

Appendix



Resiliency Best Practice Cost Estimation

The following tables describe estimated costs of a range of resiliency strategies described in the industrial business case studies in Chapter 4. These were developed by a professional cost estimation consultant with experience working in New York City on a range of resiliency projects.

For many resiliency strategies described below, costs may vary substantially from one site to the next, based on flood vulnerability, specific characteristics of the site and building, and the level of work that may be conducted in-house, among other factors. For this reason, the tables below are intended to be used by businesses to gain a general understanding of strategies or a suite of strategies that may be cost-effective based on their vulnerability. Businesses should work with certified contractors and vendors to obtain site-specific estimates. Where applicable, key sensitivity factors that influence the actual cost for each intervention are listed briefly beside each table.

Shoreline Stabilization

Average construction costs for a range of shoreline stabilization projects ranging from sheet pile bulkheads to revetments.

Technique	Cost per linear foot
Bulkhead with landside access for construction	\$2,000
Bulkhead with waterside access for construction	\$2,500
Rip Rap revetment	\$500
Concrete platform over rip rap	\$1,400

Key sensitivity factors:

- Mobilization cost are similar for large and small projects
- Depth of sheet piling influences cost substantially
- Depth of water impacts viability of water access
- Platform materials (e.g., wood or concrete) will impact initial capital cost and life cycle cost
- Use of rip rap can result in lost usable space on the property

Elevated Structural Mezzanine Within Existing Building

Construct an elevated steel platform with open riser steel stairs for protected storage or to locate mechanical equipment.

Elevation	Total cost (500 sf)	Cost per square foot
4'	\$94,000	\$188
6'	\$112,000	\$224
8'	\$129,000	\$258

Key sensitivity factors:

- Height within existing building will determine highest elevation achievable
- Weight and size of stored materials will impact size and cost of steel frame

Elevated Office Space Within Existing Building

Construct an elevated and enclosed office area within an existing structure, including finishes, HVAC, light and power, etc.

Elevation	Total cost (500 sf)	Cost per square foot
4'	\$197,000	\$394
6'	\$214,000	\$428
8'	\$232,000	\$464

Key sensitivity factors:

- Footprint area of office will impact cost per square foot
- Finishes and facility choices will impact cost
- Height within existing building will determine highest elevation achievable

Rooftop Addition on Existing Building

Build a small second floor addition to an existing industrial building for protected storage, office, or to house mechanical equipment.

Construction Type	Total cost (500 sf)	Cost per square foot
Build small rooftop addition	\$214,000	\$428
Install modular building on roof	\$206,000	\$412

- Key sensitivity factors:**
- Bearing capacity of existing roof structure will need to be evaluated prior to introducing more weight to the roof

Accessible Lifts

Install handicap lift to improve access to elevated storage or office spaces.

Elevation	Total cost	Cost per linear foot in elevation
4'	\$40,000	\$10,000
6'	\$56,000	\$9,300
8'	\$72,000	\$9,000

Elevate Mechanical or Electrical Equipment

Construct 200 square foot steel-framed platform with open steel grate and perimeter rails.

Elevation	Cost per square foot
4'	\$277
6'	\$304
8'	\$330

- Key sensitivity factors:**
- Weight and size of equipment will impact size and cost of steel frame
 - Height within existing building will determine highest elevation achievable

Internal Waterproof Room

Build a waterproof room on 12" concrete platform to house critical equipment or store valuable items during a storm event.

Room size (square feet)	Total cost	Cost per square foot
200	\$73,000	\$365
400	\$129,000	\$323

Flood Damage-Resistant Materials

Install flood damage-resistant finishes within existing industrial facilities

Finishes	Cost per square foot
Flooring	
Epoxy Painted Flooring	\$5
Sheet Vinyl Flooring	\$8
"Dexotex" Built-up Epoxy Flooring	\$13
Tile Flooring	\$19
Walls	
Mold Resistant Wall Board	\$30
Cement Board	\$35
Water Resistant Wainscott on Existing Wall	\$40

Flood Vents

Install flood vents as a component of wet floodproofing

Number of vents	Total cost	Cost per flood vent
10	\$17,500	\$1,750
25	\$44,000	\$1,760

Dry Floodproofing

Construct reinforced concrete flood walls around exterior walls of buildings

Elevation	Cost per square foot
2'	\$37
4'	\$43
6'	\$52
8'	\$59

Flood Doors

Replace existing building openings with flood door or flood panels

Technique	Each
3' x 7' floodproof "submarine" doors and frames	\$26,000
Install flood panels at door openings	\$15,000
Install flood panels at roll-up gate opening	\$21,000

Key sensitivity factors:

- Depth of potential flood waters and expected hydrostatic pressure will impact the design of walls
- Costs for flood panels vary depending on the size of the opening and anticipated depth of flood waters

Sump Pump

Install 3' sump pit and pump, including power and discharge piping to remove moderate amounts of seepage or floodwaters

Distance to Discharge Spot	Total Cost
20 ft.	\$24,500
50 ft.	\$26,200
100 ft.	\$28,900

Key sensitivity factors:

- Sump pumps will only be effective in conjunction with other measures such as perimeter walls and flood barriers
- Size of area to be evacuated of floodwaters will impact size and cost of pump

Backflow Preventer

Install stormwater backflow preventer on sewer or stormwater line of existing building to prevent back-up from exterior.

Cost Per Backflow Preventer	\$15,800
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Elevate Electrical Generator

Construct a platform to raise electrical generators above the DFE. Estimate does not include generator cost.

Build concrete platform to elevate a 100 KW Generator (assumes 4' x 6' platform):

Elevation	Total Cost	Cost per sf to Raise 100 KW Generator
2'	\$35,400	\$1,475
4'	\$41,800	\$1,742
6'	\$50,000	\$2,083

Build elevated steel platform to house a 500 KW Generator (assumes 10' x 6' platform and 10,000 lb generator):

Elevation	Total Cost to Raise 500 KW Generator	Cost per sf to Raise 500 KW Generator
2'	\$65,200	\$1,090
4'	\$76,200	\$1,270
6'	\$87,600	\$1,460
8'	\$108,100	\$1,800

Hazardous Material Spill Prevention

Install storage cabinet or cage to contain hazardous materials

Technique	Total Cost	Cost Per Square Foot
Prefabricated 6' x 3' x 2' Storage Unit (Acid Cabinet)	\$8,500	\$472
Wire Mesh Cabinets with Shelves: 6' x 3' x 2'	\$7,300	\$406
Raised Pallets with Tie-Down Straps: 6' x 3'	\$4,300	\$239

Glossary

Base Flood Elevation (BFE)

The computed elevation in feet to which floodwater is anticipated to rise during the 1% annual chance storm shown on the FIRMs issued by the Federal Emergency Management Agency (FEMA). A building's flood insurance premium is determined by the relationship between the BFE and the level of the lowest floor of a structure.

1% Annual Chance Floodplain (100 Year Floodplain)

The area that has a 1% chance of flooding in any given year. It is indicated on FEMA's Flood Insurance Rate Maps (FIRMs). See "Special Flood Hazard Areas," below.

Design Flood Elevation (DFE)

As defined by the NYC Building Code, the DFE is the minimum elevation to which a structure must be elevated or floodproofed. It is the sum of the BFE and a specified amount of freeboard (see definition below) based on the building's structural category.

Flood Insurance Rate Maps (FIRMs)

The official flood map, on which FEMA has delineated the Special Flood Hazard Area (SFHA), 0.2% annual floodplain (Shaded X zone), BFEs and floodways.

Floodproofing, Dry

For nonresidential buildings, a flood resilient construction or retrofitting technique that results in the building resisting penetration of floodwater up to the DFE, with walls substantially impermeable to the passage of water and structural components having the capacity to resist specified loads.

Floodproofing, Wet

A flood resilient construction or retrofitting technique designed to permit parts of the structure below the DFE to intentionally flood, by equalizing hydrostatic pressures and by relying on the use of flood damage-resistant materials. With this technique, parts of the building below the DFE are only to be used for parking, storage, building access or crawl space.

Freeboard

An additional amount of height above the BFE to provide a factor of safety to address the modeling and mapping uncertainties associated with FIRMs, as well as a degree of anticipated future sea level rise. It is a risk reduction requirement found in Appendix G of the NYC Building Code and recognized by NFIP as an insurance premium reduction factor. In New York City, one to three feet of freeboard is required for commercial buildings, depending on the structural occupancy of the building and the flood zone.

National Flood Insurance Program (NFIP)

Federal program that makes flood insurance available to municipalities that enact and enforce floodplain management regulations that meet or exceed the criteria established by FEMA. Under this program, properties within the SFHA with a federally backed or regulated mortgage are required to buy flood insurance. Communities participating in the NFIP must incorporate flood-resistant construction standards into building codes.

Special Flood Hazard Areas (SFHA)

Area of the floodplain that has a 1% chance, or greater, of flooding in any given year. Also referred to as the 100-year floodplain or the 1% annual chance floodplain. The SFHA is separated into zones depending on the level of hazard:

V Zone

The area of the SFHA subject to high-velocity wave action that can exceed three feet in height. More restrictive NYC Building Code standards apply.

Coastal A Zone

A sub-area of the A Zone that is subject to moderate wave action between 1.5 and three feet in height. Current building regulations are the same in A Zones and Coastal A Zones in NYC.

A Zone

The area of the SFHA that is subject to still-water inundation by the base flood with specific NYC Building Code standards.

Substantial Damage

Damage sustained by a building whereby the cost of restoring the structure to its pre-damaged condition would equal or exceed 50 percent of the market value before the damage occurred. When a building is substantially damaged or substantially improved (see below), it is required to comply with Appendix G of the NYC Building Code as if it were a post-FIRM structure.

Substantial Improvement

Any repair, reconstruction, rehabilitation, addition or improvement of a building with cost equaling or exceeding 50 percent of the current market value of the building. When a building is substantially improved, it is required to comply with the flood-resistant construction requirements of Appendix G of the NYC Building Code.

Wave Action

A condition in which wave heights or wave runup depths can result in velocity flooding, leading to greater damage to structures than equivalent flood depths without velocity flooding.

Endnotes

- 1 New York City Department of City Planning, "Employment in New York City's Manufacturing Districts: Employment trends in M districts outside Manhattan: 2000-2014," 2016.
- 2 Federal Emergency Management Agency, "Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program," Technical Bulletin 2, 2008.
- 3 New York City Office of the Mayor, "A Stronger, More Resilient New York," developed for the Special Initiative for Rebuilding and Resiliency. 2013.
- 4 New York City Department of City Planning, "Draft Open Industrial Uses Study," 2014.
- 5 New York City Panel on Climate Change, "Climate Change Adaptation in New York City: Building a Risk Management Response," 2010.
- 6 New York City Panel on Climate Change, "Climate Change Adaptation in New York City: Building a Risk Management Response," 2010.
- 7 New York State, Department of Labor, Quarterly Census of Employment and Wages. 2010, 2016.
- 8 New York State, Department of Labor, Quarterly Census of Employment and Wages. 2015.
- 9 Hazardous Materials Management in New York City: 2016 Annual Report. NYC Department of Environmental Protection. http://www.nyc.gov/html/dep/pdf/derta/dep_hazmat_annual_report_2016.pdf
- 10 New York City Community Right-to-Know: Recommendations for Chemical Safety and Spill Prevention during Flooding Events. NYC Department of Environmental Protection. http://www.nyc.gov/html/dep/pdf/tier2/flood_safety.pdf
- 11 Pisano, Steven. NYC Street Scenes - Brooklyn. <https://tinyurl.com/y9az9zh6>
- 12 New York City Department of City Planning, "Employment in New York City's Manufacturing Districts: Employment trends in M districts outside Manhattan: 2000-2014," 2016.
- 13 New York City Department of City Planning, "Employment in New York City's Manufacturing Districts: Employment trends in M districts outside Manhattan: 2000-2014," 2016.
- 14 New York City Economic Development Corporation, "Five Borough Food Flow: New York City Food Distribution and Resiliency Study Results." 2016.
- 15 Yoon, Sunghwan. 2013. <http://www.flickr.com/photos/jacopast/9993381765/in/album-72157635999594303/>
- 16 Yoon, Sunghwan. 2013. <https://tinyurl.com/y9g3fx2a>

Informational Resources

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OneNYC

nyc.gov/onenyc

Mayor's Office of Recovery and Resiliency

www.nyc.gov/resiliency

New York City Emergency Management

<https://www1.nyc.gov/site/em/about/overview.page>

New York City Panel on Climate Change

onlinelibrary.wiley.com/doi/10.1111/nyas.2015.1336.issue-1/issuetoc

Technical Guidance

Federal Emergency Management Agency

Floodproofing for Non-Residential Buildings
/ July 2013

fema.gov/media-library/assets/documents/34270

Technical Bulletin 3, Non-Residential
Floodproofing - Requirements and
Certification (1993)

fema.gov/media-library/assets/documents/3473

Technical Bulletin 2, Flood Damage-
Resistant Materials Requirements (2008)

fema.gov/zh-hans/media-library/assets/documents/2655

Flood Insurance Manual, Effective
November 1, 2015

fema.gov/media-library/assets/documents/110085

New York City Department of Buildings

Building Code Appendix G Flood-Resistant
Construction

nyc.gov/html/dob/html/codes_and_reference_materials/reference.shtml

New York City Department of City Planning

Retrofitting Buildings for Flood Risk

<https://www1.nyc.gov/site/planning/plans/retrofitting-buildings/retrofitting-buildings.page>

Designing for Flood Risk

nyc.gov/designingforfloodrisk

Urban Waterfront Adaptive Strategies

nyc.gov/uwas

Resilient Retail

nyc.gov/resilientretail

Acknowledgments

New York City Department of City Planning

Marisa Lago, Director
Purnima Kapur, Executive Director

Resilient Industry Program Team

Dylan Sandler, Project Manager
Jennifer Gravel, Director of Housing,
Economic, and Infrastructure Planning
Michael Marrella, Director of Waterfront
and Open Space Planning
Charles Dillard, City Planner
Allan Zaretsky, City Planner
Ryan Jacobson, Urban Designer
Amritha Mahesh, Urban Designer
Thaddeus Pawlowski, Senior Urban
Designer
Johane Clermont, City Planner
Manuela Powidayko, City Planner
Nilus Klingel, City Planner

Advisors and Contributors

Danielle DeCerro
Barry Dinerstein
Christopher Holme
Trevor Johnson
Mary Kimball
Eric Kober
Beth Lebowitz
Christopher Lee
Nicholas Moore
Howard Slatkin
Laura Smith
Tony Widjarnarso

Consultant Teams

Nasco Construction Services, Inc.
Pure+Applied

External Contributors

Mayor's Office of Recovery & Resiliency
(ORR)
Department of Buildings (DOB)
Department of Small Business Services
(SBS)
NYC Emergency Management (NYCEM)
NYC Department of Environmental
Protection (DEP)
NYC Department of Sanitation (DSNY)
NYC Economic Development Corporation
(EDC)
NYC Department of Small Business
Services (SBS)
NYS Department of Environmental
Conservation (DEC)
Port Authority of New York and New Jersey
United States Coast Guard
Maritime Association
Sandy Hook Pilots
United Metro Energy
NYC Environmental Justice Alliance
Waterfront Alliance
Hudson Riverkeeper
New York University, International Center
for Enterprise Preparedness
College of Staten Island
Brooklyn Navy Yard
Staten Island Economic Development
Corporation
SoBRO
Evergreen
Southwest Brooklyn Industrial
Development Corporation
Long Island City Partnership
THE POINT CDC
El Puente
UPROSE
HR&A
Assured Partners NL
OptiRTC
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Key Data Sources

National Flood Insurance Program,
Preliminary Flood Insurance Rate Maps
(2015)
Federal Emergency Management Agency,
NFIP Hurricane Sandy Claims Data
NYS Department of Labor, Quarterly
Census of Employment and Wages
Primary Land Use Tax Lot Outputs
(PLUTO)
NYC Panel on Climate Change

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