READY TO RESPOND

Strategies for Multifamily Building Resilience

Disaster Preparedness for Affordable Housing Organizations

Enterprise green communities®

Enterprise Community Partners, Inc.

Enterprise works with partners nationwide to build opportunity. We create and advocate for affordable homes in thriving communities linked to jobs, good schools, healthcare and transportation. We lend funds, finance development and manage and build affordable housing, while shaping new strategies, solutions and policy. Over more than 30 years, Enterprise has created nearly 340,000 homes, invested $18.6 billion and touched millions of lives.

Enterprise Recovery and Rebuilding Program

Following Superstorm Sandy, Enterprise initiated the Recovery and Rebuilding Program in response to the needs of New York and New Jersey's multifamily housing community. The formation of the Learning Collaborative for Multifamily Housing Resilience was a core component of the program. The Collaborative provided a forum for a broad community of affordable multifamily housing groups to share experiences and best practices after Superstorm Sandy. In 2012, Enterprise worked with Collaborative participants to assess the resilience of 56 multifamily properties, all located in the flood zone. Resulting findings provide the background for the recommendations in this manual.

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Clockwise from top right: Ethan Caplan, N. Patterson, Gabor Ekecs, Pete Eckert, Warwick Green, Edward Blake.

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We would like to dedicate this manual to Mrs. Isabel Gomez-Aulestia, Senior Construction Manager at Enterprise Community Partners, who worked tirelessly to support the resilience of affordable multifamily housing organizations for more than 15 years.

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Foreword

Cities, towns and states across the nation are regularly experiencing natural disasters or recovering from them. While all communities are at risk, low-income communities are disproportionately hurt by climate events and often have limited resources to recover.

My direct experience working with low-income and vulnerable communities on disaster response and recovery has taught me that wealth can significantly contribute to community resilience while poverty can be a strong indicator of vulnerability to disaster.

The increasing frequency of all types of extreme weather means that damage to housing facilities is rising, causing a substantial financial burden for owners of affordable housing properties.

Many of the most vulnerable Americans live in affordable multifamily housing that is not designed to sustain extreme climate shocks. The changing climate presents the affordable multifamily housing community with new design challenges and it is vital that housing owners adapt their buildings to a "new normal." Investing in resilient infrastructure upgrades for multifamily housing owners in advance of an event has never been more critical. Not building with an eye to resilience exposes low income communities and crucial housing assets to substantial losses and disruption of housing and services.

Owners and operators of multifamily housing need practical guidance on re-designing and retrofitting their buildings to adapt to and provide protection from climate impacts and other potential hazards. Tools like *Enterprise's Ready to Respond: Strategies for Multifamily Building Resilience* help our affordable multifamily housing partners shape and build sustainable and resilient communities that will provide healthy, safe and affordable housing for generations.

Harriet Tregoning
Principal Deputy Assistant Secretary, Office of Community Planning and Development, U.S. Department of Housing and Urban Development

The thoughts expressed in this forward are Harriet Tregoning's personal views and do not necessarily reflect the views of the Department of Housing and Urban Development or the United States Government.

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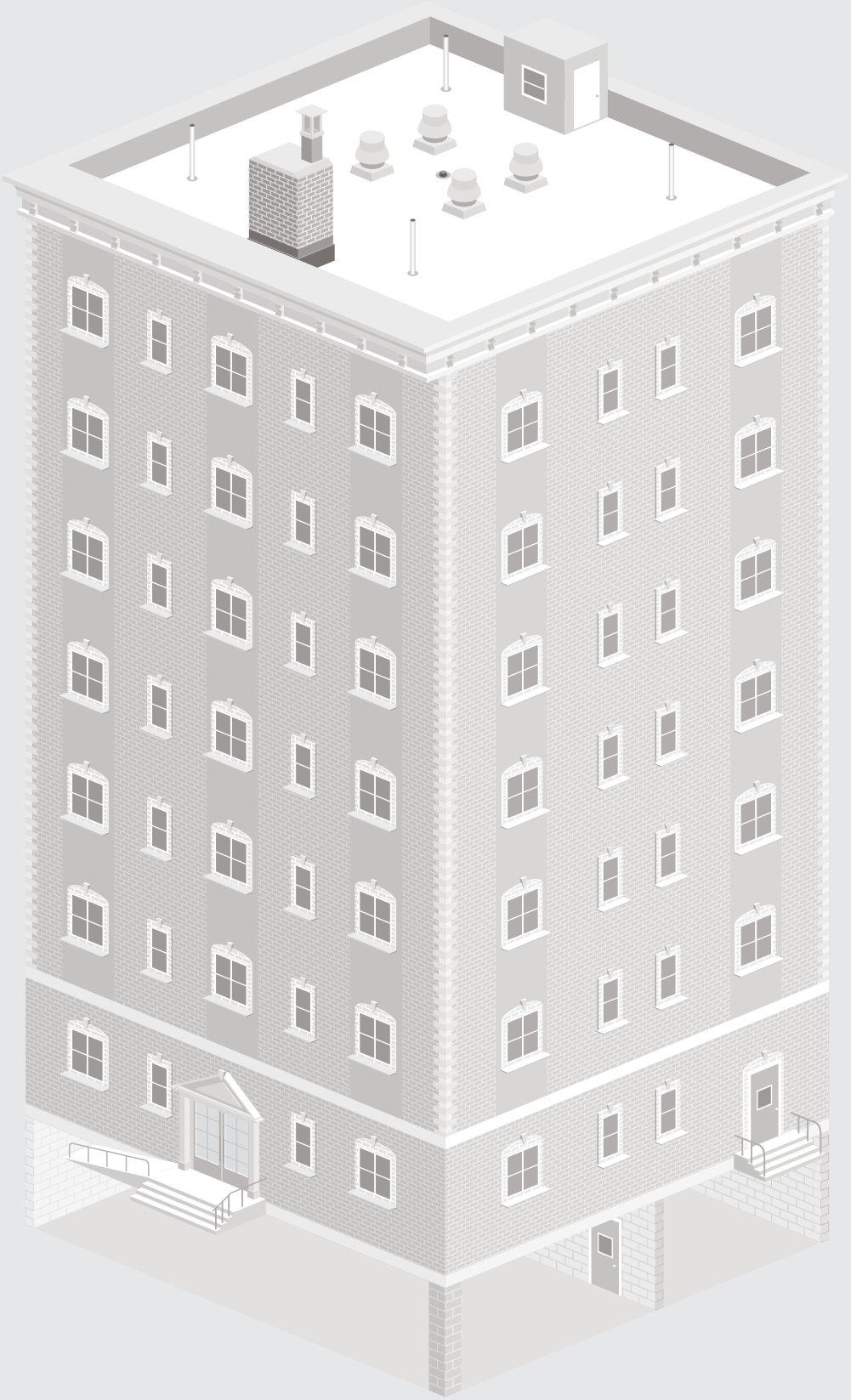


Image: Colin Hayes.

Introduction

Climate change is an ever-present threat to urban communities, increasing the possibility of extreme weather events like storms, blizzards and heat waves. Extreme weather can lead to flooding, power loss, property damage, transportation disruptions, interrupted access to critical resources and even loss of life.

"Resilience is the capacity of a community, business or natural environment to prevent, withstand, respond to and recover from a disruption."

US-Climate Resilience Toolkit↗

Recent disasters, including Hurricane Katrina and Superstorm Sandy, have made it clear that multifamily building owners face unique challenges when designing and retrofitting for resilience. Most residential design guidelines for resilience target single-family dwellings and are impractical for multifamily buildings. For example, existing multifamily properties cannot be elevated above the floodplain easily because of the high costs and technical difficulties of relocating equipment and residential units.

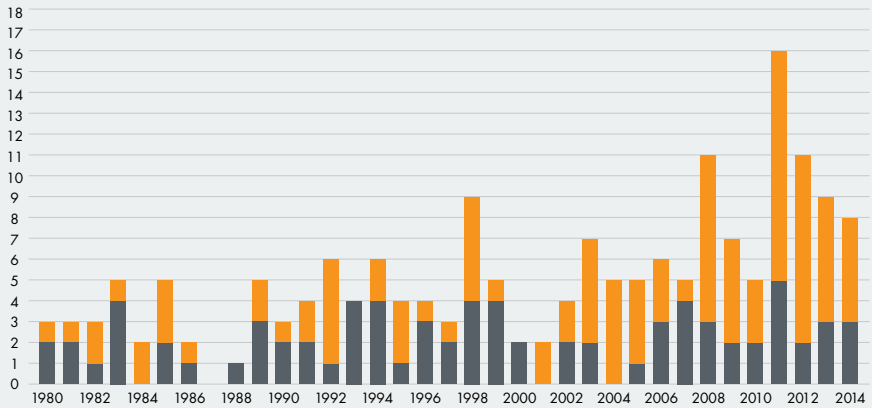
Affordable multifamily housing is especially vulnerable – when disaster strikes, low-income residents have less access to resources to help them recover. Short-term displacement can lead to long-term homelessness, short-term business closures can lead to a neighborhood-level economic downturn, and disruption of community services can lead to an extended loss of service continuity. Loss of rental income due to evacuation and property damages can have a tremendous impact on the ability of housing owners to provide affordable housing.

With the increasing frequency of storms, floods and other extreme weather events, the costs associated with not investing in resilience are rising rapidly. This manual provides practical guidance for multifamily building owners on a variety of retrofit strategies, and outlines mitigation strategies against a variety of hazards encountered in the northeastern U.S.

Climate data shows a distinct rise in the number of billion-dollar disaster events in recent years – a trend projected to continue as the effects of climate change intensify.

Data: National Oceanic and Atmospheric Administration (NOAA). Adjusted for inflation.

Billion-Dollar Weather Events in the US



Guiding principles

What Does Resilience Mean for Multifamily Housing?

This manual will help new and existing multifamily housing developers, owners and organizations adapt and respond to climate change and other threats. These guiding principles are the basis of the manual's recommendations.

- **Resilience is a smart investment.** An upfront investment in the long-term resilience of a housing property yields financial protection against future losses. Each dollar invested in pre-disaster mitigation leads to an average $4 savings from avoided damages.[1] Smart resilience investments can help save on energy use, reduce operational expenses and lower insurance premiums.
- **Resilience should be a part of the capital improvement planning process.** Enhancing building resilience makes the greatest economic sense as part of a planned series of capital improvements. Even if funding for resilience retrofits is not immediately available, it is wise to be ready with an action plan for future building upgrades. Energy and water efficiency upgrades offer an opportunity to invest in resilience as well.
- **Use lessons learned from extreme weather events to rebuild smarter.** An extreme weather event reveals building's vulnerabilities. A climate event can provide an opportunity to integrate these lessons into a building retrofit and operations which will allow the building perform more efficiently.
- **Buildings and communities should be resilient to natural disasters and the effects of climate change.** Buildings and communities should be able to survive storms, flooding, earthquakes and other natural disasters. Long-term planning should address the impacts of climate change.
- **Multifamily housing should keep occupants safe and healthy.** Housing should be designed and operated to keep residents safe and healthy. During extended loss of power or fuel supply when residents are not called to evacuate, housing should be able to maintain its habitability.
- **Connected communities are more resilient.** When people know each other, stay in communication and share resources during a disaster, communities are more resilient. Strengthening personal ties is a high priority in building resilience.

[1] *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*. Multihazard Mitigation Council.↗

Getting Started

If you have experienced a damaging weather event or aim to proactively protect your residents and property from the impact of climate change, this section will help your team determine which retrofits are appropriate for your building.

Identify your hazard exposure.

Learn the lessons of previous climate and emergency events, research the location and climate zone of your site and your community and evaluate future risk.

Assess your risks.

Assess potential threats and anticipate their impact on your infrastructure and residents to determine where to focus your attention.

Determine your resilience strategies.

Once you understand your hazards and risk, you can assess which resilience strategies make sense for your building.

Identify your hazard exposure.

Potential Hazard	Determine your Exposure
Flooding Housing in coastal areas or next to bodies of water is at the greatest risk of flooding, but heavy rainfall can drastically damage buildings in any area. Conventional guidance can often be technically and financially impractical for multifamily properties undergoing retrofit. For instance, elevating a building or its systems above the flood elevation may be unfeasible.	» Locate your Flood Zone and Base Flood Elevation on the **FEMA flood map center**.↗ » Hire a surveyor to provide you with an Elevation Certificate and your flood zone determination. » Determine how future sea-level rise will impact your property using **NOAA's Sea Level Rise Viewer**.↗ » Areas with combined sewer-stormwater systems are at risk for flooding, even if not located within the Flood Zone.
Extreme Temperatures, Winter Storms and Blizzards Power grids and HVAC systems become overtaxed and may fail during extreme temperatures. Buildings with little natural ventilation and poor envelope performance are at risk during heat waves from overheating. The Urban Heat Island Effect (UHIE) can make heat waves worse.	» FEMA and the National Oceanic and Atmosphere Administration (NOAA) provide tools to assess risks of long-range changes in weather and climate. » Third-party subscription services provide severe weather alerts by Email or SMS.
Severe High-Wind Events Winds above 86 mph can strip roofs, overturn objects and damage windows and doors. In urban areas, broken glass and flying objects can harm pedestrians and building residents.	» Determine your wind-speed zone in accordance with **FEMA guidelines**.↗ » ASCE-7 provides design requirements for wind speeds and wind pressures. Check if your local building codes require ASCE 7 compliance.
Fire Fire may quickly destroy entire blocks of housing. Multifamily buildings are at risk because of the number of residents living in buildings and the density of buildings in the urban environment.	The following buildings are at a higher risk for fire: » Buildings that allow smoking in units. » Buildings whose residents have special needs and may be at risk of accidentally starting a fire or being unable to put one out. » Buildings that consume highly flammable fuels.
Explosion Gas or fuel leak explosions can happen at any time and may not be detected until it's too late.	» Work with your utility company to ensure that your fuel lines are secure and maintained. » Check often for illegal fuel diversion.

Assess your risks.

Risks to Residents	Risks to Buildings	Risks to Business Continuity	Risks to the Community
» Injury or loss of life. » Psychological trauma. » Loss of property. » Economic hardship and loss of jobs. » Exposure to pathogens and toxins. » Security risk. » Housing displacement. » Loss of community services.	Damage to: » Envelope. » Building systems. » Communications infrastructure. » Roof. » Foundation. » Loss of housing units. » Loss of commercial and institutional tenants.	» Cost of repairs. » Displacement of tenants and loss of rental income. » Rising insurance rates. » Reduction in property value. » Regulatory fines.	» Destruction of public infrastructure. » Downturn in community business and economy. » Evacuation and Migration. » Disruption in transportation. » Loss of faith in public institutions. » Water supply contamination.

Questions for building owners when assessing your risk:

- How much financial loss have you incurred over the last 10 years due to climate-related events?
- Do you inventory your critical equipment with a list of serial numbers and equipment models?
- Do you have an emergency plan in place? Is your staff trained to execute it? Will your staff be on hand during an event?
- Have you communicated to your renters the importance of having their own insurance?
- If your mechanical and electrical systems are incapacitated, do you have the operating reserve to repair them? How many months of rent can you afford to lose if units become uninhabitable?
- If your building is severely damaged, could that cause injury or loss of life to residents?
- Have you discussed your insurance coverage with your asset manager or bank? Do you have coverage sufficient to protect your property from all hazards including flood, wind damage, power outage, mold or loss of income? (See **Ready to Respond Disaster Staffing Toolkit: Business Continuity**.↗)

Determine your resilience strategies.

	Low to mid-rise walk-ups	Low-rise contemporary	Mid-rise contemporary	High-Rise contemporary
Protection				
1 Wet Floodproofing	◉	◉	●	●
2 Dry Floodproofing	◉	◉	◉	◉
3 Site Perimeter Floodproofing	○	◉	◉	◉
4 Resilient Elevators	◉	○	●	●
5 Backwater Valves	●	●	●	●
6 Sump Pumps	●	●	●	●
Adaptation				
7 Envelope Efficiency	●	●	●	●
8 Elevated Equipment	◉	◉	●	●
9 Elevated Living Space	◉	◉	◉	◉
10 Surface Stormwater Management	●	●	●	●
11 Window Shading	●	●	●	●
12 Distributed Heating and Cooling	●	●	◉	○
Backup				
13 Maintaining Backup Power to Critical Systems	●	●	●	●
14 Emergency Lighting	●	●	●	●
15 Access to Potable Water	●	●	●	●
Community				
16 Building Community Ties	●	●	●	●
17 Creating Community Resilience Spaces	◉	◉	●	●
18 Developing an Emergency Management Manual	●	●	●	●
19 Organization for Community Resilience	●	●	●	●

Estimated Cost	Related Strategies
Protection	
$$-$$$	6, 8, 9, 10
$$-$$$	3, 5, 6, 14
$$-$$$	2, 6, 10
$$-$$$	2, 3, 6, 8, 13, 18
$	2, 6, 10
$	1, 2, 5, 8, 10, 13
Adaptation	
$$$-$$$$	11, 12
$$$-$$$$	1, 7, 9, 12
$$$-$$$$	1, 2, 8
$$-$$$	2, 3, 5
$	7
$$	7, 8, 11
Backup	
$$-$$$	4, 6, 8, 15, 18
$	13
$	13
Community	
$	17, 18, 19
$-$$	13, 15, 16, 18, 19
$	16, 17, 19
$	16, 17, 18

Legend

Applicability

- ○ Minimally applicable
- ◉ Potentially applicable
- ● Applicable

Building Types*

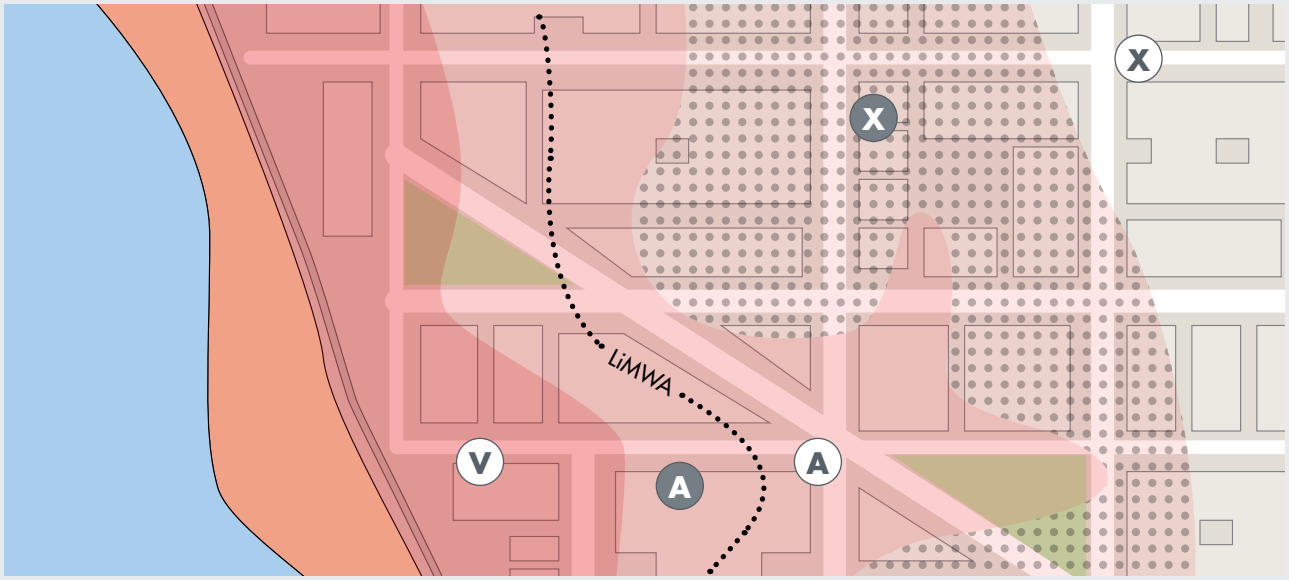
	Units	Floors	Year built	Typical building construction	Elevator
Low to mid-rise walk-ups	8-50	3-6	pre-1929	Masonry structural walls, brick envelope, rubblestone or brick foundation, wood roof and wood joist floors.	Yes / No
Low-rise contemporary	4-8	2-3	1920-present	Wood Frame, concrete block foundation and shingled roof.	No
Mid-rise contemporary	10-250	4-12	1920-present	Masonry bearing wall with wood joists or concrete, concrete foundation, brick- or wood-framed envelope and tar roof membrane or shingled roof.	Yes
High-rise contemporary	50-400	12-40	1950-present	Concrete masonry structure, CMU or slab on grade foundation, brick envelope and tar roof membrane.	Yes

Flood hazards

Many of the strategies in this manual relate specifically to flood risk. Water-related disasters account for approximately 85 percent of all disaster declarations[1] and flooding risks are expected to increase over time.

Flood Insurance Rate Map (FIRM)

Official FEMA maps which show flood zone areas.



V **Flood Zone V** includes coastal properties at risk from wave action greater than 3 ft above still-water base flood levels.

A **Flood Zone Coastal A** includes properties at risk of a base flood and waves between 1.5 and 3 ft.

A **Flood Zone A** includes properties beyond the Limit of Moderate Wave Action (LiMWA), or near rivers and lakes.

V A **Special Flood Hazard Area (SFHA)** Any land area at risk by a 100-year base flood (Flood Zones V and A).

X **Flood Zone Shaded X** includes properties in the 500-year floodplain.

X **Flood Zone Unshaded X** designates properties that are outside the 500-year floodplain and at very low risk of flooding.

National Flood Insurance Program (NFIP) is an insurance option administered by FEMA for participating communities. NFIP premiums for building owners are determined by flood risk to the building. Premiums may be reduced by implementing NFIP-approved mitigation measures. Any building owner holding a federally-backed mortgage on a property in the SFHA is required to purchase flood insurance from NFIP or a third party. NFIP also covers property loss and is available to renters and condominium owners.

[1] *www.fema.gov/news-release/2015/02/05/federal-flood-risk-management-standard*

Elevation Terminology

Guidance on flood mitigation can be highly technical. Being familiar with these terms will help you better understand the recommendations in the following strategies.

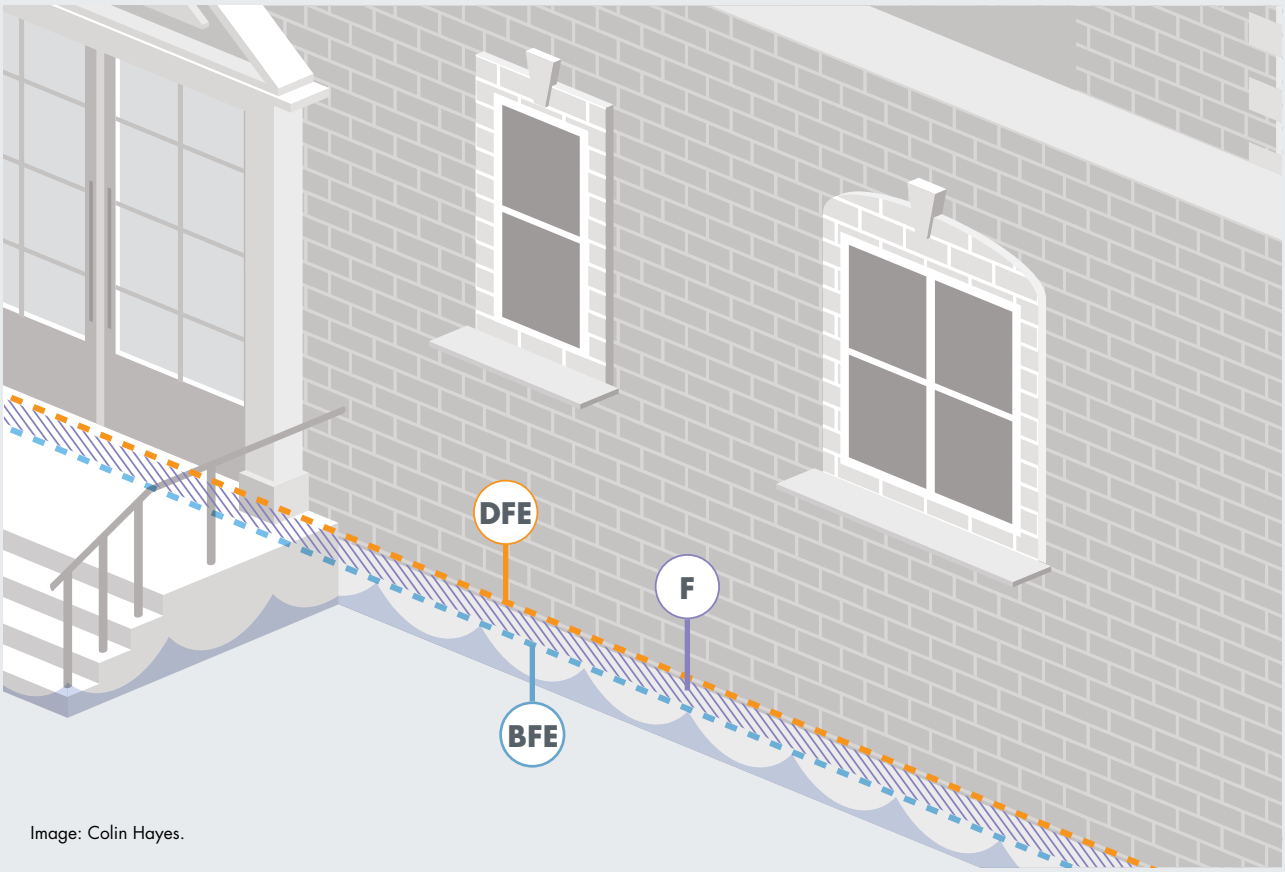


Image: Colin Hayes.

BFE **Base Flood Elevation (BFE)** is measured from the crest of expected wave height. It does not take into account future sea-level rise from climate change.

DFE **Design Flood Elevation (DFE)** is BFE plus an additional amount of safety buffer or "freeboard". Although guidance varies by local codes, this is generally 1-2 ft. above the BFE. All design and elevation recommendations in this manual will refer to DFE.

F **Freeboard** is an additional safety buffer above the Base Flood Elevation. It can be thought of as the difference between the Base Flood Elevation and Design Flood Elevation

Elevation Certificate lets a homeowner determine where their building lies in relation to the BFE. This document is required when purchasing flood insurance.

Protection

Strategies to reduce a building's vulnerability to extreme weather.

Image: Flood Control America.

1 Wet Floodproofing

Aligns with Enterprise Green Communities Criteria: **5.8a Resilient Energy Systems: Floodproofing.**

1 Engineered flood vents allow water to infiltrate non-living space.

Strategies not pictured:

Use water-resistant building materials.

Relocate or elevate equipment that cannot be exposed to water.

Image: Colin Hayes.

1 Wet Floodproofing

Wet floodproofing allows unoccupied portions of a building to be flooded during a storm. It can greatly reduce damage and recovery time. Older buildings may not be designed to withstand the hydrostatic pressure that occurs with dry floodproofing (blocking water from entering the building). With these buildings, or when dry floodproofing is prohibited by code, it is important to allow water to flow through a building in a controlled way. The space can then be dried after flood water has receded.

Description + function

FEMA defines wet floodproofing as "permanent or temporary measures applied to a structure or its contents that prevent or provide resistance to damage from flooding while allowing floodwaters to enter the structure or area. Generally, this includes properly anchoring the structure, using flood resistant materials below the Base Flood Elevation (BFE), protection of mechanical and utility equipment, and use of openings or breakaway walls."[2]

Strategy into action

Relocate or protect equipment that cannot be exposed to water.

Electrical panels, mechanical equipment, gas and electric meters and shut-offs should be relocated from flood-prone areas to locations above the DFE. If that is not possible, they should be protected in place. (See Strategy: Dry Floodproofing.)

Provide floodwater entry and exit points.

To avoid structural damage due to hydrostatic pressure during flooding, provide multiple vent openings through which floodwater can enter and exit.

To satisfy NFIP requirements, the entry points should be flood openings that meet NFIP requirements for number, size and location. Blockage of entries by flood debris must also be taken into consideration.

Wet floodproofing vents should be located below the BFE and no more than 1 ft. above the ground.
(See Strategy: Elevated Equipment)
Image: www.yourfloodrisk.com.

[2] www.fema.gov/floodplain-management/wet-floodproofing

Use water-resistant building materials below the Design Flood Elevation (DFE).

Building materials installed in floodable spaces—including framing, wallboard, flooring and ceiling paneling—should be able to survive water exposure without major damage, promoting mold or mildew, or absorbing contaminants. Building materials under the DFE should be able to withstand contact with flood waters for up to 72 hours without requiring more than cosmetic repairs.

In coastal areas with salt water, corrosion of metals may be a problem. Materials that might dry out and be usable after exposure to fresh water may be damaged beyond repair by salt water.

Operations + maintenance

Before flooding.

Items used or stored in flood-prone basements or ground-floor spaces should be moved out of the building or to higher floors in advance of a flood. These include:

» Vehicles.

» Mechanical equipment including lawn mowers and snow blowers.

» Furniture.

» Area rugs.

» Residents' belongings.

» Cleaning supplies and toxic chemicals.

How to quickly remove such items out of floodable spaces before a predicted flood should be clearly laid out in an emergency plan. (See Strategy: Developing an Emergency Management Manual).

After flooding.

Polluted floodwater poses a health risk to facility operators. Engage professional cleaning teams who have been trained and have equipment to mitigate exposure risk. Use commercial fans and dehumidifiers to dry out affected areas to prevent mold growth.

Hydrostatic pressure refers to the pressure exerted by still or slowly-moving floodwater or groundwater against building walls and floors. Hydrostatic pressure increases as the depth of the floodwater increases.

If soil is saturated during flooding, pumping out basements too quickly can lead to structural problems in foundations. If buildings share common foundation or party walls, and one flooded basement is pumped out while the adjacent basement is not, hydrostatic pressure on the common foundation wall can cause damage or collapse. See Resources for FEMA advice on pumping out basements.

Prevent mold growth.

Mold growth is a common problem after flooding. All materials in a flooded space should be dried as soon as possible. The space should be well-ventilated. Porous materials such as drywall, wood or carpeting will need to be discarded. Hardened, non-porous materials including plastic and glass may be cleaned with a commercial cleaner.

Floodwater is often polluted and carries the risk of exposure to pathogens, pollutants, asbestos and heavy metals, as well as danger of electrocution caused by submerged wires. Contaminants can soak into unsealed concrete floors or walls. With paper drywall, wicking action may pull contaminants into the core of walls on upper floors, even if this is not visible from the outside.

Mold growth can lead to serious health problems for building occupants.
Image: Jewish Women's Archive

[2] *"Don't Pump out Basements too Early or too Fast"*↗

Estimated cost

$	$$	$$$	$$$$

Supporting strategies

6 Sump Pumps.

8 Elevated Equipment.

9 Elevated Living Space.

10 Surface Stormwater Management.

Resources

Don't Pump out Basements too Early or too Fast, FEMA.
www.fema.gov/news-release/2011/07/09/dont-pump-out-basements-too-early-or-too-fast

Floodproofing: Techniques, Programs, and References, U.S. Army Corps of Engineers, May 2000.
cdm16021.contentdm.oclc.org/cdm/ref/collection/p16021coll11/id/359

Wet Floodproofing, NYC Department of Design and Construction Building Resilience Database.
ddc-resiliencedatabase.wikispaces.com/Wet+Floodproofing

Case Study Installing Floodwater Vents.

Background

During Superstorm Sandy, Hoboken, NJ suffered heavy damage to its buildings and infrastructure, including this six unit multifamily building, 132 Jackson St., located in the AE flood zone. After the storm, the property faced escalating insurance costs.

Strategy

To mitigate future risk and reduce insurance premiums, the owner chose a wet floodproofing strategy, which added nine Smart Vents on the first floor and used 9 inches of gravel and concrete fill to raise the floor to ground level. To minimize heat loss during cold weather, the owner chose insulated Smart Vents.

Cost

Total cost of the renovation, including installation of Smart Vents and the first floor fill, was $25,000. The one-panel Smart Vents cost $200 to $250 each. **After the retrofit, the building experienced an 83 percent reduction in the cost of its flood insurance policy.** Originally, the owner paid $12,000 for $300,000 worth of coverage; after the retrofit, their premium fell to $2,000 and coverage rose to $820,000. The owner experienced a return on investment in just two and a half years.

Images: www.yourfloodrisk.com

Location
132 Jackson St., Hoboken, NJ

Scale
6 Units

Cost
$25,000

2 Dry Floodproofing

Aligns with Enterprise Green Communities Criteria: **5.8a Resilient Energy Systems: Floodproofing.**

1. Seal cracks or openings in walls and foundation.
2. Install flood gates to prevent water from coming through entryways.
3. Install backflow preventers in floor drains.
4. Install a waterproof sidewalk hatch.
5. Protect against seepage by installing a sump pump.
6. Flood-proof equipment which cannot be elevated.
7. Flood doors are engineered to keep water out.

\+ *Strategies not pictured:*

Protect any electrical equipment with waterproof enclosures.

Image: Colin Hayes.

2 Dry Floodproofing

Sealing buildings to keep water out – dry floodproofing – can prevent damage to critical systems and mechanical equipment, reduce recovery time and deter mold growth.

Description + function

Dry floodproofing may be less disruptive and have less impact on the building because equipment doesn't need to be relocated above the DFE.

There are two types of dry floodproofing: active and permanent.

Active measures require removable elements to be put into place before an anticipated flood. Permanent measures are fixtures and systems integrated into the structure itself, which do not need to be manually deployed in the event of an emergency.

Due to the risk of failure, FEMA does not recommend dry floodproofing the building exterior and openings for residential buildings. Dry floodproofing measures are not permitted for substantially damaged or substantially improved residential buildings. Dry floodproofing measures will not reduce an owner's NFIP premium.

The hydrostatic pressure of floodwaters places enormous stress on the structure of a dry floodproofed building, so it is not suitable for buildings with wood frames or which share party walls.

Effective dry floodproofing requires a design by a qualified engineer and an operations and maintenance plan, and should include:

» Sealing cracks or openings on exterior walls or the foundation.

» Covering entry points below the DFE.

» Protecting against and remove seepage inside the building.

» Protecting mechanical and electrical systems.

Strategy into action

Immediate.

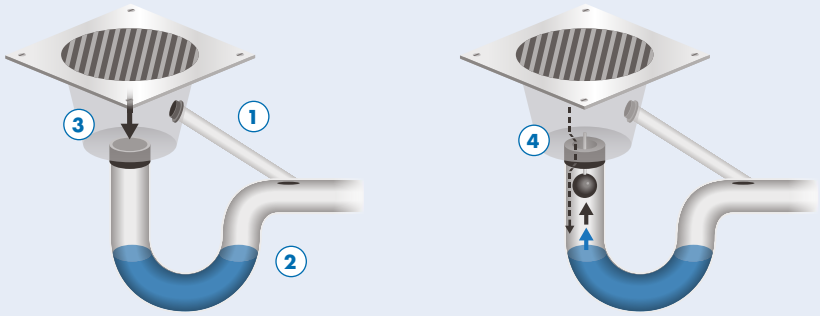
» Seal all cracks and openings in exterior walls below the DFE.

» Install backwater control plugs in floor drains, and permanently seal floor drains that are no longer in use. Before anticipated flooding, sandbag floor drains.

» Obtain waterproof covers for vents and louvers located under the DFE and install them before an anticipated flood.

1. Clean-out valve.
2. The U-bend holds a reservoir of water that keeps sewer gas and odors from coming out of the drain.
3. Before a flood event, the drain should be temporarily sealed.
4. With an automatic backflow preventer, a floating stopper is pushed by rising water into the mouth of the drain, plugging it.

Image: Colin Hayes.



Medium-term.

» Install sewer backwater valves (See Strategy: Backwater Valves). Cap house trap to prevent water from flowing into basement if sewer main is backed up.

» Install a sump pump at the lowest point of the basement (See Strategy: Sump Pumps).

» Protect electrical equipment which cannot be relocated with waterproof NEMA 6P enclosures.

A typical NEMA 6P enclosure.
Image: www.L-com.com.

Long-term.

» Permanently replace first floor doors with sealed-gasket flood doors and install removable flood gates over entry ways.

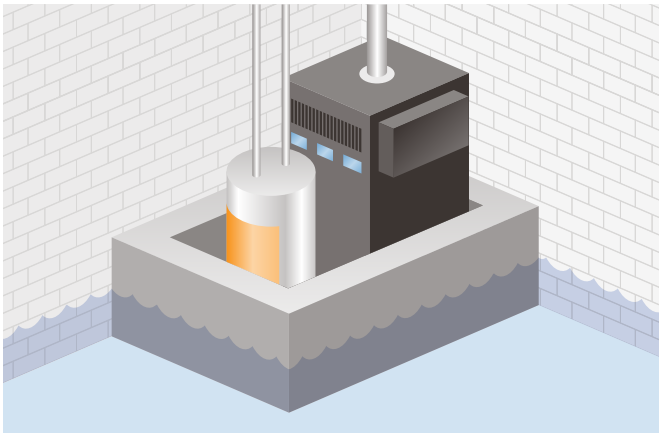
Above: Flood gates protecting an entryway.
Image: Flood Control America.

Above right: A trench drain.
Image: Samantha Yost.

» Install waterproof hatch doors on sidewalk hatches. A trench drain at the base of the stairs can reduce seepage from a non-protected hatch.

» If they cannot be elevated, critical building systems can be floodproofed by building a perimeter wall and allowing the rest of the space to flood (rather than protecting the entire building exterior). Due to hydrostatic pressure, these enclosures are recommended only for shallow floodwaters up to 3 ft.

Dry component floodproofing is often an effective solution for equipment that cannot be elevated or relocated out of basements.
Image: MAP Architects, New York Engineers.



Because of hydrostatic pressure, component floodproofing barriers should designed to a maximum of 3 ft.
Image: Colin Hayes.

Sources of water infiltration into a basement or below-grade space

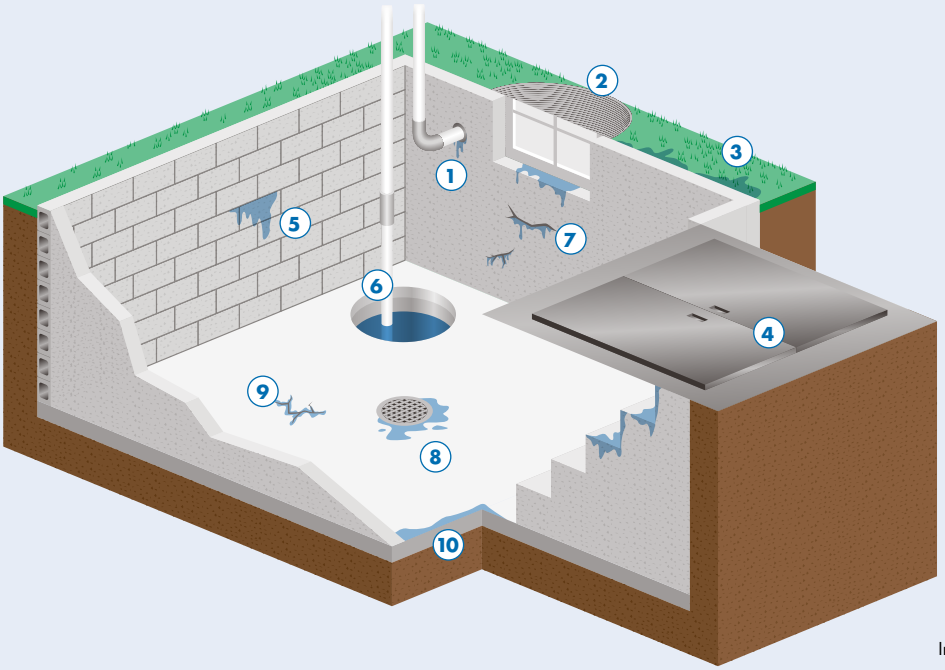


Image: Colin Hayes.

1. Pipe penetrations through the foundation walls.
2. Window wells.
3. Ground pitched towards the foundation.
4. Entry hatch and its perimeter.
5. Mortar cracks.
6. Sump pumps without backwater valves (See Strategy: Backwater Valves).
7. Cracks in walls.
8. Backflow from drains.
9. Cracks in floors.
10. Cove joint where foundation walls join the slab.

Operations + maintenance

It is vital to have an active operations and maintenance plan in place. Building staff should know how to properly install and operate temporary dry floodproofing measures before they are needed.

» Regularly inspect outdoor fixtures for signs of rust and corrosion.

» Inspect building areas below DFE for leaks, seepage and cracks.

» Install temporary flood barriers at entrances in advance of an anticipated flood event. Consult an engineer to see if this is a viable strategy.

2 Dry Floodproofing

Estimated cost

$	$$	$$$	$$$$

Supporting strategies

3 Site Perimeter Floodproofing.

5 Backwater Valves.

6 Sump Pumps.

Resources

Can I Dry Floodproof my Building? CDM Smith.
www.floods.org/Files/Conf2015_ppts/F3_Perotin.pdf

Dry Floodproofing: Selecting Appropriate Mitigation Measures for Floodprone Structures, Chapter 7, FEMA.
www.fema.gov/es/media-library/assets/documents/10618

Floodproofing Non-Residential Buildings, FEMA.
www.fema.gov/media-library/assets/documents/34270

Reducing Damage from Localized Flooding, FEMA.
www.fema.gov/es/media-library/assets/documents/1012

Case Study Dry Floodproofing Utility Rooms.

Background

The supportive housing facility at 318 Beach 85th St., Queens, NY, has 71 housing units operated by Services for the Underserved (SUS). It serves mentally ill and formerly homeless residents.

The building is located between Jamaica Bay and the Atlantic Ocean. During Superstorm Sandy, floodwater reached 4 ft. above the first floor, and the building lost power for a month. Total disaster-related costs from Sandy exceeded $4.6 million.

Strategy

Four floodgates were installed in the building, two over the rear kitchen doors and two over the front doors. The floodgates vary in width from 40 to 54 inches, and offer an additional 24 to 36 inches of protection. In the basement, integrated waterproof flood doors replaced doors at two corridor entrances, a resident emergency exit and all utility rooms including the boiler room, electrical room, elevator room and fire pump room. The flood doors are designed to provide water protection to a height of 48 inches.

These retrofits were paired with other resilience measures, including the installation of sump pumps and a rooftop natural gas generator.

Cost

- Total cost including installation: $100,000.
  - Four floodgates: $4,600.
  - Seven flood doors: $56,700.
  - Installation: $35,700.

One of the newly-installed, waterproof flood doors at 318 Beach 85th St.
Image: Services for the Underserved.

The newly-installed flood gates over entryways.
Image: Services for the Underserved.

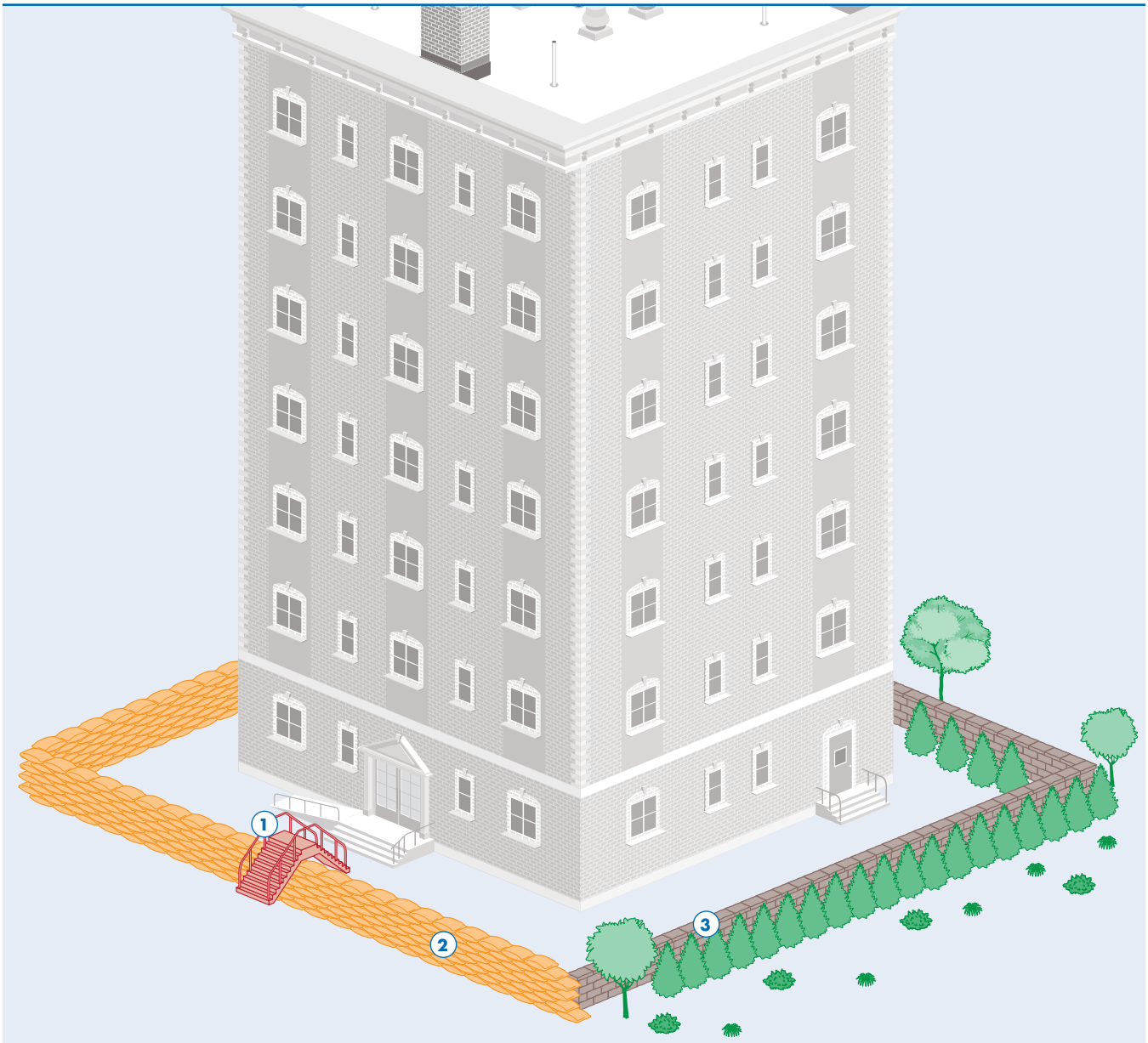
Location
318 Beach 85th St., Queens, NY

Scale
71 Units

Cost
$100,000

3 Site Perimeter Floodproofing

Aligns with Enterprise Green Communities Criteria: **5.8a Resilient Energy Systems: Floodproofing.**



1. Provide entry and exit over barriers.
2. Temporary flood barriers can be deployed before a flood.
3. Permanent barriers can be part of landscaping or security plans.

Image: Colin Hayes.

3 Site Perimeter Floodproofing

Deploying physical barriers may prevent floodwaters from reaching the building and does not require modifications to the building structure.

Description + function

Protective barriers may be temporary or permanent.

Temporary barriers.

Temporary barriers can be quickly deployed, generally in less than 24 hours. However, a flood must be anticipated with sufficient warning time. They include:

- **Sandbags** Although inexpensive and effective, they are heavy and hard to transport.
- **Water-inflated tube systems** These large vinyl, rubber or polyethylene tubes are typically filled from a fire hydrant, then anchored to the ground. Due to freshwater buoyancy in salt water, they are not recommended for coastal flooding zones.
- **Panelized systems installed into foundation slots** Temporary flood panels can be fitted into permanent slots.
- **Other Systems** A variety of new technologies are emerging to support flood protection (See Case Study on "sand-less sandbags").

Sandbags are one of the most commonly-used temporary flood barriers.
Image: FEMA / Jeannie Mooney.

Protective barriers do not fulfill NFIP floodproofing requirements and cannot be used to bring a substantially improved property into compliance.

Practice installation of a Tiger Dam inflatable system.
Image: US Flood Control Corp.

Erection of a panelized flood wall
Image: Flood Control America.

Permanent barriers.

» **Floodwalls** are typically made of reinforced concrete or reinforced concrete blocks. They are built on solid foundations and engineered to support the hydrostatic pressure from a flood. Because they are permanently installed, they are effective against unanticipated events.

» **Berms** are earthen structures with wide, shallow-sloping sides, carefully built with compacted layers of clay to prevent water penetration. Levees are long, linear berms usually meant to keep a river within its banks, while smaller earthen berms can be used to encircle buildings.

A permanent flood wall.
Image: Michael Jeffries.

A permanent levee and floodwall system protecting Grand Forks, ND.
Image: FEMA / Brenda Riskey

Flood barriers are meant to keep water out, but they will also keep water in. Consider how to manage stormwater that enters the enclosure as runoff or infiltration, either by pumping it out or giving it an outlet.

Floodwalls should always provide a way for residents and emergency personnel to get in or out. These include steps, ladders, ramps or waterproof doors.

Building owners will likely need to get permission from the Department of Transportation before deploying temporary flood barriers on sidewalks or streets.

Strategy into action

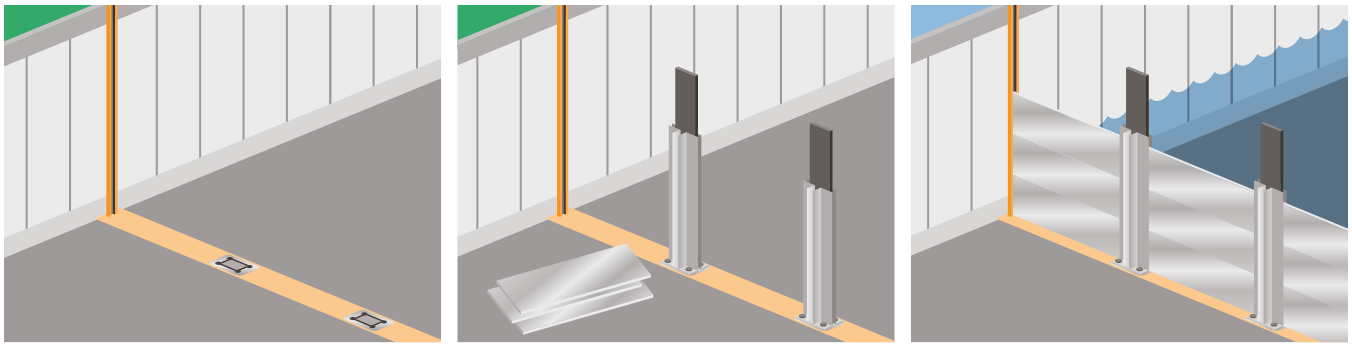
Due to the risk of barrier failure, it is important to consult a professional to ensure the system can withstand the hydrostatic pressure of floodwaters.

Building setback requirements.

Berms and levees are an option only if there is adequate space around a building. The width of berms and levees requires greater setbacks than floodwalls, and may be impractical in an urban environment.

Deploying temporary barriers.

Deployable floodwalls consist of interlocking panels inserted into permanent slots. Temporary flood barriers are unrolled and inflated with water, usually using fire hoses. The barriers are then anchored to the ground with straps.



Most deployable barrier walls are less than 6 ft. high and can be deployed in several hours, though taller systems could take a day or more to install.
Image: Colin Hayes.

Integrating permanent barriers with landscape design.

Permanent flood barriers can serve additional purposes, including recreational use and landscape design, in which they provide seating or erosion control. Check with local regulations on flood barriers before installing a permanent system.

Permanent barriers may be integrated into landscaping or security planning .
Image: Samantha Yost.

Operations + maintenance

Inflatable dams can be very space-effective when stored properly.
Image: Samantha Yost

When multifamily buildings are threatened with flooding, evacuation is usually necessary, even with permanent flood barriers in place. If an evacuation is ordered by the local municipality, building owners should comply.

Inspect permanent berms, levees and floodwalls after any flooding, and at least annually, to identify potential points of failure—berms and levees can erode quickly if a leak forms. Floodwalls, both permanent and temporary, can fail if concrete footings degrade or fissures open up. If the water table rises under flood walls, they are likely to destabilize. Monitor perimeter floodwalls closely during a flood event.

» **Inspection** Temporary, panelized floodwalls may not install properly if foundations or grooves in walls or structural columns are damaged. Frequent inspection is necessary.

» **Storage** Water-inflated flood barriers and flood-door gaskets may deteriorate from exposure to UV, dust and dirt. Store these systems in a clean environment away from sunlight.

» **Training** Conduct yearly trainings on the proper installation of temporary flood barriers, so staff members can practice deploying the system. Following a deployment, inspect and repair barriers.

Estimated cost

$	**$$**	**$$$**	$$$$

Supporting strategies

2 Dry Floodproofing
6 Sump Pumps
10 Surface Stormwater Management

Resources

Fluvial Design Guide, Chapter 9, Floodwalls and Flood Embankments, UK Environment Agency.
evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide/Chapter_9_Background.aspx

Selecting Appropriate Mitigation Measures for Flood-Prone Structures, Chapter 5, Barriers, FEMA 551, March 2007.
www.fema.gov/media-library/assets/documents/10618

Temporary and Demountable Flood Protection Guide: Flood and Coastal Erosion Risk Management Research and Development Programme, UK Environment Agency.
www.gov.uk/government/uploads/system/uploads/attachment_data/file/290837/scho0711buak-e-e.pdf

Case Study Temporary Barrier Systems

Background

The Jewish Association Serving the Aging (JASA) owns and operates several multifamily residential buildings across New York City, primarily housing for seniors. Superstorm Sandy caused $2 million dollars worth of damage to JASA's properties. Several of its larger senior housing facilities lost power. To protect buildings against future storms, JASA implemented a host of resilience measures.

Strategy

As part of its comprehensive plan, JASA purchased 10 cases of **Floodsax**↗, a commercial product that functions like a sandbag but is filled with a dehydrated gel. When exposed to water, the gel expands, absorbing the water and swelling to several times its original volume. When dry, the bags are much lighter and easier to store and transport than sandbags.

Floodsax complement JASA's other floodproofing measures, including removable dry floodproofing barriers at entrance doors. In addition to physical resilience efforts, JASA has implemented an organization-wide emergency response plan in preparation for future disasters.

Cost

JASA purchased 10 cases of Floodsax for approximately $2,500. Each case contains 20 reusable bags.

Images: Floodsax.

Location New York, NY

Scale Organization-wide

Cost $250 per case of 20 bags

4 Resilient Elevators

Aligns with Enterprise Green Communities Criteria: **5.8a Resilient Energy Systems: Floodproofing.**

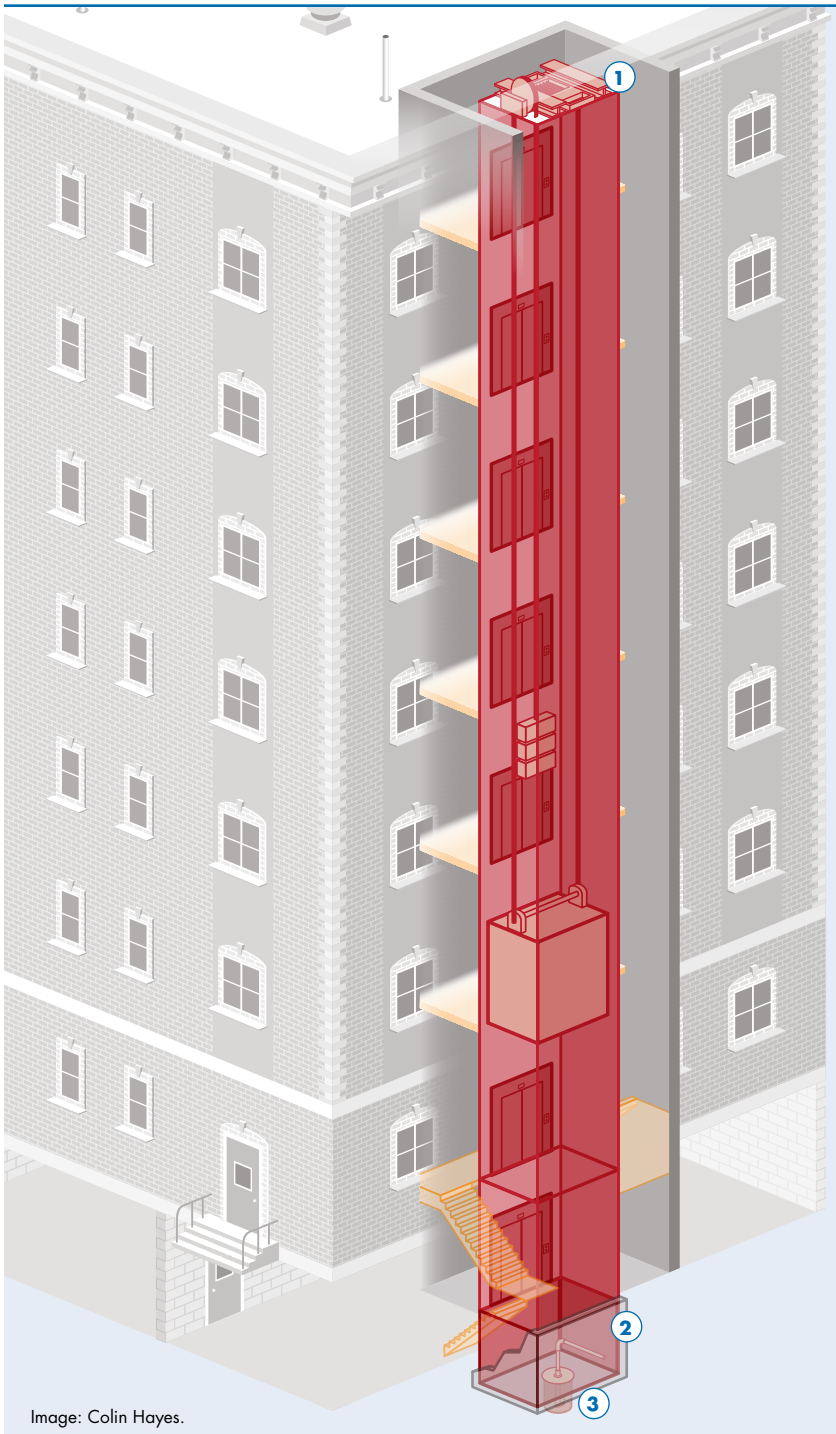


Image: Colin Hayes.

1. Install elevators with motors and controllers above the Design Flood Elevation.
2. Reinforce the shaft below the Design Flood Elevation.
3. Install a sump pump in the elevator pit.

+ *Strategies not pictured:*

Dry floodproof pit components that cannot be elevated.

Install flood alarms in the elevator pit.

Set controls to prevent the cab from lowering into floodwater.

4 Resilient Elevators

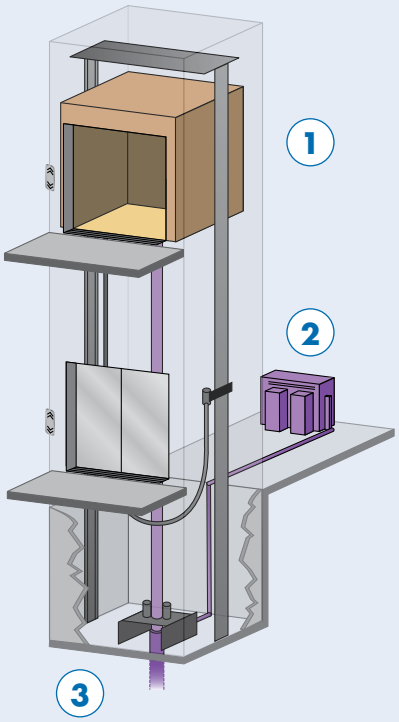
Elevators are often the only way vulnerable residents have to reach higher floors, making them a critical building system. They are particularly vulnerable to flood damage because elevator pits typically extend well below the lowest floor. Even outside flood zones, elevators can be damaged by plumbing failures, sprinkler system runoff after a fire and sewer backup.

Description + function

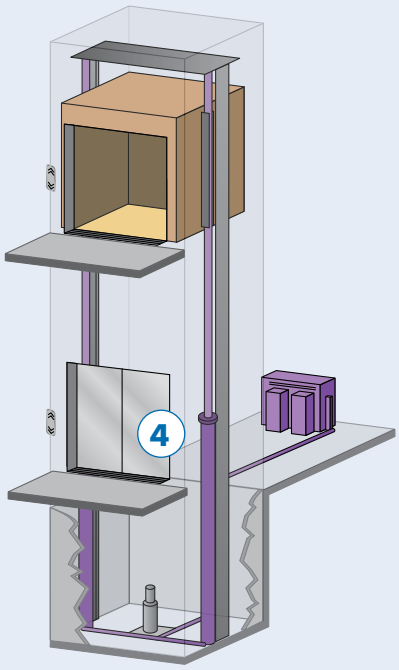
Different types of elevators have different vulnerability to flooding.

» **Hydraulic elevators** are pushed up by pistons. They are found in some low-rise buildings (usually with five floors or fewer). Holeless hydraulic elevators are preferred in flood zones because the piston is positioned well above the bottom of the elevator shaft, which reduces the risk of hydraulic fluid contaminating the floodwater. The elevator pit usually extends 4 to 5 ft. below the lowest access level of a hydraulic elevator.

Hydraulic



Holeless hydraulic

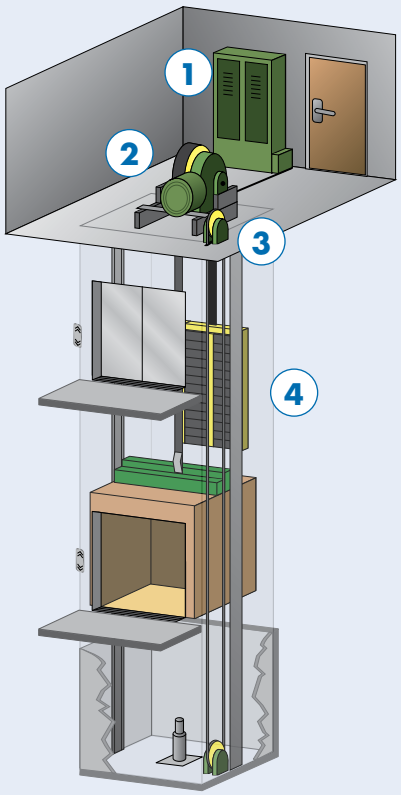


1. Cab.
2. Hydraulic fluid tank/controller, elevated above the DFE.
3. In-ground cylinder (vulnerable to flooding).
4. Above-ground plungers (less vulnerable to flooding).

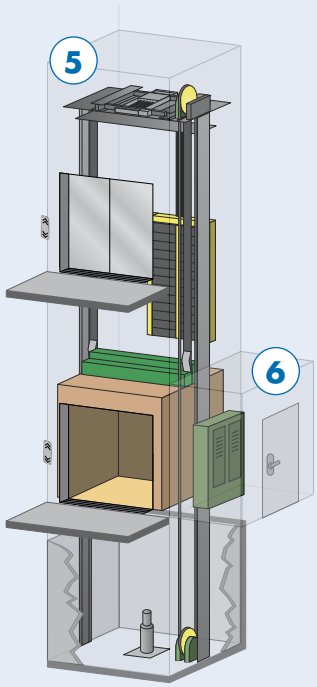
Images: Samantha Yost.

» **Traction elevators** hoist the elevator up with a traction motor and are more common in multifamily buildings. In many older traction elevators, a machine room on the roof houses the elevator controls and mechanical elements. Newer machine room-less (MRL) traction elevators require a control closet, which can be located at any level near the elevator shaft. The elevator pit usually extends 6 to 8 ft. below the lowest access level of a traction elevator.

Traction



MRL traction



1. Controller.
2. Traction motor.
3. Governor cable.
4. Counterweight.

5. MRL traction motor.
6. MRL control closet.

Images: Samantha Yost.

Strategy into action

» Sizing of elevator motors are an important consideration when determining backup power requirements.

» Elevator shafts that extend below the DFE should be designed and built to resist the hydrostatic pressure of floodwater. Appropriate shaft construction materials include reinforced masonry block and reinforced poured concrete.

» During power outages in buildings of four stories or more, advanced elevator controls should automatically shut down all but one elevator at a flood-safe floor, while allowing the functioning elevator to operate on backup power. (See Strategy: Maintaining Power to Critical Systems).

Elevator controls.

» Keep electronic elevator controls above the DFE in the rooftop machine room (for conventional traction elevators) or in a mechanical closet adjacent to the elevator shaft on an upper floor (for MRL traction elevators).

» Set elevator controls to prevent cabs from being lowered to a flood-prone lower floor during a power outage or flood. Install one or more float switches in the elevator pit with controls to prevent the elevator cab from descending into a flooded pit. Designate fire recall floors above the DFE.

» Install flood alarms in pits. Install controls to keep the elevator cab out of a flooded shaft.

1. Relocate the hydraulic controller or traction motor to a location above the DFE.
2. In new construction, install hole-less hydraulic elevators, in which the plungers are located high off the ground and out of the reach of floodwater.
3. Install a flood alarm to alert the operator when the pit is flooded.
4. Dry floodproof any electric equipment that cannot be elevated.
5. Install a sump pump with a separator for hydraulic fluid.
6. Reinforce shaft walls and floors below the DFE.

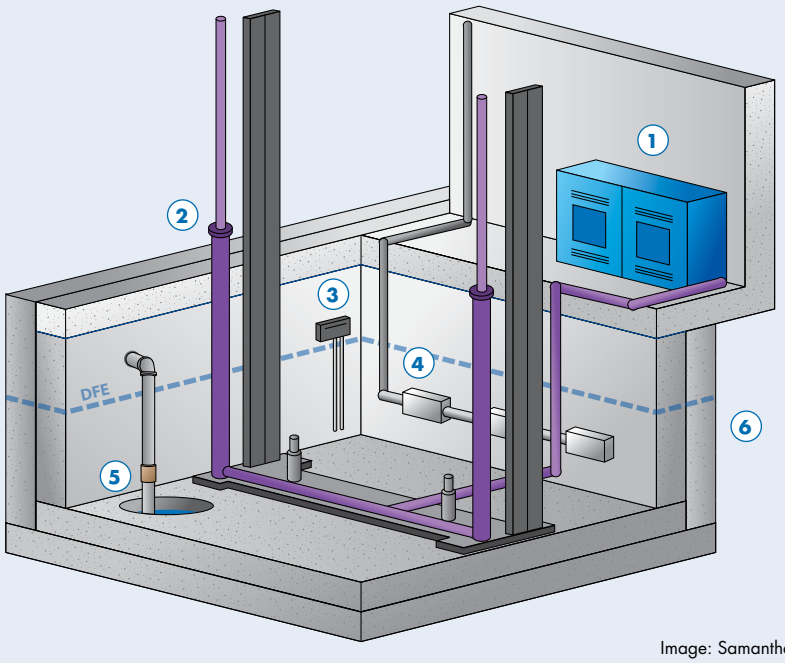


Image: Samantha Yost.

While elevator cabs are typically covered by the National Flood Insurance Program (NFIP), elevator equipment located in the elevator shaft below the BFE is typically not covered. Clarify exact coverage with your insurance carrier.

Components.

» Relocate hydraulic controllers or traction motors out of the elevator pit.

» Dry component floodproof any electronic equipment that cannot be relocated out of the elevator pit.

» Install sump pumps at the bottom of the elevator pits. Hydraulic elevator sump pump systems should include separators to remove hydraulic fluid from the discharge. (See Strategy: Sump Pumps).

Operations + maintenance

Park elevators in advance of a flood.

Prior to a flood, bring elevator cabs to an upper floor above the DFE, park them and shut off power. If one elevator is kept operational on emergency backup power, it should be prevented from descending to a flooded floor.

Inspect elevators after flooding.

After flooding, use caution around elevator equipment that may have been damaged. Engage an elevator service company to conduct a detailed inspection to determine any damage. With traction elevators, little can be done to protect governor cables, which extend to the bottom of the elevator pit. These usually have to be replaced following a major flood.

If an elevator has been damaged, ensure that a technician services it before it is returned to use.

Estimated cost

$	$$	$$$	$$$$

Supporting strategies

- 2 Dry Floodproofing.
- 3 Site Perimeter Floodproofing.
- 6 Sump Pumps.
- 8 Elevated Equipment.
- 13 Maintaining Backup Power to Critical Systems.
- 18 Developing an Emergency Management Manual.

Resources

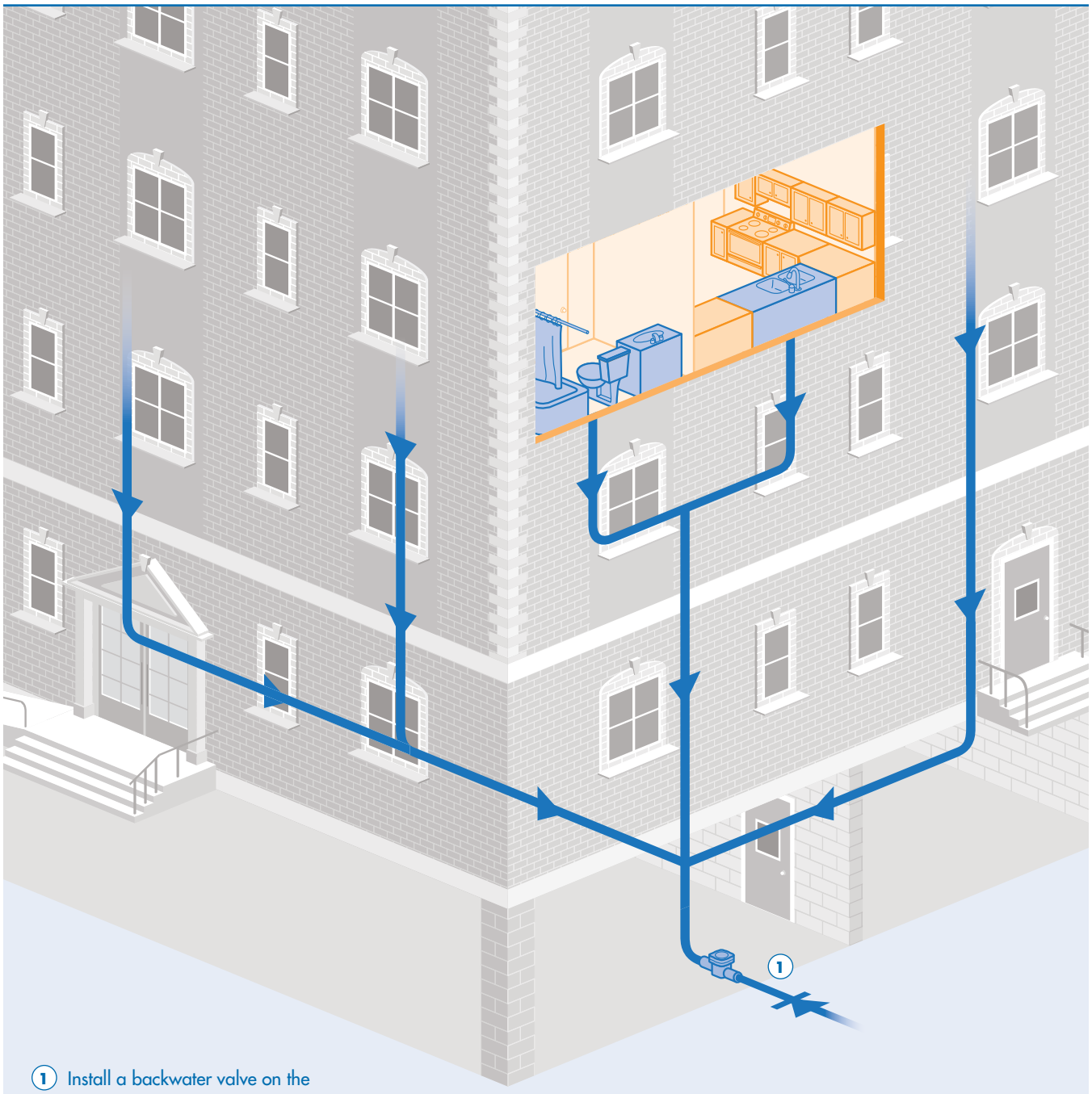
Elevator Hurricane Preparedness, Miami Dade County Government.
www.miamidade.gov/facilities/elevator-hurricane-preparedness.asp

Elevator Installation for Buildings Located in Special Flood Hazard Areas in Accordance With the National Flood Insurance Program, Technical Bulletin 4, FEMA, November 2010.
www.fema.gov/media-library/assets/documents/3478

Guidance on Record-Keeping, Rising Waters: Impact on Elevators.
www.kja.com/rising-waters-impact-on-elevator-and-escalators-p154285

5 Backwater Valves

Aligns with Enterprise Green Communities Criteria: **5.8a Resilient Energy Systems: Floodproofing.**



1 Install a backwater valve on the house sewer line.

Image: Colin Hayes.

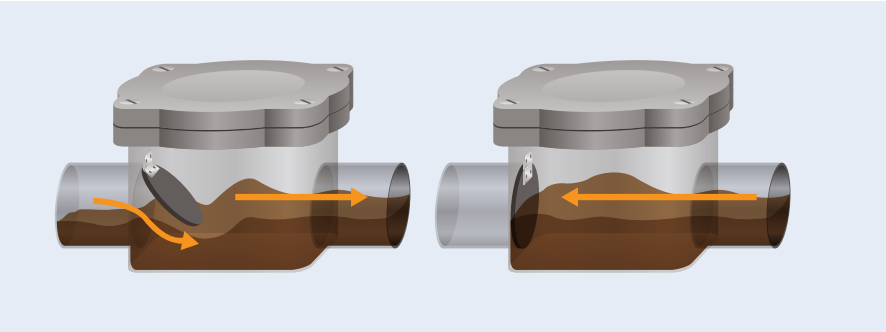
5 Backwater Valves

Sewage backflow occurs when storm water backs up into a building basement because of sewer line blockage or storm drain overflow due to flooding. A backwater valve is a relatively inexpensive retrofit that can prevent significant problems from sewer line failure by blocking reverse flow from entering the building through wastewater pipes.

Description + function

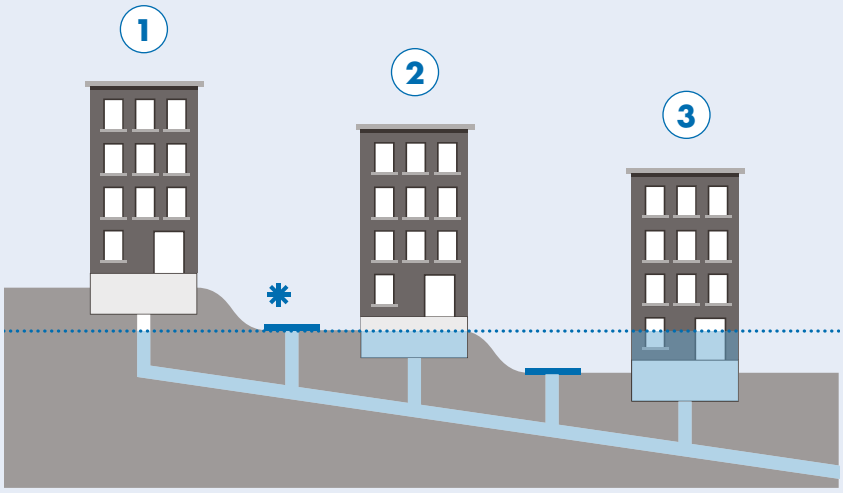
Backwater valves allow waste water to flow out, but automatically close if the flow is reversed.
Image: Colin Hayes.

Backwater valves are installed where the wastewater pipe exits the building, so sewage only flows outward. Valves have a hinged flapper that remains open to allow outward flow, but seals tightly if there is backpressure.



Backwater valves are situated above the external sewer line and should be installed in buildings that have sewer connections below the highest manhole cover in the sewer system, especially if the property is within the Special Flood Hazard Area (SFHA). Although sewer blockage can occur any time, it is most likely to happen during storms when large amounts of water and debris move through the system.

Building (1) does not require a backwater valve because it is located above the highest manhole in the sewer system.* Building (2) may have some basement flooding if a backwater valve is not installed. Building (3) will be flooded in its basement and some living spaces if sewers back up.
Image: Samantha Yost / Matthew Goodrich.



Strategy into action

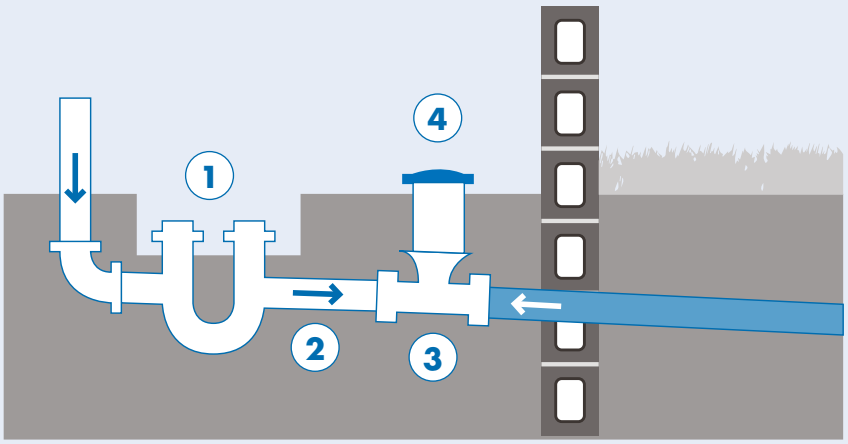
Installation.

Municipal codes often require the installation of backwater valves in new construction sited in flood zones. Property owners outside flood zones should also consider backwater valves because sewers can back up any time, not just during extreme weather events. Building codes may also prohibit backwater valves. A plumbing professional will be able install a code-compliant system.

Backwater valves should be installed on the street side of the house trap. Improper installation could cause the trap to fail. To ensure smooth flow, there should be at least 2 ft. of un-branched pipe upstream of the backwater valve.

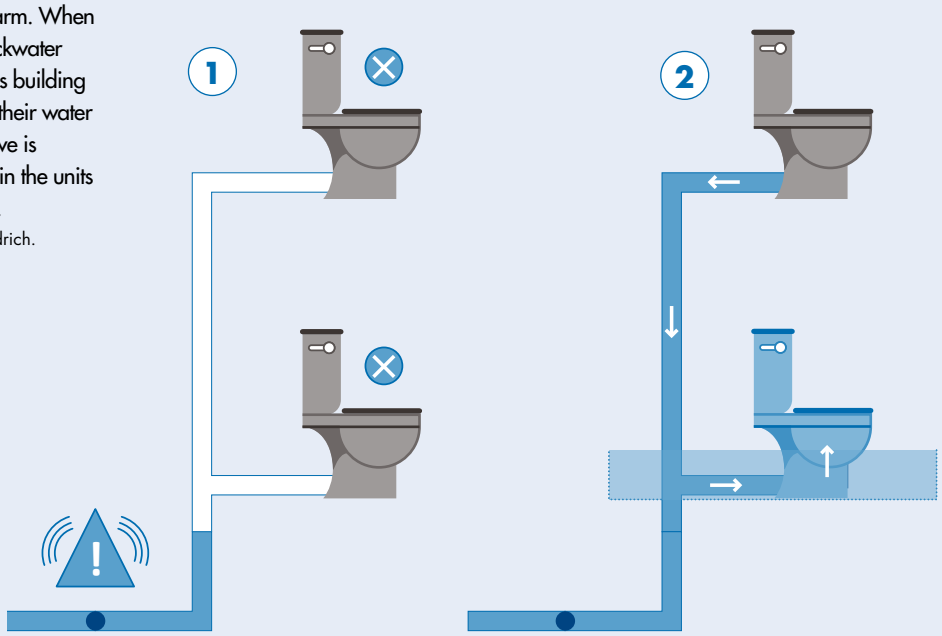
1. Backwater valves should be installed on the street side of the house trap.
2. There should be 2 ft. of unbranched pipe at a 2 percent slope upstream of the backwater valve.
3. Backwater valves stop backflow from the municipal sewer system.
4. An access hatch allows cleaning and maintenance.

Image: Samantha Yost / Matthew Goodrich.



Depending on its size and the configuration of drain piping in the basement, a building may have just one backwater valve connected to the main sewer line, or separate valves may be installed on different lines and drains. Backwater valves should be enclosed in a masonry pit with a waterproof cover giving access for cleaning and maintenance.

Always install a sewer backup alarm. When a sewer backup occurs and a backwater valve is activated, the alarm warns building operators and residents to curtail their water use (1). When the backwater valve is closed, failure to cease water use in the units will result in wastewater spills (2).
Image: Samantha Yost / Matthew Goodrich.



Operations + maintenance

Inspect backwater valves regularly.

Inspect backwater valves frequently to ensure there is no debris in the device or cleanout port and the valve functions properly.

Cast-iron backwater valves may be damaged in areas with salt water and heavy minerals in the water. Check them regularly for rust and internal corrosion.

Manage stormwater onsite.

Should the backwater valve be closed to prevent stormwater from entering the building, it would also prevent stormwater collected onsite from leaving, causing flood damage inside the building. Consider other options for managing stormwater onsite, such as storing it in rainwater cisterns or infiltrating the water into the site.

Estimated cost

$	$$	$$$	$$$$

Supporting strategies

2 Dry Floodproofing

6 Sump Pumps

10 Surface Stormwater Management

Resources

How Much Does a Backflow Preventer Cost? Cost Helper.
home.costhelper.com/backflow-preventers.html

Sewer Backwater Valves, LA Department of Building and Safety.
ladbs.org/LADBSWeb/LADBS_Forms/Publications/backwater_valves.pdf

Sewer Maintenance Tips, Lamont Public Utility District.
lpud.org/sewer-tips/

Case Study Installed Backwater Valve

Background

With a restaurant on the ground floor and six housing units above, 141 Fifth Ave. is one of 56 affordable multifamily buildings in South Brooklyn owned and managed by Fifth Avenue Committee (FAC), a non-profit community development organization. It is in the unshaded X flood zone – above the 500-year flood line – but basement stormwater flooding is a constant challenge. During heavy rains – up to 10 times a year – the basement fills with about 1 ft. of water.

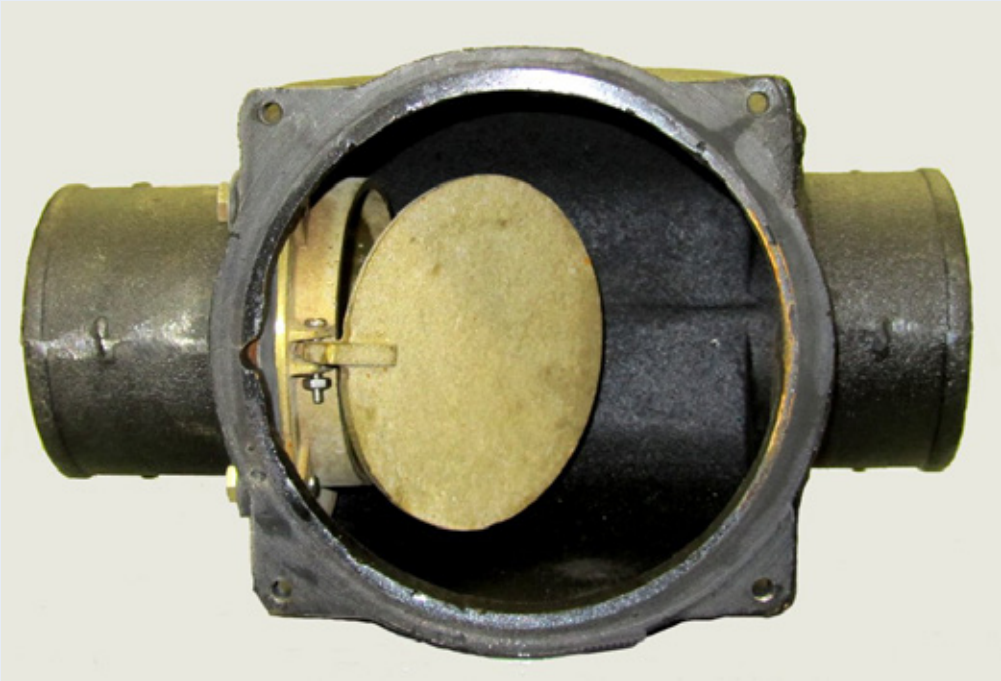
Strategy

In 2011, FAC installed a backwater system at 141 5th Ave. A sump pump removes water that builds up when it rains, and the backwater valve prevents additional stormwater from forcing its way into the building. The building manager has also implemented a flood action plan. Staff are trained in system operation and communication protocols that alert residents to stop using water fixtures when the valve is engaged.

Cost

$3,000 for installation.

Image: David Balkan, Balkan Sewer & Main.



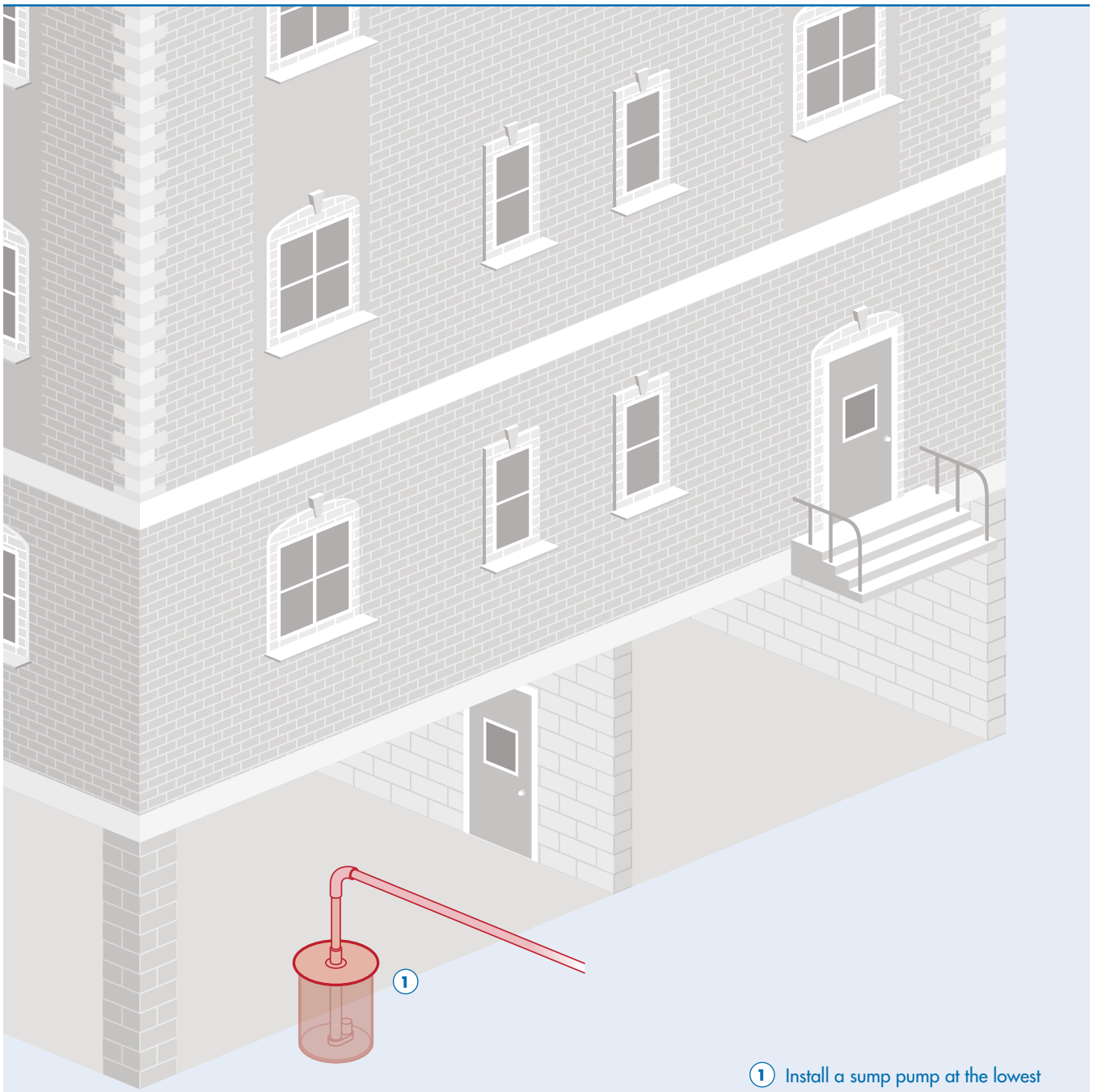
Location
141 5th Ave, Brooklyn, NY

Scale
6 units

Cost
$3,000

6 Sump Pumps

Aligns with Enterprise Green Communities Criteria: **5.8a Resilient Energy Systems: Floodproofing.**



1 Install a sump pump at the lowest point in the building.

Image: Colin Hayes.

6 Sump Pumps

Sump pumps remove water which accumulates in the low points in a building, typically the basement. They are an effective and affordable way to reduce costly flood damages.

Description + function

Sumps are typically built in sump basins in basement floors but can also be incorporated into slab-on-grade floors and elevator pits. Pumps are installed in these sump basins to remove water during minor to moderate floods.

Sump pumps are designed for intermittent use. Chronic water problems require repairing the drainage system.

Strategy into action

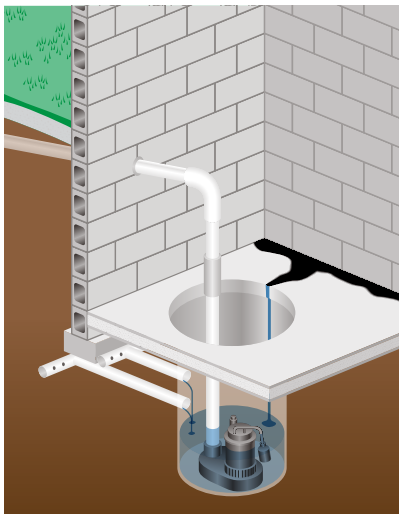


Image: Colin Hayes.

Sump pumps should be installed at low points in a basement floor to collect water, reducing water damage risk to vital equipment. If a concrete floor is uneven and water collects in puddles, channels can be cut into the slab, allowing the water to drain.

A basement sump can be a source of radon, a radioactive gas naturally occurring in some soils. If radon levels are too high or if required by code, a heavy-duty cover with an outside vent pipe may be installed.

Float switch-activated submersible sump pumps are recommended for permanent locations; they will start pumping water automatically once water reaches a certain level.

A sump pump rated at 5.5 amps can remove about 100 gallons of water a minute. A lower vertical rise or a larger pump will remove more water more quickly. Determine the number and size of the sump pumps you need based on:

» Maximum amount of water anticipated in a flood.

» How high water needs to be pumped.

In some jurisdictions, water outflow from sump pumps may not be allowed in storm or sanitary sewers. In this case, this strategy may be combined with infiltrating stormwater onsite (See Strategy: Stormwater Management) or installing a holding tank for gray water. Contaminated floodwater should be treated as regulated waste and not sent into a sewer system or infiltrated onsite.

Image: State Farm.

Design sump pumps to handle moderate flooding but not catastrophic flooding such as a coastal storm surge.

Power supplies for sump pumps should be rated for submersion, and wiring should extend up from this equipment rather than along the floor. Locate controls for the system above the DFE. Pumps should be connected to an emergency backup generator to maintain power during outages. Be sure that the generator has adequate capacity to power the pumps. Some sump pumps require considerable power draw so battery power may not be adequate.

To prevent backflow through the sump connection, the sump pump discharge pipe should have a backwater valve and have the capacity to pump higher than the DFE.

Operations + maintenance

Inspect regularly.

Inspect permanently installed sump pumps regularly to ensure that they are in good working condition.

Check and clean the pump inlet screen, particularly while in operation, since debris or blockage can drastically reduce flow rates.

Estimated cost

$	$$	$$$	$$$$

Supporting strategies

- 1 Wet Floodproofing or 2 Dry Floodproofing
- 5 Backwater Valves
- 8 Elevated Equipment
- 10 Surface Stormwater Management
- 13 Maintaining Backup Power to Critical Systems

Resources

Sizing up a Sump Pump, Land and Water, Conserving Natural Resources in Illinois.
abe-research.illinois.edu/pubs/factsheets/SumpPumps.pdf

Sump Pumps, Dry Floodproofing Measures, Section 3.7.1, pages 3-27, FEMA Guidance for non-residential buildings, July 2013.
www.fema.gov/media-library/assets/documents/34270

Case Study Installed Sump Pump

Background

Operated by the Fifth Avenue Committee, the three-story, four-unit property at 190 Butler Street in Brooklyn was built in 1920. It is on the border of the 100-year AE FEMA flood zone.

Sewer system backflow from Superstorm Sandy drove water into the cellar to a height of about 10 inches above the floor. Electrical circuits, junction boxes and light fixtures were damaged, though fortunately only in a small area of the cellar.

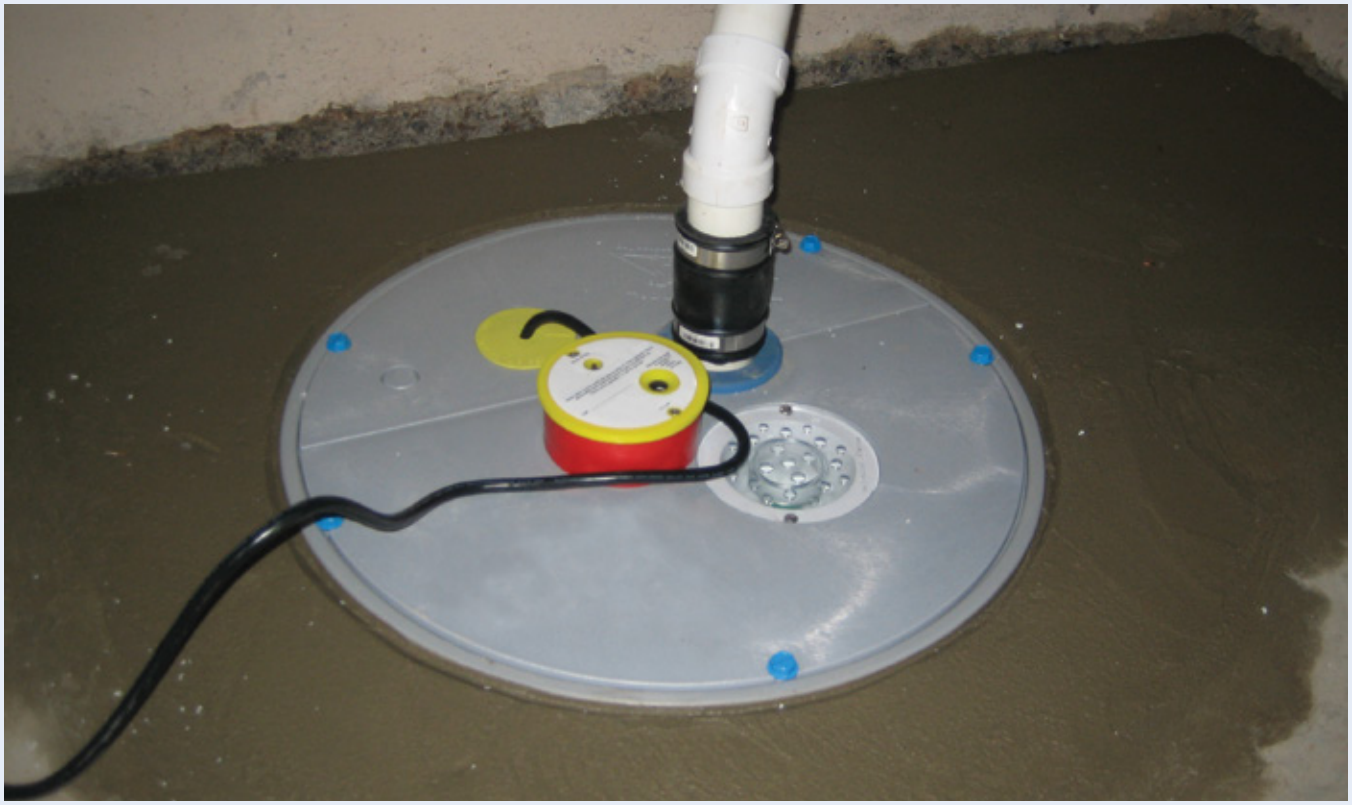
Strategy

FAC hired a plumber to install a sump pump at the lowest point in the basement. It has a floater device that controls the power. When water rises to a certain level, the floating valve activates the pump. When the water level in the sump drops sufficiently, the pump shuts off automatically.

Cost

$2,000, not including installation.

Image: Tom Simpson.



Location
190 Butler Street, Brooklyn, NY

Scale
4 units

Cost
$2,000

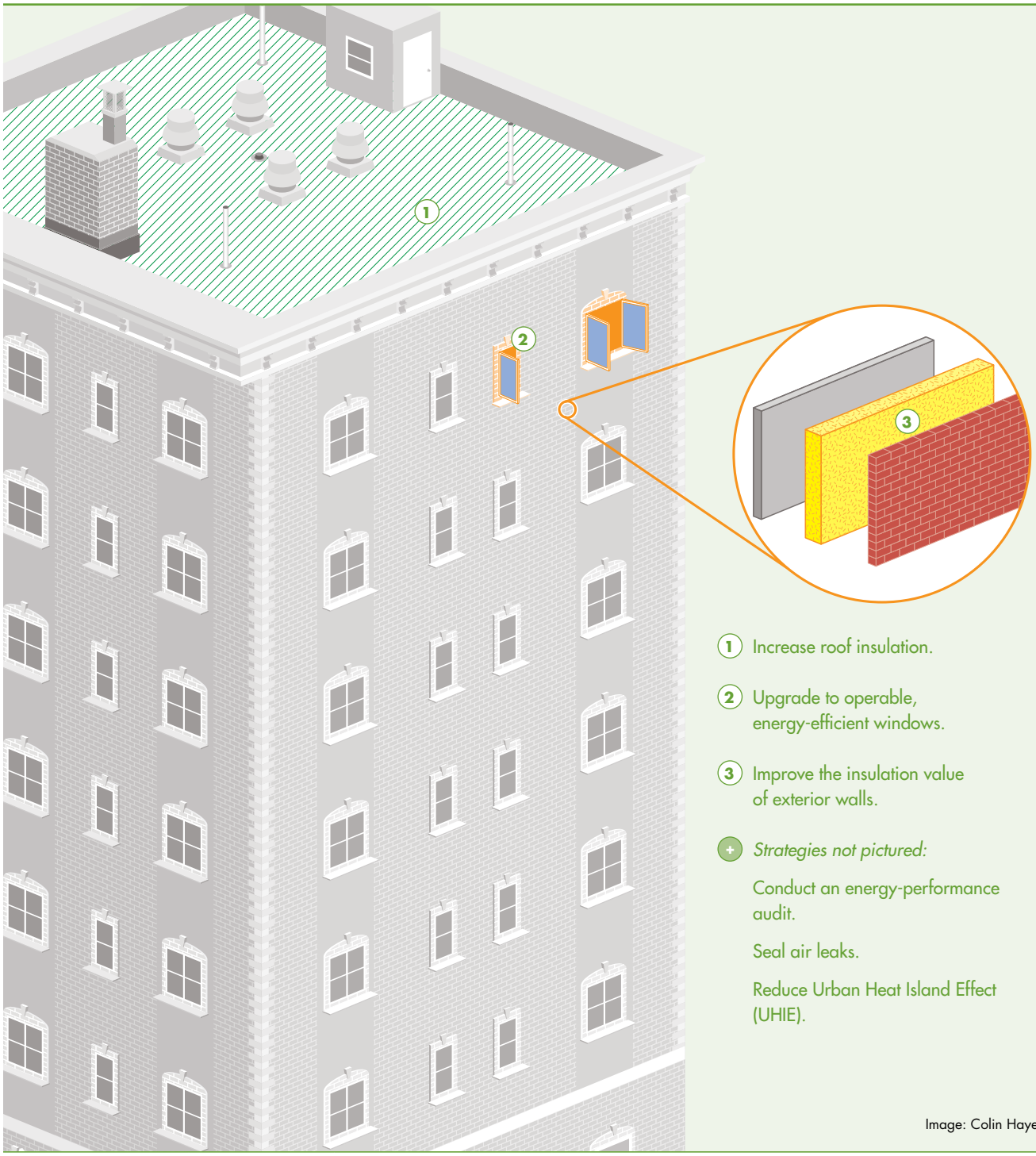
Adaptation

Strategies that improve a facility's ability to adapt to changing climate conditions.

Image: University of Central Arkansas.

7 Envelope Efficiency

Aligns with Enterprise Green Communities Criteria:
3.6 Surface Stormwater Management.
5.2b Advanced Certification: Nearing Net Zero.
5.2a Additional Reductions in Energy Use.



1. Increase roof insulation.
2. Upgrade to operable, energy-efficient windows.
3. Improve the insulation value of exterior walls.

+ *Strategies not pictured:*

Conduct an energy-performance audit.

Seal air leaks.

Reduce Urban Heat Island Effect (UHIE).

Image: Colin Hayes.

7 Envelope Efficiency

Most buildings are not designed to remain habitable during extended power outages. Heat loss through the building envelope determines how quickly interior temperatures will rise or fall. A high-performance envelope is especially valuable during a power outage because indoor temperatures change more slowly, increasing a building's "passive survivability."

Description + function

The thermal performance of a building envelope or building skin depends on several key factors:

» **Insulation value (R-value)** The effectiveness of the insulation in the windows, walls and roof.

» **Air leakage** How much outside air leaks into a building through gaps and holes.

» **Thermal bridges** Places where a lack of insulation lets heat flow in or out more quickly.

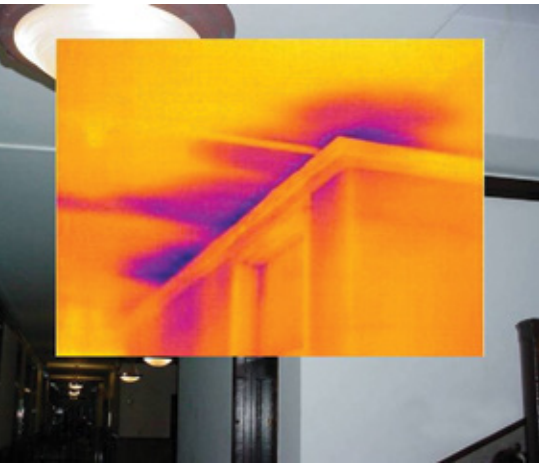
Note the drastic difference in envelope efficiency between the Passive House (middle) and its neighbors.
Image: Sam McAfee, BuildingLabs.com.

Strategy into action

Conduct an envelope performance audit.

A professional energy auditor can help you find areas which should be air-sealed or insulated.

The energy auditor should perform blower door testing to measure air leakage and pinpoint heat loss areas, a visual examination of the building envelope, and an infrared scan.



Infrared photographs help pinpoint areas of greatest heat loss.
Image: FLIR Systems.

Identify moisture issues.

Ensure that envelope upgrades do not make moisture-related problems worse. Improper insulating or air-sealing can trap moisture and cause damage.

Reduce air leakage.

» Seal high leakage areas including elevator shafts, stairwells with permanently open louvers, dumbwaiters, window air conditioners, packaged terminal air conditioning units (PTACs), interior partitions, penetrations through the building envelope for pipes and conduits, band joists, cantilevered decks, doorways and windows. Local codes may restrict areas in which complete air-sealing is allowed.

» In rooftop elevator machine rooms, install an automatic louver that will stay open only when ventilation is needed.

Roof.

If a building's roof makes up a substantial percentage of the envelope area, consider adding roof insulation.

Ensure that all equipment located on the roof and attached to the building is properly anchored. To keep the roof cover intact during high winds, the flashing edge must be secured. Loose flashing will allow wind and rain to penetrate the roof cover, causing moisture damage and uplift pressure. A roof cover system can also peel away from the edge if the flashing fails. This is a common failure point which can cause partial or total failure of the system.

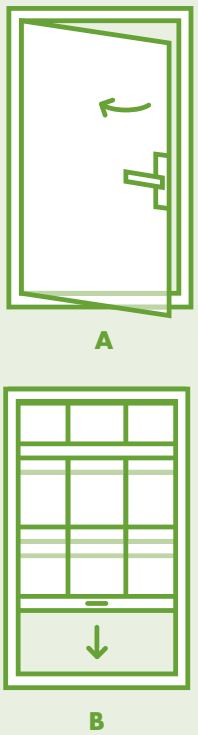
Wall insulation.

Depending on the climate, existing insulation level and other factors, an additional layer of interior or exterior insulation may be cost-effective. Be mindful of trapped-moisture issues.

Windows.

Window replacement is costly and hard to justify economically unless windows are single-glazed or in poor condition. If windows are upgraded, determine if other envelope improvements can be done at the same time.

Some envelope efficiency upgrades may also reduce the threat of wind damage. For added protection, consider installing shutters or shatterproof glass.



Casement windows (above) open on a hinge and provide a tight seal; double-hung windows open vertically and are usually less airtight.

Consider these features:

» **Multiple layers of glass in sealed insulated glass units (IGUs).** At least double-glazed windows (two layers of glass). Triple-glazed windows are preferable but more expensive.

» **Low-emissivity (low-e) coating.** At minimum one low-e coating; two low-e coatings can boost performance further.

» **Low-conductivity gas fill.** Argon is most common. Krypton is more expensive, but performs better.

» **Casement, double-hung or sliding windows.** Casement windows are usually more airtight than double-hung or sliding.

» **Durability.** Look for AAMA Product Certification indicating that a window has passed tests for water, wind and air-tightness.

Natural ventilation.

Natural ventilation can greatly reduce the need for air conditioning. In many older multifamily buildings, windows may be painted over, screwed shut or otherwise unusable. Ensure that windows in resident areas are operable. During a power outage when the HVAC system is out, a building can quickly overheat if its windows can't be used.

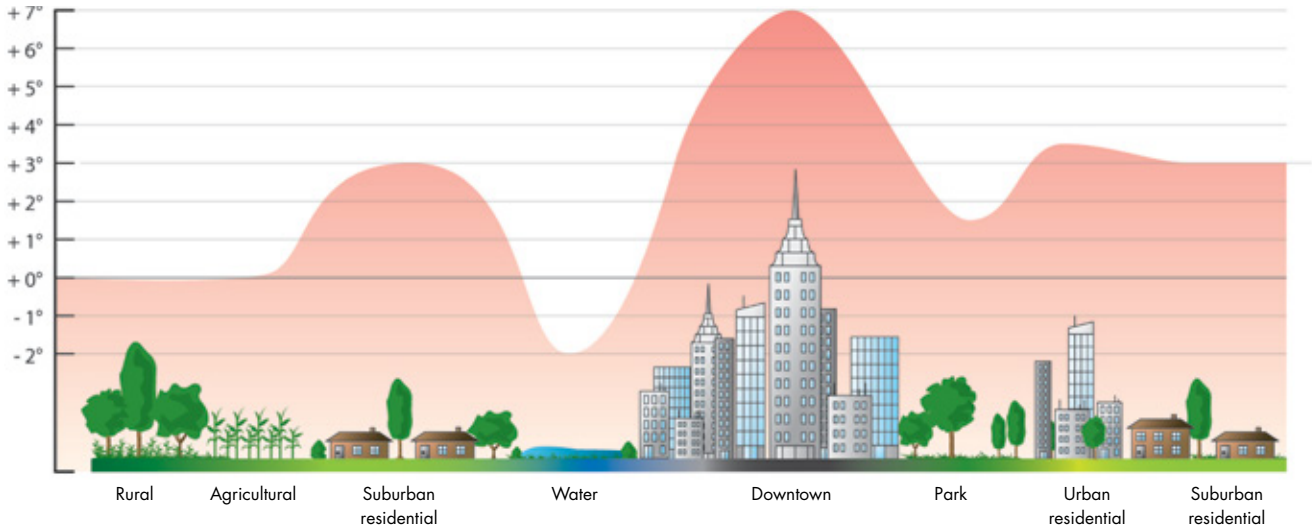
It often makes sense to close windows during the day, preventing warm outdoor air from entering the building. Windows or vents can be opened in the evening, after the sun has gone down and temperatures have dropped. This "night flushing" strategy costs much less than air conditioning.

Installing ceiling fans and providing residents with window fans can increase natural ventilation and cut energy use during warm months.

When planning multi-year improvements, ensure work is phased to save cost and materials. Consider future repairs and maintenance and determine if other envelope retrofits can be done at the same time.

Reduce urban "heat island" effect.

Cities tend to be warmer than the areas which surround them, creating a heat island. Lowering the ambient temperature around your building can help reduce summer heat stress. Some strategies:



Areas with more vegetation, bodies of water and lighter-colored surfaces are typically cooler than urban areas.
Image: Samantha Yost.

» **Vegetation** Through a process called evapotranspiration, trees and other vegetation cool the ambient temperature by an average of 4 to 6 degrees F. Broadleaf trees provide shade in summer but allow sunlight through during winter.

» **Albedo** refers to how light or dark a surface is. A light-colored surface will reflect heat; a dark surface will absorb it. Painting roofs white, installing light-colored facades and limiting blacktop surfaces will greatly reduce your building's heat absorption.

Painting a rooftop white is a fast and highly cost-effective way to reduce energy use.
Image: The White Roof Project.

Operations + maintenance

Maintenance staff should watch out for moisture problems or other evidence of damage to the building envelope. Inspect and maintain windows occasionally to ensure they work at peak performance.

Spot check multiple sections of roof flashing and pay particular attention to corner areas, as these areas are most vulnerable to damage.

Estimated Cost

$ | $$ | **$$$** | **$$$$**

Supporting Strategies

11 Window Shading

12 Distributed Heating and Cooling

Resources

Baby, It's Cold Inside, Urban Green Council, 2014.
urbangreencouncil.org/babyitscoldinside

Evaluating Flashing Attachment for Wind Resistance, Insurance Institute for Business and Home Safety.
disastersafety.org/wp-content/uploads/Evaluating-Flashing-Attachment-for-Wind-Resistance_IBHS.pdf

Indoor Ventilation, Minimum Best Practices Guide: California Energy Commission, based on ASHRAE 62.2.
www.energy.ca.gov/2010publications/CEC-400-2010-006/CEC-400-2010-006.PDF

Operations and Maintenance Best Practices: A Guide to Achieving Operational Efficiency. FEMA. August 2010.
www1.eere.energy.gov/femp/pdfs/OandM.pdf

Passive House Guidelines.
www.passivehouse-international.org/index.php?page_id=80

Saving Energy in Commercial Buildings, National Renewable Energy Laboratory.
www.nrel.gov/tech_deployment/pdfs/commercial_building_checklists.pdf

The White Roof Project.
www.whiteroofproject.org/

Case Study Energy Performance Upgrades

Background

Castle Square Apartments is an affordable multifamily housing complex in Boston's South End, operated by the Castle Square Tenants Association. In 2010, 192 of the 500 units in the 40-year-old property underwent a "deep energy" retrofit, which cut use by more than 50 percent. It also made residents more comfortable by stabilizing temperatures within apartments.

Strategy

The renovation included increased exterior insulation, a reflective roof, extensive air-sealing and new casement windows. In addition to envelope upgrades, more efficient building systems, fixtures and appliances were installed. The installation of solar PV panels on the roof offset some of the building's energy demand.

Cost

The total cost of the retrofit was $8 million, or about $42,000 per apartment. The incremental cost (i.e. the cost above and beyond a conventional upgrade) was $3.5 million, or $18,000 per apartment. Financing for the Castle Square Apartments deep energy retrofit came from federal, state and private sector sources. Annual energy savings come to about $1,900 per apartment.

Before and after the deep energy retrofit
Photos: Castle Square Tenants Association

Annual Energy Cost

	Before Retrofit	After Retrofit	Annual Savings
Natural Gas	$400,000	$180,000	$220,000
Electricity	$200,000	$50,000	$150,000
		Total	**$370,000**

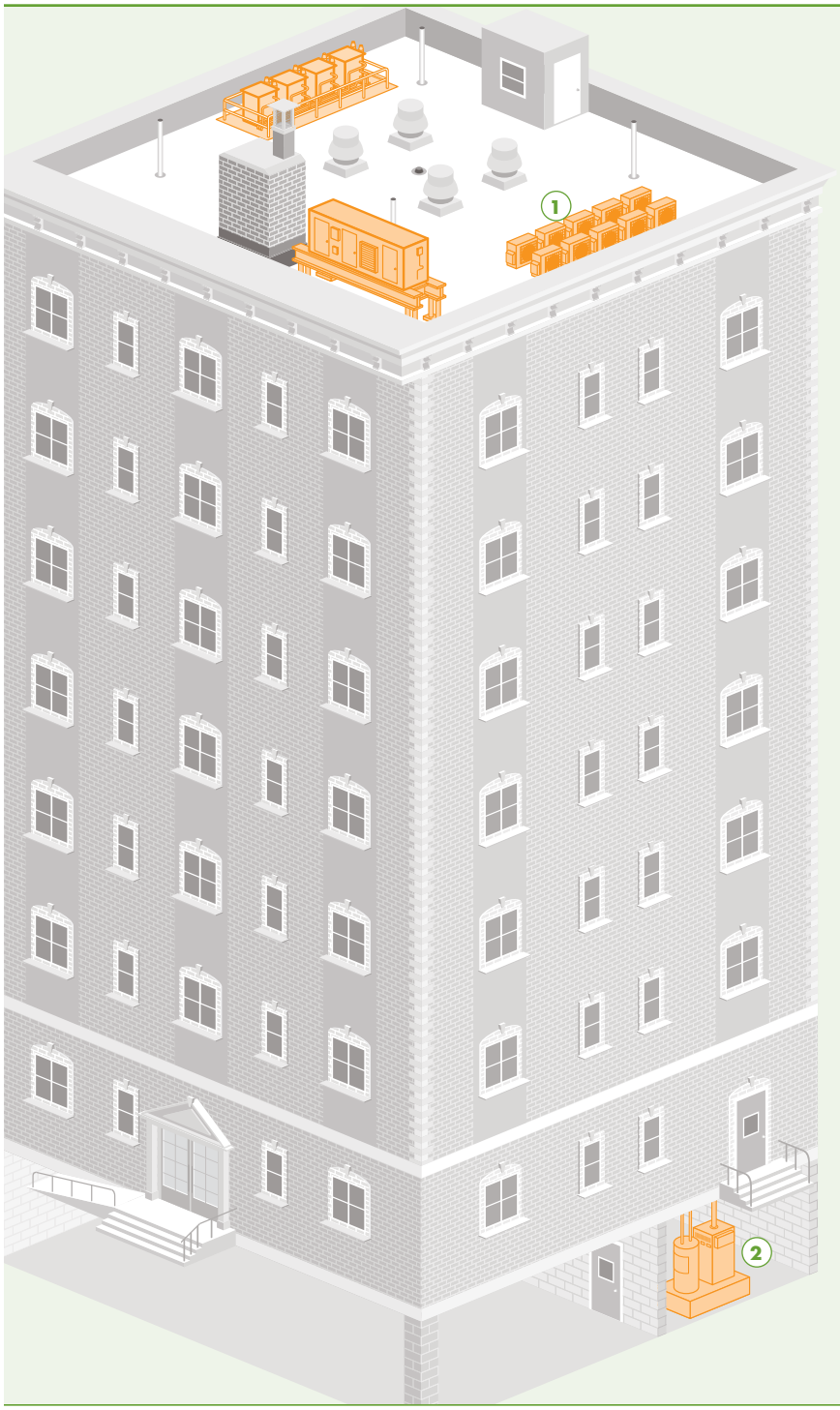
Location
484 Tremont St., Boston, MA

Scale
192 units

Cost
$3.5 million

8 Elevated Equipment

Aligns with Enterprise Green Communities Criteria: **5.8a Resilient Energy Systems: Floodproofing.**



1. Relocate mechanical equipment to upper floors or roof.
2. For equipment that cannot be relocated, elevate in place above the Design Flood Elevation

Strategies not pictured:

Relocate electrical systems above the Design Floor Elevation.

Anchor or elevate fuel storage tanks.

Image: Colin Hayes.

8 Elevated Mechanical and Electrical Systems

With more extreme weather events causing coastal flooding, elevating or relocating mechanical and electrical equipment out of flood-prone basements and lower floors increases building resilience.

Description + function

Critical equipment can be elevated in place or moved to higher floors, the roof or an outdoor platform. Equipment that could be at risk for water damage in case of flooding includes:

Mechanical

- Boilers and furnaces.
- Water heaters.
- Fuel storage tanks.
- Fire-suppression sprinkler controls.
- Elevator machine rooms.
- Duct work.

Electrical

- Electrical panels and switch gear.
- Backup generators.
- Alarm controls and components.
- Service wiring and receptacles.
- Energy management systems.
- Telecommunications equipment.
- Electric and gas meters.
- Utility shut-off switches.

Relocating heavy equipment onto a roof usually requires a crane, which will have to be coordinated with municipal authorities. Relocating electrical equipment will require approval from the utility. If you plan to change in-unit wiring, you will have to coordinate with residents.

If only shallow flooding is anticipated, raising equipment in place to a platform or slab is typically the most cost-effective approach, and is preferable to component protection (See Strategy: Dry Floodproofing).

Within coastal flood zones (Zone V), elevating equipment above the BFE is required for NFIP compliance for new and substantially improved buildings. Dry floodproofing equipment in place is not an approved strategy.

Strategy into action

Elevate or relocate mechanical and electrical equipment.

» Audit the facility's heating and cooling needs. Consider downsizing equipment, purchasing more efficient equipment or decentralizing the system. Envelope efficiency upgrades can reduce the demand on mechanical systems and allow them to be downsized (See Strategy: Envelope Performance). It may be less expensive to buy equipment than to relocate heavy, inefficient older equipment.

These high-efficiency boilers are mounted above the BFE.
Image: Steven Winters Associates.

Right: Outdoor electrical and mechanical elements may be elevated on platforms to keep them away from floodwater.
Image: FEMA, Liz Roll.

» Use your elevation certificate to identify the Base Flood Elevation to determine possible relocation (See:Getting Started).

Possible locations include converted areas on floors above the DFE, an exterior courtyard on a raised platform or the roof.

» Consult the local utility to discuss relocation options for equipment and service entrances. Consider bringing in an electrical contractor or architect for advice.

» Consult a structural engineer to ensure the upper floors or roof are capable of supporting the relocated equipment. Rooftop equipment must be properly secured against high winds.

» Consider the type of enclosure necessary to ensure water-tightness and wind-resistance if equipment is moved outside or on the roof.

» Code-mandated electrical fixtures and switches below the DFE should be on a separate circuit that can be shut off when the area is flooded, allowing the rest of the electrical system to run normally. Any wiring below the DFE should be rated for wet locations.

Fuel tanks anchored to a slab.
Image: Jon Gravelin.

Anchor fuel storage and tanks.

Fuel is typically stored in basements. A partly-filled tank exerts tremendous buoyancy and, during a flood, can break free of the floor and float.

Proper anchoring will prevent tanks from moving, lines from rupturing and fuel from leaking into floodwaters, while preventing fires and other environmental hazards. Both permanent and temporary fuel tanks should be strapped and anchored to a concrete slab or mounted on anchored pillars.

Operations + maintenance

When relocating equipment, consider access for servicing, cleaning and inspection.

Relocation also provides an opportunity to clean ducts or heat exchanger coils and carry out general service and efficiency retrofits. Even if a heating plant is being replaced, the distribution system may need cleaning or other improvements. These improvements can be highly cost effective.

Estimated Cost

$	$$	$$$	$$$$

Supporting Strategies

1. Wet Floodproofing
7. Envelope Efficiency
9. Elevated Living Space
12. Distributed Heating and Cooling

Resources

Evaluating Water-Damaged Electrical Equipment, National Electrical Manufacturer's Association, 2011.
www.nema.org/Standards/Pages/Evaluating-Water-Damaged-Electrical-Equipment.aspx

Protecting Building Utilities and Ductwork from Flood Damage.
www.fema.gov/media-library/assets/documents/21322

Protecting Building Utilities from Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems, FEMA, P-348, November 1999.
www.fema.gov/media-library/assets/documents/3729

Quick Reference Guide: Comparison of Select NFIP and Building Code Requirements for Special Flood Hazard Areas, FEMA. March 2012.
www.fema.gov/media-library/assets/documents/25986

Case Study Elevate Boiler and Electrical Equipment

Background

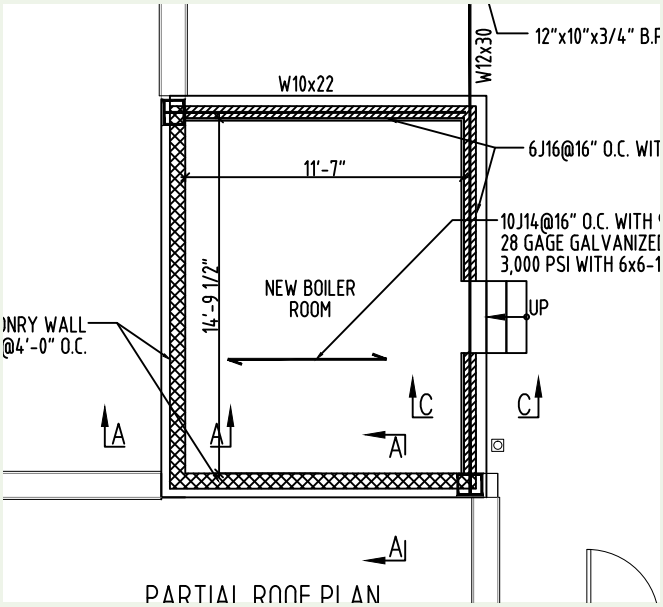
Located in the AE Flood Zone, the 22-unit building at 134 Avenue C, New York is operated by the Lower East Side People's Mutual Housing Association (LESPMHA). During Superstorm Sandy the basement was flooded, damaging the mechanical and electrical systems, boilers and meter rooms.

Strategy

LESPMHA is beginning work on a new rooftop boiler room that will protect the elevated system from the elements. Electrical systems and meters are being installed on the first floor, above the BFE, and emergency systems, HVAC and plumbing are being repaired and upgraded.

Cost

Elevating the boiler will cost $315,000 and the electrical components, $174,000. Funding for the project came from a Community Development Block Grant, Disaster Recovery (CDBG-DR).



The site of the new rooftop boiler room.

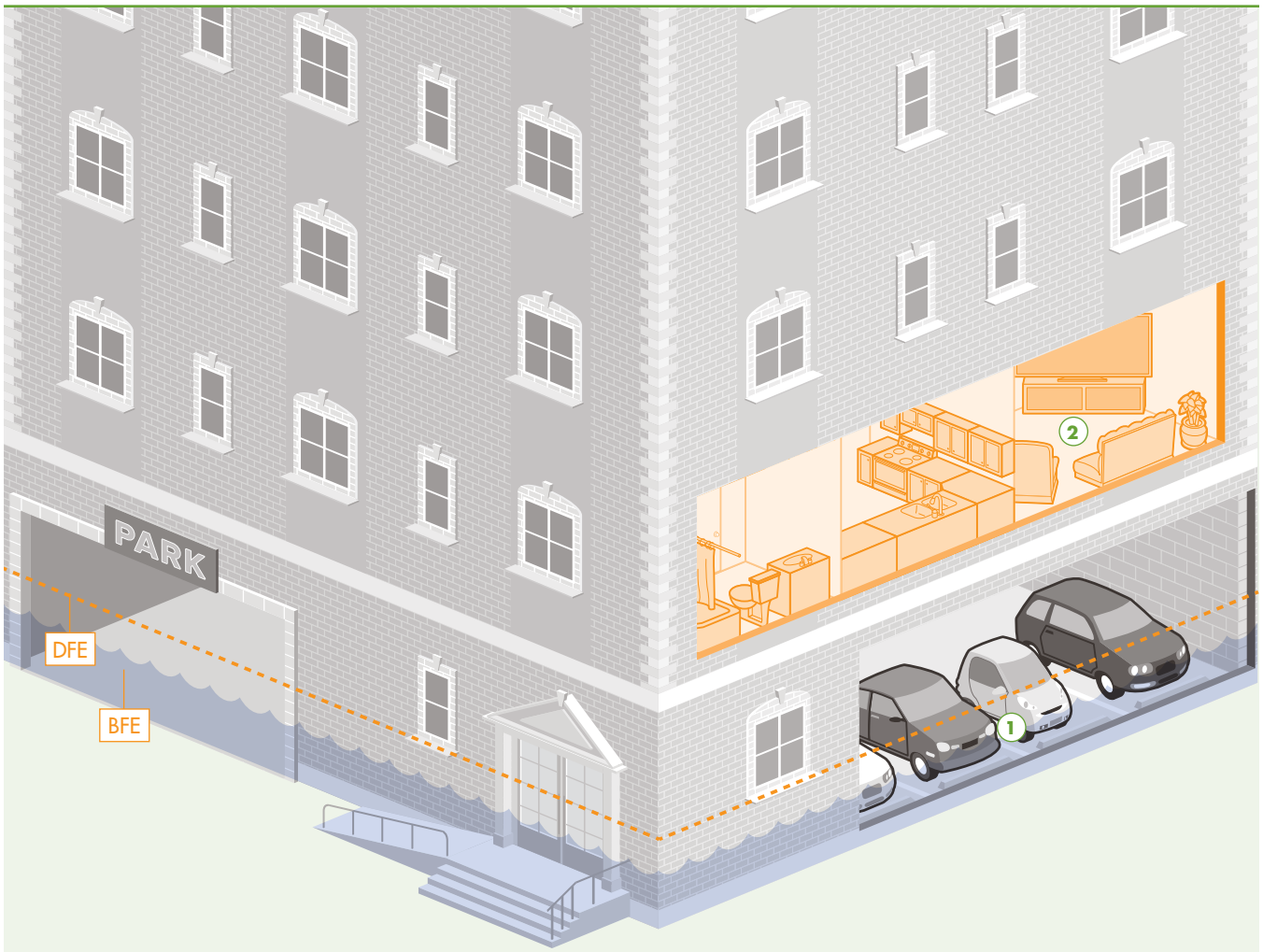
Images: Chris Benedict.

Location
134 Avenue C
New York, NY

Scale
22 Units

Cost
$489,000

9 Elevated Living Space



1. Repurpose at-risk floors to parking, storage or entryways.
2. All living areas should be elevated above the Design Flood Elevation.

Strategies not pictured:

Fill in the basement.

Rezone first floor for commercial use.

Image: Colin Hayes.

9 Elevated Living Space

Abandoning floors below the DFE or using them for a non-residential purpose can limit damage to critical equipment or living space during a flood.

Description + function

Although elevating an entire house is a feasible strategy for single-family homes in flood-prone areas, it is generally not practical for multifamily buildings.

By eliminating living spaces and mechanical systems below the BFE and incorporating wet floodproofing measures (See Strategy: Wet Floodproofing), buildings may become eligible for lower insurance rates.

For new construction, a building even a few feet above grade may be able to withstand significant flooding, but this is often not a practical retrofit strategy for multifamily buildings.
Image: Samantha Yost.

Strategy into action

Repurpose floors below the DFE.

Convert floors below the DFE to parking, storage or entryways. Ensure equipment in these areas is portable and can be moved to safety before anticipated flooding. In addition:

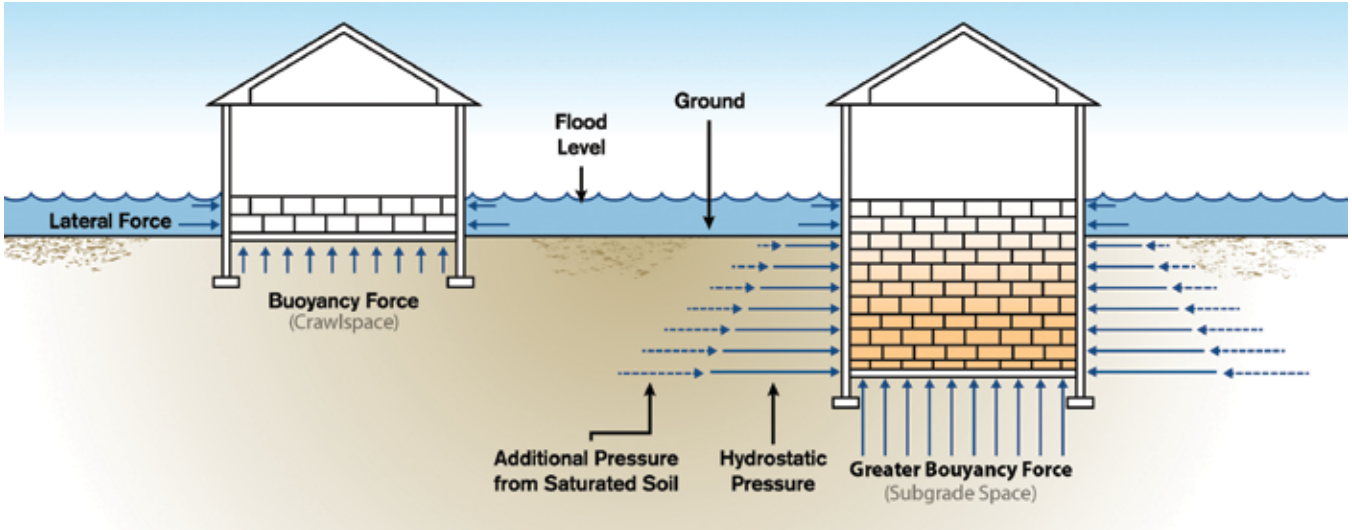
» Calculate the financial loss that will be incurred if living space is reduced. Many affordable housing financing programs restrict conversion of living space to non-residential use.

» Some municipalities allow the addition of residential space on top of the building to offset units lost below the BFE.

» Ensure there are exits and access above the DFE for those with disabilities.

NFIP requires that space below the BFE is used only for parking, building access and storage.

Parking is a possible use for an at-risk first floor.
Image: Samantha Yost.



The deeper a basement or crawlspace, the greater the hydrostatic pressure pushing against it.
Image: www.yourfloodrisk.com.

Fill in the basement.

Filling in the basement will reduce the hydrostatic pressure on the building. This will place enormous stress on party walls of adjoining buildings, so this effort must be coordinated with neighbors a structural engineer. If all buildings on a block share common foundation walls, the entire block will have to be filled evenly at the same time.

Convert the first floor to commercial use.

Repurposing the first floor of a building for commercial use will permit dry floodproofing measures that are not recommended for all-residential buildings.

To determine what elevation and component protection options you can use in your flood zone, see the FEMA manuals in Resources.

Operations + maintenance

Before a storm, move portable equipment out of areas below the DFE. Ask users of space on the first floor to move their belongings. If first floor and underground garages are susceptible to flooding, ensure that residents move their vehicles.

Estimated Cost

$ | $$ | **$$$** | **$$$$**

Supporting Strategies

1 Wet Floodproofing or 2 Dry Floodproofing

8 Elevated Equipment

Resources

Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures, FEMA, P-259, January 2012.
www.fema.gov/media-library-data/20130726-1506-20490-2593/fema259_complete_rev.pdf

Above the Flood: Elevating your Floodprone House, FEMA.
www.fema.gov/es/media-library/assets/documents/725

FEMA Homeowner's Guide to Retrofitting, Chapter 5: Elevating your House.
www.fema.gov/es/media-library/assets/documents/480

Designing for Flood Risk, NYC Planning.
www.nyc.gov/html/dcp/pdf/sustainable_communities/designing_flood_risk.pdf

Retrofitting Buildings for Flood Risk, NYC Planning.
www.nyc.gov/html/dcp/pdf/retrofitting/retrofitting_complete_online.pdf

Case Study Elevated Housing Development

Background

The Carolina and Connecticut Crescent developments in Atlantic City, NJ are two new affordable housing complexes constructed by Community Investment Strategies, a leading NJ-based affordable housing developer. Located in the the AE flood zone, were rebuilt after Sandy to be resilient to future flood damage.

Strategy

Residential areas were elevated 8 ft. above grade, raising them 2 to 3 ft. above the BFE. Wheelchair lifts were added to first-floor units to make them ADA-compliant. All areas below the BFE use wet floodproofing strategies including flood vents, reinforced foundations and waterproof construction materials.

Cost

Funds for the project were provided through a Community Development Block Grant, Disaster Recovery (CDBG-DR).

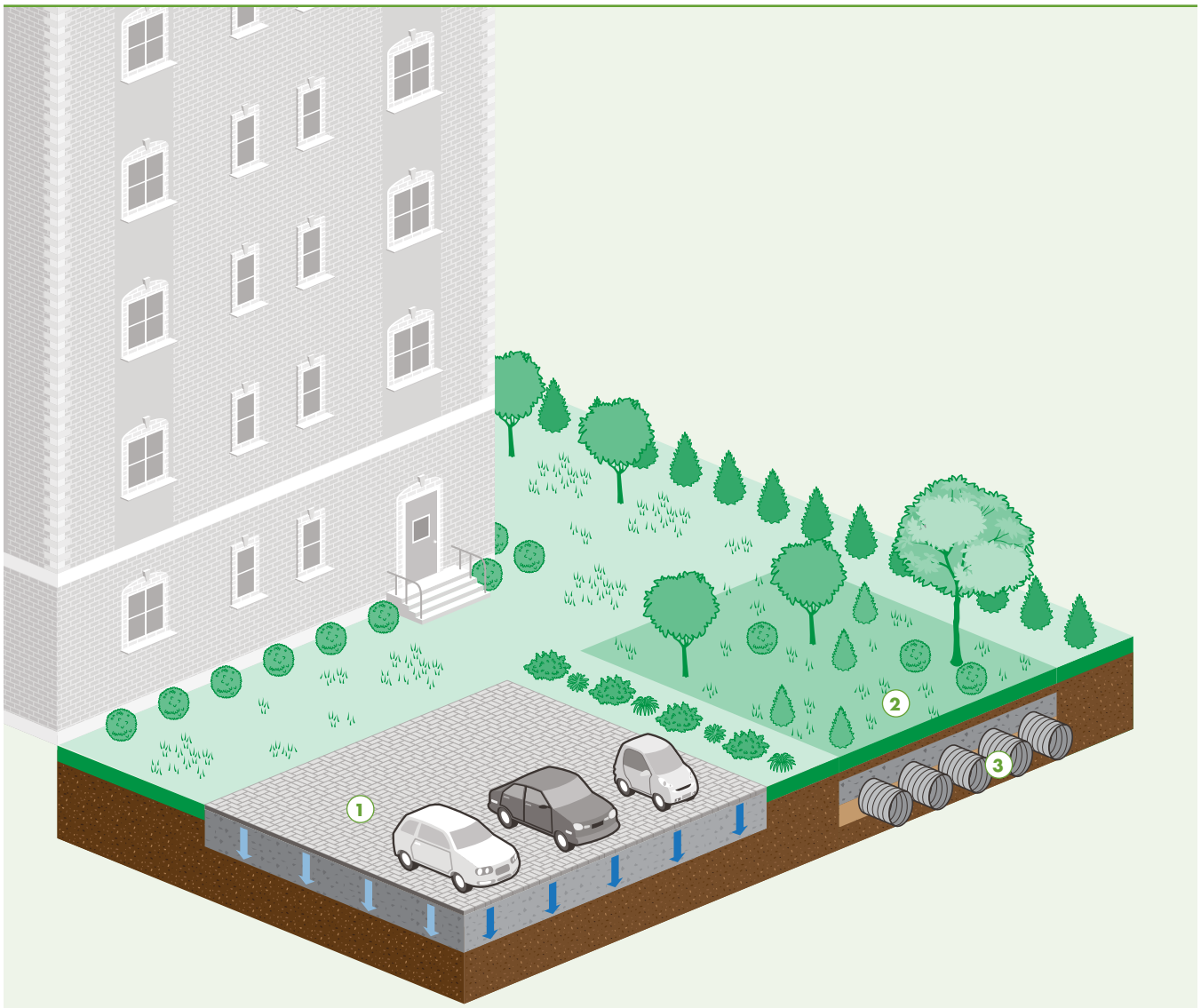
Image: PhotoGraphics Photography.

Location
1353 Mediterranean Ave.
Atlantic City, NJ

Scale
9 buildings, 91 units

10 Surface Stormwater Management

Aligns with Enterprise Green Communities Criteria: **3.6 Surface Stormwater Management.**



1. Permeable paving allows water to infiltrate intro the soil instead of running off into a storm sewer.
2. Bioswales capture and infiltrate excess stormwater.
3. Dry wells store captured rainwater and allow it to infiltrate slowly after the storm is over.

\+ *Strategies not pictured*: Green roofs absorb stormwater and improve insulation.

Image: Colin Hayes.

10 Surface Stormwater Management

Stormwater is a major cause of urban flooding, especially in cities with combined sewer and stormwater systems. Many combined municipal water treatment systems are working at maximum capacity and can't handle additional volume during a large storm. Infiltrating water into the ground on-site reduces the need for large infrastructure projects and can ease flooding, speed recovery after a storm and reduce sewer backups.

Description + function

Containment and infiltration are the two most common approaches to managing onsite stormwater. Buildings with well-draining soil can often infiltrate rain water directly into the ground. Urban zero-lot-line sites or buildings with poorly draining soil can store rainwater on-site for slow release into a traditional storm sewer system.

Many municipalities now require some level of on-site rain water management in all new construction.

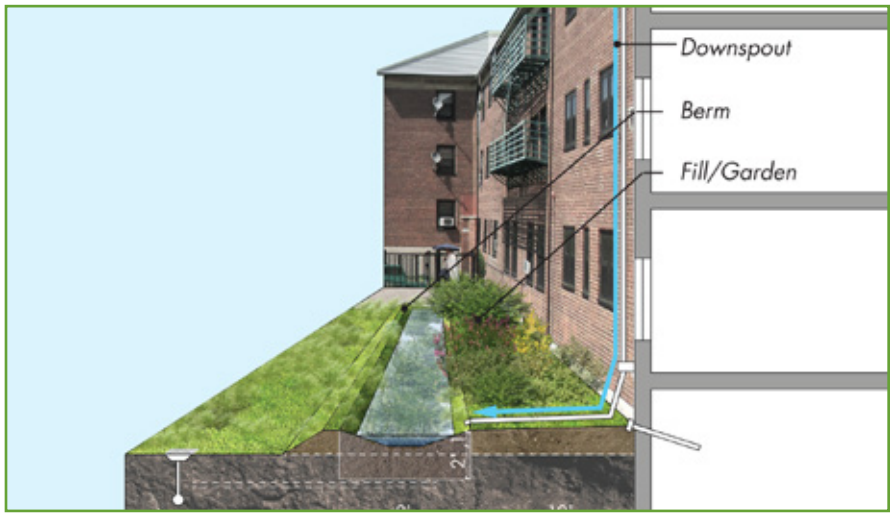
Check with a civil engineer before implementing any significant stormwater management plan. The level of the water table and the stability of the soil must be considered, as damage to the foundation or basement flooding could occur if too much water is added to the ground too quickly.

Strategy into action

Stormwater storage.

Additional water storage capacity can be effective in small spaces, or in areas with non-porous soil.

Captured or stored rainwater should be treated as greywater. It is not potable, but can be used for irrigation or flushing toilets, depending on building codes.



A trench bioswale designed to control run-off from rooftops and façades.
Image: Jersey City Housing Authority.

Bioswales not only help manage stormwater runoff but also support the urban ecosystem.
Image: Dylan Passmore.

Bioswales.

Water from rooftops and impermeable surfaces such as parking lots can be transferred to cisterns through direct piping or through vegetated filter areas, or bioswales. These systems are designed to store rainwater until the municipal storm sewer system is ready to handle additional volume after a large storm. They can be located next to streets or in a low area adjacent to a building.

Green roofs.

Vegetated or green roofs can support stormwater storage while providing increased roof insulation, reducing urban heat island effect, and creating new habitats and enhanced outdoor views. The roof may require reinforcement to handle the added weight, and large plants and trees can become a debris risk in high winds. Green roofs can be cost effective if a municipality requires a specified level of rain water storage and provides incentives for storage system installation.

Green roofs offer an effective solution to stormwater management but may be costly.
Image: Samantha Yost.

Onsite infiltration.

Urban on-site water infiltration systems often include a permeable surface over crushed stone or gravel and an infiltration trench or drywell.

A water infiltration system starts with permeable pavers made of asphalt, concrete or a planted surface. Under the surface is usually 3 to 4 ft. of crushed stone, gravel or other loose fill material with rows of piping interlaid. This layer stores water before it infiltrates into the soil below. An effective stormwater management system should be designed to capture and hold the rainfall from a 5 to 10-year storm. Water collects in these underground storage systems and infiltrates slowly, often until well after the storm has ended.

Operations + maintenance

Permeable surfaces used for parking or driving require annual cleaning with a vacuum street sweeper. This fairly fast and easy procedure will help maintain permeability for many years. In pavers not designed to have vegetation, weed growth is a sign that too much sediment has been deposited and maintenance is required. Surface cleaning with a power washer is important in areas where salt is used for melting snow or ice. Avoid winter sanding of these paving systems as it will reduce permeability.

Drywells and cisterns should be inspected annually to flag any emerging problems.

Installation of a stormwater management drywell system.
Image: JASA.

Right: Permeable paving stones allow stormwater to infiltrate, but require different maintenance than asphalt.
Image: Dylan Passmore.

Estimated Cost

$ | **$$** | **$$$** | $$$$

Supporting Strategies

2 Dry Floodproofing
3 Site Perimeter Floodproofing
5 Backflow Valves

Resources

Cisterns: Design, Construction and Water Treatment, Penn State University.
extension.psu.edu/natural-resources/water/drinking-water/cisterns-and-springs/rainwater-cisterns-design-construction-and-water-treatment

Cistern Design, Stormwater Management Guidance Manual, Chapter 7, Philadelphia Water Department, City of Philadelphia, February 2014.
www.pwdplanreview.org/upload/pdf/Full%20Manual%20(Manual%20Version%202.1).pdf

EPA Stormwater Management resource page.
water.epa.gov/polwaste/npdes/stormwater/

Guidelines for the Design and Construction of Stormwater Management Systems, NYC Department of Environmental Protection and NYC Department of Buildings, July 2012.
www.nyc.gov/html/dep/html/stormwater/stormwater_management_construction.shtml

San Francisco Public Utilities Green Infrastructure Design Guidelines.
www.sfwater.org/index.aspx?page=446

Case Study Gowanus Canal Conservancy (GCC) Bioswales

Background

A relic of unchecked industrial misuse, the Gowanus Canal is a Federal Superfund site. During Superstorm Sandy, many businesses and homes in the Gowanus area flooded with contaminated water and large amounts of raw sewage were released into the canal.

In 2011, the Gowanus Canal Conservancy (GCC) received funding from the NYC Department of Environmental Protection (DEP) and Environmental Protection Agency (EPA) to install and maintain 11 bioswales along a mixed residential and commercial corridor to reduce flooding and help clean the canal.

The GCC bioswales are part of a DEP plan to manage stormwater and sewage overflow in the Gowanus sewer shed.
Image: Samantha Yost.

Strategy

The 11 bioswales manage 300,000 gallons of storm water each year. They intercept trash, which is then picked up by volunteers before it enters the canal. The bioswales also provide much-needed greenery for area residents. Maintenance includes keeping the bioswales clear of trash and weeds, watering the plants and cleaning sediment out of drains. Ongoing monitoring ensures that water quality is maintained. GCC volunteers maintain the bioswales and will pilot a stewardship course to engage local citizens.

Cost

The GCC received $874,470 for construction and three years of monitoring and maintenance of the bioswales.

The bioswales intercept a large amount of trash, which is picked up by volunteers before it breaks down into smaller pieces and enters the canal.
Image: Samantha Yost.

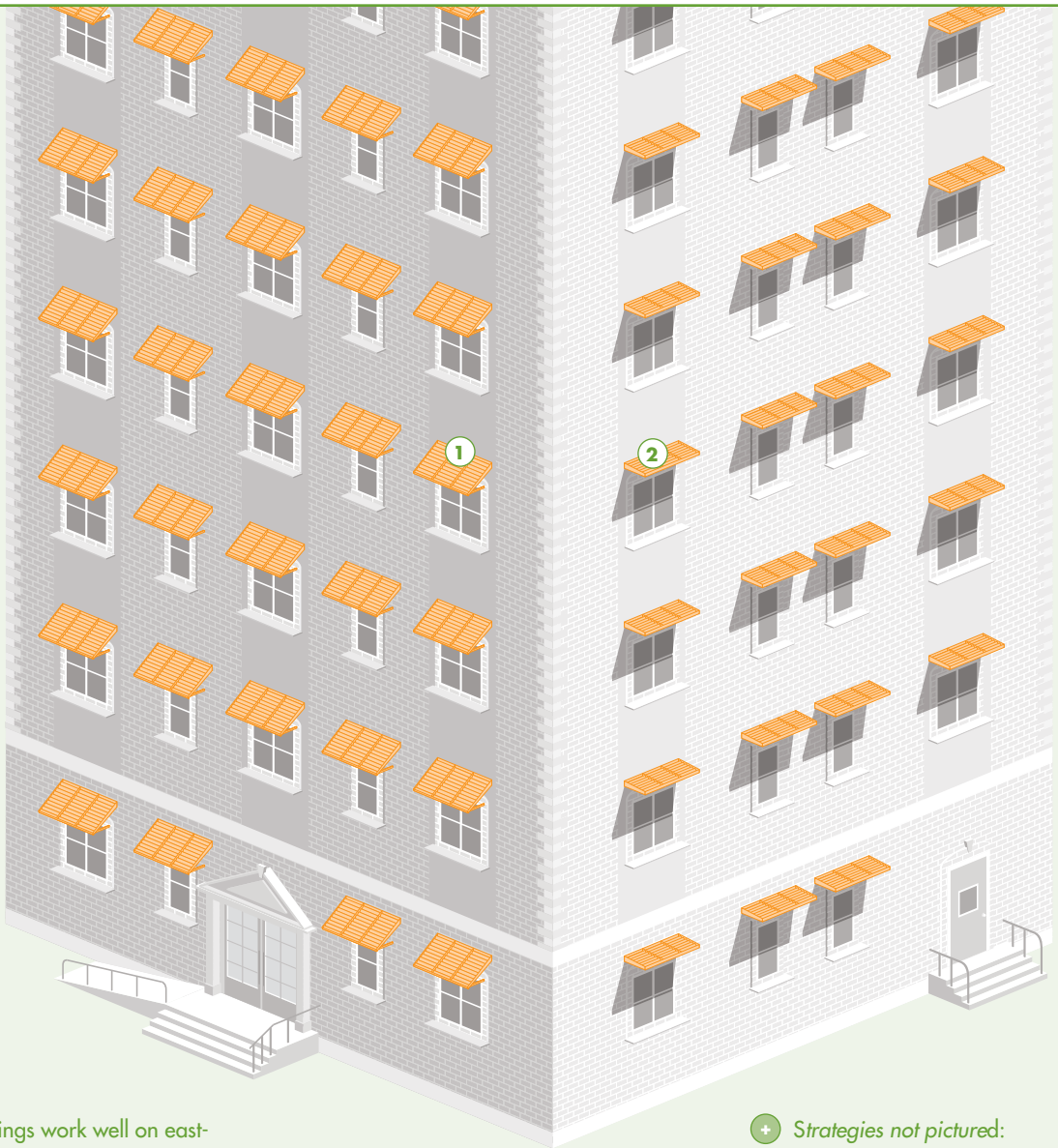
Location
Sixth Street. between Second and Fourth avenues. Brooklyn, NY

Scale
2 city blocks

Cost
$80,000 / bioswale

11 Window Shading

Aligns with Enterprise Green Communities Criteria: **2.10 Passive Solar Heating/ Cooling.**



1. Awnings work well on east- and west-facing windows where the sun strikes lower.

2. Overhangs are effective on the southern face where the sun is at its highest.

+ *Strategies not pictured*:

Install exterior shades.

Install interior blinds and curtains.

Shade windows with vegetation.

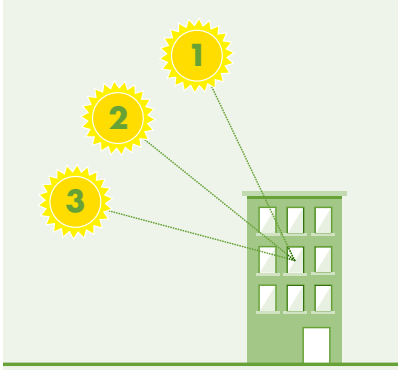
Image: Colin Hayes.

11 Window Shading

Exterior or interior window treatments that shade rooms can lessen solar heating in the summer and insulate against heat loss in winter.

Description + function

In summer, the sun strikes south-facing windows mostly from above. These windows are easy to shade with overhangs. Windows on the east and west benefit more from awnings and window treatments like blinds or curtains, because the sun usually strikes them head-on as it rises and sets.



The position of the sun changes during 1 summer, 2 spring and fall and 3 winter.

Right: Although not as effective as external window treatments at blocking heat, indoor shades are an easy, cost-effective way to reduce overheating in the summer and increase comfort in the winter.
Image: Samantha Yost / Matthew Goodrich.

In the winter, the sun is lower in the sky and the direct solar gain is beneficial. At night, window treatments like exterior storm windows, exterior roller shutters, interior glazing panels, interior curtains or insulating blinds can help reduce heat loss.

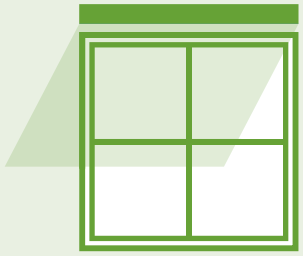
Strategy into action

Exterior shades block sunlight before it reaches the window, making them more effective than interior shades and blinds. However, exterior treatments are difficult to retrofit onto existing buildings, and protrusions from the building may be limited by zoning or historic preservation regulations.

Interior window treatments are protected from the elements, less expensive and easier to install and clean, but not as effective as exterior treatments.

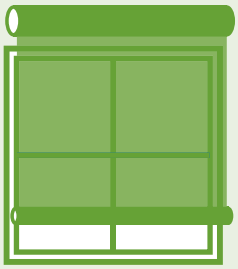
Falling snowpack and icicles on window overhangs could become a public safety hazard, especially if situated directly above walkways.

Exterior Treatments

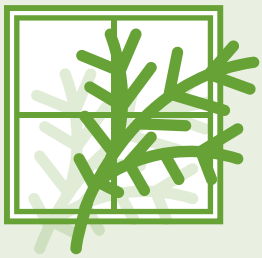


Overhangs.
Overhangs are best for south-facing windows. The sun is high overhead during hot summer months, and a relatively short overhang can provide effective shade.

Awnings.
Like overhangs, awnings block sunlight effectively. Awnings often extend further than overhangs work best on east- and west-facing windows.

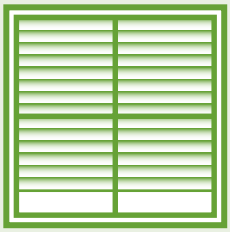


Exterior roller screens, shades and shutters.
Roller screens, shades or shutters are more common in Europe. They block sunlight before it strikes the window, and some products provide high wind protection too. In the U.S., exterior roller shutters are used primarily in coastal locations prone to hurricanes. Most shade screens allow some visibility, even when fully deployed.



Vegetation.
Deciduous vegetation blocks sunlight in the summer. In the winter, when it sheds its leaves, it allows sunlight to penetrate. Greenery also provides important psychological and health benefits for residents.

Interior Treatments



Blinds and curtains.
The simplest and least expensive interior shading systems are blinds and curtains. Insulated window blinds, either cellular or quilted, are more effective at shading than simple pull-down shades.

Emergency window treatments.
During emergencies, temporary window treatments like sheets and cardboard or aluminum foil can cut solar gain. Windows that account for the most solar gain should be the priority.

Operations + maintenance

Most exterior shades are passive and require little maintenance. Interior window treatments are most effective when used consistently. Inform residents about the benefits of opening blinds and curtains at the times of the day when it will do the most good.

Cellular blinds offer better insulation than standard blinds, and double- and triple-layered ones are even more effective.
Image: Hunter Douglas.

11 Window Shading

Estimated Cost

$	$$	$$$	$$$$

Supporting Strategies

7 Envelope Efficiency

Resources

Energy Efficient Window Treatments, U.S. Department of Energy.
energy.gov/energysaver/articles/energy-efficient-window-treatments

Vital Signs Curriculum Materials Project: The Dynamic Pattern of Shading and Solar Heat Gains through Windows, Scott A Johnston.
vitalsigns.ced.berkeley.edu/res/downloads/rp/shading/shade.pdf

Window Coverings and Attachments, Lawrence Berkeley National Laboratory.
www.efficientwindowcoverings.org/

Case Study Aluminum Solar Shading

Background

Formerly a public school, Castle Gardens in Harlem, NY is an affordable housing development completed in 2010. The project was developed by Jonathan Rose Companies in partnership with the Fortune Society, a nonprofit group that helps the formerly incarcerated re-enter communities. The project includes 113 affordable housing units. The facility is LEED Gold, ENERGY STAR and Enterprise Green Communities certified.

Strategy

On the south façade, aluminum solar shades block the sun in the summer, keeping apartments cool. In the winter, the shades allow sunlight through to warm the rooms. The shades are fixed and durable, requiring virtually no maintenance.

Cost

Castle Gardens relied on 14 different financial supporters—from federal, city and state agencies to corporate foundations—to construct the building.

The total cost for the south façade was $300,000.

Image: Jonathan Rose Companies.

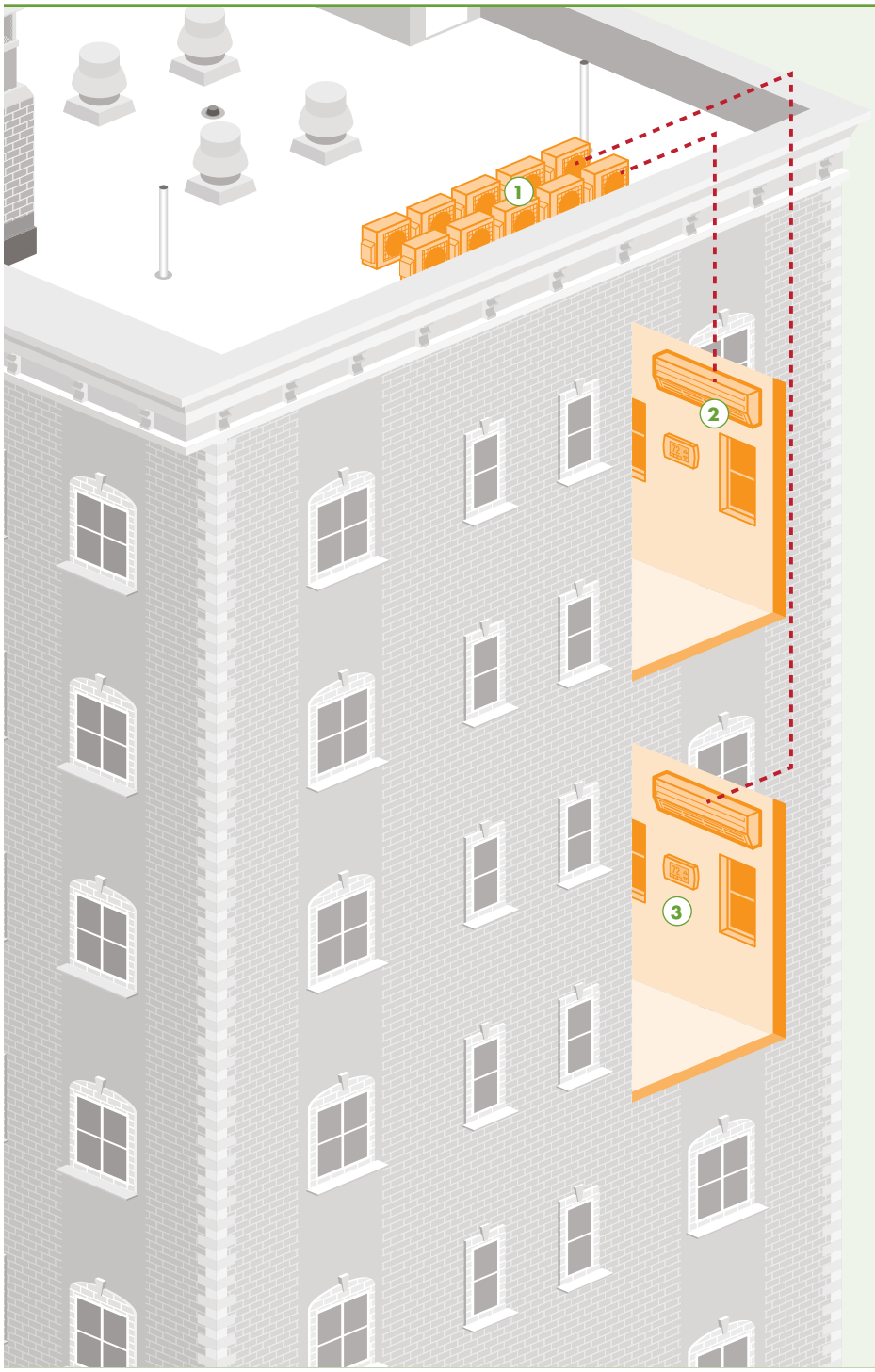
Location
625 West 140th St.
West Harlem, NY

Scale
113 units

Cost
$300,000

12 Distributed Heating and Cooling

Aligns with Enterprise Green Communities Criteria: **5.8a Resilient Energy Systems: Floodproofing.**



1. Exterior units can be installed above the Design Flood Elevation.
2. Interior units provide heating and cooling as needed.
3. Residents have more control over the temperatures in their homes.

Image: Colin Hayes.

12 Distributed Heating and Cooling

Decentralized and high-efficiency heating and cooling systems distributed throughout a building can help avoid flood damage while lowering operating costs. Distributed systems are most effective in buildings with high-performance windows and well-insulated, airtight envelopes.

Description + function

Distributed systems provide heating and cooling inside a residential unit, giving residents greater control over the temperature in their apartment and dramatically reducing distribution losses. Dedicated boilers, warm-air furnaces, window-mounted air conditioners or through-the-wall heating/cooling units can be installed in individual apartments. Air-source variable refrigerant flow (VRF) units, also known as mini-splits, are a newly viable option for residential multifamily buildings. A split system locates some hardware indoors and some outdoors. Mini-splits are much smaller than commercial split systems.

A mini-split interior unit provides localized heating and cooling.

Right: The exterior unit is connected to the interior unit via small refrigerant pipes

Until recently, VRF units were not very efficient, especially in colder climates. New units work much better, even in northern areas.

Conversion from a central to a distributed system provides many advantages:

- Virtually eliminates flood risk because almost all the equipment is located above the basement.
- Improves climate control efficiency by heating or cooling only spaces in use—not the entire building.
- Provides residents with a significantly greater control of temperature in their homes.
- Allows sub-metering of heating and cooling energy (where permitted by law).

Mini-splits can be significantly less expensive to operate than many fossil-fueled systems. An *online fuel cost calculator*↗ developed by BuildingGreen, Inc. compares operating costs of different heating options (See Resources).

Strategy into action

Installing equipment.

Outside condenser units can be mounted on raised platforms outside the building, on special brackets on exterior walls, or on the roof, depending on the building. All exterior units must be sufficiently anchored against high winds.

Connecting the inside and outside components of the mini-split system will require drilling through interior and sometimes, exterior walls.

Operations + maintenance

Residents who do not have air conditioning may have increased electricity costs with the installation of a sub-metered mini-split system. Tenants should be informed about how to operate their units cost-efficiently.

Mini-split maintenance includes cleaning filters and condenser coils, and regular refrigerant charge, and inspection of drain pan, blower wheel, fan, condensate tubing and electrical connection.

Mini-splits on a roof above the risk of flooding.
Image: The Bluestone Organization.

Estimated Cost

$	**$$**	$$$	$$$$

Supporting Strategies

7 Envelope Efficiency
8 Elevated Equipment
11 Window Shading

Resources

Air Conditioning Sizing Calculator.
www.supplyhouse.com/pex/control/MiniSplitCalculator

Comparison between Decentralized and Centralized Air Conditioning Systems, ILK Dresden.
www.troxchina.com/xpool/download/en/technical_documents/air_water_systems/ilk_study.pdf

Energy Star Guide to Heating and Cooling Systems.
www.energystar.gov/ia/partners/publications/pubdocs/HeatingCoolingGuide%20FINAL_9-4-09.pdf

Fuel Cost Calculator, BuildingGreen, Inc.
www.buildinggreen.com/calc/fuel_cost.cfm

Heating and Cooling Systems, Energy.gov.
energy.gov/energysaver/home-heating-systems

Case Study Distributed Heating and Cooling System

Background

The Bluestone Organization pioneered the use of distributed heating and cooling in affordable multifamily housing at Norman Towers, a 101-unit building in Jamaica, Queens, NY.

Strategy

Each Norman Towers apartment has its own heat pump. External components of the distributed system are located on the roof and at ground level in a covered carport.

Bluestone paired the distributed heating and cooling system, with a high performance envelope to create low-energy, efficient housing. In case of a power outage, the building is sufficiently insulated to maintain livable temperatures in residents' homes.

Cost

Installed cost for the mini-splits was $6,200 per unit.

Norman Towers roofs showing solar panels and green roof area.
Image: The Bluestone Organization.

Outdoor components of the mini-splits.
Image: The Bluestone Organization.

Location
90-11 160th and 90-14 161st St. Queens, NY

Scale
101 Units

Cost
$6,200 / Unit

Backup

Strategies that provide critical needs when a facility loses power or other services.

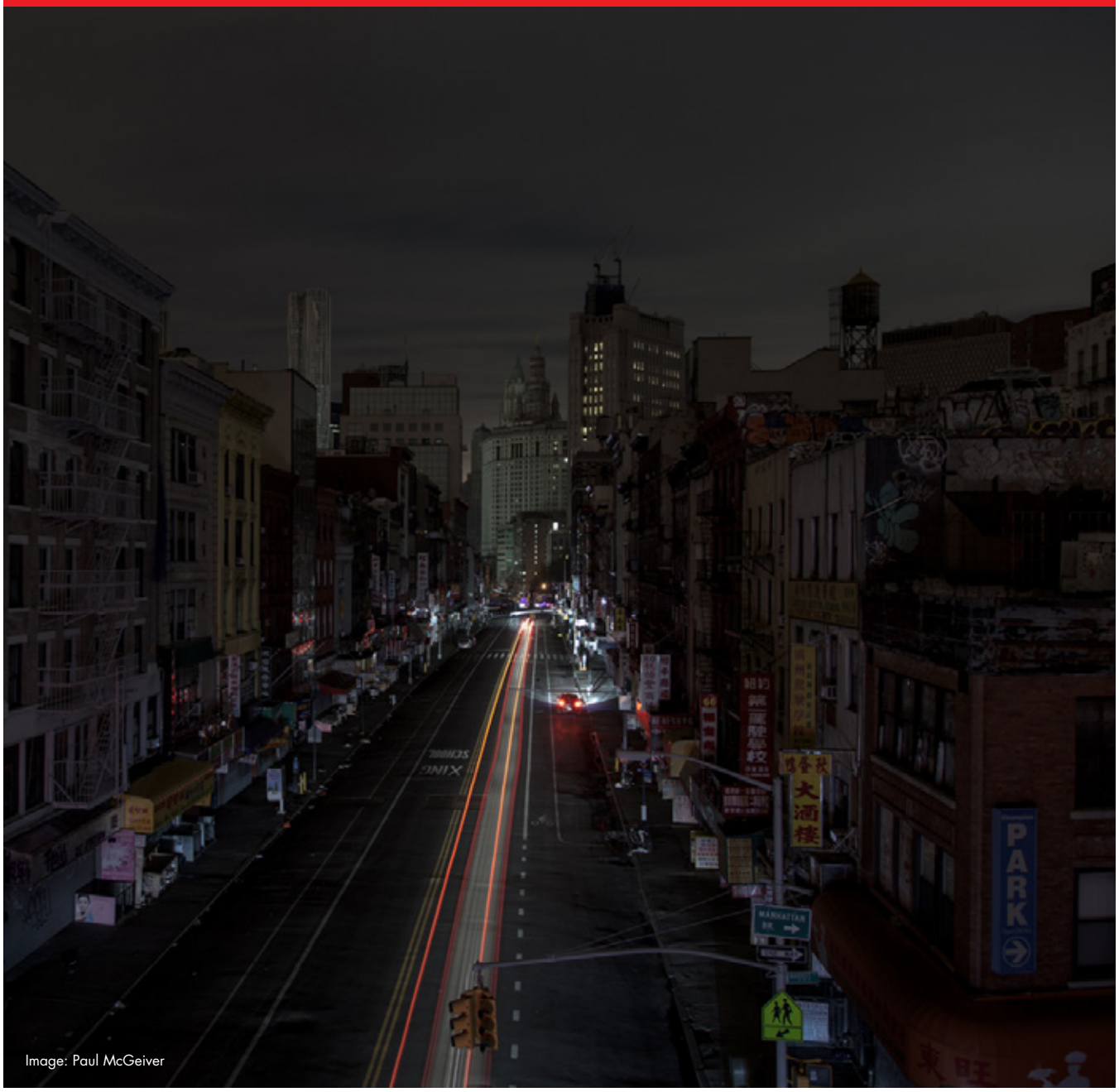
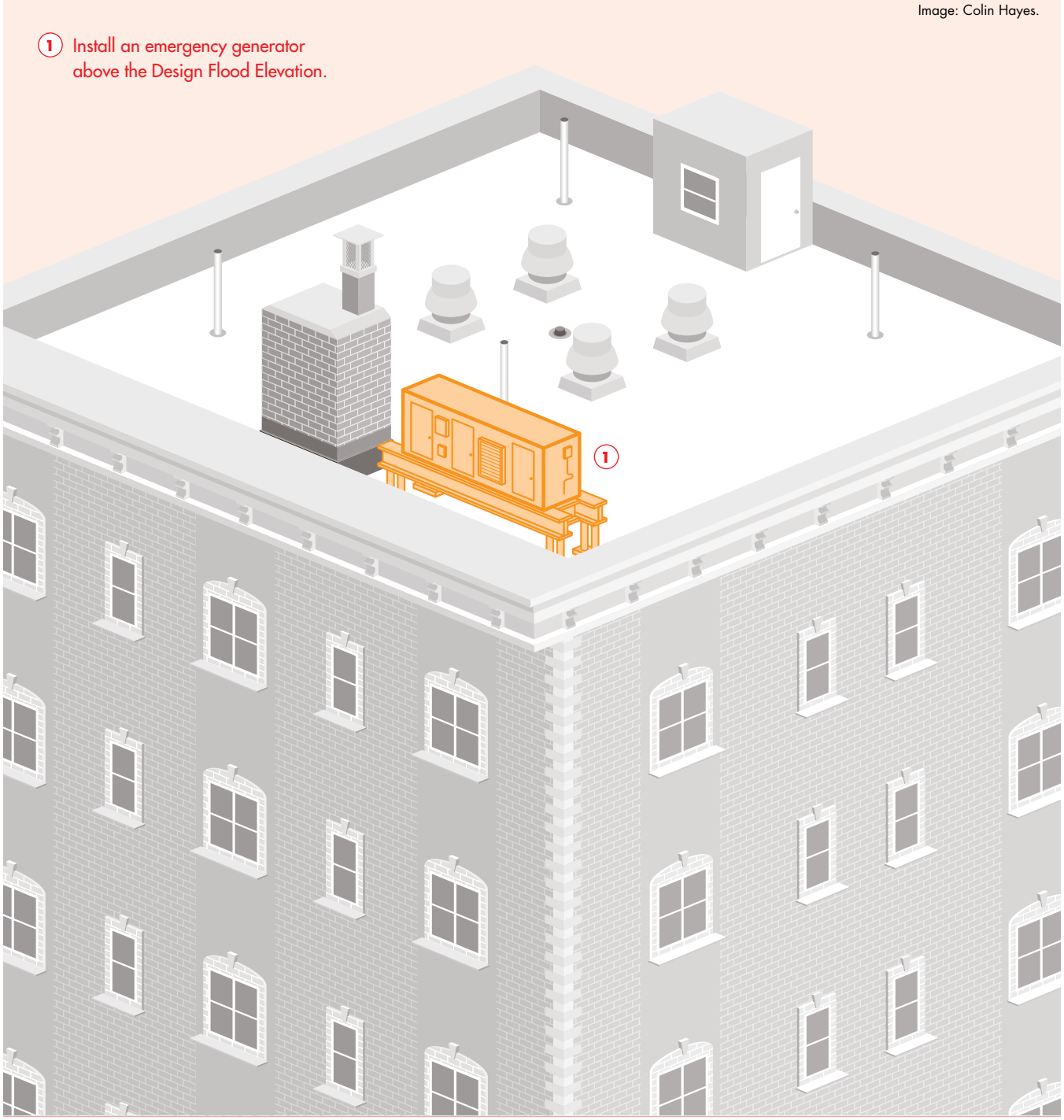


Image: Paul McGeiver

13 Maintaining Backup Power to Critical Systems

Aligns with Enterprise Green Communities Criteria: **5.8b Resilient Energy Systems: Islandable Power.**

Image: Colin Hayes.



13 Maintaining Power to Critical Systems

During a power outage, backup power is vital to continue building operations and make repairs during and after a storm event.

Description + function

Larger, high-rise residential buildings are typically required to have backup power for critical functions, such as the operation of one elevator and a fire-suppression pump. Smaller buildings are not. Backup power becomes even more necessary if residents are sheltered in place during power outages.

Some buildings install a permanent exterior connection so it is easy to roll up a temporary generator and plug it into the emergency circuits.

During a large-scale emergency, generators, fuel and energy professionals will be in high demand and short supply.

Strategy into action

Outlets on the critical-load circuit can be designated for emergency use only.
Image: Kristy Johnson

Sizing a generator.

Consider what systems will be connected to the generator's emergency circuit. The higher the power needs, the more complex and costly the system must be.

Local codes frequently require that when a generator is installed, it powers emergency lighting, fire-suppression pumps, at least one elevator, at least one sewer ejector and other equipment.

In addition to the minimum requirements, consider adding:

» Emergency outlets to charge cell phones and computers.

» Electronic igniters for gas- or oil-fired heating systems.

» Fans and pumps for heating systems.

» Water-booster pumps to deliver potable water to upper floors.

» Sump pumps.

» Telecom systems.

» Cable modems and wireless routers.

» Alarms and security equipment.

» A central washer and dryer.

Transfer switches.

» When utility power fails it is essential to smoothly and safely switch to emergency power. Most systems include a transfer switch which makes this happen.

Automatic transfer switch (ATS).

» An ATS continuously monitors electric utility power and automatically switches over to emergency power when necessary, then back to normal power.

Manual transfer switch (MTS).

» An MTS must be activated by staff and takes much longer to switch power over than an ATS. Much less expensive than an ATS, an MTS is much more challenging to operate.

A place to charge cell phones is a high priority for residents during a disaster.
Image: Kiersten Chou.

Generator systems

There are many types of backup generators, each with advantages and disadvantages. You must consider the needs of your site when selecting an appropriate generator, including the location where it will be installed, fuel storage issues, the amount of emissions it will produce and your budget.

Gasoline Generators.

» Small, portable and used in single-family homes.
» Store only a few gallons of gasoline. Need to be refilled daily.
» Should never be used indoors. Emissions must be prevented from entering the building.

Storage	Quantity of Emissions	Fuel Cost	Special Issues
On-site, usually in small containers.	Moderate	$	Storage life limited; plan for cycling needed. Highly flammable. Tanks must be anchored.

Propane / LPG (Liquified Petroleum Gas).

» For mid-sized systems serving multifamily buildings.
» Work like natural gas generators, but fuel is stored on-site.

Storage	Quantity of Emissions		
On-site, in tanks.	Low	$$	Highly explosive. Tanks must be anchored; larger tanks are usually buried.

Natural Gas Generators.

» Use piped, utility-supplied fuel rather than stored fuel.
» Will not function if gas supplies are shut off during natural disasters .

Storage	Quantity of Emissions	Fuel Cost	Special Issues
Piped to site.	Low	$$	Gas pipelines may be shut off during disasters to avoid fires. Highly flammable.

Diesel Generators.

» Larger generators serving multifamily buildings typically use diesel fuel.
» Usually permanent rather than portable, but can be delivered by trailer.
» Can be mounted on roofs or upper floors to protect against flooding, if your building will accommodate this.

Storage	Quantity of Emissions	Fuel Cost	Special Issues
Onsite; must be protected from freezing.	High	$	Storage life limited; plan for cycling needed. Lower flammability than gasoline. Tanks must be anchored.

Biodiesel Generators.

» Work like diesel generators, but with fuel that is typically cleaner, generates fewer CO2 emissions and is less harmful if spilled or leaked.
» Fuel must be stored more carefully and does not last as long as standard diesel.

Storage	Quantity of Emissions	Fuel Cost	Special Issues
Onsite.	Low	$$	Plan for cycling needed. Lower flammability. Tanks must be anchored.

Combined Heat and Power (Cogeneration) Generators

» Used for larger residential buildings.
» Waste heat from power-generation is used to heat water or make steam for space heating.
» Can use fuel sources including: natural gas, propane, oil, wood chips or wood pellets.

Storage	Quantity of Emissions	Fuel Cost	Special Issues
Onsite; various fuel types.	Low	$-$$$	Extremely fuel-efficient.

Battery Storage.

» Primarily for short-term needs, such as uninterruptible power for computers, data systems and emergency exit lighting.
» Becoming more efficient, but cost and maintenance are obstacles.

Storage	Quantity of Emissions	Fuel Cost	Special Issues
On-site; capacity limited.	None	--	Potential for solar battery charging.

This permanent backup generator is housed in a rooftop machine room, protected from the elements and far above the threat of flooding.
Image: John Gravelin.

Using backup power.

» Employ only a licensed electrician to install and maintain a backup power system.

» For larger systems, consult an experienced engineer to oversee installation and maintenance.

» Install generators and the systems that support them (transfer switches, fuel pumps, etc.) above the DFE.

» Ensure that your building is able to support the weight.

» Minimize noise and vibration of generators to avoid disturbing residents and neighbors.

Balance advantages and disadvantages to best locate generators:

Generator Placed Indoors.

✓ Leaves, snow and other debris do not need to be removed.	✗ Can cause noise and vibration problems for residents.
✓ In cold climates, heating elements are not required to keep the generator ready.	✗ Involves structural considerations to make sure the building frame can handle the weight.

Generator Placed Outdoors.

✓ Can be located away from residents to minimize noise and vibration.	✗ Exhaust can enter building through HVAC systems.
✓ Saves valuable interior space.	✗ Heating/cooling systems are required to keep the generator ready.

Operations + maintenance

Generator fuel must be carefully stored in code-appropriate enclosures and tanks.
Image: Samantha Yost.

Develop a maintenance plan that "exercises" the generator regularly and cycles through stored liquid fuel on a defined schedule so you can be sure it will be available and not stale when needed. Train facility staff in equipment operation.

Building codes typically require regular inspection and testing of generators.

Develop a maintenance log protocol, which can be used for manufacturer reimbursement in cases of system failure.

Estimated cost

$ | **$$** | **$$$** | $$$$

Supporting strategies

- 4 Resilient Elevators
- 6 Sump Pumps
- 8 Elevated Equipment
- 15 Access to Potable Water
- 18 Developing an Emergency Management Manual

Resources

Applications of Solar Technology for Catastrophe Response, Claims Management, and Loss Prevention, NREL.
www.nrel.gov/docs/fy99osti/25866.pdf

Combined Heating and Power Acceleration Program, System Catalog, NYSERDA.
www.nyserda.ny.gov/-/media/Files/FO/Current%20Funding%20Opportunities/PON%202568/2568attc.pdf

Emergency Power, Engineering Principles and Practices of Retrofitting Floodprone Residential Structures, Chapter 5, FEMA, January 2012.
www.fema.gov/media-library/assets/documents/3001?id=1645

Siemens Generator Sizing Guide Including Load Calculators.
www.siemens.com/download?BTLV_40972

Case Study Rooftop Backup Power

Background

Built in the early–1900s as a hospital, 318 Beach 85th St., Queens, NY is a 62,000 sq. ft. state-licensed residence operated by Services for the Underserved (SUS). It provides 71 units of supportive housing.

Less than 100 yards from Jamaica Bay, and 50 ft. from the Atlantic Ocean, the building is located within the FEMA AE flood zone, an area subject to inundation during a 100-year flood. After Superstorm Sandy, the first floor was flooded with 4 ft. of water and the building was without power for a month. Residents could not return to their homes for a year.

Strategy

SUS installed a natural gas-fired, 261 kW generator on the roof. The generator is connected to an Automatic Transfer Switch, and is sized to carry the entire electrical load of the building.

Cost

The generator and installation cost about $250,000. Funding came from a Community Development Block Grant, Disaster Recovery (CDBG-DR).

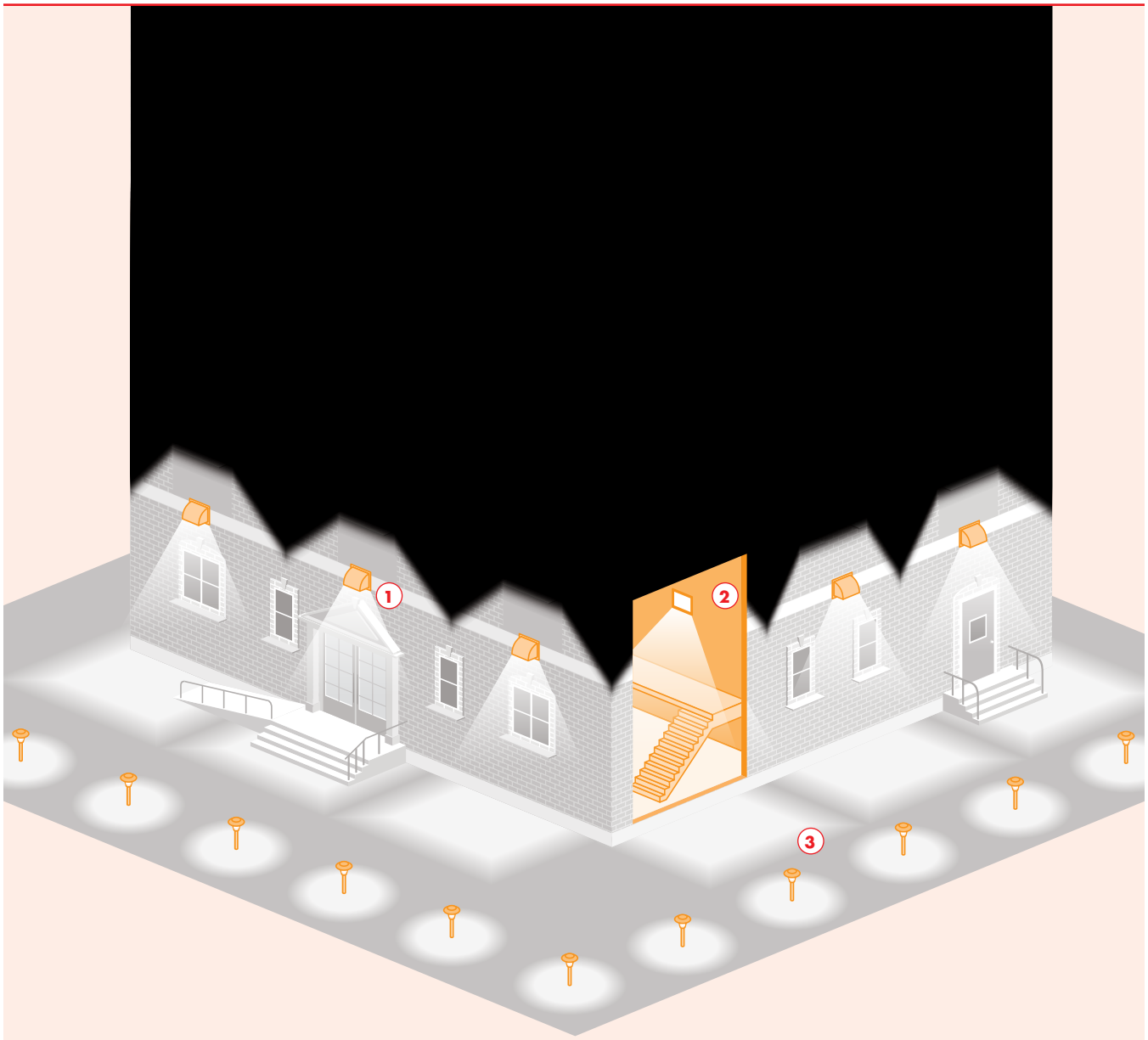
Image: Services for the Underserved.

Location
318 Beach 85th St.
Queens, NY

Scale
71 Units

Cost
$250,000

14 Emergency Lighting



1. Efficient, battery-powered indoor and outdoor lights keep public spaces well-lit during a blackout.
2. Daylight corridors and stairwells.
3. Solar-powered outdoor lighting keeps the grounds secure.

Image: Colin Hayes.

14 Emergency Lighting

Many multifamily buildings are not designed to provide residents with lighting during an extended power loss. There are a number of options to provide emergency illumination for residents planning to either evacuate or shelter in place.

Description + function

Code-mandated emergency lighting, such as exit signs with emergency area illumination, are frequently designed to function only long enough for residents to evacuate. Building codes generally require only 90 minutes of emergency illumination. Different lighting strategies are necessary to keep buildings operating safely during and after emergencies.

Strategy into action

Natural daylighting for corridors and stairwells during a power outage.

Once emergency exit lighting has stopped, windowless stairwells with artificial lighting cannot be used without flashlights, even during the daytime. In stairwells where it is not possible to install windows, skylights can provide some daylight.

Daylighting not only saves energy, but also helps keep vital areas usable during a power outage.
Image: Samantha Yost.

This battery-power LED spotlight is motion-activated, easily mounted and has an extensive battery life.
Image www.mrbeams.com.

Battery-powered emergency lighting.

Lighting units that use removable batteries to provide 24 hours or more of continuous illumination are now available. A photo-sensor can turn the light off when there is adequate daylight, and illumination can be supplied for several days before batteries need to be replaced. Relatively inexpensive battery-powered LED lights with screws or adhesive backings can be stored and quickly installed in case of an outage.

Solar-powered outdoor lighting.

Outdoor lighting for walkways can be installed inexpensively and with minimal labor. Light fixtures automatically turn on at night, and batteries are recharged during the day.

Solar lights charge during the day and turn on automatically at night.
Image: Lars Kristian Flem.

Luminescent strips are a passive, inexpensive way to provide safety in dark spaces during a blackout.
Image: Samantha Yost.

Operations + maintenance

Windows and skylights should be regularly cleaned, particularly in urban areas, to ensure that daylight isn't blocked.

Battery-operated lighting systems should be tested and batteries replaced when necessary.

Estimated cost

$ | $$ | $$$ | $$$$

Supporting strategies

13 Maintaining Backup Power to Critical Systems

Resources

Lighting: Off Grid Energy Options, Alternative Energy.
www.altenergy.org/Glossary/light.html

Skylighting Design Guidelines, Energy Design Resources.
energydesignresources.com/resources/publications/design-guidelines/design-guidelines-skylighting-guidelines.aspx

Tips for Daylighting with Windows, Lawrence Berkley National Laboratory, US Dept. of Energy, 2013.
windows.lbl.gov/daylighting/designguide/LBNL_Tips_for_Daylighting.pdf

Case Study Purchasing Battery-Operated LED Lights

Background

The Village at Sterling Hill is a senior condominium complex in Exeter, New Hampshire. Residents expressed concern about hallways, the garage and other public areas which might not be safe during a power outage.

Strategy

The owner of the complex purchased 108 **Mr. Beams™ 360** ↗ lights, small, battery-operated, durable, and highly-efficient LED lights that have both a photo-sensor and motion detector so they turn on only when needed. Because the units require only a screw to mount them to the wall and do not connect to the electrical system, the complex did not have to rewire the entire building.

Cost

Each Mr. Beams 360 unit costs about $20. The Village ordered 108 lights to provide emergency lighting in all public areas.

Photos: www.mrbeams.com.

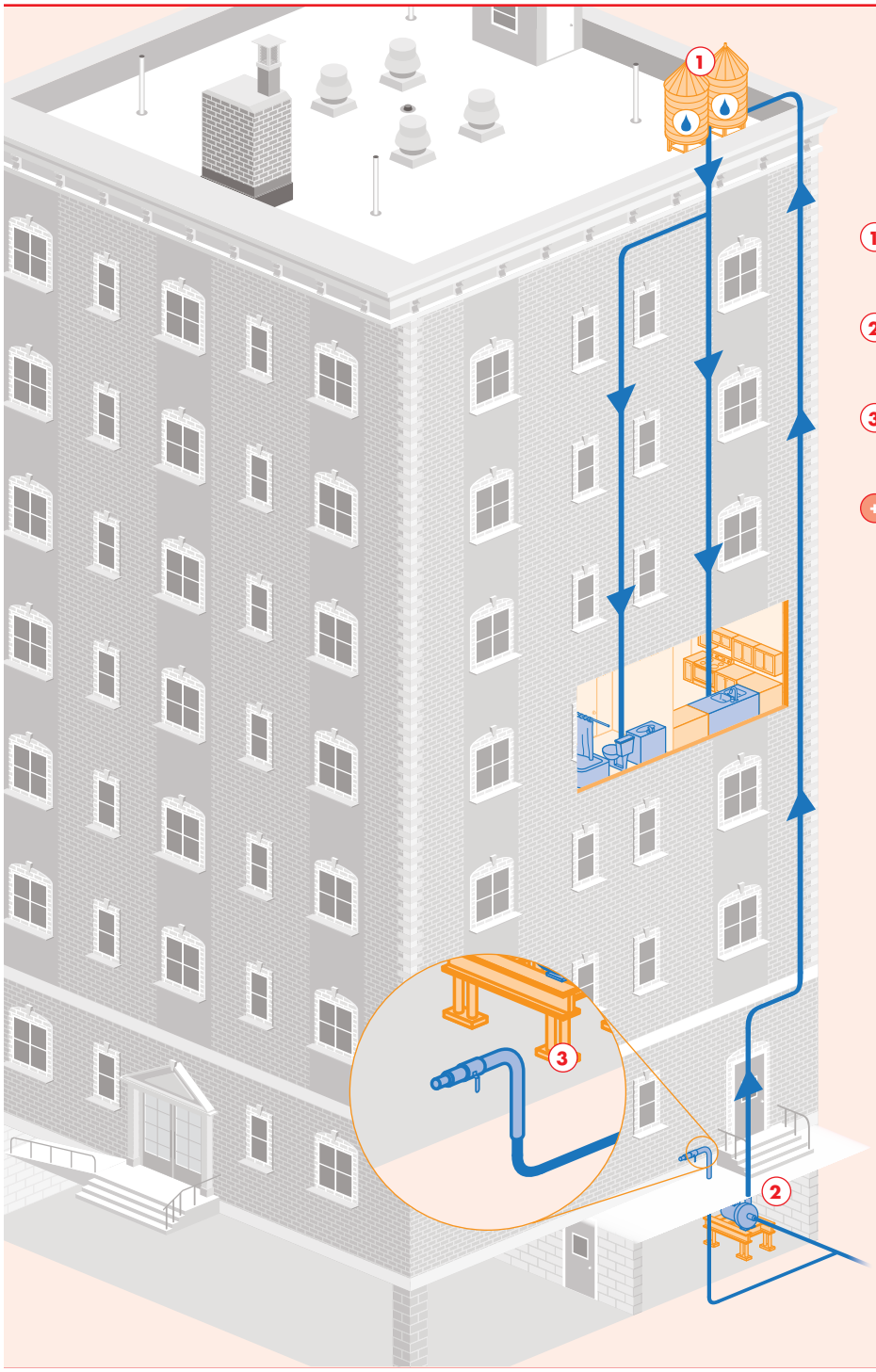
Location
The Village at Sterling Hill
Exeter, NH

Scale
120 units

Cost
$20 / light

15 Access to Potable Water

Aligns with Enterprise Green Communities Criteria:
4.2 Advanced Water Conservation.
4.5 Water Reuse.
4.6 Access to Potable Water during Emergencies.



1. Rooftop water tanks provide gravity-fed water.
2. Electric water pumps will not function during a power outage.
3. An emergency faucet bypasses the main building pump.

\+ *Strategies not pictured:*

Install water-efficient appliances.

Harvest rainwater for irrigation or sanitation.

Image: Colin Hayes.

15 Access to Potable Water

A reliable source of potable water is essential if a building is to remain livable during a power loss.

Description + function

Standard municipal water pressure may be adequate to keep buildings up to 6 stories high supplied with water during of a power outage. Taller buildings typically either use pressure-booster pumps or pump water to a roof tank.

Strategy into action

Rooftop water tanks.

During an outage, buildings with rooftop water storage have a resilience advantage since their water supply is gravity-fed and may last for days if residents know to strictly curtail water use. Structural considerations may make the retrofit installation of rooftop tanks difficult.

Many taller residential buildings have rooftop water tanks. During an extended loss of power, pumps are unable to replenish the water in the tank.
Image: Alexander Rabb.

Emergency water faucet.

Many water pump systems have a bypass valve which enables the building to bypass the pumps and run water to lower floors. The emergency water faucet should be located in a public place close to the municipal water supply entrance.

A low-flow showerhead.
Image: Wil C Fry.

Water efficiency measures.

Efficient toilets, showerheads and faucet aerators pay back their installation cost quickly, and reduce the amount of water used during emergencies. Leaks are also a large source of waste. Repair all leaks immediately, and encourage residents to report leaky fixtures.

Critical-load circuits.

If the building has a water pump, consider adding it to the critical loads served by a backup generator.

Rainwater storage.

Storage tanks and rain barrels can provide water for non-potable uses during emergencies. Rainwater should be treated as greywater and used only as code allows. Tanks should be enclosed to keep out mosquitos and other pests, and cleaned out once a year.

A rain barrel connected to a building downspout.
Image: Arlington County.

Drinking water storage.

Keep a water cooler with multiple containers of spring water on-hand, or store cases of bottled water. Plastic containers of water should be stored in a dark location protected from freezing and leeching. Encourage residents to store emergency bottled water or store tap water in clean containers and bathtubs.

Ask your plumber for recommendations about backflow preventers to avoid contaminating the municipal water supply. A licensed plumber can help select a proper device.

Operations + maintenance

Water storage systems need regular flushing and cleaning, even for non-potable uses. Check with the local health department to see if special permits are required for potable water cisterns.

Store several clean water containers near the emergency faucet for unanticipated power outages.

Estimated cost

$ $$ $$$ $$$$

Supporting strategies

13 Maintaining Backup Power to Critical Systems

Resources

Emergency Drinking Water Supplies, Dorothy Miner.
www.bae.ncsu.edu/extension/ext-publications/water/drinking/emergwatersupply-minner.pdf

EPA WaterSense.
www.epa.gov/watersense/

Overview of Greywater Reuse, The Potential of Greywater Systems to Aid Sustainable Water Management, Pacific Institute.
www.pacinst.org/wp-content/uploads/sites/21/2013/02/greywater_overview3.pdf

Case Study Emergency Water Connection

Background

The Verdesian is a multifamily residential building in lower Manhattan.

Strategy

The building installed an emergency water faucet on the ground floor above the DFE. The faucet bypasses the roof tank pump and connects directly to the municipal water supply, assuring a reliable source of potable water even during an extended power outage.

Cost

The backup water valve was added during an extensive resilience retrofit at minimal cost.

The emergency faucet has hook-ups for both fire and regular hoses.

Images: Samantha Yost.

Location
211 North End Ave.
New York, NY

Scale
253 Units

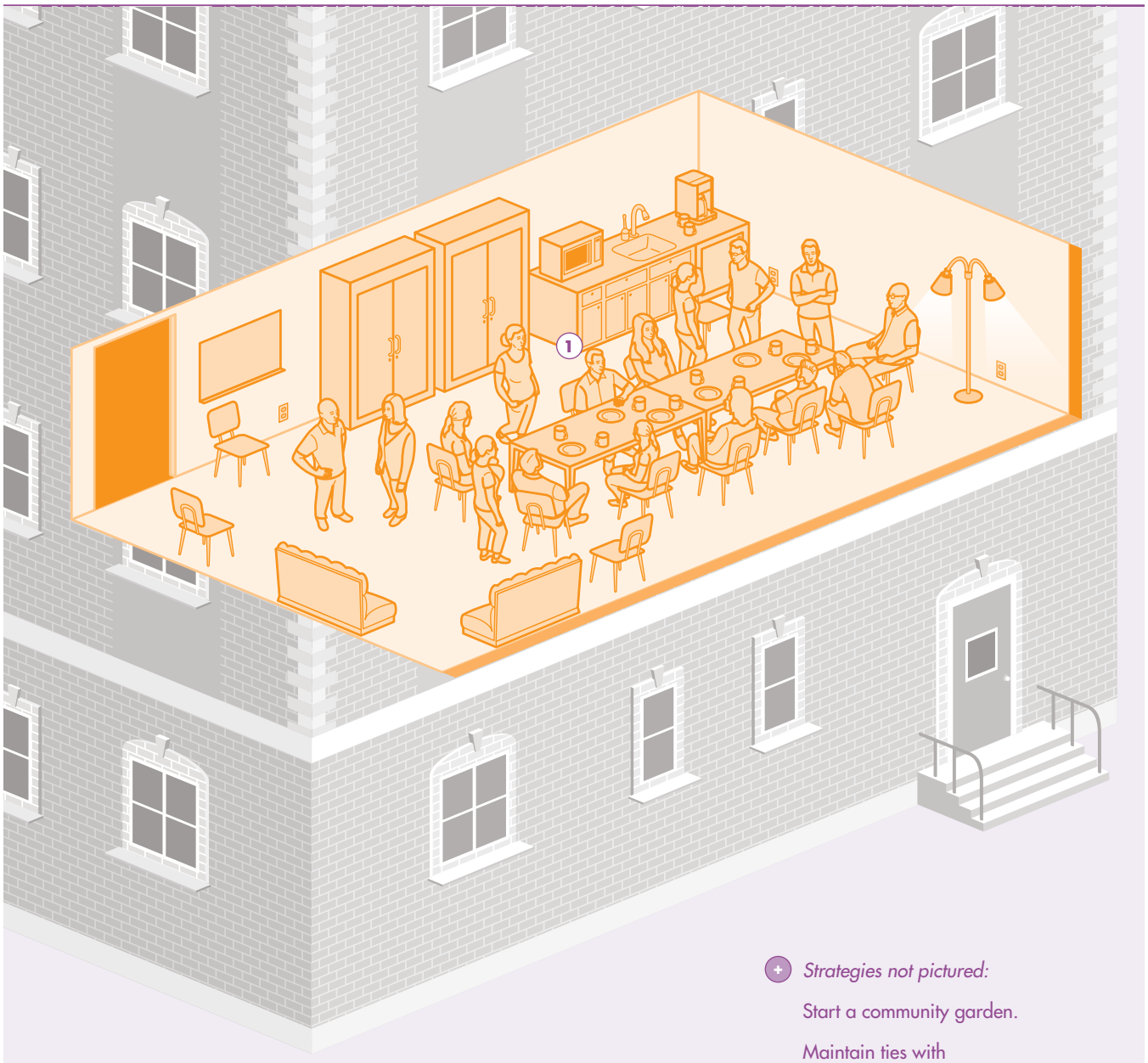
Cost
Minimal

Community

Strategies that encourage behavior which enhances resilience.

Image: Direct Relief, USA.

16 Building Community Ties



Strategies not pictured:

Start a community garden.

Maintain ties with emergency officials.

Establish communication infrastructure resilience.

1 Encourage community events and social gatherings.

Image: Colin Hayes.

16 Building Community Ties

When residents have strong ties to each other, communities can better weather a storm event and the aftermath, especially when first responders are unable to access the community. Often, neighbors become the most important source of support and information.

Description + function

Residents who know one another will be more likely to turn to each other for support during an emergency. This becomes especially critical if they shelter in place.

Develop infrastructure to support community engagement and interaction. Set aside common space for posting information, convening meetings and hosting parties and other group activities.

Find out if residents have limited English. Ensure that communications are translated as needed. Children can help translate for older relatives.

Strategy into action

Residents work at a community garden.
Image: D Olwen Dee.

Develop community.

Build a sense of community by hosting events for residents, such as:

- Social gatherings such as building picnics, block parties, movie nights or meals in a community room.
- Youth activities.
- Maintain communication with residents through a facility newsletter or a notice board where announcements and flyers can be posted.
- Community gardens allow residents to exercise, enjoy the outdoors, build community ties and have healthier food options. This is especially effective in urban “food deserts”. Consult a gardening professional or non-profit organization to navigate zoning and soil contamination issues.

Image: City of North Charleston.

Connect to the broader neighborhood.

Building a sense of community among residents is a starting point, but also encourage strong ties to the larger neighborhood, including local police and fire departments, social service agencies, faith-based organizations, medical clinics, service providers and other organizations.

Strategies to maintain relationships.

» Keep an up-to-date contact list for important service providers. Post paper copies of this information in key locations. Keep an up-to-date electronic version of the contact list and ask staff to add key contact numbers to their cell phones.

» Coordinate with residents to invite police, firefighters, agency staff and other service providers to building social functions.

» Many community-based organizations have civilian volunteers trained in disaster preparedness. Encourage staff and residents to join your local disaster preparedness group, or consider launching one.

» Conduct a building walk-through with residents, building owners and property staff to show the building's green features and operations, maintenance, and emergency procedures.

Communications resilience.

During an emergency, residents must be able to communicate with loved ones. Ensure that at least one land line telephone is available. If your facility has reliable back-up power, consider hosting a cell tower. Personal solar charging units are an inexpensive option for maintaining connectivity during extended power loss. Placing cables underground or hardening above-ground cables can minimize service loss.

A personal charger for cell phones.
Image: Alan Levine.

Right: Cell providers usually pay monthly rent for building roof space. Get residents' permission before agreeing to install a tower.
Image: Andy Padian.

Operations + maintenance

Keeping contact information up-to-date reflecting staff changes. Sharing these activities with other housing or community service organizations can build closer ties.

Community Emergency Response Team (CERT) prepares residents to respond to and cope with a disaster. CERT empowers community residents to respond to and become leaders during an emergency. See the FEMA webpage for more information.
Image: Flickr user "rokhed."

Estimated cost

$ | $$ | $$$ | $$$$

Supporting strategies

17 Creating Community Resilience Spaces
18 Developing an Emergency Management Manual
19 Organizing for Community Resilience

Resources

A Whole Community Approach to Emergency Management: Principles, Themes and Pathways for Action, FEMA, 2011.
www.fema.gov/es/media-library/assets/documents/23781

Neighborhood Empowerment Network: Empowered Communities Program, San Francisco.
empowersf.org/ecp/

Ready to Respond: Disaster Staffing Guide, Resident Engagement.
www.enterprisecommunity.com/solutions-and-innovations/green-communities/tools-and-services/ready-to-respond/disaster-staffing-toolkit/resident-engagement-team-leader

Case Study Clinton Community Garden

Background

Established in 1978, the Clinton Community Garden occupies a former junkyard in Hell's Kitchen on the west side of Manhattan. The front garden is open to the public and maintained by volunteers. The back garden, open only to those with keys, has 108 plots assigned to community members on a first-come, first-served basis. Composting facilities are also available.

Strategy

Garden members include young professionals, middle-aged and elderly residents, from a range of ethnic and economic backgrounds. School groups come to learn about urban agriculture, adding to the strong sense of community.

Because the garden was a brownfield site, members regularly test the soil for lead and have lessened previous soil damage.

Cost

The garden is maintained by volunteers and does not charge for plots. It is funded by city grants, the sale of merchandise, commemorative bricks and contributions.

The front garden contains ornamental plants, lawns, and features an apiary.

The rear garden contains 108 member plots.

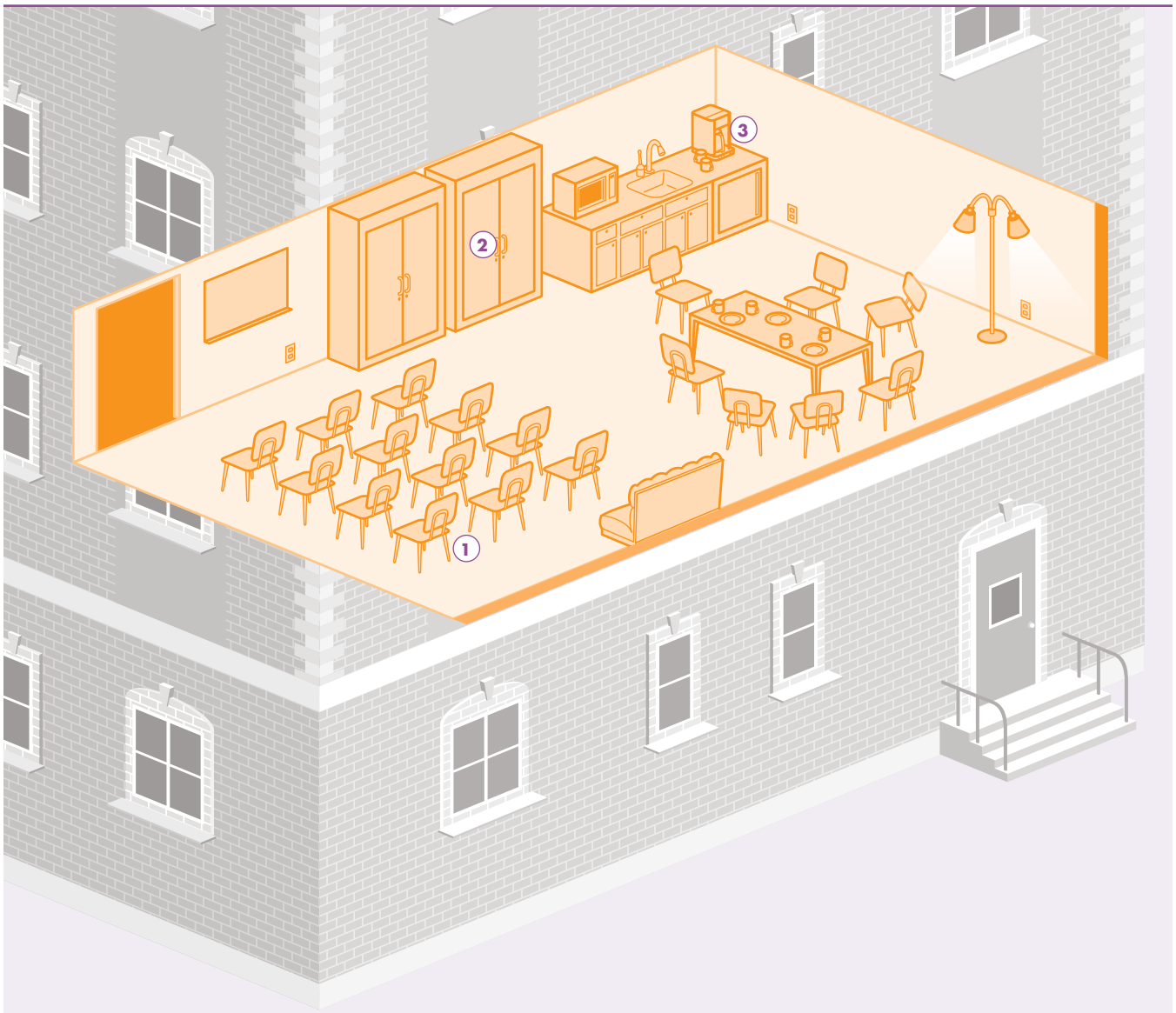
Images: Samantha Yost.

Location
434 West 48th St.
New York, NY

Scale
0.35 Acres

Cost
Grant-supported

17 Creating Community Resilience Spaces



1. A community resilience space allows residents to meet each other, socialize and hold events or relief efforts.
2. Storage for emergency supplies.
3. Backup power and potable water.

\+ *Strategies not pictured:*

Provide communications options.

Provide restrooms that can function without grid power.

Image: Colin Hayes.

17 Creating Community Resilience Spaces

Community spaces play a vital role in building resilience—getting residents involved and connected to each other.

Description + function

A designated community resilience space can be the location for relief efforts during an emergency.
Image: FEMA / Liv Roll.

Community spaces should offer a safe and secure environment for residents and a central location for emergency services.

Strategy into action

Spaces designated as fallout shelters may be ideal for a community "safe room".
Image: Andrew Gonsalves.

Locating the community space.

Your resilience space might be located in an existing multi-purpose area such as a dining or activity room, where residents will feel comfortable taking shelter or receiving emergency services.

Image: United Workers.

Hold non-emergency gatherings that could draw residents together.

If a multi-purpose community room does not exist in your building, consider setting aside a "safe room" located above the DFE for it. Notify residents about the new resource and potential uses such as fitness classes, recreation and meetings.

A community resilience space should not replace a formal evacuation center. When an evacuation is ordered by the municipality, residents should leave the property for the nearest designated evacuation center.

Keeping emergency supplies handy and organized is a vital function of a community resilience space.
Image: Samantha Yost.

Setting up the space.

» **Put together a plan.** Work with resident leadership to establish a resilience committee which will reach out to residents in planning for resilience space.

» **Provide backup power.** Ensure that the community resilience space's lighting and outlets are on the building's critical-load circuit. (See Strategy: Maintaining Power to Critical Systems).

» **Store emergency supplies.** Use a closet, cabinet or storeroom in the space to store emergency medical supplies, flashlights, batteries, a hand-operated emergency radio with weather band and possibly cots and blankets.

Emergency supplies should be locked up to keep them from non-emergency use. A spare key must be on-site and several residents should know its location.

» **Provide multiple communications options.** A hard-wired telephone, wireless internet components (cable modem, wireless router, etc.) powered by the backup generator and a satellite phone can facilitate communications during emergencies.

» **Provide access to potable water.** Store potable water or provide access to municipal water or safe well-water in the community resilience space. Taller buildings may not have access to municipal water during power outages; if so, a backup water plan will be necessary. (See Strategy: Access to Potable Water).

- **Functioning toilets.** A restroom should be provided near the community resilience space. Automatic toilet and sink fixtures should operate without grid power.
- **Food storage and cooking.** For larger community resilience spaces, provide emergency food supplies and cooking equipment sufficient to satisfy the short-term needs of those sheltering in place.
- **Recreation.** Residents may spend a long time in the community resilience space depending on how long an emergency lasts. Consider storing books, board games, playing cards and other recreational materials for adults and children.
- **Information boards.** The community space should have a designated location for communicating information such as a bulletin board. Residents should know where to find up-to-date and critical messages, especially if cell phone service fails.

Establish your community resilience space as a neighborhood hub.

A central safe space is vital during an emergency. Consider positioning your space as a resilience hub to serve the broader community, offering translation services, medical care, food distribution and more.

Operations + maintenance

A staff member should periodically inspect supplies and equipment in the community resilience space so they are ready for an emergency. Equipment not used regularly is more likely to fail.

Estimated cost

$	$$	$$$	$$$$

Supporting strategies

13 Maintaining Backup Power to Critical Systems

15 Access to Potable Water

16 Building Community Ties

18 Developing an Emergency Management Manual

19 Organizing for Community Resilience

Resources

Community Emergency Hubs, Seattle Office of Emergency Management.
www.seattle.gov/emergency-management/working-together/community-emergency-hubs

Design and Construction Guidance for Community Safe Rooms, FEMA.
P-361, August 2008.
www.fema.gov/media-library/assets/documents/3140

Taking Shelter from the Storm, Building a Safe Room for your Home or Small Business, FEMA P-320, December 2014.
www.fema.gov/es/media-library/assets/documents/2009

Case Study A Resilience Hub During Superstorm Sandy

Background

Brookdale Village Senior Center is part of a senior residential complex operated by the Jewish Association Serving the Aging (JASA) in Far Rockaway, Queens, NY. During Superstorm Sandy, Brookdale had functioning backup systems and emergency supplies on hand, allowing it to become a resilience hub for the broader neighborhood. Of all the JASA buildings in Far Rockaway, Brookdale suffered the least damage, with no ground-floor flooding. Sixty percent of the building's elderly residents chose to shelter in place rather than evacuate.

Strategy

Brookdale has two outside emergency back-up generators mounted 6 ft. above the ground. They supplied enough power to charge cell phones, run an elevator and provide limited heating for the residential building and a smaller community center nearby. The dining room, which serves 300, was divided and used as a common space where supplies were distributed. JASA staff provided security for the common spaces.

In planning for the next disaster, Brookdale has implemented a full-scale emergency plan and staff trainings. JASA has also ordered additional emergency supplies such as cots and plans to install emergency generators in another community center to extend its ability to function as a community resilience hub.

Cost

Brookdale has about $5,000 worth of emergency supplies on hand, including stored water, blankets, non-perishable food items, batteries and a satellite radio.

Brookdale Senior Center is a large, multifamily building located in Far Rockaway.
Images: JASA.

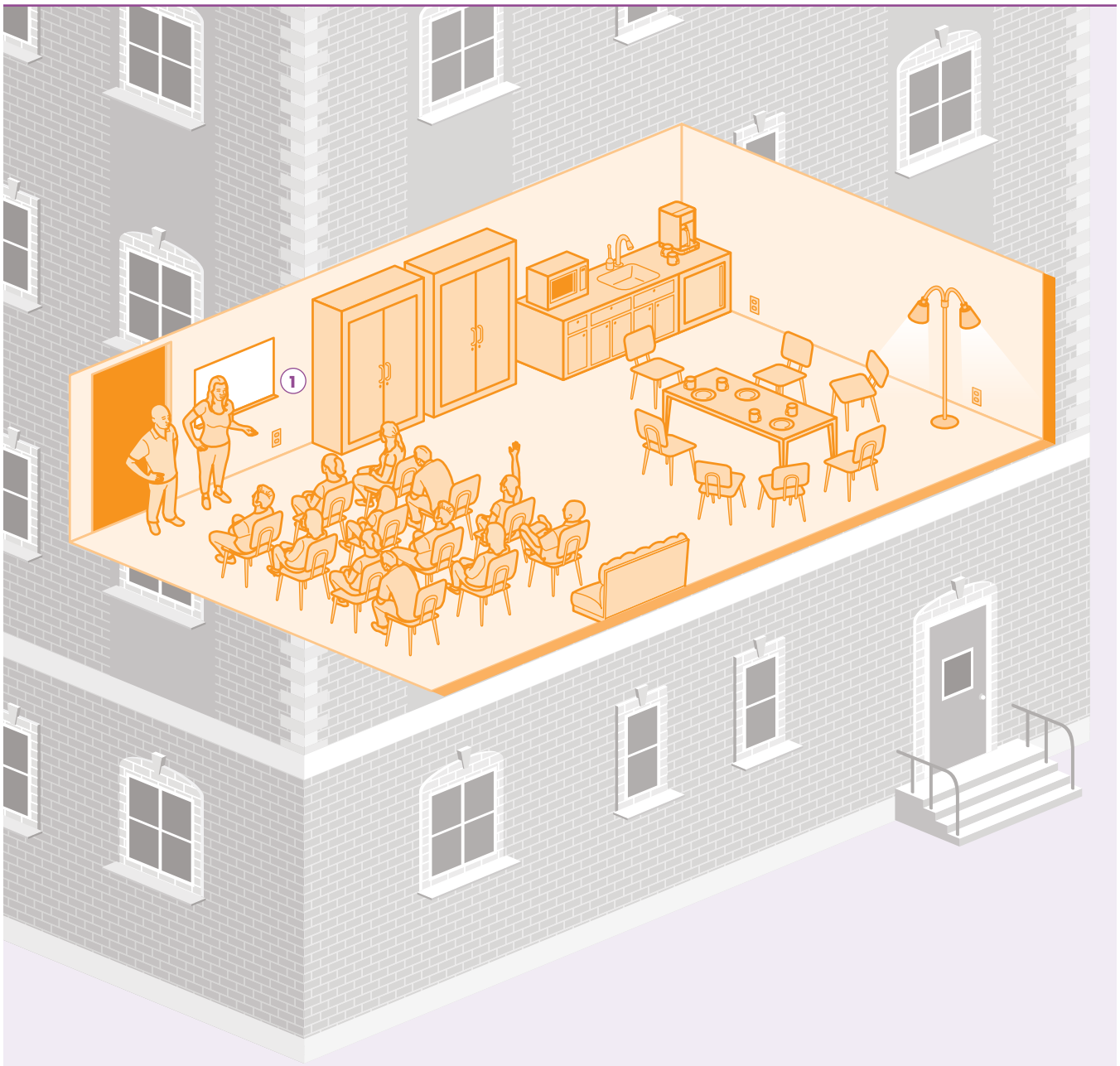
Location
131 Beach 19th St.
Queens, NY

Scale
274 Units

Cost
$5,000

18 Developing an Emergency Management Manual

Aligns with Enterprise Green Communities Criteria: **1.3b Resilient Communities: Multi-Hazard Risk / Vulnerability Assessment.**



1 Gather all stakeholders to create an emergency response plan.

Image: Colin Hayes.

18 Developing an Emergency Management Manual

Disaster can strike anywhere, anytime. An organization may have time to plan a coordinated response in advance, or the emergency may come without warning. Either way, an organization which has a clear, well-rehearsed emergency plan will better manage a more coordinated, effective response.

Description + function

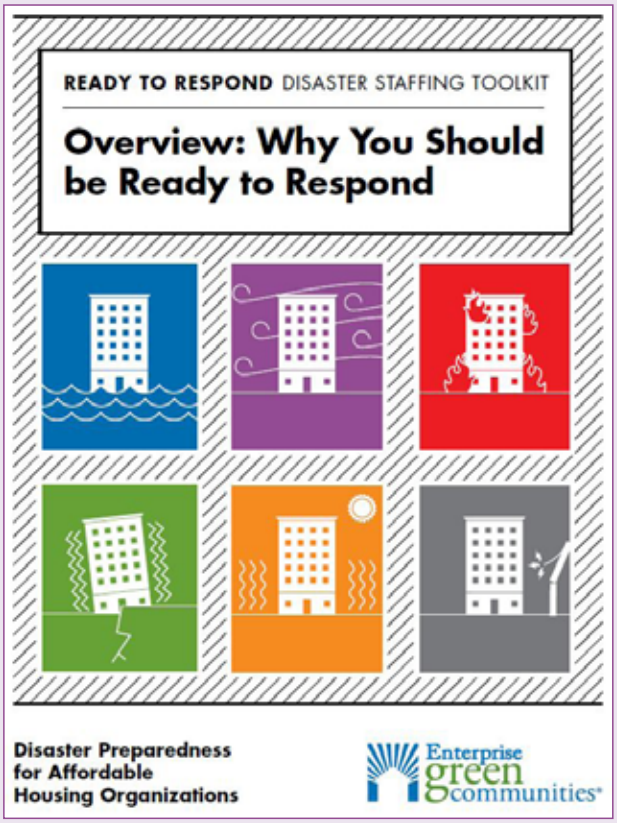
An effective emergency plan prepares the entire organization for an emergency, promoting three core capabilities:

» **Coordination.** The organization works in a unified way across departments and with organizations and people outside.

» **Communication.** Staff and leadership communicate efficiently throughout a disaster.

» **Information sharing.** Vital updates reach staff, residents, leadership and outside people quickly.

Enterprise Community Partners' Ready to Respond: Disaster Staffing Toolkit↗ is a user-friendly, ready-made collection of tools to help housing organizations build comprehensive disaster plans.



Strategy into action

Having emergency kits and go-bags on hand is essential to an emergency plan.
Image: FEMA / Red Cross.

Assess your vulnerabilities and risks.

Analyze the hazards your buildings are vulnerable to. (See: Getting Started: Identify your hazard exposure, and Assess your risks).

Develop an emergency plan.

Assign an emergency preparedness coordinator (EPC) to oversee the development of an emergency plan. The EPC will work with senior leadership to assign staff to emergency response roles, customize preparedness materials and tasks, coordinate trainings and implement revisions to the plan.

An emergency plan should consider:

Task	Example
Building protection. Minimize damage and ensure quick return to service.	Equipment inventory and action plans, protecting IT and telecommunications infrastructure, shut-down and re-open protocols, managing vender relationships.
Resident engagement. Support the safety, preparedness and recovery of residents.	Emergency kits and go-bags, up-to-date information on residents, preparedness surveys, updated flyer templates, evacuation tracking sheets.
Business continuity. Maintain key business operations throughout a disaster.	Hard-copy record backups, insurance information, financial preparedness plan, staff work policies, emergency-related expense tracking sheets.

Children, seniors, those with disabilities and other residents with special needs may need additional support, particularly during extreme heat or cold. Maintain detailed records about residents' medications and medical or mobility equipment for residents who may need extra assistance in case of an emergency.

Operations + maintenance

Organizations should host training exercises to test their emergency plan and practice communication and coordination among staff members. Trainings attended by senior leadership, resident leaders and all staff involved in emergency planning should be held at least once a year.

Trainings may include a simulated emergency event, emphasizing the importance of emergency planning and allowing staff to practice their roles. The training facilitator should document training activities in a post-training report asking for feedback for what could be improved.

Image: FEMA / Hans Pennink

Estimated cost

$ | $$ | $$$ | $$$$

Supporting strategies

16 Building Community Ties
17 Creating Community Resilience Spaces
19 Organizing for Community Resilience

Resources

Emergency Action Plan Checklist, OSHA.
www.osha.gov/SLTC/etools/evacuation/checklists/eap.html

Enterprise Community Partners, Inc. Ready to Respond: Disaster Staffing Toolkit
www.enterprisecommunity.com/solutions-and-innovation/green-communities/ready-to-respond/disaster-staffing-toolkit

Incident Command System, Review Materials, FEMA.
training.fema.gov/emiweb/is/icsresource/assets/reviewmaterials.pdf

Case Study Developing an Emergency Plan for a Supportive Housing Organization

Background

Bailey House is a supportive housing organization providing services for the homeless and people living with HIV/AIDS. Located in New York's Greenwich Village at 180 Christopher St., the facility is in the AE flood zone within the 100-year floodplain.

The building had experienced flooding before, and had an evacuation procedure and emergency supplies in place. But the plan did not adequately prepare the Bailey House for Superstorm Sandy.

Photos: Bailey House.

Strategy

After Sandy, Bailey House created an emergency plan based on the Incident Command System, a federally-recognized emergency management framework.

Bailey House divides its housing section into two areas. Facility Management combines resident engagement and building protection. Client Services maintains the social services Bailey House provides.

The emergency plan assigns roles to staff members and works on two levels, implementing disaster preparedness measures while setting up policies and procedures to be used during an actual disaster.

Cost

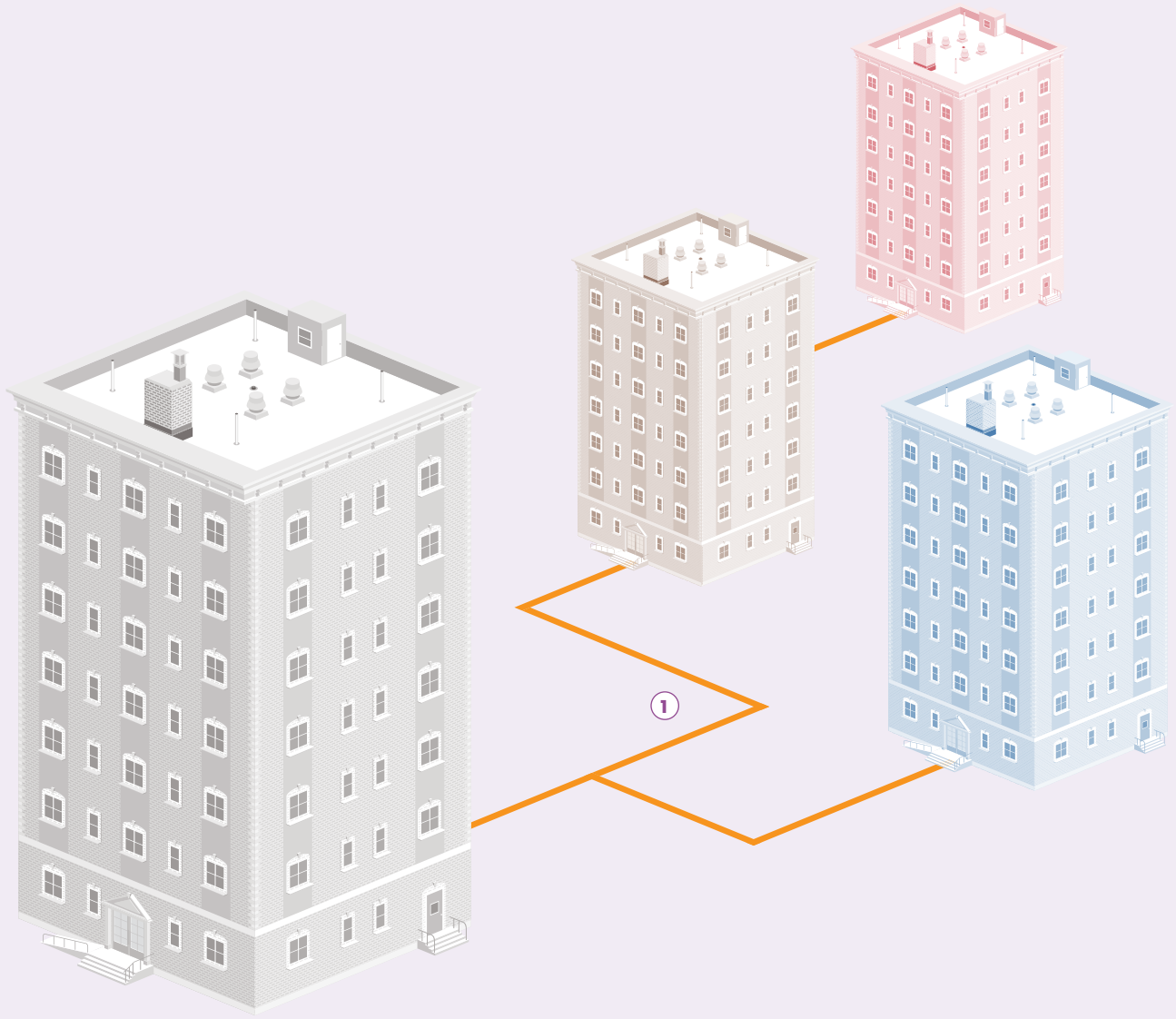
To create a custom-tailored emergency plan, Bailey House hired a private consultant at a fee of approximately $2,500.

Location
180 Christopher St.
New York, NY

Scale
45 Units

Cost
$2,500

19 Organizing for Community Resilience



1 Develop a learning collaborative to share information with other housing owners and organizations.

Image: Colin Hayes.

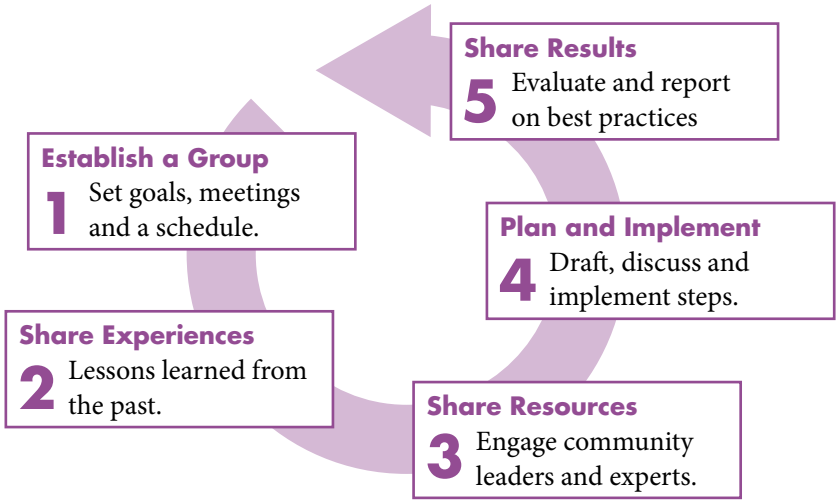
19 Organizing for Community Resilience

Collaboration with other multifamily housing organizations can make your resilience plan stronger and more effective. Organizations can share their experiences in resilience planning and emergency preparedness.

Description + function

Coming together with other housing organizations can help you identify local and shared resources, pool information about equipment and infrastructure pricing and the best ways to get residents involved.

Following a well-defined process of sharing, implementation and sharing again can help set the goals of a collaborative group.
Image: Linnean Solutions.



Strategy into action

Organizing a group.

To start a multi-organizational learning group, identify a facilitator and make a list of potential members. The facilitator will schedule meetings and run them, draft agendas and keep gatherings productive and focused.

Explore private and government funding to enhance your collaboration's resilience capacity.

Actions of an effective collaboration.

» **Develop a group mission statement** beginning with its function and purpose. This will create group identity and structure.

» **Logistics.** Each organization should commit two staff members to attend group meetings and represent the organization, conveying information to organizational leadership. Schedule meetings on a consistent basis. Send out the agenda a week in advance.

Photos: Enterprise.

» **Capacity building.** Invite local government officials such as council members and community board representatives and technical experts to build your group's capacity and connection to the neighborhood.

» **Develop a communication platform which group members can easily access.** Develop an Email list to support communications between meetings. Establish a communications plan to remain in touch during a disaster.

» **Funding.** Apply for philanthropic and government funding.

Operations + maintenance

Encourage the group to devise strategies for their buildings and surrounding areas. Ask group members to invite building managers, emergency preparedness coordinators and other management members to meetings. Field staff are the first line of defense during emergencies, and their participation in your meeting is vital.

The Lower East Side Long Term Recovery Group is a coalition of more than 75 community groups and institutions that coordinate disaster response, resources, preparedness planning and training. Group members share resources in times of crisis using an active mailing list.

LES READY! Long Term Recovery Group of the Lower East Side of Manhattan

Estimated cost

$	$$	$$$	$$$$

Supporting strategies

16 Building Community Ties

17 Creating Community Resilience Spaces

18 Developing an Emergency Management Manual

Resources

Integrating Hazard Mitigation into Local Planning, FEMA, March 2013.
www.fema.gov/es/media-library/assets/documents/31372

Lower East Side Long Term Recovery Group.
lesready.org/mission-statement/

Resilience Learning Collaborative, Enterprise Community Partners.
www.enterprisecommunity.com/where-we-work/new-york/priorities-and-impact/hurricane-sandy-rebuilding

Case Study Setting up a Resilience Multifamily Housing Learning Collaborative

Background

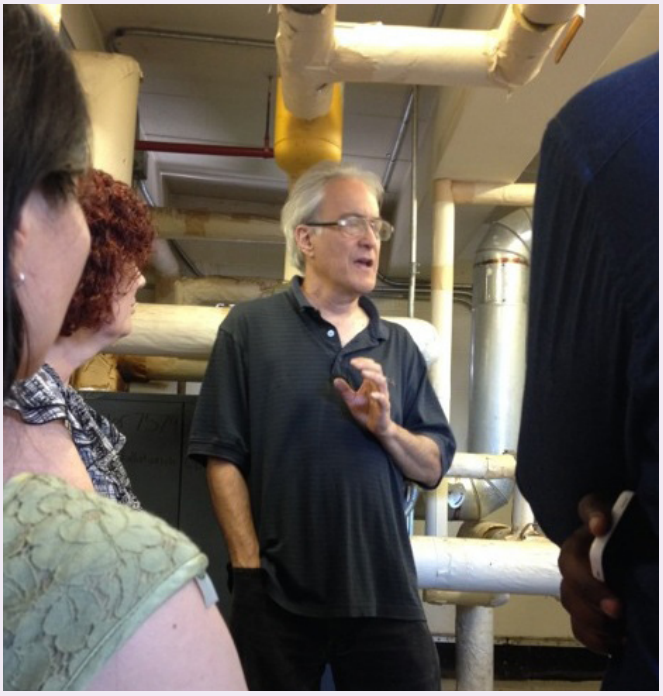
In the wake of Superstorm Sandy, Enterprise brought together 12 affordable housing organizations from New York and New Jersey for a two-year learning collaborative program designed to build resilience. Participants manage 293 multifamily buildings with 14,500 housing units.

The goal was to identify shared best practices and challenges in response and recovery after Sandy, and to develop a long-term resilience plan for multifamily housing.

Strategy

Enterprise facilitated the group's meetings and development. The group met every three months and each meeting featured a speaker. At the end of the two-year period, the accomplishments included:

- A unique emergency plan and protocols customized to each organization.
- Resilience assessments and capital plans for 56 vulnerable buildings, and the implementation of a variety of resilience measures from on-site generators to backflow prevention valves.
- A framework for multifamily resilience which divided resilience planning into four themes: Resident Resilience, Building Resilience, Organizational Resilience and Community Resilience.
- The development of a series of tools promoting emergency preparedness and resilience for multifamily buildings.



The Enterprise Learning Collaborative brought together diverse housing groups from all over New York City.
Photos: Enterprise.

Location
1 Whitehall St.
New York, NY

Scale
12 Housing Organizations

Case Study Large-Scale Resilience Retrofit for Affordable Multifamily Housing

Background

Arverne View is an 11-building, 1093-unit complex of affordable housing in Far Rockaway, Queens, NY. Far Rockaway is a peninsula between the Atlantic Ocean and Jamaica Bay located in the FEMA AE flood zone.

The complex suffered extensive damage during Superstorm Sandy. When the resilience retrofit began, the complex was in disrepair – 350 units were vacant, many uninhabitable because of water leaks, mold and inadequate envelope sealing.

The Averne View Complex, before and after.
Images: L+M Development Partners, Inc.

Strategy

L+M Development Partners Inc. led a renovation of the entire complex, employing several of the strategies in this manual.

3 Site Perimeter Floodproofing

A permanent flood barrier was installed to protect against wave surge and perimeter flooding.

7 Envelope Efficiency

An Exterior Insulation Finishing System (EIFS) was installed to prevent envelope water infiltration, improve envelope efficiency and improve the look of the buildings and community.

8 Elevated Equipment

Electric and mechanical equipment was elevated above the DFE to protect it from flooding.

10 Surface Stormwater Management

A campus-wide stormwater management plan was put in place to help manage on site stormwater.

13 Maintaining Backup Power to Critical Systems

Generator capacity was added to provide backup power to the community during a power outage.

17 Creating Community Resilience Spaces

Meeting and disaster relief areas were identified to be used as resilience hubs during an emergency event.

18 Developing an Emergency Management Manual

An emergency action plan to manage future disasters was developed.

These energy efficiency measures were also installed: ENERGY STAR appliances, LED light fixtures, motion sensors in the stairwells and hallways and low-flow water fixtures.

Cost

L+M financed the acquisition and construction using New York Housing Development Corporation (HDC) taxable and tax-exempt bonds, equity and existing restated debt. Energy upgrades were sponsored by the Multifamily Performance Program of the New York State Energy and Research Development Authority (NYSERDA).

Savings

With the resilience retrofit the development:

- **Reduced energy use by 30 percent.**
- **Cut private flood insurance premiums.**
- Filled all 350 vacancies.
- Significantly lowered resident turnover.
- Improved rent collection rates.
- Reduced climate risk.

Basketball courts, before and after.
Images: L+M Development Partners, Inc.

Walkway, before and after.
Images: L+M Development Partners, Inc.

Location
57-17 Shore Front Pkwy.
Arverne, NY

Scale
11 buildings, 1093 units

Putting it All Together

Once you determine which resilience strategies to pursue, begin pre-development. This section will help you determine who should be involved, what agencies and regulations can help and what public funding may be available.

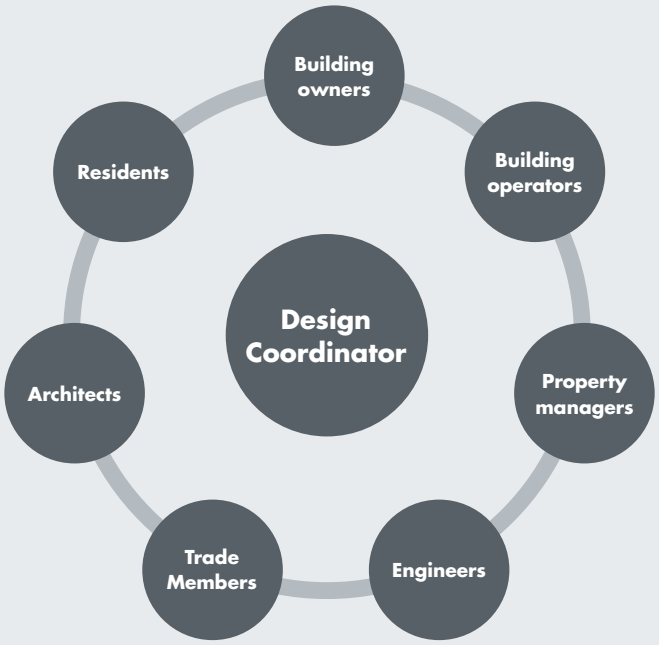
Pre-development using integrative design

Conventional building design involves a series of hand-offs from owner to architect, from builder to resident. Not all participants are brought into the planning and their needs, expertise and insights may be missed. Incompatible design elements are often discovered late in the process, when it is expensive to make changes.

Save time and money and assure quality control by using an integrative design approach, bringing together everyone who should be involved in the beginning stages of your retrofit. The integrative design process involves collaboration by key leaders, staff members and design professionals from start to finish.

Review the Enterprise Pre-Development Design toolkit for an overview of the process.

Participants in an Integrative Design Process



This information can be found in much greater detail in *Enterprise's Pre-Development Design Toolkit*↗ and *Green Charrette Toolkit*↗, along with sample materials and worksheets to help make your plans a reality.

Design Visioning *Early Planning* — 3 WEEKS

STEP 1
Getting Started
Build a diverse project team to help you

STEP 2
Define Project Program and Create Design Brief
Develop a vision and a program for your project

Design Team Selection *Finding Teams* — 3 WEEKS

STEP 3
Draft and Distribute the Project RFP
Find design teams qualified to work on your project

STEP 4
Select Teams to Submit Proposals
Select the best design teams to compete for your project

Design Team Selection *Reviewing Designs* — 5 WEEKS

STEP 5
Host Site Visit and Receive Proposals
Help those teams better understand your project vision

STEP 6
Review Proposals and Prepare for Interviews
Review the proposals that design teams submit

STEP 7
Interview and Select Design Team
Select the best design team to work on your project

Next Steps
Green Charrette
Identify goals and strategies for sustainability

Integrative design resources.

Enterprise Green Charrette Toolkit.
www.enterprisecommunity.com/solutions-and-innovation/enterprise-green-communities/resources/charrette-toolkit

Enterprise Green Communities Pre Development Design Toolkit.
www.enterprisecommunity.org/resources

The Integrative Design Guide to Green Building: Redefining the Practice of Sustainability.
www.sevengroup.com/integrative-design-guide/

US Green Building Council Green Building 101: What is an integrated process?
www.usgbc.org/articles/green-building-101-what-integrated-process

Whole Building Design Guide.
www.wbdg.org/design/engage_process.php

Who should be involved

Image: Enterprise.

In the retrofit process, a variety of key people should be involved in design, building and operations:

Architects.

» **Building Architect** Responsible for design, drafting and project management. Provides guidance on code compliance and regulatory issues such as ADA compliance.

» **Landscape Architect** Designs and implements the outdoor elements of a project, including stormwater management techniques.

Engineers.

» **Civil Engineer** Designs infrastructure including roads, bridges, site-work, canals, dams and buildings. Should be included in decisions about site design and the interaction between building infrastructure systems and the larger community.

» **MEP (Mechanical, Electrical, Plumbing) Engineer** Designs the building's infrastructure systems, including heating and cooling, ventilation, power distribution and loads, lighting, security and alarm systems, potable water inflow and sewage outflow. Should be involved in decisions concerning the movement of mechanical equipment.

» **Structural Engineer** Ensures the building structure can withstand a certain amount of weight and forces from earthquakes, high winds and heavy snowfall. Should be involved in strategies for dry floodproofing, elevators and other issues which affect the building structure.

Other key people.

» **Asset Manager** Verifies the financial sustainability of the retrofit strategy.

» **Building Science Consultant** Performs building performance and efficiency testing, benchmarking and monitoring.

» **Contractor** Responsible for construction work.

» **Local Floodplain Manager** Oversees community-level flood preparation efforts, maintains insurance and FEMA documentation and issues permits for development in floodplains.

» **Property Manager** Responsible for collecting rent, tenant relations, maintenance and repair and maintaining a budget. Familiar with building staff and operations.

» **Building Superintendent** Responsible for day-to-day operations, this is your most critical link to the building.

» **Residents** Should be consulted and informed about building improvements and construction schedule.

» **Surveyor** Makes measurements to determine property lines and collects measurement data for engineers and contractors. Provides elevation certificates.

» **Utility Company** Coordinates efforts to move or upgrade electrical or gas delivery systems.

» **Vendors** Supply information and requirements about the equipment they sell or manufacture.

» **Insurance Broker** Reviews your risk, which determines your policy premium levels. Engaging your broker in the resilience planning may help reduce your insurance premiums.

Regulations + compliance

Navigating the many local, state and federal regulatory agencies involved in compliance and granting permits for resilience-related retrofits can be daunting. Some resilience improvements may call for additional compliance issues—for instance raising residential floors may trigger additional ADA compliance. For most strategies in this manual, you will only need to engage your local building department through your architect or general contractor. Several strategies require no external approvals and can be implemented in-house.

Public agencies.

These agencies are involved in shaping a retrofit decision process.

Federal Agencies Minimum general standards.

	FEMA / NFIP	Makes recommendations on resilience issues and administers the National Flood Insurance Program [NFIP], which uses that advice to determine insurance premiums.
	Department of Housing and Urban Development (HUD)	HUD finances and supports an array of multifamily housing. Funding from HUD may come with particular compliance requirements.

State Agencies Stricter community-level standards.

	State Historic Preservation Offices [SHPO]	Provides recommendations and regulations for buildings in special historic preservation areas.
	Environmental Protection	Responsible for wastewater and stormwater management and enforcement. Regulates excavation and construction in coastal and ecologically sensitive areas. Broadly regulates fuel and chemical storage.

Local Agencies Most specific neighborhood and building-level standards.

	Floodplain Management	Maps flood hazard areas, implements local flood-protection measures and mitigation.
	Buildings	Develops and enforces building occupancy codes and regulations.
	City Planning	Develops and enforces zoning and land-use rules. Regulates and keeps records of buried and above-ground public utilities.
	Fire Department	Develops and enforces fire codes, regulates fuel storage, maintains entrance, exit and evacuation requirements for buildings.

Substantial improvements.

Code regulations and NFIP requirements are generally stricter on new construction and substantially damaged or rehabilitated buildings. If your work qualifies as a substantial rehab, you may need to undertake other improvements to comply with codes and minimize your insurance premiums.

Substantial improvement	=	The cost of the improvement ≥ 50% the market value of the pre-improved building.
Non-substantial improvement	=	The cost of the improvement < 50% the market value of the pre-improved building.

Special permitting zones.

Different guidelines apply to different property types and zoning. If your building is designated historic or is near an ecologically sensitive area, you will have a different set of guidance. An architect can help determine how your zoning designation will affect your retrofit. Your state historic preservation office (SHPO) can provide a list of architects experienced in historic buildings

Image: David Bruce.

When flood insurance is required.

If a property is located within the 100-year floodplain and you have a mortgage from a federally-insured bank, you are required to carry flood insurance. You may purchase insurance through FEMA's NFIP or your insurance broker. FEMA also determines what mitigation measures will reduce your NFIP premium.

> **"NFIP floodplain management regulations provide significant relief to historic structures. Historic structures do not have to meet the floodplain management requirements of the program as long as they maintain their historic structure designation. They do not have to meet the new construction, substantial improvement or substantial damage requirements of the program. This exclusion from these requirements serves as an incentive for property owners to maintain the historic character of the designated structure (44 CFR §60.3)"**
>
> *Floodplain Management Bulletin Historic Structures, FEMA P-467-2↗.*

Regulatory resources.

Floodplain Management Bulletin Historic Structures, FEMA.
www.fema.gov/media-library/assets/documents/13411

National Trust for Historic Preservation Treatment of Flood-Damaged Older and Historic Buildings .
www.preservationnation.org/resources/disaster-recovery/additional-resources/flood-recovery-resources/flood-book/Flood-Damage.pdf

Floodplain Management Regulations and Building Codes and Standards, FEMA.
www.fema.gov/media-library-data/20130726-1459-20490-1112/fema489_chap2.pdf

Funding a resilience project

Due to shifts in budget priorities at the federal, state and local levels, funding availability varies from place to place and year to year. These agencies may offer funding for resilience projects.

Federal.

» FEMA offers federal funding for pre- and post-disaster planning and retrofits through a variety of grant programs.

› **Hazardous Mitigation Grant Program (HMGP)↗** provides funding for events after a disaster declaration is made.

- › **Pre-Disaster Mitigation (PDM)** ↗ provides general funding for resilience efforts.
- › **Flood Mitigation Assistance (FMA)** ↗ offers funding for flood resilience projects insured under NFIP.

» Department of Housing and Urban Development (HUD) offers grant opportunities for affordable housing development and preservation.

- › **Community Development Block Grants – Disaster Recovery (CDBG-DR)** ↗ provide funding for recovery from Presidential-declared emergencies

» The Environmental Protection Agency (EPA) funds projects that improve water infrastructure and the nation's watersheds.

» The National Oceanic and Atmospheric Administration (NOAA) offers funding to make coastal communities more resilient to climate change and rising sea levels.

- › **The Sea Grant Program** ↗ provides integrated research, communication, education, extension and legal programs to coastal communities.

State and local.

» State offices administer the **Weatherization Assistance Program (WAP)** ↗, which provides funding for energy efficiency and envelope upgrades in low-income housing.

» State environmental protection agencies may fund more targeted stormwater management-related projects than those receiving federal funding from the EPA.

» Funding for energy-efficiency upgrades may be offered through local energy-efficiency agencies. In New York, the New York State Energy Research and Development Authority (NYSERDA) provides support through its **Multifamily Performance Program (MPP)** ↗.

» Local government offices may offer funding to further environmental goals including clean air, clean water and carbon reductions, especially in urban areas.

Non-Governmental and private organizations.

» Non-profits and philanthropic organizations may offer implementation and technical support for retrofit projects.

» Utility companies may offer rebates or trade-in programs for more efficient fixtures and appliances that reduce energy demand.

Funding resources.

US Climate Resilience Toolkit, Funding Opportunities.
toolkit.climate.gov/content/funding-opportunities

Appendix

Enterprise Green Communities Criteria certification

The Enterprise Green Communities Criteria is a national green building standard for affordable housing. The 2015 Criteria included several new mandatory and optional criteria, in an effort to align the green building and resiliency-planning movements. Here is a selection of 2015 resilience-focused criteria that directly relate to strategies in this manual.

Enterprise Green Communities Design for Resilience-Focused Measures.	Ready to Respond: Strategies for Multifamily Building Resilience.
1.3b Resilient Communities: Multi-Hazard Risk / Vulnerability Assessment. Carry out a Vulnerabilities Assessment and implement building elements designed to enable the project to adapt to, and mitigate, climate impacts given the project location, building /construction type and resident population.	Getting Started: Climate Hazards Assessment 18 Developing an Emergency Management Manual
2.10 Passive Solar Heating/Cooling. Design and build with passive solar design, orientation and shading that meet specified guidelines. [5 points max]	11 Window Shading
3.6 Surface Stormwater Management. Retain, infiltrate and /or harvest the first 1.0 inch of rain that falls [4 points] OR as calculated for a 24-hour period of a one-year storm event, so that no stormwater is discharged to drains / inlets. [8 points] For both options, permanently label all storm drains and inlets.	7 Envelope Efficiency 10 Surface Stormwater Management

4.2 Advanced Water Conservation. Reduce water consumption either by installing water-conserving fixtures in all units and all common space bathrooms with the following specifications: Toilets: WaterSense-labeled and 1.1 gpf [1 point]; Showerheads: WaterSense-labeled and 1.5 gpm [1 point]; kitchen faucets: 1.5 gpm and lav faucets: WaterSense-labeled and 1.0 gpm [1 point] OR Reduce total indoor water consumption by at least 30% compared to the baseline indoor water consumption chart, through a combination of your choosing. [6 points maximum]	15 Access to Potable Water
4.5 Water Reuse. Harvest, treat, and reuse rainwater and/or greywater to meet a portion of the project's total water needs: 10% reuse [3 points]; 20% reuse [4 points]; 30% reuse [5 points]; 40% reuse [6 points]	15 Access to Potable Water
4.6 Access to Potable Water During Emergencies. Provide residents with access to potable water in the event of an emergency that disrupts normal access to potable water, including disruptions related to power outages that prevent pumping water to upper floors of multifamily buildings or pumping of water from on-site wells. [8 points]	15 Access to Potable Water
5.2a Additional Reductions in Energy Use. Design and construct a building that is projected to be at least 5% more efficient than what is required of the project by Criteria 5.1a–d. [5-12 points]	7 Envelope Efficiency

5.2b Advanced Certification: Nearing Net Zero. Certify the project in a program that requires advanced levels of building envelope performance such as PHIUS, Living Building Challenge and/or DOE Zero Energy Ready Home. [12 points]	7 Envelope Efficiency
5.8a Resilient Energy Systems: Floodproofing. Conduct floodproofing, including perimeter floodproofing (barriers /shields), of lower floors. Design and install building systems as specified by the full criterion so that the operation of those systems will not be grossly affected in case of a flood.	1 Wet Floodproofing 2 Dry Floodproofing 3 Site Perimeter Floodproofing 4 Resilient Elevators 5 Backwater Valves 6 Sump Pumps 8 Elevated Equipment 12 Distributed Heating and Cooling
5.8b Resilient Energy Systems: Islandable Power. Provide emergency power through an islandable photovoltaic (PV) system or an efficient and permanent generator that will offer at least limited electricity for critical circuits during power outages per one of the three options listed.	13 Maintaining Backup Power to Critical Systems

Chester Garden Project at
Ruth L. Bennett Homes, Chester, PA.
Image: Blaine O'Neill.

Other resilience resources

ARUP Resilience Framework.
www.arup.com/cri

A Stronger, More Resilient New York, The City of New York, 2013.
www.nyc.gov/html/sirr/html/report/report.shtml

Climate Risk Information 2013: Observations, Climate Change Projections and Maps, New York City Panel on Climate Change, June 2013.
www.nyc.gov/html/planyc2030/downloads/pdf/npcc_climate_risk_information_2013_report.pdf

NFIP Flood Insurance Manual
www.fema.gov/flood-insurance-manual

Designing for Flood Risk, NYC Department of Planning Coastal Climate Resilience.
www.nyc.gov/html/dcp/pdf/sustainable_communities/designing_flood_risk.pdf

Resilient Cities Initiative, The Rockefeller Foundation.
www.100resilientcities.org/#/-_/

Returns on Resilience: The Business Case, Urban Land Institute.
uli.org/wp-content/uploads/ULI-Documents/Returns-on-Resilience-The-Business-Case.pdf

The Cost of Resilience – Can Multifamily Housing Afford to Adapt? NYU Furman Center, July 2014.
furmancenter.org/files/NYUFurmanCenter_ThePriceofResilience_July2014.pdf

The Insurance Institute for Business & Home Safety (IBHS).
disastersafety.org/ibhs-risk-flood/

Guide for Assessing Climate Change Risk, Urban Land Institute.
uli.org/wp-content/uploads/ULI-Documents/ULI-A-Guide-for-Assessesing-Climate-Change-Risk-final.pdf

What the Real Estate Industry Needs to Know about the Insurance Industry and Climate Change, Urban Land institute.
uli.org/wp-content/uploads/ULI-Documents/Insurance-White-Paper-FINAL.pdf

US Climate Resilience Toolkit.
toolkit.climate.gov/

FEMA materials.

Construction manuals

Above the Flood: Elevating your Floodprone House.
www.fema.gov/es/media-library/assets/documents/725

Coastal Construction Manual.
www.fema.gov/es/media-library/assets/documents/3293

Engineering Principles and Practices of Retrofitting Floodprone Residential Structures.
www.fema.gov/es/media-library/assets/documents/3001

FEMA National Flood Insurance Program Portal.
www.floodsmart.gov/floodsmart/

Floodproofing Non-Residential Buildings.
www.fema.gov/media-library/assets/documents/34270

Homeowner's Guide to Retrofitting.
www.fema.gov/media-library/assets/documents/480

Protecting your Home and Property from Flood Damage.
www.fema.gov/es/media-library/assets/documents/21471

Safe Rooms for Tornadoes and Hurricanes.
www.fema.gov/media-library/assets/documents/3140

Taking Shelter from the Storm.
www.fema.gov/media-library/assets/documents/2009

Technical bulletins

Below-Grade Parking Requirements.
www.fema.gov/media-library/assets/documents/3498

Corrosion Protection of Metal Connectors in Coastal Areas.
www.fema.gov/media-library/assets/documents/3509

Crawlspace Construction.
www.fema.gov/es/media-library/assets/documents/3527

Design and Construction Guidance for Breakaway Walls.
www.fema.gov/es/media-library/assets/documents/3514

Elevator Installation.
www.fema.gov/media-library/assets/documents/3478

Ensuring that Structures Built on Fill In or Near Special Flood Hazard Areas are Reasonably Safe from Flooding.
www.fema.gov/media-library/assets/documents/3522

Flood Damage – Resistant Materials Requirements.
www.fema.gov/media-library/assets/documents/2655

Free-of-Obstruction Requirements.
www.fema.gov/media-library/assets/documents/3490

New Residential Floodproofing – Requirements and Certification.
www.fema.gov/media-library/assets/documents/3473

Openings in Foundation Walls and Walls of Enclosures.
www.fema.gov/es/media-library/assets/documents/2644

Protecting Building Utilities from Flood Damage.
www.fema.gov/media-library/assets/documents/3729

Wet Floodproofing Requirements.
www.fema.gov/media-library/assets/documents/3503

EnterpriseCommunity.org

Disaster Preparedness for Affordable Housing Organizations

Enterprise green communities®