U.S. GREEN BUILDING COUNCIL

G325

Climate Resilience Strategies for Buildings in New York State: Part 1

USGBCNYU_CRSB1

Nicholas B. Rajkovich

April 25, 2019

Learning Objectives

At the end of the this course, participants will be able to:

1. Understand the role of windows, wind protection, emergency management, and redundant building systems when developing climate resilience strategies during project planning and design in New York State.
2. Explain climate resilience strategy implementation beyond the physical application of a material, technique, or technology; including planning, occupant health, safety and welfare, costing, and the development of standards, operations, and maintenance.
3. Utilize the information in this course as a tool to assist in the implementation of the covered climate resilience strategies during project planning and design.
4. Understand that all those involved with the building sector, including owners and operators, policy makers, planners, architects, and engineers should play a role in the implementation of climate resilience.


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U.S. GREEN BUILDING COUNCIL
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Nicholas B. Rajkovich, Elizabeth K. Gilman, Hope Forgus, and Thomas J. Mulligan

Research

Our Approach

Centers and Labs

Initiatives

The UB Affordable Housing Initiative

Adapting Buildings for a Changing Climate

See It Through Buffalo

University Heights Initiative

Insights

Related Links

Graduate Research in Architecture

Graduate Research in Urban Planning

Adapting Buildings for a Changing Climate

ap.buffalo.edu/adapting-buildings

Climate Resilience Strategies for Buildings in New York State

Final Report | Report Number 18-11 | June 2018

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

University at Buffalo School of Architecture and Planning

ap.buffalo.edu/adapting-buildings

Building Flood Protection

PROTECTING BUILDINGS DURING FLOOD EVENTS

LOCATION

LOW MEDIUM HIGH

HAZARDS

FLOODING

RISING SEA LEVELS

HURRICANES / TROPICAL STORMS

RELATED STRATEGIES

Neighborhood Flood Protection
Building Systems Flood Protection
Building Foundations
Roof Drainage
Building Operations
Potable Water Systems

Tropical Storm Lee

In 2011, New York State was struck by two major storm events within a week.

In the last week of August, Hurricane Irene made landfall in New York State, affecting ClimAID Regions 2, 3, 4, and 5. Then on September 2, the remnants of Tropical Storm Lee dropped nearly a foot of rain in the Southern Tier (ClimAID Region 3). The storms were the second-largest natural disaster in the history of the State,[12] with FEMA awarding more than $1.5 billion in public assistance and over 33,000 residents registering for individual assistance. Since 1955, NYS experienced 42 flood-related Presidential Disaster Declarations.

DESCRIPTION

Responding to Climate Change in New York State states that New York will experience changing patterns of precipitation,[1] increasing the risk of flooding events statewide. To respond to this growing concern, it is critical to break the damage-rebuild-damage cycle[2] and approach building flood resilience with preemptive measures. With the State facing an increased likelihood of inundation, high-velocity flows, erosion, and damage from floating debris, tactics such as flood resistant building materials[3] and flood barriers can help to improve resilience.

The USGS explains the effects urbanization has on flooding,[4] including changes of land use, the removal of vegetation, and increased runoff from man-made drainage networks and how they can increase the chances of flood events in urban areas. According to the Centers for Disease Control and Prevention, flood waters can instigate issues with electrical services and mold,[5] which can be devastating, especially in urban areas. Understanding these impacts will help drive improvements to building flood protection in all regions of New York State.

OWNERS AND OPERATORS

There are multiple FEMA documents that owners and operators can use to improve building flood protection. For example, the Homeowner's Guide to Retrofitting[6] explains how homeowners can implement building flood protection tactics, including elevating the home, installing flood barriers, and wet flood proofing. Additional information can be found in FEMA's guide to Reducing Flood Risk to Residential Buildings That Cannot Be Elevated.[7]

In 2012, Superstorm Sandy proved that flood zone delineations do not always show the true extent of areas exposed to flooding. As a result, the Superstorm Sandy Recovery Advisories from FEMA explain the need to prepare for floods above the base flood elevation[8] to reduce damage during flooding events. Owners and operators can use this document, as well as the Home Builder's Guide to Coastal Construction, for guidance on improving the performance of residential buildings[9] during coastal flooding events. Chapters 14 and 15[10] in Volume II of FEMA's Coastal Construction Manual provide information on maintaining and retrofitting buildings for flood protection based on damage analysis of previous storms. FEMA recommends all owners and occupants should prepare for flooding hazards by purchasing flood insurance.[11]

Hospital Flood Protection

Dry flood mitigation measures keep critical facilities operational during major storm events.

Our Lady of Lourdes Hospital[23] suffered over $20 million in losses when the Susquehanna River flooded in the summer of 2006. With funding from FEMA, the hospital constructed a flood wall around the hospital. In September 2011 following Tropical Storm Lee, the flood wall was tested when the Susquehanna River flooded once again and devastated many parts of Binghamton, NY. The hospital was able to remain fully operational. The flood wall cost approximately $7 million and was built over a period of five years.

POLICYMAKERS AND PLANNERS

Policy makers and planners can learn from previous events what type of damage flood events can cause. After Superstorm Sandy, the NYC Building Resiliency Task Force[13] recommended new legislation and amendments to the New York City Building Codes that can help limit the spread of damage when the next major event occurs. Communities taking part in the National Flood Insurance Program's Community Rating System[14] can assess risks and improve flood hazard preparedness by understanding and making improvements to the things that make their buildings vulnerable.

According to the DEC,[2] flood recovery efforts should include the implementation of resilience strategies that reduce the likelihood of damage caused by future events. The EPA and FEMA released a document entitled Planning for Flood Recovery and Long-Term Resilience in Vermont[15] to discuss policy and planning suggestions for flood disaster resilience. This document could be useful for neighboring areas in New York State, including those in ClimAID Regions 5 and 7. FEMA also completed a Mitigation Assessment Team Report after Superstorm Sandy[16] that documents building failures and suggests how flood-prone areas can adapt and overcome. The failures identified in this document can help policy makers and planners understand what to do and what not do when rebuilding damaged buildings.

ARCHITECTS AND ENGINEERS

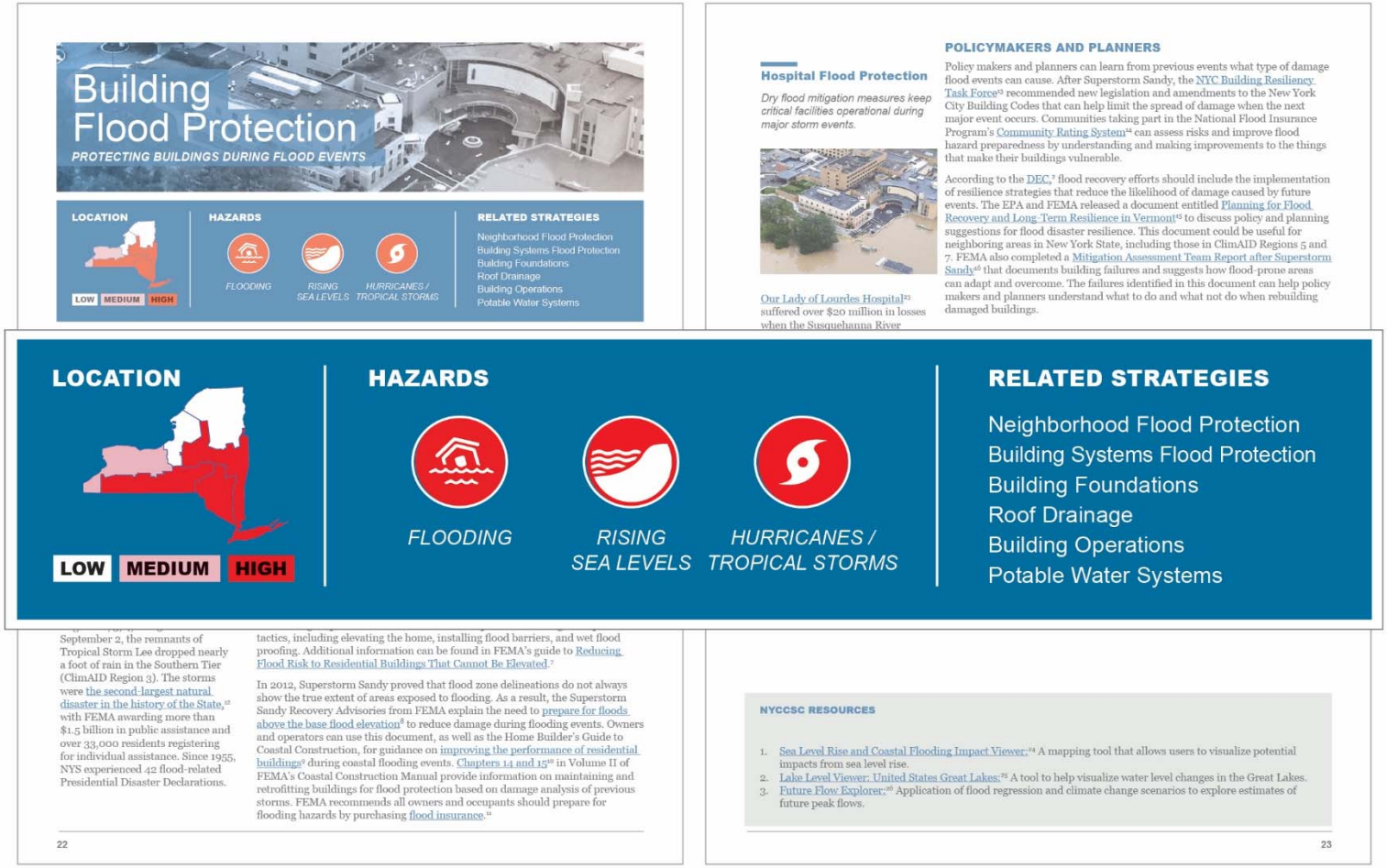
After Superstorm Sandy, changes were made to the New York City Building Code, specifically under Appendix G Flood-Resistant Construction.[17] These changes modified standards dealing with backflow prevention, healthcare facilities, survey data and flood maps, cabling and fuel oil storage, and flood barriers in order to ensure safety, resilience, and limited damage during future flooding events. To help guide the design of flood resilient buildings, FEMA released the Floodproofing Non-Residential Buildings[18] document as a comprehensive guide to flood proofing existing buildings. Designers should be aware of the differences between the requirements in the National Flood Insurance Program and the current New York State Building Code, which references the American Society of Civil Engineers' 24-14 Flood Resistant Design and Construction.[19]

FEMA's Technical Bulletin 2[20] for buildings located in special flood hazard areas provides information on flood resistant materials that correspond with NFIP requirements. Other technical bulletins from FEMA provide information on other strategies,[21] including wet flood proofing, below-grade parking, breakaway walls, and metal connector details. The New York City Planning Department Retrofitting Buildings for Flood Risks[22] guide contains a comprehensive analysis of retrofit options based on building type and use for buildings in the New York City flood plain. Strategies from this document can be used in other flood-prone areas within New York State.

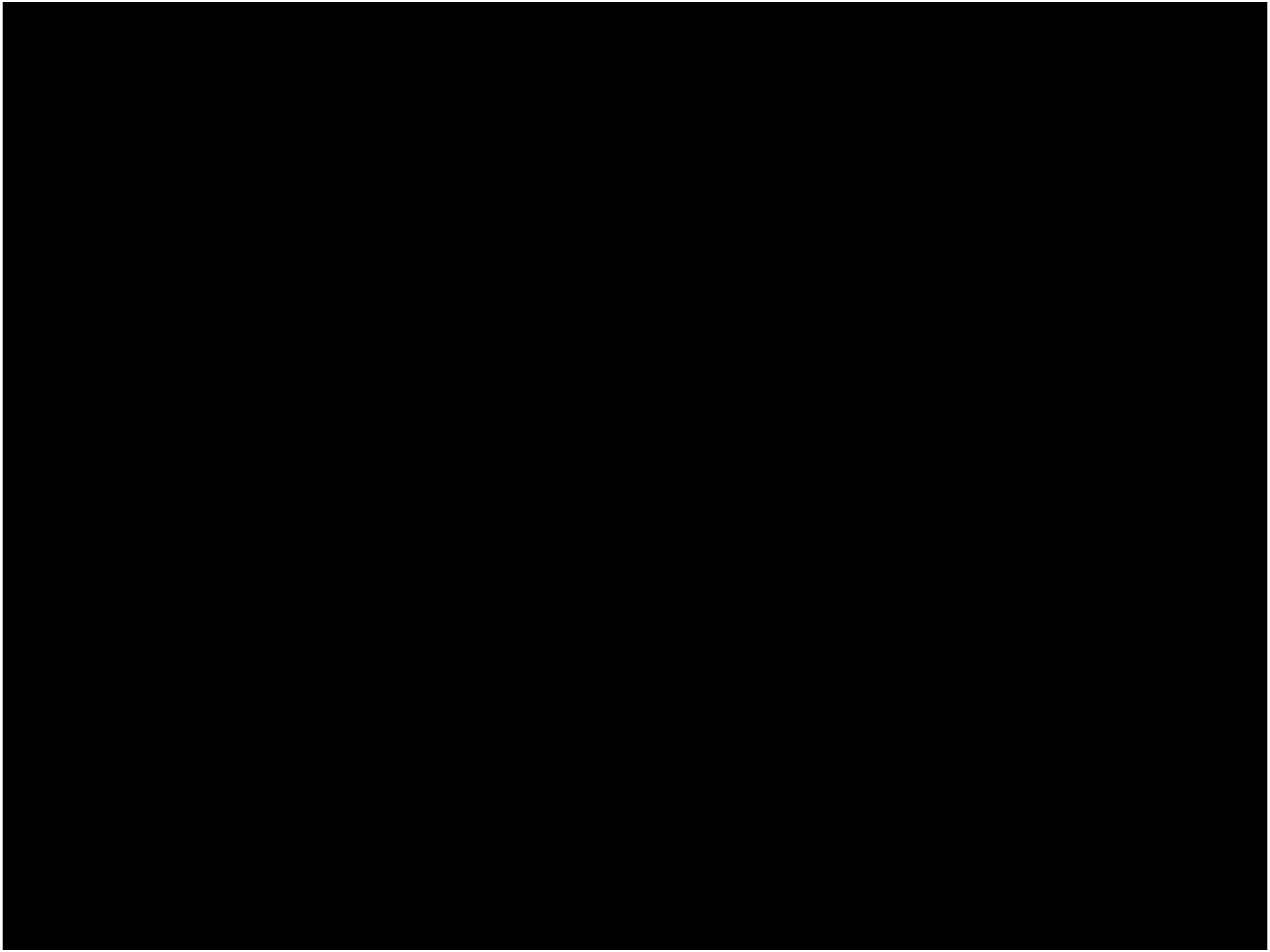
NYCCSC RESOURCES

1. Sea Level Rise and Coastal Flooding Impact Viewer:[24] A mapping tool that allows users to visualize potential impacts from sea level rise.
2. Lake Level Viewer: United States Great Lakes:[25] A tool to help visualize water level changes in the Great Lakes.
3. Future Flow Explorer:[26] Application of flood regression and climate change scenarios to explore estimates of future peak flows.

Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.



Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.



Windows

IMPROVING SAFETY AND THERMAL PERFORMANCE

LOCATION

LOW MEDIUM HIGH

HAZARDS

HURRICANES / TROPICAL STORMS

SEVERE STORMS

HEAT WAVES

RELATED STRATEGIES

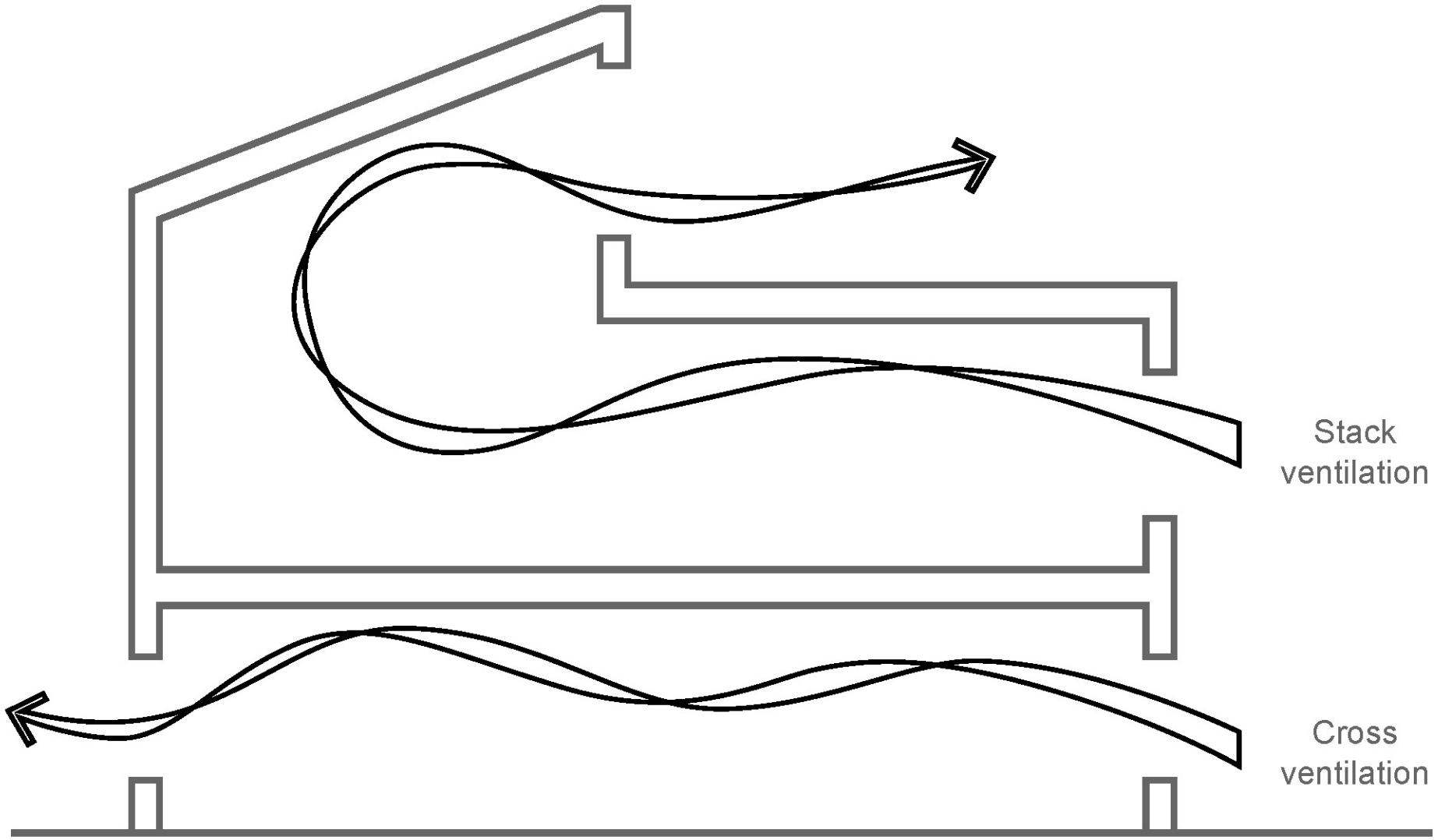
Wind Protection
Building Fire Protection
Insulation
Building Ventilation
Indoor Air Quality
Passive Building Systems

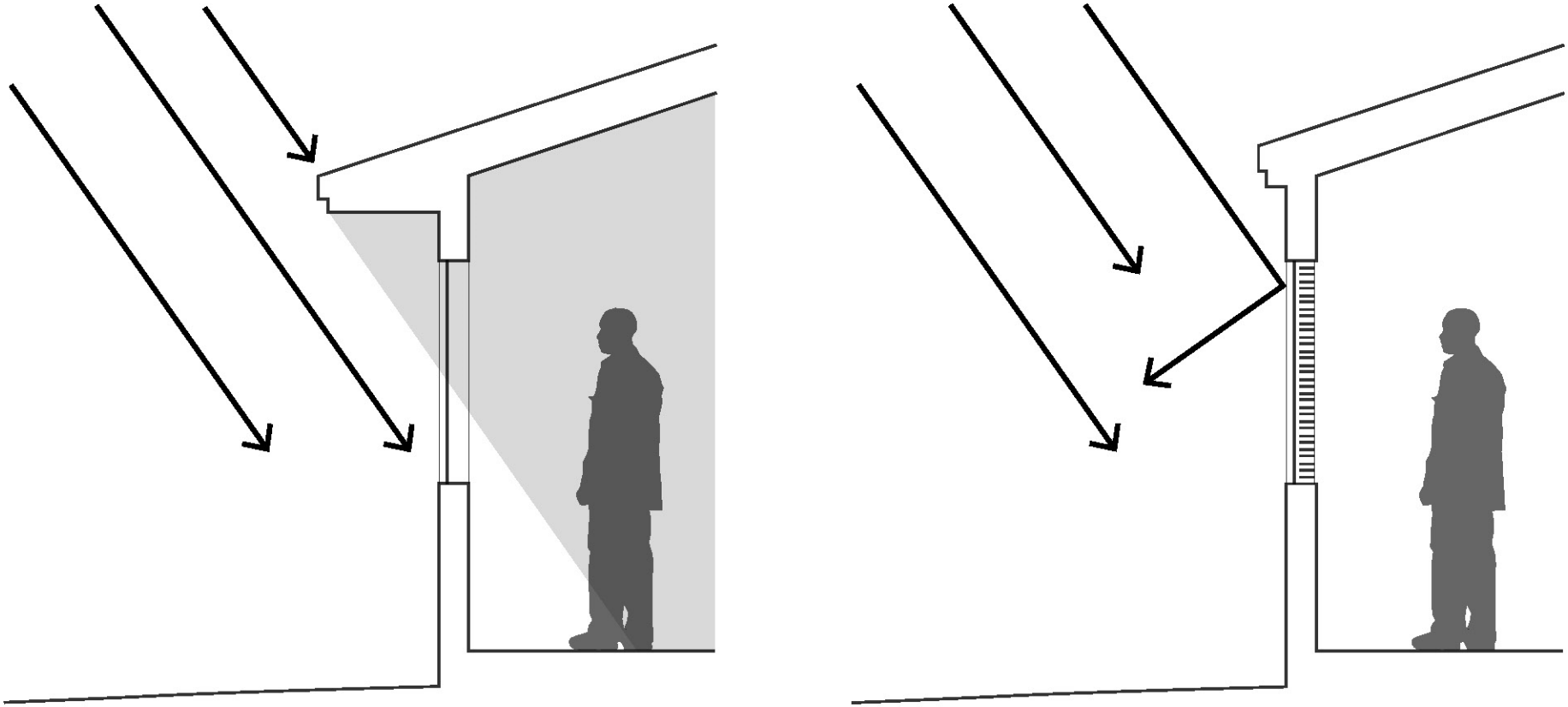
New York Times Building

DESCRIPTION

According to Responding to Climate Change in New York State, rising temperatures[1] increase the likelihood and severity of climate hazards including

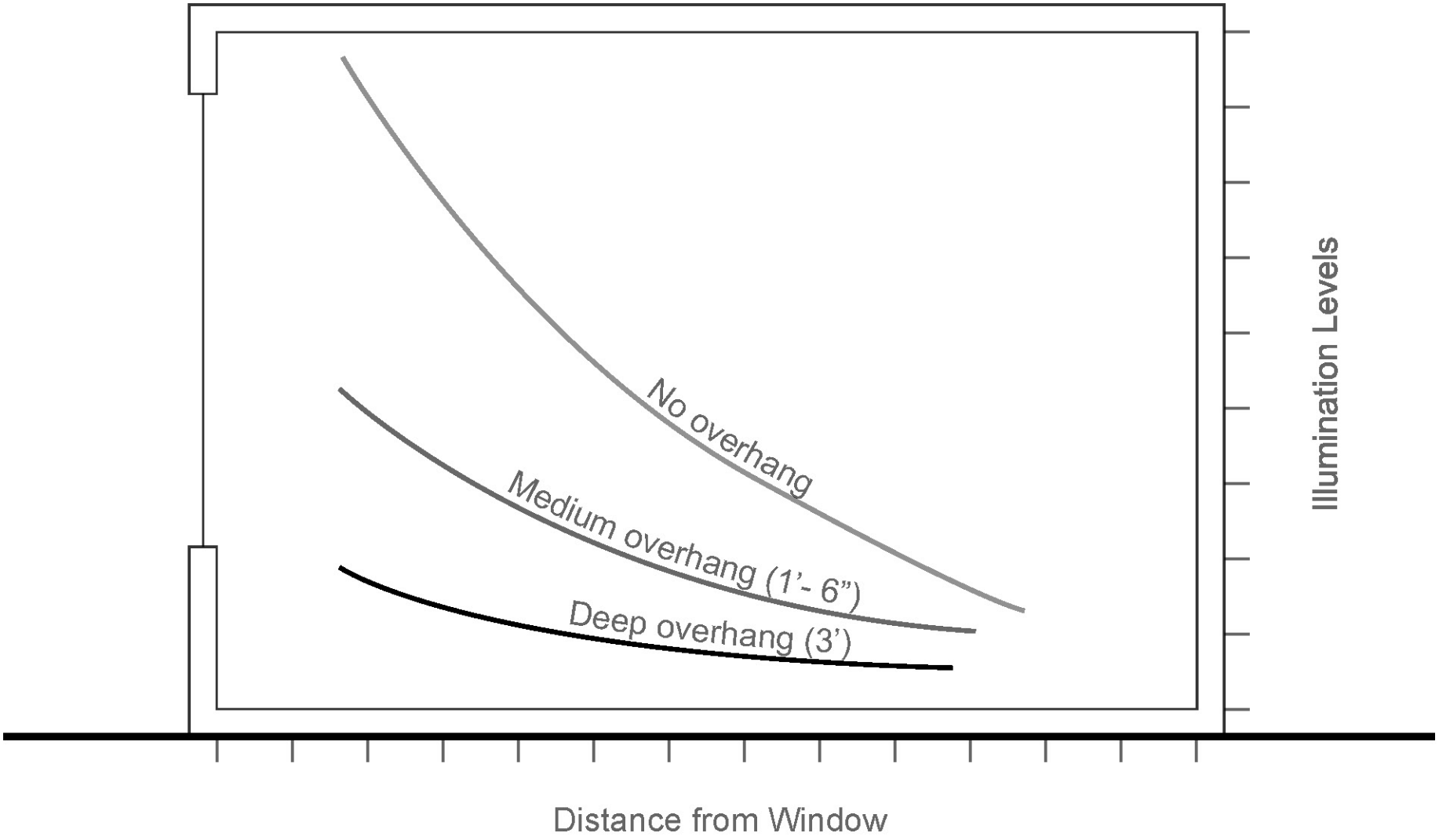
Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.


Stack
ventilation
Cross
ventilation

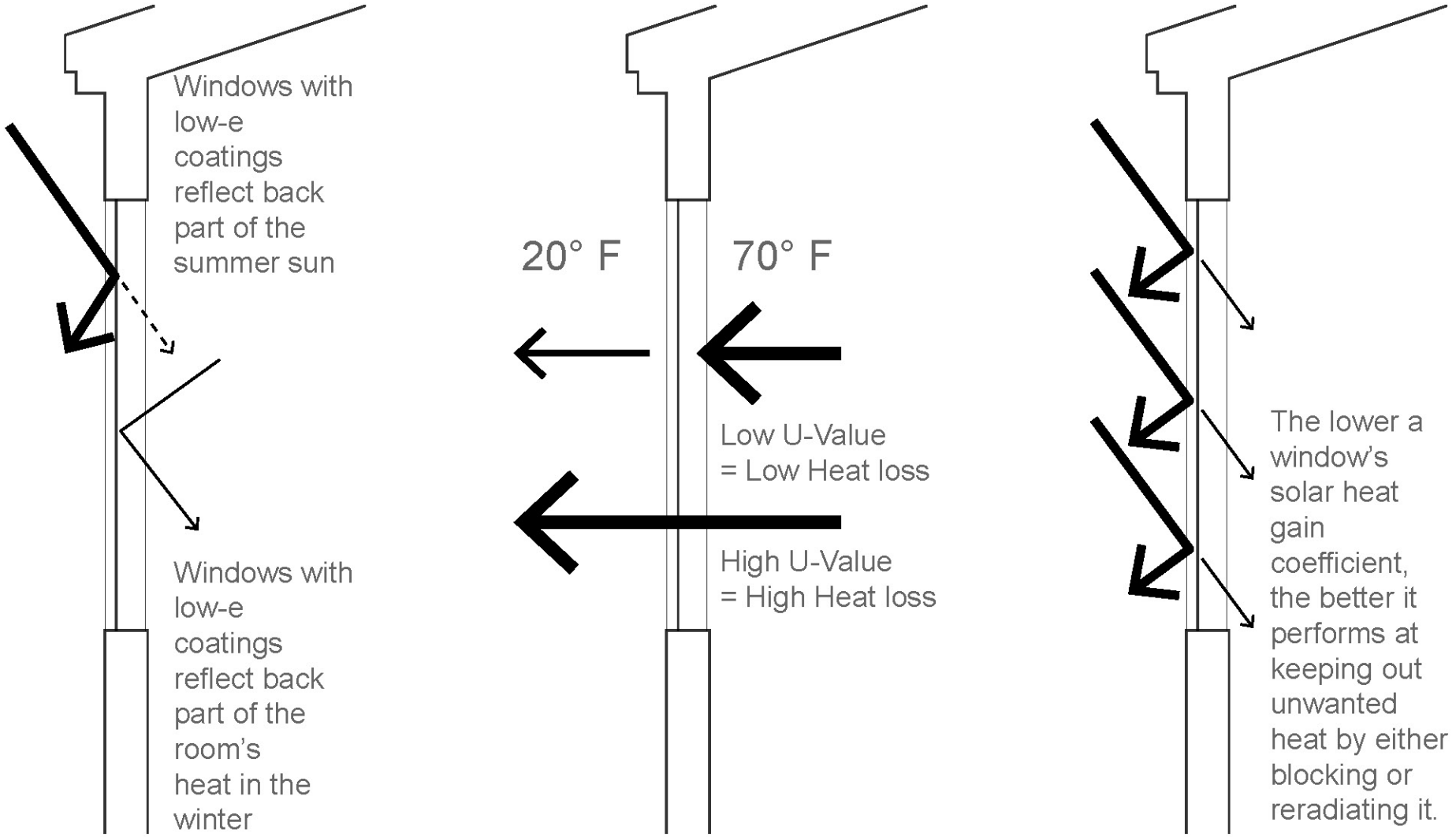


Shading strategies can reduce solar heat gain that enters through the window

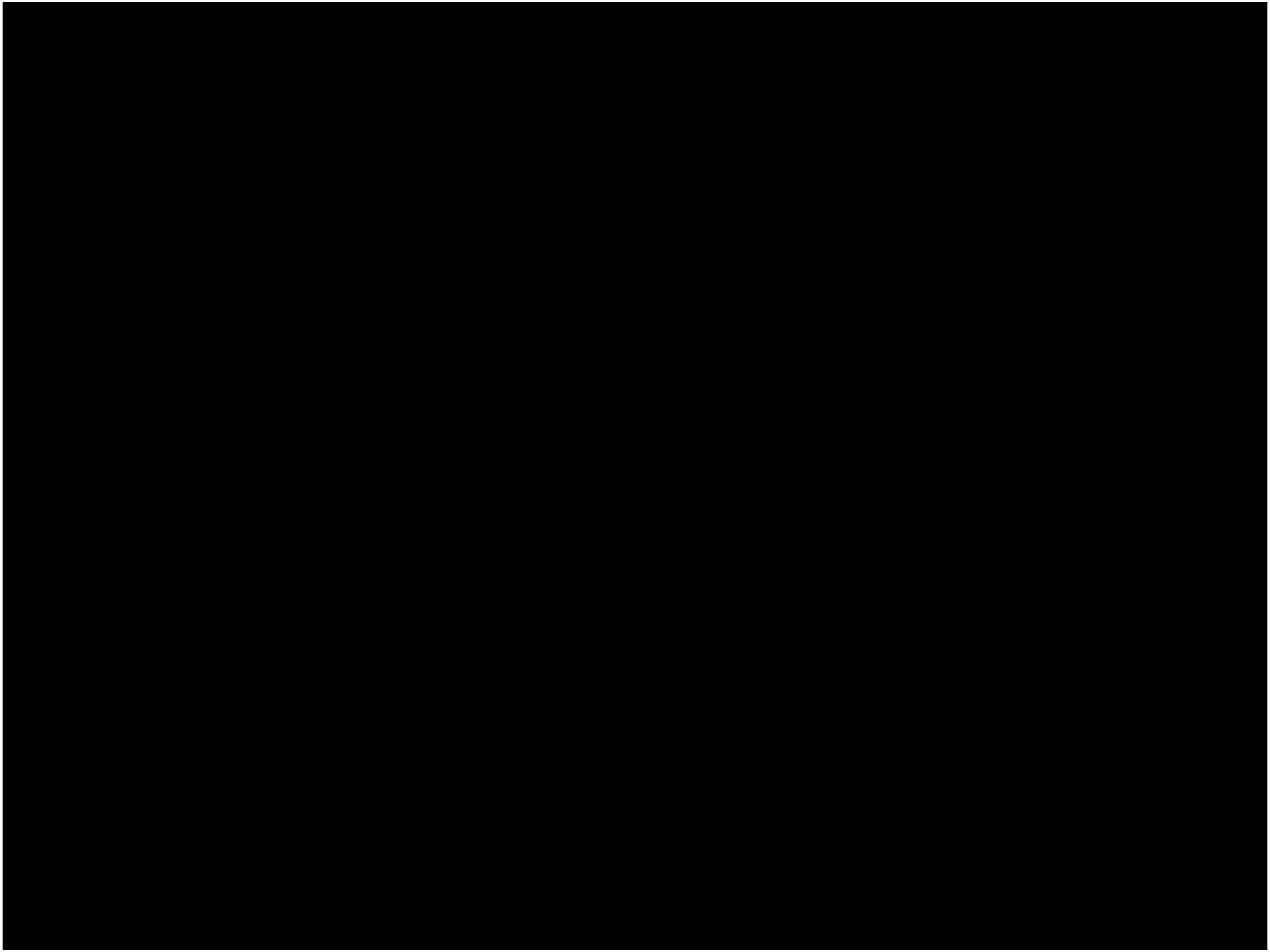
Adapted from: Efficient Windows Collaborative. 2013. *"Design Guidance for New Windows in a Cold Climate*."
http://www.efficientwindows.org/downloads/ColdDesignGuide.pdf



Adapted from: O'Connor, J., E. Lee, F. Rubinstein, and S. Selkowitz. *Tips for Daylighting with Windows: The Integrated Approach.* http://energy.gov/eere/wipo/weatherization-assistance-program



Adapted from: U.S. Department of Energy. "*Energy Efficient Windows*."
http://www.energy.gov/energysaver/energy-efficient-windows



Wind Protection

SAFETY FROM HIGH WINDS AND AIRBORNE DEBRIS

LOCATION

LOW MEDIUM HIGH

HAZARDS

HURRICANES / TROPICAL STORMS

SEVERE STORMS

WINTER STORMS

RELATED STRATEGIES

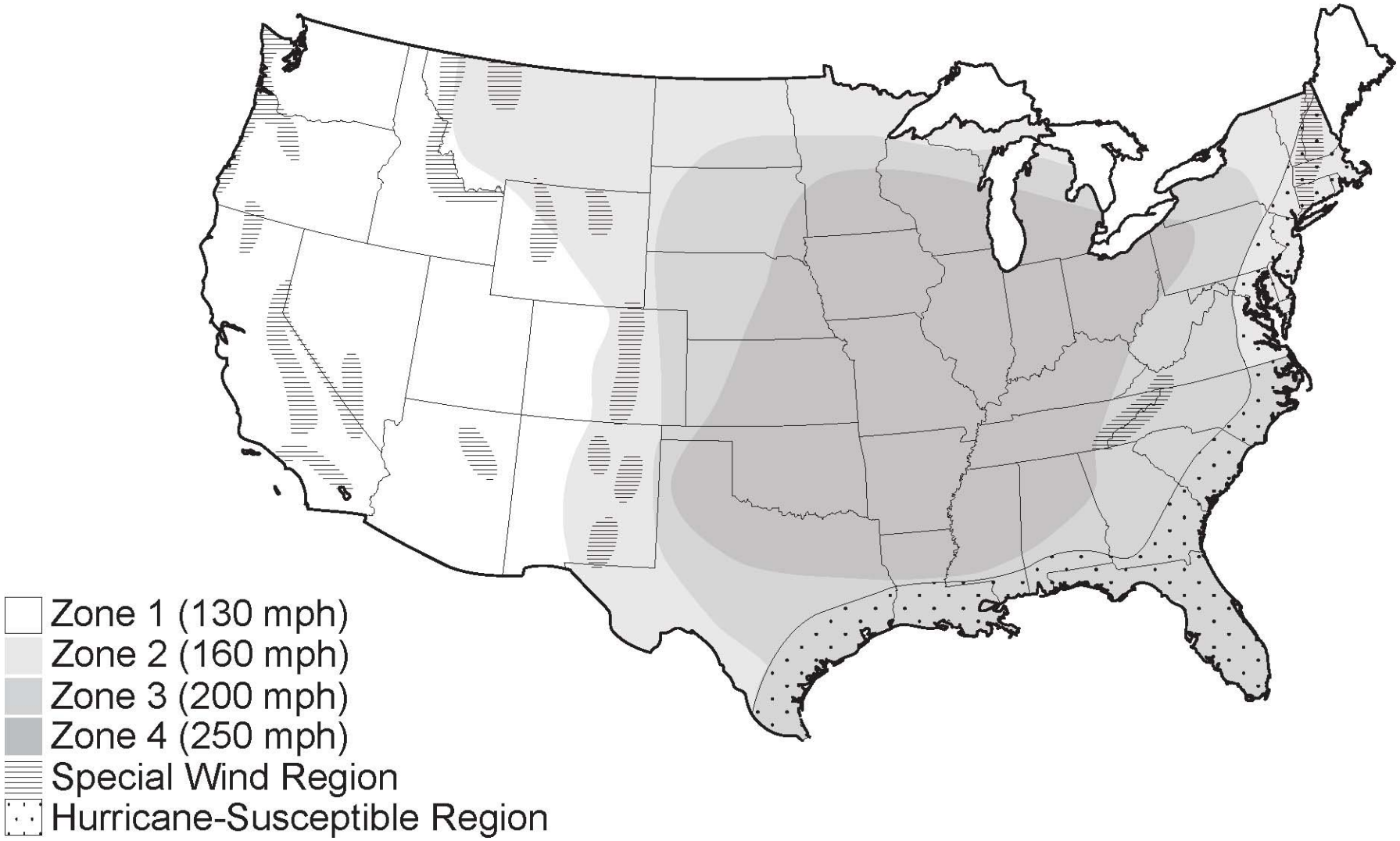
Windows
Building Foundations

The Adirondack Derecho

DESCRIPTION

This strategy helps buildings withstand extreme winds common in climate hazards including hurricanes, and severe storms such as tropical and winter

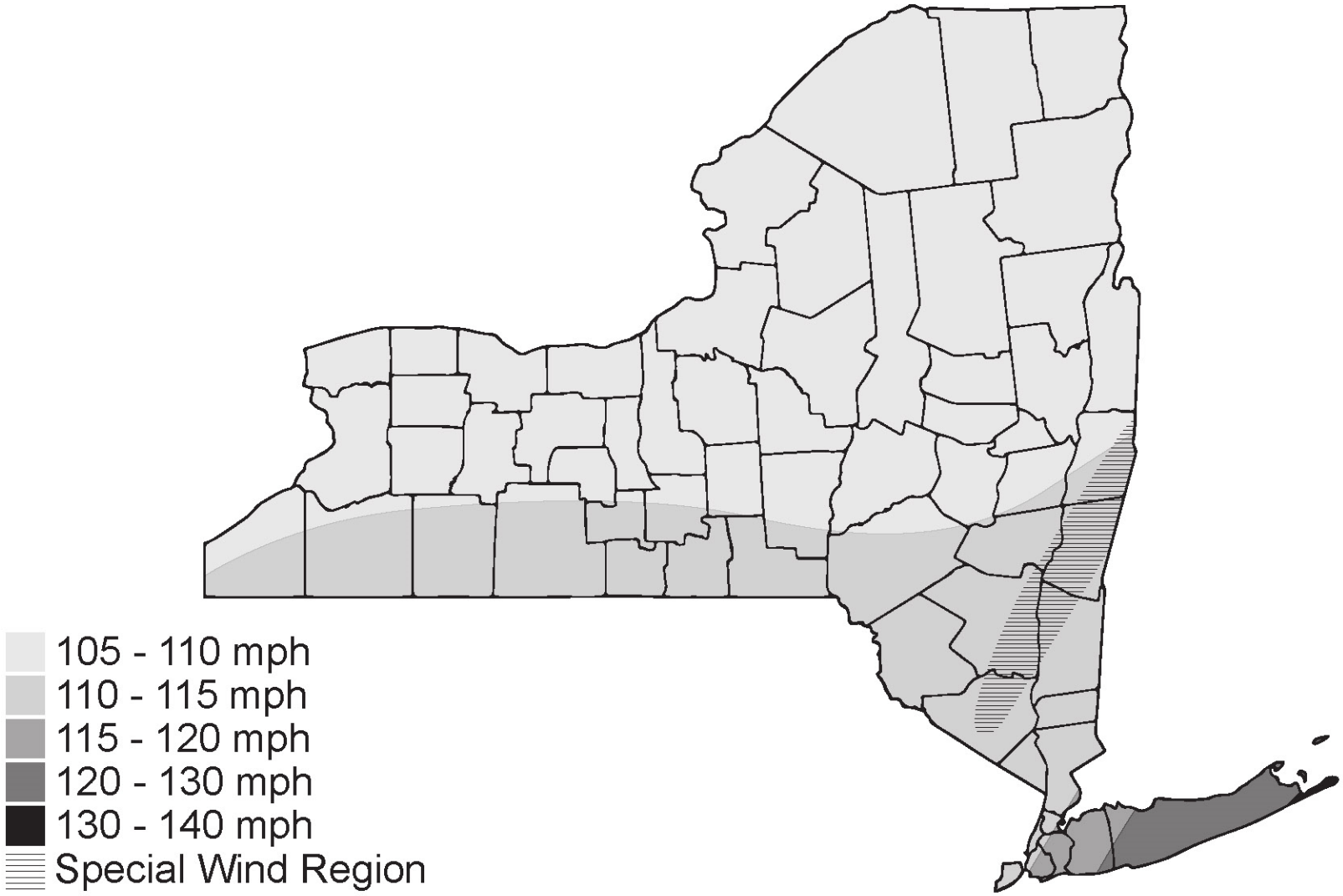
Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.



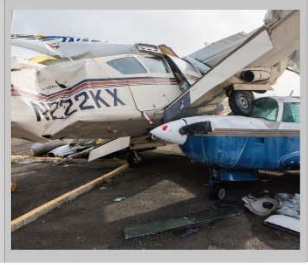
Adapted from: Federal Emergency Management Agency. 2005. *"Protecting Your Home or Small Business From Disasters."* https://training.fema.gov/emiweb/is/is394a/is%20394a_complete.pdf

EF-0	EF-1	EF-2	EF-3	EF-4	EF-5
65-85 mph	86-110 mph	111-135 mph	136-165 mph	166-200 mph	> 200 mph
					
					

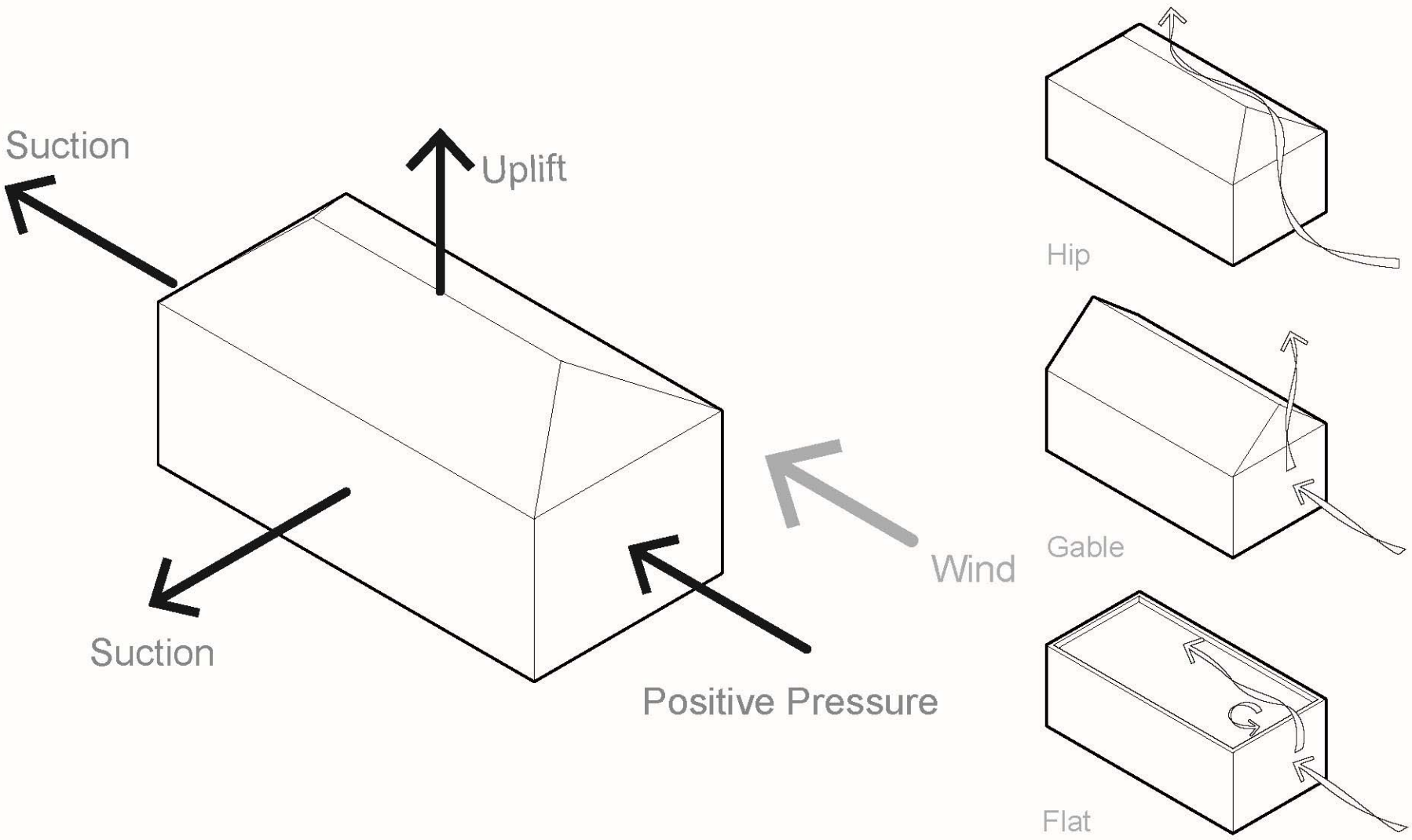
Adapted from: IBHS and State Farm. 2016. "*Tornado EF-Scale*."
https://disastersafety.org/thunderstorms/wind-infographics/



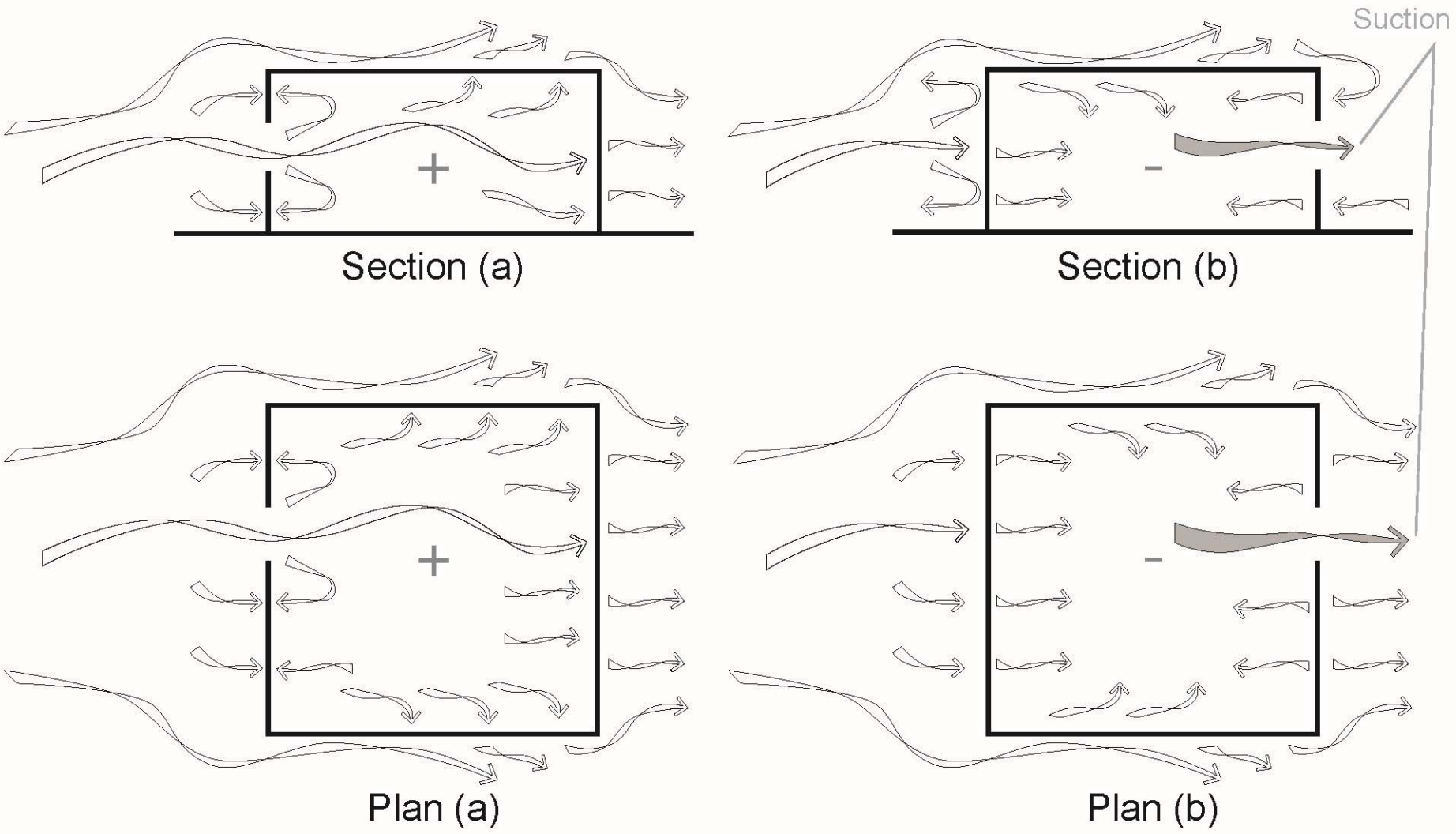
Adapted from: American Society of Civil Engineers. 2017. *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-16).* https://www.asce.org/asce-7/

Tropical Storm	Category 1	Category 2	Category 3	Category 4	Category 5
39-73 mph	74-95 mph	96-110 mph	111-130 mph	131-155 mph	> 155 mph
Irene 2011 Brooklyn, NY 65 mph	Sandy 2012 Atlantic City, NJ 80 mph	Bob 1991 Long Island, NY 105 mph	The Long Island Express 1938 Long Island, NY 120 mph	Maria 2017 Puerto Rico 155 mph	Irma 2017 Cuba 160 mph
					

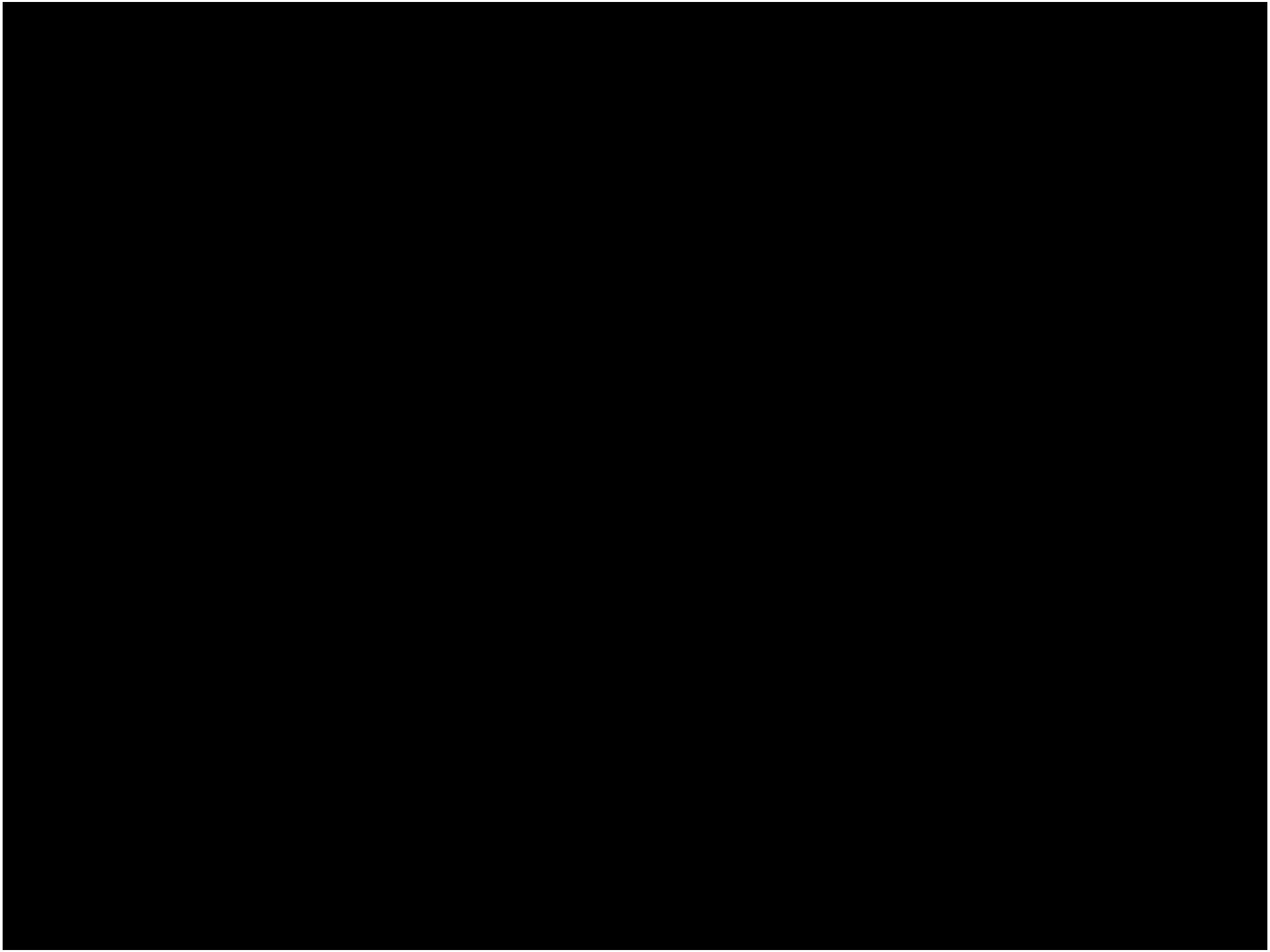
Adapted from: Division of Homeland Security and Emergency Services. 2008. "*3.5 – Hurricane Hazard Profile.*" http://www.dhses.ny.gov/recovery/mitigation/archive/documents/2011/3.5-Hurricane-2011.pdf



Adapted from: Federal Emergency Management Agency. 2009. "*Local Officials Guide for Coastal Construction.*" http://www.fema.gov/media-library-data/20130726-1706-25045-9843/logcc_rev1.pdf



Adapted from: Federal Emergency Management Agency. 2007. *"Design Guide for Improving Critical Facility Safety from Flooding and High Winds."* http://www.fema.gov/media-library/assets/documents/8811



Emergency Management

BUILDING COMMUNITY RESILIENCE BEFORE DISASTER STRIKES

LOCATION

LOW MEDIUM HIGH

HAZARDS

HURRICANES / TROPICAL STORMS

WINTER STORMS

FLOODING

RELATED STRATEGIES

Neighborhood Flood Protection
Neighborhood Fire Protection
Building Fire Protection
Neighborhood Development
Urban Heat Island
Potable Water Systems

DESCRIPTION

Federal Transit Authority

Affecting one-third of the nation's

While emergency management is crucial to all hazards, it applies to hurricanes, winter storms, and floods in particular due to their severity and increased likelihood[1] as a result of climate change. Emergency management[2] can help

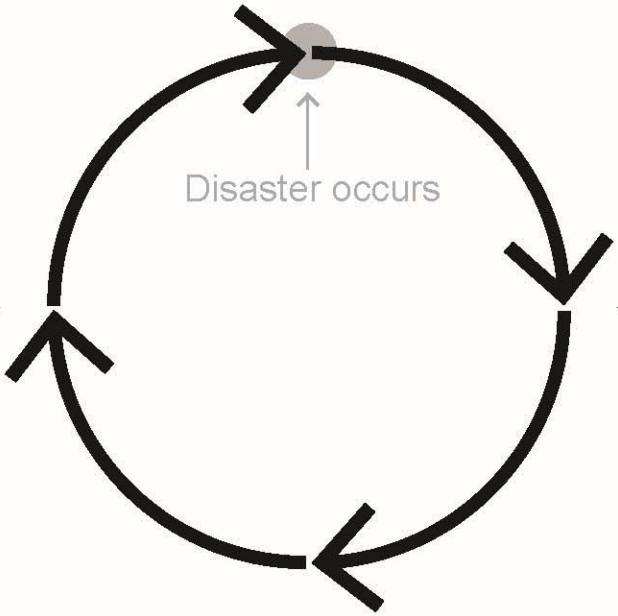
Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.

Preparedness

Vulnerability assessment
Building performance analysis
Business continuity planning
Disaster scenario planning
Training

Response

Rapid safety assessments
Temporary housing
Policy recommendations
Permitting assistance



Mitigation

Building code and land-use update
Incentive retrofit programs
Design innovation
Renovation and retrofits

Recovery

Detailed building assessments
Repair, rebuild, relocate
Transitional housing
Community and land-use planning
Community charrettes

Adapted from: American Institute of Architects. 2017. *Disaster Assistance Handbook,* 3rd ed.
http://aiad8.prod.acquia-sites.com/sites/default/files/2017-05/Disaster_Assistance_Handbook_050917.pdf

1
Know the Community

Members of the community can assist by offering local knowledge on:

Hazards

Population

Capabilities

2
Engage the Community

Connect with existing community based programs

Identify existing programs and contacts

Familiarize with community events and programs

3
Partner with Community Leaders

Support the work of the community

Establish level of engagement

Partnerships with community leaders

Adapted from: Federal Emergency Management Agency. 2010. "*Developing and Maintaining Emergency Operations Plans*." https://www.fema.gov/media-library-data/20130726-1828-25045-0014/cpg_101_comprehensive_preparedness_guide_developing_and_maintaining_emergency_operations_plans_2010.pdf

1
Develop a Plan

Develop a response plan at home

Learn about plans at your workplace (and other places you and your family spend time)

Include contact information in your plans

2
Build a Kit

Be aware that electricity, heat, air conditioning or telephone service may not work during an emergency

Be prepared to make it on your own for at least 7-10 days

Stock up on emergency tools and supplies

3
Be Aware

Sign up for NY-ALERT at nyalert.gov to receive emergency notifications

Know what other resources can provide up-to-date information during an emergency

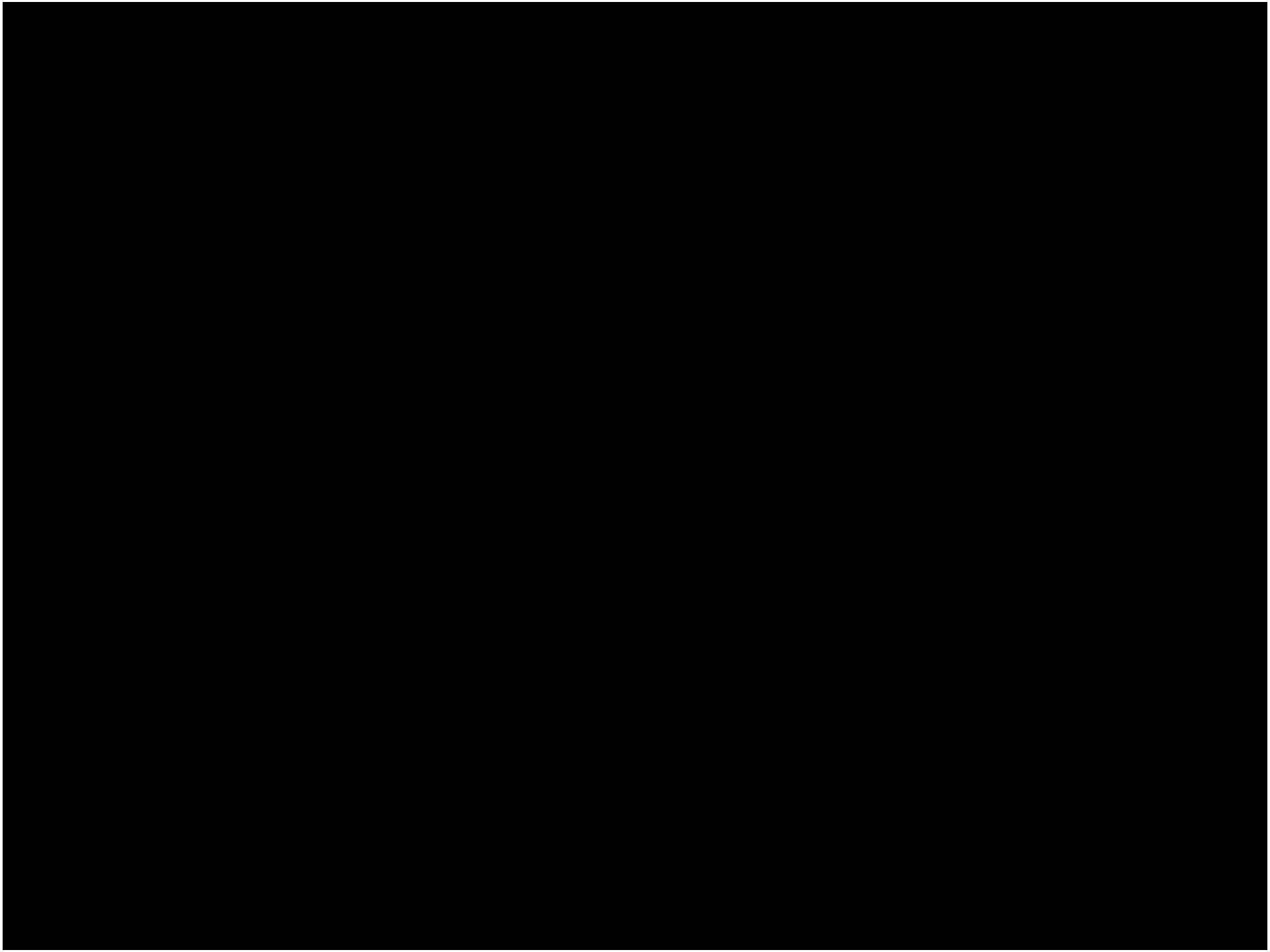
Pay attention to the news and your surroundings

4
Get Involved

Learn what types of programs for volunteers exist within your community

Be generous and donate some time to your community

Adapted from: New York State Citizen Preparedness Corps. 2016. "*4 Steps to Preparedness*."
https://prepare.ny.gov/be-prepared



Redundant Building Systems

PROVIDING BACKUP FOR VITAL BUILDING SYSTEM OPERATIONS

LOCATION

LOW MEDIUM HIGH

HAZARDS

HURRICANES / TROPICAL STORMS

HEAT WAVES

WINTER STORMS

RELATED STRATEGIES

Building Systems Flood Protection
Active Building Systems
Building Operations
Potable Water Systems

DESCRIPTION

Climate change has the potential to severely affect building and infrastructural systems through extreme climate hazards including winter weather, heat waves,

Superstorm Sandy

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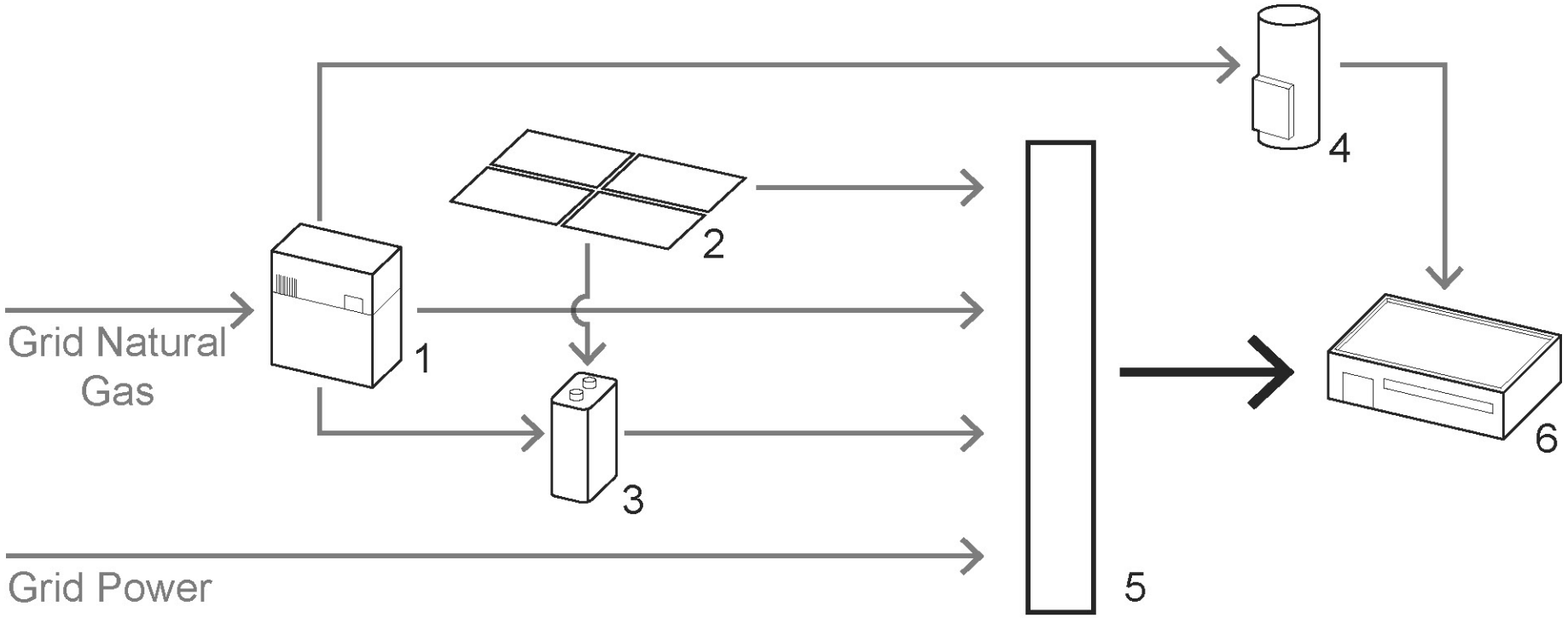
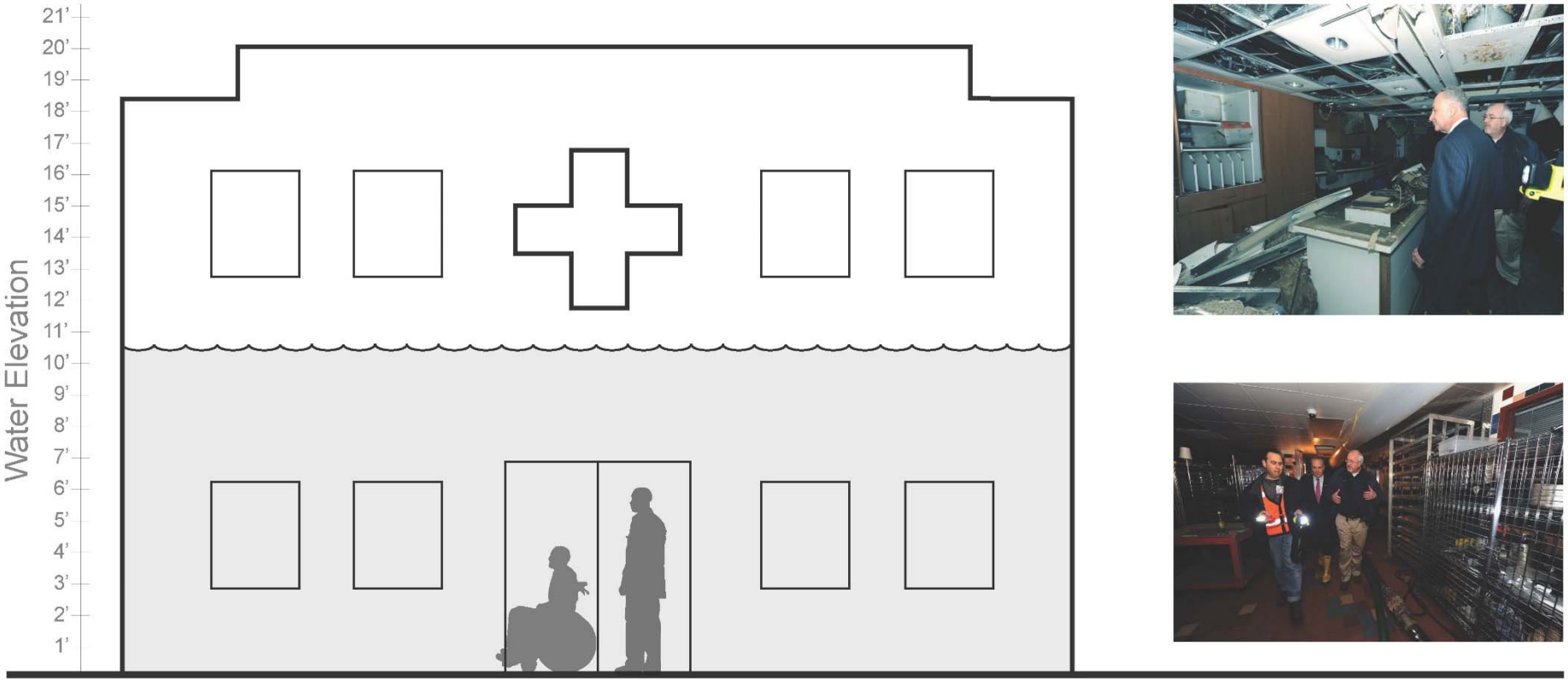


1. Natural Gas Co-Generator
2. Solar Photovoltaic Array
3. Energy Storage
4. Hot Water Tank
5. Smart Control System
6. Core Building Systems (kept on during grid failure)

Adapted from: Nandan, G. 2015. *"Resilient Power Hubs: Emergency Power That Pays Off."*
http://www.naiop.org/en/Magazine/2015/Fall-2015/Business-Trends/Resilient-Power-Hubs.aspx



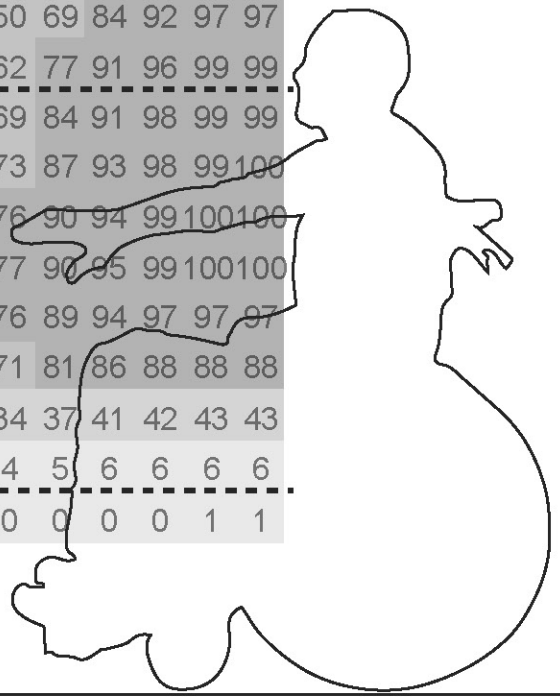
Hoboken University Medical Center
Bellevue Hospital
Coney Island Hospital
NYU Langone Medical Center
Jersey City Medical Center
Beach Terrace Care Center

Adapted from: Federal Emergency Management Agency. 2013. "*Hurricane Sandy in New Jersey and New York*." http://www.fema.gov/media-library-data/1386850803857-025eb299df32c6782fdcbb6f69b35b13/Combined_Sandy_MAT_Report_508post.pdf

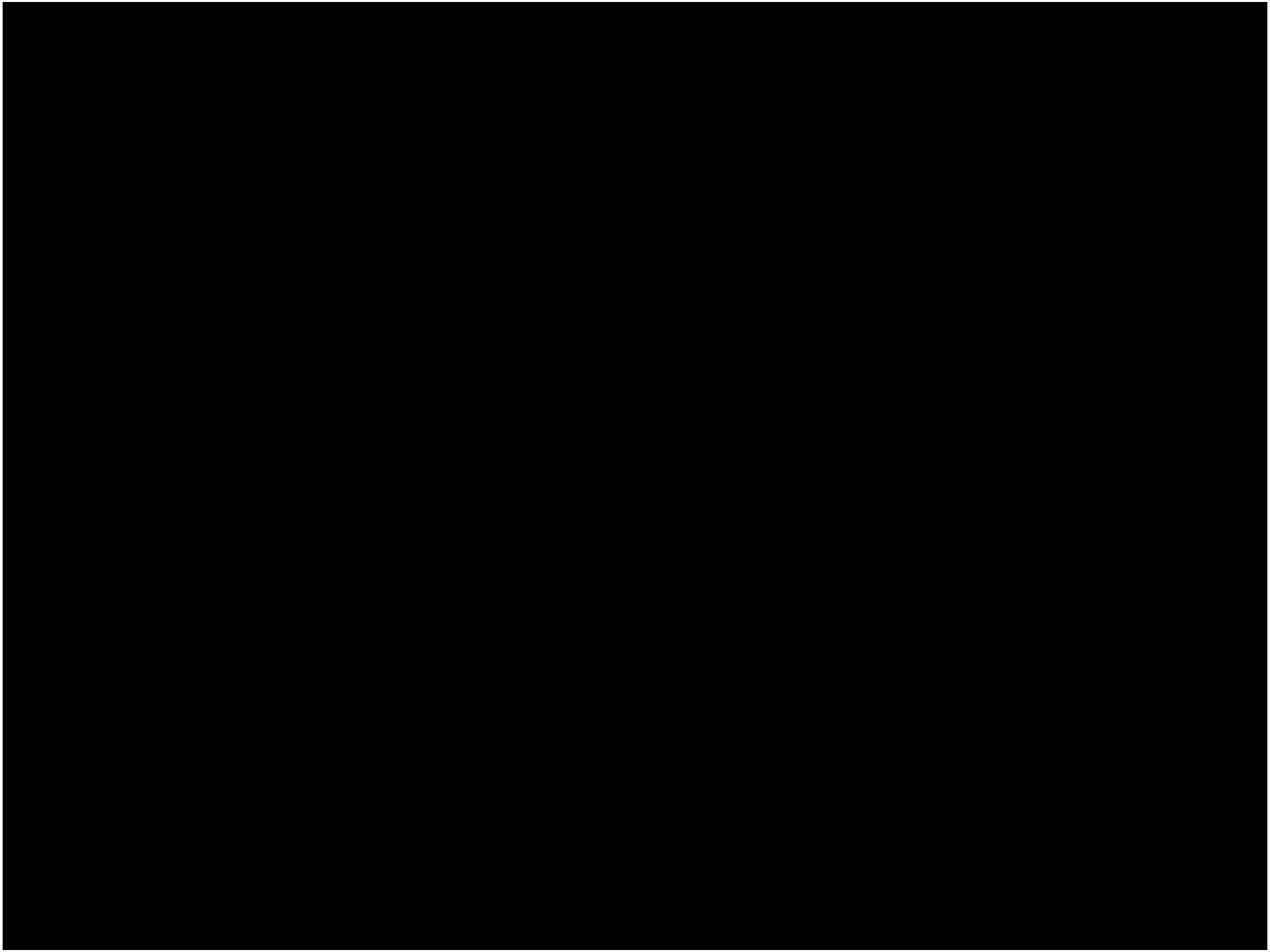
	12”	8”	4”	0”	4”	8”	12”	16”	20”
74.9-78.7”	0	0	0	0	0	1	1	1	1
70.9-74.8”	0	0	0	1	1	1	1	1	1
67.0-70.8”	0	0	2	3	5	7	7	8	8
63.1-66.9”	0	3	8	14	18	24	31	35	37
59.1-63.0”	2	8	16	23	33	47	57	62	63
55.2-59.0”	7	15	26	38	54	67	79	84	87
51.2-55.1”	13	20	36	50	69	84	92	97	97
47.3-51.1”	16	28	43	62	77	91	96	99	99
43.4-47.2”	20	33	53	69	84	91	98	99	99
39.4-43.3”	22	39	57	73	87	93	98	99	100
35.5-39.3”	26	41	60	76	90	94	99	100	100
31.6-35.4”	29	43	62	77	90	95	99	100	100
27.6-31.5”	30	43	60	76	89	94	97	97	97
23.7-27.5”	29	41	56	71	81	86	88	88	88
19.7-23.6”	14	20	27	34	37	41	42	43	43
15.8-19.6”	1	2	3	4	5	6	6	6	6
11.9-15.8”	0	0	0	0	0	0	0	1	1

Horizontal Distance (from forward-most point)

Vertical Distance (from floor)



Adapted from: D’Souzza, C., E. Steinfeld, V. Paquet, and D. Feathers. 2011. “*DR #20: Functional Reach Capability for Wheeled Mobility Users*.” http://udeworld.com/documents/designresources/pdfs/Reach.pdf



Neighborhood Flood Protection

PROTECTING NEIGHBORHOODS DURING FLOOD EVENTS

LOCATION

LOW MEDIUM HIGH

HAZARDS

FLOODING

RISING SEA LEVELS

HURRICANES / TROPICAL STORMS

RELATED STRATEGIES

Emergency Management
Building Flood Protection
Building Systems Flood Protection
Green Infrastructure
Gray Infrastructure
Neighborhood Development

Breezy Point Flooding

Flooding during Superstorm Sandy

DESCRIPTION

Flooding[1] is the most frequent and most costly natural disaster in the United States, accounting for up to 90% of all natural disasters. With a changing

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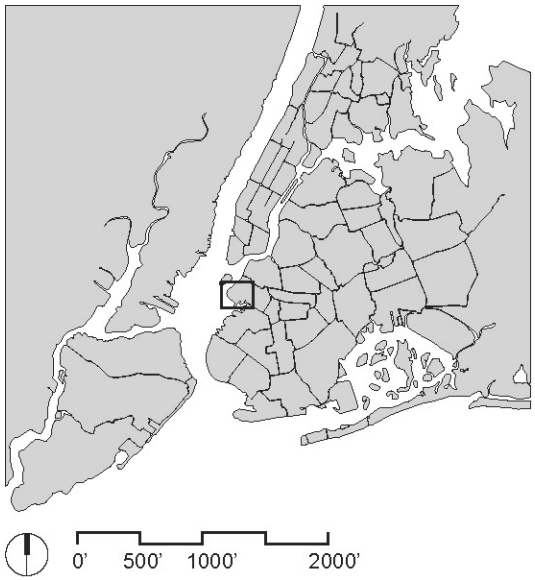


Flood Risk

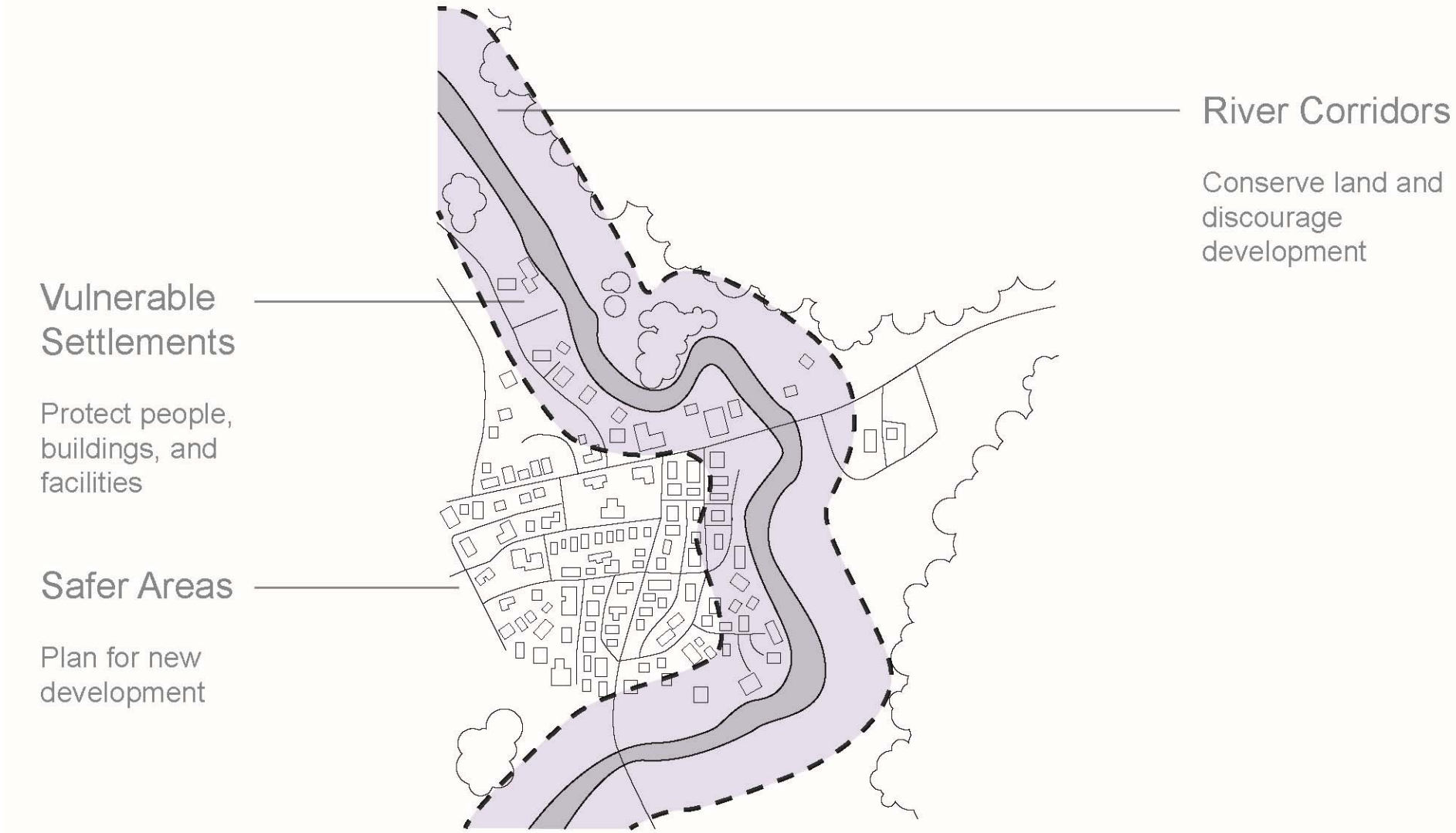
Moderate

High

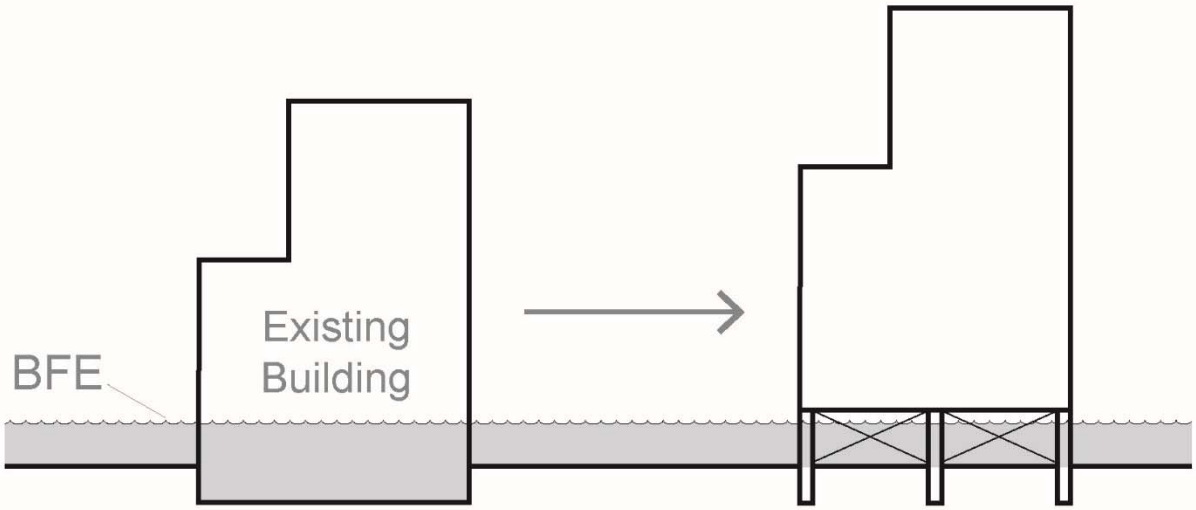
Extreme

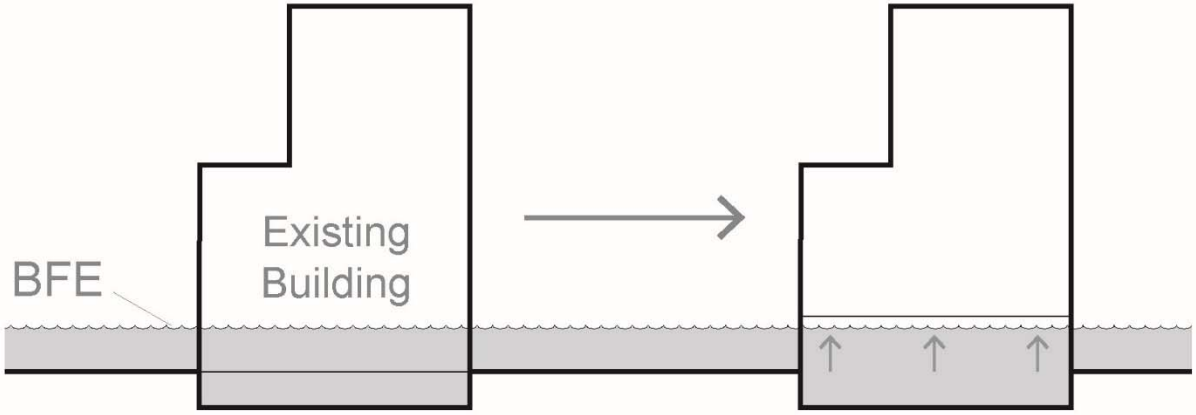
Health/Service Location

Adapted from: NY Rising Community Reconstruction Red Hook Planning Committee. 2014. *"Red Hook: NY Rising Community Reconstruction Plan."* https://stormrecovery.ny.gov/sites/default/files/crp/community/ documents/redhook_nyrcr_plan_20mb_0.pdf

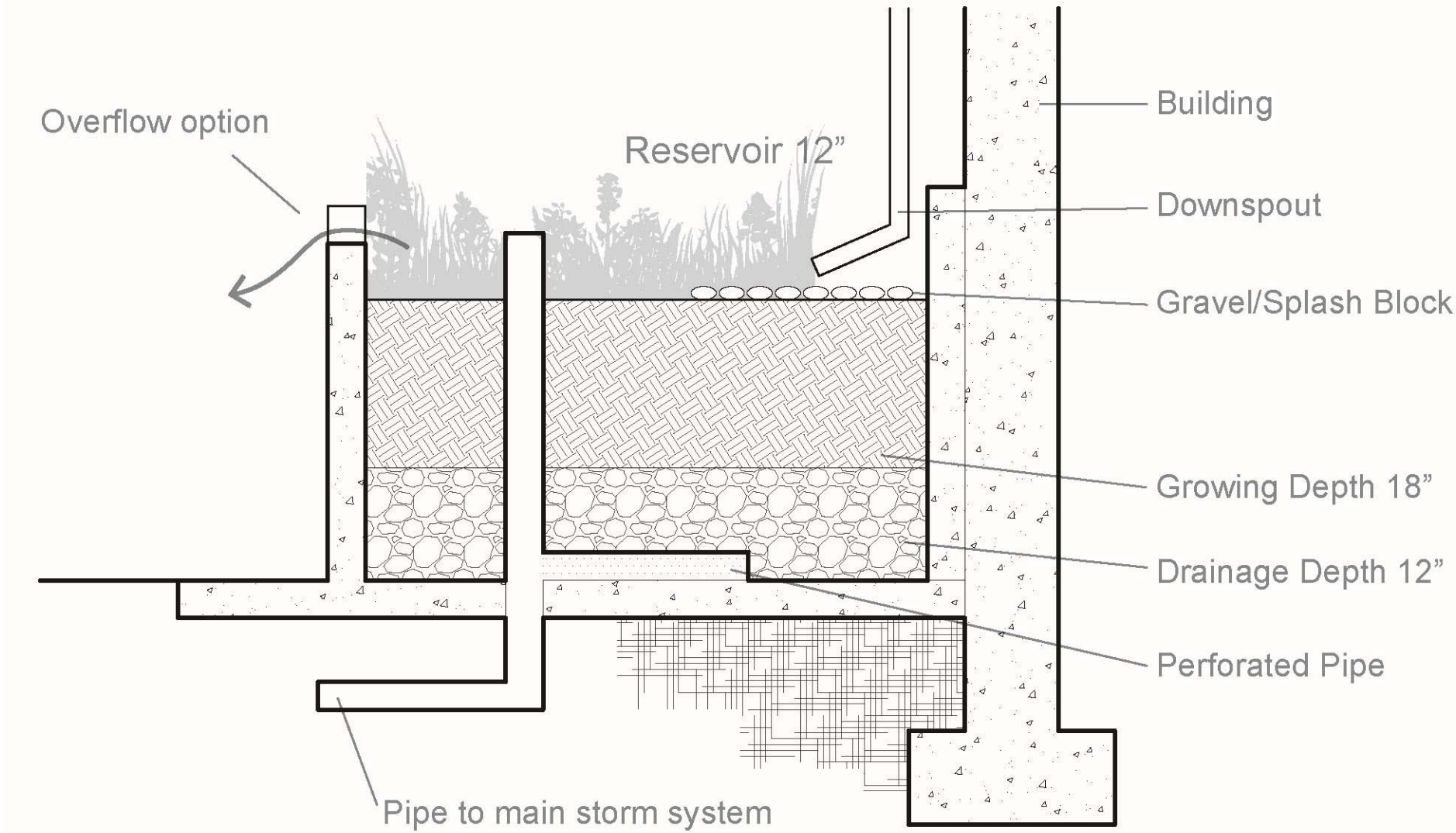


Adapted from: US EPA. 2014. *Planning for Flood Recovery and Long-term Resilience in Vermont: Smart Growth Approaches for Disaster-Resilient Communities*. https://www.epa.gov/sites/ production/files/2014-07/documents/vermont-sgia-final-report.pdf

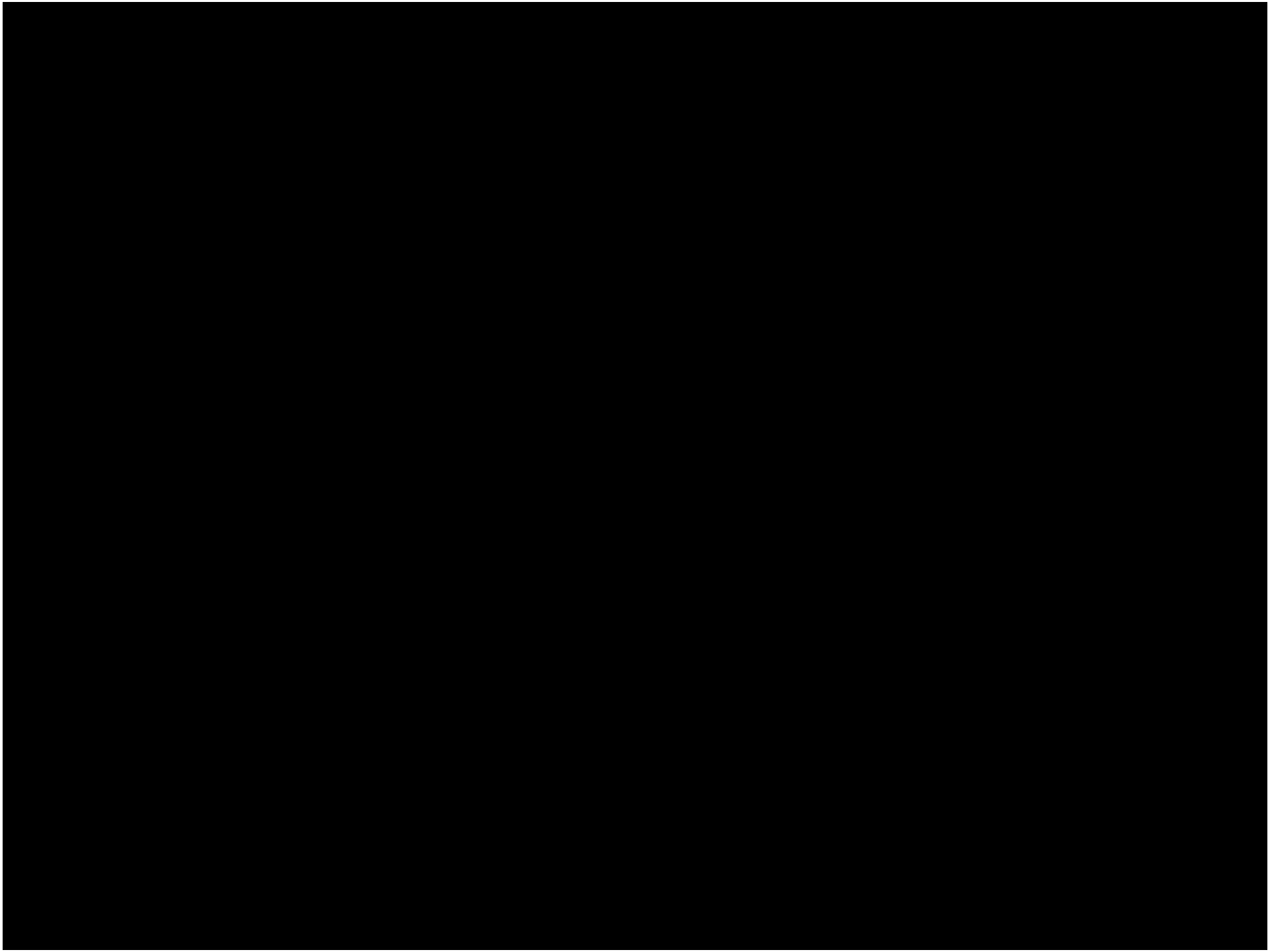




Adapted from: Urban Green Council. 2013. *NYC Building Resiliency Task Force*. https://urbangreencouncil.org/sites/default/files/2013_brtf_fullreport.pdf



Adapted from: Center for Watershed Protection and New York State Department of Environmental Conservation. 2015. *New York State Stormwater Management Design Manual*. http:// www.dec.ny.gov/docs/water_pdf/swdm2015entire.pdf.



Building Flood Protection

PROTECTING BUILDINGS DURING FLOOD EVENTS

LOCATION

LOW MEDIUM HIGH

HAZARDS

FLOODING

RISING SEA LEVELS

HURRICANES / TROPICAL STORMS

RELATED STRATEGIES

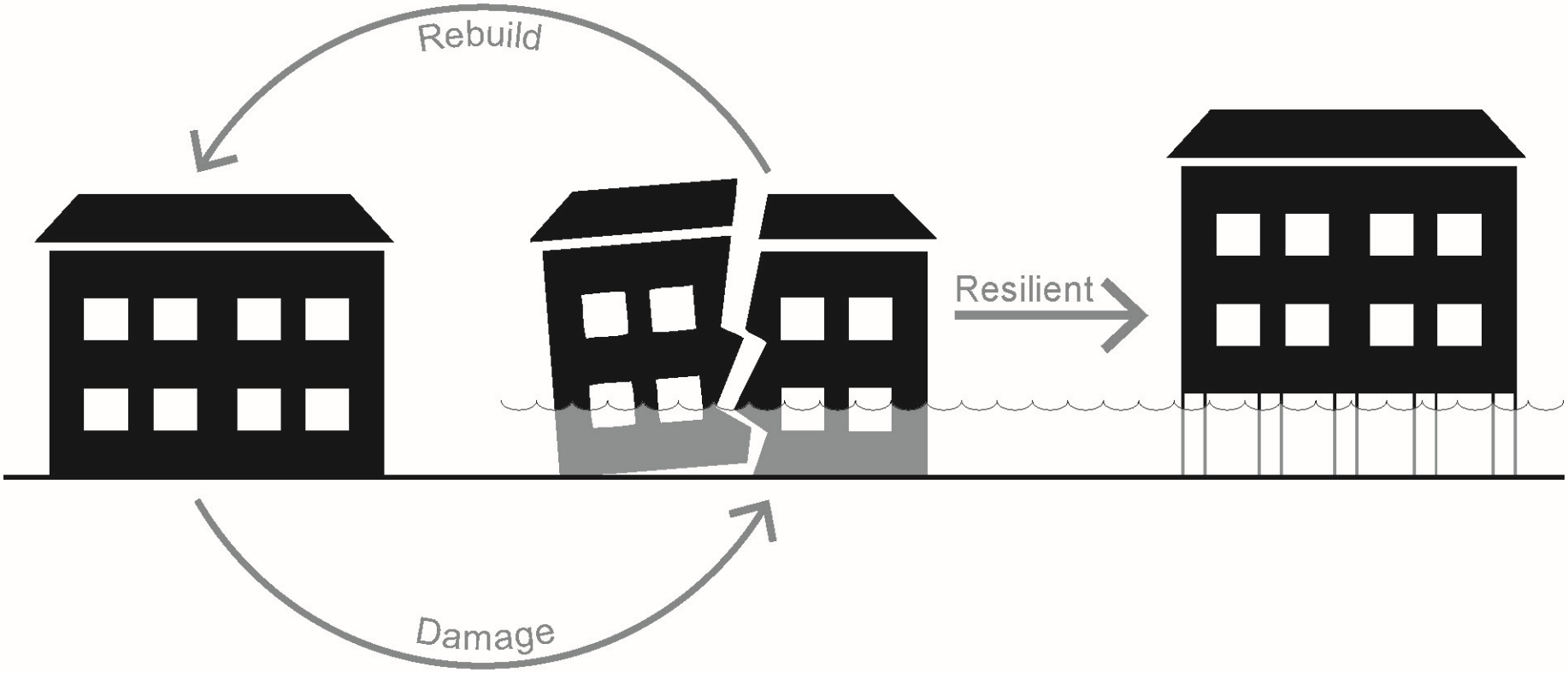
Neighborhood Flood Protection
Building Systems Flood Protection
Building Foundations
Roof Drainage
Building Operations
Potable Water Systems

DESCRIPTION

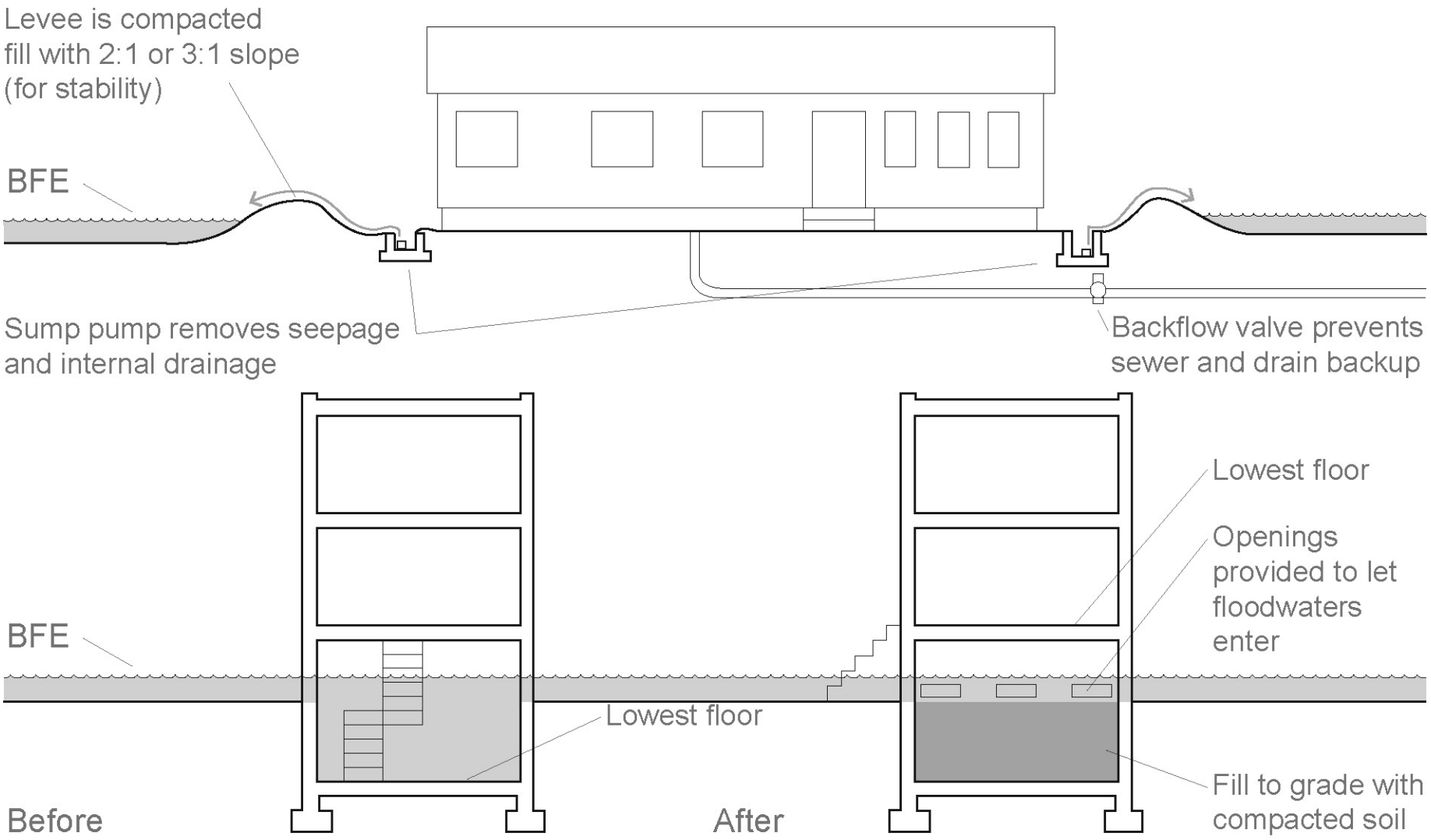
Responding to Climate Change in New York State states that New York will experience changing patterns of precipitation,[1] increasing the risk of flooding

Tropical Storm Lee

Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.



Adapted from: New York State Department of Environmental Conservation. 2016. *"Floodplain Management Requirements after a Flood."* http://www.dec.ny.gov/lands/75774.html



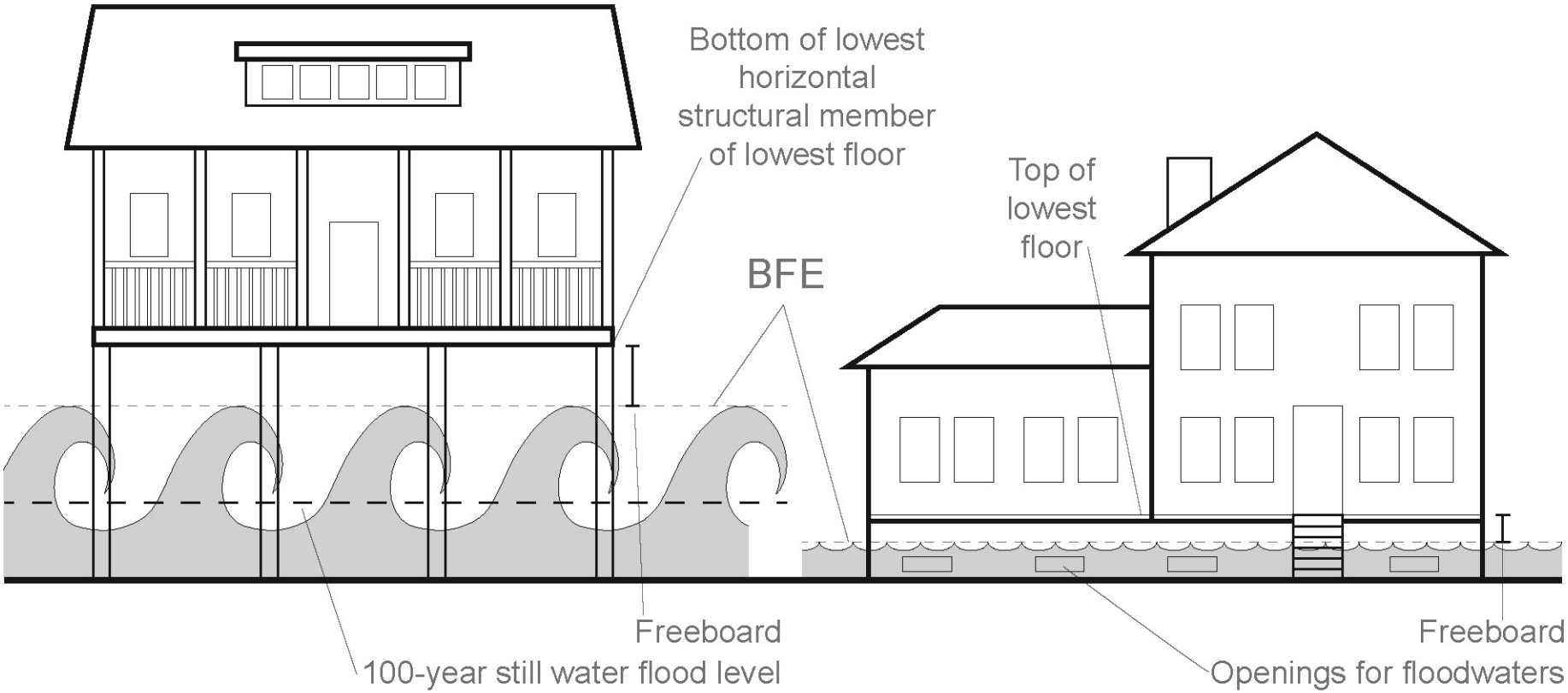
Adapted from: Federal Emergency Management Agency. 2015. *"Reducing Flood Risk to Residential Buildings That Cannot Be Elevated."* https://www.fema.gov/media-library/assets/documents/109669

Zone V + Coastal Zone A

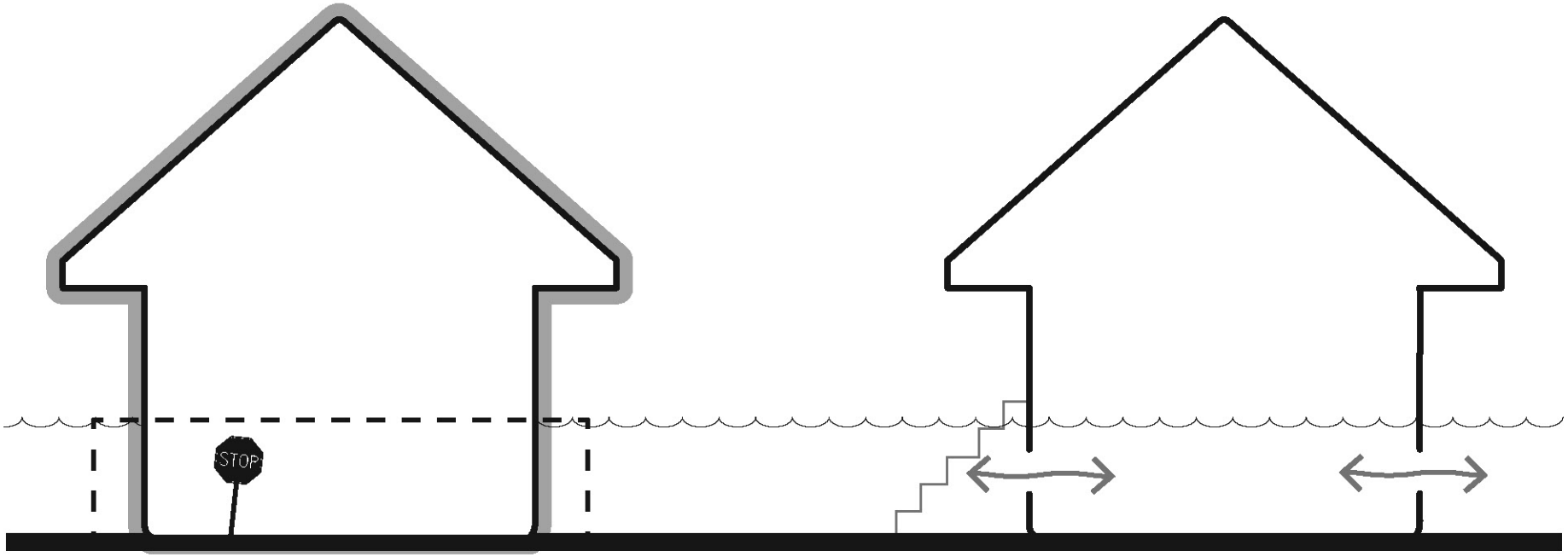
Towards flood source

Zone A + Zone X

Towards flood source



Adapted from: Federal Emergency Management Agency. 2013. *"Designing for Flood Levels above the BFE after Hurricane Sandy."* http://www.fema.gov/media-library-data/1381405016896-8bdeadf634c366439c35568a588feb24/SandyRA5DesignAboveBFE_508_FINAL2.pdf



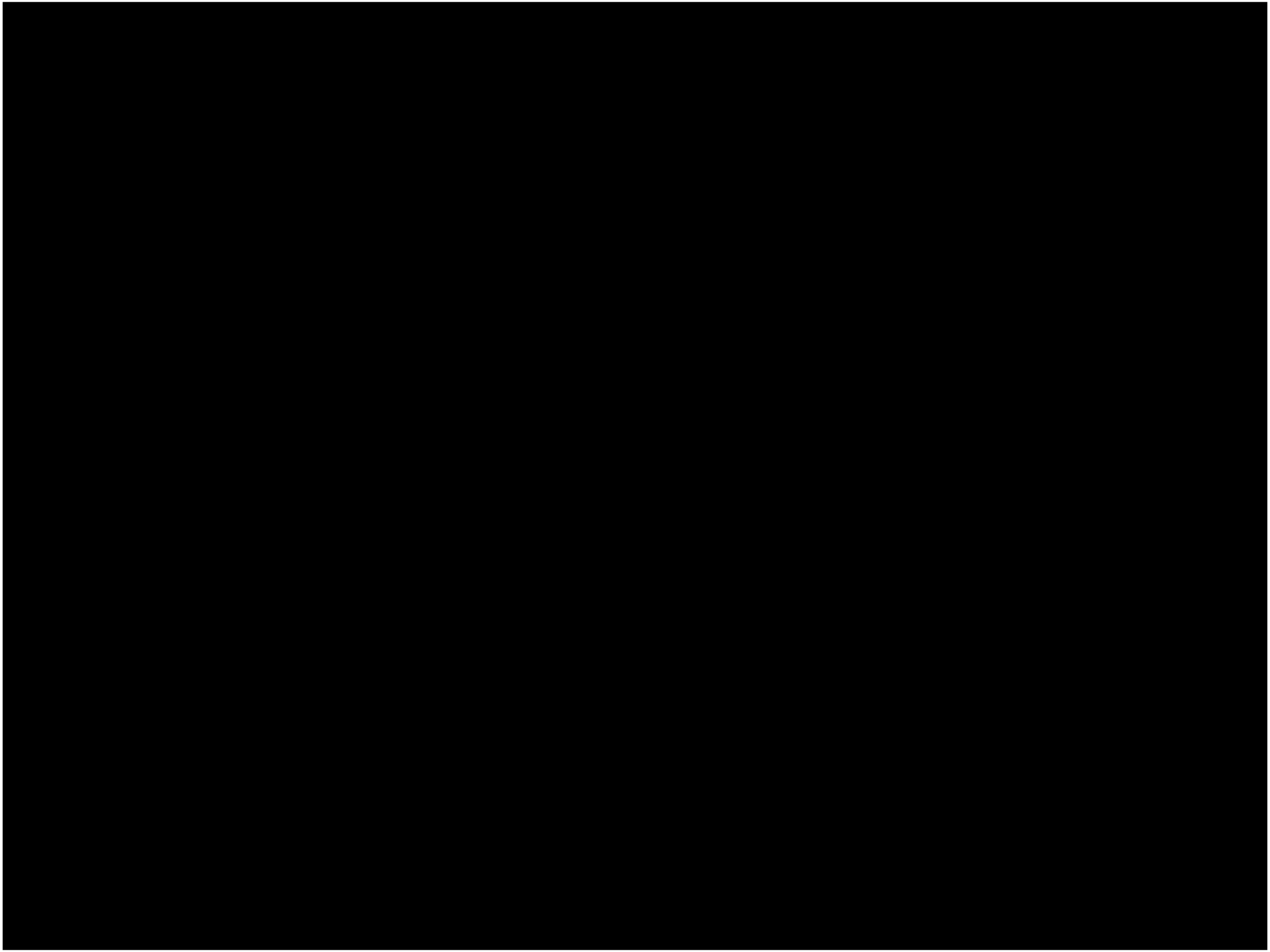
Dry Floodproofing

- Make the structure watertight below the BFE
- Seal walls with waterproof coatings, impermeable membranes, or a supplemental layer of masonry or concrete

Wet Floodproofing

- Allow flood waters to enter and exit space within structure
- Reduces the chance of structural failure by equalizing hydrostatic pressure of the interior and exterior

Adapted from: Federal Emergency Management Agency. 2014. *"Technical Bulletins (13)."* https:// www.fema.gov/media-library/resources-documents/collections/4https:/www.fema.gov/media-library/resources-documents/collections/4



Building Systems Flood Protection

PROTECTING EQUIPMENT DURING FLOOD EVENTS

LOCATION

LOW MEDIUM HIGH

HAZARDS

FLOODING

RISING SEA LEVELS

HURRICANES / TROPICAL STORMS

RELATED STRATEGIES

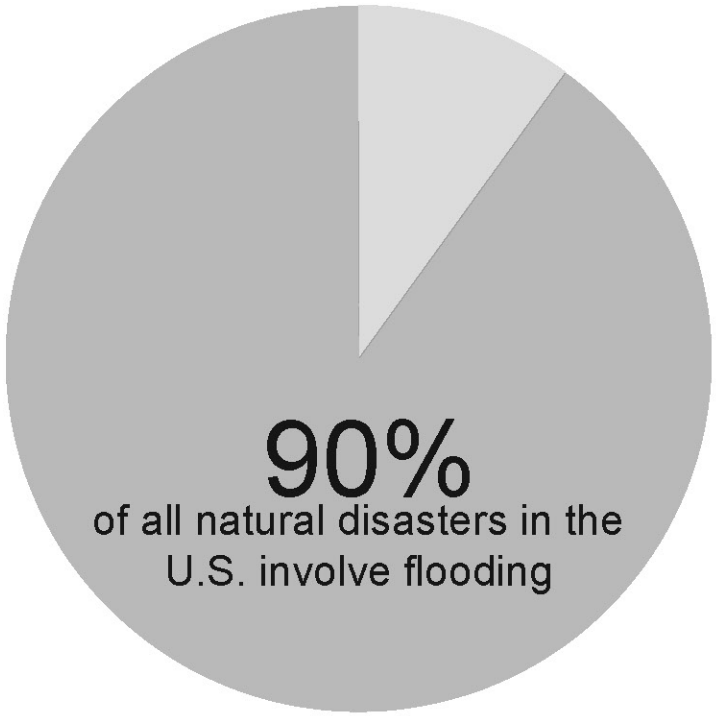
Redundant Building Systems
Neighborhood Flood Protection
Building Flood Protection
Roof Drainage
Active Building Systems

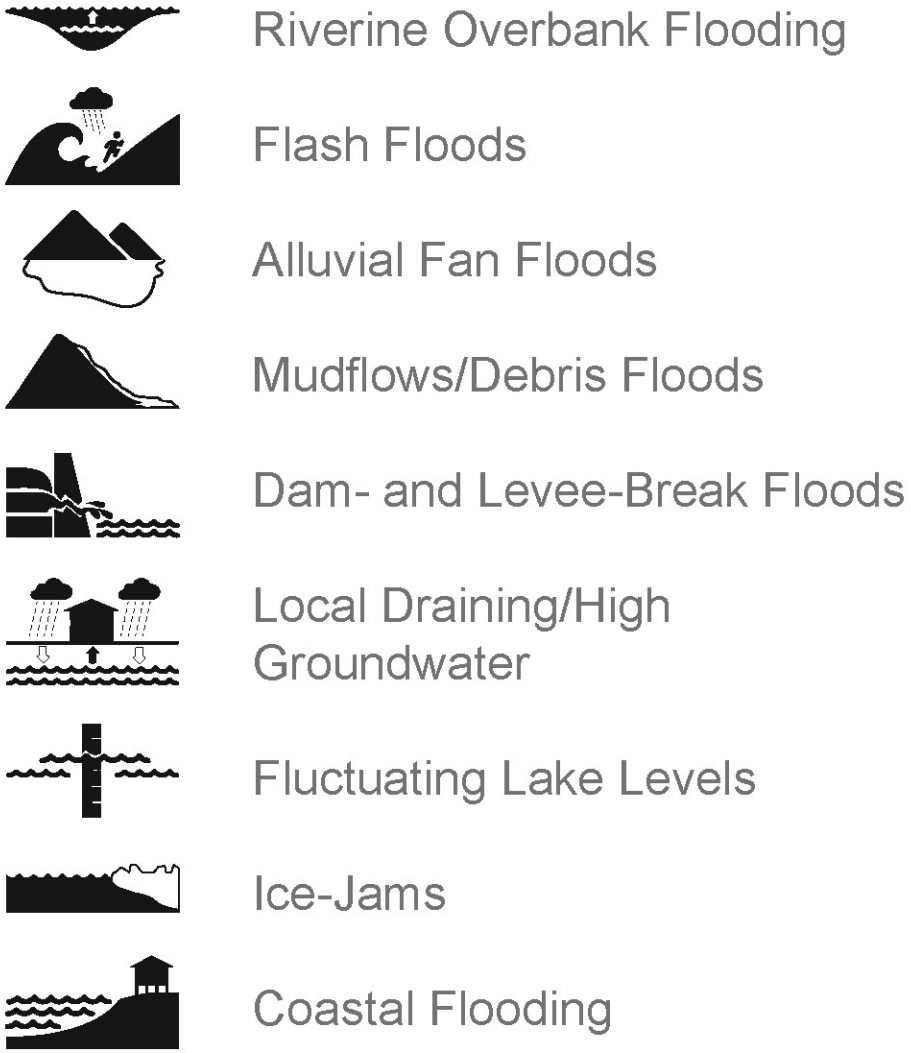
Critical Facility Damage

DESCRIPTION

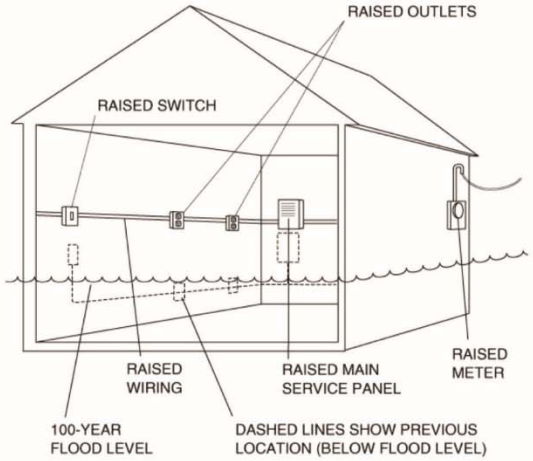
This strategy helps building systems, including mechanical equipment and internal infrastructure, more resilient to the impacts of climate change as

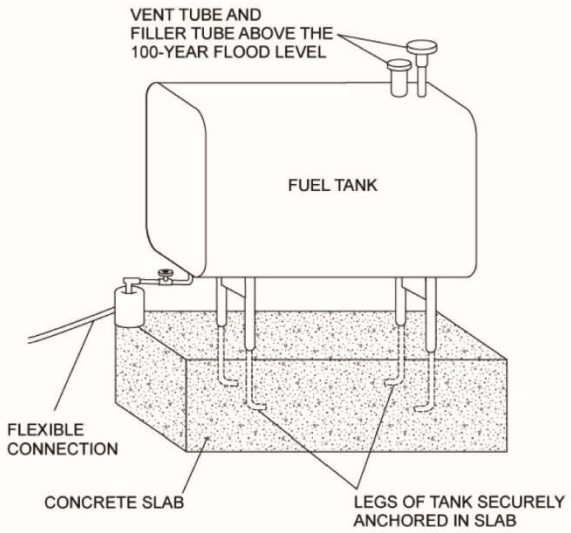
Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.





Adapted from: Federal Emergency Management Agency. 2009. *"Flooding: Our Nation's Most Frequent and Costly Natural Disaster."* http://www.aces.edu/eden/documents/FloodHistoryandCauses-final.pdf





For every $1 spent on mitigation,

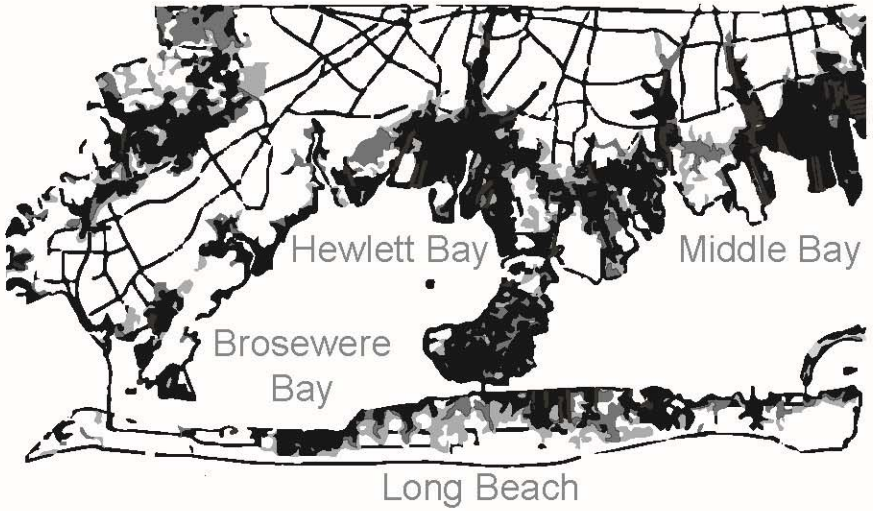
$6 are saved from future losses.

Elevate or floodproof HVAC and/or mechanical units, ductwork, electrical systems, and other utilities above the BFE to protect against flood damage and reduce repair costs.

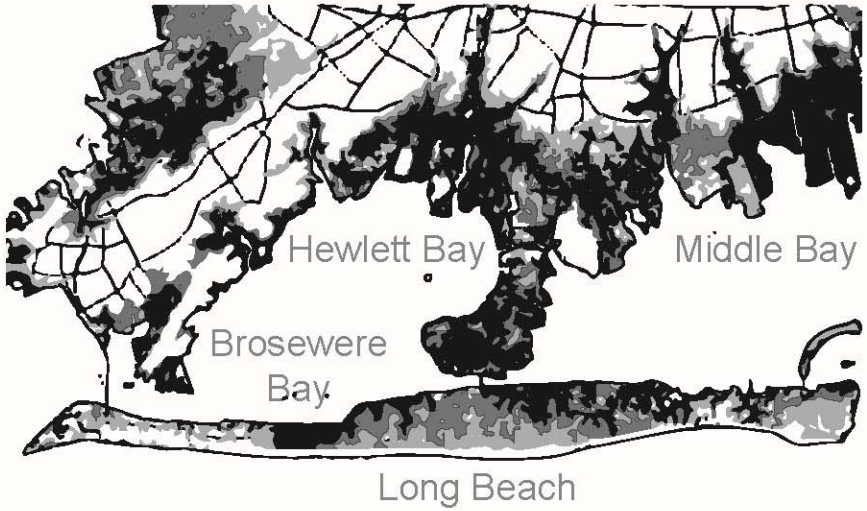
Anchor any fuel tanks to the floor and make sure vents and fill line openings are above the BFE. A fuel tank can tip over or float in a flood, spilling fuel and becoming a fire hazard.

Adapted from: Federal Emergency Management Agency. 2011. *"Protect Your Property from Flooding."* https://www.fema.gov/media-library/assets/documents/13261

ClimAID GCM-based



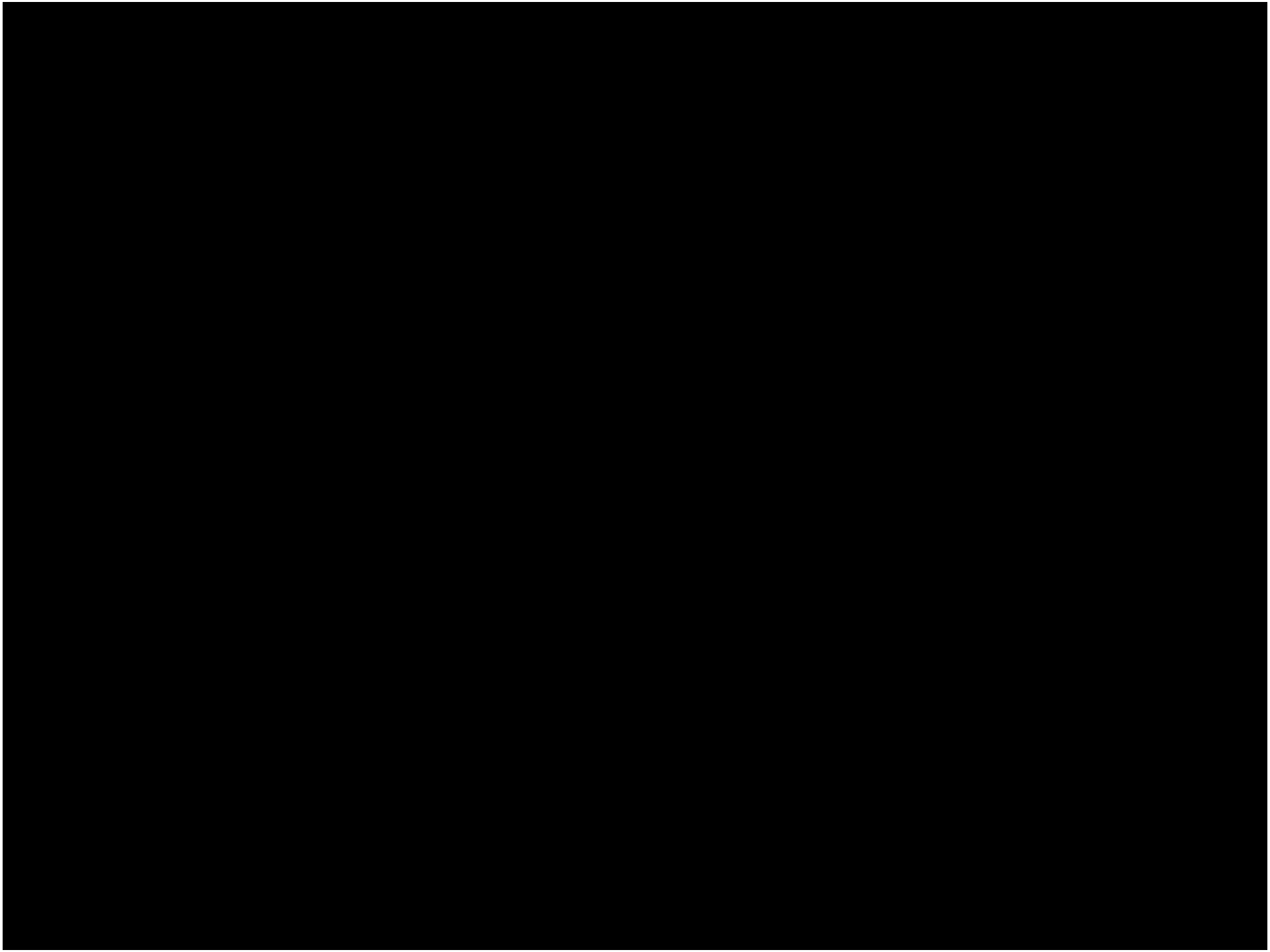
Rapid Ice-melt Scenarios



1 in 10 year flood zone
- 2020s
- 2050s
- 2080s
- Major Roads

0 1 2 3 Miles

Adapted from: Rosenzweig, C., et al. (Eds.). 2011. *Responding to Climate Change in New York State.* http://www.nyserda.ny.gov/About/Publications/Research-and-Development-Technical-Reports/Environmental-Research-and-Development- Technical-Reports/Response-to-Climate-Change-in-New-York



Building Foundations

REDUCING CLIMATE CHANGE IMPACTS FROM THE GROUND UP

LOCATION

LOW MEDIUM HIGH

HAZARDS

FLOODING

RISING SEA LEVELS

WINTER STORMS

RELATED STRATEGIES

Wind Protection
Building Flood Protection
Insulation
Integrated Pest Management

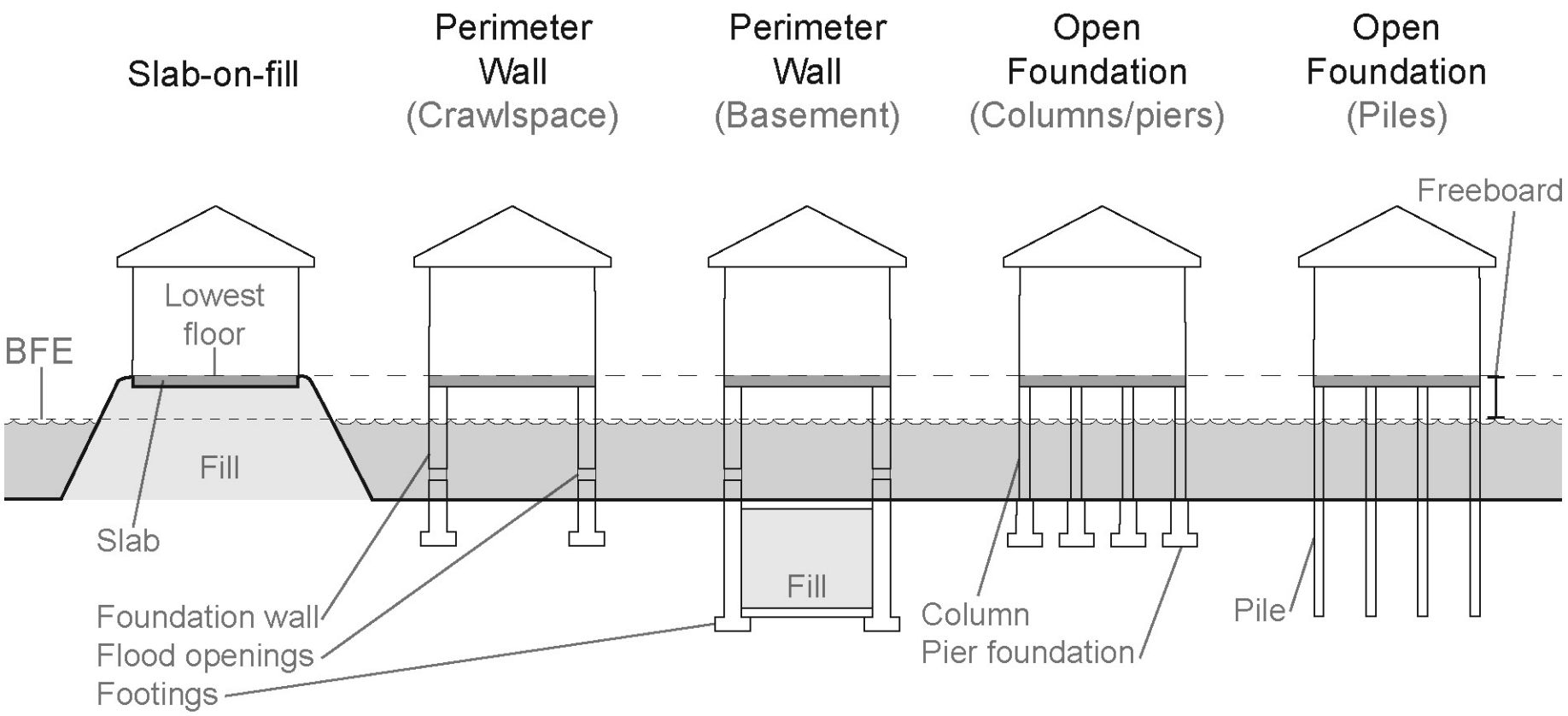
Scour from Storm Surge

Shallow and open foundations are

DESCRIPTION

Foundations in coastal environments are subject to hazards such as wave action, storm surges, erosion and scour, and floodborne debris. According to

Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.



Adapted from: Federal Emergency Management Agency. 2013. *"Foundation Requirements and Recommendations for Elevated Homes."* http://www.fema.gov/media-library-data/1386073605870-56034eb27952e0 4bd44eb84b72032840/SandyFS2OpenFoundation_508post2.pdf

Designers should be conservative with their foundation designs, making them stronger, deeper, and higher than what has been used in the past. This will help account for the possibilities of erosion and scour.

Erosion:

A lowering or wearing away of the ground surface over a wide area due to the movement of wind, water, or ice

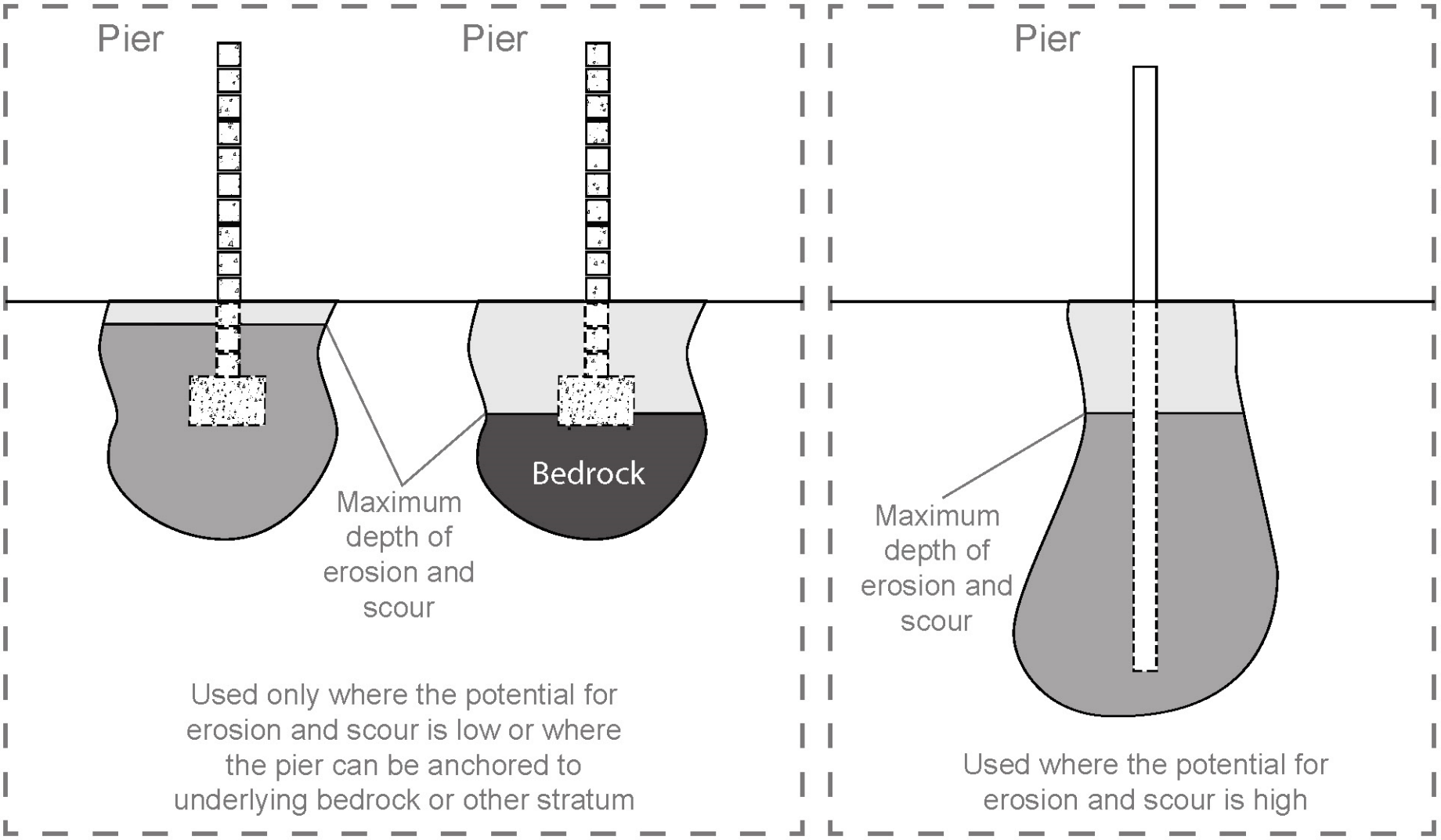
Scour:

A localized loss of soil that occurs when floodwater moves around an obstruction, such as a foundation element

3 Steps to Estimate Future Ground Elevations and Flood Conditions of a Site:

1. Determine the most landward shoreline location expected during life of building
2. Define the lowest expected ground elevation during life of building
3. Define the highest expected BFE during life of building

Adapted from: Federal Emergency Management Agency. 2009. *"Erosion, Scour, and Foundation Design."* http://www.fema.gov/media-library-data/20130726-1644-20490-8177/757_apd_5_erosionscour.pdf



Adapted from: Federal Emergency Management Agency. 2009. *"Local Officials Guide for Coastal Construction."* https://www.fema.gov/media-library/assets/documents/16036

Foundation construction types depend on the following factors:

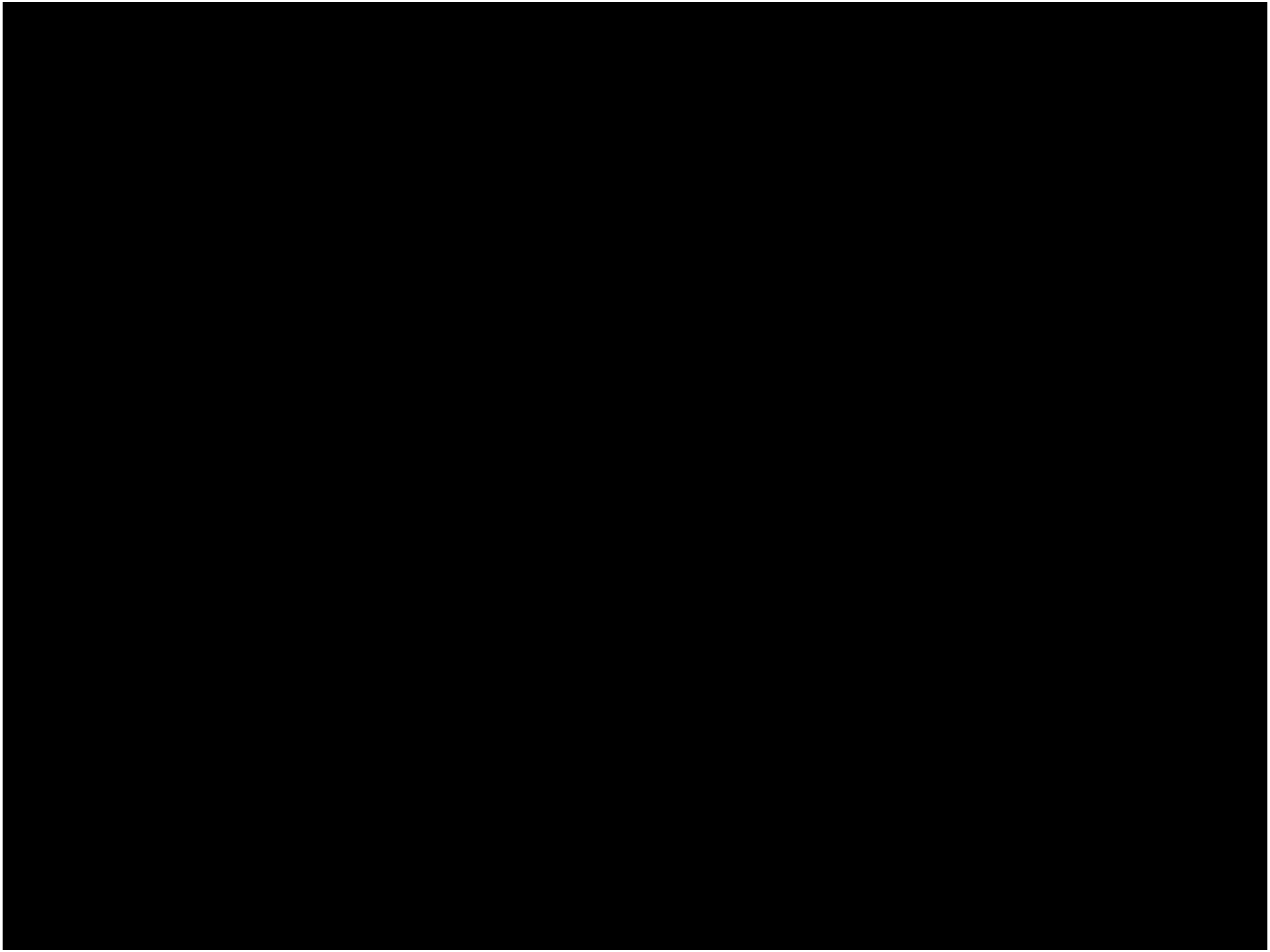
1. Basic wind speed determines the wind velocity used in establishing wind loads for a building. For the foundation to be properly designed, all forces must be taken into account.

2. The required height of the foundation depends on three factors: the DFE, the site elevation, and the flood zone.

3. The flood zone dictates whether the lowest habitable finished floor must be placed at the or the bottom of the lowest horizontal member must be placed at DFE.

4. To optimize the foundation design, consideration should be given to performing soil tests on the site.

Adapted from: Federal Emergency Management Agency. 2009. *"Recommended Residential Construction for Coastal Areas: Building on Strong and Safe Foundations."* http://www.fema.gov/media-library-data/20130726-1517-20490-9361/fema_p550_rev3.pdf



Save the Rain Program

DESCRIPTION

According to Responding to Climate Change in New York State,[1] temperatures and precipitation amounts in New York State are expected to increase. Extreme

Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.

Manage Flooding

Enhance infiltration through rain gardens, bioswales, and permeable pavements

Reduce volume that flows into waterways through open space preservation and floodplain management

Prepare for Drought

Replenish local groundwater reserves through infiltration based infrastructure

Allow water to soak naturally into the ground by placing infrastructure in or near parking lots, streets, and buildings

Reduce Urban Heat Island

Bring greenery to cities by planting trees, greenroofs and other vegetation to shade buildings, deflect sun radiation, and increase air humidity

Spend Less Energy on Water Management

Introduce green infrastructure to reduce the amount of rainwater in sewer systems, recharge aquifers and conserve water to reduce energy association with healthy and moving water

Protect Coastal Regions

Create a "living shoreline" to improve water quality and aquatic habitat, and to sequester carbon

Restore wetlands to reduce wave heights and damage

Adapted from: U.S. Environmental Protection Agency. 2016. *"Green Infrastructure for Climate Resiliency."* https://www.epa.gov/green-infrastructure/green-infrastructure-climate-resiliency

Green Infrastructure is used as a tool to achieve the goals of environmental sustainability, smart growth, and climate adaptation, which all help to increase the resilience of communities.

Alisha Goldstein, EPA
Clarion Associates, EPA

The largest barrier to the introduction of green infrastructure is a lack of funding. Green infrastructure projects can be strong competitors for different funding sources due to their environmental and economic benefits.

Federal Funding Sources:

U.S. Department of Energy

U.S. Department of Housing and Urban Development

U.S. Department of the Interior

U.S. Department of Transportation

U.S. Department of Agriculture

National Oceanic and Atmospheric Administration

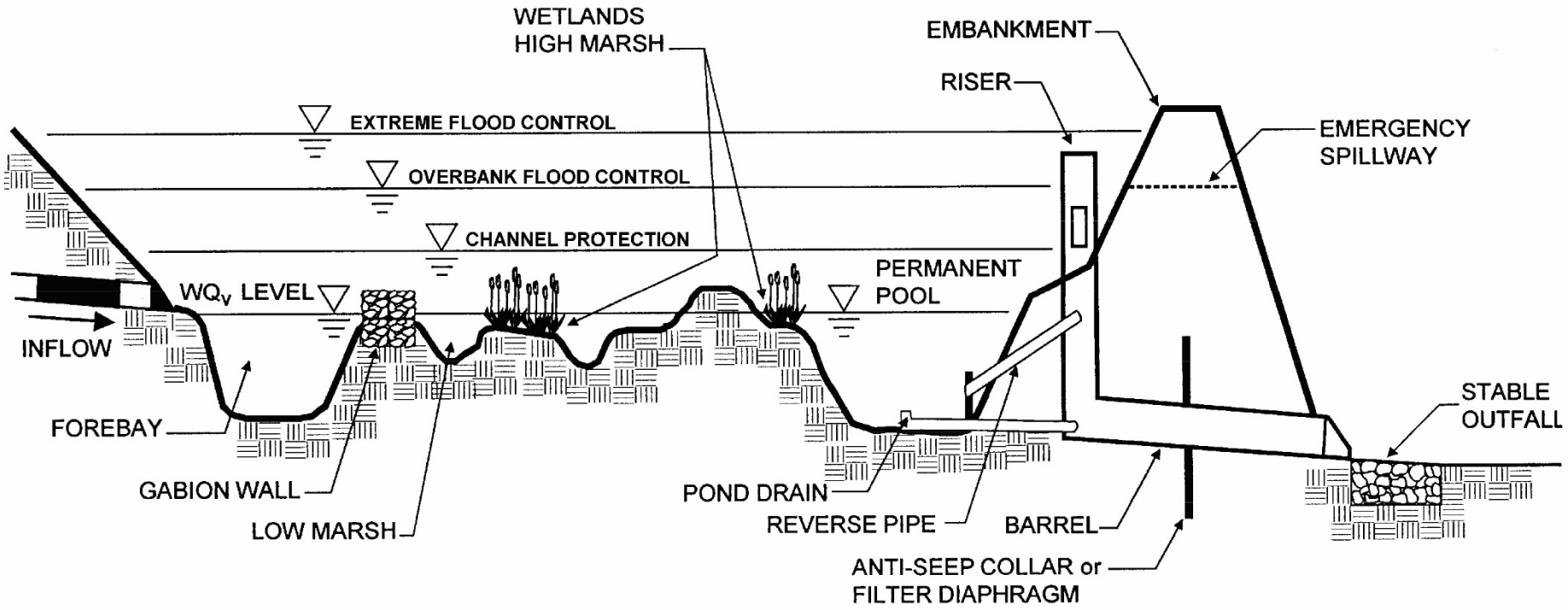
U.S. Economic Development Administration

U.S. Environmental Protection Agency

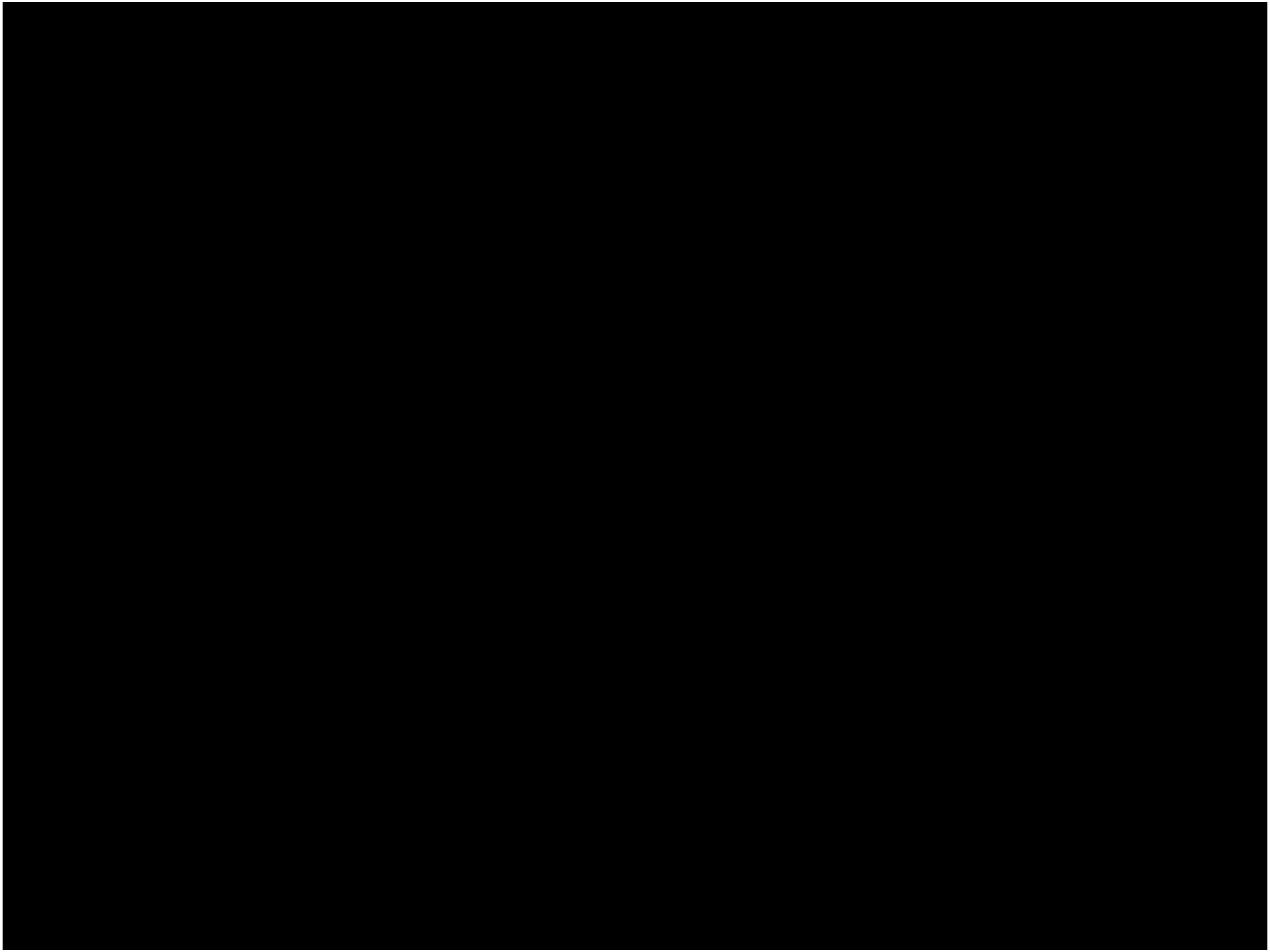
Adapted from: U.S. Environmental Protection Agency. 2016. *"Green Infrastructure Funding Opportunities."* https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities

Guidelines for the Design of Constructed Treatment Wetlands

- Minimal impact
- Natural structure
- Buffer zones
- Vector control
- Hazing/exclusion devices
- Biological diversity and physical heterogeneity
- Seasonality and capacity
- Forebays
- Multiple cells
- Public acceptance
- Public use
- Pilot project and design criteria
- Dedicated water sources
- Maintenance access



Adapted from: U.S. Environmental Protection Agency. 2009. *"Stormwater Wet Pond and Wetland Management Guidebook."* https://www3.epa.gov/npdes/pubs/pondmgmtguide.pdf



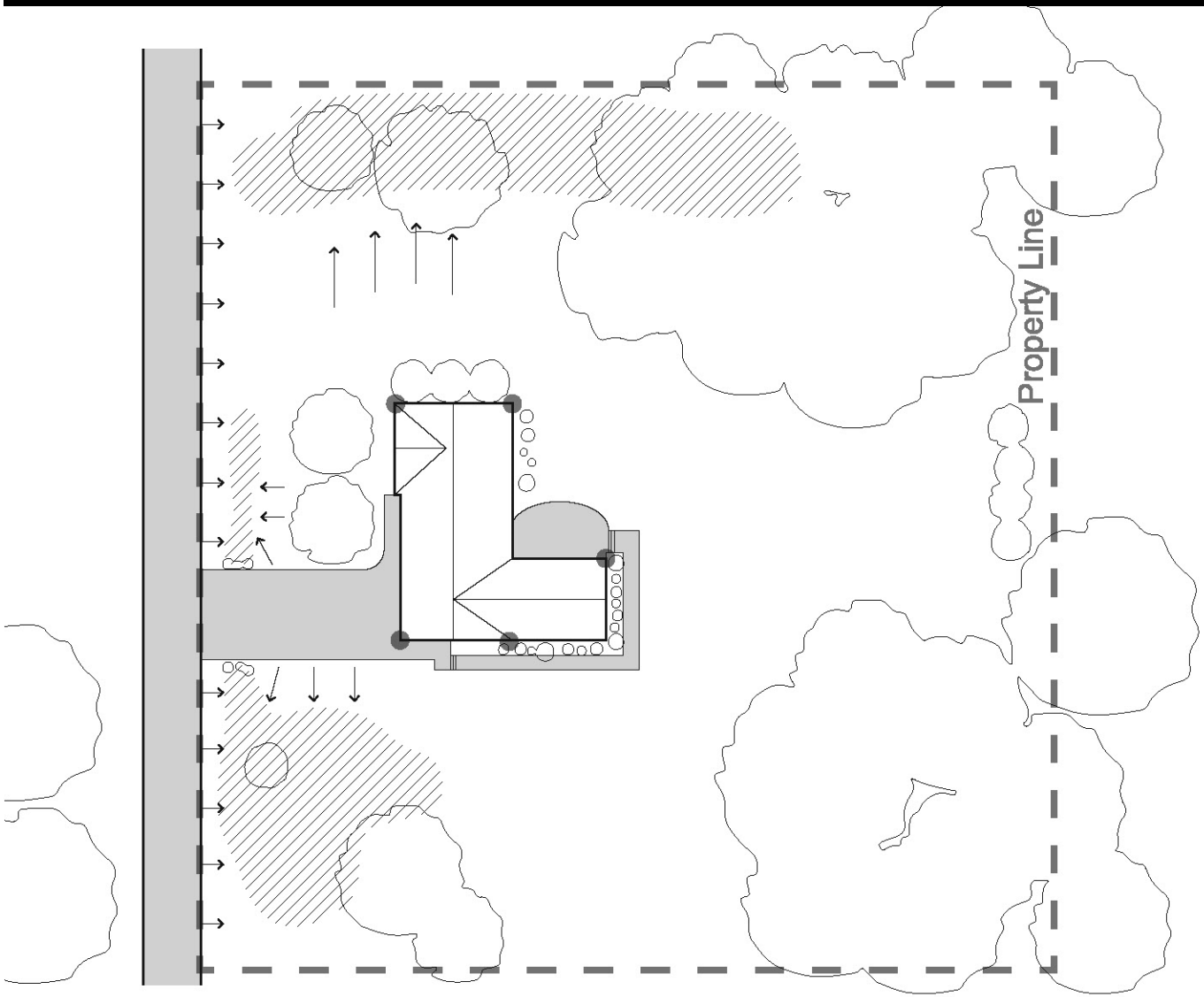
Wastewater Treatment

Improving existing infrastructure

DESCRIPTION

Gray infrastructure includes critical systems[1] that provide sanitation and stormwater control for communities. According to the Third National Climate

Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.



For a 1" rainstorm, use the following equation:

(sq ft of impervious area) x
.0833 x 7.48
= ___ gallons of runoff

Implement stormwater management practices:

- Rain garden
- Riparian buffer
- Tree planting
- Native meadow
- Pervious pavers
- Rain barrel

Impervious Areas
Areas of Ponding
Roof Downspouts
Stormwater Flow Paths

Adapted from: Lancaster County Convervation District. 2013. *"The Homeowner's Guide to Stormwater."*
www.stormwaterguide.org/static/HomeownersGuide.pdf

Structural Adaptations to Climate Change for the NYSDOT

Storm Surge and Sea Level Rise

- Grade and raise roads
- Flood proof areas by constructing levees, sea walls, floodgates and pump stations
- Construct road embankments as super levees to serve as flood protection and transportation corridors
- Redesign bridge protection based of scour pattern
- Design ditches for an increase in storm intensity
- Relocate roads and critical systems to higher elevations

Intense Precipitation

- Increase the carrying capacity of drainage systems
- Maintain facilities in order for design capacity performance
- Raise embankments and strengthen slopes
- Move roads away from future flood zones
- Monitor and fix scour at bridge foundations
- Reduce runoff onto roads from other properties through implication of permeable surfaces, retention basin, regrade slope away from transportation, etc.

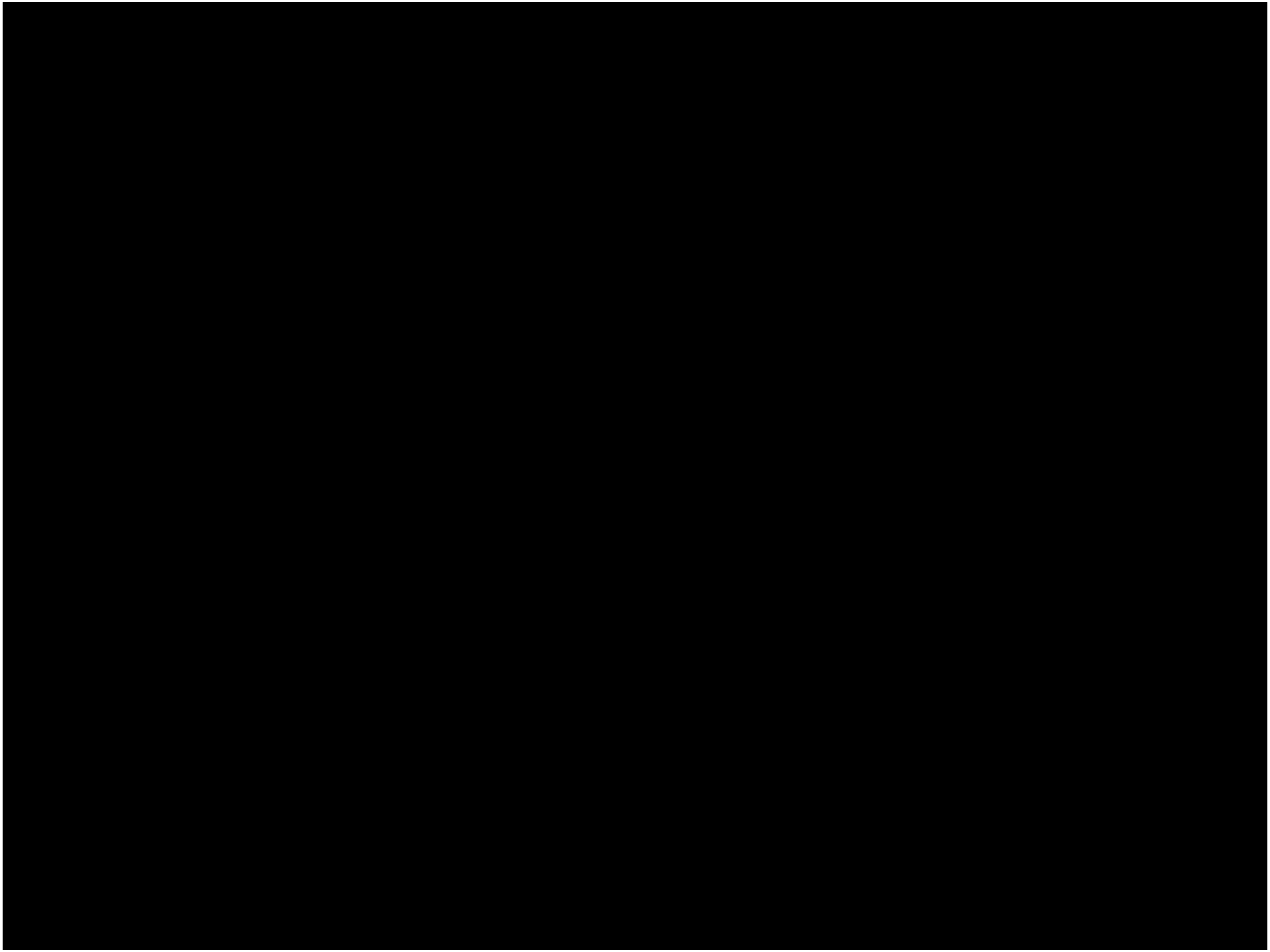
Adapted from: *Mainstreaming Climate Change Adaptation Strategies into New York State Department of Transportation's Operations: Final Report.* https://www. dot.ny.gov/divisions/engineering/technical-services/trans-r-and-d-repository/C-08-09_synthesisfinalReport1.pdf

Risk Assessment: Impact of Climate Change on Wastewater

Minor Risk Moderate Risk Major Risk

Hazard	Today	2020s	2050s	
Gradual				
Sea level rise				Compromised operability during heavy rain events will lead to releases of untreated sewage into waterways.
Increased precipitation				Combined sewage and stormwater will overload treatment plants, leading to releases of untreated sewage into waterways.
Higher temperatures				Minimal impact
Extreme Events				
Storm surge				Asset damage and power disruption can lead to releases of untreated sewage into waterways.
Heavy downpour				Combined sewage and will overload treatment plants, leading to releases of untreated sewage into waterways. Exceeded sewer system capacities will lead to street flooding and sewer backups.
Heat wave				INDIRECT: Utility power outages can lead to reduced treatment levels and sewage bypass.
High winds				Minimal impact

Adapted from: PlaNYC. 2013. *A Stronger, More Resilient New York.*
http://www.nyc.gov/ html/sirr/html/report/report.shtml



Roof Covering

UNDERSTANDING THE IMPACT OF BUILDING HEAT ABSORPTION

LOCATION

LOW MEDIUM HIGH

HAZARDS

HEAT WAVES

RELATED STRATEGIES

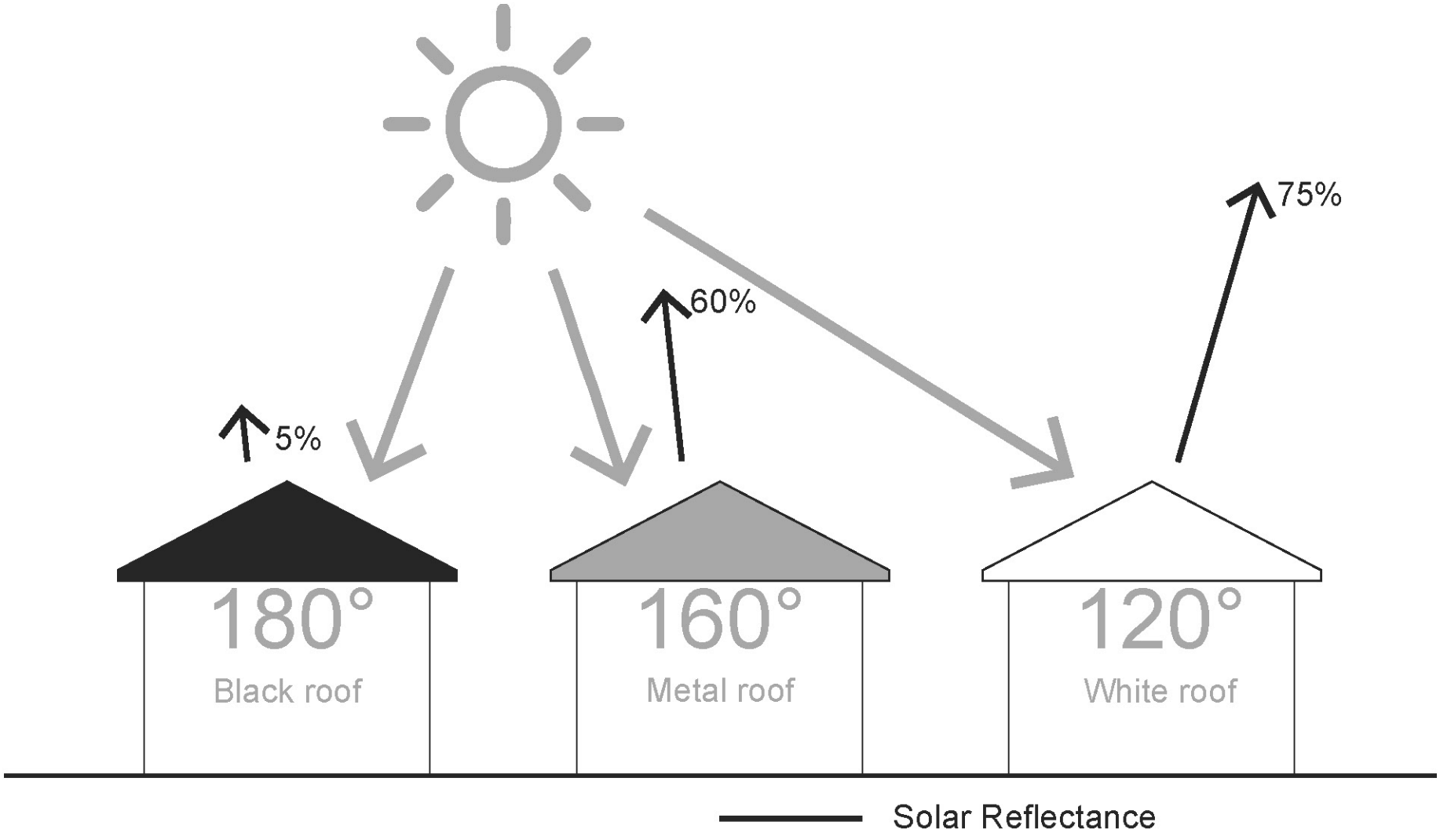
Green Infrastructure
Roof Drainage
Insulation
Urban Heat Island
Reclaimed Water Systems

DESCRIPTION

Building roofs absorb excessive amounts of heat, which radiates into buildings and increases the demand for active cooling systems. The absorbed heat can

SUNY ESF Gateway Center

Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.



Adapted from: U.S. Environmental Protection Agency. 2008. *"Reducing Urban Heat Islands: Compendium of Strategies."* https://www.epa.gov/sites/production/files/2014-06/documents/ coolroofscompendium.pdf

Benefits of Green Roofs

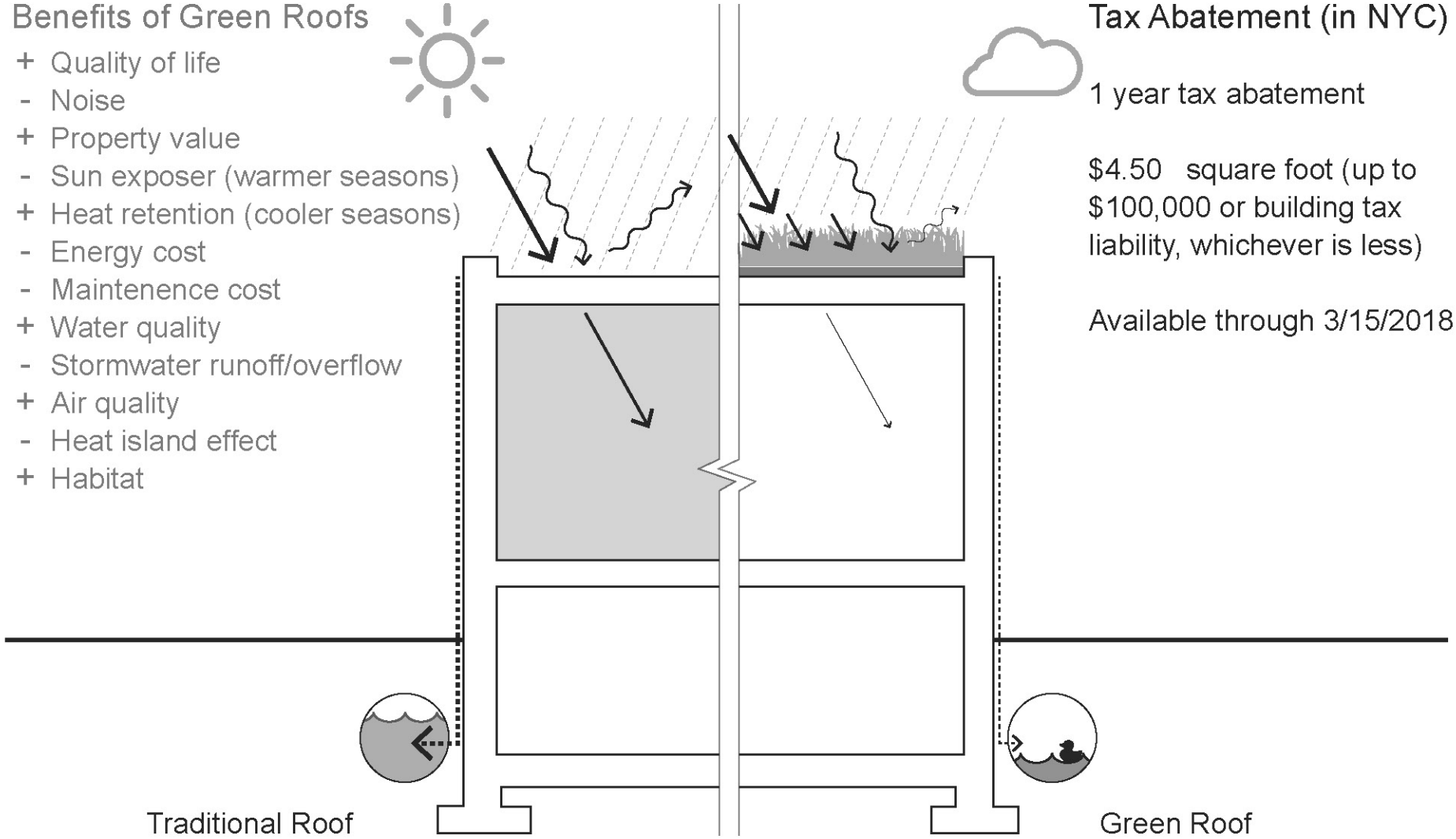
+ Quality of life
- Noise
+ Property value
- Sun exposer (warmer seasons)
+ Heat retention (cooler seasons)
- Energy cost
- Maintenence cost
+ Water quality
- Stormwater runoff/overflow
+ Air quality
- Heat island effect
+ Habitat

Tax Abatement (in NYC)

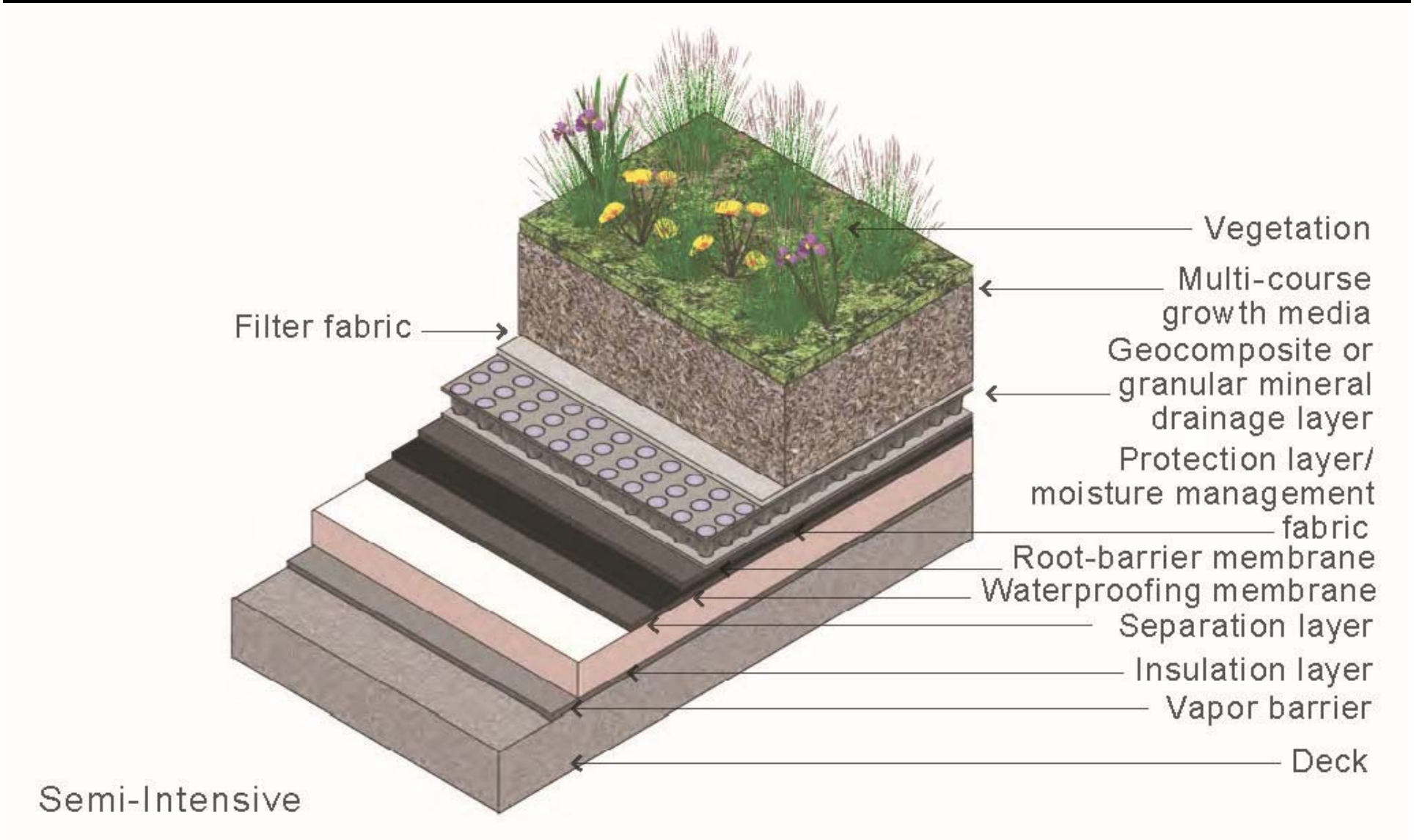
1 year tax abatement

$4.50 square foot (up to $100,000 or building tax liability, whichever is less)

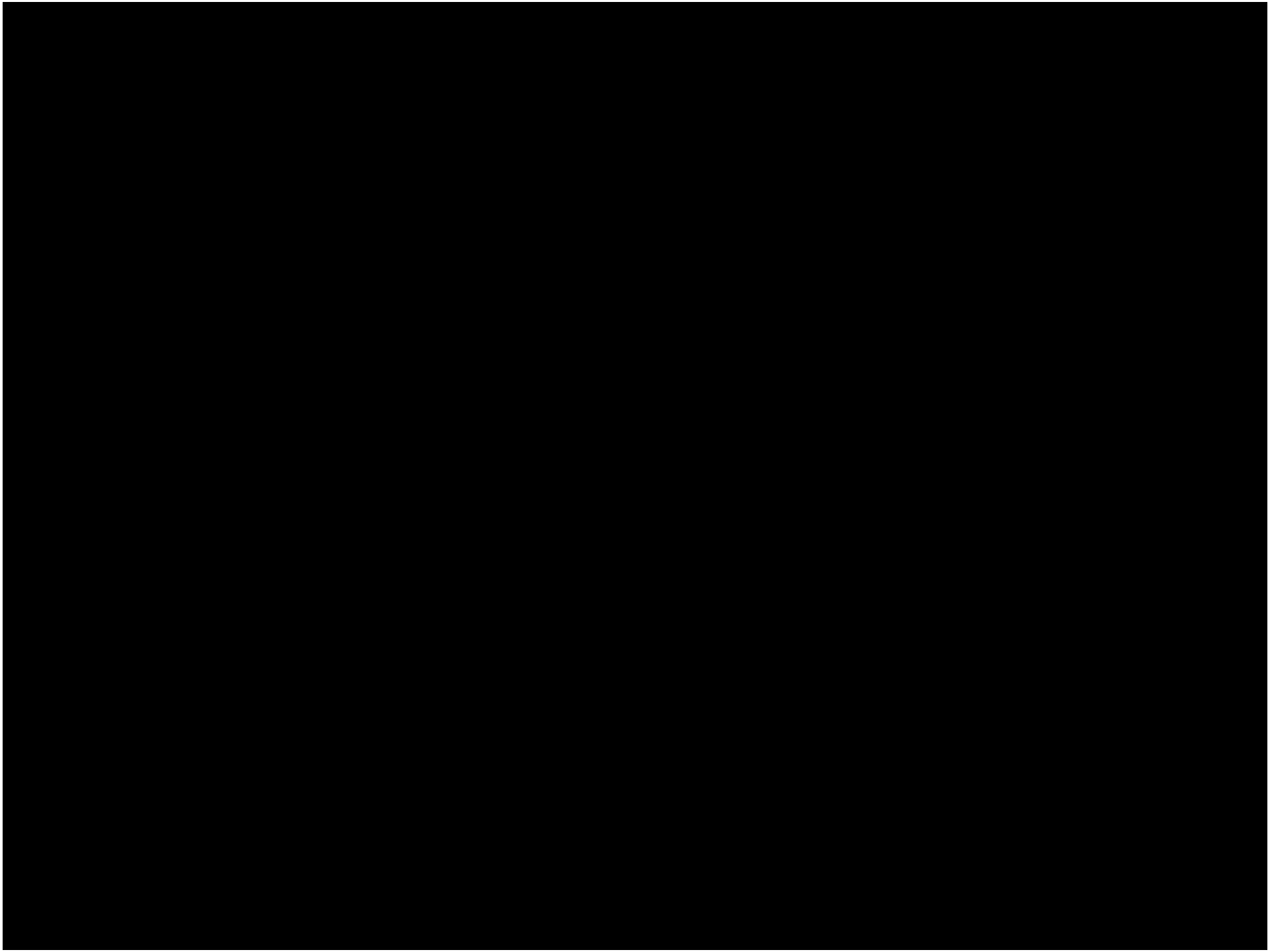
Available through 3/15/2018



Adapted from: NYC Mayor's Office of Sustainability. 2016. *"Green Roof Tax Abatement."* http://www.nyc.gov/html/gbee/html/incentives/roof.shtml



Adapted from: Miller, C., et al. 2011. *"The Benefits and Challenges of Green Roofs on Public and Commercial Buildings."* http://www.gsa.gov/portal/mediaId/158783/fileName/The_Benefits_and_Challenges_of_Green_Roofs_on_Public_and_Commercial_Buildings.action



Roof Drainage

ADDRESSING EXTREME AMOUNTS OF PRECIPITATION

LOCATION

HAZARDS

SEVERE STORMS

WINTER STORMS

HURRICANES / TROPICAL STORMS

RELATED STRATEGIES

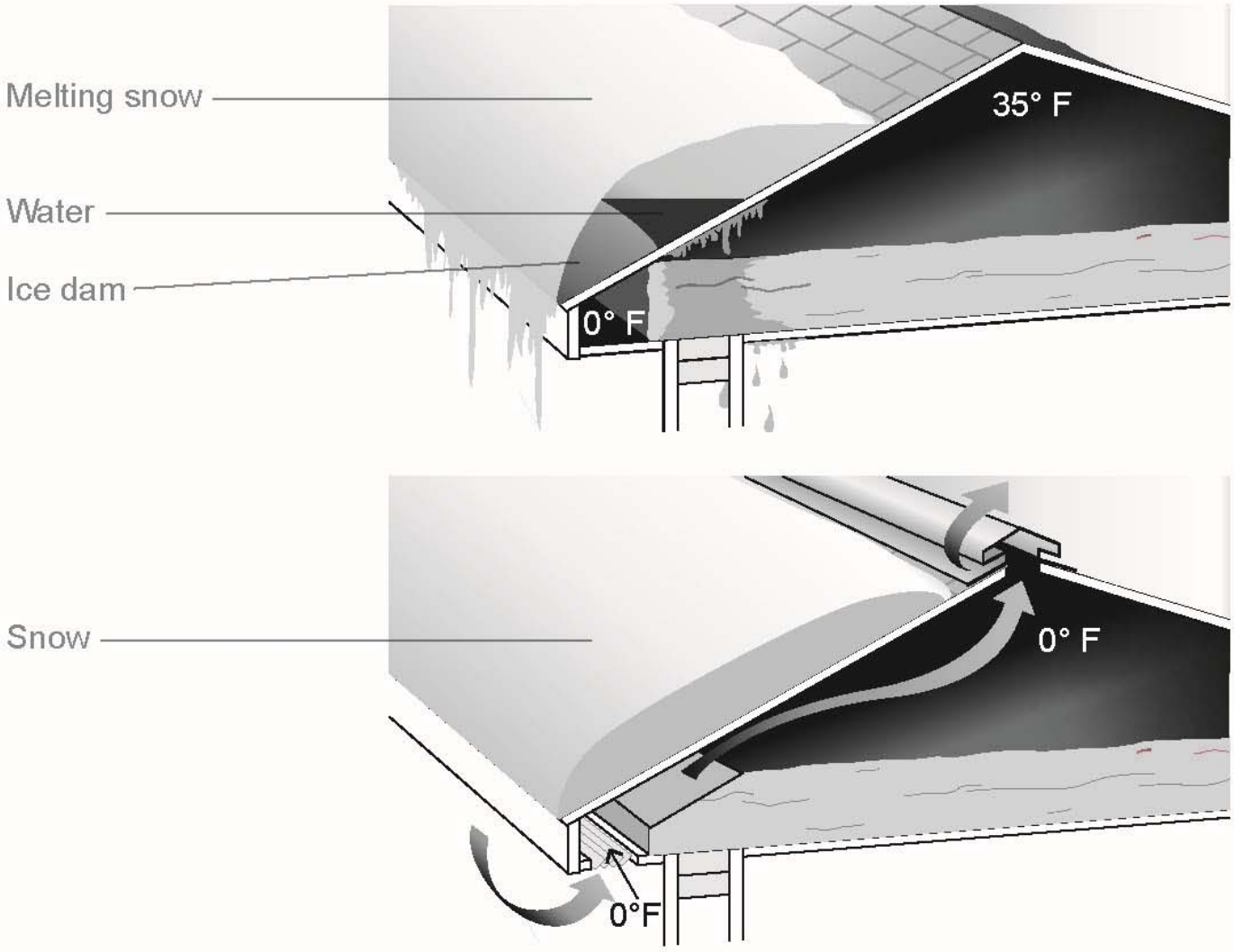
Building Flood Protection
Building Systems Flood Protection
Green Infrastructure
Gray Infrastructure
Roof Covering
Reclaimed Water Systems

DESCRIPTION

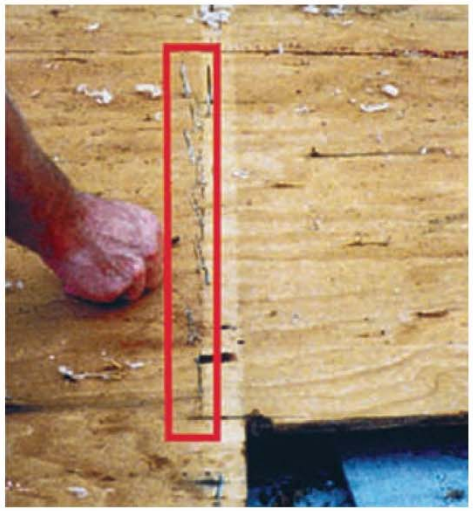
The Responding to Climate Change in New York State states that New York will likely experience increased amounts of precipitation[1] in the coming years as a

Snowvember 2014

Rajkovich, Nicholas B., Michael E. Tuzzo, Nathaniel Heckman, Krista Macy, Elizabeth Gilman, Martha Bohm, and Harlee-Rae Tanner. 2018. *Climate Resilience Strategies for Buildings in New York State*. NYSERDA, Albany, New York.



Adapted from: Straube, John. 2006. *"BSD-135: Ice Dams."*
http:// buildingscience.com/documents/digests/bsd-135-ice-dams



Inspect roof cover: material condition is critical to performance

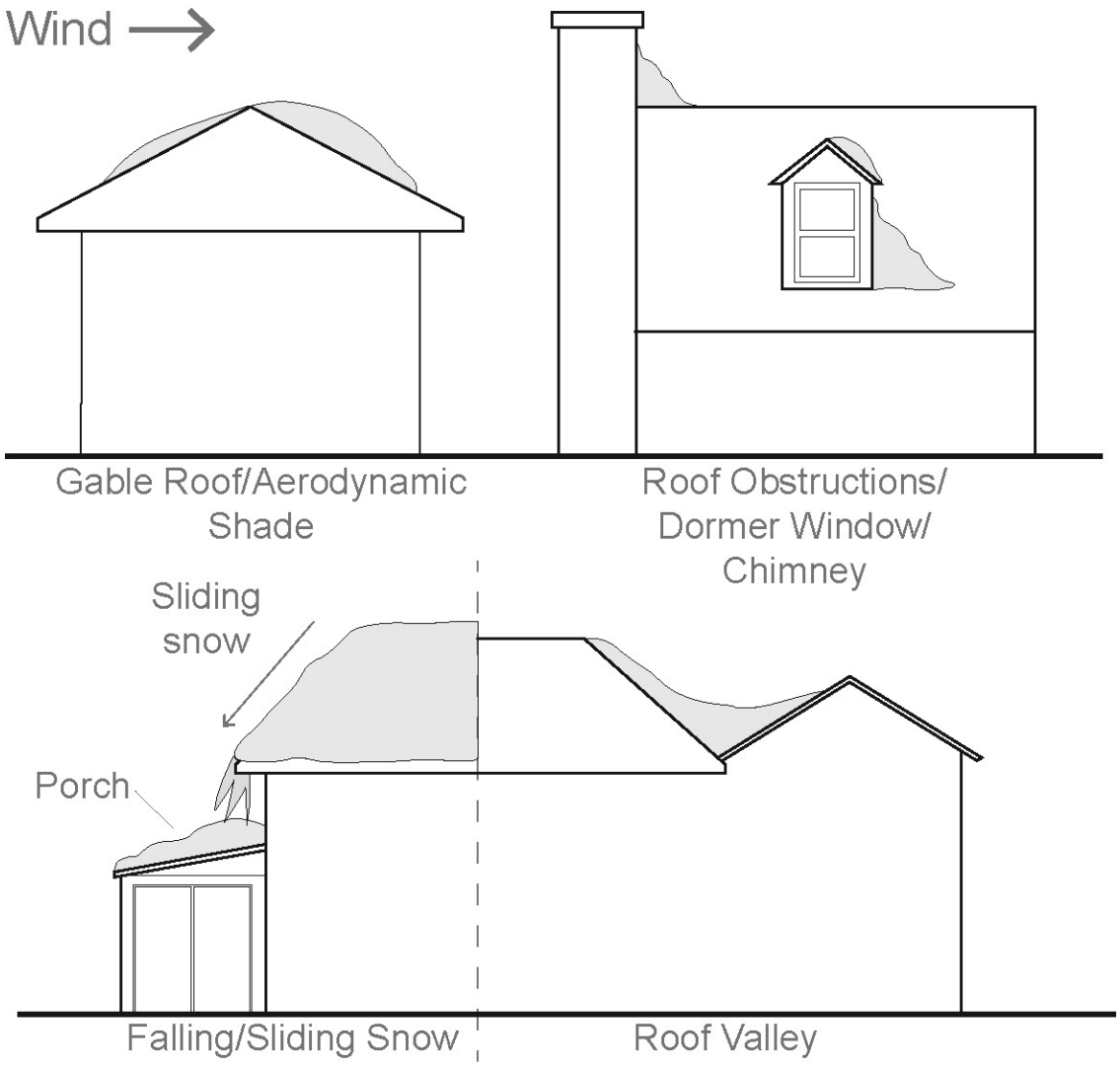
Inspect penetrations: look for poorly sealed gaps or holes

Inspect off-ridge vents: make sure they are well attached

Inspect ridge vents: make sure they are tightly screwed to roof

Inspect for roof leaks: check for leaks in attic, water stains or discoloration of decking or structure, water stains on the ceiling, cracked paint, and peeling wall paper

Adapted from: Green Seal. 2016. *"About Green Seal."*
http://www.greenseal.org/AboutGreenSeal.aspx



Unbalanced snow loads offer a greater risk for structural failure than balanced snow loads

Short span structures are less vulnerable to failure from excessive snow loading and less apt to deflection, ponding, and improper roof drainage

Heavier structural materials have a lower tendency to fail from excessive snow loads than lighter materials

Adapted from: Federal Emergency Management Agency. 2013. *"Snow Load Safety Guide."* https://www.fema.gov/media-library-data/7d8c55d1c4f815edf3d7e7d1c120383f/FEMA957_ Snowload_508.pdf