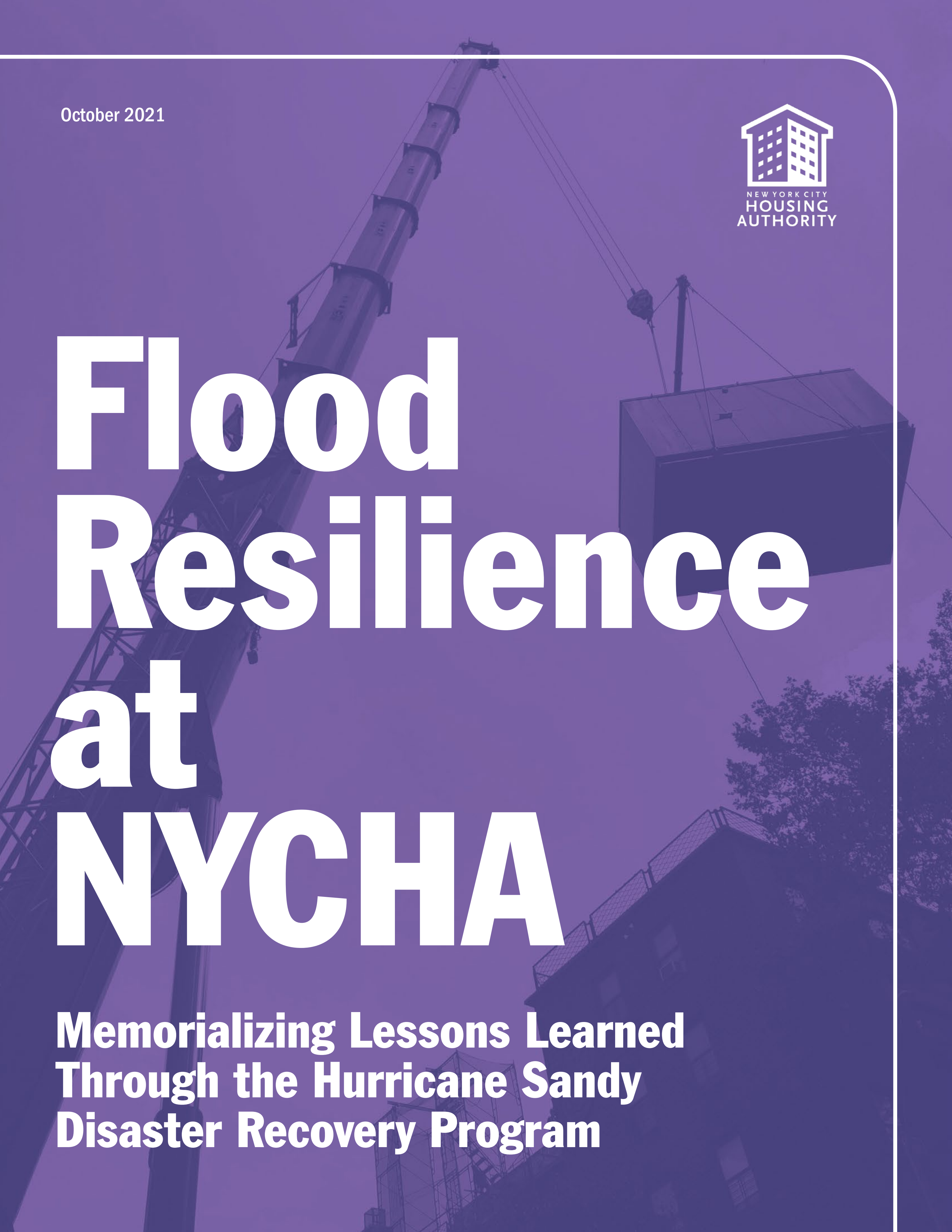

October 2021

NEW YORK CITY HOUSING AUTHORITY

Flood Resilience at NYCHA

Memorializing Lessons Learned Through the Hurricane Sandy Disaster Recovery Program


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Letter from the Vice President for Recovery & Resilience

Dear New Yorkers,

Hurricane Sandy devasted New York City in October 2012. Despite living in a city with 520 miles of coastline, residents had never grappled with storm surge at this scale. Salt water and debris covered huge swaths of the five boroughs, including many NYCHA campuses. Unlike prior major storms, the impacts didn't dissipate when the weather improved. Salt water corroded critical infrastructure that was stored below grade. The homes of tens of thousands of public housing residents—most of whom couldn't evacuate before the storm—were without water, power, heat, hot water, or elevator service for weeks. NYCHA's operational staff worked day and night to restore service by clearing debris, replacing system components, and installing mobile boilers, but many developments required major capital investments to recover.

Other cities tore down public housing after storm damage like this. NYCHA chose to preserve its public housing, creating the Recovery and Resilience Department to address critical repairs at the 35 most severely impacted developments and to protect NYCHA residents from similar impacts in the future. To fulfill this mission, the Department has awarded over $3 billion in contracts and spent over $2.4 billion to implement storm surge protection for 50, 60, and 70-year old buildings, install boilers and generators on rooftops, and add architecturally significant annexes. This took a special kind of entrepreneurial approach to secure funding, engage residents, manage massive projects, and operationalize equipment. The work isn't over yet, but with 67 multi-family buildings ready with storm surge protection for the 2021 hurricane season and 73 buildings with full back up power generators operational, we wanted to share what we've learned so far. Retrofits will be critical to the majority of New York's built waterfront and to public housing authorities across the country. By memorializing NYCHA's challenges and successes, we hope to make a contribution to New York City's evolving understanding of how to build resilience in a changing climate.

In partnership,

Joy Sinderbrand

Vice President
for Recovery & Resilience

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FDNY

Summary

In October of 2012, Hurricane Sandy hit New York City, inundating large parts of the city with salt water and leaving lasting damage to buildings and infrastructure. Thirty-five New York City Housing Authority (NYCHA) developments, home to over 60,000 New Yorkers, suffered major storm-related damage, including disabled mechanical equipment, compromised building structures, and deteriorated landscapes.

In December 2015, NYCHA received an unprecedented $3.2 billion in disaster recovery funding—including the largest single grant in FEMA history—to repair the developments that were severely affected by the storm and protect them from future storm surge flooding. Much of the work that was done introduced new flood resiliency features to NYCHA, as well as to the New York City planning, design, and construction industries.


EXIT

NYCHA's disaster recovery program is unique not only because of its scope and scale: it is also a rarity for a city to preserve all of its affected public housing after a disaster. Cities more typically use disaster recovery money to demolish flooded public housing, replacing it with mixed-income development containing far fewer public housing units and permanently displacing most public housing residents from their communities.[1] NYCHA's recovery program, by contrast, was carried out in continuously occupied buildings, effectively preserving 100% of the public housing that existed in the affected developments before the storm. Understanding the challenges of performing resilience upgrades while continuing to serve residents is essential to preserving existing housing at risk from future storms.

This study memorializes the investments that were made and the lessons learned which can serve as best practices. As NYCHA began to close out construction on sites that were protected as part of the Sandy Recovery program, the Recovery & Resilience team recognized the need to look systematically at the flood protection systems used at each site and document the reasoning for using them, the benefits brought by each, and the challenges experienced in implementing them. In the summer of 2020, the Recovery & Resilience Department supplemented an internal analysis of how each site was protected with a series of discussions, moderated by the American Institute of Architects' Committee on Design for Risk and Reconstruction, with the architecture and engineering firms that worked with NYCHA on the program. This report integrates the NYCHA team's experience with observations and experiences from contractors who participated in this series and provided their perspectives. This report begins by reviewing the storm damage to NYCHA developments, the decisions that were made about what work was needed to recover from storm damage, and the types of solutions that were implemented at the 35 affected sites to protect from similar damage in the future. A series of cross-cutting lessons learned from the program is presented first; this is followed by detailed descriptions of NYCHA's work to repair the various types of damage inflicted by Sandy and build resilience to future storms, along with what NYCHA learned from implementing each component of the program. This report will inform future resilience efforts at NYCHA and may also be useful for property owners, engineers, architects, and others that may face flood protection needs.

Cross-Cutting Lessons Learned

In compiling material for this report, it was clear that NYCHA staff, as well as architects and engineers involved in the Sandy Recovery and Resilience program took a great deal of pride in its accomplishments. While those who shared their experiences spoke freely about what could have been done differently and what they would improve if similar programs are needed in the future, participants overwhelmingly were proud to have worked on repairing and protecting NYCHA housing and were confident that these developments will be in a much better position the next time a storm surge event occurs in New York. Participants expressed an admirable level of commitment to continuing to improve flood protection practices and the state of the industry in New York and beyond. Four categories of broad, cross-cutting lessons emerge from the study of this program. The first three – design, construction, and operationalization—have direct implications for design and construction teams, while the last—disaster recovery program consideration—holds more relevance for policymakers.

Funding & Design

- **The Recovery and Resilience Program was a unique opportunity to invest in NYCHA Developments.**

NYCHA's $3.2 billion Sandy recovery program is the largest infusion of funds into public housing since NYCHA's inception. While the devastation from Sandy was an extremely challenging time in NYCHA's history, there was a silver lining: the ability to replace infrastructure that otherwise might not have had funding available in the near future. With decades of disinvestment in public housing, FEMA's funding is allowing NYCHA developments most impacted by the storm to be rebuilt stronger and more resilient, protecting this housing for future generations of New Yorkers.

- **Using FEMA's 428 program presents both opportunities and challenges.**

NYCHA chose to participate in a new method for distributing disaster recovery funds—the FEMA 428 pilot program – that was created after Hurricane Sandy to give recipients more flexibility in spending FEMA Public Assistance funds[2]. The terms of funding under this new program took a considerable amount of time to negotiate and required the use of a fixed overall funding amount that was agreed on after the pre-design phase. The time frame for determining the fixed funding amount was compressed and did not account for all of the needs that emerged during the full design phase, particularly related to tying into existing infrastructure with deferred maintenance needs. Although the 428 program imposed major risk to NYCHA, it presented the opportunity to think about developments holistically, even if a particular scope item was not funded. For example, at Red Hook, not all the boilers were damaged by the storm and under the 406 program, NYCHA would have only been able to address the damaged boilers. Under the 428 program, NYCHA was able to design a new development-wide heating system.

- **Devote time during the design process to identifying co-benefits.**

Many participants expressed the desire to incorporate more solutions that provide co-benefits to residents' daily lives, rather than solely providing protection in the rare storm event. In many cases, NYCHA was able to incorporate co-benefits such as wayfinding, aesthetic improvements to the campuses, and new seating areas into project scopes. Unfortunately, disaster recovery funding rules—which by law, must focus on repairs associated with a singular event and mitigate against damage that could occur in the future because of the same event—precluded many of the most ambitious suggestions. Solutions like re-cladding buildings, creating co-generation plants, installing neighborhood micro-grids, and comprehensive storm-water management for heavy downpours were pursued, but ultimately could not fit into the funding streams available or were not able to align with funding rules.

- **Dedicated community outreach staff are essential for large projects at NYCHA.**

Robust stakeholder outreach and a consistent point of contact for residents is important for large-scale projects with multiple components. During design it is helpful to find opportunities to maximize co-benefits and there are many instances where designs changed due to resident, development staff, and Operations staff input. Throughout construction, coordination and updates are critical, especially since resilience work is very disruptive. The outreach was also an opportunity to engage with stakeholders about emergency preparedness and other resources available to them. An outreach team that is knowledgeable about the entire project facilitates more productive community engagement.

Construction

- **Multiple trade projects are more efficient than several component-based projects.**

Typically, NYCHA's funding and construction contracts have been component-based, such as individual contracts at different times for roof replacement, boiler replacement, playground construction, or site lighting. Recovery & Resilience projects bundled together most, if not all, of the work at a particular development to create efficiency in project management, construction coordination, and limit resident disturbance. A typical project would include: a new heat and hot water system, full backup power generators, repaired/new electric, mechanical and plumbing systems, raised annex structures for critical equipment, floodproofing of existing buildings, site lighting, CCTV, playgrounds, and grounds restoration. This provided a learning opportunity for NYCHA that will help to inform future work as the Authority plans for more comprehensive modernizations as part of its Blueprint for Change.

- **New components mean Capital team members have to think through precedent-setting construction methods and operations processes.**

Most of the project team—construction managers, contractors and NYCHA—had never installed or worked with flood protection systems and other resilience elements that were in the scope of work. An iterative process had to be undertaken to ensure that systems were designed, installed, handled, stored, and labeled correctly. In some cases, this resulted in modifying installation techniques to ensure that flood protection systems can be expected to perform as designed. NYCHA worked closely with contractors, manufacturers, designers, and NYCHA Operations to get the installations right and advance familiarity with the systems on the part of the project teams.

- **Integrating new equipment into old buildings requires additional contingency in design and construction.**

Unanticipated field conditions and infrastructure that had not seen proper maintenance or investment in decades required creative thinking and innovation on the part of the department to complete certain retrofits. A common example was attempting to install back flow preventers on pipes that were deteriorated and well beyond their useful life. Another challenging component was the backup generators, which had the most precedents and dependencies; they needed to be supported by existing or new structures, required running new gas lines, and had to be connected to existing power distribution systems. This is not unique to the Recovery and Resilience program and holds true for many of NYCHA's recent major initiatives: Healthy Homes, Energy & Sustainability, and Strategic Planning. On the front end, during design, additional time and funds should be dedicated to pre-design investigations, such as borings or utility line determination. During construction, additional contingency should be assumed to be necessary, so that existing conditions can be dealt with in real time by the contractor instead of having to cobble together funding across divisions to progress the critical path of a complex project.

Operationalization & Recommendations for Changes in Non-Disaster Practices

× **Commissioning, turnover, and maintenance require multi-departmental evolution of processes and systems.**

NYCHA staff were familiar with turnover, maintenance, and warranties associated with typical capital investments. By contrast, there were initially no clear processes for the ownership of emergency generators, flood logs, green roofs, and stormwater management systems and NYCHA needed to develop tracking systems and standard operating procedures for these new systems.

× **Reflective self-evalutation improves future projects.**

An additional lesson learned through the compilation of this report has been that reflective documentation of the successes and challenges of retrofits is invaluable. By releasing this summary of NYCHA's Hurricane Sandy Recovery & Resilience program, NYCHA hopes not only to document this work and ensure its lessons are not lost, but to create a new model for memorializing best practices as the Authority embarks on major modernizations, each of which will surely bring its own learnings for the Authority.

× **Best practices can be integrated into new work immediately.**

Over time, NYCHA will determine which of the design elements represent best practices for the portfolio at large and will integrate these into standard design processes. In the meantime, boiler elevation in zones at risk of flooding has already been determined to be a best practice and is being incorporated into the design at four additional campuses where heat system replacement is being done in a non-disaster recovery context—Bay View, Gowanus, Smith, and Marcy.

Disaster Recovery Program Considerations

× **Project teams can seek integration into larger-scale projects without delaying immediate needs.**

The projects that were implemented as part of the program were designed to protect NYCHA property; but the campuses that were damaged by Hurricane Sandy are all in neighborhoods that are vulnerable, as a whole. Some of the interviewees mentioned having worked on ideas for projects that could have offered more holistic protection: selecting a single NYCHA development in Coney Island and turning it into a fully equipped assembly site for all developments in the neighborhood; or greater integration with the Big U project in Lower Manhattan to better integrate NYCHA's work with neighborhood-wide protection plans. But mixing funding streams and combining scopes from different projects on different timelines made more holistic ideas like this difficult to implement. In addition, this coordination would have slowed the process of funding NYCHA's repairs even further. Nevertheless, NYCHA's independent resiliency strategies will combine with New York City's larger scale protections to provide layers of resiliency that will further protect NYCHA assets.

× **Additional sources of resilience funds are needed beyond disaster recovery.**

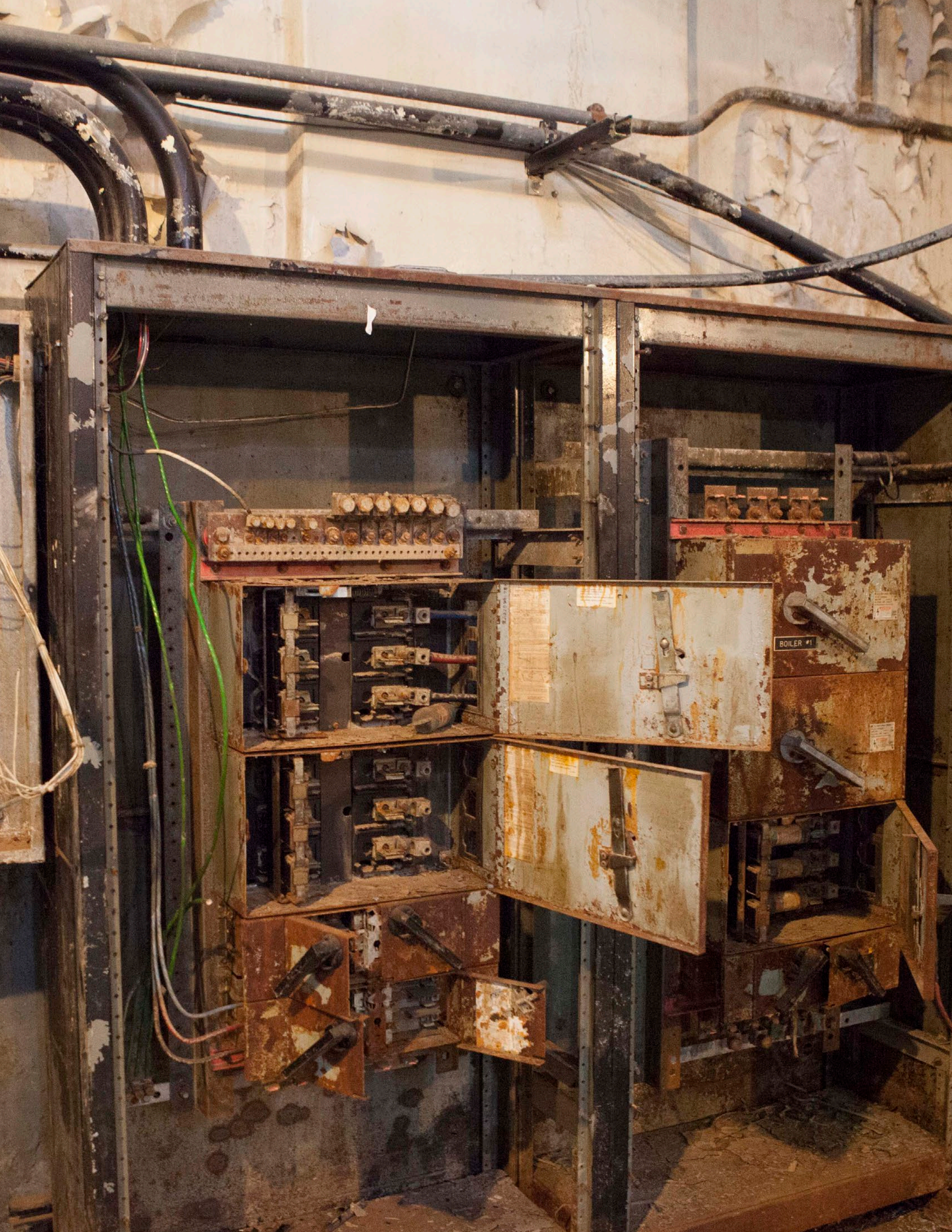
A consistent frustration was that disaster recovery funds are focused on the last disaster—they do not necessarily fund items that are essential to getting some of these projects done or protecting the sites from future climate hazards holistically. For example, Sandy disaster recovery funds from FEMA could not pay for replacement trees removed as part of construction, even though trees mitigate extreme heat. Additionally, items that were in poor condition and replacement of which would contribute to a site's resilience, like stormwater pipes, were not funded if they were not damaged as a direct result of the storm. If funding from other federal agencies could be allocated for a more holistic project at the same time, it would result in a more comprehensive project in the end. Fortunately, in the years since this program was launched, Congress has allocated more funding to pre-disaster planning and mitigation, and FEMA has re-envisioned its programs to invest in larger-scale, innovative mitigation programs through the Building Resilient Infrastructure and Communities program.[3]

Overview of Resiliency Strategies

INSTALL MORE SUSTAINABLE AND RESILIENT INFRASTRUCTURE			
Strategy	**How It Was Used**	**Benefits**	**Challenges**
New, more efficient boilers	Where boilers were severely damaged after Hurricane Sandy, the Recovery and Resilience program installed new heat and hot water systems and protected them from future flooding	· New boilers are more efficient and emit less pollution than the boilers they replaced, improving environmental performance as well as resiliency	· When boilers are replaced without a full system replacement, the full benefit can be difficult to realize
Provide resilient back-up power	NYCHA installed full back-up power generators at over 200 buildings that experienced power outages and flooding during Hurricane Sandy	· Back-up power allows buildings to be re-occupied quickly after a coastal storm and minimizes interruptions to daily life for residents · Generators can provide protection from outages that are unrelated to coastal storms as well, a co-benefit of full-building, permanent back-up generation · Back-up power ensures that sump pumps remain operational during a flooding event	· Generators require extensive new gas and electrical connections · Generators were an entirely new class of asset at NYCHA, that required new maintenance protocols · Extensive coordination with utilities is required for installation · No funding for controls to allow for revenue generation
PROTECT MECHANICAL , ELECTRICAL, AND PLUMBING INFRASTRUCTURE			
Build raised annexes to protect mechanical, electrical, and plumbing equipment	MEP annexes were built at 23 sites—this was often the most cost-effective way to provide ongoing, passive protection to MEP systems. Centralized generator enclosures were also installed at 15 sites.	· Critical equipment can more easily be protected in excess of the Design Flood Elevation and is protected without the need for flood walls or deployable barriers · Construction of new buildings can provide co-benefits by bringing new spaces to developments · Provides easier access to equipment on a day-to-day basis for service	· Increased cost · Requires installation of new site-wide distribution · Not all sites could accommodate new buildings given site constraints and zoning limitations
Protect mechanical, electrical, and plumbing equipment inside buildings	Sometimes, it was most cost-effective to create protected zones within buildings by constructing flood doors and barriers around mechanical rooms or elevating equipment above the design flood elevation indoors.	· Often less expensive than constructing a new structure · Reduces impacts to open spaces and air and light in apartments	· Does not provide co-benefits like easier access for service & creation of new spaces · Space constraints can make the installation of flood doors inside buildings challenging, especially in narrow hallways · Elevating equipment inside buildings creates a considerable challenge servicing equipment for staff because it is so high off the ground

PROTECT MECHANICAL , ELECTRICAL, AND PLUMBING INFRASTRUCTURE (CONTINUED)			
Strategy	**How It Was Used**	**Benefits**	**Challenges**
Locate mechanical equipment on the roofs of buildings	Generators were located on roofs at 21 developments, while boilers were relocated to building roofs at just one development, Bayside.	· When generators are installed on roofs, each building has an independent resilient power supply that is not at risk of flooding · When boilers are located on individual buildings' roofs, they can be more efficient because they minimize distribution losses	· Not all roofs were able to structurally support generators · Maintaining many individual buildings' generators is more costly and time-consuming than maintaining at a central location · Moving from a centralized to a distributed boiler system requires extensive in-building work, which is challenging outside of a comprehensive building renovation
PROTECT STRUCTURES			
Floodproof buildings, using deployable flood barriers for entrances and windows	Used at 22 developments, this strategy allowed NYCHA to create a continuous barrier to floodwaters around a building by reinforcing the buildings' walls and adding floodproof perimeter walls in some locations. Entrances and windows below the Design Flood Elevation are sealed with deployable elements when necessary.	· Protects entire building from flooding · Barriers can be deployed as needed prior to a storm · Costs are lower than passive barrier systems	· Storage and long-term maintenance of deployable elements is challenging · Ensuring that trained operators of deployable systems are available in the event of a storm is a challenge · Structural reinforcement of existing building walls is challenging and costly · Long-term maintenance and operations funding for deploying barriers prior to storm
Floodproof buildings, using passive barriers for entrances	This strategy, used at eleven (11) developments, creates a continuous barrier around the building. Elements at building entrances deploy automatically when water begins to rise around a building.	· No need to store or deploy flood barrier elements	· Not feasible if there is not enough underground space for the installation of barriers · System must be maintained to ensure it functions during a storm event · Structural reinforcement of existing building walls is challenging and costly · More costly than deployable barriers
Install backwater prevention valves	Backwater prevention valves are required by code wherever plumbing is modified, but they are also an essential element in preventing sewage and stormwater from inundating buildings during a storm	· Necessary element of flood protection to prevent water from entering the building through sewer and stormwater systems	· New maintenance protocols are required for buildings with backwater prevention valves

PROTECT STRUCTURES (CONTINUED)			
Strategy	**How It Was Used**	**Benefits**	**Challenges**
Use “wet” floodproofing to protect buildings from floods without sealing water out	Used in six developments, wet floodproofing allows floodwaters to pass through a building without endangering a building’s structural stability or critical systems. Critical infrastructure is relocated above the design flood elevation, and vents are installed to allow water to enter and exit the building. In some cases, certain rooms are dry floodproofed to protect critical spaces.	· Structural reinforcement of walls is not required · Cost is much lower than dry floodproofing strategies	· Requires acceptance that some degree of damage will result from a storm
Use floodwalls and changes in landscape grade to protect the site	At two developments—Baruch and Bayside—landscape-based flood walls were used to provide passive, consistent flood protection for large areas of the site. In Red Hook, an innovative “Lily Pad” design will raise the elevation of large areas between buildings and provide sitewide passive protection.	· Landscape-scale strategies provide protection beyond the buildings, keeping areas of the grounds protected during a flood event · These strategies can provide major co-benefits, such as the seating created by the flood wall at Baruch and the re-imagined community spaces that will be created at Red Hook	· This type of solution is only possible at large developments and where the site’s configuration allows · Construction of landscape-scale solutions can be extremely disruptive and often requires the removal of large numbers of trees · Unexpected locations of utilities and abandoned older infrastructure can create significant unanticipated costs


BOILER #1

1

Install Sustainable and Resilient Critical Infrastructure

Hurricane Sandy's most acute impacts at NYCHA were a result of outages of its most critical systems: heat, hot water, and power. Storm surge had inundated hundreds of public housing buildings, particularly affecting the crawlspaces, basements, and ground floors where most of the mechanical and electrical infrastructure was located. On top of electrical outages within the apartments, shared infrastructure like elevators could not be utilized and lights in hallways and stairwells were out, limiting the accessibility of the apartments.

In addition, damage to the electrical systems caused the failure of heating systems and the pumps necessary for domestic water in high-rise buildings. Surface runoff combined with contaminated floodwater from the NYC stormwater and sewage system backed up on NYCHA properties and into buildings, proving to be as damaging as the saltwater from the storm surge. The interruption of essential building utilities created serious public health and safety concerns for NYCHA residents limiting their mobility and access to health care due to egress issues, as well as the ability to engage in necessary daily activities. Recovering from Sandy and building resilience to future storms involved, first and foremost, replacing heat and hot water systems with new equipment and providing for backup generation in case of future power outages.

STRATEGY 1

New, More Efficient Boilers

Maintaining consistent and reliable heat and hot water is a priority for NYCHA and protecting these systems from the risks associated with climate change is a focus of this program. But not every flooded boiler was determined to require replacement by the NYC Department of Buildings or authorized for funding by FEMA. Disaster recovery funding was allocated to replace the systems at 18 of the 35 developments severely damaged by Hurricane Sandy. At another two developments, NYCHA used Federal Capital funds bundled with the disaster recovery funds to replace heating systems.

Additional developments with potential flooding risk are scheduled to receive system upgrades as part of NYCHA's heating plant upgrade program; design for these systems and a consideration of the cost of mitigating a potential risk versus the immediate need will have to be made based on funding constraints.

Prior to Hurricane Sandy, boilers at the affected developments were between 13 and 35 years old. The program is installing boilers that have better efficiency and are low-emitting. At many of the developments, NYCHA installed boilers that are Environmental Protection Agency (EPA)-rated low-emission (rated for 30 parts per million (ppm) nitrogen oxide (NOx) emissions).

Historically, NYCHA's boilers were capable of using both gas and fuel oil but relied primarily on gas, with oil used only on the coldest days. During Sandy, the

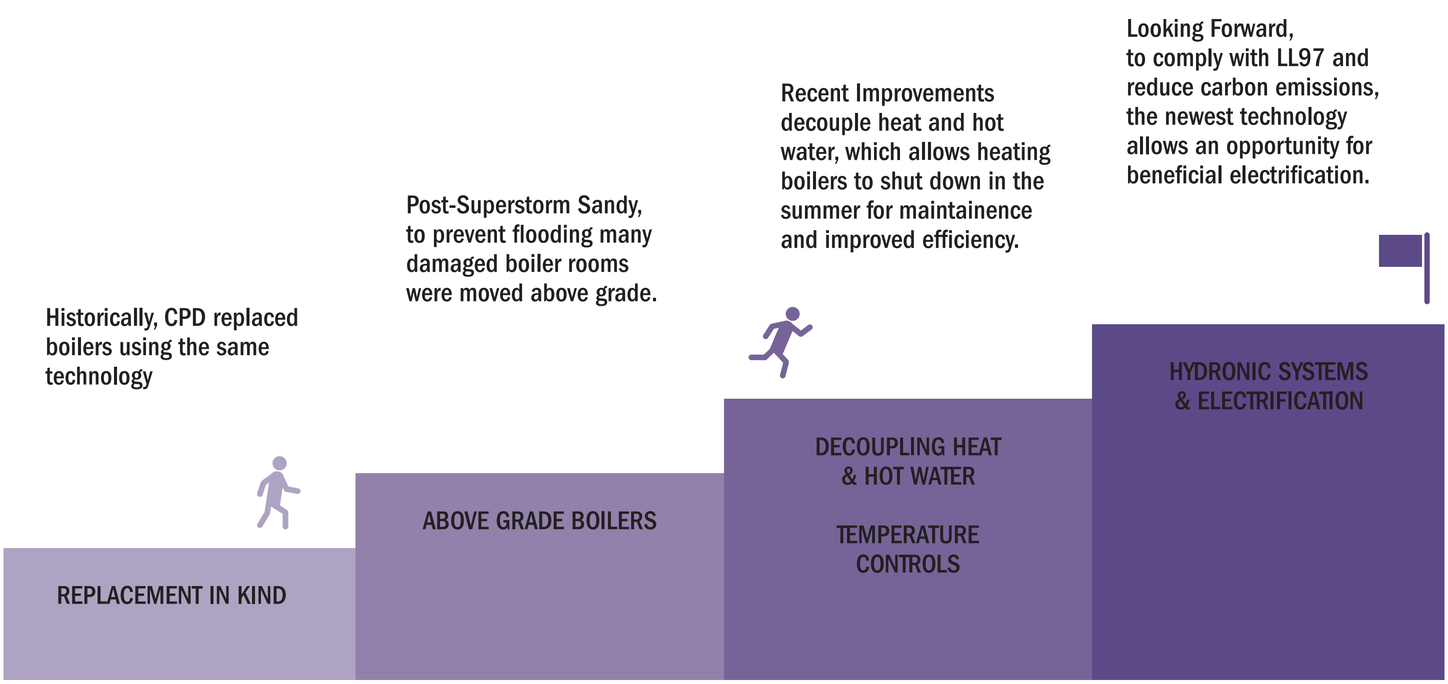
Boiler room in Coney Island 1B

gas distribution did not fail at most sites that used it as a fuel source. Given this experience, gas was used when possible in the program, because it was considered most reliable at the time. Gas distribution systems are not foolproof—gas networks were disrupted in some neighborhoods as a result of Sandy flooding, and low-pressure gas networks remain somewhat vulnerable to water intrusion; however, compared to other fossil fuel sources they are considerably more reliable during an emergency.[4] This is partially because the gas distribution from the utility company is all underground.

Each new boiler installed as part of the Sandy program is fueled primarily by natural gas with a secondary option to run on #2 fuel oil, stored in small above-ground backup tanks in case of emergency. Each #2 fuel oil backup tank has a 5,000-gallon capacity to provide a minimum of eight hours of service if the natural gas service becomes interrupted. Tanks are located above the design flood elevation (DFE) and are equipped with alarm systems and other spill control and containment measures. NYCHA has moved away from the dual fuel standard since the Recovery and Resilience program designed and constructed these systems but the increased efficiency and above-grade location of boilers installed as part of the Sandy Recovery program were a crucial step in moving NYCHA toward more advanced heating systems (Figure 1).

In coordination with the FEMA investments, NYCHA leveraged the energy savings created by new boiler systems to pursue Energy Performance Contracts in coordination with other energy efficient upgrades to these developments. NYCHA's Sustainability Agenda, released in 2016 with an updated version to be released in September of 2021, details how Energy Performance Contracts help NYCHA achieve efficiencies and meet its greenhouse gas emissions reduction goals. At the same time, installations such as these are typically eligible for rebates from the utilities.

FIGURE 1 NYCHA's standards for heating plant replacement continue to evolve; the Recovery & Resilience program was a key step along the way.



Boiler room in Coney Island 1B

STRATEGY 2

Resilient Back Up Power

Power outages after Sandy were widespread throughout New York City. Some areas of the city were able to be restored relatively quickly. By contrast, the waterfront neighborhoods were the most severely damaged. NYCHA developments located in waterfront neighborhoods had dual challenges of salt-water damaged utility company equipment and the damaged or destroyed equipment within the buildings themselves. Con Edison and PSE&G were stretched to their limits as they worked to restore their transformers and distribution systems. At the same time, NYCHA was just one of many agencies and property owners trying to commandeer the tools, materials, and skilled labor needed to test and restore power to each building. Some buildings were without power for as long as three weeks with no elevators, lights in apartments or hallways, and in some cases no water pumps. This was a completely untenable situation for residents and for those trying to bring all critical services back online and cleaning up the property from the damage and destruction caused by the storm.

Ensuring that residents can return to their buildings as soon as possible after a flood requires permanently installed backup power generators. Unfortunately, not every building impacted by the power outages after Sandy was funded for backup power, but NYCHA continues to pursue funding and research options for expanding this service. Altogether, 220 buildings will be serviced by full-building backup natural gas-power generators through this disaster recovery program, which will be operational as long as the utility continues providing gas service to the area or immediately after gas service is restored in case of interruption. This type of generator does not require fuel deliveries, which may be disrupted due to the storm aftermath as seen with Hurricane Sandy.

Generator Characteristics

The program is installing generators powered by natural gas that provide a total of 98 megawatts (MW) of power generation. The generators range in size from 150 kilowatts (kW) up to 600 kW depending on the electrical needs of the building or development served, and meet or exceed EPA standards for emissions levels. The generators are stationary and sized to provide for the complete power demands for the residential buildings and site lighting that they support. The “generator sets” are served by natural gas and consist of a generator enclosure (walk-ins and reach in), generator and all ancillary devices such as controls, power distribution equipment, sound attenuation canopies, ventilation/exhaust systems, control panel systems, circuit breakers, safety alarms, and automatic transfer switches. Generators, by themselves, are just one component of the intricate gas and electrical system they are tied into to power these buildings. New natural gas service from the utilities was installed at every building that received a generator to power the building.

A major component of installing generators was having the utilities run new service lines to supply NYCHA’s equipment with natural gas, which made NYCHA

Newly installed backup generator at Coney Island 1B

Rooftop generators at Coney Island Houses

heavily reliant on utility scheduling, contractors, and resources. During NYCHA's generator construction, National Grid instituted a moratorium on new natural gas service, preventing NYCHA from completing the installation and operating the backup generators on the anticipated schedule. The moratorium was temporarily lifted but new natural gas service for backup generator installations is not a given. The newly installed electrical equipment had to be tied into the generators whether they were located in a new annex building or placed on the rooftops of existing buildings, requiring long runs of conduit and gas piping.

On the whole, generators were one of the most important new resources for campuses vulnerable to coastal storms; at the same time, they represented the most complicated new asset for NYCHA to manage. Integrating the use of generators required not just learning how to use the new equipment, it also required NYCHA to consider how to distribute new maintenance responsibilities among existing staff. While NYCHA established a third-party maintenance contract for the generator units, there was a gap in the responsibility for all the ancillary gas and electrical equipment tied to the generators, critical to their functioning. The maintenance challenges for NYCHA are mostly associated with the technology of systems that support them. Generators are tied into Automatic Transfer Switches, Emergency Stop and gas shutoff devices, fire and gas leak monitoring systems, and the custom-built enclosures, all of which are new to NYCHA staff and require their own understanding and maintenance of the system as a whole as well as these individual parts. Additionally, NYCHA plumbers were dedicated to heating and cooking gas supplies, and did not have the capacity to take on the responsibility of maintaining the extensive gas supply system supplying natural gas to the generator most of which are on the roof and have externally exposed gas piping.

Beyond maintenance and service challenges, integrating generators into NYCHA's portfolio required the agency to adopt appropriate messaging about when and how the new equipment will protect residents. For example, some residents may assume that the availability of backup power means that their building does not have to be evacuated during a coastal storm emergency, which is not the case. Additionally, only those buildings determined to be eligible per FEMA's criteria were funded for backup power, resulting in some campuses having generators in only a portion of the buildings. The incorporation of

NYCHA's pre-purchase of standardized Generac generators allowed all sites receiving backup power to install the same equipment, reducing variability in maintenance and training needs for NYCHA staff overseeing this new type of equipment.

significant resiliency investments requires spreading an understanding of how the investments protect and the limits of their protection throughout the agency.

Demand Response

Since NYCHA was able to install full back up power generators (as opposed to emergency power only), as an unintended benefit some of the covered buildings are eligible for enrollment in demand response programs. During times of high-energy usage, such as a hot summer day, the utility company can ask NYCHA to turn on the generators for a certain period – and remove the building demand from the grid – to reduce the total load. This helps NYCHA avoid possible electrical outages and adds capacity to the entire neighborhood. As of 2021, 13 generators at 5 developments are enrolled in a Con Edison Demand Response Program for a combined potential reduction of 3,115 kilowatts of demand at a given time. NYCHA is seeking funds to install the remote monitoring and control equipment necessary to enroll more generators in the Demand Response Program.

NYCHA's analysis of potential demand response programs indicate the need for operating generators and Automatic Transfer Switches in "closed transition" in order to avoid planned outages impacting building operations. Closed transition allows a seamless transition from grid power to generator power and requires specific purposefulness during design.

Upon investigating the requirements for this from the utilities, we discovered that Con Edison has upgraded its equipment to be a closed system that allows for immediate transfer to the generator – those developments do not see any interruption during demand response scenarios and allows for the remote start up with the addition of the control systems. Meeting the requirements of Con Edison to allow these systems to operate in closed transition has been a challenge, as these requirements were not considered at the initial stages of design because the FEMA scope was aimed at powering the building in an outage, not the ability to participate in load reduction programs.

PSEG, the other utility provider, which primarily covers the Rockaways neighborhood has an open system which requires a split-second delay when switching power over from the grid onto the generators. That break is long enough that elevators need to be shut down in advance and pumps and other equipment need to be manually turned back on, thus creating a heavy burden for NYCHA operations. At this time, NYCHA has not considered enrolling this subset of the portfolio in load reduction programs, but the opportunity may be possible in the future.

In future projects involving full back up power generators, it would be critical to have alternate funding available to ensure that systems can be designed for closed transition from the beginning to allow for a smoother transition for load reduction programs, as well as a dedicated funding source to pay for the installation of control systems to remotely monitor and control the generators for an easier transition into demand response programs.

Pre-purchase Agreements

To eliminate the variability of maintenance between developments, NYCHA required contractors in the program to install boilers and generators pre-purchased by NYCHA. The agency had previously awarded contracts through a competitive RFP processes to standardize the equipment. NYCHA purchased Burnham boilers for this program through Boileroom Equipment Sales LLC and Generac generators from Huntington Power to ensure that there was standardized, consistent equipment throughout the portfolio. This ensured boilers would be available when contractors needed them onsite and allowed for consistent trainings across campuses. Warranty and guarantee periods for the boilers are with a single vendor across the program which also eliminated variability from site to site. Similarly, having all the generators provided by one vendor allowed for that company to assist in building out a team at NYCHA to become experts in generators. The staff that oversee this new equipment for NYCHA receive thorough trainings before the turnover of each generator unit that can be expanded and elaborated on as the NYCHA staff become more familiar with the equipment. Finally, NYCHA was able to directly control the quality of the products, reduce delays in generator purchase and delivery times and reduce costs by centralizing this purchase.

Lessons

NYCHA's work installing new, more sustainable and resilient critical infrastructure at NYCHA developments provided some key insights for the authority:

- **NYCHA should set aside additional funds and plan for additional time to account for the challenging existing conditions into which new systems are being installed.** Deferred maintenance needs expand project scope not only due to components directly tied to the project (e.g., a backwater valve being inserted into a decayed sewer line), but due to components that are indirectly associated with the project (e.g., a pre-existing need to replace conduit that is precedent to installing backup power generators). NYCHA is moving toward more comprehensive modernizations that will reduce these challenges, but for major projects that tie into older systems, the deferred maintenance needs and challenging site conditions consistently result in higher than expected costs.
- **When recovering from a disaster, equipment standards should be upgraded to deliver the greatest benefit to residents.** Large-scale replacement of systems is an infrequent occurrence, and one of NYCHA's greatest opportunities to increase efficiency is in using higher standards when equipment needs to be replaced. Disaster recovery can be a way to incrementally move a large organization forward. NYCHA's standards for heating system replacement continue to evolve, and the Recovery and Resilience program has been a key contributor to advancing better practices for the authority as a whole.

2

Protect Mechanical, Electrical and Plumbing Infrastructure

Heat, hot water and electrical equipment, as well as related components are critical pieces of equipment for NYCHA developments and protecting them is a main focus of this program.

Protection of mechanical equipment was accomplished using several methods:

- × Leaving equipment under the design flood elevation but protecting the whole building from flooding (see Section 3, Protect Structures).
- × Protecting equipment by:
    - Moving equipment from basements to annexes above grade, higher than the design flood elevation. These can be localized in MEP annexes that serve one or two buildings or centralized in development-wide boiler plants,
    - Protecting equipment inside buildings, and
    - Moving equipment to the rooftops of buildings.

STRATEGY 1

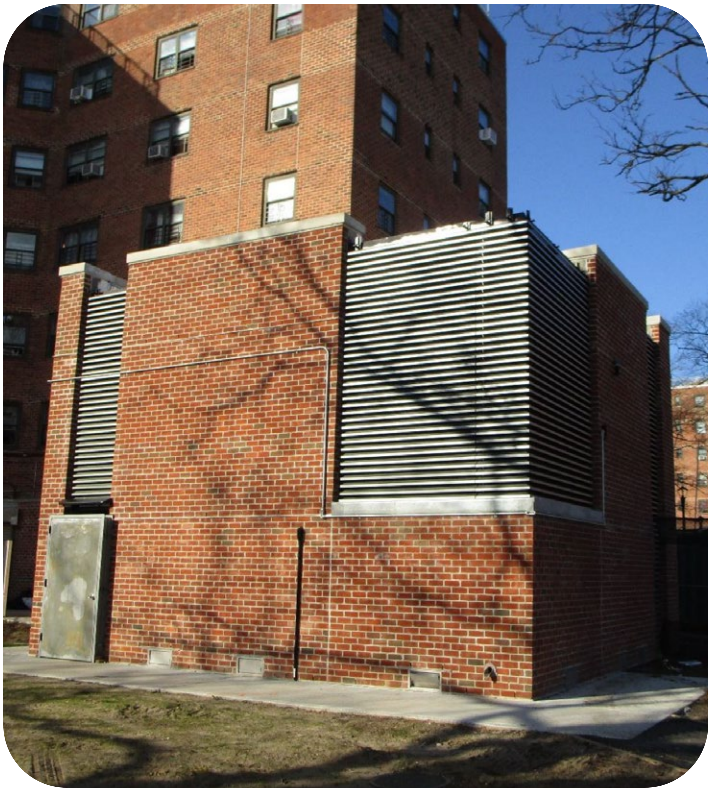
Raised MEP Annexes and Boiler Plants

NYCHA committed within the scope of work proposed to FEMA to protect Mechanical, Electrical and Plumbing (MEP) infrastructure from a 100-year flood in addition to incorporating future Sea Level Rise (SLR). In a large majority of developments (23), the creation of MEP annexes was cost-effective and has been pursued as the most viable solution. MEP annexes can house various types of equipment, including dual fuel boilers, boiler feedwater pumps, steam separators, transformer cabinets, automatic transfer switches and electrical distribution panels, steam-to-hot water tanks, and high-pressure natural gas service for generators.

These new structures also were opportunities to improve the aesthetics on campuses with various façade colors and materials, differentiated from the existing and sometimes aged brick buildings. In some places, such as Red Hook, the structures are being used to improve the wayfinding on campuses. The annexes will have the numbers of the adjacent buildings displayed prominently and their color schemes were designed to differentiate areas of what is currently a very architecturally repetitive site.

Raised annexes were installed for generators serving multiple buildings or the entire development at ten sites. In some cases, this was because the rooftop could not support the weight, as was the case at Lower East Side Rehab V, a small two-building tenement-style building in Lower Manhattan. For some developments, heat and hot water systems, as well as backup generators, were consolidated into plants protecting equipment for several buildings as in LaGuardia or Red Hook, the largest plant in the entire program.

The new MEP annex at Coney Island Houses contributes to a renewed image of the development



The new MEP annex in Gravesend with its brick facing blends into the surrounding landscape.

The new boiler plants are either standalone buildings or attached to existing buildings, depending on individual site conditions. The cumulative footprint and estimated maximum height of new boiler plant buildings varies by development, but the footprint generally ranges from 3,000 to 10,000 square feet. The new boiler plant buildings require pilings that have generally been driven to a nominal depth of 90 feet or to the bedrock depth, whichever is shallower. Each new boiler plant building foundation generally requires 24 to 60 structural pilings. Piles subsequently are encased in the concrete foundation of the new boiler plant following conduit installation for utilities. Each new boiler plant building has controls for the boiler emissions. The type of emission control system largely is dependent on site-specific conditions.

Red Hook is the largest site, with total construction cost estimated to be approximately $500M. The East Plant will contain a high temperature boiler and central emergency generator plant. The functioning principle of the boiler system is that high temperature water is produced at about 450°F which is pressurized so that it remains liquid, not becoming steam. It is then transferred to heat exchangers in the pods.

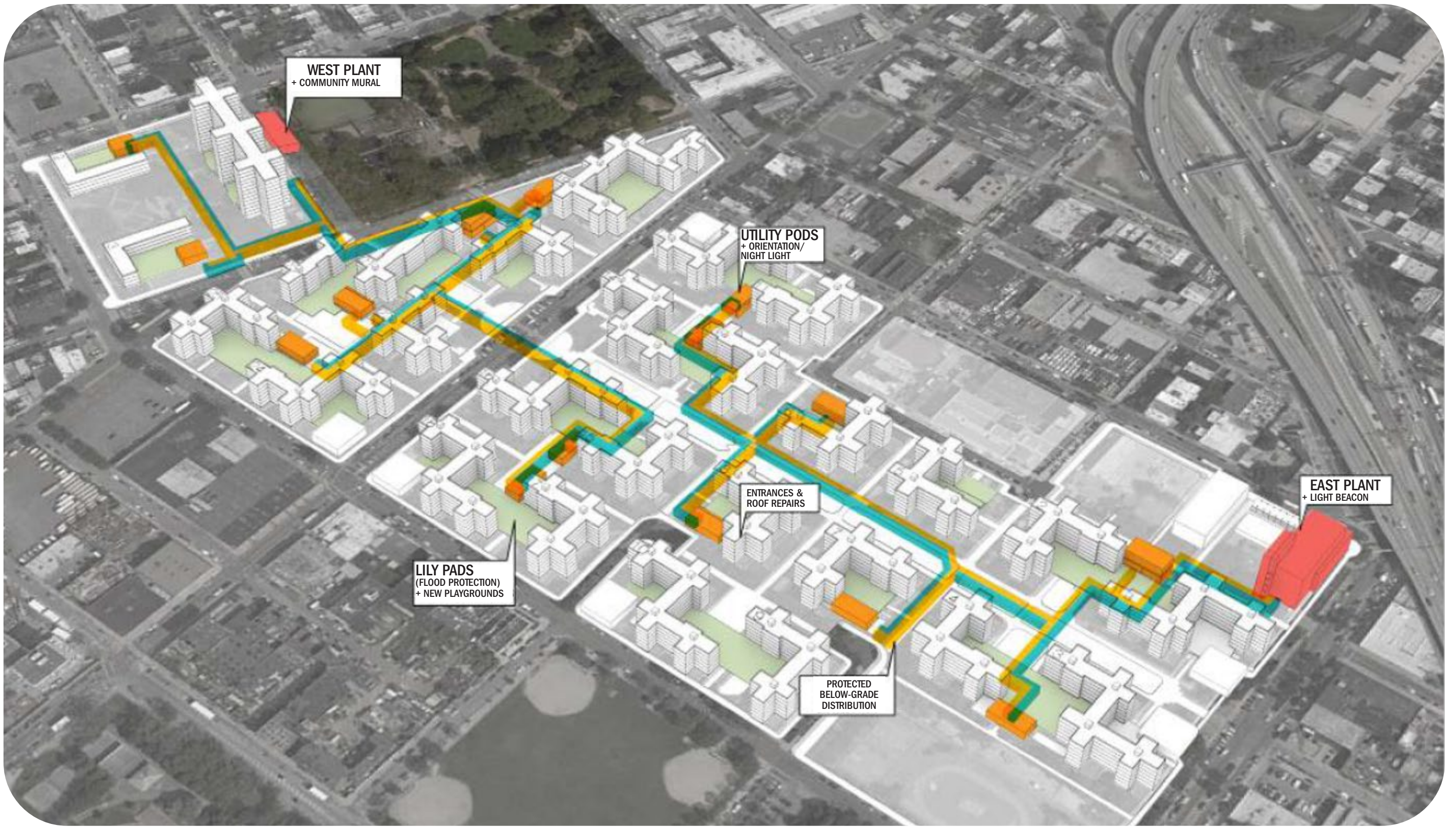
The pods include heat exchangers (water/steam): hot pressurized water exchanges energy with a secondary distribution system of steam that then distributes heat to the buildings. The pods also include electrical services: the utility company provides electricity to the pod and then it is distributed in the buildings.

At Red Hook, two additional options were considered in the mechanical assessment report:

- **Centralized steam distribution (new plant) and decentralized back-up power (on the roof)**However, this was not feasible due to the structural integrity of the roofs of these 80-year old buildings. Additionally, centralized power plants were more cost efficient and in the end two structures serve the backup power needs of the entire almost 40-acre site.

- **Co-generation plant using a gas turbine to provide both heating and electricity**
  Co-generation creates efficiencies because the excess heat generated from making electricity is used to heat buildings and provide hot water. NYCHA investigated the potential to use this option, but it was not cost-effective without the ability to feed excess power back into the electric grid, an option that the utility did not make available to NYCHA at the time. NYCHA especially needed the ability to receive credit for excess electricity generation during the summer months, when steam is not needed to heat buildings.

The Coney Island Houses project contains a new elevated boiler plant building to provide heat and hot water for the entire development. In this case, the backup power generators have been placed on building roofs. The new boiler plant required changes to parts of the distribution (from the central plant to the MEP annexes and from the MEP to the building) but the distribution in the building and the apartments themselves were not modified. Space for a multipurpose room was created as an artifact of elevating the boiler plant.



Location of MEP annexes (in orange) and centralized plants (in red) in Red Hook

Conceptual rendering of MEP annexes in Red Hook (Credit: KPF)

Community space created within and adjacent to the new boiler plant in Coney Island Houses

Green roof on top of the boiler plant at Coney Island Houses

STRATEGY 2

Protect Equipment Inside Existing Buildings

For boilers and other equipment remaining in spaces that are below the design flood elevation (DFE), NYCHA protected boiler rooms and electrical rooms with dry floodproofing beyond the city-mandated DFE incorporating up to 2.5 feet for sea level rise (SLR). Similar to the flood protection measures that were used to protect entire buildings, described in a separate section, solutions such as reinforced walls, flood doors, or channels for flood logs were applied inside buildings to protect critical infrastructure. As part of a layered protection strategy, critical interior rooms are protected by flood doors and logs to an even higher level than the building as a whole.

Another strategy developed in Coney Island Sites has been to repurpose apartments above flood elevation into technical rooms in order to prevent the need for costly protections of underground spaces.[5]

At Ocean Bay Oceanside in Far Rockaway, the ground floor of each of the seven buildings contained critical equipment. In the five buildings that had sufficient space, that equipment was doubly protected. The perimeter of each building had flood walls around the entrances and deployable flood logs and panels for doors and windows protecting the interior space to the design flood elevation and accounting for sea level rise. In addition, equipment was raised off the floor or enclosed in a reinforced room with a second set of flood logs to increase the level of protection.

Two Bridges: in order to protect a fire pump room, a deployable flood barrier is installed inside the building

Two Bridges: Flood door in a hallway in the basement to delineate a protected zone

Raised equipment at Ocean Bay Oceanside

STRATEGY 3

Locate Critical Infrastructure on Rooftops

Placing equipment on rooftops was an important strategy for flood protection of various types of critical equipment. Placement on roofs was not universally possible; it requires not only sufficient space on the rooftop, but also a structural analysis of the building to verify that it can support the additional weight, which would not have been contemplated when the structure was originally built. When the structure could not support the weight, the prohibitive cost of structural reinforcement often exceeded the cost of an alternate strategy, such as the construction of an annex building.

At 21 sites across the Recovery and Resilience program, generators were located on roofs to protect them, whereas boilers were located on roofs at only one development—Ocean Bay Bayside. This was because—beyond structural concerns—hydronic rooftop boilers would have required a completely new heat and hot water distribution system within the building. This would have represented an extraordinary additional cost, as well as being very disruptive work within the buildings. This type of system change is feasible with a more comprehensive approach to a renovation as was the case at Bayside, which was rehabilitated as part of NYCHA's PACT program.[6]

This type of holistic approach is embraced in NYCHA's Transformation Plan, which includes a comprehensive modernization approach to development investment, as opposed to component-based repairs.

Hydronic Boilers on the roof at Ocean Bay Bayside

The advantage of placing generators on roofs is to keep a backup source of power far from the risk of flooding. At each development, the design team would consider the additional resilience of each building having its own source of backup power versus several buildings or a campus depending on a centralized source. The decentralized system may be more resilient, but it also increases the maintenance and operation efforts necessary to run those generators.

Placing generators on rooftops requires conduit runs for the natural gas and electrical connections. Different materials and colors can be used for additional aesthetic benefit. However, at specific sites, the **State Historic Preservation Office** has added requirements on the exterior look of the new construction.

For conduit enclosures, different solutions have been developed:

- **Specific color or use of contemporary enclosures** – the objective is to change the overall presentation of the building.

- **Exposed** – the objective is to show off the technical parts of the building and to change the overall presentation.

- **Brick color** – the objective is to be discreet and meet with the requirements of the State Historic Preservation Office.

Natural gas conducts, different design solutions: Blue conduit enclosures in Ocean Bay Bayside (bottom left), Exposed conduits in Gowanus (top left), Brick color enclosure in Smith houses (top right), Contemporary enclosure and reuse of existing conduit in Coney Island Houses (bottom right)

STRATEGY 4

Scaffolding

Where roof capacity or structural integrity precludes use, an alternative is to raise the equipment on a simple scaffold-like structure. This solution requires enough space on the ground, which can be challenging, but has been possible in even the smallest development included in the program (Lower East Side V).

Installation of a generator on post at Lower East Side V

STRATEGY 5

Backwater Valves

Across the portfolio, NYCHA installed approximately 400 backwater valves to prevent sewage from an overloaded main from backing up into a building or into first floor apartments. This is a risk both in cases of flooding caused by storm surge, as well as when there is a particularly heavy rainstorm, which is becoming more common in New York. In many cases, this installation was critical to floodproofing strategy and in other cases, it was an element of the code compliance required by the Department of Buildings due to other investments being made on the plumbing.

These are relatively standard devices for licensed plumbers and were familiar to the contractors, but they could be unexpectedly challenging to install. In many cases, it was not practical for design teams to uncover the sewer pipes for which they were designing the retrofit. Repeatedly across the portfolio, the contractor would excavate the pipe only to find that it was being held together by the packed soil surrounding it and or that it had major cracks that would never have been discovered if they hadn't uncovered it, but now it couldn't accommodate the retrofit without replacement.

The valves require NYCHA to change its training and standard operating procedures for clean-outs. Sewer pipe blockages are common and are usually resolved with tools—snakes and sewer augers, hydrojets and cameras—that are not compatible with backwater prevention valves. For pipes with backwater valves, the best practice for clearing blockages involves removing the check valve flapper and cleaning the line from the house trap's clean-out cap; however, the flappers must be reinstalled correctly after this is done or they will malfunction in the event of a flood, so new training for plumbers is required. The backwater valves can also increase the frequency of backups because they have been reported to catch baby wipes and other more solid types of items that are flushed down toilets. Installing cleanout caps on the building exterior could alleviate the danger of damaging backwater valves when lines are being cleared, and this solution should be considered in future installations.

An additional consideration is that while the backwater valves prevent wastewater from coming in, they also prevent it from being discharged. In accordance with current city policy, NYCHA intends to evacuate buildings in advance of the type of major storm that would trigger the valves. However, with the increase in the frequency of severe weather events in the future, it is very likely that there will be some circumstances in which the valves are triggered and the building is not evacuated or is only partially evacuated. In that event, wastewater will fill the pipe within the building and then may back up into apartments.

A future retrofit to these buildings—and a standardized best practice going forward—would be to install associated wastewater storage tanks. This would allow for limited building wastewater use until the flooding has receded. Installation of wastewater storage tanks was not within the scope of the program at most sites, but because they were necessary for normal building operation at Coney Island Houses, ejector pumps and wastewater tanks were installed at that site that are capable of managing surplus wastewater in the event of a flood.

Lessons

By installing flood protection at 35 developments under highly varied conditions with different site constraints, NYCHA now has the benefit of having seen a large number of strategies used to protect critical infrastructure. When protecting these essential systems, NYCHA recommends:

- **Protect critical infrastructure with passive systems where possible.** Critical infrastructure that is physically elevated out of the design flood elevation is safest; NYCHA has moved to installing above-grade boiler buildings where flooding is a threat where site constraints allow it because there is no need to deploy protection systems to be sure that this equipment is safe.
- **Where site constraints and costs prevent passive systems from being employed, protecting indoor rooms containing critical infrastructure can be a cost-effective and manageable strategy.** Dry floodproofing key critical infrastructure within buildings is much less costly and intrusive than dry floodproofing an entire building's first floor and basement, and is a good alternative where there is not enough space or budget to build a separate boiler or MEP annex.

3

Protect Structures

Protecting entire buildings from flooding ensures not only that critical infrastructure continues to function, but also protects first-floor uses such as community centers, maintenance offices, and apartments. NYCHA protected structures using two main methods: dry floodproofing, which prevents water from entering the building entirely, and wet floodproofing, which allows water to enter and exit the building while ensuring that critical equipment and other essential uses are out of the potentially inundated zones.

Passive barriers at Campos Plaza

STRATEGY 1

Dry Floodproofing

Dry floodproofing is a method that has been broadly used in the program on 32 sites of different sizes and layouts. The method prevents floodwaters from entering all or part of a structure through the use of impermeable materials and flood barriers.

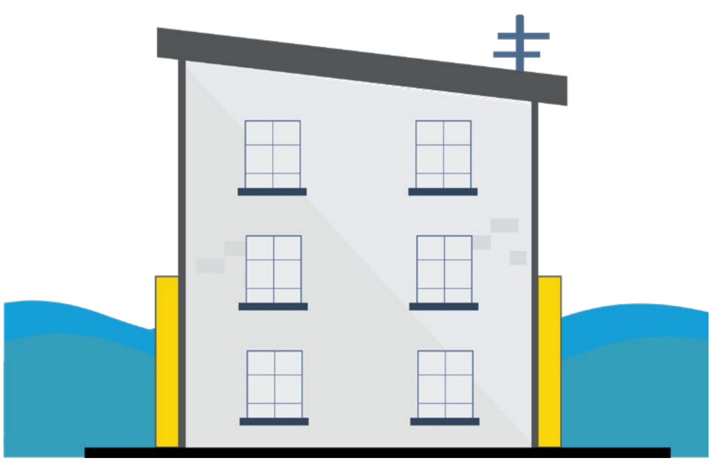
Lower East Side V: Deployable flood panels in front of a store

There are a variety of techniques available to implement dry flood proofing.

At eight developments, **passive flood barriers** are being installed as part of the overall flood mitigation strategy. When there is no flooding, the barrier is horizontal and flush with the ground. In case of flooding, the water pressure will cause the barrier to flip into a vertical position thereby protecting the building without requiring the deployment of staff.

Passive barriers have a great advantage in that they do not require labor to deploy them. However, the presence of a limited number of NYCHA staff will be required regardless in some capacity during an emergency to verify that the system responds correctly.

FIGURE 2 Principle of dry floodproofing



Also, there is still a component of maintenance that needs to be performed annually and prior to events to ensure debris, dirt or other items do not impact the operation of the system.

It is not possible though to install this system in every situation as it requires space in the ground (at a minimum the height of the protection) and the systems are often far more expensive than a deployable system to protect the same entrance.

At 26 developments—75% of the total—**deployable flood barrier systems** are being installed. These barriers are composed of structures that have been custom fabricated; they are usually made of concrete for the permanent parts and then aluminum for the vertical channels that serve as the place where horizontal flood logs have to be installed. These barriers can also be placed directly in front of windows or doors.

In Lower East Side V, a small tenement style two-building development in Lower Manhattan with retail on the first floor and residential apartments above, existing stairs and ramps and a roll down security gate near the entrance prevented the implementation of passive barriers.

Challenges

Dry floodproofing solutions rely on appropriate storage and correct deployment of a large number

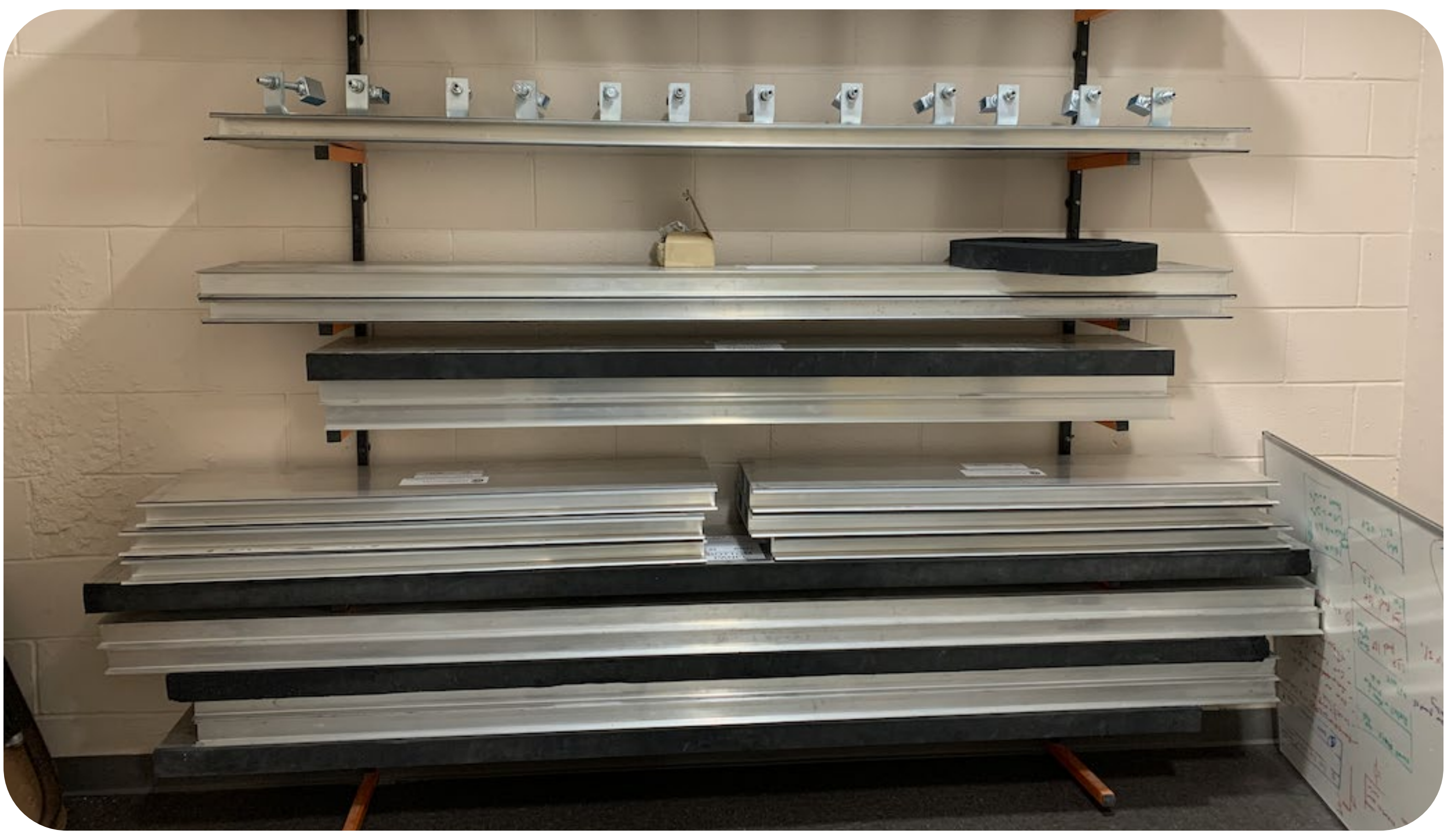
At Lower East Side V, site constraints required critical infrastructure be protected in existing below grade spaces of elements to protect buildings and infrastructure from flood damage. In the event of a deployment, teams have to be dispatched—potentially simultaneously—on numerous sites in far flung neighborhoods, which is a logistical and organizational challenge. For the 2021 Hurricane Season, NYCHA has chosen to engage an emergency services deployment contract; this will be reconsidered in the future as NYCHA staff become more familiar with deployment methods and the agency considers taking on deployment internally. NYCHA continues to explore ways to improve the ease and speed of deployment where deployable elements are installed, including providing property management with specialized drill bits to avoid the need to hand screw components and potentially replacing the connectors that are most labor-intensive to install with simpler pieces.

Considering the enormous challenge of the deployment process, design details of deployable flood protections should be chosen with ease of deployment in mind, while balancing design and other considerations as needed.

NYCHA's experience installing deployable systems leads to the following recommendations for any future flood protection projects:

× **Design Appropriate Storage Spaces**

While deployable barriers have fewer constraints that prevent them from being incorporated into a variety of locations, one site constraint of deployable barriers is the availability of appropriate and convenient storage spaces. Appendix G of the NYC Department of Buildings code requires different storage spaces in different buildings in order to diminish the time of installation by having the barriers located as close as possible to the place of deployment. As NYCHA was not subject to Appendix G, the program applied various models for storage. While centralized storage space on each campus might have the advantage of making it easier to secure and track barriers and allow more efficient use of storage space overall, this approach is not necessarily implementable in existing structures with already programmed back of house spaces.



Storage room in Coney Island 1B

Coney Island 4/5: Example of gasket damage that has to be avoided

In addition, NYCHA storage spaces do not have good climate control, are subject to leaks from above, and flooding of sanitary water coming up from floor drains when stoppages occur. These conditions can do damage to the gaskets on the flood protection system components stored there. This is a major challenge for the reliability of these systems. A best practice is to store these components in constructed places that are not susceptible to undermining conditions. This was done at Smith Houses where components were put in external raised shipping containers. For any storage spaces used, facilitating appropriate labeling and access to keys is essential so that deployment is not delayed in an emergency.

Flood panels have rubber gaskets in order to waterproof the structure. These gaskets are located on the side or on the bottom part of the center post mullions. Gaskets may be damaged if they are stored in a position where the weight of the panel pushes on the gasket. This issue has been reported at Coney Island Houses, Coney Island 4&5, and Ocean Bay Oceanside.

It is essential that inspection of each gasket occurs when components are delivered and then on an ongoing basis in order to have an effective system. Proper and sufficient storage space must be arranged in order to diminish this risk of damage. Horizontal storage, as in Coney Island 1B, is an efficient way to approach this issue. As the rail system can deteriorate the rubber gasket, the metal side must face the wall.

× **Use Interchangeable Logs Where Possible**

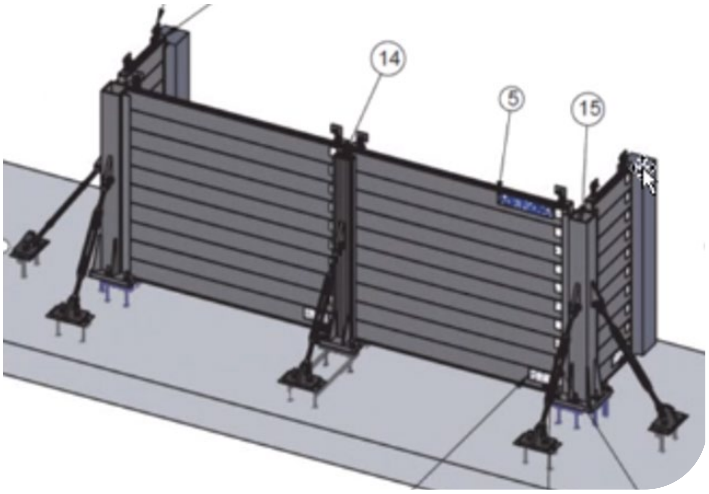
The bottom parts of a flood wall receive more hydrostatic pressure than the upper parts. Thus, in certain cases, structural reinforcement is necessary for some logs. Reinforcement is done by fixing an extra piece of aluminum to the log to increase strength.

Concrete part of the wall in Smith houses where logs can be deployed between the two pillars to protect the building. The designer had the opportunity to change the lengths of the logs by modifying the distance between the 2 pillars.

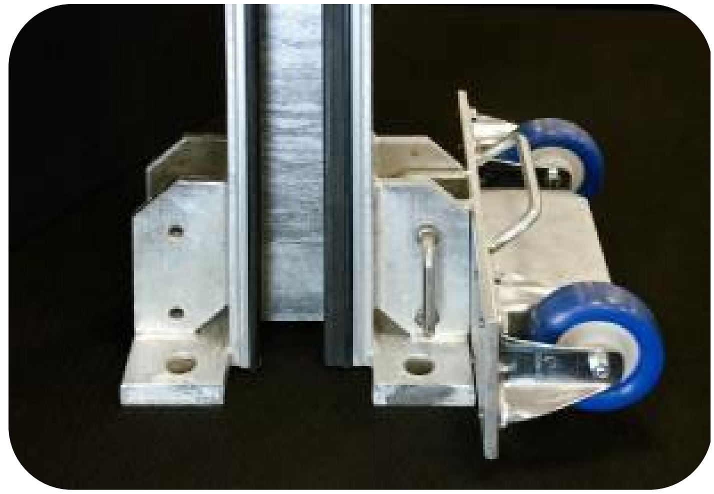
One solution is to reinforce only the logs for which it is a structural necessity, meaning the ones on the bottom. A more expensive solution is to reinforce every log that will be deployed, even the ones that don't need reinforcement from a structural point of view. This solution has the advantage of making the logs interchangeable and reduces the risk of improper or delayed deployment. The owner and the designer must make a decision about this issue weighing the various benefits, risks, and costs.

Furthermore, in some cases the length of the logs is defined by the site constraints. In other cases, the designer has the opportunity to make some logs the same length. If there is a greater consistency of log size, there is less chance for deployment installation errors and a shorter deployment time.

Log structural reinforcement at Smith Houses



Astoria: A flood barrier composed of 4 panels and 3 posts to deploy


Attachable set of transit wheels in Coney Island 1B

× Consider the Weight of Flood Logs When Determining Their Length

Another question that has to be taken into account when determining the length of the logs is the ability to store and transport them. Longer logs are heavier and more difficult to maneuver in tight spaces and, subsequently, will take more time to be deployed. Some removable components are heavy and have gaskets that can be damaged if dragged on the ground. At Coney Island 1B, the manufacturer has made an attachable set of transit wheels. Property Owners should consider these additions as the heavier removable posts can be damaged if dragged and could put workers at more risk of injury from lifting.

× Balance the Difficulty of Deploying a Large Number of Elements Against Design and Safety Considerations

At certain sites, designers have the option to choose whether to increase the number of logs or to increase the area of a permanently installed structure.

This was the case in Astoria Houses Building 23 which has four panel openings, two corner posts, and one center post to cover one door.

In this case, an alternative design replacing the two parts perpendicular to the building with concrete walls would have reduced the number of panels but increased the number of unattractive concrete elements permanently installed, which NYCHA chose not to do.

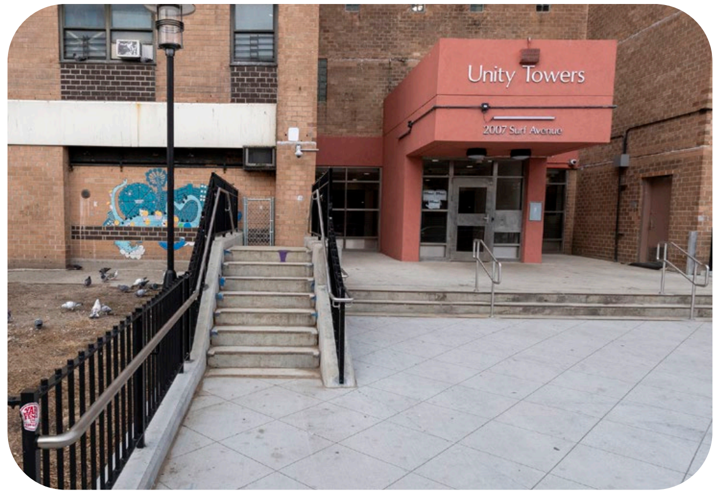
By contrast, the original design at Ocean Bay Oceanside had walls as high as 8’ tall around entrances. Feedback from residents and property management was that this would make the spaces feel unsafe and that visibility was a priority as flood risk was only a rare occurrence. The design was amended to incorporate additional wall cut-outs at every main entrance; however, this has increased the number of flood logs to deploy considerably. The seven buildings at Oceanside now require deployment of more elements—2,200—than any other development in the program, even campuses with many times the number of buildings or acreage.

NYCHA worked to balance concerns about safety and aesthetics with concerns about the more difficult deployment of flood protection elements.

× Seek Easily Deployable Emergency Stairs

In order to allow access to the building in case of an emergency after deployment of flood barriers, NYC Department of Buildings requires code-compliant stairs. At most of the campuses, these stairs are designed to be dismantlable or collapsable for storage; they are intended to be deployed at the same time as the barriers. Each design is different in order

Permanently deployed stairs at Gravesend



Permanently deployed stairs at Coney Island 1B

Deployable stairs on a hand cart in Oceanside cannot be bolted to the ground.

The deployable stairs in Smith houses can be bolted to the ground for stability

to correspond to the site constraints. These stairs must be carefully designed to fit storage constraints and have a reasonable deployment time.

The number of pieces required to assemble the stairs is an important factor and these pieces must be easily transportable and trackable. A particular design challenge has been to minimize the number of bolts required to deploy the stairs. In some cases, designers incorporated the option to bolt the stairs to the ground to create more structural stability.

NYCHA is particularly sensitive to the level of effort to construct and deploy the stairs across the portfolio due to the scale of the program. However, the challenges of designing deployable code compliant stairs for retrofit projects is worth industry consideration. As the demand grows, the development of modular, easy-to-construct, code compliant stairs would help less resourced property owners to implement feasible projects in multi-family buildings.

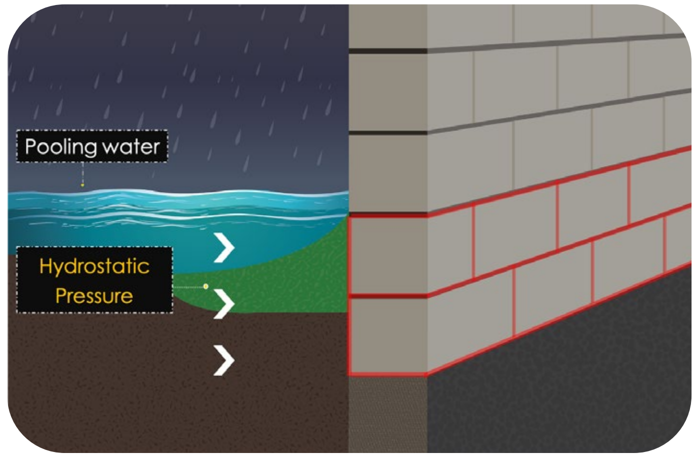
To reduce deployment time and storage needs, at some locations, such as Coney Island 1B and Baruch Houses, stairs were integrated into the flood-proofing and are permanently deployed. Where space is available, permanent stairs for use during flood panel deployments is a best practice, but it is not always feasible due to entrance design. At Gravesend, there are both permanent and portable stairs.

STRATEGY 2

Structural Reinforcement

The level of protection NYCHA was going to incorporate in these projects started with the **base flood elevation (BFE)**, which is determined by FEMA. NYC Department of Buildings requires one foot of freeboard, additional protection to be added on top of BFE which sets the **design flood elevation (DFE)**. For critical infrastructure, NYCHA added 2.5 feet of anticipated **sea level rise (SLR)** to determine the level of protection. These projections for sea level rise are in line with projections from the New York City Panel on Climate Change at the time of design.

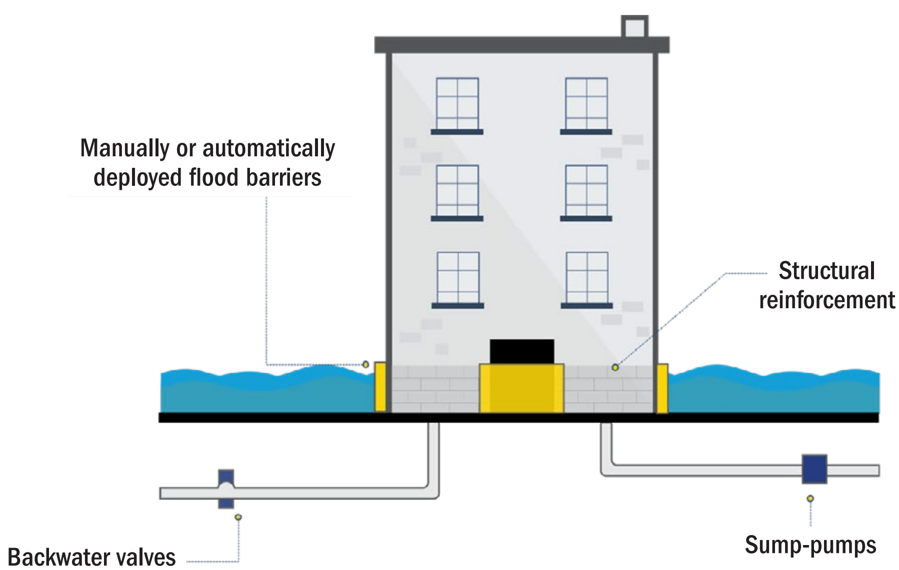
When a building is dry floodproofed, structural reinforcement may be necessary because of hydrostatic forces on the structure of a building that was not designed to handle these forces. In some cases, it was determined that the existing structures were sufficient if, for instance, the DFE was close to grade. However, at many of the buildings it was determined that this reinforcement was required for the slab of the building, the below grade portions of the foundation, and the above grade portions of the façade below the DFE.

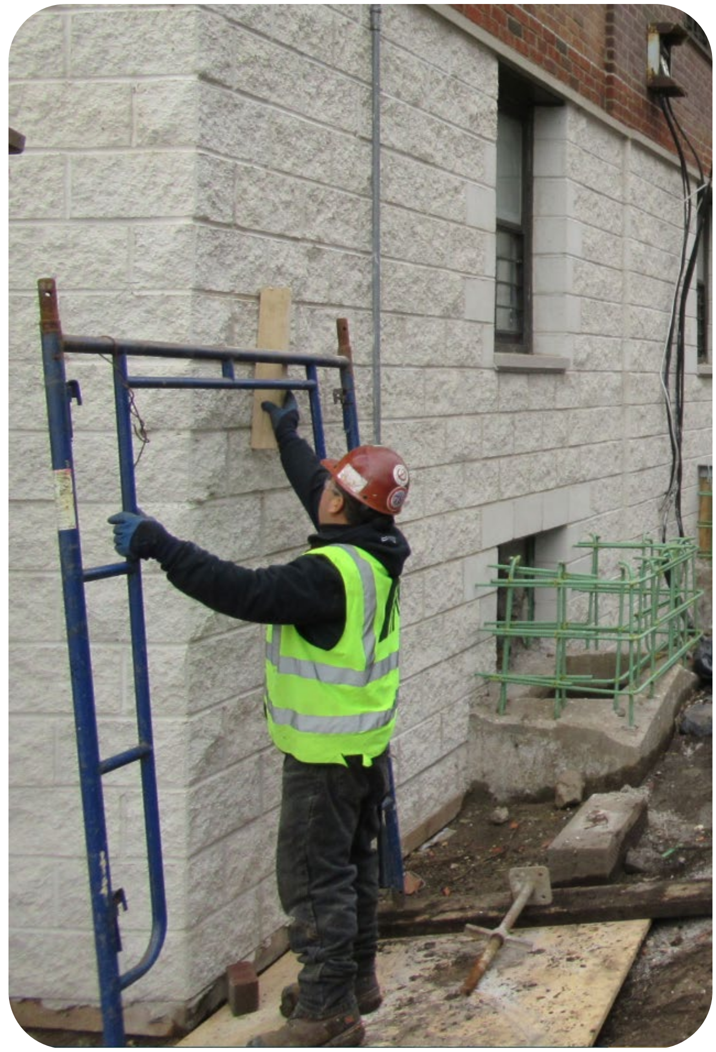


A variety of solutions were used across the program:

- Additional layer added to the exterior of the building (example: Coney Island Houses)
- Interior reinforcement of walls and slabs (example: Two Bridges)
- Partial demolition of walls prior to reinforcement (example: Riis)
- Addition of an interstitial layer to the existing structure to provide reinforcement from hydrostatic pressure and prevent seepage (examples: Gravesend and Baruch)

FIGURE 3 Principle of dry floodproofing: Structural Reinforcement





Coney Island Houses: The reinforcement of the first floor responds to a structural constraint but at the same time contributes to a new identity for the site.

Coney Island Houses: reinforced wall (left) and sum pumps (right) in the basement that need to be protected from flooding.

Often, the solution at a single site is a combination of several methods to fit the varying requirements of the existing structure.

At Coney Island Houses, reinforcement inside the building below the level of the DFE has been done to provide reinforcement from hydrostatic pressure, prevent slab uplift, and prevent seepage.

On the first floor of every building, an additional layer has been added in order to reinforce the structure. In addition to responding to this technical requirement, the use of stone for the facing contributes to the creation of a new visual identity for the site.

Two Bridges in Lower Manhattan was very site constrained, so critical equipment – the boiler room, gas room, electrical room, fire pump room – has not been moved to a higher location. Rather, deployable flood barriers have been installed in front of the doors outside of the room housing this critical equipment and its walls have been reinforced. With the desire to minimally impact the existing pipes and electric wires, certain reinforcements were installed outside of the room and others inside of the room. In the case of the boiler room, some walls have been entirely replaced as well, as that was the easiest solution. In all cases, the slab was replaced and reinforced to protect the room from groundwater.

Gravesend: Structural reinforcement was designed to blend with the existing facade.

Two Bridges: Structural reinforcement inside the gas room and outside of the fire pump room

STRATEGY 3

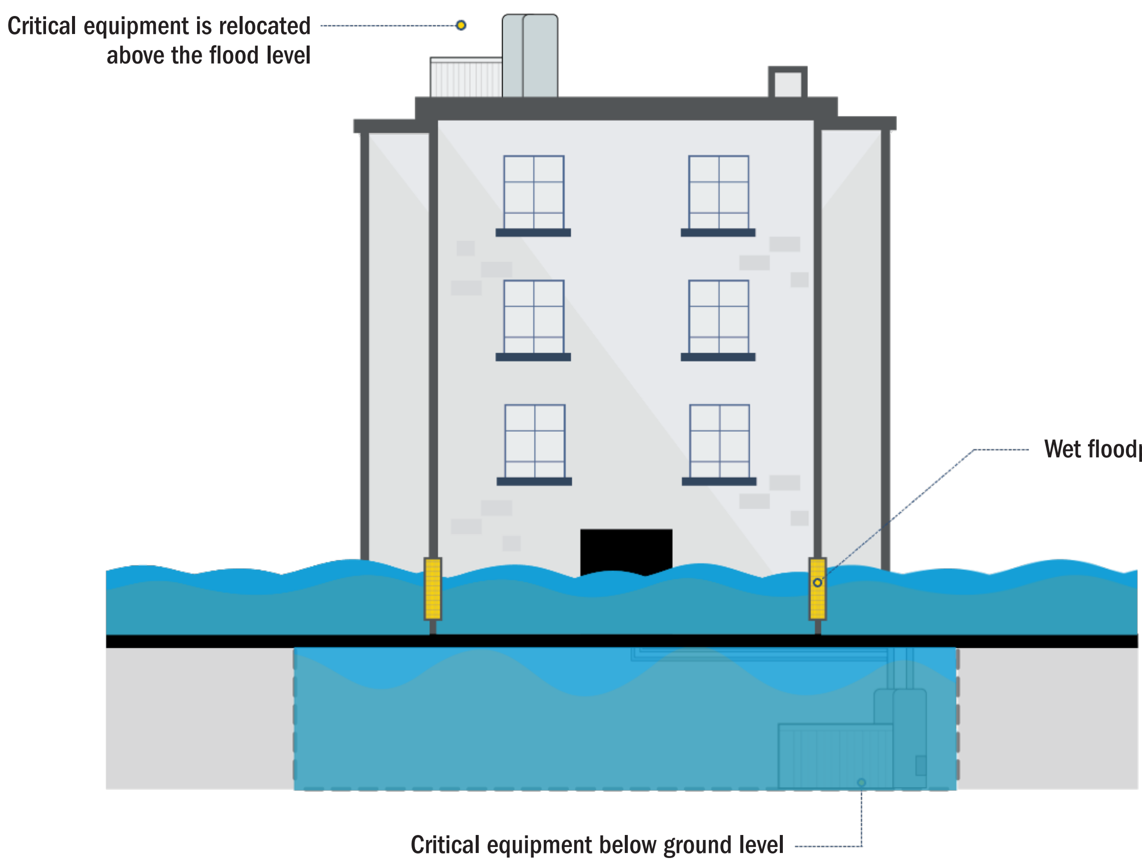
Wet Floodproofing

The principle of wet floodproofing is to allow floodwaters to enter a building to equalize hydrostatic forces on the walls and floors, thus eliminating the need for expensive structural reinforcements. This technique has been implemented in limited circumstances in the Recovery and Resilience program – at Isaacs, Haber, Redfern, Red Hook East & West, and Two Bridges.

An alternative and interesting solution is to combine dry flood proofing and wet flood proofing as has been done in Two Bridges. This single building high-rise is very site constrained and has an existing below ground parking garage.

To protect the structure of the building itself, flood vents have been installed in the inside parking garage which is located mostly below grade. The boiler room, gas room, electrical room, and the fire pump room could not be relocated from areas at risk of flooding on the first floor and in the basement. These rooms have been dry floodproofed and reinforced structurally. As a result, only a few rooms required structural reinforcement instead of the whole building, which was highly cost effective.

FIGURE 4 Principle of Wet Floodproofing



Two Bridges: wet floodproofing vents seen from the outside of the building

An open vent in case of flooding (Picture courtesy of Smart Vent Products, Inc.)

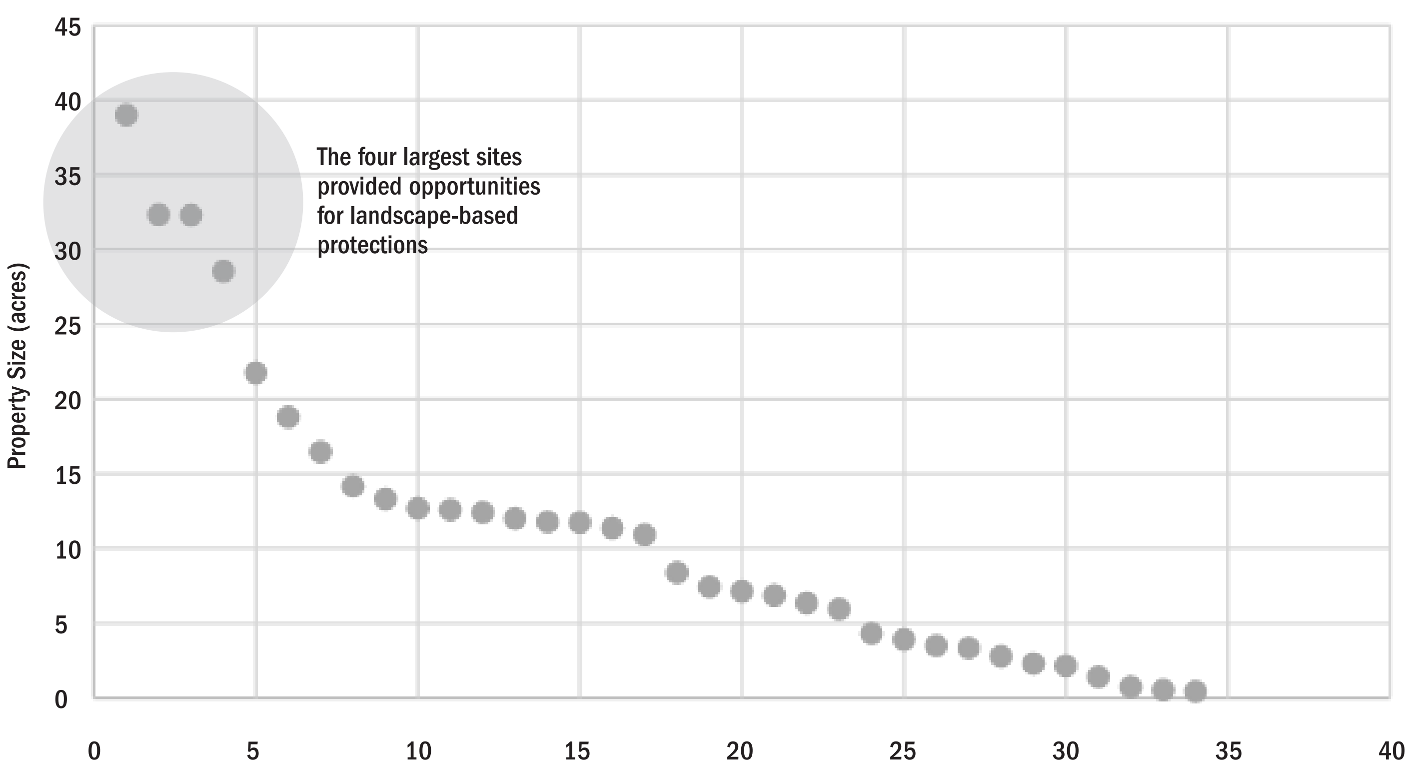
Two Bridges: the parking area has vents in order to wet floodproof

STRATEGY 4

Post Flooding

In addition to evacuating water from wet floodproofed buildings, the same will also be needed for the dry floodproofed buildings. This is because of allowable water infiltration through flood barriers and other flooding factors such as rooftop stormwater will be collected inside the flood protection system and will need to be evacuated following a flood event. Our design team considered this by including post flood sumps and portable pumps specifically for this effort. The sumps are about 2' square and 2' deep and placed at the low points in the building basement or along the building exterior such as basement ramps. These pits are meant to fill with water creating a low point to place a portable pump to remove all water. Because sump pumps can't pick up the bottom inch of water, these sumps reduce the quantity of water that can't be pumped out post flooding to just under 5 gallons. This design created some additional issues that NYCHA will need to manage. For example, these sumps constantly fill with water accumulated from pipe leaks, storm water and other sources such as sewer stoppages. If this water is not evacuated regularly, they will promote insect and rodent infestation. Additionally, NYCHA will need to ensure the supplied sump pumps are maintained and stored for this purpose. This will be challenging as NYCHA is constantly in need of these types of sump pumps for other purposes.

FIGURE 5 Developments within the Recovery and Resilience program range from less than half an acre to 39 acres for the combined Red Hook East and West site.



STRATEGY 5

Site-Based Protections

Site-based and landscaping protections are attractive and have the potential to provide placemaking and aesthetic co-benefits. The ability to use this type of solution, though, depends both on having a site that is large enough to accommodate new landscape features, and on topography that can be modified in a way that protects buildings. For small sites, building walls or barriers would have resulted in an unappealing fortress-like feel.

Site-based protections were designed only for the largest sites in the program: Baruch Houses, Ocean Bay Bayside, and Red Hook East and West FIGURE 5.

STRATEGY 5A

Flood Walls

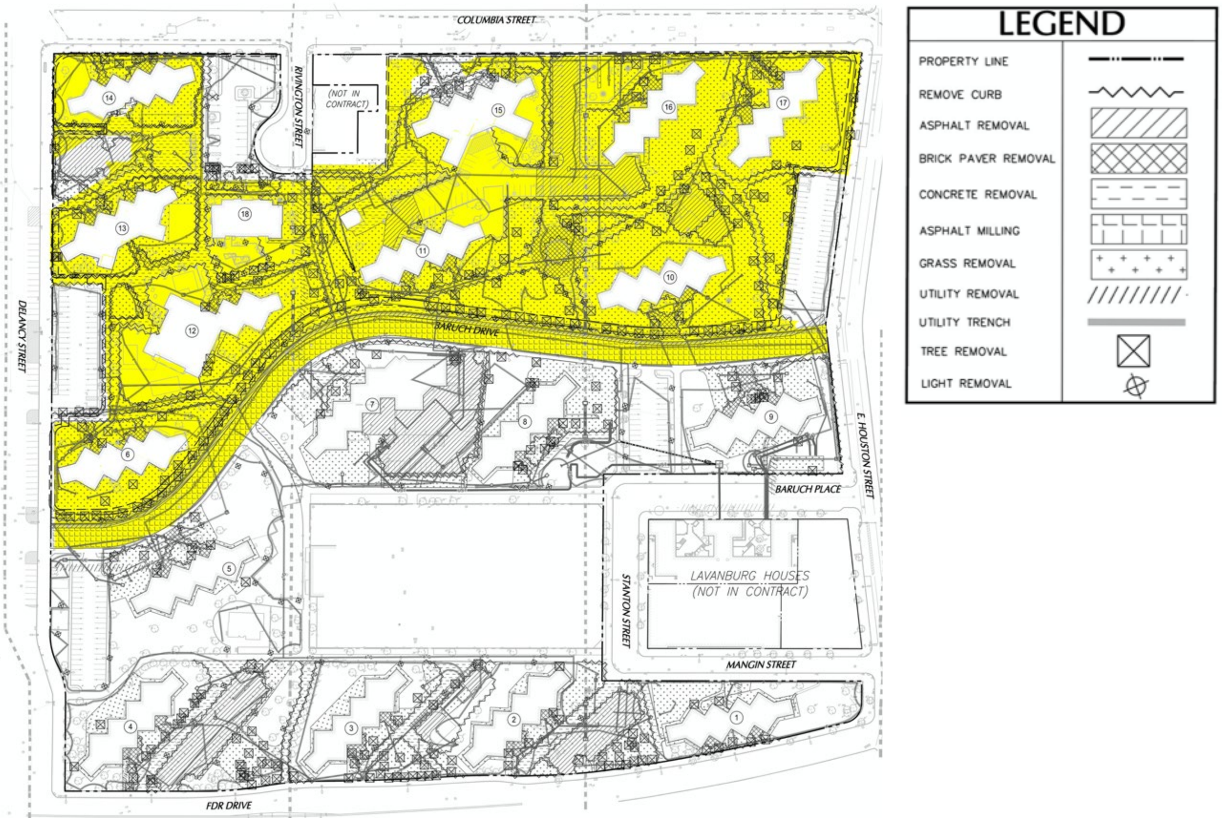
At Baruch and Ocean Bay Bayside, flood walls were built to protect the site passively. This solution prevents floods by creating a raised, uniform freeboard, but also requires a strategy for water retention, such as bioswales. Protecting one property cannot increase runoff at adjacent sites, so retention basins are required to capture, detain, and drain the excess. The main advantage of a flood wall is that it is a passive system that does not need deployment in case of an emergency.

Baruch Houses

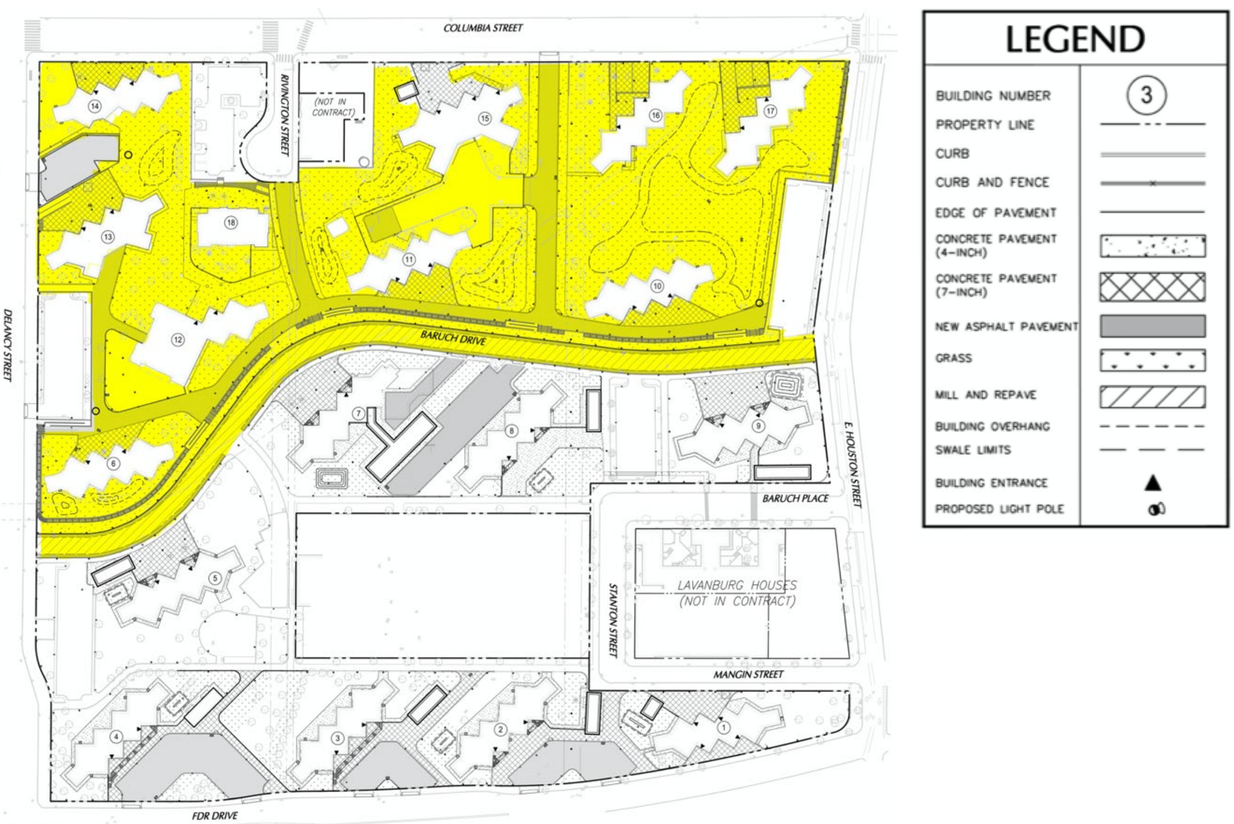
The topography at Baruch Houses provided the opportunity to envision a more ambitious design, but in this case the implementation was only possible because the initial FEMA 428 funding was supplemented by the FEMA Hazard Grant Mitigation Program (HMGP). Initially, only the 10 buildings closest to the East River (as well as the management office that serves the whole development) were funded for floodproofing through the FEMA 428 program. The other 9 buildings at Baruch were still at risk of future flooding despite a lack of severe damage from Hurricane Sandy. NYCHA continued to pursue additional funds through HMGP for these buildings. The slope of the site allowed the installation of a flood wall following an existing road that bifurcated the site in order to protect these buildings in a more cost-effective way than what would have been possible on a building-by-building basis. This land-based solution allowed for passive flood protection of almost 15 acres of a 30-acre site.

Installation of the wall has not been without challenges. Many New York City waterfront sites, including Baruch Houses, are built on urban fill, which tends to include unexpected and oversized historic debris that has required excavation beyond what was anticipated. In addition, this particular site is crisscrossed with various unmapped and unmarked utilities, which required additional testing to determine which pipes were still active and the adaptation of the wall footings to accommodate the distribution systems. The flood wall presented difficulties with Fire Department access to the building's standpipe Siamese connections as well. They could no longer locate and connect to the building mounted connection easily from the fire apparatus on the other side of the wall. To solve the problem, NYCHA modified the design to bring the standpipe connection out from the building through the wall. Finally, Baruch Houses is built in an area of potential

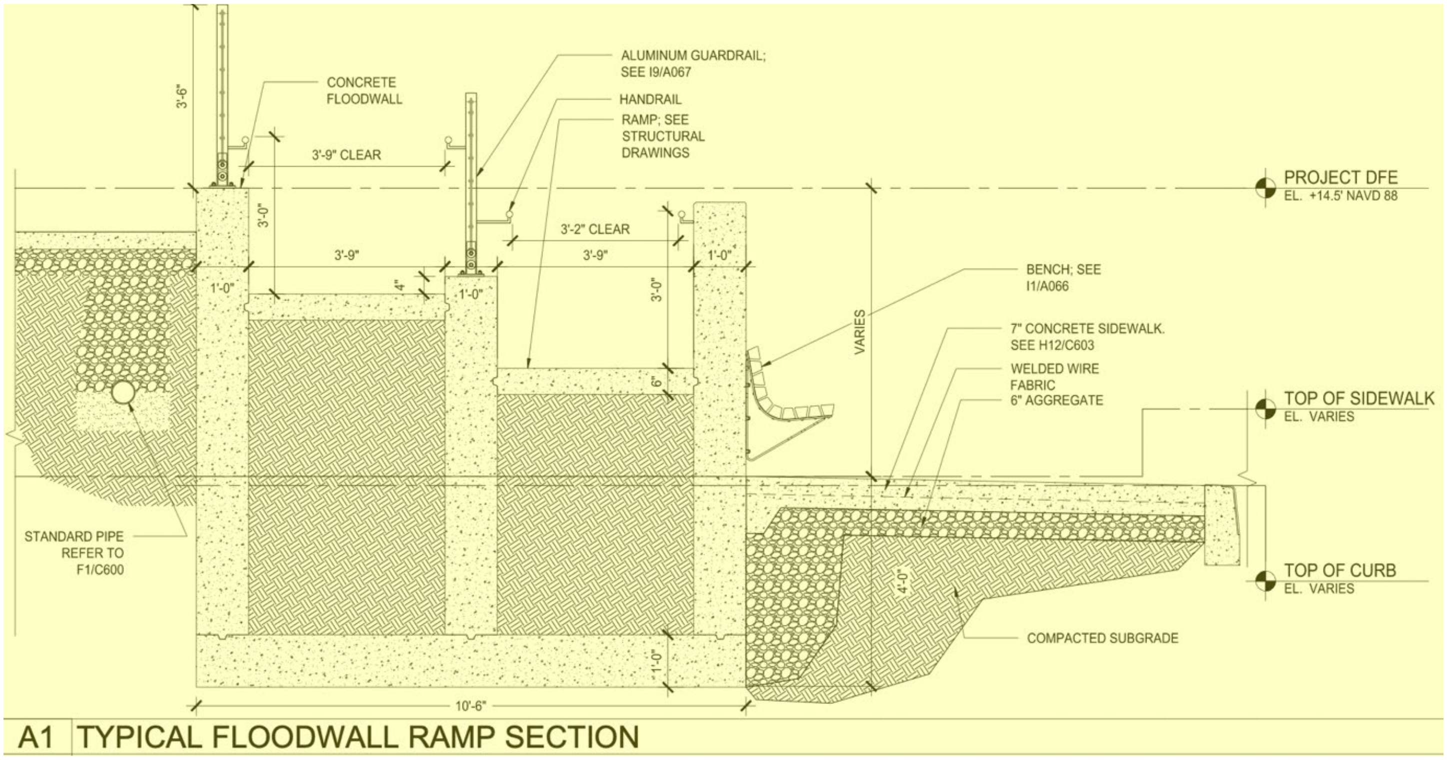
Vinyl poster explaining flood protection elements under construction at Baruch Houses

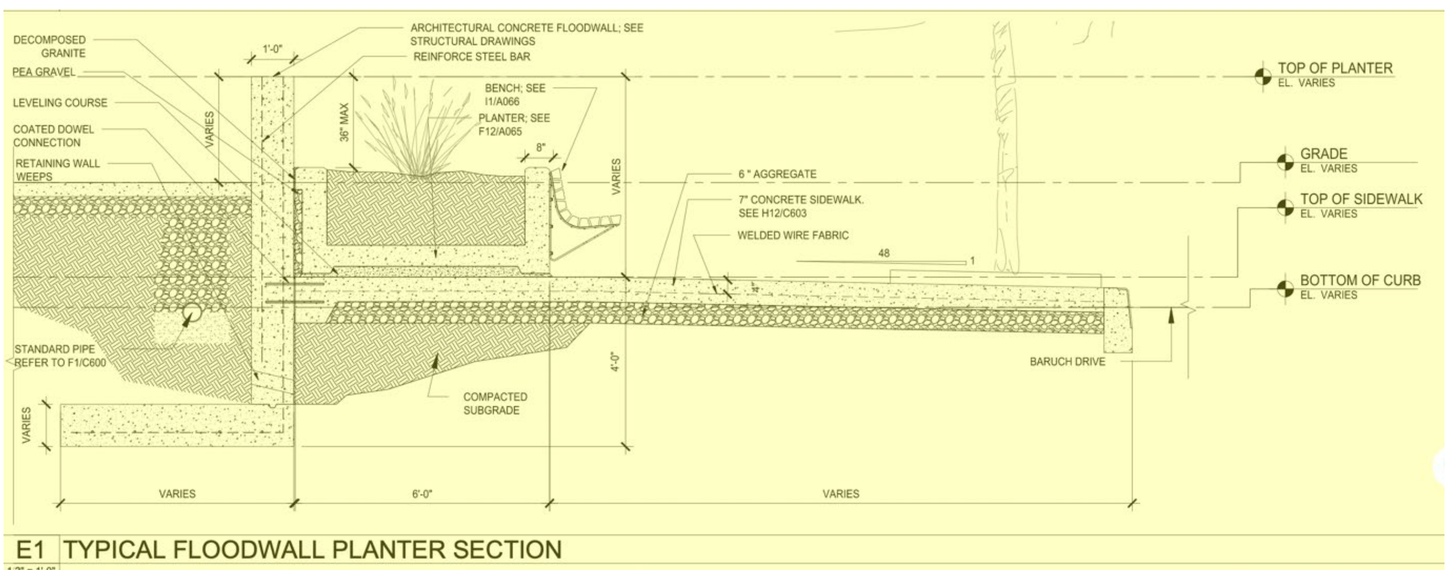


Baruch site removal plan



Baruch general site plan





Typical sections of ramp section and planter section in Baruch (Courtesy of Nelligan White)

Baruch Houses: Design representation (Courtesy of Nelligan White)

historic significance, so an archeologist was brought in advance of and during the project to ensure that excavation would not impact potentially historic findings. The initial archaeological report identified locations with potential archaeological sensitivity associated with tenant dwellings erected prior to 1850 where mid-19th century features could remain intact, such as cisterns and privy pits. By way of field investigation, a determination of no archaeological significance for all locations was determined and submitted to the State Historic Preservation Office (SHPO) and FEMA, per the requirements for the site.

As the floodwall nears completion, NYCHA is pursuing additional funding to leverage the 4,104-foot-long wall as a palate for art and a message board for education on resilience. This is an opportunity to work with the community to turn a piece of resilience infrastructure into an opportunity to improve the pedestrian experience and site aesthetics.

Baruch's flood wall design has been able to integrate ramps, as well as flower beds. It also includes an integrated bench that makes the public space more welcoming.

Ocean Bay Bayside

Following the award of disaster recovery funding to Ocean Bay Bayside, the site was also slated to receive funding through a Rental Assistance Demonstration (RAD) program through which management of the site was transferred to a private developer. The resilience elements of the investments at the 32-acre site were designed and funded through the FEMA 428 program. These included full backup power generators housed in elevated structures along with new electrical equipment, rooftop hydronic boilers, and a flood wall with passive flood gates around the site which utilize portions of existing building envelopes. The structures incorporated protection anticipating 3.5 feet of sea level rise, the most in the program.

The residential buildings are recessed from the sidewalk around the property sufficiently to allow for a gradual natural grass slope that reduced the necessary height of the wall, reducing a wall that would have obstructed views to one that is only waist high. The paths through the site and through the walls around the buildings are protected via passive flood barriers.

Rooftop hydronic boilers and elevated structures housing generators and electrical equipment

Passive flood gate and flood wall

Red Hook green spaces in poor condition in May 2020

STRATEGY 5B

Elevation of Landscape

At Red Hook, the design team developed a passive, site-based flood protection system that used sitewide grade changes to protect buildings and create large areas of refuge during a flood.

Red Hook East and West

At over $500 million, the Recovery and Resilience investment at Red Hook Houses East & West is by far the largest project in the program. Flood protection at the site was designed with a campus focus. Kohn Pederson Fox developed the idea of “lily pads” - elevated courtyards to provide areas of refuge adjacent to building entries. In addition, it allows for a redesign of all the green spaces between the buildings. The courtyards also serve as a great opportunity for co-design with the residents, place-making, and programming activities.

This solution has been implemented on a large scale all across Red Hook East and Red Hook West.

A necessary condition to be able to implement this type of solution is to be able to think at the scale of the development and not only building by building. A disadvantage of this solution is that by lifting the topography, existing green spaces and trees have to be removed, which is less than ideal in terms of sustainability and impacts the resident experience throughout the construction project.

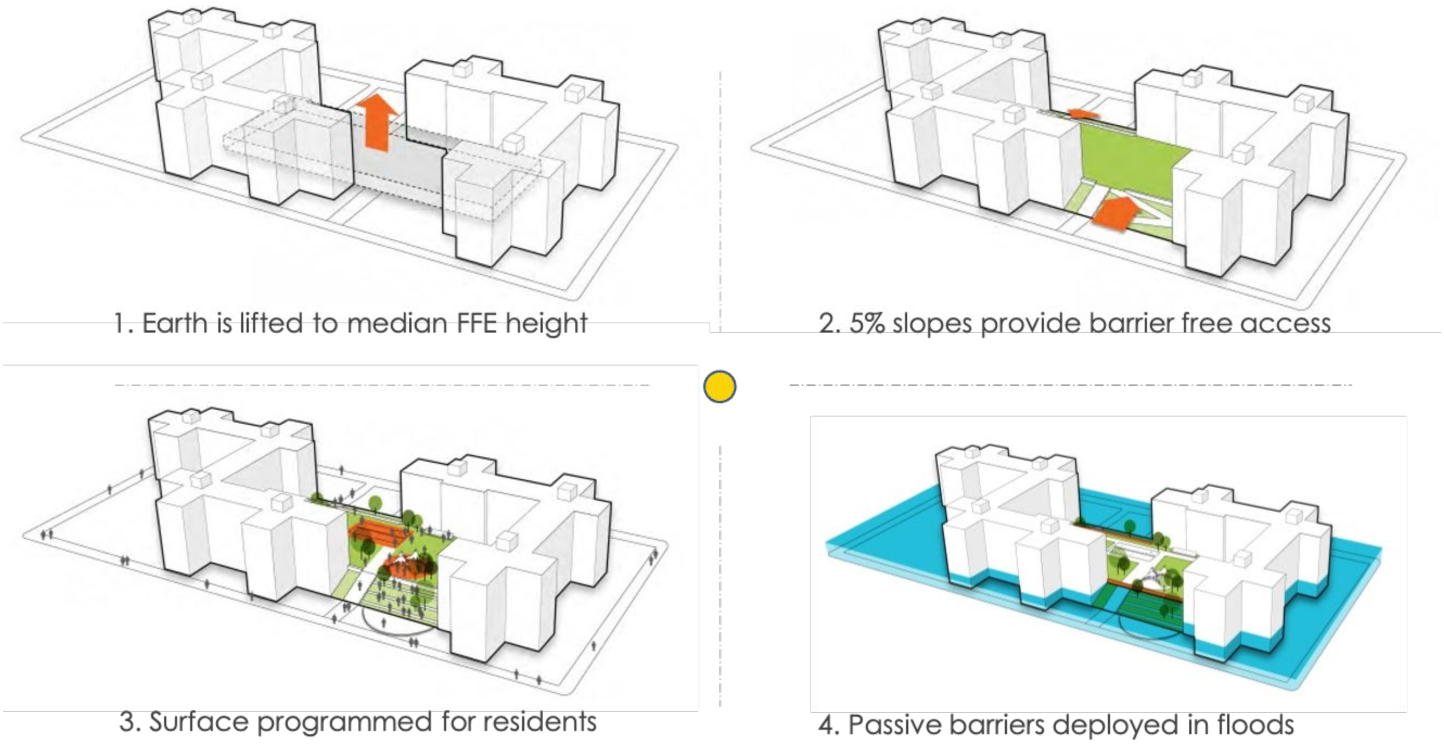
In the case of Red Hook though, a number of factors that led to this solution must be highlighted. First the existing green spaces were in poor condition. A large portion of trees that were removed were deemed by an arborist to be in poor or very poor health and needed to be replaced regardless of construction. Second, since the project included the construction of a raised central mechanical plant and elevated MEP annexes, it was necessary to install site-wide distribution systems for natural gas lines, electrical conduit, and steam distribution. The associated trenching would require the disruption of the site. Trees, grass, and plants had to be removed to implement this state-of-the-art and energy efficient infrastructure. Even if the budget would have permitted it, tree relocation is a precarious operation that often results in the death of the tree. Adjustments to the design were made to reduce the total number of trees removed from 572 to 457 (-20%). NYCHA strives for one-to-one replacement at the end of each project as space constraints and funding permit. As FEMA funds tree removal but not tree planting, alternative funding will be leveraged for this purpose.

Third, a social analysis of the site showed that buildings in Red Hook are felt to be isolated. Visitors and emergency personnel say it is difficult to navigate the site or differentiate one building from another. Today, there are physical disconnections within the buildings themselves: up to 6 lobbies in the same building with different entries and no connection between the 6 parts of the building. Thus, apart from protecting the infrastructure from flooding, the project tried to address these additional questions:

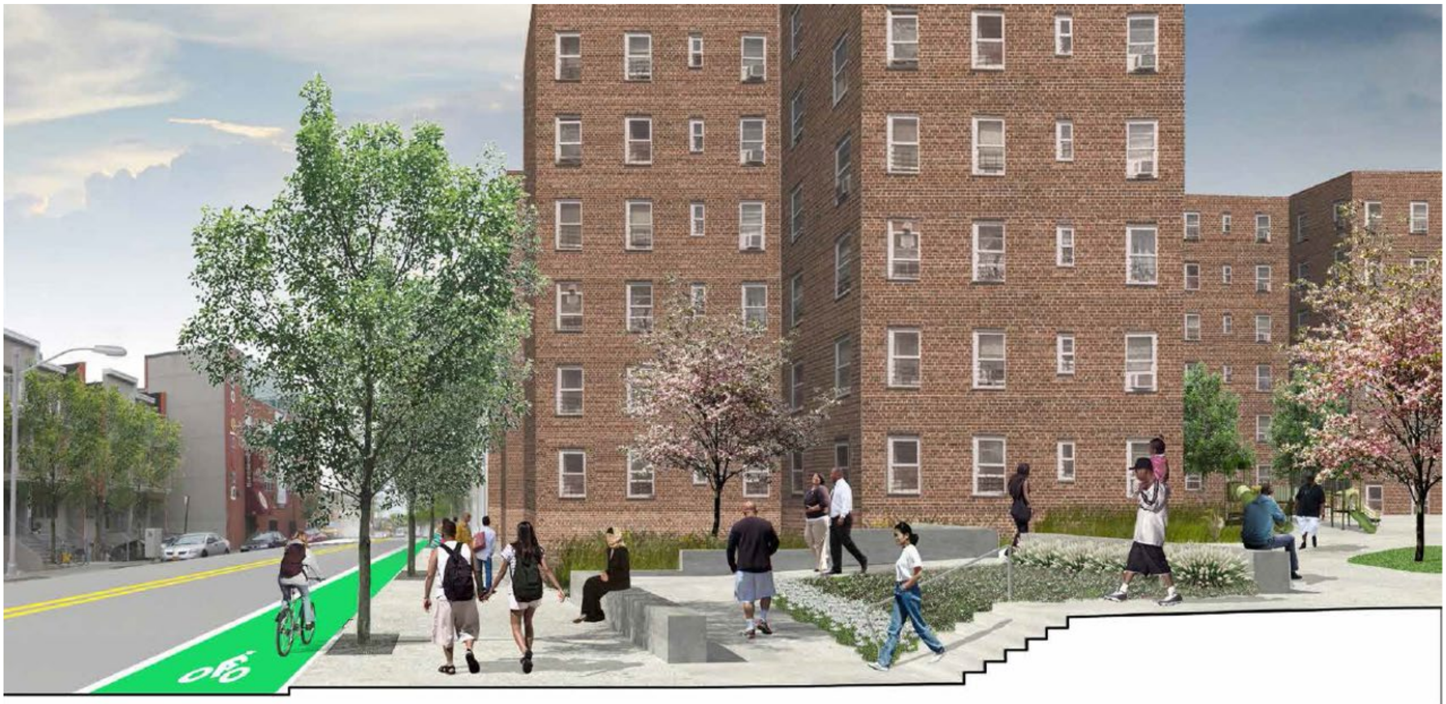
- How to get from one building to another?
- How to connect people to one another?

Lily pads have been designed to connect two buildings facing one another. Besides the main concept of flood protection and the integration of permanent structures, with the Lily Pads (elevated courtyards) the design provides a direct and same level access to each building from the courtyard, and a dry area for evacuation during flood events. This resulted in a significant reduction of removable flood barriers and decrease in the existing excessive number of ramps and stairs while refining ADA access to all building entries as well as improving the relationship between residents.

Lily pads in Red Hook conceptual rendering (courtesy of KPF)



Lily pads location in Red Hook East and West



Lily pad principle developed in Red Hook rendering (courtesy of KPF)

Lessons

Protecting structures was one of the most complex and costly components of NYCHA's Sandy Recovery program. Lessons after completing this work include:

Future projects should focus on passive protection for critical infrastructure. Dry floodproofing entire buildings is extremely costly and entails very difficult challenges related to installation and maintenance. A best practice would be to relocate residential uses and critical infrastructure above the design flood elevation and wet floodproof non-critical spaces. This, however, is extremely challenging to accomplish in practice in fully occupied buildings.

Strategies that involve relocating many residents should also be avoided. Wet floodproofing first floors throughout the Sandy program would have involved massive relocations of residents, a path that NYCHA did not want to pursue and that residents strongly opposed. Due to Recovery and Resiliency work, residents in 300 apartments were relocated temporarily and residents in 13 apartments were relocated permanently out of the total 24,000 units that are being protected through the program. Even residents who had been present in a flooded apartment during Hurricane Sandy and knew the full potential impact of future storms were reluctant to move to another apartment.

Decisions on how to protect structures must be made on a site-specific basis incorporating community engagement to the extent possible under funding constraints. Best practices for avoiding dry floodproofing and avoiding resident relocations are in conflict with each other. As New York City's flood risk continues to increase and New York City residents become more aware of the need to relocate out of flood-vulnerable units, decisions will likely be made differently in the future. In addition to evolving cultural perceptions, evolving city policy may preclude the type of work that was done during this program in the future.

4

Community Engagement from Beginning to End

NYCHA worked to communicate clearly with residents at the developments in the program at every step of the process. The communities at NYCHA developments affected by Hurricane Sandy had experienced difficult conditions during and after the storm and were eager to see damages repaired and developments protected. NYCHA worked to advocate for a level of funding that would provide long-term protection and quality of life co-benefits to residents, but remained tightly constrained by the limits of federal disaster recovery funding. The Recovery and Resilience team strove to include resident input into design and construction decisions where possible, and to be clear about what the program could and could not accomplish with residents at all stages. A dedicated Community Outreach Team was created in 2014 to give residents consistent contacts at NYCHA who were knowledgeable about the program and the specific concerns of each affected development.

Community outreach and architects from KPF partnered with Kaboom! to run a playground design event at a charter school adjacent to Red Hook Houses

NYCHA structured its communications around major goals throughout the program:

- First, NYCHA had to provide the information residents needed to protect their health and safety throughout construction. Examples of this included informing residents of areas of the development that were off-limits for safety reasons, providing information about upcoming outages that were necessary to work on power and gas lines, and impacts on the availability of water or heat.

- Second, Recovery and Resilience worked to foster an understanding of the long-term goals of the program. Given the extensive, long-term disruption that the program's work created, it was important to explain why the work was needed and how it provided protection for the affected developments and residents.

- Third, NYCHA aimed to create partners in advocacy for resiliency at the development. Community meetings and design charrettes incorporated input where possible, but in many cases the desires expressed by residents went beyond what the program could provide. A greater understanding of resiliency enabled residents to advocate elsewhere for additional resiliency funding and for other resident priorities.

- Finally, communications aimed to further residents' understanding of the intersection between capital investments that protect against storms and emergency preparedness in the event of a storm.

- Communication has been one of the most critical aspects of program success. At every step of the process, the department had to evolve its efforts to engage stakeholders.

STRATEGY 1

Funding

It is not unusual for disaster recovery funding to take a considerable amount of time to get authorized and the standard procurement and design processes for structure and infrastructure investment are lengthy and complex in the best of circumstances. NYCHA worked with many stakeholders over the course of several years to maximize repair and mitigation funding associated with Sandy. A majority of the funding wasn't awarded and available to NYCHA until December 2015.

During those years, it was critical for stakeholders to understand what progress had been made and what was yet to come. It was also an opportunity for NYCHA to emphasize how audaciously it was advocating for funding, which was a partial reason for the delay. Emergency repairs and interim solutions were implemented until the permanent repairs could be made, including temporary boilers. An example of resident feedback incorporated during this period was that the oil-burning boilers installed immediately after the storm were not meeting resident needs. NYCHA took the time to procure a contract to swap out the originally installed temporary boilers for natural gas boilers that provided more consistent service to residents and were also more energy efficient.

STRATEGY 2

Design

Incorporating stakeholder input, wherever possible, can have numerous benefits for the project. Resilience design is bound by funding and code requirements, technical constraints, and—in NYCHA's case—a capped grant requiring installation of a specific scope, so it was important to leverage every opportunity for input.

At Coney Island Houses, the new boiler structure needed to be centrally located to serve the development most efficiently. The final location was decided upon collaboratively through careful planning, engineering, and community input. NYCHA residents were presented the pros and cons of two viable options for the structure's location. The first option impacted a highly utilized seating space but provided a constructability advantage since it could be tied into an existing boiler flue. The second option preserved the seating area, but would have been more costly, resulting in less funding for other improvements. Ultimately, the residents chose to give up their seating area temporarily and have NYCHA replace it behind the new structure. This collaboration was recognized in the 2016 New York Housing Conference Community Impact Gallery Competition.[7]

STRATEGY 3

Construction

Understanding the disruptive nature of construction and the importance of resident cooperation, NYCHA reinforced the need for a special outreach team dedicated to the Sandy-damaged developments. The prime objective was to maintain effective and productive channels of communication between NYCHA's Recovery and Resilience Department and residents, community leaders, local elected offices, and community groups throughout all construction phases.

The campuses in the program were receiving a substantial amount of investment and that meant the work was more all-encompassing and included efforts that were completely unfamiliar. For example, crane lifts were required to install rooftop equipment and per NYC Department of Buildings the top two floors of residents had to temporarily evacuate. This had never been done at NYCHA, so Recovery and Resilience developed a communication plan and process.
Over the last four years, the team has successfully executed over 130 lifts by engaging stakeholders early and often via phone calls, e-mails, door-to-door

canvassing, and on-site support during the crane lifts.

Each NYCHA campus has a dedicated liaison—some of whom are NYCHA residents—responsible for distributing weekly email updates to residents, community organizations, and elected officials, attending every resident meeting, and coordinating outreach efforts prior to any disruptive construction activities (e.g. service disruption, entrance or pathway closure). The team communicates through flyer distribution, robocalls, door knocking, a direct program hotline, e-mail, attendance at every Tenant Association meeting and Family Day event, a frequently updated website, project-specific vinyl information posters, and Recovery and Resilience-organized update meetings. Critical information is posted in multiple languages—English, Spanish, Russian and Chinese—and staff are available for language translation for other materials.

Sandy construction voting annex flyer

TABLE 1 Community Outreach for CY2015 through 2020

Calls	In Person Meetings	Flyers
264,819	6,428	183,310

STRATEGY 4

Resident Relocation

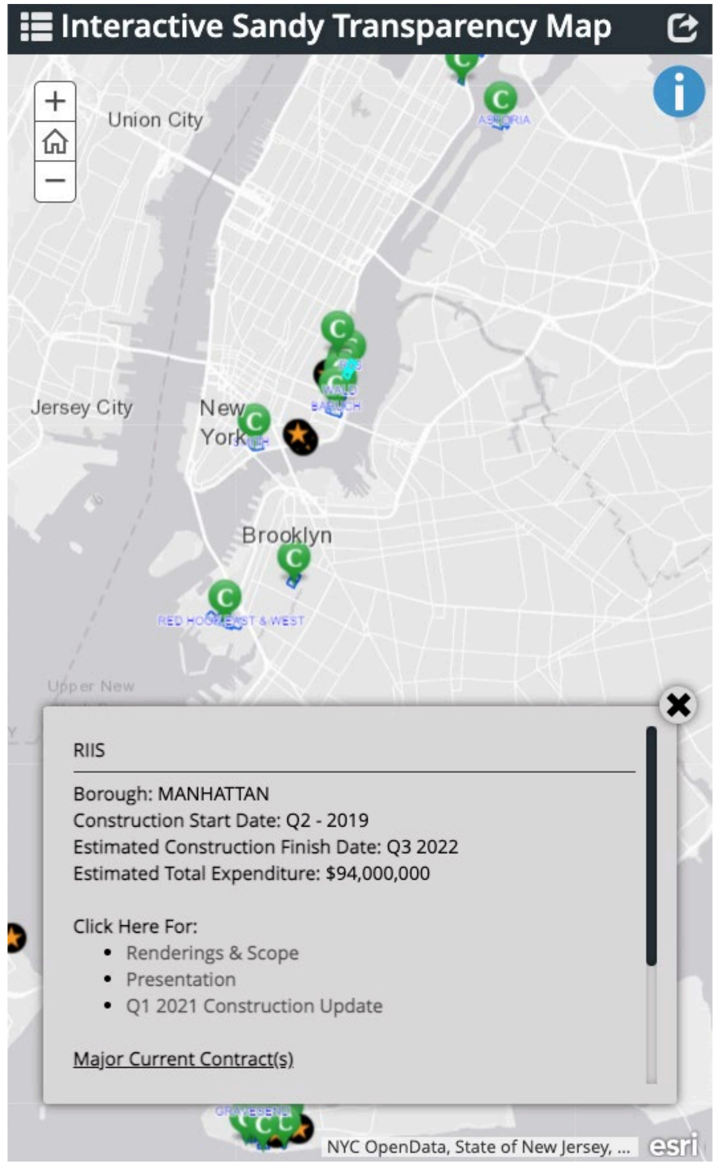
The Recovery and Resilience program represents the largest effort to temporarily relocate residents by the Capital Projects Division on any major scale to facilitate a capital project. The program was funded to partially renovate 300 first-floor units across 69 buildings in three boroughs and residents in most of those units required relocation – temporarily or permanently, if they desired - so that apartments damaged by flooding could be fully accessed. FEMA funding covered remediation, clean-up, abatement, restoration and renovation of these apartments.

Work included, but was not limited to: abating lead and asbestos, when required; cleaning and applying biocide; upgrading damaged electrical wiring; removing, replastering and repainting walls as needed due to electrical upgrades; and architectural work such as removing and replacing floor tile, appliances, cabinetry, and countertops. This work could range from three months to over a year, depending on whether and how much abatement was needed at a particular unit and if there were other repairs needed in conjunction with the FEMA scope of work.

Over the course of seven years, the Community Outreach Team conducted nearly 400 apartment visits and dedicated eight staff members to work with families in 120 of the units to explain the relocation process, convince residents to move, work with Property Management to find the appropriate unit for their family composition that also fit their relocation preferences, schedule potential apartment match viewings, arrange for movers once the apartment match was accepted (temporarily or permanently), assist the family during the move, keep the family informed of renovation progress, and assist on the return move if the family did not choose to relocate permanently. The Community Outreach Team had members who spoke Spanish, Russian, and Mandarin so that translators were not needed for regular interactions.

While the team attempted to systematize this procedure, it was far from standard and ranged from immediate acceptance of the process to seven years of effort. Residents were hesitant to move for various reasons. Some had concerns that they would not be able to return to their unit despite the agency's commitment. Others had more individuals living in the unit than were on the lease and that expanded household could not be accommodated in the temporary unit due to HUD and NYCHA guidelines. There were residents who did not want to leave a large unit they had lived in with their family for decades because they were no longer eligible to return to it as a couple or single person under HUD and NYCHA guidelines for apartment composition. In some cases, there were requests for specific developments, buildings, or buildings with certain services, such as those for seniors or with handicap accessibility.

Working with Property Management and Applications & Tenancy Administration Department, the team would ask for certain apartments to be held once they became available so that they could be used for relocation. This apartment would be kept off the lease rolls until the resident had been relocated back to their original unit.



STRATEGY 4

Shifting Outreach to a Virtual World

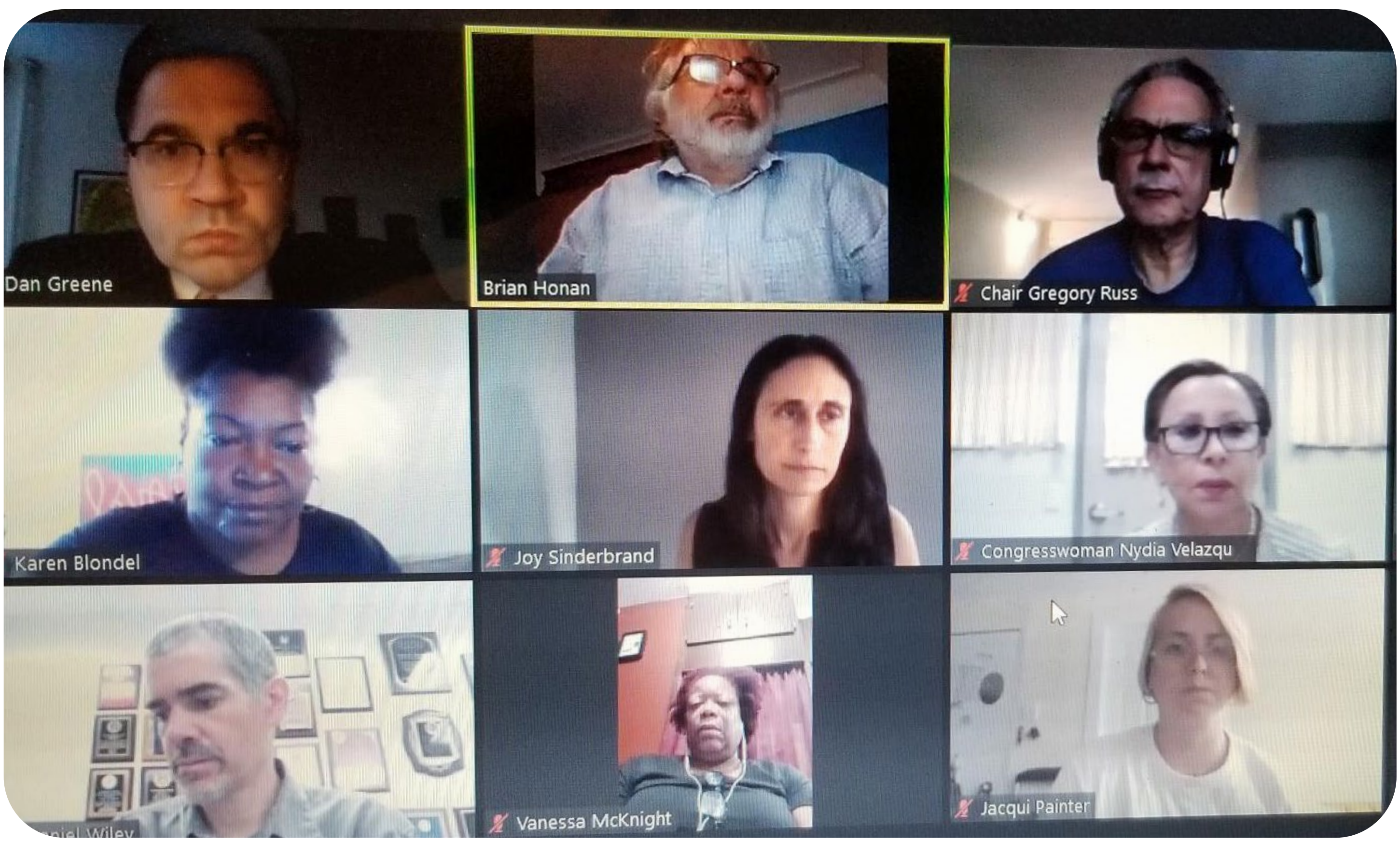
In March 2020, COVID-19 upended the processes that had been in place for ongoing communication. All Recovery and Resilience construction projects were deemed essential by New York State and the New York City Department of Buildings. At the same time, residents were now quarantined at home so impacts from construction were noticed by more people. Initially, phone and e-mail were key to responding to questions and concerns about the continuing work. Recovery and Resilience quickly pivoted to using Zoom to update residents and elected officials. Public facing video conferencing was a new tool for NYCHA and required training, especially to take advantage of translation rooms and other tools.

Remote meetings turned out to have some benefits for stakeholders. Residents who did not typically attend the in-person meetings due to family obligations, accessibility challenges, or convenience found it easier to connect via Zoom or calling into the meeting from their home. The chat function allowed questions to queue during the presentation without interrupting the speaker and made it possible for speakers to see if there was information requested by attendees that could be incorporated in real time. Some questions could be answered in the chat and links to additional resources were also shared that way. Meeting recordings could be made available for those who could not attend. The shift to online communication also streamlined the feedback process. After meetings, the team set up public online polls to hear what stakeholders thought they did well and what could be improved (e.g. clearer instructions for how to ask questions during the meeting). The process has helped finetune outreach efforts and improve the quality of the presentations.

Community input that had typically been gathered at a one-time in-person event, such as a weekday evening community meeting, was now translated to survey methods that were more broadly accessible. At Coney Island Sites, a large project that spanned three developments, there was an opportunity for residents to opine on the color of the façade of mechanical buildings. Recovery and Resilience posted flyers and emailed information to stakeholders so that residents could vote over a two-week period by web form via a QR code, email, or phone. In the Fall of 2020, when the majority of residents were spending most of their time at home, over 250 people voted.

The department leveraged the website to be a portal for the latest information on the program. A regularly updated interactive map showed project status with links to renderings, scope of work, and presentations on each development in the program. Interested stakeholders could also sign up for weekly construction e-mail updates.

The site was also a resource for residents and vendors who wanted to work on the program with information on how to find out about career opportunities and requests for proposals.



NYCHA Zoom

Lessons

NYCHA's Community Outreach Team was essential to facilitating the work done as part of the Recovery & Resilience program. Future construction programs can benefit from incorporating knowledge gained from this experience, including the following.

1. **For major construction programs, it is necessary to have onsite representatives to assist residents with concerns around construction and coordination, collect feedback, and understand the complete scope of work involved in the program.** Community engagement is not optional on major projects: resident cooperation is essential for accomplishing very disruptive construction work. Residents of buildings' top two floors must leave apartments when a crane boom will swing over the building; parking spaces need to be re-arranged in order to make room for construction equipment; and residents need to plan for utility outages when they are necessary. Without consistent community outreach presence, this type of coordination is impossible and construction delays are inevitable.

2. **Systematize outreach early in the construction process.** The Community Outreach Team developed best practices and standard methods of outreach at each phase of design and construction over time; future project teams could benefit from laying out a systematic approach from the beginning of a construction program so that residents know ahead of time what opportunities will be available for input and communication.

3. **When engaging with residents, it is important to provide opportunities to bring up concerns that are not directly related to the specific construction program being discussed.** Recovery & Resilience had the most success gaining meaningful resident feedback when additional resources were made available beyond the resilience scope of work. For example, often a table was set up where residents could initiate work tickets if they had specific concerns about their apartments; at some events, other departments such as Resident Economic Empowerment and Sustainability, Emergency Management, or Safety and Security attended to address concerns that fell within their areas of responsibility. This can be difficult to coordinate, but with many meetings having been conducted over Zoom during the pandemic, having the appropriate staff available can actually be easier.

4. **Resident relocation is extremely challenging, and any project teams carrying out temporary or permanent relocation should approach the task with sensitivity and patience, keeping in mind the following:**

× **It takes time and personal interactions to build trust.** Some residents were called weekly for months or years to build and maintain a channel of communication. This process cannot be fully standardized and cannot be outsourced to a typical construction contractor for which this is not an existing expertise.

- × **Consider the process challenge when writing the specifications for associated work.** If completion of a unit or clearing a floor is precedent to, say, replacing a gas riser, then it needs to be clear if and how the contractor will be held responsible for construction timelines. If NYCHA is unable to compel a resident to move via building trust and goodwill, the process moves to litigation and can be drawn out for an extended time.

- × **There are times when residents won't move despite best efforts to accommodate.** In the end, despite all efforts, there were 12 units that were never vacated. In the case of this program, that did not preclude completion of other units, but if it were necessary for an entire floor or riser to be cleared for a different type of project to proceed efficiently, construction timelines could be very difficult, if not impossible, to maintain.

5. **Complete consensus is not possible, but genuine opportunities for input and open, honest engagement are valued.** Project funding limitations, site constraints, and a variety of other factors limit the degree to which projects can be aligned with resident preferences; and individuals' preferences will never be completely unified across a development. Residents, however, value transparency with regard to which elements of a project can incorporate feedback and open engagement around problems that arise. Future project teams should seek opportunities to foster collaborative relationships with residents at developments to maximize the benefits that NYCHA's investments deliver to NYCHA residents.

Conclusion

NYCHA's Recovery & Resilience program will restore critical systems, repaired damage, and protect public housing units in 35 developments across four boroughs, making a stronger and more resilient NYCHA. Public housing is one of the most critical elements of New York City's affordable housing stock and preserving this asset for future generations of New Yorkers is a top priority.

NYCHA was able to devote approximately fifty percent of its disaster recovery funding to resiliency—mitigating against future storms—rather than simply replacing equipment in kind ensuring that the funding NYCHA received will protect public housing units into the future. This was possible because NYCHA worked collaboratively with FEMA to demonstrate the cost effectiveness of these resiliency measures in the face of sea level rise.

Resilience construction is known to be technically challenging to implement and requires long time horizons in the simplest of circumstances, and the Recovery and Resilience program is no exception. Since December 2015, when NYCHA received access to the FEMA funds, tremendous strides have been made to reverse decades of disinvestment. As the largest investment in public housing since its inception, NYCHA's Recovery and Resilience Program has made the case that when funds are allocated, NYCHA can deliver large scale capital investments to better living conditions for the residents who call these developments home. As NYCHA pursues comprehensive modernization and benefits from new funding pipelines through the State, City, and Federal government, this type of holistic and thoughtful capital improvement will be replicated across its portfolio to improve the lives of the hundreds of thousands of New Yorkers who call NYCHA home.

Sources

1. See, for example: Hamideh, S., & Rongerude, J. “Social Vulnerability and Participation in Disaster Recovery Decisions: Public housing in Galveston after Hurricane Ike.” Natural Hazards (2018): 1629-1648; Graham, L. “Razing Lafitte: Defending Public Housing from a Hostile State,” Journal of the American Planning Association 78, no.4 (2012): 466-480. https://doi.org/10.1080/01944363.2012.738143

2. https://www.fema.gov/assistance/public/policy-guidance-fact-sheets/public-assistance-alternative-procedures-paap-archives

3. https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities

4. https://www1.nyc.gov/assets/sirr/downloads/pdf/Ch_6_Utilities_FINAL_singles.pdf

5. Across the program, this was a last resort strategy as preservation of public housing units is a top priority. In a program of about 23,500 apartments, only 13 units were vacated to facilitate the extensive construction across the Sandy Recovery portfolio. All the residents in those units were relocated within the same development or neighborhood, depending on apartment size required and resident preference.

6. In 2016, Bayside was NYCHA’s first conversion under HUD’s Rental Assistance Demonstration (RAD), which allows housing authorities to access private capital to meet funding needs while protecting affordability. This project was a joint venture between MDG Design + Construction and Wavecrest Management.

7. https://thenyhc.org/projects/

Appendix

Recovery and Resilience Scope Overview

◑ = Partial use

	ASTORIA	BARUCH	BEACH 41ST STREET	CAMPOS PLAZA II	CAREY GARDENS	CARLTON MANOR	CONEY ISLAND (SITE 8)	CONEY ISLAND HOUSES	CONEY ISLAND IB	CONEY ISLAND 4&5	EAST RIVER	GOWANUS	GRAVESEND	HABER	HAMMEL
SITE IMPROVEMENT															
Electrical Feeders Replacement	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Upgraded Site Lighting	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Upgraded Playground Areas		●	●	●	●	●	●	●	●	●	●		●		●
Green Infrastructure Implementation		●			●		●					●	●		
FACILITIES															
Roof Replacement	●	●		●	●	●	●	●	●	●	●	●	●	●	●
Façade Repair			●				●	●				●	●		◑
Lobby Upgrade		●			●	●	●	●	●	●			●		●
Community Center Upgrade										●			●	●	●
Community Center Addition					●										
Child Care Center Upgrade/Addition					●										
Boiler Room Addition		●			●	●	●	●	●	●			●	●	●
MEP Building Annexes		●			●	●	●	●		●			●	●	
FLOOD PROOFING															
Development Flood Wall		●													
Wet flood proofing														●	
Dry flood proofing	●	●	●	●	●	●	●	●	●	●	●		●	●	●
Passive barriers		●		●	●		●								
Manually deployed barriers	●		●	●		●		●	●	●	●		●	●	●
ELECTRICAL SYSTEMS															
Upgraded Switchgears	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Relocating all Panels above Project Flood Elevation	●	●		●	●	●	●	●	●	●	●		●	●	●
Centralized Back-up Power			●		●	●			●				●		
Localized Back-up Power	●	●		●	●		●	●		●	●	●		●	●
HEAT AND HOT WATER SYSTEMS															
Boiler Replacement		●			●	●	●	●	●	●			●	●	●
Upgraded heat/hot water system	●	●	●	●	●	●	●	●	●	●	●		●	●	●
Steam & Condensate Piping Replacement		●			●		●						●		
Dry flood proofed H/HW system			●	●					●	●	●		●	●	●
Elevated H/HW system		●			●	●	●	●	●	●			●		

ISAACS	LA GUARDIA	LAVANBURG HOMES	LINCOLN HOUSES	LOWER EAST SIDE REHAB 5	METRO NORTH	NEW LANE	OCEAN BAY APARTMENTS (BAYSIDE)	OCEAN BAY APARTMENTS (OCEANSIDE)	O'DWYER	RANGEL	REDFERN	RED HOOK EAST	RED HOOK WEST	RIIS	RIIS II	SMITH	SURFSIDE	TWO BRIDGES	WALD	Total
●	●	●	●	●	●	Only Slope Stabilization Scope	●	●	●	●	●	●	●	●	●	●	●	●	●	35
●	●	●			●		●	●	●		●	●	●	●	●	●	●		●	30
●					●		●	●	●		●	●	●	●	●		●	●	●	25
							●		●				●				●			9
		●			●		●	●	●		●	●	●	●	●	●	●	●	●	28
					●		◑	●	●								●			11
		●					●		●		●						●		●	15
							●	●				●								7
											●									2
											●				●					3
		●			●		●		●		●	●	●				●			18
●	●				●		●	●	●	●	●	●	●	●	●		●	●	●	23
							●													2
●											●	●	●							5
	●	●	◑	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	32
		●					●		●		●	●	●				●			11
	●			●	●			●		●	●			●	●	●		●	●	22
●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	34
●		●			●		●		●	●	●	●	●	●	●	●	●	●		27
●	●	●		●	●				●		●	●	●				●			15
●							●	●		●	●			●	●	●		●	●	21
		●		●	●		●		●		●	●	●				●	●		20
●		●	●		●		●	●	●	●	●	●	●	●	●	●	●	●	●	31
●		●					●		●		●	●	●				●			12
●	●			●	●		●	●		●		●	●	●	●			●	●	21
		●			●		●		●		●	●	●				●			16

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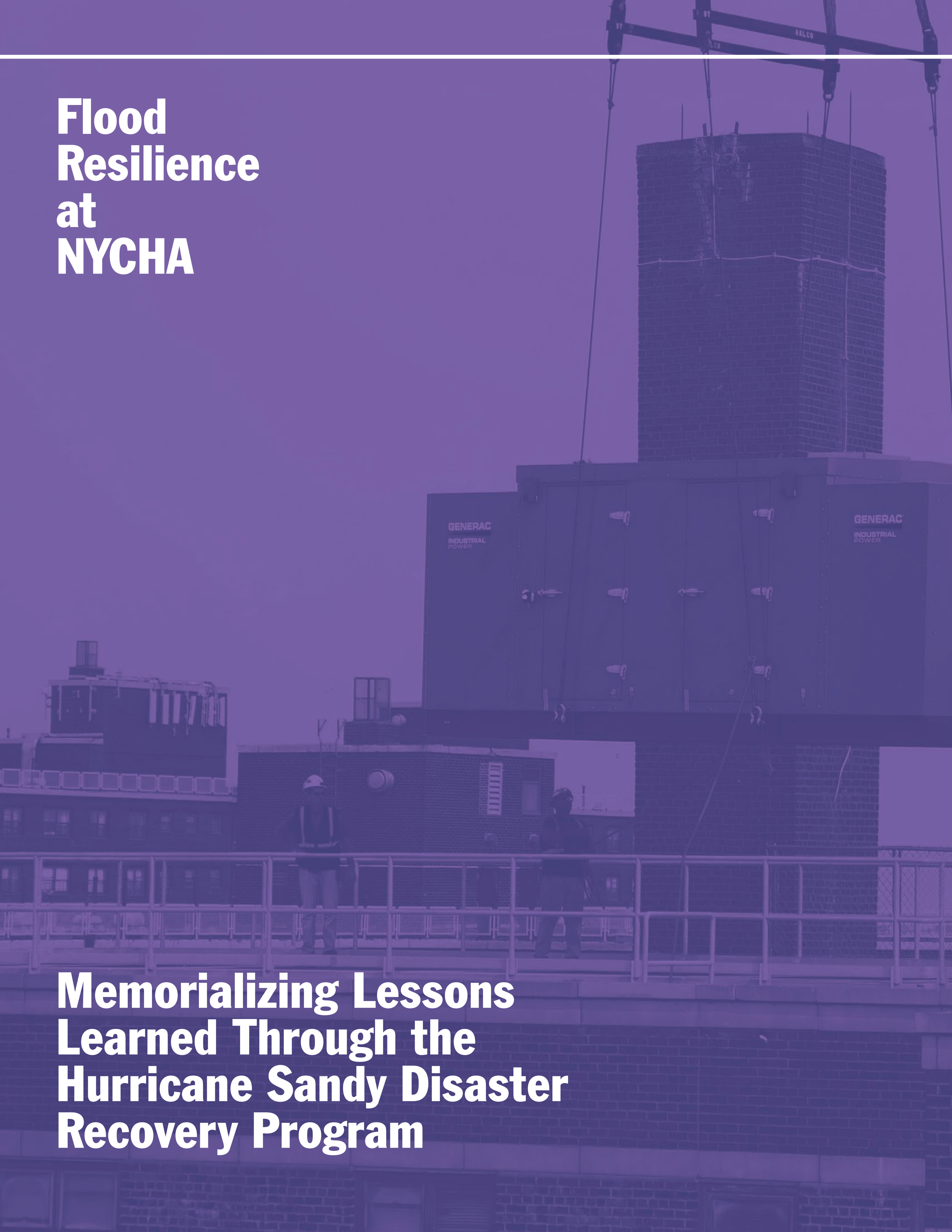
Flood Resilience at NYCHA



Memorializing Lessons Learned Through the Hurricane Sandy Disaster Recovery Program