severity of recent and anticipated climate events reveals much existing data to be inadequate, and highlights an urgent need to update and reach consensus on such standards.

Second, the critical roles of specific buildings should be established. A building, or a portion of one, should be considered a critical facility if it is required to withstand the effects of a disaster and remain in operation, whether to safeguard the activity conducted within it, or the lives and well-being of its occupants, other disaster victims, or emergency-services personnel. Critical facilities include, for example, hospitals, police and fire stations, data centers, evacuation shelters, and

Systems Matrix

This matrix illustrates the kinds of changes that can be integrated into code, using healthcare facilities as a category of building.

Utility Services	Risk Addressed	Proposed Measure	Critical Facility	
			New	Existing
Incoming Electric Service	Flood	Locate or relocate incoming service above FEMA flood evaluation	Req.	BP
		Existing Utility Rooms to be made watertight with bulkhead or submarine doors and extensive waterproofing. Waterproof cable entries below flood plain.	N/A	Req.
		Existing Utility Rooms to be made watertight with bulkhead or submarine doors and extensive waterproofing. Waterproof cable entries below flood plain.	Req.	Req.
	Extreme Heat	Electric Utility Rooms to be provided with ventilation and/or air conditioning to maintain room temperature to stay below equipment temperature ratings. Use ASHRAE Weather Data.codemandated	Req.	BP
	Wind	Evaluate overhead distribution (where permissible) versus direct buried based on potential wind and flood events. Design overhead distribution to FEMA Wind Zone Maps.	Req.	BP
Incoming IT Services (Telephone & Data)	Flood	Locate or relocate incoming services above FEMA flood elevation using approved cables	Req.	BP
		Existing Utility Rooms to be made watertight with bulkhead or submarine doors and extensive waterproofing. Waterproof cable entries below flood plain.	N/A	Req.
	Provider Interruption	If existing Utility Rooms cannon be relocated, consider redundant wireless communication and data system.	BP	BP
Gas Service	Flood	Locate or relocate incoming gas service above FEMA flood evaluation	Req.	BP
		Existing Gas Service Rooms to be made watertight with bulkhead or submarine doors and extensive waterproofing. Waterproof pipe entry.	N/A	Req.
Domestic Water	Flood	Locate or relocate incoming water service above FEMA flood evaluation	Req.	BP
	Provider Interruption	Consider water storage tanks on site.	BP	BP
Steam Service	Flood	Locate or relocate incoming steam service above FEMA flood evaluation	Req.	BP
		Existing Steam Service Utility Rooms to be made watertight with bulkhead or submarine doors and extensive waterproofing.	N/A	Req.
Mechanical Equipment (boilers, chillers, pumps, fans, air conditioning units, storage tanks, etc.) essential for the facility to operate and fulfull its mission	Flood	Locate or relocate above FEMA flood elevations.	Req.	BP
		Existing Mechanical Rooms to be made watertight where practical with bulkhead doors and extensive waterproofing. External flood barriers should be considered.	N/A* Req.	BP
	Wind	All exterior equipment to be property strapped down to meet FEMA Wind Maps.	Req.	Req.
		Provide barriers to protect against damage from wind-blown projectiles.	N/A	Req.
	Extreme Heat	Systems to be designed to maintain minimum code requirements for occupant and building functionality. Load shedding to be employed. Use code-mandated ASHRAE Weather Data.	Req.	BP
Fire Pump	Flood	Locate fire pumps above FEMA flood plain elevation. If not feasible due to code or inadequate street pressure, provide submersible watertight room. Review with FDNY.	Req.	BP
Emergency and Standby Power	Flood	Locate or relocate generators above FEMA flood evaluation	Req.	Req.
	Wind	Protect exterior equipment from wind-blown damage and projectiles.	Req.	Req.
	Extreme Heat	Evaluate capacity to serve life safety loads during extreme heat.	BP	BP
	Extended Widespread Outage	Evaluate and add additional loads above Code mandated to fulfull the building's functional requirements during prolonged outages. Provide additional standby generation.	BP	BP
Emergency and Standby Generator Fuel Source	Flood	Fuel oil tank's pumps and controls to be located in a submersible watertight room with bulkhead or submarine doors. Fuel pump to be submersible to pump up to transfer tank and pumps on level located above the FEMA flood plain elevations.	Req.	Req.
	Prolonged Outage of Power	Provide additional fuel capacity above code-mandated minmum for emergency and stanby loads needed for building functionality, or provide dual fueld source (oil and gas) fired generators to extend existing oil storage. Technology not readily available.	BP	BP
Sump Pumps & Ejectors	Flood	Locate in watertight submersible room with bulkhead or submarine doors and put on emergency power.	Req.	BP
Enhanced Standby Power Generation and/or Co-Generation	Prolonged Outage of Power	Based on a regional plan for healthcare and critical facilities, designate those facilities that need to operate in a self-sufficient mode with no reliance on the normal electric grid.	BP	BP
Fire Alarm Command Station	Flood	Provide redundant Fire Command Station above the FEMA flood plain.	Req.	BP
Fire Alarm Devices	Flood	Locate fire alarm system devices above the FEMA flood plain.	Req.	BP
Elevators	Flood	Locate power and controls above FEMA flood plain. Cars to recall above FEMA flood plain.	Req.	BP

BP = Best Practices   Req. = Required   *N/A for Healthcare Facility buildings or portions of buildings that provide essential support to them. Other vulnerable buildings should be required to withstand a climate disaster without failure of structural components, including façade elements, though they need not remain functioning and are likely to be evacuated during the disaster; these should be considered protected facilities rather than critical.

Third, survey building systems. Essential building systems comprise the design features, technologies, and equipment necessary to support continued operations. For critical facilities, for example, these include emergency power systems, water and ventilation systems, vertical transportation systems, and food storage and preparation facilities. For critical facilities, the survey should assess the ability of essential building systems to continue functioning during a disaster. For protected facilities, the survey should evaluate the ability of the building structure and façade to survive intact.

Meeting Updated Technical Standards

Two building components—structure/facades and internal systems—are key to resisting climate-driven threats whether from flooding, wind, snow, or extreme temperatures. Simply put, the goal is to assure that a building's physical structure remains intact and relatively undamaged by the forces of a disaster, especially the structural system and the building envelope, including fenestration.

Façade and structure: Current New York City and State codes specifying design requirements for snow resistance and flood resistance do not require changes. For wind load design, however, requirements should be upgraded to ASCE/SEI 7-10; this code provides ultimate wind-speed values and introduces maps that incorporate the risk categories. For example, for Occupancy Category III and IV buildings, which include those posing a substantial hazard to human life in the event of failure, such as schools, hospitals, and critical facilities as defined above, this code requirement corresponds to wind speeds with only a 3% probability of being exceeded in 50 years.

Hospital protected from flood water by a flood wall in mid-state New York.
Photo credit: FEMA

Systems: We studied a range of building system and utility issues, including the vulnerability points of electricity, IT, gas, water, and steam services as they enter a building; the location and protection of mechanical equipment; emergency equipment to provide for and back up supplies of water and power; fire alarm and firefighting systems; and elevators. We reviewed these in the context of three facility types—commercial and institutional; healthcare; and other mission-critical buildings—and for both new and existing structures. Examples of options for making these systems more resilient are shown here.

In general, a new critical building must meet higher performance standards than a commercial building, since its services are to be available before, during, and after a climate-driven event; new critical buildings should comply fully with new standards. Existing buildings demand more flexibility in determining the best corrective action. A realistic approach for an existing building is generally a best-practice standard, with some latitude in offering equivalent solutions. In some cases for existing buildings, even those deemed critical in function, evacuation may be the only feasible action to permit compliance.

Developing Operational Plans

While many New York City-area agencies and institutions have disaster plans in place, in general these need to be updated to reflect the increased risks our region is now understood to face. Moreover, disaster planning should always consider buildings and their particular vulnerabilities and requirements.

Before An Event

Not all disasters can be foreseen, but for some—in particular, weather events—there may be substantial warning and the ability to anticipate specific effects like flooding. Building owners' advance operational plans should address a range of issues, including the evacuation and relocation of occupants, building shutdowns, and the possible extended relocation of occupants afterwards. For critical facilities, emergency equipment and supplies should be accommodated, temporary relocations should be envisioned, and advance arrangements should be made with the NYC Office of Emergency Management for disaster-zone access for essential personnel.

Flood wall near New Orleans, LA, USA
Photo credit: FEMA

During An Event
Planning should consider the provision of security for evacuated buildings; in Class E high-rise buildings, the risk of a fire-detection system failure requires particular attention. Hospitals by definition are both especially vulnerable and uniquely essential during disasters, and disaster planning for them creates distinct obligations. For example, hospitals should plan for surge capacity for emergency and inpatient departments, the capability to house and feed stranded staff, and provisions for "passive operational survivability," such as natural ventilation during power failures and electric generation capabilities independent of the City's grid.

After An Event
Plans for continuing or resuming operations in the wake of a disaster should consider that normal transportation and supply routes will most likely be disrupted. Therefore, back-up supplies and the on-site storage capacity for them are necessary. Emergency-supply agreements made in advance with vendors may be advisable. Portable emergency trailers housing heating or electrical generators, water or oxygen supply, and sewage or waste containment may need to be accommodated as well.

Clean-up and decontamination may require, for example, pre-negotiated arrangements with specialized contractors or vendors for mold removal, fuel or sewage overflows, debris removal, disposal of floodwater and the like, and environmental waivers for removing contaminated water and debris to disposal points. Restoration of normal operations may require post-storm inspections of floor and façade walls; testing and remediation of mechanical, electrical, plumbing, and communications systems; drying out of flooded areas; prioritizing of repairs and/or demolition; and even a strategy for abandonment or managed retreat, if a facility is found to be damaged beyond repair.

Implementing a Plan

Determining A Building's Risks, Strengths, and Weaknesses
Conducting a vulnerability assessment of a building and evaluating it against updated technical standards will indicate what must be done to make it disaster-ready. This process will also illuminate relative priorities among the risks a building faces and the available solutions, and create a sense of sequence for how to proceed.

Calculating Available Resources
Implementation of a plan requires evaluating both capital and human resources. Capital resources could be funds from internal sources, such as operating budgets and borrowing; or from external sources, such as grants, tax incentives, and philanthropy. Human resources include the personnel who will be expected to follow the operational procedures developed for withstanding and recovering from an extreme event. They also include a building's stakeholders who may be potential allies or opponents in preparedness planning.

Reconciling Needs and Resources
Arriving at a realistic plan will mean reconciling needs with resources. Typically, needs outstrip resources, so that strategic trade-offs and deferments are necessary. These can be arrived at by:

- Developing a detailed plan;
- Conducting cost-benefit analyses of its elements;
- Determining a timeframe and budget;
- Assembling a team responsible for implementation.

Keeping On Track

- A progress-monitoring system, and honest assessments of progress, should be part of establishing a building's preparedness.
- Deviations from a plan must be corrected.
- Standards may change, our understanding of the risks may change, and available funding may change, so periodic re-examination and re-calibration will be necessary. Intervals of four and eight years are realistic to stay up to date.

POLICY CONSIDERATIONS AND REGULATORY IMPLICATIONS

Because vulnerability assessments are the necessary first step in making buildings resilient, and because no obstacles exist to undertaking them immediately, the City Council should enact a law requiring building owners to conduct vulnerability assessments of their properties.

A great number of specific changes to current zoning and building codes will be called for if the City and its buildings are to withstand repeated climate-driven and other disasters. In general, these include:

- An updated building code mandating a more robust disaster resistance capability for all new buildings.
- Hardening and retrofitting of existing buildings deemed vulnerable. This will be expensive, and in some cases impossible. The building code should provide a mechanism for permitting non-compliance; in such cases, an alternative strategy of evacuation should be required. Critical-function buildings in vulnerable locations must have a plan for Transfer of Service to a protected alternate facility, and these alternate facilities should be required to have the additional capacity and equipment to accommodate such a transfer.
- Zoning for land-uses should appropriately align with new and updated knowledge of flood zones and other risks, which may mean downzoning in some areas; and revisions to zoning and density limits for other areas that may in the future be required to absorb growth previously destined for flood zones and vulnerable waterfronts.

OPPORTUNITIES AND NEXT STEPS

Long Term

Innovation in the development of disaster-resistant building design strategies, technologies, and materials is essential. Where applicable, such innovations that already exist or are being implemented in other countries where resiliency planning is more advanced should be adopted or adapted. New York City's particular vulnerabilities call for:

- Policies that move toward elimination of non-compliant existing buildings that cannot be hardened, and their replacement—with an exception path for buildings deemed of significant historic or cultural value.
- Regional protective systems that enhance, or eliminate the need for, individual building responses. These should involve making utility, data, and security networks redundant and resilient, and finding regional strategies for maintaining essential services and supplies, such as public transport, food, and fuel, during disasters. In particular, regional networks for maintaining essential healthcare services must be established.

Medium Term

Numerous scientific, governmental, and professional organizations and collaboratives are exploring the potential impacts of climate change on natural and built environments; these include the Federal Emergency Management Agency, the National Academy of Sciences, the National Oceanic and Atmospheric Administration, the U.S. Conference of Mayors, C40 Cities Climate Leadership Group, and many others. The specific challenges that extreme climate events pose for buildings, cities, and in particular for densely populated areas, illuminated by our experience of Sandy and explored by this and other initiatives in the storm's aftermath, must be brought to the attention of these research bodies. The goals should include:

- Better simulation models of water and wind behavior on built structures;
- New national reference code for building construction;
- Zoning and planning approaches that bring patterns of development into line with present and emerging knowledge of disaster-prone areas.

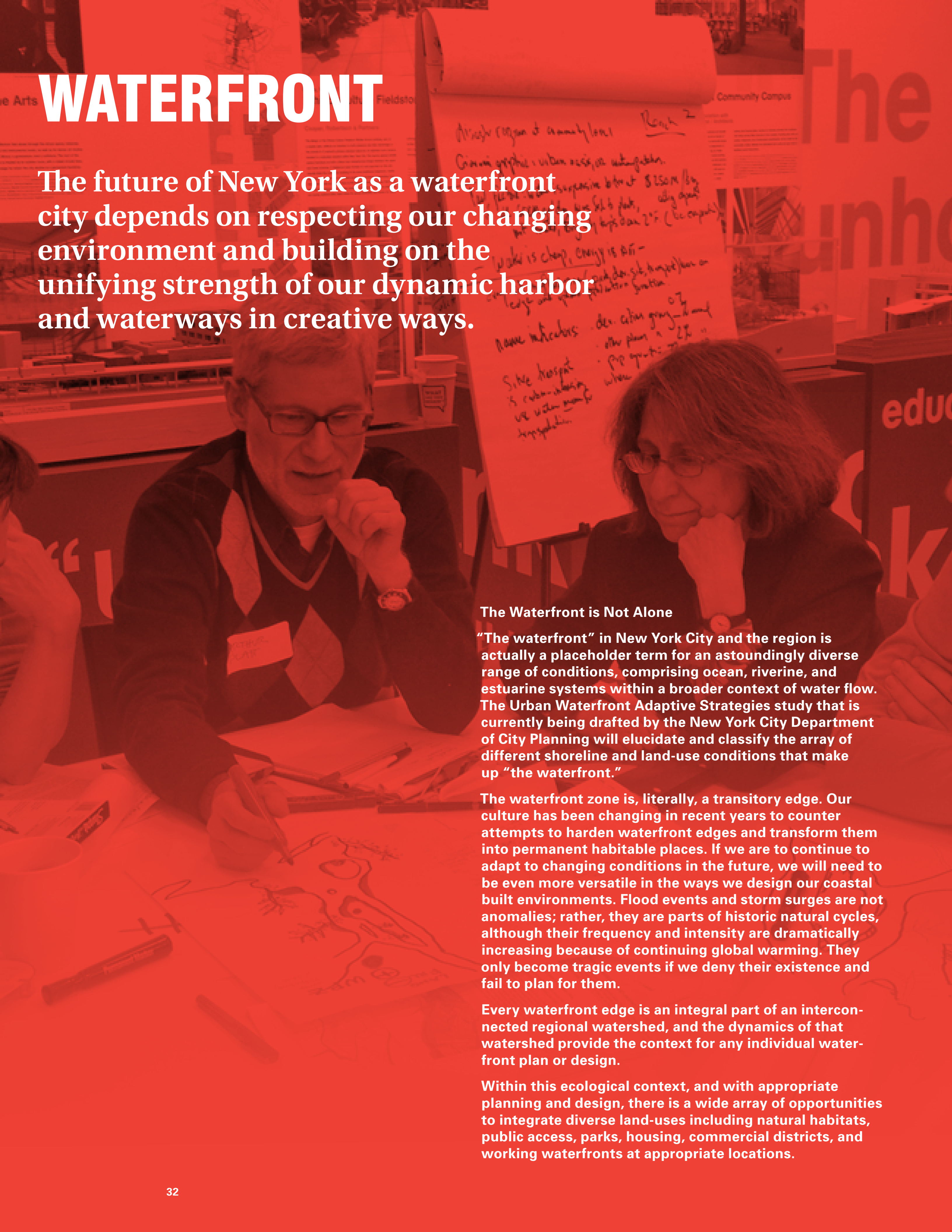
Short Term

Advisory bodies have been established at the City and state levels, and among professional associations, to develop recommendations for changes to codes and zoning, façade and structural systems, building systems, and operational requirements. Similar groups focused on disaster-response planning will also have recommendations relevant to the design and operation of buildings. Their valuable findings will need to be aligned and reconciled. In the meantime, building owners should begin assessment programs to determine their risks; undertake voluntary upgrades to their properties; and update operational plans for disaster events.

A collaborative, integrated design approach to assessing and upgrading critical and commercial buildings will enable these important facilities to remain in operation when we most need them.

Watertight submarine door for creation of a protected infrastructure space. Photo credit: FEMA

Watertight submarine door for protection of critical equipment within an unprotected passageway. Photo credit: FEMA



WATERFRONT

The future of New York as a waterfront city depends on respecting our changing environment and building on the unifying strength of our dynamic harbor and waterways in creative ways.

The Waterfront is Not Alone

"The waterfront" in New York City and the region is actually a placeholder term for an astoundingly diverse range of conditions, comprising ocean, riverine, and estuarine systems within a broader context of water flow. The Urban Waterfront Adaptive Strategies study that is currently being drafted by the New York City Department of City Planning will elucidate and classify the array of different shoreline and land-use conditions that make up "the waterfront."

The waterfront zone is, literally, a transitory edge. Our culture has been changing in recent years to counter attempts to harden waterfront edges and transform them into permanent habitable places. If we are to continue to adapt to changing conditions in the future, we will need to be even more versatile in the ways we design our coastal built environments. Flood events and storm surges are not anomalies; rather, they are parts of historic natural cycles, although their frequency and intensity are dramatically increasing because of continuing global warming. They only become tragic events if we deny their existence and fail to plan for them.

Every waterfront edge is an integral part of an interconnected regional watershed, and the dynamics of that watershed provide the context for any individual waterfront plan or design.

Within this ecological context, and with appropriate planning and design, there is a wide array of opportunities to integrate diverse land-uses including natural habitats, public access, parks, housing, commercial districts, and working waterfronts at appropriate locations.

The challenges of climate change lead us to reexamine traditional approaches to coastal management, and to seek new, creative solutions to supplement the range of available adaptation strategies. ...It will be important to establish partnerships among practitioners of many disciplines—including planning, engineering, design, marine biology, and ecology—to develop and test new coastal interventions that have the potential to promote a safe city and sound ecology within a changing environment. Studies that provide information on the benefits and drawbacks of emerging strategies will be helpful as part of this effort. Pilot projects that gather empirical data on the effectiveness and ecological value of alternative strategies will also be valuable.

Vision 2020: New York City Comprehensive Waterfront Plan, The City of New York, Department of City Planning, March 2011, page 111.

Superstorm Sandy emphasized the many planning and design issues on the waterfront affecting New York City and the region. The Waterfront Working Group is a task force of architects, planners, landscape architects, engineers, ecologists, environmental consultants, and maritime experts. Professionals on the team hail from a number of organizations allied with the American Institute of Architects New York (AIANY), including the American Planning Association New York Metro Chapter (APA-NYM), and the American Society of Landscape Architects NY Chapter (ASLA-NY), as well as the Metropolitan Waterfront Alliance (MWA), and engineering associations including the Structural Engineering Association of New York (SEAoNY) and the American Consulting Engineers Council (ACEC New York).

This collaborative effort builds on the work of other interdisciplinary working groups that have addressed waterfront issues in previous years. This new model of collaboration among professional designers, scientific researchers, and policy makers may begin to address the enormous challenges that climate change holds for the future of the region.

KEY CONCEPTS AND FINDINGS

The principles described here emphasize the overall context and commitments needed to support successful, innovative adaptations to changing waterfront conditions.

Innovation, Experimentation, Research

More scientific research is needed to understand the interactions between urban waterfronts and human ecologies, especially in terms of communication with regulators and designers about the impacts of design decisions.

Our challenges over the next decades and centuries will be genuinely unprecedented, considering the number of people living in waterfront environments and the uniqueness of the variables facing the New York metropolitan region. We must create new opportunities for a dynamic and innovative approach to waterfront projects—one that allows for experimentation through multiple scales and flexible policies, and provides for short- and long-term innovations with novel strategies for resiliency.

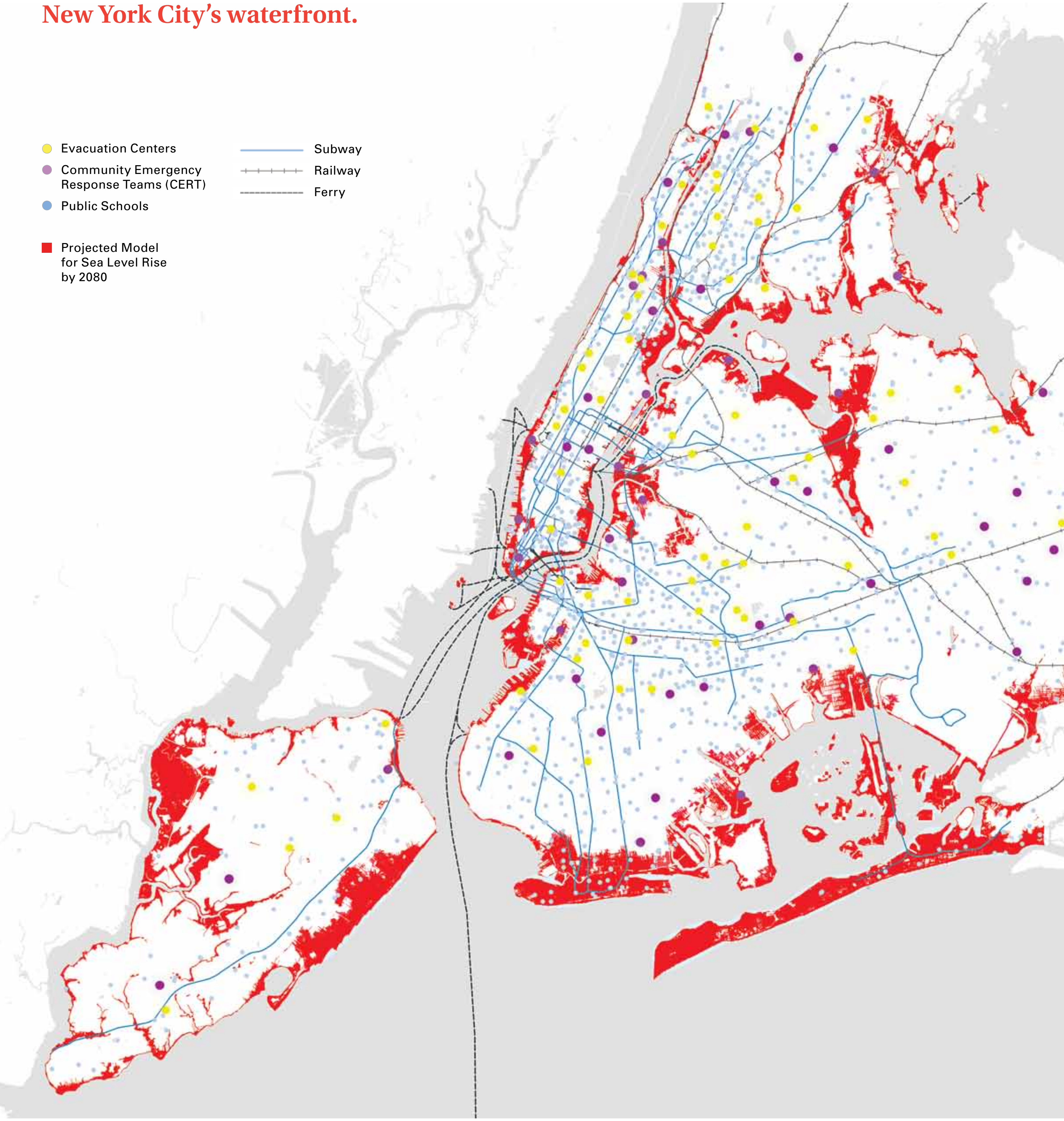
Interdisciplinary Collaborations

Organizational structures and funding mechanisms must be created to allow for more robust collaboration among pure and applied disciplines linking the design, scientific research, and regulatory communities.

Teams of architects, landscape architects, engineers, planners, and permitting specialists, working closely with scientists (ecologists, biologists, and climate scientists), environmental regulatory staff, and local communities, have the capacity to identify innovative options and opportunities and to create smart, novel, and feasible solutions.

Current project and research funding structures enforce occupational and disciplinary silos that often preclude innovation. Waterfront regulatory restrictions need to evolve with more interdisciplinary research, more opportunities for experimental projects in selected locations, and more feedback from these projects.

By 2080, sea level rise is projected to flood many areas along New York City's waterfront.



Map credit: Composite map by Richard Gonzalez, Architect with data from New York City Mayor's Office, Office of Emergency Management (OEM), Department of City Planning (DCP), NYC Police Department (NYPD),Federal Emergency Management Agency (FEMA), and Intergovernmental Panel on Climate Change (IPCC), LandScanTM GIST.

Complexity and Site-Specificity
With 520 miles of shoreline in the City alone, and an enormous set of variables in geomorphology, hydrology, land-uses, and habitat types, there is an equally broad range of types and combinations of solutions.

Even within a specific area there is more than one solution. Rather, it is important to increase alternatives. There are short-, medium-, and long-term possibilities for a range of flexible scenarios that allow for success and provide safeguards in the event of failure. Planning and design of waterfront areas should embrace their unique, authentic, site-specific attributes and capture the essence and identity of each one.

We need to set priorities for use of current and future funding for the alternatives being discussed at the City's Special Initiative for Rebuilding and Resiliency (SIRR), the Department of City Planning's year-long Urban Waterfront Adaptive Strategies Study, and NYS 2100 Commission. These include nourishing beaches and expanding dunes; reinserting wetlands; raising bulkheads; adding tide gates and revetments; building breakwaters; installing passive and deployable floodwalls; constructing seawalls and surge barriers; and conceiving of dual-use or multi-purpose levees.

Ecological Sensitivity
Rich waterfront habitats are among the most productive ecosystems on the planet, and shoreline designs in the coming years need to be based on a healthy respect for the water and natural systems.

We must learn to "go with the flow," both a more controlled flow from the watershed to the sea, balanced with a mitigated flow from the sea onto land. The notion that the human-built realm should be considered first and foremost, often to the exclusion of other life processes, needs to be rethought. With current extreme declines in fish, bird, and pollinator populations (to name a few), better waterfront management practices can protect the ecosystems of which we are a part, and provide a better scientific understanding of how they function.

Redundancy and Modularity
Flood protection and stormwater management should duplicate critical functions and be self-sufficient in densely-populated areas.

Such approaches are similar to those employed to ensure the stability of essential infrastructure systems and services (power, transportation, and waste).

Inclusivity
Involving all members of waterfront communities in ongoing planning and implementation requires making community outreach and communication priorities.

Engaging and supporting well-developed social networks and information dissemination will promote trust and local leadership among and within communities, and foster both inter-agency communication and collaboration among government, professionals, and local citizens.

The Waterfront Lab is a place to test ideas, produce data, and monitor results. In a rapidly changing environment, well-planned "experiments" can help create a safer, more resilient city.

Photo credit: Bonnie A. Harken, AIA, APA, Nautilus International Development Consulting, Inc., 2010

POLICY CONSIDERATIONS AND REGULATORY IMPLICATIONS

There are strategies that can enhance and enable the ability of planning and design professionals to act on opportunities:

- Break out of occupational silos. Foster meaningful, longer-term collaborations among designers, ecologists, biologists, and climate scientists.
- Recognize naturally occurring districts - bioregions, watersheds, and smaller ecosystems. Although jurisdictional rather than natural divisions structure our political geography, there are other precedents such as watershed management entities worthy of emulation.
- Seek out environmental regulators willing to be involved with experimental approaches and problem solving. Current regulations and regulators are sometimes change-averse, even when projects might have the potential to improve environmental conditions.
- Advocate for appropriate funding levels to adequately maintain and operate public urban environments.
- Put in place mechanisms and funding for long-term monitoring and evaluation of waterfront design solutions.
- Educate stakeholders on the value of "green" solutions and stewardship of urban open spaces. These elements are sometimes misguidedly value-engineered out of projects because of funding constraints and a lack of understanding and commitment.
- Widely implement green infrastructure approaches to stormwater management throughout watersheds and "sewer sheds"—water harvesting, capturing, treating, and management at all scales, from building and site to metropolitan and regional.
- Give consideration to other issues such as inland flooding and wind damage in addition to our major focus on coastal flooding from sea-level rise and storm surges.

Victorian Seawall in 2007. Design and Photo credit: AECOM

Design Conecpt in 2008. Design and Photo credit: AECOM

Design and Photo credit: AECOM

New seawall defenses protected more than 600 businesses and created new places for people to enjoy the popular seaside resort of Blackpool, UK, along a 3.2 km reach.

OPPORTUNITIES AND NEXT STEPS

The Waterfront Lab: Design and Planning for Resiliency

The tremendous amount of uncertainty about the future—from the effects of climate change and rising sea levels to the frequency with which we will be experiencing major environmental events—provides an opportunity to explore and test the effectiveness of innovative ideas to expand the range of current waterfront strategies.

Numerous governmental, academic, professional, and advocacy groups are already collecting and analyzing data and making recommendations. Rather than duplicate those efforts, the Waterfront Lab focuses on complementary explorations of new and innovative waterfront planning and design strategies.

The starting point was to ask, "What went right?" and draw lessons from what weathered Superstorm Sandy successfully. That investigation raised the additional questions of "What could be explored further?" and "What needs to open up for that to happen?" The answer was to create a Waterfront Lab for testing ideas, producing data, and monitoring results, especially after substantial environmental events. The Lab is a place to investigate strategies with the potential to mitigate storm surge, prevent erosion along the urban edge, and soften the impact of rising tides. Such experiments would focus on testing ideas for both predictable and unpredictable events within a framework that does not threaten the life and property of surrounding areas. Experiments also take into account the different typologies found in the New York City region—the ocean, estuaries, and rivers—and the widely different scales of projects, from individual sites and neighborhoods, to larger areas and the region as a whole.

The work of the Waterfront Lab could be an important contribution to how the City assesses new proposals that have never been put in place here—efforts that could advance flexible and sustainable waterfront planning and design for the future—based on best practices around the country and world.

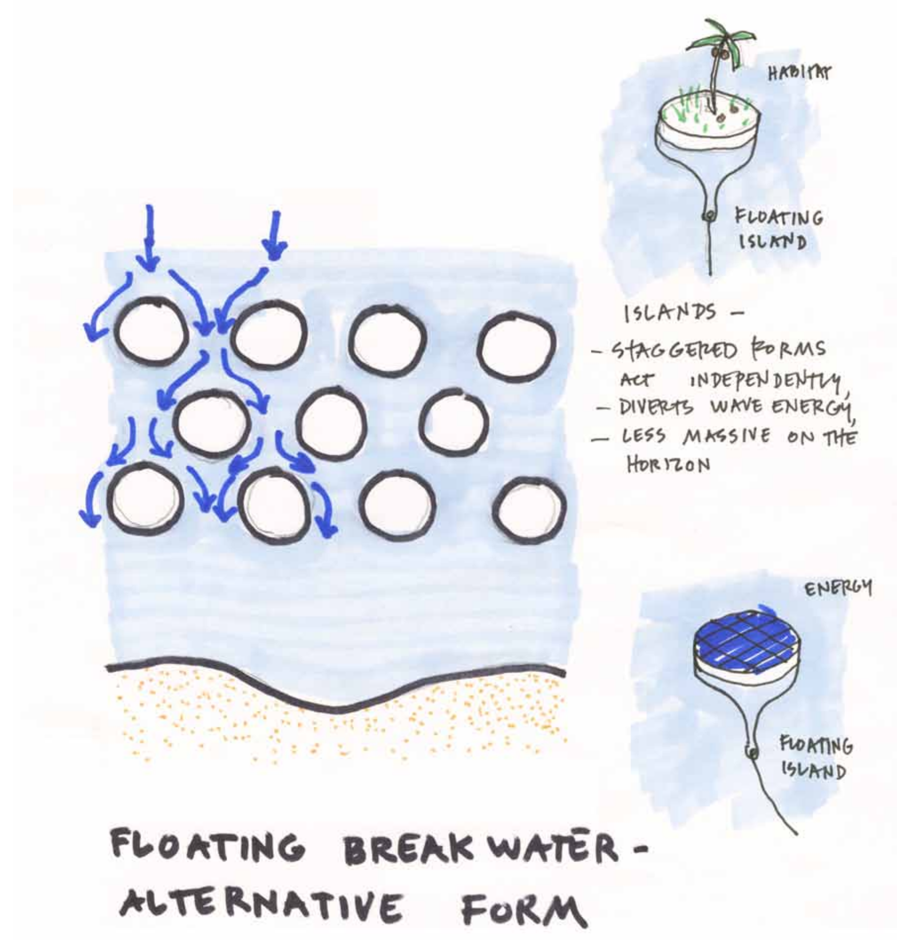
As the number of major events on the waterfront is projected to increase by designating areas for experiments along the water's edge, promising strategies can be implemented and their performance examined. Those that prove successful may then be expanded upon and put into practice in other locations throughout the region.

Looking holistically at potential strategies, there are both short- and long-term experiments that could be employed. Instead of merely replacing outdated structures or landscapes in kind, more resilient and climate-neutral alternatives could be put in place and evaluated. Waterfront planning and design must continually adapt to maximize response to rapidly changing ecosystems.

CONCLUSIONS

The challenges facing New York City and the region as we adapt to new realities brought on by climate change over the coming decades are enormous. Cross-disciplinary collaboration within a broad structure that allows for innovative strategies to be applied and tested can address public safety issues and protection of the built environment, and can also integrate innovative solutions for managing stormwater, enhancing biodiversity, incorporating renewable energy, and creating myriad combinations of new strategic approaches.

By connecting local communities with teams of professionals—from architects, landscape architects, planners and engineers, to environmental consulatants, maritime experts, ecologists,



Drawing by Caleb Crawford, Coggan + Crawford Architecture + Design

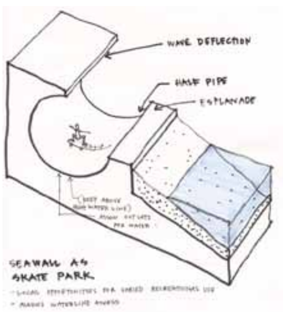
Experiments also take into account the different typologies found in the New York City region—the ocean, estuaries, and rivers—and the widely different scales of projects, from individual sites to neighborhoods and larger areas of the region as a whole.

Drawings by
Ocean/Site: Caleb Crawford, Coggan + Crawford Architecture + Design;
Ocean/Neighborhood: WWG;
Ocean/Reach: AECOM;
Estuary/Site: Caleb Crawford, Coggan + Crawford Architecture + Design;
Estuary/Neighborhood & Reach/Region: WWG;
River/Site: Carl Carlson, ASLA;
River/Neighborhood & Reach/Region: WWG

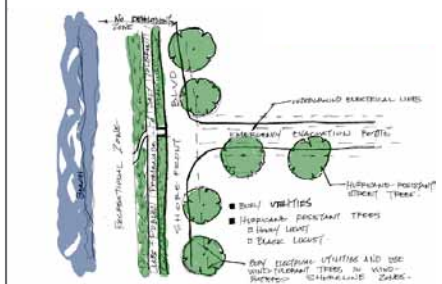
SCALES: SITE | NEIGHBORHOOD | REACH/REGION

SHORELINE TYPES

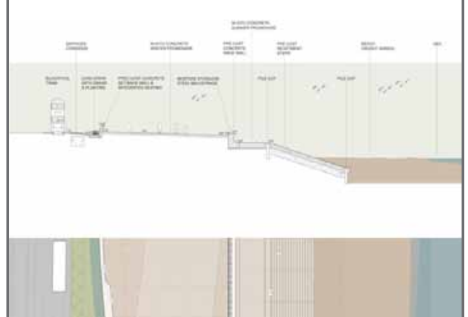
OCEAN



Bulkhead Redevelopment

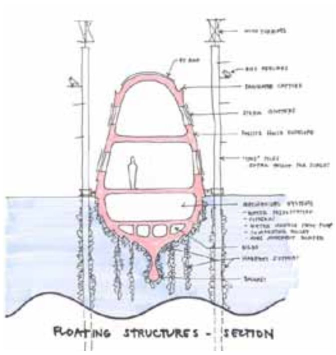


Resilient Evacuation Route

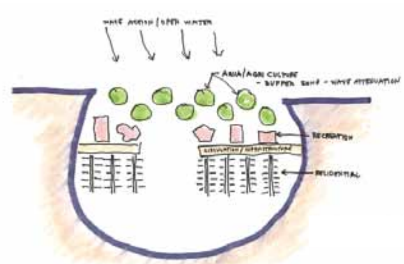


Resilient Beach Community

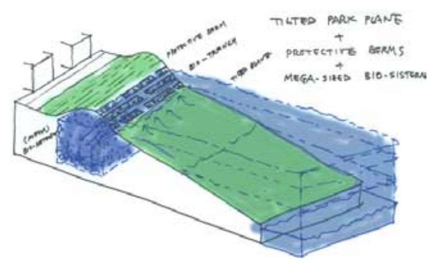
ESTUARY



Floating Habitat



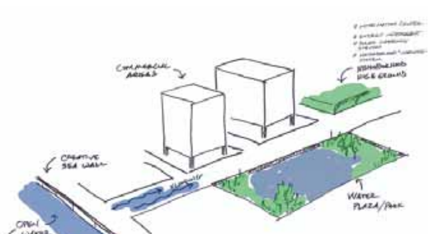
Floating Community



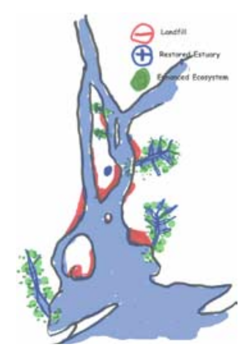
Waterfront Park as Stormwater Device

RIVER

Floodable Single Family Housing



Floodable Community with a Contingency Plan

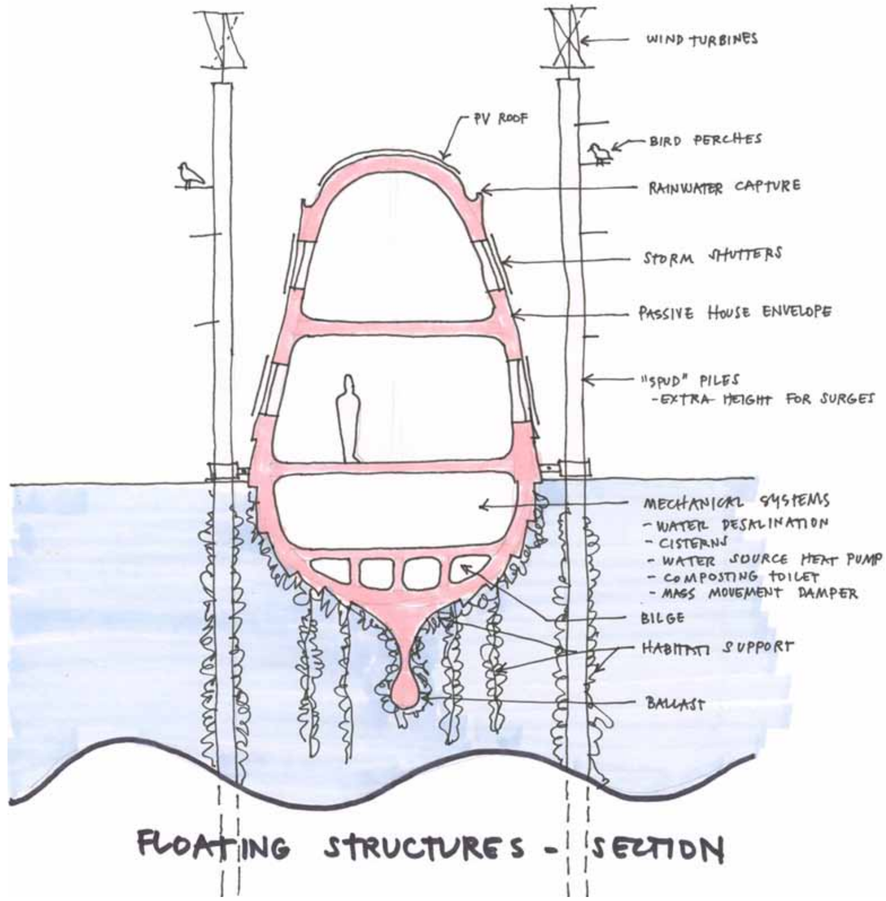


Waterfront Enhancement Plan

and biologists—a case can be made for obtaining funding for meaningful projects. The design and scientific communities can, together, contribute to solving urgent issues confronting the City. What is needed is a ground-up, incremental approach—not just a few high-cost, high-profile projects. Partnering with local communities we can develop sensitively formulated, localized solutions, arming property owners with a menu of resilient strategies, and lending our voice to the important discussion about what uses are put on the waterfront.

From the government side, we look for agility and flexibility in the planning and design of waterfront solutions in the context of a collaborative, problem-solving approach. This need for agility applies to all scales—from new regional models for watershed management to site-specific experimental projects to test the performance of materials. We must evaluate zoning and land-use along our shores, where hard and soft edges are best suited, and how to integrate buildings and open space in response to rising water levels.

Funding for Waterfront Lab projects (research, capital, maintenance and operations, and monitoring) could come through planing and financial structures that allow for deeper, longer-term collaborations among many disciplines and stakeholders. The Waterfront Lab could be a continuing means of testing innovative ideas, bringing New York City to the forefront of innovative waterfront resiliency planning and design.



Drawing by Caleb Crawford,
Coggan + Crawford Architecture + Design

EXAMPLES OF POTENTIAL WATERFRONT LAB EXPERIMENTS

An array of potential Waterfront Lab experiments can be applied to ocean, estuarine, and riverine systems at different scales:

Networks and rhizome systems of floodable open spaces and infrastructure (such as day-lighted streams, water plazas or piazzas, streets, canals, or multipurpose bioretention projects);

High-ground safe areas in neighborhoods with solar-powered cell phone charge stations and other essential post-emergency services;

Defensive strategies, such as naturalized edges, berms/dunes, large capacity bioswales, or native, salt-resistant plantings;

Renewable energy (i.e., wind- and hydro-powered turbines) integrated into waterfront structures and infrastructure;

Creative concepts for seawalls/wave walls that dissipate storm surges and provide ecological edges;

Natural and armored dunes using various types of materials;

Biodiversity integrated into infrastructure, e.g., bulkheads as habitat or floating breakwaters;

Combined sewer outfalls (CSOs) with lightweight fiber which then attracts suspension feeders for water filtration;

Habitat for fish, oysters, and other mollusks or beneficial organisms;

Permeable waterfront parks in floodplains;

Floating habitat, wetlands, recreation, breakwaters, evacuation routes, and housing.

Wind-resistant streets and resilient evacuation routes; and

Model waterfront districts with distributed infrastructure (energy, waste, sewer, water).

ADAPTATION, ADVOCACY & NEXT STEPS

Adaptive Response
Based on our initial examinations of options and opportunities by the various working groups—Transportation & Infrastructure, Housing, Critical & Commercial Buildings, and Waterfront issues—some general conclusions can be drawn for how to define and implement resilient planning and development strategies in this new post-Sandy world.

Can we prevent Sandy-like occurrences in the future? No one pretends we can, even with the most aggressive carbon-reduction programs. Although compounded by man-made situations, such events are punctuations in a timeless and continuing cycle of natural change—a cycle that appears to be increasing in intensity and frequency, and which will bring us extreme events that are an evolving reality with which we need to contend.

Can we mitigate the impact of these extreme occurrences and protect ourselves against their effects? The answer is a qualified "yes"—if we take a deliberate and measured risk-management approach based on adaptive responses. Such an approach must carefully balance the benefits of various interventions and their costs, bearing in mind that, as always, we are dealing with scarce economic resources. We must balance expenditures for other pressing public and private needs with disaster recovery and protection (in which a dollar spent today will save multiple dollars tomorrow).

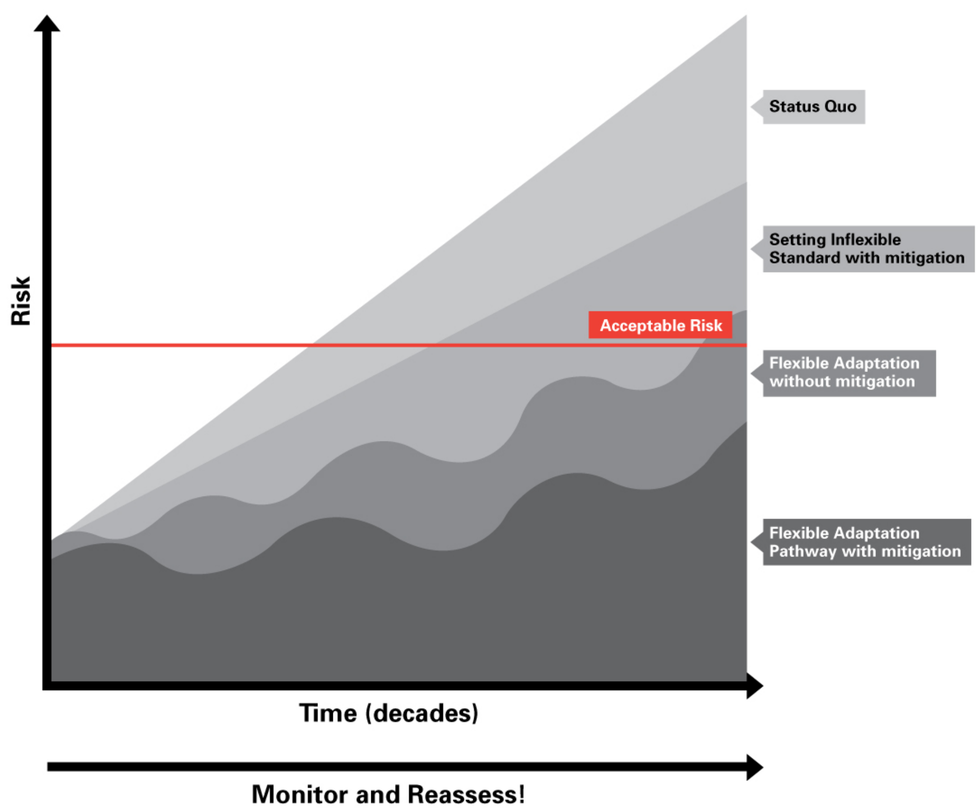
One of the conclusions emerging from the investigations undertaken as part of this Post-Sandy Initiative is that different types of investments may require different adaptation strategies.

This conceptual graph, presented at "Futureproofing Our Cities," a symposium held in March 2013 at the Newman Real Estate Institute of Baruch College/CUNY, describes the relative costs and benefits of potential adaptive responses:

The Status Quo represents the most rapid accumulation of risk over time.

An inflexible adaptation strategy can retard the rate of risk but through high-cost front-end investment, leaving the problem of not realizing all benefits until the long-term future.

By contrast, a Flexible adaptation approach, described by the wavy lines at the bottom of the graph, makes lower-cost, medium-term investments for medium-term benefits, reinvesting over time with new science and technology whenever conditions threaten to surpass acceptable risk levels.



Graphic adapted from: Lowe, J., T. Reeder, K. Horsburgh, and V. Bell. "Using the new TE2100 science scenarios." UK Environment Agency, as cited by NYC Panel on Climate Change (NPCC), 2010.

For instance, long-term investments should be those with the longest useful lives—the 100-year-plus life span for many types of new large transportation and utility infrastructure (whose failure can be truly catastrophic), or the similar time frame for extensive rebuilding of waterfront areas (where protection is critical to nearby social and economic stability). These should be designed with the long view, even at a premium cost, to deal with maximum potential risk. This strategy commits the government to protect its public investments, guarding its citizens against the threat of failure.

On the other hand, buildings and redevelopment in threatened areas present shorter-term opportunities and needs. New and renovated housing and critical/commercial structures—and remediation, as opposed to reconstruction of infrastructure or waterfronts—should involve lower but more affordable costs and risk levels. The caveat is that they may be required to upgrade to a higher level of risk protection as conditions change over time—accepting the potential of failure, coupled with a commitment to learn from experience. This strategy can bring private investments, insurance funding, and relevant public subsidies more in line with realistic capabilities—an issue that today threatens individual capacities.

Advocacy

In the immediate term, the planning and design community will undertake a program of advocacy for both shorter-term tactics to deal with critical issues at hand, and longer-term strategies growing out of these larger-concept approaches:

- Giving input into the various task forces now under way to develop consensus on next steps for public investment and private response—including challenges to be examined as part of the upcoming mayoral election.
- Contributing to considerations at the City level (Mayor Bloomberg's SIRR initiative and other agency responses and approaches), at the regional level (partnering with other planning and design professionals in adjacent municipalities and states in areas of common interest), at the New York State level (both short-term recovery responses and longer-term policy proposals), and at the national level (for instance, lobbying for possible refinements to FEMA standards and regulations).
- Reinforcing analysis through relationships developed with various city agencies both prior to and during our interactive post-Sandy events.
- Building upon the collaboration among organizations represented by this Post-Sandy Initiative, developing common positions, sharing research and proposals, and propounding advocacy initiatives—with the understanding that speaking with one voice is more powerful than many uncoordinated efforts.
- Apprising other organizations that are not part of the collaboration of this work, undertaking parallel efforts to generate conclusions, and engaging in dialogue to learn from other initiatives.
- Expanding outreach and educational efforts through contacts with education groups, institutions, student groups, and others.
- Advocating for refinements to laws that facilitate planning and design assistance in disaster recovery (such as the proposed Good Samaritan Law exemption to indemnify professionals for pro bono responses in times of emergency).

In many ways, the most important advocacy point going forward is to ensure that architects, planners, landscape architects, and engineers—those who understand the physical implications of the various policy and strategic options under consideration—are part of the discussions at the outset.

Next steps

Taking into consideration these proposed adaptive strategies, the areas studied by the working groups should be further analyzed and more detailed implementation steps proposed. This report presents a framework for this continuing, broad, and multi-disciplinary evaluation of options and opportunities. The issues are varied, and many are beyond the scope of our volunteers. For the most part, responsibility resides with various levels of government and institutional advisors currently examining these critical issues. Together we can develop implementation steps for:

- Waterfront and infrastructure: make an in-depth comparison of regional options and opportunities for protection of natural and man-made features. The objective should be to make the hard decisions, based on what we know now, as to what long-term expenditures are necessary for long-term benefits. The scenario approach spearheaded by the Regional Plan Association (RPA) is a valuable framework for this effort.
- Buildings: examine the tactics of regulation—zoning, codes, and other standards—in terms of what is feasible relative to medium-term benefits. The objective should be to mitigate the economically unsustainable pinch faced by home and property owners, between one-size-fits-all standards and government/private insurance premiums. A detailed comparative analysis of the range of assumptions that underlie potential standards, and the implications of their implementation, will be an important part of this effort.
- Continue to advance our knowledge. We know as design professionals that it is critical to expand the proportion of funding allocated to research and development of resilient, sustainable systems for buildings and the public realm—super insulation, better glass, fuel cells, storage batteries, innovative transit, and stormwater technologies. Our future could be that our buildings produce as well as consume energy, that we minimize the need for fossil fuels, and that we handle all by-products, including waste, in a sustainable manner.
- Finally, the imperative of sustainability must underlie the need for resiliency. We must ensure that new development not only adapts to extreme weather conditions, but also defines how to mitigate long-term climate change concerns. In a recent white paper, the AIANY Committee on the Environment (COTE) put forward a summary

description of potential strategies to achieve this goal—from suggestions for urban policy and legislation, to district systems and strategies, and individual building scale.*

The decision-making process needed to refine such recommendations can be undertaken in the framework of proposed labs—multidisciplinary investigations, rigorously defined to posit, test, and evaluate potential solutions so that the best possible choices can be made.

This report is the first step, a summary of where we are in our response as planning and design professionals to these unprecedented challenges in trying to understand the big-picture options ahead of us even as we grapple with the minutiae of pressing details. As we document more specific information from work already undertaken, and as we investigate the implications of these assumptions further (through workshops, charrettes, labs, and scenarios), we will present material on our new website, www.postsandyinitiative.org The site—currently a repository for appendices and background material generated at various working group events—will be a flexible and open-ended vehicle for next steps, updated regularly to reflect ongoing research, ideas, and recommendations.

Our working groups are readying their next-phase efforts beyond this report's initial definition of options and opportunities. They will continue this work using the website as a platform:

- Transportation & Infrastructure will continue advocacy efforts for best practices, both through collaborative programs and through interaction with regional agency and institutional initiatives.
- Housing will expand its work to: propose changes to FEMA multi-family standards; design options for spaces below the base flood elevation; explore alternatives to evacuation where infeasible or impossible; building system emergency responses, and further analyze best practices in the United States and worldwide.
- Critical & Commercial Buildings will prepare guidelines for implementation of recommendations for building owners and regulatory agencies, both locally and, to the extent relevant, nationwide.
- Waterfronts will press forward with its Waterfront Lab approach to defining and evaluating experimental solutions for testing ideas, producing data, and monitoring results, especially after substantial environmental events.

In addition, the AIANY Design for Risk and Reconstruction Committee (DfRR) will continue its multi-pronged focus on education, training, preparedness, and advocacy, based on its partnerships with various city agencies and institutions. The other consortium members will continue their own independent efforts (for example, APA Far Rockaway consultations, CHPC zoning proposals, SEAoNY damage analysis coordination, etc.).

Join Us

Through this consortium and its member organizations, we will continue our pro bono efforts to analyze alternatives, assimilate potential responses, and advocate for relevant public policies and private approaches for the preservation and growth of New York City and the region in this new and challenging environment of unpredictable change. Please join us in advocating for the options and opportunities defined in this summary, and by responding to our evolving work posted on the website at www.postsandyinitiative.org

* *"Where Mitigation Meets Adaptation: An Integrated Approach to Addressing Climate Change in New York City"* AIANY Committee on the Environment, March 2013 (posted on www.postsandyinitiative.org)

We would like to express appreciation to the many volunteers who gave their time and knowledge to the Post-Sandy Initiative.

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Glossary

An abbreviated glossary of important terms*

Adaptation
Adaptation is the set of adjustments that society or ecosystems make to limit negative effects of climate change. It can also include taking advantage of opportunities that a changing climate provides.
http://www.epa.gov/climatechange/impacts-adaptation/adapt-overview.html

Disaster
A serious disruption of the functioning of a community or a society involving widespread human, material, economic, or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.
http://www.wcpt.org/node/36996

Mitigation
Mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. Mitigation is taking action now—before the next disaster—to reduce human and financial consequences later (analyzing risk, reducing risk, insuring against risk). Effective mitigation requires that we all understand local risks, address the hard choices, and invest in long-term community wellbeing. Without mitigation actions, we jeopardize our safety, financial security, and self-reliance.

Preparedness
Preparedness is achieved and maintained through a continuous cycle of planning, organizing, training, equipping, exercising, evaluating, and taking corrective action. Ongoing preparedness efforts among all those involved in emergency management and incident response activities ensure coordination during times of crisis. Moreover, preparedness facilitates efficient and effective emergency management and incident response activities.

Prevention
Encompasses activities designed to provide permanent protection from disasters. This includes engineering and other physical protective measures, as well as legislative measures controlling land-use and urban planning.
http://www.wcpt.org/node/36996

Recovery
A focus on how best to restore the capacity of the government and communities to rebuild and recover from crisis, and to prevent relapses into conflict. In so doing, recovery seeks not only to catalyze sustainable development activities, but also to build upon earlier humanitarian programs to ensure that their inputs become assets for development.
http://www.wcpt.org/node/36996

Regenerative Design
Regenerative design (sometimes referred to as cradle-to-cradle design) is a process-oriented systems theory based approach to design. The term "regenerative" describes processes that restore, renew, or revitalize their own sources of energy and materials, creating sustainable systems that integrate the needs of society with the integrity of nature. (Wiki)

Resilience
Ability of systems, infrastructures, government, business, communities, and individuals to resist, tolerate, absorb, recover from, prepare for, or adapt to an adverse occurrence that causes harm, destruction, or loss.

Response
Activities to address the immediate and short-term effects of an emergency or disaster. Response includes immediate actions to save lives, protect property, and meet basic human needs. Based on the requirements of the situation, response assistance will be provided to an affected state under the National Response Plan (NRP) using a partial activation of selected Emergency Support Functions (ESFs) or the full activation of all ESFs to meet the needs of the situation.

Risk
Risk is Hazard + Vulnerability. Risk is potential impact to people, environment, and economy of a community (FEMA 2004). Vulnerability is measured by identifying exposure, sensitivity, and ability to cope. Hazard is a natural process with the potential to harm people or property (FEMA 2001).

Risk Assessment
Methods used to quantify risks to human health and the environment.

Sustainable Design / Development
Involves activities that meet the needs of the present without compromising the ability of future generations to meet their own needs.
http://www.wcpt.org/node/36996

SWOT Analysis
A process used to identify Strengths, Weaknesses, Opportunities, and Threats in business organizations, public agencies, and other entities. Can be useful as applied to determining building resilience.

*All are FEMA definitions unless noted otherwise.