Hudson Waterfronts on the Rise

Climate-adaptive Design Studio

Regional Look Book

2015-2022

Acknowledgments

We humbly acknowledge that the Hudson Valley is the ancestral homeland of the Lenape and Muhheaconneok people, and that these nations were removed from the land through forced dispossession that caused tremendous hardship. We respect the relationships that exist between indigenous people and the land and waterways. While the Hudson is currently named for a European explorer, the indigenous name is Muhheacannituck, “the waters that are never still”. We understand that this acknowledgement is just a small step in the process of building a more inclusive and equitable space for all.

We would like to express our thanks to our key municipal partners since the inception of the CaD studio in 2015: the cities of Hudson, Kingston, and Poughkeepsie; the Villages of Catskill, Piermont, Tarrytown, and the Town & Village of Ossining. The studio would not have been possible without the interest, guidance, and insights of stakeholders in these communities, including residents, community-based organizations, waterfront users, and business owners.

We greatly appreciate the expertise and assistance provided by a variety of Hudson Valley organizations, including NYS Department of Environmental Conservation, NYS Department of State, the Hudson River National Estuarine Research Reserve, Cornell Cooperative Extension associations, Scenic Hudson, and Riverkeeper. We would also like to thank the Cornell faculty, research fellows, research and teaching assistants who have worked with us over the years. Special thanks to the many students who have participated in the CaD studio, some of whose work is displayed here.

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Sincerely,

The CaD Team

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Cover Image:
Kingston studio, 2018
Tuning Up
Yixuan Li
Xining Wan

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Who We Are

A dynamic public-academic partnership

The Climate-adaptive Design (CaD) studio is a design studio course led by Cornell University Associate Professor Josh Cerra. The studio links landscape architecture students with Hudson riverfront communities to explore design ideas for more climate resilient and connected waterfront areas.

The CaD studio is an education and research effort made possible by a partnership between the Cornell University Department of Landscape Architecture, the NYSDEC Hudson River Estuary Program, the NYS Water Resources Institute, and host communities in the Hudson Valley.

What We Do

Inspiring change for waterfront communities

The CaD studio is a semester-long landscape architecture studio course that engages a riverfront community in a design process focused on their waterfront.

Students study climate change impacts and use the NYS official sea-level rise projections to propose a variety of design strategies for the waterfront.

During the course of the studio, students meet with stakeholders to understand community issues and interests with respect to the waterfront, and seek feedback on design ideas.

By semester's end, the students have created a set of creative and insightful designs for the host community to access during their ongoing dialogues on waterfront adaptation.

Why We Do It

The CaD team wants to help communities...

- Start the conversation on what change could look like on their waterfront.
- Feel inspired and knowledgeable about adapting to climate change, especially by using natural and nature-based solutions.
- Apply CaD concepts and principles during planning and decision making.
- Access new funding and resources.
- Communicate with regulatory agencies.
- Increase public awareness and support for climate adaptation projects.
- Advance CaD-inspired design projects toward implementation.

The Hudson River Valley

Making strides toward greater sustainability and resilience

The Hudson Valley is a vibrant region located in the eastern portion of New York State, stretching from New York Harbor to the Federal Lock and Dam in Troy. Encompassing ten counties north of New York City, the Hudson Valley is a dynamic mix of urban centers, scenic landscapes, farms and forests, suburban areas, and historic locales. The river hosts a wide range of waterfront uses including commercial, residential, recreational, ecological, transportation, and industrial. The Hudson Valley has played a significant role in the history of the United States and the development of the modern environmental movement. Once heavily impacted by chemical and organic pollutants, the Hudson is undergoing a rehabilitation, thanks to the efforts of many people and organizations. Today, there is a resurgence of interest in this ecologically important waterway.

Even as the river recovers from past abuses, Hudson Valley communities face threats from climate change including increasing temperatures, and flood risks from heavy precipitation events, storm surge, and sea-level rise. Municipalities are responding to the climate crisis by participating in state initiatives such as the NYS Climate Smart Communities and Local Waterfront Revitalization programs, joining regional entities like the Hudson River Flood Resilience Network, conducting climate adaptation planning, and hosting the Climate-adaptive Design studio.

Climate Risk on the Hudson

Flooding due to extreme precipitation, stormwater runoff, storm surge, and sea-level rise.

Temperature extremes impacting seasonal conditions and causing dangerous heat waves.

Disrupted precipitation patterns leading to greater likelihood of short-term drought.

Flooding and Sea-level Rise

- The 1% or “100-year” floodplain is defined as a waterfront area that has a 1% chance of flooding in any year, based on historical data.
- Added up over time, there is a 25% chance of such a flood happening over the span of a 30-year mortgage, making floodplain properties vulnerable to damage.
- These floods are likely to occur more frequently and impact more of the waterfront by the 2050s due to projected sea-level rise and intense precipitation.
- In 2017, NYS adopted official projections for sea-level rise, stating that by the 2080s, sea level in the Hudson could be as high as 58” above baseline levels. CaD studios used these projections to guide design concepts through 2023.

Ossining’s waterfront provides an example of increasing flood risk in many Hudson River towns. Depths of temporary flooding from the “100-year” or 1% annual chance flood for the 2020s baseline condition. Darker blue = greater depth.

Inundation depths (blue) and temporary flooding depths (green) for the “100-year” or 1% flood on the Ossining waterfront with 60” of projected sea-level rise, which could occur as soon as the 2080s, according to NYS official projections.

Data source: Columbia University Hudson River Flood Impact Decision Support System Version 2

CaD Studio Host Communities

New York State's Hudson Valley

The first CaD studio was hosted by the **Village of Catskill** in 2015. The studio focused on the tidal portion of the Catskill Creek.

In 2016, the **City of Hudson** hosted the studio which focused on its southern waterfront, including the South Bay..

Grants from the USDA and NYS WRI supported three CaD studios in the **City of Kingston** in 2016, 2017, and 2018. The studios focused on the Rondout Creek and the Hudson River.

The **Village of Piermont** hosted the studio in 2017, with a focus on flood risk in downtown, as well as the Hudson riverfront, and Sparkill Creek neighborhoods.

The studio was hosted by the **Town and Village of Ossining** in 2019, with a focus on the Hudson waterfront and the Sing Sing Kill.

In 2021, the **City of Poughkeepsie** hosted the CaD studio. The study area included the Fall Kill, Waryas Park, Kaal Rock Park, and the former DeLaval site.

In 2022, the **Village of Tarrytown** hosted the studio, with a study area that included the waterfront, train station, and downtown.

Stakeholder Insights

Stakeholder meetings in all of the CaD communities identified some common themes, challenges and opportunities.

Key Themes

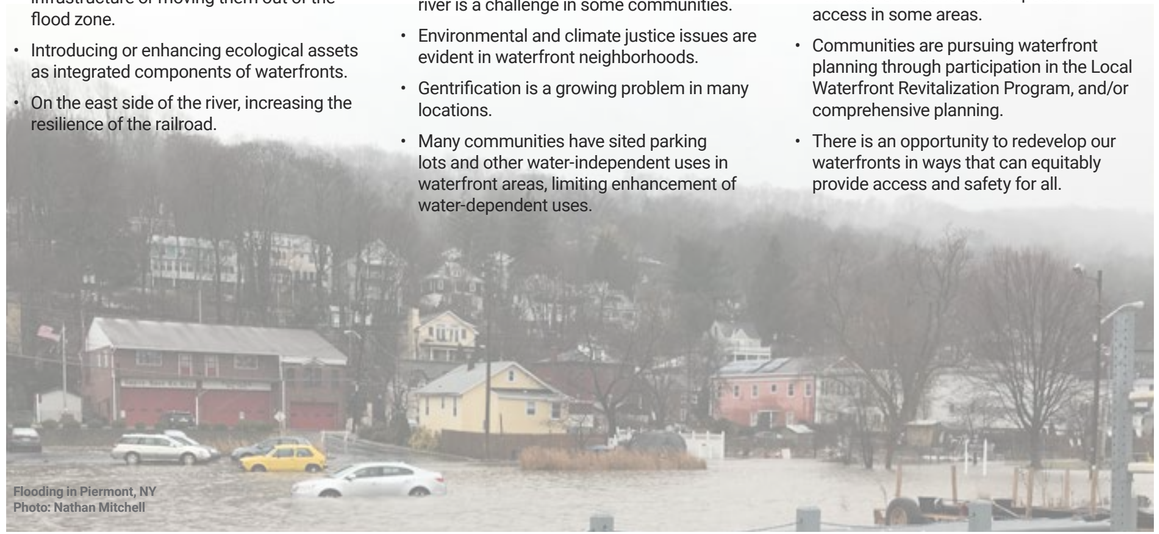
- Enhancing waterfront access & circulation.
- Improving connections between the waterfront and downtown areas.
- Encouraging economic development and historic preservation.
- Attracting tourists while enhancing amenities for residents.
- Adapting key roads, buildings, and infrastructure or moving them out of the flood zone.
- Introducing or enhancing ecological assets as integrated components of waterfronts.
- On the east side of the river, increasing the resilience of the railroad.

Challenges

- Most of the study areas are already at flood risk. New York State official sea-level rise projections indicate that some areas will be inundated in the future.
- Key assets, such as wastewater treatment infrastructure, fire stations, and municipal buildings, are at risk and must be floodproofed and/or relocated.
- Adequate and equitable public access to the river is a challenge in some communities.
- Environmental and climate justice issues are evident in waterfront neighborhoods.
- Gentrification is a growing problem in many locations.
- Many communities have sited parking lots and other water-independent uses in waterfront areas, limiting enhancement of water-dependent uses.

Opportunities

- Community interest in the waterfront is growing, and tourism is increasing.
- Improvements to boating and recreational infrastructure have enhanced river access.
- Brownfield cleanup and redevelopment provides opportunities for new development and river access.
- The Empire State Trail and other regional trail networks can enhance pedestrian access in some areas.
- Communities are pursuing waterfront planning through participation in the Local Waterfront Revitalization Program, and/or comprehensive planning.
- There is an opportunity to redevelop our waterfronts in ways that can equitably provide access and safety for all.



Flooding in Piermont, NY
Photo: Nathan Mitchell

Protecting The River That Connects Us

The Hudson Estuary

The Hudson flows for 314 miles from the Adirondack Mountains to New York Harbor. For half of its length, the Hudson is an estuary, a place where salt and fresh water mix. Daily tides from the Atlantic Ocean reach over 150 miles from New York Harbor to the Federal Dam in Troy.

Estuaries are nurseries for ocean fish, such as striped bass, American shad, and Atlantic sturgeon, which swim into the river to lay their eggs each spring. In this way, the health of the Hudson is directly connected to the condition of the marine ecosystem in the Atlantic Ocean.

In the past, much of the Hudson shoreline was characterized by shallow water habitats that provided ample food and shelter for fish and wildlife, which also supported the well-being of human inhabitants.

A History of Shoreline Development

The Hudson's natural shorelines have been dramatically altered by human development. According to the Hudson River Comprehensive Restoration Plan nearly half of the shoreline from the Mario M. Cuomo Bridge to the Troy dam has been altered. The natural shoreline has been converted to bulkheads, riprap, dikes, and other hard structures intended to protect property from erosion or to facilitate industry, transportation, or cultural use[2].

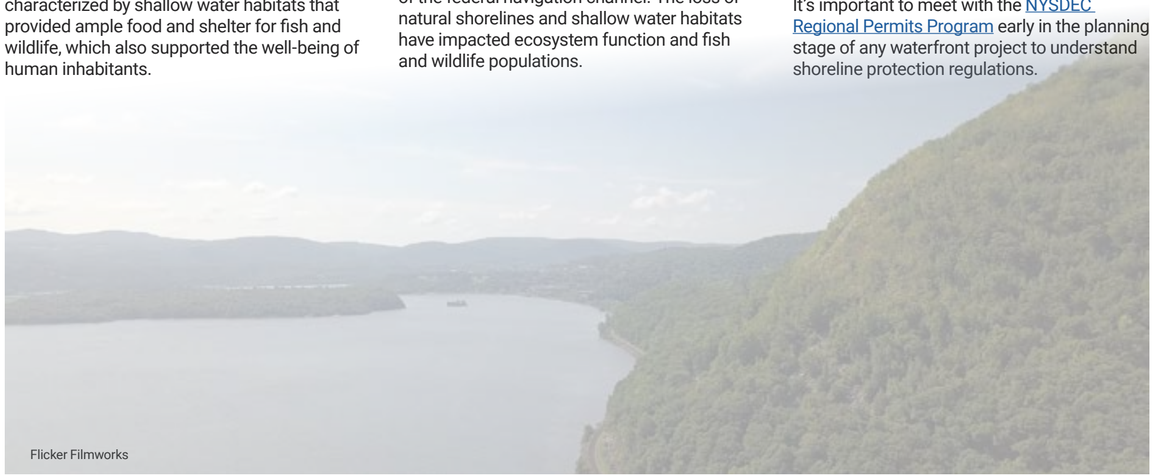
Comparisons between modern and historic maps estimate that 71 miles of shoreline in the upper estuary were eliminated when backwaters were filled during construction of the federal navigation channel. The loss of natural shorelines and shallow water habitats have impacted ecosystem function and fish and wildlife populations.

Looking to the Future

How communities respond to sea-level rise will affect the health of the Hudson. Protecting against flooding by building hard structures, like sea walls and levees, can lead to unintended consequences. When barriers are overtopped by floodwaters serious damage can occur. Hard structures may increase erosion and flooding in other locations and do not commonly provide habitat value.

If your community has critical infrastructure that may require the protection of hard structures, a good reference to start with is 10 Questions to Ask When Building Defenses to Protect Hudson River Shorelines.

It's important to meet with the NYSDEC Regional Permits Program early in the planning stage of any waterfront project to understand shoreline protection regulations.



Flicker Filmworks

The Future of Hudson Habitats

Sea-level Rise and Tidal Marshes

The Hudson estuary currently includes over 7,000 acres of tidal wetlands, which protect shorelines, trap greenhouse gases that contribute to climate change, and help keep water clean. Freshwater tidal wetlands, like those in the northern reaches of the estuary, are globally rare and very valuable to young fish and other animals.

Sea-level rise is influencing where tidal wetlands can flourish, with many mudflats and marshes likely to become submerged by rising waters. If sediment accumulation, or accretion, keeps pace with rising waters, wetlands may persist. Marsh plants may be able to migrate inland as water levels rise. But, in many areas existing development and hardened shorelines are at odds with inland marsh migration.

Protecting Marsh Migration Pathways

Scenic Hudson's Protecting the Pathways is a climate change adaptation initiative for tidal wetlands in the Hudson River Estuary. Their interactive map predicts which wetland areas will be gained or lost under different sea-level rise and sediment accretion scenarios. The map also indicates where development could be in conflict with marshes migrating inland to maintain their viability.

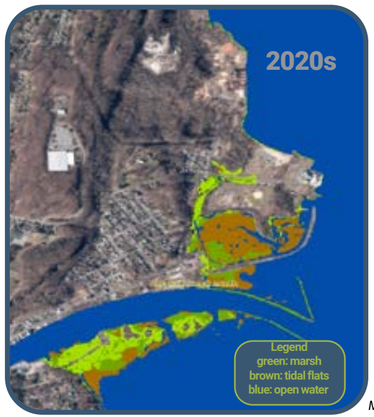
We recommend that communities consult the marsh migration mapper when considering development decisions on their waterfronts. This tool can be used to prioritize conservation efforts in areas that currently support wetlands as well as those that are projected to be future marsh due to sea-level rise.

Restoring Hudson's Habitats

Initiatives to protect natural landscapes and restore critical habitats are ongoing. Land use ordinances, dam removals, and efforts to restore vegetated stream banks and wetlands are important to the health of the estuary.

The Hudson River Comprehensive Restoration Plan was produced in 2018 by a consortium of non-profit organizations, public agencies, municipalities, and academic institutions. The plan includes an assessment of current conditions and sets goals for ecosystem restoration and community resilience.

Read the 2020 State of the Hudson for up-to-date information on challenges the river faces and accomplishments in addressing them.

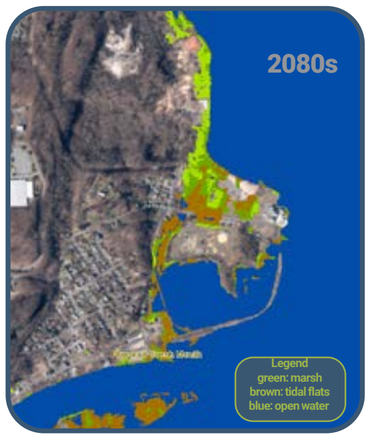


These images from Scenic Hudson's Sea-level Rise and Marsh Migration Mapper depict Kingston Point, which is located at the confluence of the Rondout Creek and the Hudson River in the City of Kingston.

The map on the left indicates the location and types of tidal wetlands currently present.

The map on the right indicates the location and types of tidal wetlands projected to exist in the 2080s under a high sea-level rise, medium sediment accretion scenario.

Under these conditions, the model predicts a significant loss of wetlands in the southern portion of the study area, but a growth in wetlands to the north. A portion of the area has been conserved by Scenic Hudson.



Maps source: Scenic Hudson Sea-level Rise & Marsh Migration Mapper

Section 1

Section 2

Design Strategies

Section 3

Kingston studio, 2018
Ponckhockie: Generator
Andrew Berger
Carsten Schmidt

CaD Principles

The CaD studio focuses on five key principles in its approach to waterfront design. These principles guide student work and inform the concepts they develop.

Design a Destination
Maximize the value of a waterfront by encouraging water-dependent & water-enhanced uses, like marinas, beaches & restaurants.

Design for Flooding
Work with water instead of working against it by pursuing adaptation strategies and considering options for relocation.

Design with Nature
Preserve & enhance natural areas on the waterfront & use nature-based techniques for erosion control & stormwater management.

Design with Community
Working closely with stakeholders can lead to projects that contribute to the well-being & prosperity of the entire community.

Design for Change
Create places that continually provide value under changing conditions. Phase projects over time in ways that are both practical & visionary.

Each CaD studio explored a number of strategies that are based on the CaD principles. The following pages provide brief introductions to the design strategies. Full designs from each studio can be viewed at https://trophic.design/cad/

Before You Turn the Page...

Each strategy comes along with Actions to Take -some that you can do today and others that will take more time and planning to implement.

Each strategy also features student work to visualize possible ways they could be used.

Five icons flag important facts about each strategy. Descriptions about these types of information are detailed here:

+ This section describes how the strategy can create benefits both for people and the ecosystems.

$ Click here or go to page 39 to find sources of funding.

! Important considerations for each strategy are indicated by this icon.

CSC These numbers correspond to Climate Smart Community Actions that can earn points for your city. Click on the icon or visit page 42 to learn more.

? For more information about a strategy, explore the references in this section, located on page 40.

If you are viewing the LookBook on the computer, click the icon to see more information!

Resilient Waterfront Parks

Waterfront parks are an excellent choice for flood-prone areas - they offer recreational opportunities, shoreline access and wildlife habitat, while reducing vulnerability and risk. Waterfront parks should be designed with input from residents to meet the needs of the community and be universally accessible to people of diverse abilities and resources. Parks can be designed to accommodate floodwaters and graded to drain quickly.

Installing or improving waterfront parks may also have unanticipated consequences. The term “green gentrification” describes inequities linked to environmental improvement projects. Greening of urban areas may increase local property costs and displace lower-income residents. Strategies to avoid green gentrification should be part of a park planning process.

Actions To Take

- ☐ Consult resources such as the *Flood Resilience Handbook for Public Access Sites Along the Hudson River* to analyze the resilience and accessibility of current and planned waterfront parks.
- ☐ When establishing new parks and promenades in future flood-prone areas, identify flood-adapted uses and features that can recover quickly from storm impacts.
- ☐ The design of a floodable park should include recommendations for flood-resilient plants and trees.
- ☐ Review policies and procedures of the parks department and revise as needed to require more climate-adaptive and sustainable practices.
- ☐ Evaluate the feasibility of installation of green infrastructure to capture stormwater when designing or evaluating waterfront parks.

+ Naturalized land cover helps to keep urban areas cooler and allows stormwater to infiltrate while providing habitat for wildlife and health benefits for people.

$ DEC HREP || DEC CSC || EFC GIGP || DOS LWRP || OPRHP || Hudson River Valley Greenway

! Municipalities can protect residents by enacting rent control laws, increasing affordable housing availability and working with a Community Land Trust to promote home ownership.

CSC 7.8 || 7.12 || 7.14 || 7.15 || 7.16

? Flood Resilience Handbook for Access Sites Along the Hudson River
High Performing Landscape Guidelines: 21st Century Parks for NYC
Naturally Resilient Communities

Kingston, 2017
Actipelago
Yifu Kang & Xuru Yuan

Flexible open space can be periodically inundated by flooding without major infrastructure impacts. Flood-tolerant vegetation provides habitat and aesthetic benefits.

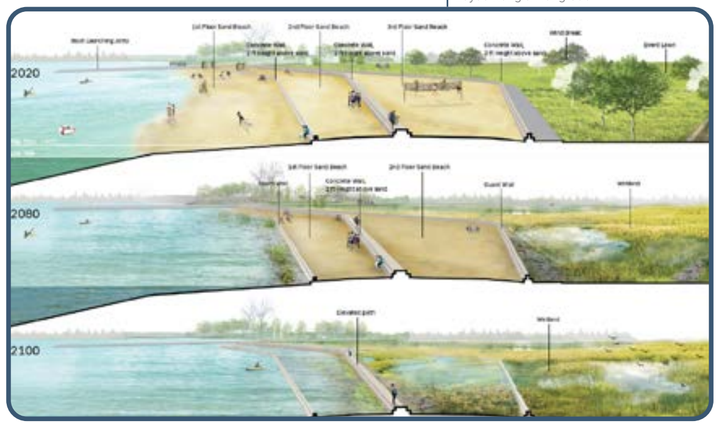
Park spaces can have a flexible program and compatible infrastructure that allows for periodic flooding.

Tarrytown, 2022
Traces of Change
Vanessa Dikuyama Zapata

Poughkeepsie, 2021
Permeable Connection
Kate Flaherty

Hillsides or elevated areas in a flood-prone park can be taken advantage of to create assets outside of the floodplain, such as an elevated amphitheater for performance and gatherings.

Kingston, 2017
Weaving the Waterfront
Luyao Kong & Hong Gao



In response to interest in preventing erosion and prolonging the use of a beloved beach in Kingston, this design envisions a terraced waterfront with a set of three linear elements which become elevated waterfront walkways as water level rises, converting the sandy shore to a vegetated marsh in the 2100s.

Sustainable Shorelines

Nature-based shoreline techniques provide erosion control using methods that incorporate living material and limit disturbance of existing habitat. These design techniques often provide ecological benefits, recreational assets, and opportunities for water-dependent businesses. In gently sloped areas with suitable soils, sustainable shorelines can provide pathways for wetland migration as sea-levels rise.

By some estimates, nearly half of the Hudson's shoreline has been hardened with bulkheads and riprap. Previously hardened shorelines that are protecting dense development or key infrastructure may be not be suitable for nature-based shoreline techniques but can still be enhanced with ecological features.

Actions To Take

- ☐ Visit the *Hudson River Sustainable Shorelines Project Best Management Practices* webpage to learn about shoreline protection methods, including ecologically enhanced structures.
- ☐ Read Hudson River Sustainable Shoreline's *Managing Shore Zones for Ecological Benefits* guide.
- ☐ Visit the NYS Climate Risk and Resiliency Act website to download the *Using Natural Measures to Reduce the Risk of Flooding and Erosion* guide.
- ☐ Consider recommendations in the Waterfront Alliance's *Waterfront Edge Design Guidelines* (WEDG).
- ☐ Download NYSDEC's *Tidal Wetlands Guidance Document.*
- ☐ Contact NYSDEC Regional Permits Program in the early stages of any shoreline project.

+ Sustainable shorelines can provide cost-effective erosion control while enhancing aesthetics, ecological function, and habitat value of a waterfront area.

$ DEC HREP || DOS LWRP || OPRHP || Hudson Valley Greenway

! According to the US National Oceanic and Atmospheric Administration, living shorelines can be more resilient against storms than bulkheads.

CSC 7.8 || 7.14 || 7.16

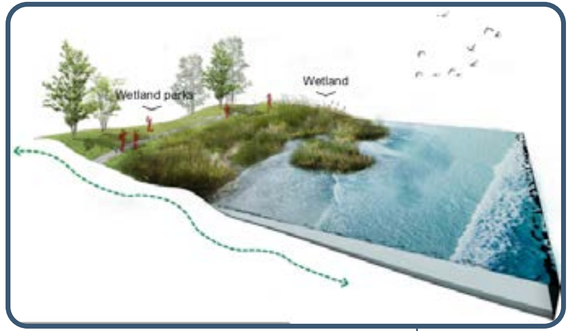
?
Hudson River Sustainable Shorelines Best Management Practices
NYS Climate Risk and Resiliency Act
Waterfront Alliance's WEDG
NYS DEC Tidal Wetlands

Hudson, 2016
Unsinkable
Alisa Chirco
Graham Smith

A student design team re-envisions the riverfront in the City of Hudson to restore wetland function in the South Bay, and enhance natural landscapes in the waterfront park.

Hudson, 2016
Hudson Rising
Sara Hirsch
Kyle Sitzman
Alice Sturm

A naturalized shoreline is created in phases as sea-level rises. Gradual sloping into shallow water areas create intentionally floodable habitats and access to the river for exploration and recreation.



Ossining, 2019
Eco-line
Zikun Zhang

A gently sloped shoreline with vegetation that ranges from wetland plants at the water's edge to trees and shrubs upland is characteristic of a natural condition.

Poughkeepsie, 2021
Eco-Restoration at Play
Yvette Pollack

Marsh Migration

Freshwater tidal wetlands are globally rare and serve as our “rain forests” in terms of the biodiversity and habitat diversity they offer our region. They can also help buffer our waterfronts from wave energy, provide clean air and sequester carbon. Climate change threatens to drown many marshes if we do not allow pathways for them to migrate inland with sea-level rise.

Coastal marshes help to reduce the impact of climate change by capturing and storing carbon. Known as “blue carbon”, some coastak marshes and other tidal wetlands sequester carbon at a faster rate than forests.

Actions To Take

- ☐ Visit Scenic Hudson’s *Protecting the Pathways Marsh Migration StoryMap* to learn more about the importance of tidal wetlands and to identify potential wetland pathways on your waterfront.
- ☐ Check out shoreline habitats with the NYSDEC’s Hudson Valley Natural Resource Mapper.
- ☐ Work with regional land trusts to protect wetland pathways through acquisition and easements.
- ☐ Create and adopt a zoning overlay to protect the pathways from development.
- ☐ Educate the community about the importance of wetlands.
- ☐ Manage and restore tidal wetlands by seeking opportunities to remove hard barriers, restore side channels and preserve natural shorelines.

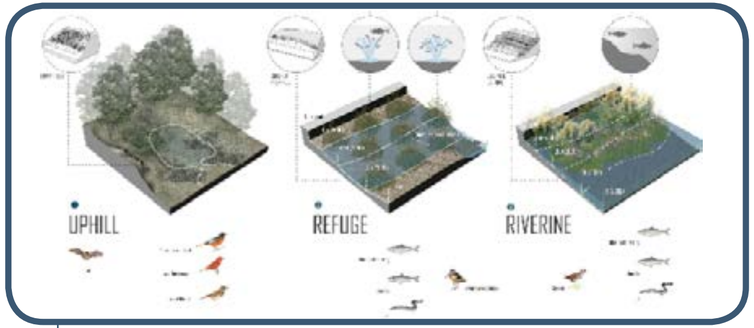
+ The Rondout Creek tidal wetland system, currently 111 acres, is projected to suffer one of the largest potential marsh losses in the Hudson Valley from sea-level rise

$ DEC HREP || DEC CSC || DOS LWRP || Hudson River Greenway

! Development and hard shorelines act as barriers to marsh migration pathways, Transfer of development rights (TDR) and buyouts help to strategically relocate existing and future development out of pathways

CSC 6.2 || 6.18 || 7.8 || 7.8 || 7.14 || 7.15 || 7.16

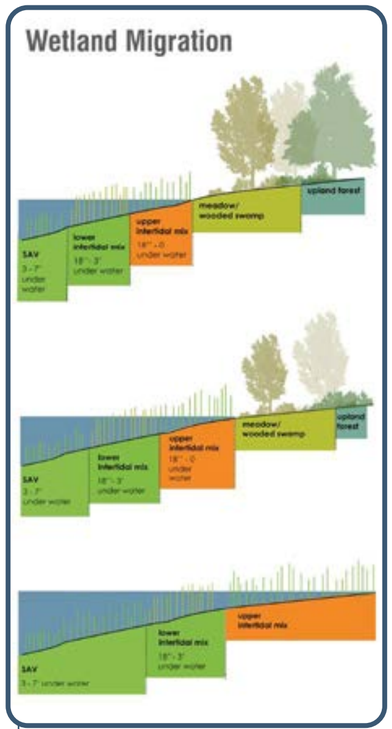
? Protecting the Pathways Marsh Migration Map
NYSDEC Natural Resource Mapper
NYS DOS Wetland and Watercourse Protection Measures
Conserving Natural Areas and Wildlife in Your Community, Ch. 9 - Zoning



Kingston, 2018
Building Bonds
Lijin Liu
Shan Ling

Accommodating marsh migration pathways is often compatible with recreational uses of the shoreline.

Poughkeepsie, 2021
Metamorphic Hudson
Monica Rourke



Hudson, 2016
Time Refractor
Xiaoying Li
Ming Chi

This image depicts how wetland types may change as sea levels rise. On the top, wetlands range from submerged aquatic vegetation (SAV) to upland forest. On the bottom, SAV and intertidal marsh persist.

Cooling Our Cities

Rising temperatures pose a threat to the quality of life, especially in our cities. The heat island effect is a term used to describe higher temperatures in urban areas, where buildings and paved surfaces absorb the sun's heat and then re-radiate it. Techniques to mitigate heat include planting trees, erecting shade structures and utilizing materials that reflect, rather than absorb, the sun's rays.

In many cities the hottest neighborhoods have a higher percentage of residents who are low-income people of color, due to historical housing discrimination. These areas should be prioritized for heat mitigation efforts, and residents should be engaged in the design and planning at the beginning of each project.

Action To Take

- Visit the US EPA heat island effect website to learn more.
- Read about Groundwork Hudson Valley's *Climate Safe Neighborhoods* program.
- Check out the NYSDEC Urban and Community Forestry, Trees for Tribs and the ReLeaf programs.
- Use tools such as the *Neighborhoods at Risk* mapper to identify and prioritize neighborhoods with low tree cover and for mitigation initiatives.
- Develop a city-wide heat emergency plan and establish cooling stations, splash pads and water fountains in key locations.
- Investigate and implement Smart Growth practices to reduce the conditions that contribute to the heat island effect.

+ Innovative approaches to heat mitigation - such as green roofs or parking lots shaded by solar arrays - provide multiple benefits, including energy savings and the reduction of greenhouse gas emissions.

$ DEC HREP || DEC CSC || DEC Urban and Community Forestry grants || EFC GIGP

! Community engagement and inclusive planning is key to designing tree planting initiatives and cooling measures that are welcomed by all residents.

CSC 6.1 || 6.8 || 6.9 ||6.17 || 6.18
7.6 || 7.8 || 7.12 || 7.14 || 7.16

? US EPA Heat Island Effect
Climate Safe Neighborhoods
Urban and Community Forestry ReLeaf Trees for Tribs
Neighborhoods at Risk
Smart Growth Network

Kingston, 2017
Blue: Kingston's New Green
Parth Divekar
Sara Vandenbroek

Shade structures can add character and visual appeal to public spaces.

Replacing pavement with trees, shrubs and ground cover can reduce the heat island effect.

Catskill, 2015
Catwalk
Zhijun Guo
Julie Romualdez

Shade trees provide many benefits, including cooling, cleaning the air, providing habitat, and improving property values.

Kingston, 2016
Kingston On The Rise
Nathan Gowen
George Anderson
Nathaniel Walsh

Green Infrastructure

Green infrastructure (GI) practices maintain or restore the pre-development flow patterns of stormwater by allowing runoff to soak into the soil. On a regional scale, GI includes preserving and restoring natural landscape features, along with reducing pavement and other impervious surfaces. At the site scale, GI includes practices that capture stormwater runoff, such as vegetated swales, infiltration planters, green roofs, pervious pavement, rain gardens, and rain barrels. When these practices include nature-based features they typically provide co-benefits like improving water quality or providing habitat.

Municipalities considering GI projects should use inclusive planning practices to ensure consideration of the interests and concerns of all residents. Issues such as neighborhood character and avoiding displacement of low-income residents should be addressed.

Actions To Take

- ☐ Become familiar with GI by reviewing the *NYS Stormwater Management Design Manual*.
- ☐ Learn more about GI at the *NYSDEC's Stormwater* website.
- ☐ Read the City of Newburgh's *GI* Guide and *GI Feasibility Report*.
- ☐ Watch the presentation *Greening (In)Equitably* by Dr. Zbigniew Grabowski from the Cary Institute for Ecosystem Studies.
- ☐ Require new development to conserve existing natural features and use GI before traditional pipe-and-gutter solutions.
- ☐ Conduct holistic GI planning for that considers social, environmental, and maintenance factors.

+ Green infrastructure can improve water and air quality, store carbon, enhance habitat diversity, and cool urban areas during hot times of the year, reducing energy costs and greenhouse gas emissions.

$ DEC HREP || DEC CSC || DEC WQIP || EFC GIGP

! Holistic GI planning includes identifying locations that will maximize stormwater benefits, ensuring ongoing maintenance, and avoiding negative social impacts, such as the gentrification of nearby neighborhoods.

CSC 6.8 || 6.9 || 7.8 || 7.12

? NYSDEC Stormwater website
NYS's Stormwater Management Design Manual
City of Newburgh's Green Infrastructure Feasibility Report
Greening (In)Equitably

Hudson, 2016
Unsinkable
Alisa Chirco
Graham Smith

A combination of impervious and pervious pavement with trees and a naturalized landscape provides many co-benefits to a former industrial site.

Catskill, 2015
Catwalk
Zhijun Guo
Julie Romualdez

Green infrastructure installations catch stormwater from roofs and pavement while enhancing quality of life for residents.

Poughkeepsie, 2021
Strand Forms
Dustin Smith

Lower and upper pathways provide access during dry and wet conditions. A linear skate park provides storm water management. Low-lying areas of the park become wetlands over time.

Kingston, 2016
Kingston Riverway
Mark J. Hirschbeck
Ilia Savin

This image depicts urban trees and other types of green infrastructure that contribute to the aesthetic and vitality of a neighborhood.

Resilient Roadways and Infrastructure

Roadways and rail lines are often located in close proximity to waterways and may be vulnerable to flooding. Bridges and culverts may contribute to flooding by restricting water flow during heavy precipitation. Infrastructure that is frequently flooded may need to be elevated or relocated to improve safe access under all conditions.

Replacing or re-routing flood-prone roadways can provide an opportunity for communities to improve safe access for residents, enhance connectivity between neighborhoods and consider circulation for all users. A 'complete street' approach to new roadway design considers pedestrians, bicyclists and other users. The approach potentially reduces greenhouse gas emissions through providing safe, accessible alternatives to operating motor vehicles. Nature-based features, like rain gardens and bioswales, can be strategically placed to absorb stormwater from paved roadways and parking lots.

Actions To Take

- Identify vulnerable roadways and infrastructure.
- Develop an inventory and prioritization plan for infrastructure upgrades.
- Include upgrades in your municipality's capital improvement plan.
- Make sure that infrastructure upgrades are included in your municipality's FEMA Hazard Mitigation Plan.
- Consider use of pervious surfaces when designing roadways, paths and parking lots.
- Learn more about the Hudson Estuary *Aquatic Connectivity and Barrier Removal* initiative, which may provide assistance in identifying culverts that are contributing to flooding and/or pose barriers to aquatic migration.

+ Green street design tools, which integrate stormwater control and management within the right-of-way, are a critical component of complete street design, ensuring the street remains usable and safe for all people during storm events.

$ DEC HREP, DEC CSC, WQIP (aquatic connectivity restoration), EFC GIGP, FEMA

! Communities that identify flood-prone roads and infrastructure in their Hazard Mitigation Plans may be eligible for FEMA funding to mitigate these problems after a declared disaster.

CSC 7.9 || 7.13

? Hudson Estuary Aquatic Connectivity and Barrier Removal
U.S. Climate Resilience Toolkit: Rebuilding Roadways to Maximize Resilience
NYS DEC Stream Crossings Best Management Practices

Kingston, 2018
Revealing Kingston's Waterfront
Sara Boutata
Kayla Mosebrook

This drawing depicts vehicular and pedestrian circulation routes to analyze their resilience and utility for residents and visitors.

Ossining, 2019
Unlocking the Ossining Waterfront
Dean Yeh

"Complete streets" offer non-motorized transportation options and include trees and plantings to help absorb storm water while increasing shade.

A conceptual design for an adjustable walkway that can be raised as waters rise.

Ossining, 2019
A Latent Buffer for Ossining
Lingyi Xu

Poughkeepsie, 2021
Strand Forms
Dustin Smith

Elevating tracks to allow water to flow freely beneath them during flooding is one way to keep rail infrastructure out of the floodplain, while allowing community uses and circulation beneath it during dry periods.

Getting Around Town

Connecting the waterfront to the community in ways that provide easy access for pedestrians, bicycles, wheelchairs, motorized vehicles, and public transportation enhances quality of life. Roadway circulation is an important consideration, especially assuring alternative access routes for flood-prone neighborhoods.

Students considered options for creating more direct connections between downtowns and waterfronts. Ideas for improving access around or over railroad tracks and major roadways are frequently suggested. North-south trails to create connections along the waterfront are a common theme in many designs.

Actions To Take

- Consider flood-risk, potential inundation, and long-term viability as part of a feasibility study for waterfront trails, roadways, and rail lines.
- Ensure easy access to trails, parking areas and waterfront amenities for people of diverse physical and mental abilities.
- Incorporate water access for pedestrians and boaters when designing waterfront improvements.
- Include EV charging stations in new and re-designed parking areas and transportation hubs to help accommodate the shift to electric vehicles.
- Include way-finding and informational signage into roadway and trail improvements to help visitors stay oriented, informed, and engaged.

+ In addition to improving circulation and mobility for many types of users, a complete streets approach incorporates natural features such as shade trees for cooling and green infrastructure for stormwater management.

$ DEC CSC || EFC GIGP|| DOT STIP

! Examine sea-level rise projection maps to identify roadways that may become inundated or more frequently flooded in the future and consider options for alternative access.

CSC 6.9 || 6.10 || 6.11 || 6.12 || 6.13 || 6.14

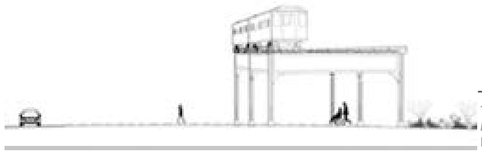
? NYS DOT – Complete Streets
Hudson Estuary Accessibility Project
Tompkin's County Way-finding & Interpretive Signage Plan

Kingston, 2017
Actipelago
Yifu Kang &
Xuru Yuan

Poughkeepsie, 2021
Untitled
Sirui Qiu

Better connections between the waterfront and downtown, including enhanced multi-modal street corridors, improve waterfront access as a city amenity.

Universal access for diverse uses is an important aspect of CaD design.



Tarrytown, 2022
Remaking the Inland Waterfront
Ilana Haimes

Waterfront circulation systems can incorporate water access, walkability, and natural features as part of an overall resilient vision.

Kingston, 2017
Blue: Kingston's New Green
Parth Divekar & Sara Vandenbroek

Flood-adapted Buildings

If a structure is located in a flood-prone area, there are a number of actions that can be taken to reduce risk of damage. Options range from elevating an entire structure above the reach of floodwaters, to raising utilities within a building to keep them dry under flood conditions. Property owners can take steps to seal a building off from water or create conditions that allow the floodwaters to enter and exit with minimal disruption. Flood insurance rates may be reduced by flood-proofing or elevating buildings.

A cost-benefit analysis of options for flood adaptation retrofits versus strategic relocation should be considered as part of a planning effort for at-risk buildings and uses in the current and/or future floodplain.

Actions To Take

- Become familiar with the NYS official sea-level rise projections.
- Conduct or update vulnerability assessments to identify key assets located in the current and future flood zones.
- Raise utilities (outlets, HVAC, etc.) to the 2080's 500-year flood height on municipal properties and critical infrastructure on the waterfront.
- Evaluate the long-term costs and benefits of flood-adapting vs. strategic relocation in flood-prone areas.
- Consider extending where additional two-foot freeboard restrictions on first-floor uses are required by local zoning code.

+ Increasing the resilience of structures located in flood-prone areas has many benefits including reduction of hazards during and after floods, greater ability to return to functionality after a flood event, and cost savings from avoided damages.

$ DEC OCC || WQIP (for waste water treatment plants) || FEMA || HUD CDBG

! Communities should consider sea-level rise projections when planning for future flood risk. FEMA recommends considering raising new residential structures to the 500-year flood elevaton in high-risk flood zones.

CSC 7.1 || 7.10 || 7.11

? NYSDEC Official Sea Level Rise Projections
FEMA: Floodproofing Non-Residential Buildings
FEMA: Base Flood Elevation (BFE)

This concept envisions how the first floor of the building could be converted to non-residential uses that accommodate floods while minimizing damage to life and property. Several techniques can be used to adapt first floors to floodable uses including elevating all utilities to higher floors, installing vents or large doors to allow outflow of water as a flood recedes, and using water-resistant materials for walls and floors.

Ossining, 2019
A Latent Buffer for Ossining
Lingyi Xu

Tarrytown, 2022
Adaptation in Tarrytown
Xiaoyun Ren

Kingston, 2018
Revealing Kingston's Waterfront to its Inhabitants
Sarah Boutata
Kayla Mosebrook

Buildings can be elevated on piles with floodable, flexible gathering space on the ground floor.

Sculpting the Landscape

According to NYS DEC, about half of the tidal Hudson's shorelines have been altered. Wetlands have been dredged or filled, and meandering reaches of the river have been channelized. Past shoreline alterations have had a negative impact on ecological function, but with careful planning, landscape grading strategies can be used to enhance habitats, maintain access and increase resilience.

Some students focused on strategies such as "cut & fill" to sculpt sites that have been previously altered. For example, in low-lying areas, fill can be removed to facilitate marsh habitat creation. Soil can also be added in other locations to maintain access amidst flooding and/or projected future inundation. Critically, 'balancing cut & fill' is a major focus of these techniques so that floodplains are not constricted.

Action To Take

- Learn more about the history of shoreline alteration and the value of shallow water habitats in the *Hudson River Estuary Habitat Restoration Plan*.
- Read about NYS permit requirements for coastal erosion management, tidal wetlands and protection of waters.
- Learn about FEMA regulations about adding fill in Special Flood Hazard Areas
- Visit Scenic Hudson's *Protecting the Pathways StoryMap* to learn about the potential for marsh migration along the shoreline.
- Visit the *Hudson River Sustainable Shorelines* website to see examples of bulkheaded shoreline area that have been restored to tidal marsh.

+ It's estimated that 71 miles of natural shoreline in the upper estuary was eliminated during construction of the Hudson's federal navigation channel.

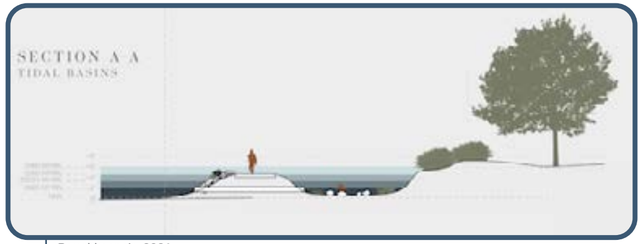
$ DEC HREP || DEC CSC || DOS LWRP || WQIP

! Discussing potential shoreline projects with the DEC Permits Office should be a first step for communities. They will provide advice and guidance to help achieve goals while complying with state regulations.

CSC 7.10 || 7.16

?
Hudson River Habitat Restoration Plan
NYSDEC Environmental Permits
FEMA glossary - Fill
Protecting the Pathways
Sustainable Shorelines Monitoring & Lessons Learned

A cut & fill strategy creates an earthen berm that prevents ice-shear erosion while providing an elevated walkway. The cut area inland is linked to river water levels to create accessible habitat features during daily tides.



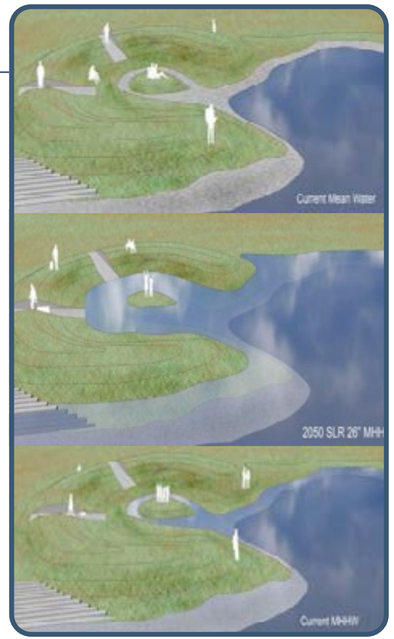
Poughkeepsie, 2021
Freeze, Thaw, Expand
Sophie Bellemare

Poughkeepsie, 2021
Metamorphic Hudson
Monica Rourke

A parking garage is built at Waryas Park and capped with a green terrace to maintain recreational space.

Hudson, 2016
Tangible South Bay
Genki Takahashi
Norihisa Hatakeyama

Landform elements can create points of interest that change with tides, floods and rising sea-level.



Poughkeepsie, 2021
Flood//Land
Dom Malacaman

Employing a phased cut & fill strategy, some areas are elevated and water is allowed into other locations to create wetland habitats.

Ecologically Enhanced Structures

Engineered structures, like levees, bulkheads, and seawalls are typically constructed of hard materials, such as metal, concrete, and stone. They are designed to hold back or control water and/or sediment in an effort to reduce the effects of flooding and erosion. While necessary to protect some assets, such as roads, bridges and critical facilities, hard structures disrupt natural processes and have little or no habitat value.

Ecological enhancement seeks to integrate habitat and ecological function into hard structures. These can be either modifications to existing structures through the addition of plantings, or the design of new structures incorporating ecologically-friendly materials, geometry or placement.

Actions To Take

- ☐ Visit the *Hudson River Sustainable Shorelines Project* to learn about shoreline protection methods, including ecologically enhanced structures.
- ☐ Read the publication *10 Questions to Ask When Building Defenses to Protect Hudson River Shorelines.*
- ☐ Inventory the shoreline on your waterfront to identify and monitor the condition of hard structural features like bulkheads.
- ☐ Contact the NYS Department of Environmental Conservation Environmental Permits office for your region to learn about regulations related to installing and maintaining hard structural features.
- ☐ Consider replacement of hard features with living shorelines or investigate ecological enhancement techniques for bulkheads and rip rap.

+ Ecologically enhanced structures prevent or reduce shore erosion while emulating the physical and biological conditions of naturally occurring, stable shorelines.

$ FEMA HMA

! Hard structures can disrupt natural features and processes, and have limited or no living components. While they can be necessary to protect critical infrastructure, they can negatively affect natural conditions that reduce risk.

CSC 7.16

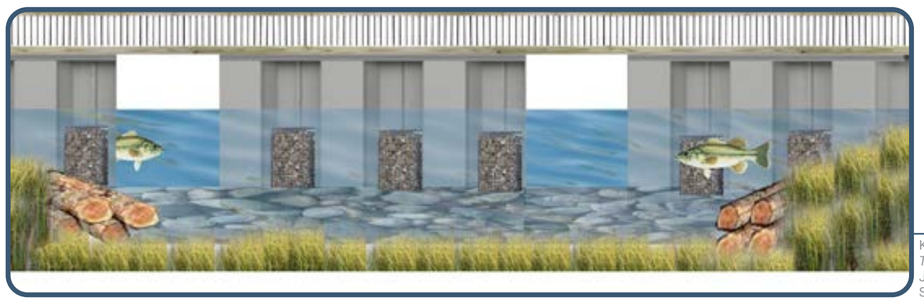
? Hudson River Sustainable Shorelines Project
10 Questions to Ask When Building Defenses to Protect Hudson River Shorelines
NYSDEC Environmental Permits
Statewide Shoreline Monitoring Framework

Poughkeepsie, 2021
A Living Shoreline For All
Xinyue Hope Shen

Combining 'soft' features, such as trees, shrubs and plantings, along with strategic limited placement of 'hard' features like riprap, can help stabilize shorelines while adding ecological benefits.

Piermont, 2017
Evolve, Connect, Redefine
Trevan Signorelli
Erin Tou
Cristian Umana

A concept to protect a residential area with a berm that includes a pedestrian path on top and a bioengineered shoreline.



This drawing envisions gabion baskets incorporated into a bulkhead for added aquatic habitat complexity.

Kingston, 2018
The Edge Effect
Jacob Dilson
Sahar Farmand

Strategic Relocation & Adaptive Reuse

Key municipal and commercial assets at high risk for damage or permanent loss under current and projected flooding and sea-level rise should be relocated out of the flood zone. Alternatively, some structures may be repurposed or adapted to reduce flooding and inundation impacts. These kinds of interventions may benefit from enhanced zoning ordinances, policy measures or incentive programs to facilitate the transition of waterfronts to more adaptive and resilient uses and features.

For residents, decisions to relocate out of a flood zone can be emotionally and logistically difficult. Many residents will require support in considering relocation options, so facilitating conversations about the issue is a key first step.

Actions To Take

- ☐ Identify municipally-owned, commercial and residential properties assets that are at high risk from flooding.
- ☐ Create a plan for the relocation of municipally-owned assets.
- ☐ Identify partnerships and funding opportunities to relocate municipally-owned assets, including FEMA Hazard Mitigation and BRIC funding.
- ☐ Read about the Village of Piermont's efforts to foster neighborhood discussions about potential relocation of flood-prone homes.
- ☐ Read Climigration Network's *Lead with Listening: A Guidebook for Community Conversations on Climate Migration.*
- ☐ Explore potential for Transfer of Development Rights (TDR) to steer development toward safe locations.

+ Transitioning residences, businesses, infrastructure and services out of the flood zone reduces risk. Returning floodplain functions provides benefits to people, wildlife and waterways.

$ DEC HREP || DEC CSC || DOS LWRP || FEMA || HUD CDBG

! A just and equitable approach to strategic relocation is critical to its successful implementation.

CSC 7.15

? FEMA BRIC
Adapting to Rising Waters Along the Hudson: Lessons from Piermont , NY
Climigration Network's Lead with Listening Guidebook
NYS Department of State Transfer of Development Rights Technical Bulletin

Kingston, 2017
Set Into Motion
Thackston Crandall
Veronica Chan

Sometimes infrastructure left after transitioning to a less flood-prone location can be adaptively reused. In this example, the designers envisioned an innovative transformation of the tanks to an arts venue.

Mobile Development Modules (MDMs) were proposed for area of the Rondout Creek waterfront in Kingston. MDMs are short-term structures that can be moved upland as flooding becomes more frequent. MDMs provide space for commercial enterprises at a location where permanent buildings are infeasible, due to flood risk.

Kingston, 2018
Ponckhockie's Working Waterfront
Eve Anderson
Liz Fabis

Ossining, 2019
Step Back, Step Up, Move Forward
Mark Schrader

In this vision of the Ossining waterfront in the 2080s, the oil transfer facility, county waste water treatment plant and the east section of Sing Sing Correctional Facility have all been relocated to higher ground. The marina has moved to the former site of the correctional facility to maintain water-dependent, recreational opportunities along the waterfront.

Inspiration & Learning

The landscape can be a canvas for installations that inform viewers about how sea-level rise may change our waterfronts. Sculpture, murals, high water marks, tide gauges, signage, and landscape installations are excellent tools for communicating how much the shoreline is projected to move inland. Waterways offer opportunities for nature study, exploration and the pursuit of imaginative expression.

Student projects often embrace the waterfront as a place to provide an aesthetic experience of water through trails and gathering spaces. Murals and sculptures that provide a visual reminder of changing sea levels are also features of many student designs. Signage that interprets past events, such as the height of floodwaters during major floods, provide long-term perspective for visitors.

Action To Take

- Learn about the FEMA High Water Mark initiative.
- Visit the indoor/outdoor climate change exhibit at the Hudson River Maritime Museum in Kingston, NY.
- Check out examples of public climate art projects, such as Rising Waters installations, Art at the Blue Line in NYC, and 5 Ecological Piers sculptures in Rhode Island.
- Check out climate education resources from NOAA.
- Read Conveying the Human Implications of Climate Change from the George Mason University Center for Climate Change Communication.

+ Working with local artists and art organizations is a great way to create place-based artwork that is specific to your location.

$ DEC HREP || NYSCA

! Collaboration is key! Non-profit arts or educational organizations may have to take the lead on projects to qualify for some grant funding.

CSC 9.1 Climate Change Education & Engagement || 9.3 Climate-related Public Events

?
FEMA High Water Mark Initiative
NOAA Climate Education Resources
Rising Waters
Art at the Blue Line
Conveying the Human Implications of Climate Change

Sculptures can highlight how tidal fluctuation, flooding, and sea-level rise influence water elevation on the shoreline. Markers such as those envisioned here can also register past flood levels and/or future sea level rise elevations on the landscape.

Hudson, 2016
Time Refractor
Xiaoying Li
Ming Chi

Poughkeepsie, 2021
Freeze, Thaw, Expand
Sophie Bellemare

A waterfront skating rink offers winter recreation as part of a design that celebrates the historic Hudson River ice industry.

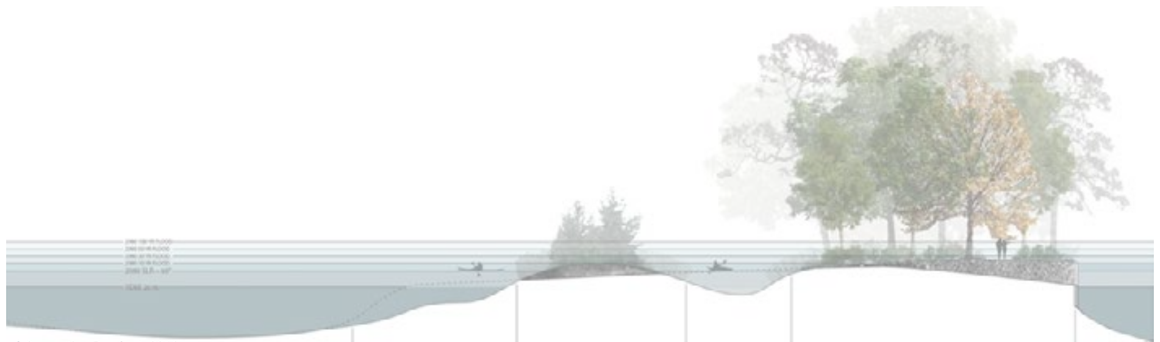
Catskill, 2015
Catwalk
Zhijun Guo
Julie Romualdez

Water murals can educate while adding visual appeal to public spaces.

Section 2

Section 3

References & Resources



Generation Rondout- 2016
Mariane Barrett
Whitney Gilbert

Funding Opportunities

State and federal agencies offer financial assistance to municipalities and non-profit organizations for activities building resilience to waterfront flooding, sea-level rise and other climate risks.

Agency	Assistance Program	Grant amounts, required match	Municipal Planning	Resilient Structures	Emergency Management	Collaboration and Public Outreach	Waterfront Economy	Floodplain protection
Department of Environmental Conservation (DEC)	Hudson River Estuary Program (HREP)	$10,500-$50,000, 15% match	•	•			•	•
	Climate Smart Communities (CSC)	$10,000-$2M, 50% match	•	•				•
	Water Quality Improvements Program (WQIP)	25-60% match		•				•
	Trees for Tribs	N/A						•
Environmental Facilities Corporation (EFC)	Wastewater Infrastructure Engineering Planning	≤$100,000, 20% match	•	•				
	Clean Water Revolving Loan Fund	N/A	•	•				•
	Green Innovation Grant Program (GIGP)	10-60% match						•
Federal Emergency Management Agency (FEMA)	Hazard Mitigation Assistance (HMA)	Over $3M, 25% match	•	•				
	Public Assistance	N/A			•			
	Building Resilient Infrastructure and Communities (BRIC)			•		•		•
	Community Rating System (CRS)	N/A			•	•		
Department of State	Local Waterfront Revitalization Program (LWRP)	15-25% match	•	•		•		
Other	NYSERDA Clean Energy Communities	≤$150,000, no match	•	•		•		
	NYS Office of Parks, Recreation and Historic Preservation (OPRHP)	≤$500,000, 25-50% match					•	•
	US Housing and Urban Development (HUD)	$50,000 - $900,000, 0-5%	•	•			•	
	Empire State Development	80% match for soft costs		•			•	
	Hudson River Greenway	$5,000 - $10,000+					•	•
	NYS Environmental Bond Act Funding Finder	N/A						

Design Strategy References

Design Strategy	Source	URL
Cooling Our City	US EPA Heat Island Effect	https://www.epa.gov/heatislands
	US EPA Smart Growth Network	https://www.epa.gov/smartgrowth/smart-growth-network
	Climate Safe Neighborhoods	https://tinyurl.com/climsmneighborhood
	NYSDEC Urban and Community Forestry	https://www.dec.ny.gov/lands/4957.html
	NYSDEC ReLeaf	https://www.dec.ny.gov/lands/5307.html
	NYSDEC Trees for Tribs	https://www.dec.ny.gov/animals/77710.html
	Neighborhoods at Risk	https://headwaterseconomics.org/apps/neighborhoods-at-risk/
Ecologically Enhanced Structures	Hudson River Sustainable Shorelines Project	https://hrnerr.org/sustainable-shorelines/
	10 Questions to Ask When Building Defenses to Protect Hudson River Shorelines	https://tinyurl.com/citenquestions
	NYSDEC Environmental Permits	https://www.dec.ny.gov/permits/6081.html
Flood Adapted Buildings	NYS Official Sea Level Rise Projections	https://www.dec.ny.gov/regulations/103877.html
	FEMA: Floodproofing Non-Residential Buildings	https://www.fema.gov/sites/default/files/2020-07/nfip_t3_04011993_0.pdf
	FEMA: Base Flood Elevation (BFE)	https://www.fema.gov/node/404233
Getting Around Town	NYS DOT – Complete Streets	https://www.dot.ny.gov/programs/completestreets
	Hudson Estuary Accessibility Project	https://www.dec.ny.gov/lands/5088.html
	Tompkins County Way-finding & Interpretive Signage Plan	https://tinyurl.com/tcwisp
Green Infrastructure	NYSDEC Stormwater website	https://www.dec.ny.gov/public/915.html
	NYS Stormwater Management Design Manual	https://extapps.dec.ny.gov/fs/docs/pdf/stormwaterdesignmanual2015.pdf
	A GI Guide for Small Cities, Towns and Rural Communities	https://edesigndynamics.com/portfolio/newburghstudy/
	City of Newburgh GI Fesibility Report	https://tinyurl.com/yytv4tg3
	Greening (In)Equitably: Visions, Processes, and Distributions for Green Infrastructure in US Cities	https://youtu.be/Yv4fyPnYkvE
Inspiration & Learning	FEMA High Water Mark Initiative	https://tinyurl.com/femahwm
	NOAA Climate Education Resources	https://www.noaa.gov/climate-education
	Rising Waters	https://www.risingwaters.org/
	Art at the Blue Line	https://tinyurl.com/artatblue
	Conveying the Human Implications of Climate Change	https://www.climatechangecommunication.org/all/conveying-the-human-implications-of-climate-change/

Design Strategy References

Design Strategy	Source	URL
Marsh Migration	Protecting the Pathways, Scenic Hudson	https://tinyurl.com/protectpathways
	NYSDEC Hudson Valley Natural Resource Mappyer	www.dec.ny.gov/lands/112137.html
	NYS DOS Wetland and Watercourse Protection Measures	https://dos.ny.gov/wetland-and-watercourse-protection-measures-0
	Conserving Natural Areas and Wildlife in Your Community, Ch. 9 - Zoning	https://www.dec.ny.gov/docs/remediation_hudson_pdf/hrebch9.pdf
Resilient Roadways & Infrastructure	Hudson Estuary Aquatic Connectivity and Barrier Removal	https://tinyurl.com/HREbarriers
	U.S. Climate Resilience Toolkit: Rebuilding Roadways to Maximize Resilience	https://toolkit.climate.gov/case-studies/rebuilding-roads-maximize-resilience
	NYS DEC Stream Crossings: Best Management Practices	https://extapps.dec.ny.gov/docs/permits_ej_operations_pdf/streamcrossbmp.pdf
Resilient Waterfront Parks	Flood Resilience Handbook for Public Access Sites Along the Hudson	https://www.dec.ny.gov/lands/5088.html
	High Performing Landscape Guidelines: 21st Century Parks for NYC	tinyurl.com/NYCParksSustainableDesign
	Naturally Resilient Communities	nrcsolutions.org/
Sculpting the Landscape	Hudson River Habitat Restoration Plan	https://www.dec.ny.gov/lands/89455.html
	NYSDEC Environmental Permits	https://www.dec.ny.gov/permits/6081.html
	FEMA glossary – Fill	https://www.fema.gov/glossary/fill
	Protecting the Pathways	https://tinyurl.com/protectpathways
	Sustainable Shorelines Monitoring & Lessons Learned	https://tinyurl.com/hrnerr
Strategic Relocation & Adaptive Reuse	Climigration Network's Lead with Listening Guidbook	https://www.climigration.org/guidebook
	Adapting to Rising Waters Along the Hudson: Lessons from Piermont	https://www.cbi.org/article/piermont/
	NYS DOS Transfer of Development Rights Technical Bulletin	https://dos.ny.gov/system/files/documents/2023/01/transfer-of-development-rights.pdf
	FEMA BRIC	https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities
Sustainable Shorelines	Managing Shore Zones for Ecological Benefits Guide	https://tinyurl.com/shorezones
	NYS Community Risk and Resiliency Act (CRRA)	https://www.dec.ny.gov/energy/102559.html
	Statewide Shoreline Monitoring Framework	https://dos.ny.gov/statewide-shoreline-monitoring-framework
	NYSDEC Tidal Wetlands	https://www.dec.ny.gov/lands/4940.html
	Waterfront Edge Design Guidelines (WEDG)	http://wedg.waterfrontalliance.org/resources/#manual-and-guidelines

Relevant Climate Smart Community Actions

Get points and funding projects related to CaD concepts through the state's Climate Smart Communities certification program. See related actions below and learn more at: https://climatesmart.ny.gov/

Pledge Element 6: Reduce greenhouse gas emissions through use of climate-smart land-use tools

6.1	Develop and adopt a comprehensive plan with sustainability elements
6.2	Incorporate smart growth principles into land-use policies and regulations
6.3	Adopt a renewable energy ordinance
6.4	Implement the energy code building standard
6.5	Establish green building ordinance
6.6	Adopt land-use policies that support or incentivize farmers' markets, community gardens and urban and rural agriculture
6.7	Utilize NYSDOTs GreenLITES voluntary self-certification program for local transportation infrastructure projects
6.8	Adopt green parking lot standards
6.9	Plan strategies that support bicycling and walking
6.10	Implement strategies that support bicycling and walking
6.11	Adopt a complete streets policy
6.12	Install electric-vehicle infrastructure
6.13	Implement strategies that increase public transit ridership and alternative transport modes
6.14	Implement a Safe Routes to School program
6.15	Implement traffic calming measures
6.16	Develop a natural resource inventory
6.17	Develop a local forestry or tree planting project or program
6.18	Preserve natural areas through zoning or other regulations

Pledge Element 7: Plan for adaptation to unavoidable climate change

7.1	Conduct a vulnerability assessment
7.2	Review existing community plans, policies and projects to identify climate adaptation strategies and policies or projects that may decrease vulnerability
7.3	Develop climate adaptation strategies
7.4	Update the multi-hazard mitigation plan to address changing conditions and identify specific actions to reduce vulnerability to natural hazards
7.5	Develop and implement a heat emergency plan
7.6	Require shade structures and features in public spaces
7.7	Open new or expand existing cooling centers
7.8	Conserve natural areas for species migration and ecosystem resilience
7.9	Create or update a watershed assessment to identify flood mitigation priorities
7.10	Design elevation & flood maps
7.11	Freeboard policies
7.12	Use green infrastructure to manage stormwater in developed areas
7.13	Right-size bridges and culverts and remove unnecessary and hazardous dams
7.14	Revegetate riparian buffers
7.15	Facilitate a strategic relocation of uses that are not water dependent from flood prone areas
7.16	Use natural, nature-based or ecologically enhanced shoreline protection
7.17	Promote community flood prevention strategies through the National Flood Insurance Program Community Rating System
7.18	Create a watershed plan to protect water quality
7.19	Implement a source water protection program
7.20	Implement a water conservation and reuse program
7.21	Encourage xeriscaping

More Information on Climate Change in the Hudson River Valley

Websites	URL
Hudson River Sustainable Shorelines	hrnerr.org/hudson-river-sustainable-shorelines
Hudson Dynamic Shorelines StoryMap Collection	https://seagrant.sunysb.edu/Images/Uploads/PDFs/DynamicShorelines-Hudson.pdf
Adaptation Clearinghouse	adaptationclearinghouse.org/
NY Community Risk and Resiliency Act (CRRA)	www.dec.ny.gov/energy/102559.html
Estuary Program's Climate Resilience webpage	www.dec.ny.gov/lands/39786.html
NYS Climate Impacts Assessment	https://nysclimateimpacts.org/
CaD studio Designs from host communites	https://trophic.design/cad/
Interactive Maps	
Hudson River Flood Impact Decision Support System	www.ciesin.columbia.edu/hudson-river-flood-map/
Protecting the Pathways, Scenic Hudson	https://arcg.is/1jbXG4
Sea-level Rise Mapper, Scenic Hudson	scenichudson.org/slr/mapper
NYS Department of State Geographic Information Gateway	http://opdgig.dos.ny.gov/index.html#/map/resilience
Publications	
Financing waterfront resilience fact sheet	https://tinyurl.com/funding-resilience
Revitalizing Hudson Riverfronts, Scenic Hudson	https://scenichudson.org/wp-content/uploads/legacy/u2/revitalizing-hudson-riverfronts.pdf
2020 State of the Hudson Report	https://www.hudsonriver.org/state-of-the-estuary#report
Flood Adaptation Strategies for Hudson Riverfront Communities	www.slideshare.net/hrepclimate/flood-adaptation-strategies
Flood Resilience Handbook for Public Access Sites on the Hudson River	https://extapps.dec.ny.gov/docs/remediation_hudson_pdf/hrefldhndbk.pdf
Hudson River Estuary Habitat Restoration Plan	https://www.dec.ny.gov/lands/89455.html
Hudson River Comprehensive Restoration Plan	http://thehudsonweshare.org/about-the-plan/
Videos	
Sustainable Shorelines	tinyurl.com/CSCvideoSS
Planning for Sea-level Rise	tinyurl.com/CSCvideoSLR
Climate-adaptive Design	tinyurl.com/CSCvideoCAD

Next Steps

- Share this Look Book with municipal staff, elected officials, planning boards, waterfront stakeholders, and other interested people.
- Learn more about CaD on the NYS Water Resources Institute website
- View student designs from all of the CaD studios at https://trophic.design/cad/
- Consider joining the Hudson River Flood Resilience Network of municipalities.
- Stay in touch and contact us with ideas, questions or if you are in need of assistance.
- When it is available, consider applying for CaD Phase 2 funding to advance preferred design ideas towards implementation on your waterfront.

Keep in Touch!

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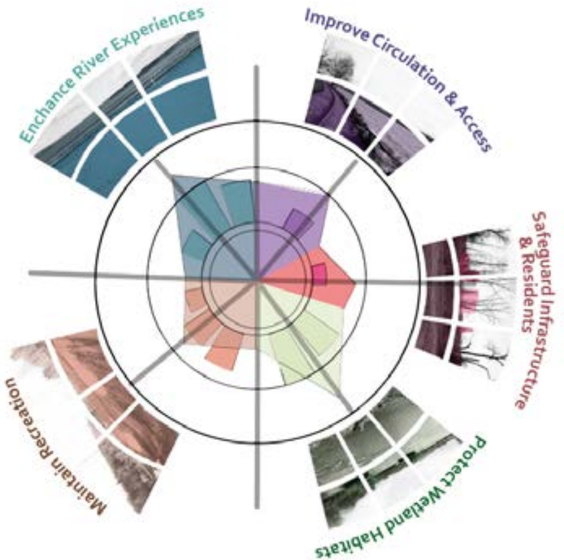

Floating With the Tides, 2017
Kelly Farrell
Yuting Liu