# RESILIENCE ROADMAP:
## *PLANNING FOR PIERMONT'S FUTURE*

*Report of the Piermont Waterfront Resilience Task Force*

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# RESILIENCE ROADMAP: PLANNING FOR PIERMONT'S FUTURE

## REPORT OF THE PIERMONT WATERFRONT RESILIENCE TASK FORCE

*September 30, 2014*

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*This document was prepared for the Village of Piermont and the Hudson River Estuary Program, New York State Department of Environmental Conservation, with support from the New York State Environmental Protection Fund, in cooperation with the New England Interstate Water Pollution Control Commission. The viewpoints expressed here do not necessarily represent those of NEIWPCC or NYSDEC, nor does mention of trade names, commercial products, or causes constitute endorsement or recommendation for use.*

*Additional support and technical assistance for this project was provided by Scenic Hudson, the Lincoln Institute of Land Policy, the Consensus Building Institute and Catalysis Adaptation Partners.*

We are a river village, nestled at the break in the Palisades at the confluence of the Sparkill and the Hudson. This place is an undeniably charmed location, one that enticed native Lenape to make their home here. Later, European settlers found both easy access to the interior farmlands of Tappan and a direct commercial route to a growing market downriver. It is this commercial access to the river that attracted the establishment of the eastern terminus of the Erie railroad, which brought the Village of Piermont to life. Generations of Piermonters have made their living from the river and have established their family history along its banks; its waters are in our blood.

Piermonters are wedded to the Hudson – born and privileged by its presence, benefiting from its bounty, but always mindful of its demeanor and at the mercy of its temperament. We enjoy the river at its best - wondrous, tranquil and benevolent. We have also borne its fury, overwhelming its banks in nor'easters and tropical storms. It is this relationship to the Hudson that recalls the poem by Henry Wadsworth Longfellow:

*There was a little girl, who had a little curl, right in the middle of her forehead.*

*When she was good, she was very good indeed, but when she was bad she was horrid.*

The Hudson is a unique river among rivers. It is, in the language of the native Lenape, the "Muhheakantuck" - the river that flows both ways. Ours is a 'drowned' river, a tidal estuary, flowing at sea level south of Troy, experiencing two tide cycles each day. At Piermont, we see an average tidal range of 3 1⁄2 feet, with astronomical extremes over 5 feet. Our highest tides, along with a minor storm surge, routinely bring water onto Village streets in low-lying neighborhoods. Hurricane Irene and Sandy brought storm tides of up to 9 1⁄2 feet through the Village.

In actuality, Piermont is a seaside village, directly connected to the Atlantic Ocean and at the mercy of its slowly rising waters. Sea Level Rise is not an abstract notion for our Village, but an intimate encroachment that is growing more evident on a yearly basis. One may debate the root cause, but the trend is undeniable. Over 150 years of data show that the mean sea level is rising at a rate of over one inch per decade. More alarming are predictions for this trend to accelerate, dependent on the increased rate of melting glaciers and potential changes in ocean currents.

Rising sea levels will impact the future of our Village. More areas of the Village will be covered by tidal water more often, and storms will bring on higher flood levels and damage to public and private property. As Piermonters, we have learned to live with the Hudson, and this document outlines a variety of tools that would enable us to continue to thrive along its banks throughout the next 75 years and beyond. I ask the current Village board to adopt these findings and urge future Village boards to heed the recommendations to become a more resilient Piermont.

My heartfelt thanks to the members of the Task Force - for their tireless effort, thoughtful attention and dedication to the process of developing this document. I also wish to thank the NYS DEC and Hudson River Estuary Program for their support of this effort, and to their representatives for their attendance and input. Lastly, this would not have been possible without the collaboration, steady guidance and project management of Scenic Hudson and the Consensus Building Institute. Their assistance was invaluable to the success of this process and I am most grateful for their partnership.

*- Chris Sanders*
*Mayor, Village of Piermont*
*September 11, 2014*

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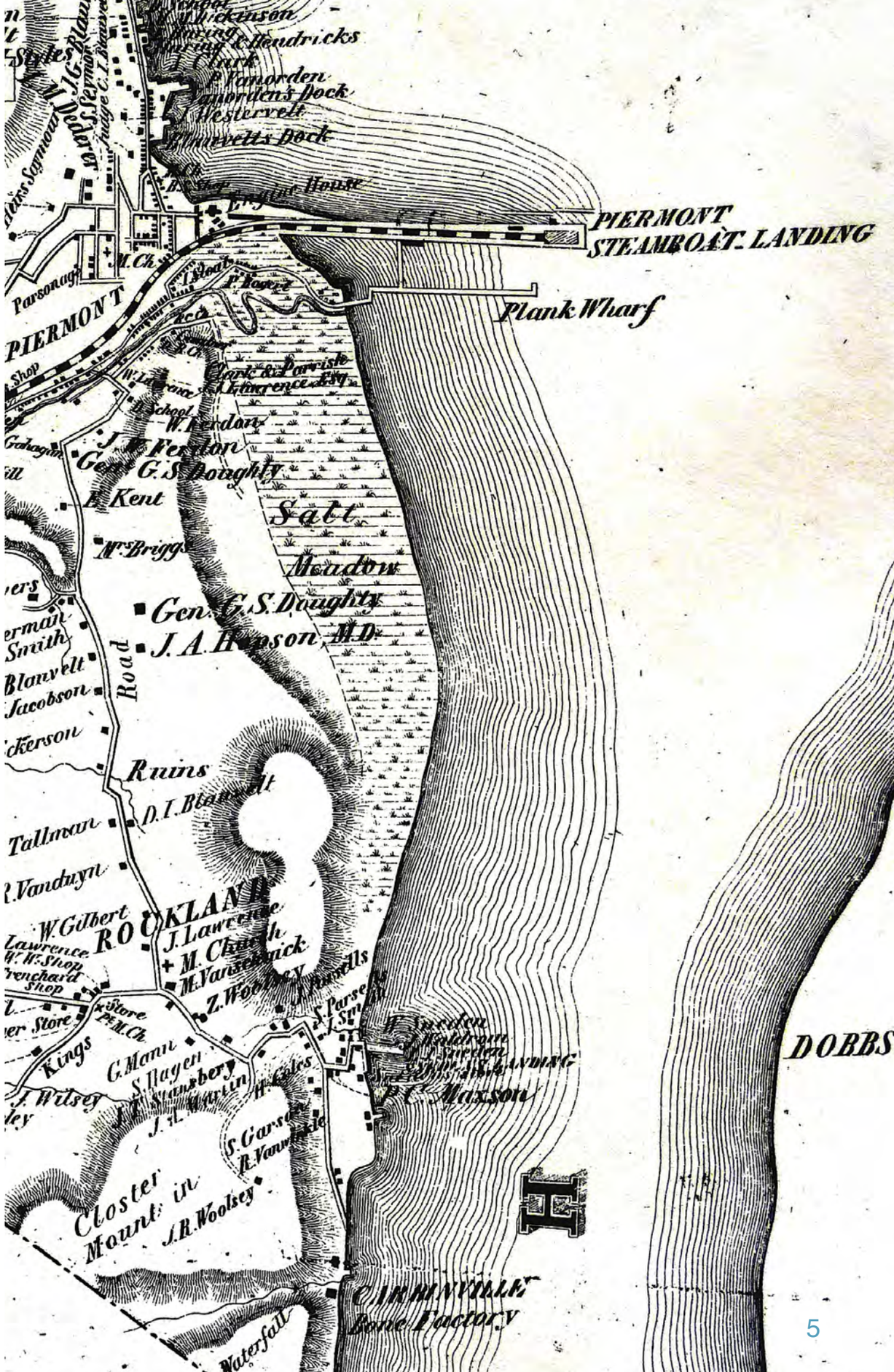


# EXECUTIVE SUMMARY

Nestled between the northern extension of the Palisades and the Hudson River, Piermont is a village of approximately 400 acres and 2,500 residents. Piermont's unique location on the banks of the Hudson River and the mouth of the Sparkill Creek is perhaps its greatest asset and, at the same time, poses a significant challenge. The same confluence of waterways and land that has attracted residents and commerce to the Village presents the risks of waterfront flooding and, over the long term, sea level rise.

When Hurricanes Irene and Lee hit in the late summer of 2011, the Village of Piermont experienced significant flooding driven by stormwater flows in the Sparkill Creek and storm surge from the Hudson River. Just over a year later, Superstorm Sandy hit the northeast, bringing with it a historic coastal storm surge and additional flooding. The village endured Sandy without loss of life, but with severe damage along its waterfront to private homes, marinas, boats and businesses. One hundred fifty homes were flooded; many business were forced to close for weeks and even months.

The village has been working actively to envision and promote a comprehensive revitalization and recognizes the central role of the waterfront in the community. When Superstorm Sandy arrived, the Village of Piermont was in the midst of updating its Local Waterfront Revitalization Program. The intersection of the Village's revitalization goals and the community's new appreciation of the risks to the waterfront from flooding and sea level rise highlighted

the need for better information about future flood risks as it advances its objectives. Seeking solutions, the Village, together with its partners Scenic Hudson and the Consensus Building Institute, sought and was awarded support from the New York State Department of Environmental Conservation's Hudson River Estuary Program, for an initiative to address coastal flooding risks related to sea level rise.

The Piermont Waterfront Resilience Task Force project was formally launched by Mayor Sanders in November 2013 to begin creating a safer, more vibrant waterfront. The Task Force worked to develop a shared vision for the waterfront and a set of concrete steps that will move Piermont toward its vision for greater resilience. Throughout, the Task Force sought to align immediate recovery actions with a longer-term perspective of how the Village will adapt to rising seas and higher floods.

The Task Force, with its project partners and with input from the public, has synthesized a list of recommendations which, if implemented by the village, can be used as a flood and sea level rise resilience action plan. This report details these recommendations and the studies that support them, which span policy and planning updates, capital investments, municipal operations and infrastructure, and future studies that will better position Piermont to begin taking action and to attract future support for waterfront improvements.

Planning for Piermont's resilience will be an ongoing civic conversation in the community for decades to come. With this report, the Task Force makes an opening contribution to that dialog.

## Sea Level Rise and Planning for the Future

Along the Hudson River, from the Battery in Manhattan to the Federal Dam at Troy, sea level has risen approximately one foot over the past century. There is evidence that annual rates of sea level rise along the Hudson River have accelerated over the past two decades and will continue to outpace the global average.

After considering a range of sea level rise projections prepared by the New York State Sea Level Rise Task Force and the New York State 2100 Commission, the Task Force selected sea level rise values of 10" in the 2020s, 29" in the 2050s and 72" in 2100 for planning and analysis during the project.

| year | 2020s | 2050s | 2100 |
|---|---|---|---|
| sea level rise projection | 10" | 29" | 72" |

The task force chose these projections for planning and analysis because it opted to develop solutions for the most severe case and guard against under-preparation, not because it considered these to be the most likely sea level rise outcomes. Indeed, slower rates of sea level rise are possible, or even likely. In this case the use of higher projections would mean that the projection levels would be reached at some later date than those used by the Task Force, as future projections resulting from increased greenhouse gas emission continue to rise after 2100.

## Vulnerability of the Piermont Waterfront Area

Public health and safety, damage to assets, business downtime, and accessibility are some of the top concerns motivating Piermont to take action against future flooding events that are likely to increase due to more frequent intense downpours, storm surge events, and sea level rise that exacerbates the impact of both upland and coastal flooding.

The financial impact of Hurricane Sandy on Piermont exceeded $20 million. Risk and vulnerability assessments suggest that, over the coming century damages to structures alone could total nearly $200 million, with many homes permanently impacted and several key public assets like the sewage treatment pump station, the Fire Department's boat house, the Department of Public Works, and many roads increasingly at risk, if no action is taken.

*The financial impact of Hurricane Sandy on Piermont exceeded $20 million. By the end of this century damages could dwarf that amount if no action is taken to mitigate and adapt to climate change.*

## A Vision of a Resilient Piermont

With input from the public and a range of stakeholders, the Task Force identified several key principles that should guide Piermont's adaptation actions now and into the future. A resilient Piermont will...

- adapt gradually to avoid and minimize risks
- help its residents and businesses to recover quickly from floods and storms
- maintain the Village's relationship with the Hudson River
- maintain a vibrant business district and local economy.
- foster and build community
- be environmentally responsible
- be a model for others

## Adaptation Strategies

Examining a wide-range of adaptation types and tools, and evaluating their strengths and weaknesses, was an important part of the Task Force's process for considering both short-and long-term adaptation alternatives for the Village of Piermont. Many tools exist to implement community-wide adaptation, from land-use planning and regulation, urban design, and coastal engineering to market- & tax-based incentives, grants from state and federal agencies, spending, and public outreach actions.

The Task Force worked to launch the process of planning and designing a more resilient waterfront, not to complete it. Task Force members learned about the range of conceptual, architectural, and regulatory approaches to adaptation currently in practice or development in other coastal areas in the United States and abroad. With this perspective, the Task Force developed and evaluated a portfolio of "Adaptation Alternatives" - alternate scenarios for how specific neighborhoods or the entire Village might reduce risks and achieve the vision statements and principles.

Photo-simulation of a vegetated levee, constructed marsh and recreational park along the north side of the Condominium neighborhood.

A wider range of Adaptation Alternatives and Benefit-Cost Case Studies were considered by the Task Force and are available in this report and in its Supplemental Materials.

# TASK FORCE RECOMMENDATIONS

*The Task Force recommends the following proactive steps toward a safer, vibrant waterfront and a more resilient Piermont, both for the next storm event and for a future of rising seas.*

*The recommendations target a broad spectrum of Piermont's physical, natural and social fabric and are focused on actions that tie immediate recovery needs to long-term adaptation goals.*

*Each recommendation is phased to a specific timeline and implementers have been identified to establish clear lines of responsibility.*

*Most importantly, these recommendations comprise an integrated set of actions that will make substantive contributions to the well-being of the community and its residents.*

1. *Improve emergency communications in the Village.*
2. *Develop a comprehensive emergency management plan.*
3. *Work with local utilities, in particular electric, gas, water, sewer, and telecommunications, to improve resilience.*
4. *Advocate and coordinate with Rockland County and Orangetown to increase infrastructure, access, and stormwater resilience.*
5. *Conduct a risk and engineering review to analyze adaptation, relocation, building and decommissioning options for municipal infrastructure.*
6. *Work through the Rockland County Multi-Jurisdictional Natural Hazard Mitigation Plan to position Piermont for resiliency actions and funding opportunities.*
7. *Establish a permanent Flooding and Storm Resilience committee.*
8. *Proceed with application to the National Flood Insurance Program's Community Rating System (CRS) and evaluate other options to reduce the impact of increasing flood insurance rates on the community.*
9. *Create and implement a Floodplain Management Plan.*
10. *Incorporate findings/ recommendations of the Piermont Waterfront Resilience Task Force into the new Local Waterfront Revitalization Program.*
11. *Identify properties which may be of high priority for acquisition/relocation in long-term resiliency plans and implement a fund to acquire such properties upon their availability.*
12. *Continue exploring long-range adaptation possibilities for the Village of Piermont, including structurally and economically viable solutions that offer a long-term pathway and can help guide wise near-term investments.*
13. *Create a Municipal Village Master Plan that incorporates flood resilience, adaptation planning, and other land use issues.*

14. *Adopt and periodically update sea level rise and flood projections recommended by New York State and FEMA for municipal decision making and planning purposes.*

15. *Train all municipal staff and emergency managers in the use of the Task Force's risk and vulnerability assessments, sea level rise projection maps, as well as changing coastal hazards risks such as storm surges.*

16. *Research financing options for supporting flooding adaptation, mitigation and protection measures.*

17. *Integrate departmental budget requests into a village-wide Capital Improvement Plan.*

18. *Consider cost-benefit analyses and long-term flood risk due to sea level rise and stronger storms in asset design and the prioritization of strategies to manage key municipal assets.*

19. *Initiate Climate Smart Communities actions and participate in the program's new certification program.*

20. *Post flood preparedness, flood-resilient building, and mitigation resources on village website.*

21. *Provide presentations and public training opportunities to inform the public of flood-related issues and solutions.*

22. *Design and install high-water-mark signs throughout the 100/500 year floodplain areas to educate the community about flood risk and refer interested residents/property owners to additional sources of flood preparedness information*

23. *Share the findings of the Piermont Waterfront Resilience Task Force and collaborate with other waterfront communities to improve understanding of and planning for coastal hazards such sea level rise and storm surge.*

24. *Advocate to the state on climate change and flooding resilience issues.*

## Implementation: Top Priorities

The Task Force has prioritized the following recommendations as the most strategic to tackle first, both for near-term recovery and to set the stage for long-term resilience.

***Establish a permanent Flooding and Storm Resilience Committee to follow up on implementing the Task Force recommendations.***

***Improve emergency communications***

***Incorporate Task Force findings/ recommendations into the Local Waterfront Revitalization Program (LWRP) update.***

***Develop a Comprehensive Emergency Management Plan.***

***Work with local utilities to improve resilience.***

***Identify financing options, including grants, for supporting flood adaptation, mitigation and protection measures.***

# OVERVIEW

Nestled between the northern extension of the Palisades and the Hudson River, Piermont is a village of approximately 400 acres and 2,500 residents. Piermont's unique location on the bank of the Hudson River and the mouth of the Sparkill Creek is its perhaps its greatest asset and, at the same time, poses a significant challenge. The same confluence of waterways and land that has attracted residents and commerce to the Village, presents the risks of waterfront flooding and, over the long term, sea level rise.

When Hurricanes Irene and Lee hit in the late summer of 2011, the Village of Piermont experienced significant flooding driven by stormwater flows in the Sparkill Creek and storm surge from the Hudson River. Just over a year later, Superstorm Sandy hit the northeast, bringing with it a historic coastal storm surge and additional flooding. The village endured Sandy without loss of life, but with severe damage along its waterfront to private homes, marinas, boats and businesses. One hundred fifty homes were flooded; many business were forced to close for weeks and even months.

At the same time, the village has been working actively to envision and promote a comprehensive revitalization and recognizes the central role of the waterfront in the community. When Superstorm Sandy arrived, the Village of Piermont was in



the midst of updating its Local Waterfront Revitalization Program (LWRP). The intersection of the Village's revitalization goals and the community's new appreciation of the risks to the waterfront from flooding and sea level rise highlighted the need for better information about future flood risks as it advances its objectives. Seeking solutions, the Village, together with its partners Scenic Hudson and the Consensus Building Institute, sought and was awarded support from the New York State Department of Environmental Conservation's Hudson River Estuary Program, for an initiative to address coastal flooding risks related to sea level rise.

The Piermont Waterfront Resilience Task Force (PWRTF) project was formally launched in November 2013 to begin the work of creating a safer, more vibrant waterfront. The Task Force, with its project partners and  input from the public has synthesized a list of recommendations which, if formally accepted by the village, can be used as a flood and sea level rise resilience action plan. This report details these recommendations, which better position Piermont to begin to take action and to compete for future state and federal support for waterfront improvements. Through this process, task force members have become well-versed in the issues surrounding sea level rise, flooding, adaptation, and resiliency planning in their community, and represent an increased capacity in the village as it endeavors towards resilience.

## TASK FORCE OBJECTIVES

At the outset of the Task Force a series of objectives were defined by the Village of Piermont Mayor Chris Sanders, the members of the Task Force, and the partner groups. These included:

- **Bring the community together to describe a shared vision for the future of their waterfront;**
- **Create a foundation of analysis, data and communal knowledge about sea level rise and flooding adaptation approaches, and use this information to determine which approaches make sense for Piermont, and why;**
- **Produce a set of locally-specific, phased recommendations for policy improvements, capital investments, open space/access opportunities and future studies that will move Piermont toward its vision for greater resilience;**
- **Position Piermont to prioritize and begin implementing the Task Force's recommendations and to attract funding for waterfront improvements;**
- **Build the community's capacity and experience in planning for waterfront resilience.**

# APPOINTED TASK FORCE MEMBERS

Mayor Sanders appointed representatives from the community with a range of interests and expertise to serve on the Task Force. Task force members included village business owners, residents, Village staff, members of the Village Board and other community leaders. The goal of this broad representation was to integrate a wide view of the Village's needs and vision and to tap into different skills and local knowledge, with the intention that the work of the PWRTF would reflect the sensibilities and priorities of the community fairly and effectively.

**Appointed Task Force members**

| | |
|---|---|
| Rob Burns* | *LWRP Update Committee* |
| Walter Cain* | *Architecture Student* |
| William Cavanaugh | *Piermont Fire Chief* |
| Lisa DeFeciani* | *Village Board* |
| Richard Esnard* | *Piermont Historical Society* |
| Meg Fowler* | *Resident* |
| Klaus Jacob* | *LWRP Update Committee* |
| Stan Jacobs* | *LWRP Update Committee* |
| Suren Kilerciyan | *Business Owner* |
| Greg McKillop* | *LWRP Update Committee* |
| Steve Silverberg* | *Village Board, LWRP Update Committee* |
| Laura Straus* | *Village Chamber of Commerce* |
| John VandenOever* | Pastor, *Reformed Church* |
| Sylvia Welch* | *Village Grant Administrator* |
| Usha Wright* | *Resident* |

* indicates attendance at 3 or more Task Force meetings

# PROJECT TEAM

Project leadership and technical assistance was provided by Scenic Hudson, the Consensus Building Institute, NYS DEC Hudson River Estuary Program and Catalysis Adaptation Partners, with additional support from the Lincoln Institute for Land Policy.

**Scenic Hudson - Science, Planning, and Project Management**
Jeffrey Anzevino - *Director of Land Use Advocacy*
Steve Rosenberg - *Senior Vice President*
Sacha Spector - *Director of Conservation Science*
Nava Tabak - *Conservation Scientist*
Mark Wildonger - *Senior Planner*

**Consensus Building Institute - Facilitation and Project Management**
Bennet Brooks - *Senior Mediator*

**NYS DEC Hudson River Estuary Program - Science and Planning**
Kristin Marcell - *Climate Program Coordinator*
Libby Murphy - *Climate Outreach Specialist*

**Catalysis Adaptation Partners - Benefit-Cost Economic Analysis**
Jonathan Lockman - *Vice President of Environmental Planning*

# PROJECT SEQUENCE AND ACTIVITIES

The Task Force, formally launched in November 2013, met 10 times and held three public workshops/presentations over a 10-month period.

The PWRTF worked through several phases to identify challenges, learn about a wide range of potential adaptation options, and develop solutions that are suited to Piermont. These phases were roughly sequential, though there was overlap at times.

**Phase 1: Data Gathering, Analysis and Risk Assessment**

**Phase 2: Community Visioning**

**Phase 3: Adaptation Strategy and Alternatives Analysis**

**Phase 4: Adaptation Recommendations Development**

**Phase 5: Presentation of Results (public engagement and final report)**

## ACTIVITIES

1. **Inventoried, mapped, classified, and evaluated current and future flood risks of waterfront assets**. Through exercises with the public and task force members, and complemented by a meeting of a small working group, Scenic Hudson used the Department of State's Inventory and Coastal Risk Assessment tool to examine risk, exposure, and vulnerability in the village. Modeled risk areas allowed for analysis of both current and future conditions, providing an overall picture of risks to private and public waterfront assets, and a focus on critical village facilities, access routes, and natural resources that will require flood resiliency planning.

2. **Selected a sea level rise projection for use in future planning**. Scenic Hudson presented the task force with the latest available projections of sea level rise for the lower Hudson River in the coming century, based on recent scientific studies endorsed by New York State. The task force elected to use increases in sea level of 10 inches for the 2020s, 29 inches for the 2050s, and 72 inches for 2100. While those projected sea level increases represent the upper ends of potential ranges for the chosen time frames, the TF used them  in planning exercises and analyses as a way to illustrate potential worst case scenarios and/or to prepare for a longer timeframe if sea level rises more slowly. (See section on Flooding Risks for a more complete discussion of this issue.)

3. **Compiled a shared vision of waterfront resiliency for the village of Piermont**. In an early public meeting, participants were invited to share their ideas of and for a resilient Piermont waterfront. The PWRTF compiled this information as a reference and guide in subsequent long-term planning exercises.

4. **Detailed past flood experiences from village residents and Task Force members.** Attendants of a public meeting were invited to share their past experiences and difficulties during recent storm and flooding events. Task force members added to this list of experiences and used them to identify emergency response and post-storm recovery issues.

5. **Developed multiple long-term adaptation scenarios for the village waterfront**. Following informational sessions on a wide range of possible flood adaptation and planning concepts, task force members collectively participated in a “design workshop” to develop ideas for the village’s long-term change. The group further developed these scenarios through an iterative process, evaluating the pros and cons of each strategy and creating additional visualizations of potential scenarios. These adaptation scenarios are meant to serve as a first step in what will be a longer civic dialog on the future of the waterfront, rather than to offer any definitive options.

6. **Compared the benefit-cost ratios of three long-term adaptation scenarios and a no-action scenario.** Catalysis Adaptation Partners used the Coastal Adaptation to Sea level rise Tool (COAST) to analyze future projected costs to village real property from one time storms and cumulative storm events at different time frames. The tool enables comparison of no-action scenarios (i.e., no adaptations are undertaken) with those scenarios in which real property assets are partially or wholly protected from flood damages. This analysis provided insight on the economic factors that will contribute to long-term plans for the village waterfront.

7. **Inventoried existing village, town, and county plans to identify strengths and planning opportunities.** The DEC Hudson River Estuary Program and Scenic Hudson led the task force and additional municipal representatives in completing the Climate Smart Resiliency Planning tool. The task force used the results from this tool and other informational resources to identify existing plans and policies that can be used to address flooding issues in the village and new opportunities for more resilient planning.

8. **Compiled a set of recommendations for actions the Village of Piermont can take for improved flood and storm resilience.** The 24 recommendations draw on the various exercises and analyses outlined above. They are categorized by recommended time frames for action (e.g. immediate, next 1-2 years, next 2-5 years) and by sector (e.g. planning and codes, municipal operations).

# FLOODING RISKS: TODAY AND INTO THE FUTURE

Historically, Piermont's waterfront has been subject to flooding from both the Sparkill Creek, due to heavy rainfall events, and coastal hazards along the Hudson River, due to high tides and coastal storm surges (associated with hurricanes, tropical storms, and nor'easters) that travel up the river.

Over the last 100 years the waterfront has experienced flooding from at least 12 hurricanes and tropical storms and many nor'easters. In recent years, the Village's entire waterfront - including residential neighborhoods and the business district - was seriously impacted by flooding from both the Hudson and Sparkill during Tropical Storms Irene and Lee in 2011 and by a record-breaking storm surge during Hurricane Sandy in 2012. Some areas of the waterfront, like the Bogertown neighborhood, are flooded regularly by the highest tides.

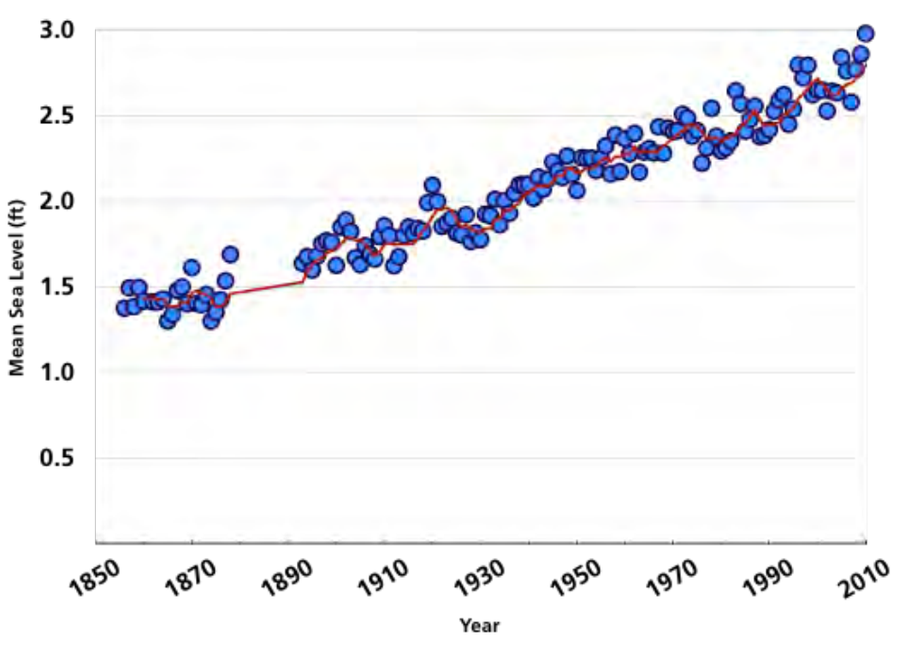
Public health and safety, damage to assets, business downtime, and accessibility are some of the top concerns motivating Piermont to take action against future flooding events, which are likely to become more severe due to more frequent and intense downpours and storm surge events, and sea level rise that exacerbates the impact of both upland and coastal flooding.

Assessing the risks facing Piermont and their shifting nature within a changing climate provides the community with critical information for taking proactive measures to maintain the Village as a safe and welcoming place.


Flooding and debris left by Hurricane Sandy in 2012.

# SEA LEVEL RISE

Around the world, ocean sea levels are rising at an accelerating pace. Along the Hudson River, from the Battery in Manhattan to the Federal Dam at Troy, sea level has risen approximately one foot over the past century. There is evidence that annual rates of sea level rise along the Hudson River have accelerated over the past two decades and will continue to outpace the global average. While the exact pace of future sea level rise is not certain, there is every reason to believe that sea level rise will continue to accelerate throughout this century and beyond. Much depends on how much greenhouse gas pollution we add to the atmosphere and how quickly the Greenland and Antarctic ice sheets melt and add their water to the oceans.




Mean sea level measured by tidal gauge at The Battery, Manhattan from 1856-2012. Blue dots denote annual mean sea level, the red line is a 5-year running average. Source: NOAA

Projections for future sea level rise on the Hudson River and elsewhere in New York State have been provided in recent reports from NYS CLIMAID, the New York State Sea Level Rise Task Force and the NYS2100 Commission. These projections are based on a combination of empirical data about the historical relationships between climate and sea level, predictions of future climate conditions generated by a suite of global circulation/climate models, and estimates of ice sheet melt behavior from current observation and models. For the lower Hudson River, they are as follows:

| | 2020s | 2050s | 2080s | 2100 |
|---|---|---|---|---|
| Sea Level Rise | 2 - 5 | 7 - 12 | 12 - 23 | 15 - 30 |
| Sea Level Rise with Rapid Ice Melt | 5 -10 | 19 - 29 | 41 - 55 | 56 - 72 |

Sea level rise projections for the lower Hudson River, from NYS 2100 Commission report (in inches, relative to a baseline year of 2000). The Sea Level Rise scenario in the upper row is based on the central range (middle 67%) of values from model-based probabilities rounded to the nearest inch. The Sea Level Rise with Rapid Ice Melt scenario is based on acceleration of recent rates of ice melt in the Greenland and West Antarctic Ice sheets and paleoclimate studies.

# LOCAL SEA LEVEL RISE PROJECTIONS

The Task Force considered sea level rise projections and planning timeframes that it felt were most appropriate for developing Piermont's adaptation goals. Broad discussion focused on balancing the scientific consensus and uncertainties surrounding sea level rise, as well as whether planning proactively for "worst case scenarios" or "best case scenarios" are desirable in preparing for long-range flooding challenges.

The task force selected the 2020s, 2050s and 2100 as the time horizons for analyzing waterfront risks, and elected to consider sea level rise values of10" in the 2020s, 29" in the 2050s and 72" in 2100. The task force chose these projections for planning and analysis because it opted to develop solutions for the most severe case and guard against under-preparation, not because it considered these to be the most likely sea level rise outcomes. Indeed, slower rates of sea level rise are possible, or even likely. In this case the use of higher projections would mean that the projection levels eventually would be reached at some later date than those used by the Task Force, as future projections resulting from increased greenhouse gas emission continue to rise after 2100.

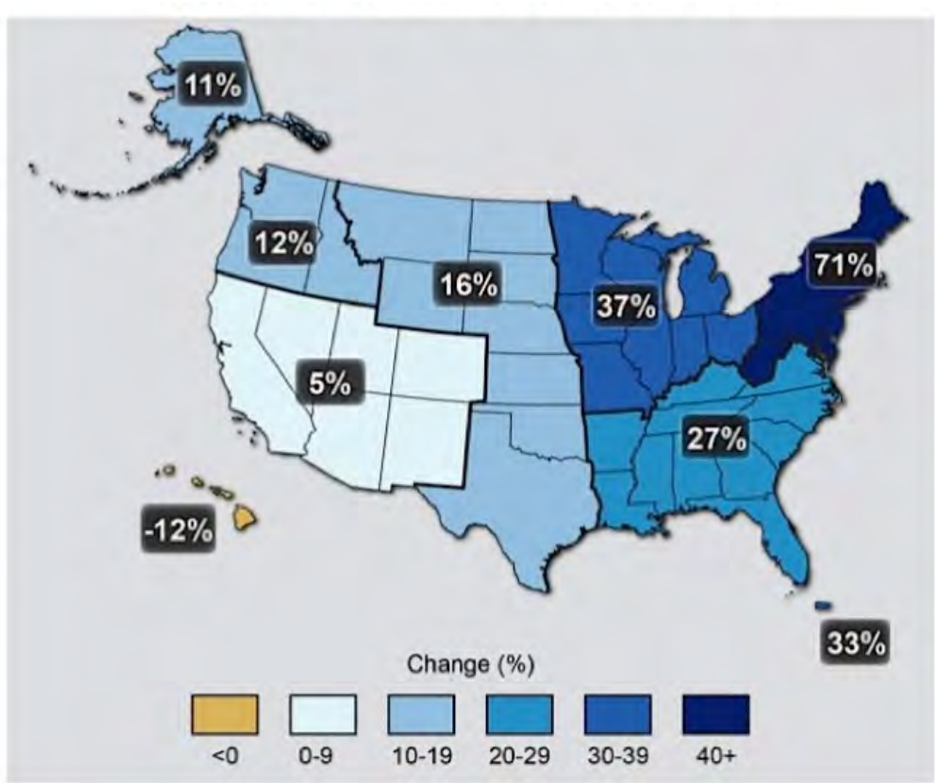
| 2020s | 2050s | 2100 |
|---|---|---|
| 10" | 29" | 72" |

Sea Level rise projections and planning timeframes selected by the Task Force. Amounts of sea level rise are relative to a baseline year of 2000.

# LOCAL PRECIPITATION AND FLOODING PROJECTIONS

Substantial evidence indicates that extreme precipitation events in the Northeast are becoming more frequent and larger. This can be expected to lead to higher stream flows and expanding riparian flood zones in Hudson River tributaries such as the Sparkill Creek.

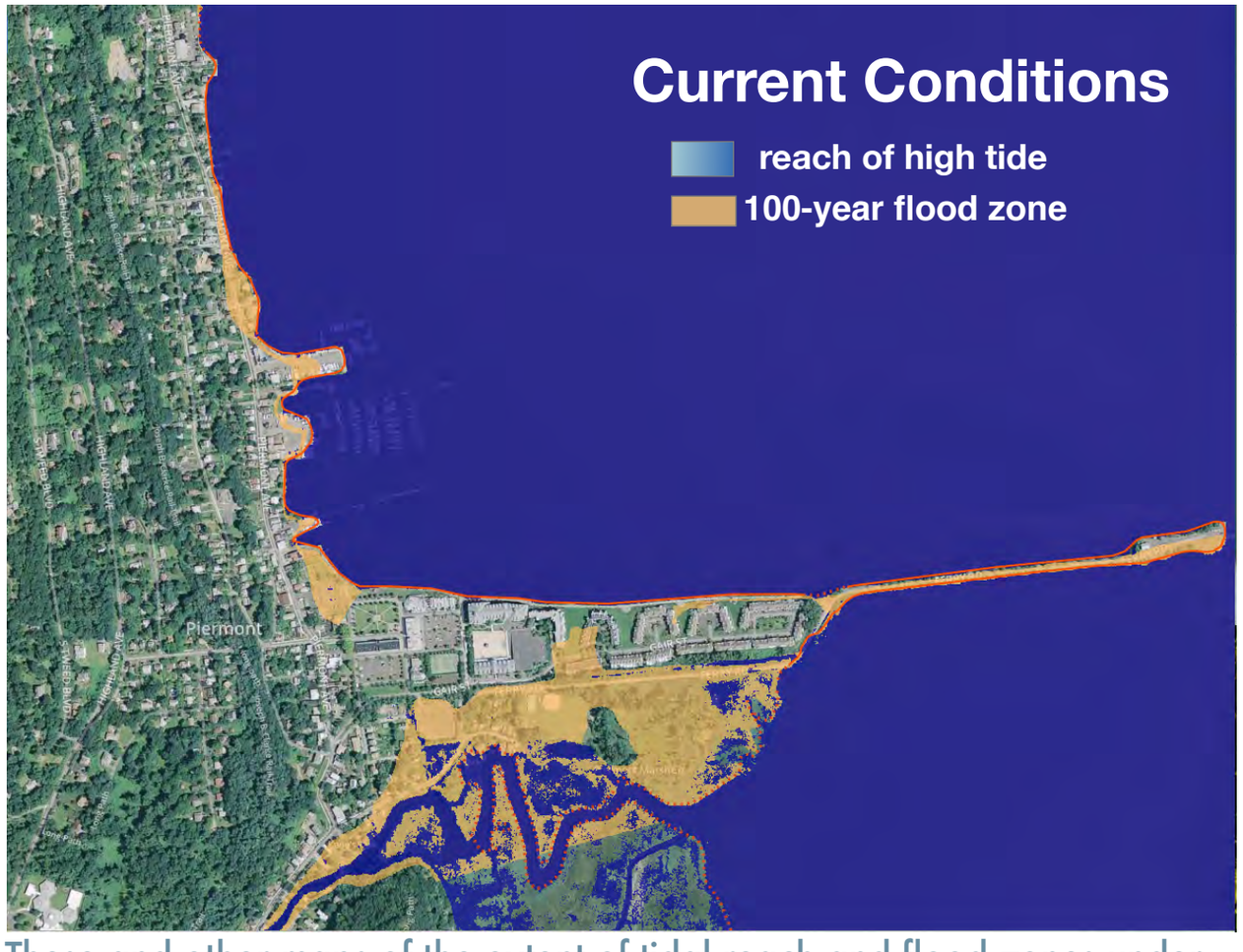
However, because there was not enough information at this time to project future rainfall amounts and incorporate upland flooding dynamics into this analysis, base flood depths along the waterfront were assumed to remain constant (though flood elevations were increased by the amount of sea level rise).



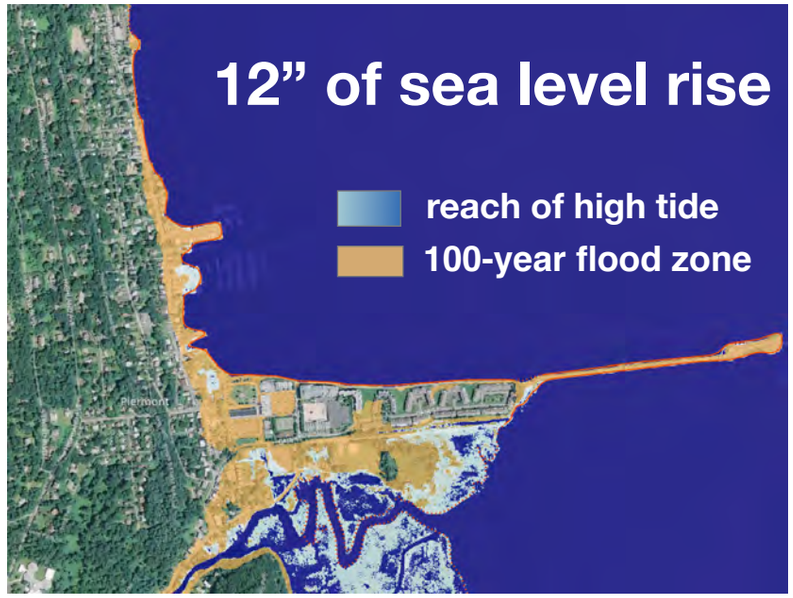

Observed Change in Magnitude of Very Heavy Precipitation Events (top 1% of all events) 1958 - 2012. Source: 2014 US National Climate Assessment.

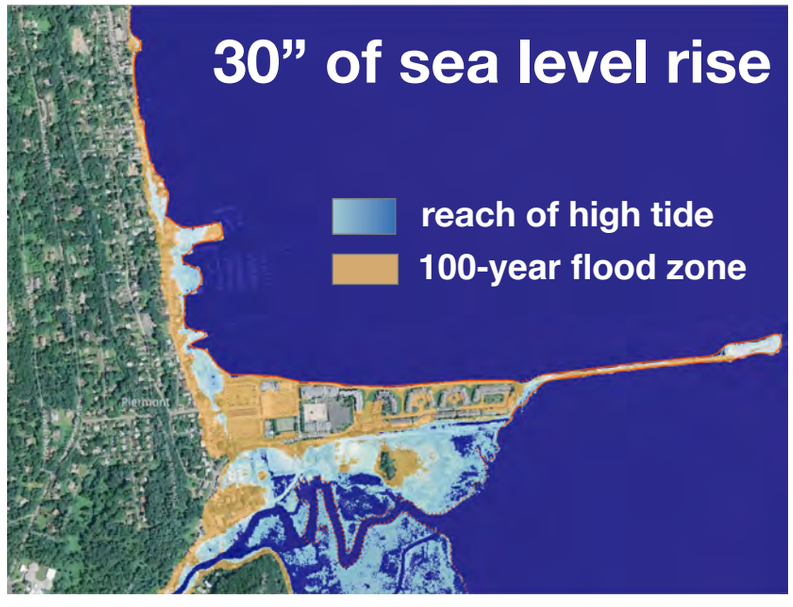
## MAPPING SEA LEVEL RISE AND FLOODING

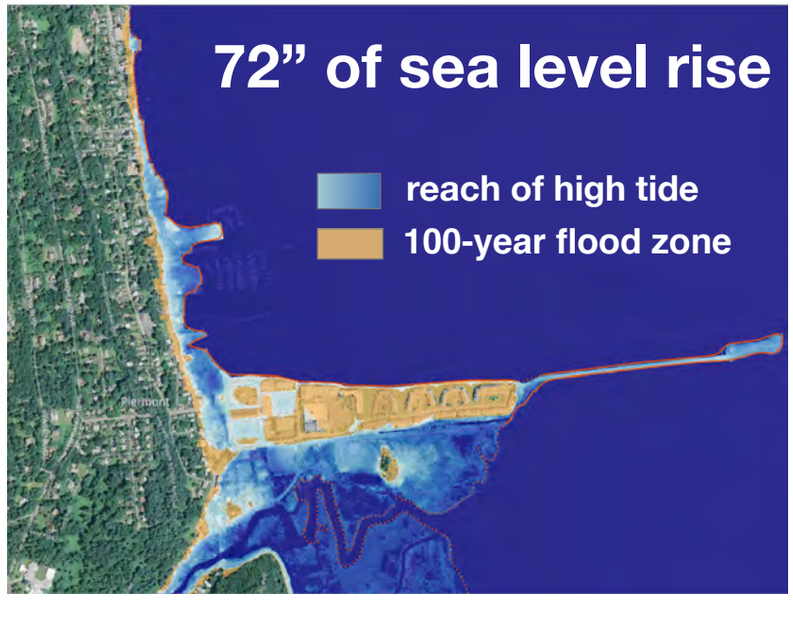
Using information from Scenic Hudson's Sea Level Rise Mapper and additional modeling by Scenic Hudson, the Task Force examined the current extent of flood prone areas, and areas that will be exposed to daily tides (inundated) or increasingly flood prone under various sea level rise scenarios. For mapping future extent of floodplains above the high tide line, future flood elevations were calculated by adding the base flood depth to projected future Mean Higher High Water (MHHW) following sea level rise.

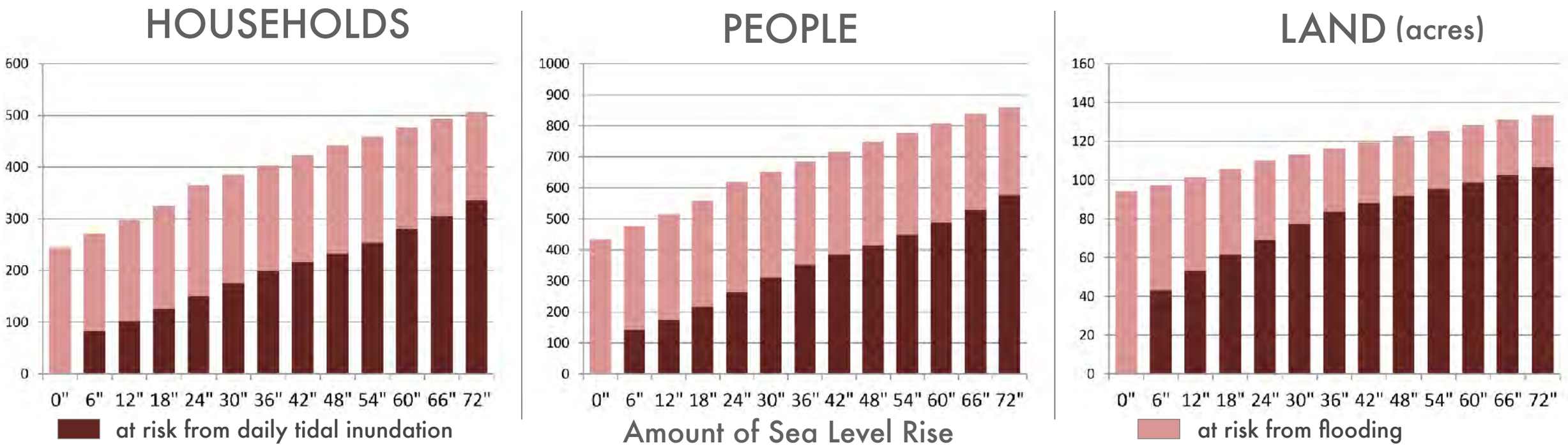



These and other maps of the extent of tidal reach and flood zones under various sea level rise are available through the Scenic Hudson Sea Level Rise Mapper. Note: The Sea Level Rise Mapper shows projected changes for 6" increments; those values closest to the task force's planning sea levels are shown at right. (www.scenichudson.org/slr)






## Expanding Hazards

Over the course of the century, as sea level rise changes the reach of daily high tides and flood elevations, risks to people and property will shift. A sea level rise of 72 inches – the sea level rise projections adopted by the Task Force for the 2100 planning timeframe – would make the areas along Piermont's waterfront and its low-lying neighborhoods increasingly subject to tides or flooding.

Modeling by Scenic Hudson estimates that the area of the waterfront subject to tides or flooding could expand by nearly 50% - from 93 acres to 132 acres. In the expanding risk zone lie additional community assets, households and citizens.

Above: Estimates of the number of Households, People and Land potentially exposed to flooding and/ or daily high tide inundation given increasing increments of sea level rise. Derived from US Census data and Scenic Hudson sea level rise data. Available through the Scenic Hudson Sea Level Rise Mapper (www.scenichudson.org/slr)

Right: A recently elevated home in Bogertown neighborhood, with the height of superstorm Sandy's floodwater indicated by homeowner.

## Assessing Risk

Using a risk assessment tool developed by the NYS Department of State as part of the New York Rising Community Reconstruction Program (NYR-CR Program), the Task Force evaluated Piermont's risk from flooding and storm surge events.

In this tool, overall risk scores are calculated based on multiple factors having to do with a particular structure, household, or item of infrastructure's position on the land, it's resiliency or ability to recover from a flood event, and the likelihood and magnitude of anticipated flood events.

(See Supplemental Materials for the full results of the NYR-CR Program Risk Assessment Tool analysis)

## HOW DO WE MEASURE RISK?

In this project, the Task Force assessed risks to property and other assets along Piermont's waterfront. Overall risk was calculated based on multiple factors according to the formula:

### RISK SCORE = HAZARD X EXPOSURE X VULNERABILITY

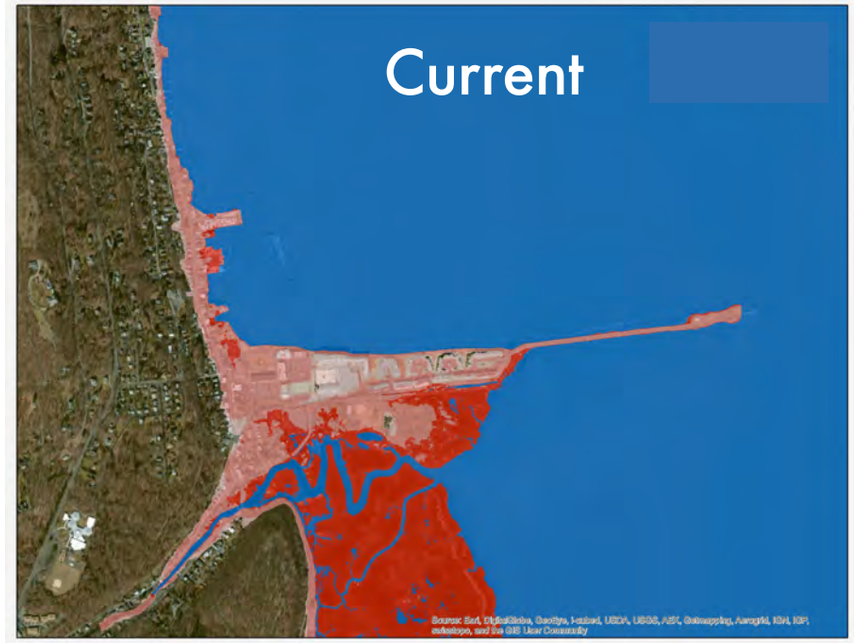
**Hazard**: the likelihood and magnitude of future storm events (in this analysis a constant for a 100 year storm was used).

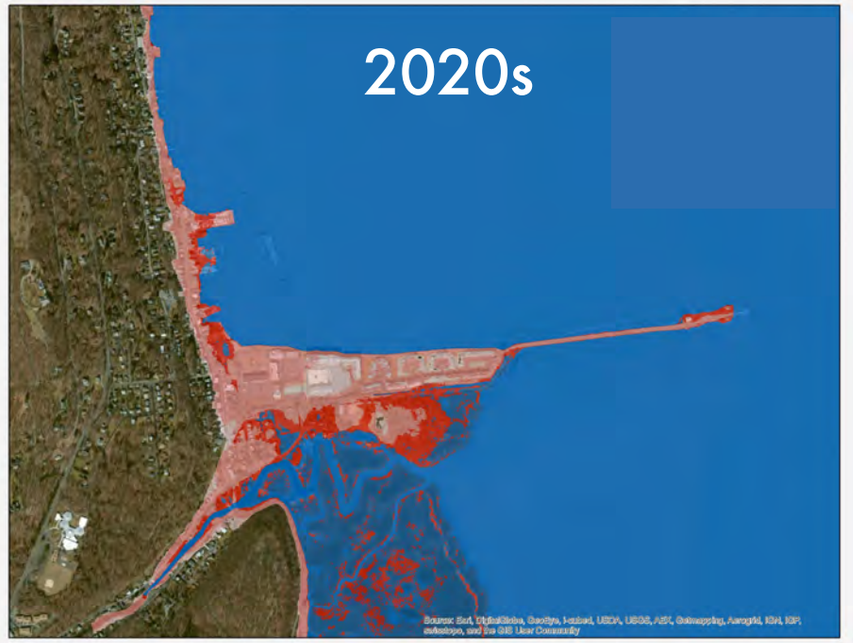
**Exposure** is a combination of Risk Area and Landscape Attributes.

**Risk Areas**: a flood-prone zone modeled based on current and projected sea levels, elevation, and FEMA's Base Flood Elevations.

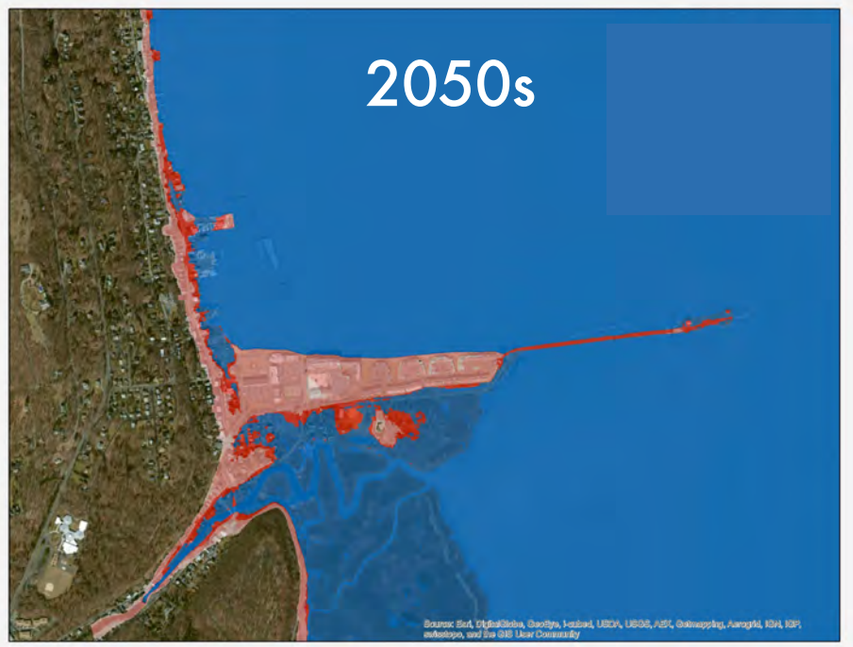
**Landscape Attributes**: the presence/absence of protective shoreline features or characteristics.

**Vulnerability**: an assigned score of the level of impairment or consequences that an asset may experience from a storm event, or its resiliency or ability to recover from an event.





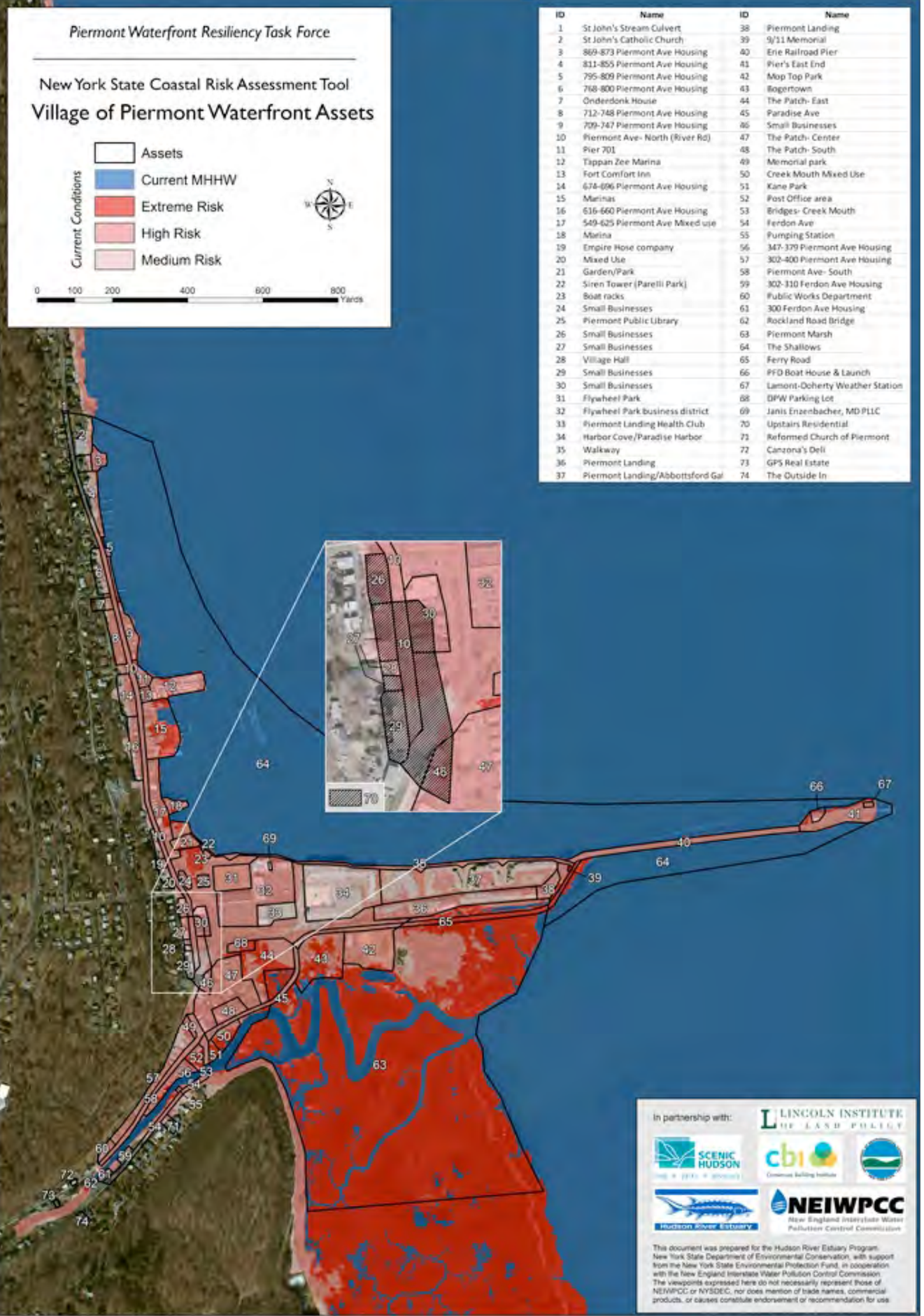



Clockwise from top left: Modeled risk areas for current conditions, 2020s, 2050s, and 2100. Inundated zones represent areas that would be expected to be underwater during daily high tides.

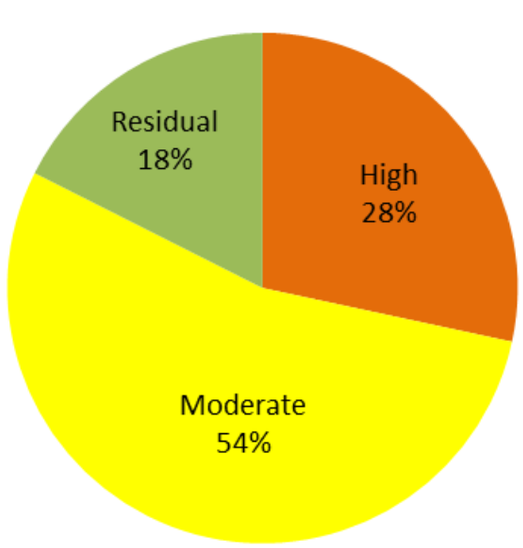
## Risk Areas

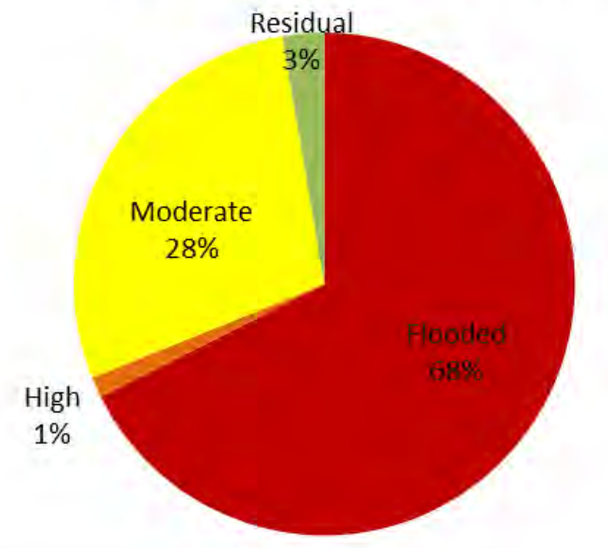
- **Inundated**
- **Extreme Risk**
- **High Risk**
- **Medium Risk**

The assessment illustrated that due to Piermont's topography, its associated risk areas are not expected to expand dramatically in size as sea level rises. Rather, we can anticipate the existing risk areas within the low-lying waterfront to gradually but dramatically shift into higher hazard categories – in other words become riskier – over time. For example, while the wide base of the pier has been elevated during its most recent redevelopment, a pattern of water pinching in from both north and south of the pier will develop in the coming century, which unless mitigated will cause regular inundation for core business district assets (commercial and residential) at the base of the pier.



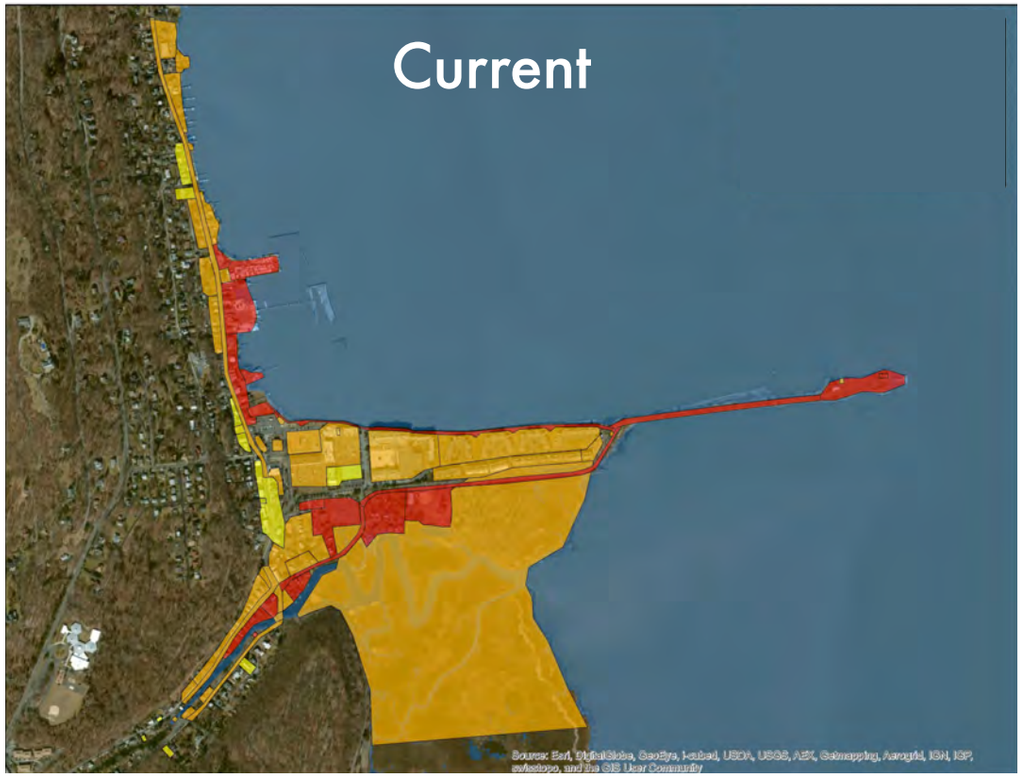

Over 70 individual structures, neighborhoods, natural and recreational areas, and infrastructure (collectively called “assets”) were assessed. Risk scores can be categorized into High, Moderate, and Residual levels. The overall pattern of risk scores is similar to that of the modeled risk areas in Piermont - a relatively small number of new assets became at-risk, while currently at-risk assets generally became more so over time. In contrast with risk areas, risk scores incorporate landscape attributes and vulnerability, thus accounting for additional ground and situational conditions that are relevant to the overall risk of assets in the village.




Proportions of assets in risk score categories under current conditions (left) and in 2100 (right).

Map of assets identified and assessed using the NYR-CR Program Risk Assessment Tool. (A larger image of this map and a full list of assets is available in Supplemental Materials.)

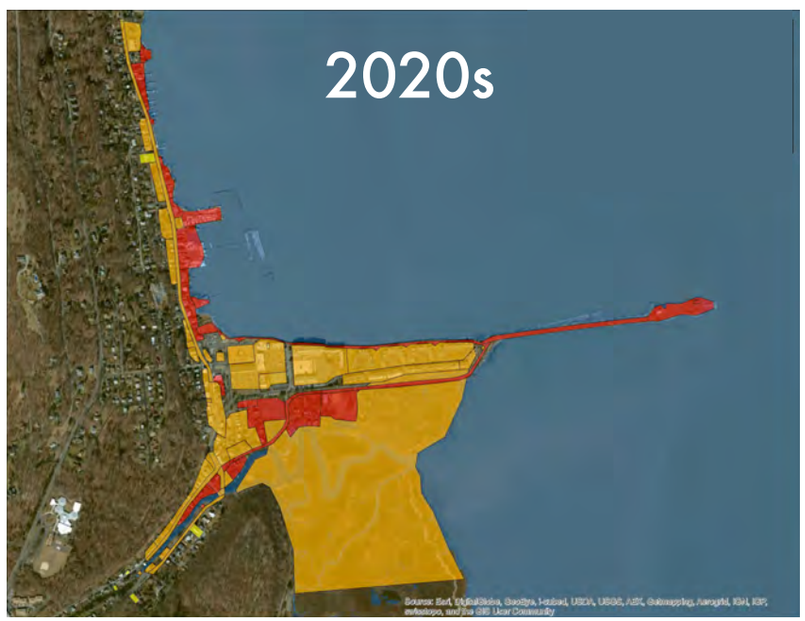


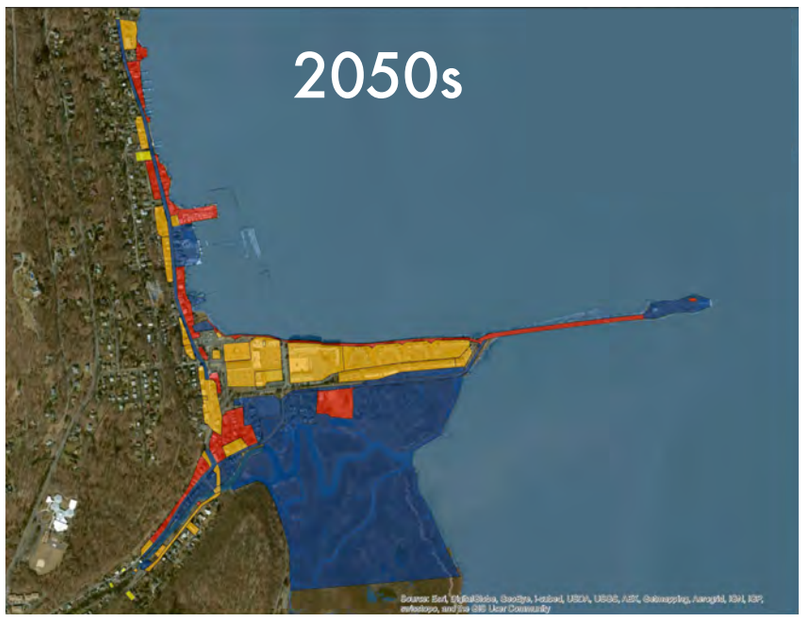

Risk scores for waterfront assets under current, 2020s, 2050s, and 2100 conditions.

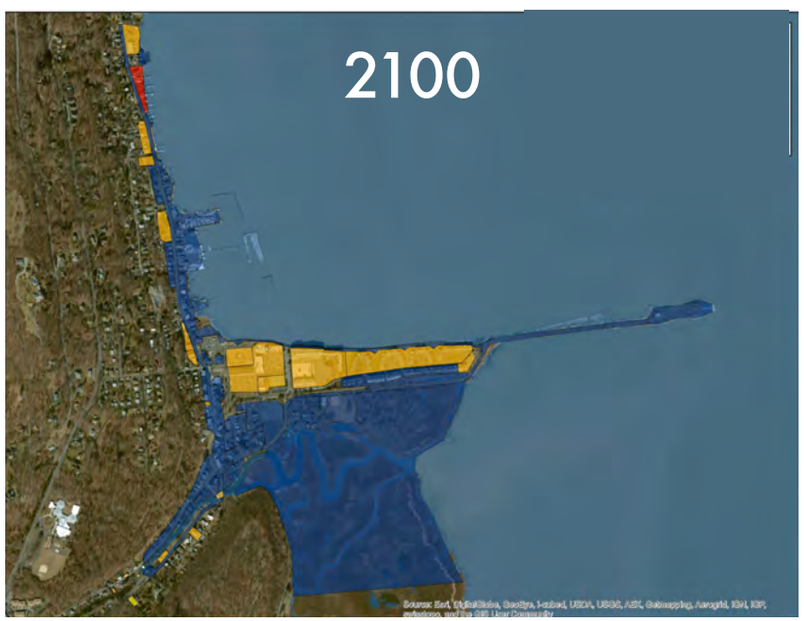
Critical assets projected to experience the highest risk by 2100 are the siren tower, sewage treatment pump station on Ferdon Avenue, the Fire Department's boat house and launch near the end of the pier, and the Department of Public Work's parking area and buildings. Several low lying sections of roads that function as important access routes were also identified as prone to flooding now and in the future.

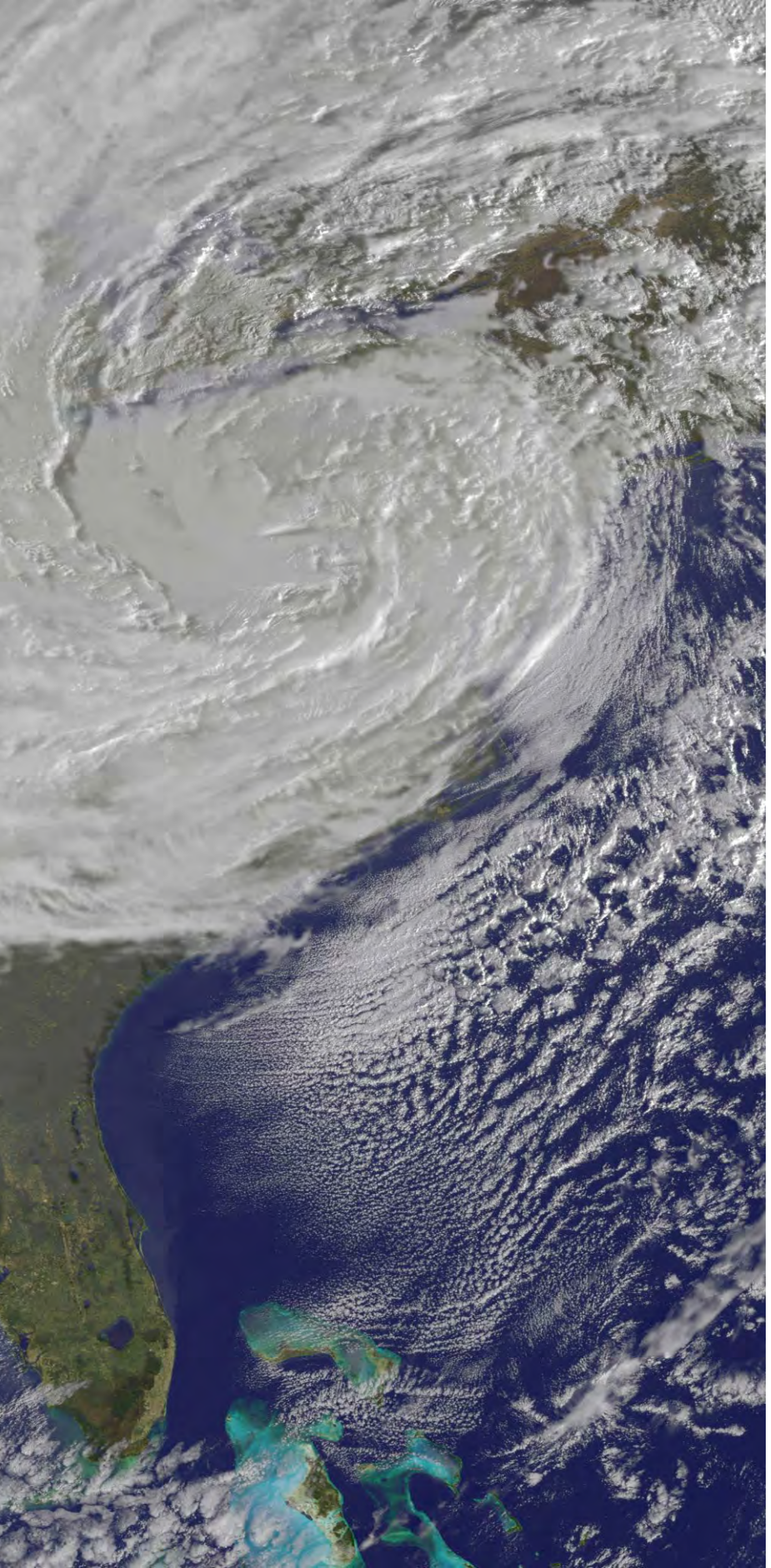
## Asset Risk Scores

- **Inundated (underwater at high tide)**
- **High Risk**
- **Moderate Risk**
- **Residual Risk**





## Estimating Financial impacts

The risk of damages from storm surges and upland flooding is a real and present issue for the people and economy of Piermont.

In 2012, Hurricane Sandy's record-breaking storm surge caused significant physical, economic and social disruption in the Village. Over 140 properties sustained damages or interruption of function - dislocating people and businesses for sustained lengths of time and leading to over $20 million in claims for rebuilding and lost income. This corresponds, when averaged over the entire village population, to a loss of about $8,000 per capita.

The Task Force worked to develop a preliminary understanding of the potential financial impacts of future flooding events and sea level rise if no actions are taken by the Village or it's residents to reduce risks. This provides both a clearer economic motivation for undertaking adaptation initiatives and an initial economic baseline against which to consider the relative benefits of potential alternatives.

The Task Force worked with Catalysis Adaptation Partners of Freeport, Maine, to use its COastal Adaptation to Sea Level Rise Tool (COAST) to conduct an economic vulnerability assessment for the Village from the threat of future storm surges, made worse by sea level rise over time.

The COAST modeling approach is designed to help communities evaluate their vulnerabilities and investigate the merits of various adaptation options, and to show which ideas might merit further study.

The results of this initial study are not considered definitive or precise, but instead are meant to offer general insights into the economic implications of changing coastal risk in Piermont. More rigorous evaluation of potential costs by engineering, architecture and planning experts will be needed before any designs are prepared or actions can be taken.

The economic projections created by COAST model outputs provide powerful motivation for local leaders and others to pursue funding to begin designing adaptation strategies to protect the community and make it more resilient.

Satellite image of Hurricane Sandy. Source: NASA GOES Project

**COAST Model for Piermont**
**Modeled Water Levels and Vulnerability Assessment Results**
**For the 100-Year Storm with Sea Level Rise in the Years**
**2025, 2055 and 2100**

| | | | Expected Damage Values to Buildings and Improvements (in $ Millions) | | |
|---|---|---|---|---|---|
| Year | Projected sea level rise | Number of Tax Parcels Affected | From a Single Storm In This Year | Permanently Inundated by SLR | Cumulative from SLR and All Storms Up To This Year |
| 2025 | 10" | 24 | 26.7 | 2.6 | 18.9 |
| 2055 | 29" | 87 | 35.7 | 17.9 | 70.8 |
| 2100 | 72" | 178 | 56.7 | 60.4 | 192.2 |

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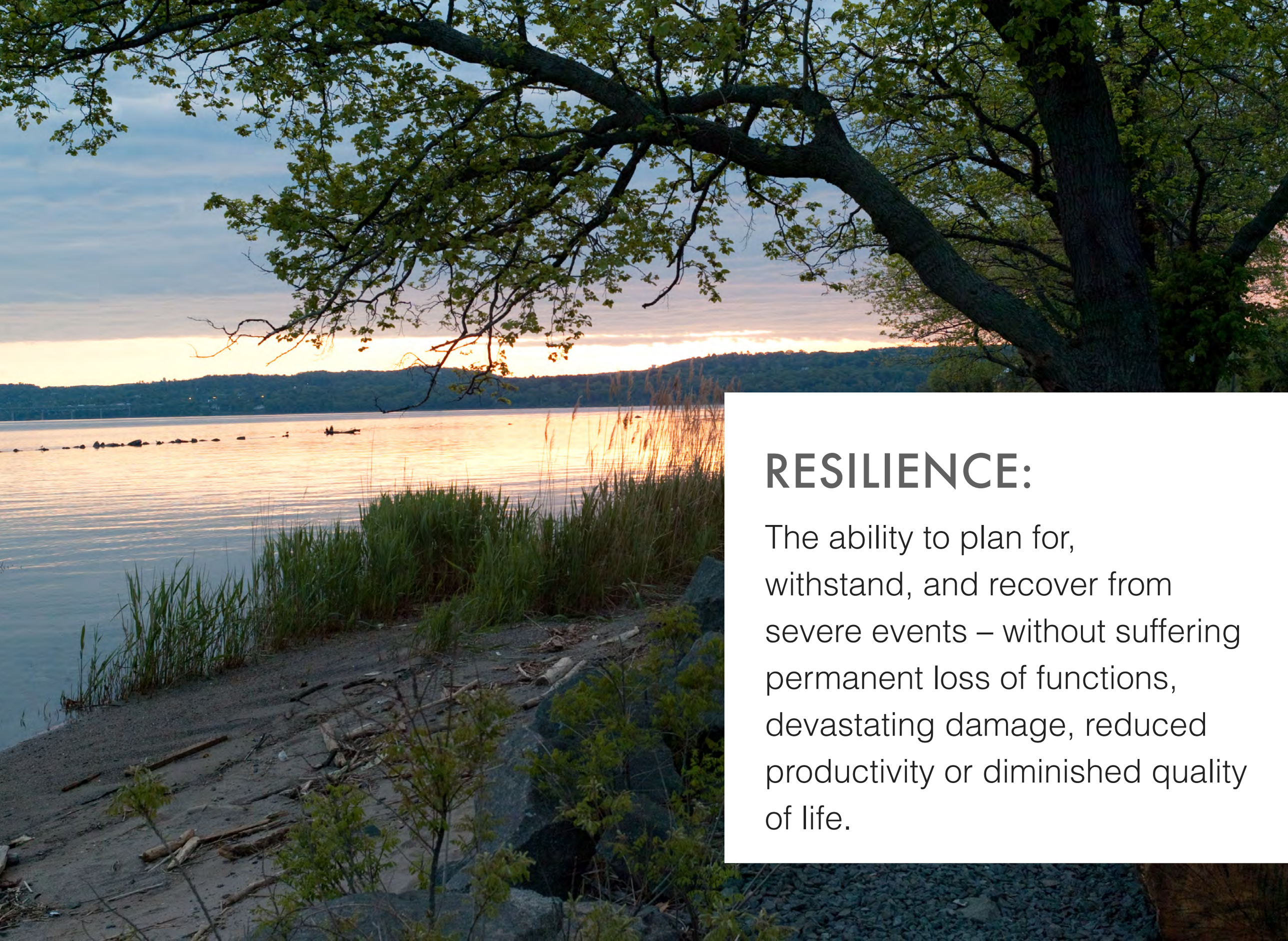
The COAST Vulnerability Assessment estimates that *with no adaptation actions*:

- By the year 2100, if sea level increases by 6 feet over today's, cumulative damages to buildings over time in Piermont, from all storms, is estimated to total $192.2 million (*in undiscounted dollars*).
- By the year 2100, if sea level increases by 6 feet over today's, 178 parcels will be permanently inundated by the Hudson River, with a total taxable assessed value of $105.5 million (*based on current assessed values*).
- A 100-year storm in the year 2055, arriving on top of a sea level increased by 2.42 feet over today's level, would inflict one-time damages of up to $35.7 million — significantly higher than from Superstorm Sandy.

Results of the COAST Model Vulnerability assessment, assuming no adaptation actions are undertaken. Results in $Million, (undiscounted dollars).

See chapter on Long-Term Planning and Supplemental Materials for full report from the COAST model work, including Benefit-Cost ratios for multiple adaptation alternatives and costs in discounted dollars.

Note: Cumulative damages for 2025 appears lower than the one time storm damage. This is because the COAST model did not project the occurrence of a 100-year storm before 2025 (though in reality such an event is possible.



# RESILIENCE:

The ability to plan for, withstand, and recover from severe events – without suffering permanent loss of functions, devastating damage, reduced productivity or diminished quality of life.

# VISIONS AND PRINCIPLES FOR A RESILIENT PIERMONT

Adaptation to new stresses such as sea level rise requires communities to change, reinvent, or even transform themselves. At the outset of its work, the Task Force developed a set of vision statements that would inform its it deliberations and establish a set of principles to ensure that its ultimate recommendations would be consistent with the community's desired outcomes for the Village. Members of the Task Force and over 30 participants at the November 25, 2013 public meeting were invited to identify what elements of the Village - physical, social, or otherwise - are most meaningful to them and to envision what a more resilient Piermont should strive to embody. Asked to complete the sentence, "A resilient Piermont will...", their responses painted a picture of a community that, among other things, would do the following:

*A resilient Piermont will...*

- *adapt gradually to avoid and minimize risks*
- *be a model for others*
- *help its residents and businesses to recover quickly from floods and storms*
- *maintain the Village's relationship with the Hudson River*
- *maintain a vibrant business district and local economy*
- *foster and build community*
- *be environmentally responsible*


Word cloud of responses from Task Force members and attendees of the November 25, 2013 public workshop. Participants were asked to complete the sentence, " A resilient Piermont will..."

# A resilient Piermont will...

## adapt gradually to avoid and minimize risks.

*comments included:*

- *Has realistic, adaptable plans that enable its waterfront areas to evolve in ways that minimize damage from flooding events*
- *Identifies solutions that can be implemented gradually*
- *Develops building codes that gradually implement solutions for the future*
- *Gradually retires, replaces, or relocates expiring infrastructure*
- *Considers gradual conversion of unsustainable residential waterfront neighborhoods into waterfront parkland*
- *Reduces "velocity" of wave action*
- *Elevates critical structures above floodplain*
- *Provides ways for water to flow off the hillsides and freely out to the river*

## be a model for others.

*comments included:*

- *Sets an example  on how to balance nature with human impact*
- *Becomes a destination for everyone to see how it's done*
- *Provides long-term solutions*

## help its residents and businesses to recover quickly.

*comments included:*

- *Allows businesses and homes to recover quickly while enjoying the day-to-day benefits of being on the waterfront*
- *Enables businesses in town and along River Road to be resilient and able to accommodate to and rebound affordably from flooding*

## maintain the Village's relationship with the Hudson River.

*comments included:*

- *Provides public boating piers for village residents as well as visitors to the community*
- *Provides open spaces (parks, riding paths, gardens) for use by residents*
- *Provides recreational opportunities at Tallman Mountain State Park, Sparkill Creek/Piermont Marsh, and the Hudson River*
- *Maintains a pedestrian village integrated with the river and its enjoyment*

## foster and build community.

*comments included:*

- *Has a vibrant village life with community involvement*
- *Is residentially-friendly*
- *Provides safe residential areas*

## maintain a vibrant business district and local economy.

*comments included:*

- *Maintains a vibrant commercial center while allowing recreational access to the river*
- *Maintains a viable restaurant base as an attraction*
- *Fosters a business-friendly community*
- *Preserves investments*
- *Maintain the value of homes and businesses regardless of water-related problems*
- *Protects tourism areas with shopping, stores and bike-friendly roads*
- *Maintains the pier as an attractor*

## be environmentally responsible.

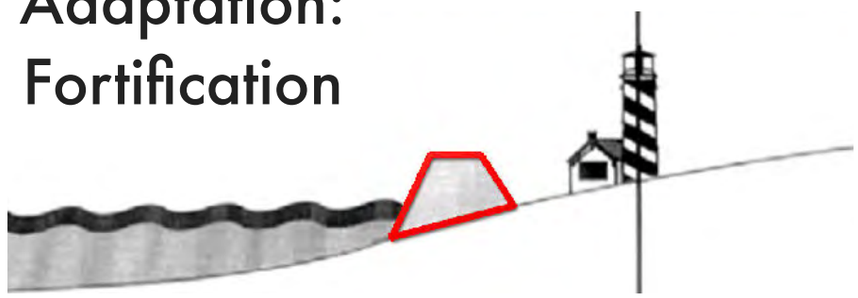
*comments included:*

- *Provides simple, green solutions that can be implemented in the near-term and maintained over time*
- *Encourages eco-friendly systems*
- *Protects scenic vistas from Tallman Mountain State Park, village, marinas, pier, and marsh*

# ADAPTATION

Actions or steps taken to minimize impacts from stresses, extreme events, or changing conditions.

# ADAPTATION STRATEGIES






Adaptation, in its most basic sense, is the process of changing to better fit or adjust to a place or situation. Climate change adaptation, in particular, includes actions to adjust to changing conditions, to minimize potential impacts, and to better cope with the consequences. Adaptation can also include taking advantages of opportunities as they present themselves to reduce risk and increase resilience.

There are many types of adaptation and various frameworks which individuals or communities can use to categorize approaches to sea level rise and other flood hazard adaptation. One framework that the Piermont Waterfront Resilience Task Force referenced, particularly in considering the built assets in the village's waterfront, divides flood adaptations into three categories: Fortification, Accommodation, and Relocation.

Fortification, sometimes referred to as structural or shoreline defenses, aims to reduce the impact of the hazard by keeping floodwaters out of contact with structures. Examples include sea walls, levees, and dry-floodproofing of buildings.

Accommodation approaches can be described as those that allow for exposure to floodwater, but reduce its impact or the extent of recovery effort needed. Structural accommodation examples include various types of building elevations (e.g. on piles or floating bases), wet-floodproofing, and enhancement/restoration of natural protective features such as shorelines and wetlands.

In a Relocation approach, individuals or communities seek to avoid exposure to flooding altogether by moving structures or uses out of the hazard areas. While this approach is conceptually straightforward, it can be socially and economically complex. There are many planning tools and incentives that can be used to reduce the economic and social impact of such relocations.

Examining a wide-range of adaptation types and tools, and evaluating their strengths and weaknesses, was an important part of the Task Force's process for considering both short- and long-term adaptation alternatives for the Village of Piermont. Many tools exist to implement community-wide adaptation, including land use planning, regulatory, market-based (e.g. incentives/taxes), spending, and outreach.

The Task Force considered how a range of fortification, accommodation, and relocation actions could be applied, and coordinated community-wide. Some adaptations were found to depend on others, while some fit particularly well with others (were considered interoperable) or provided benefits beyond flood adaptations (i.e. co-benefits).

top: Relocation - a conceptual plan for a new resilient waterfront park, Toronto, Canada

bottom left: Fortification - hard bulkhead along the Hudson River.

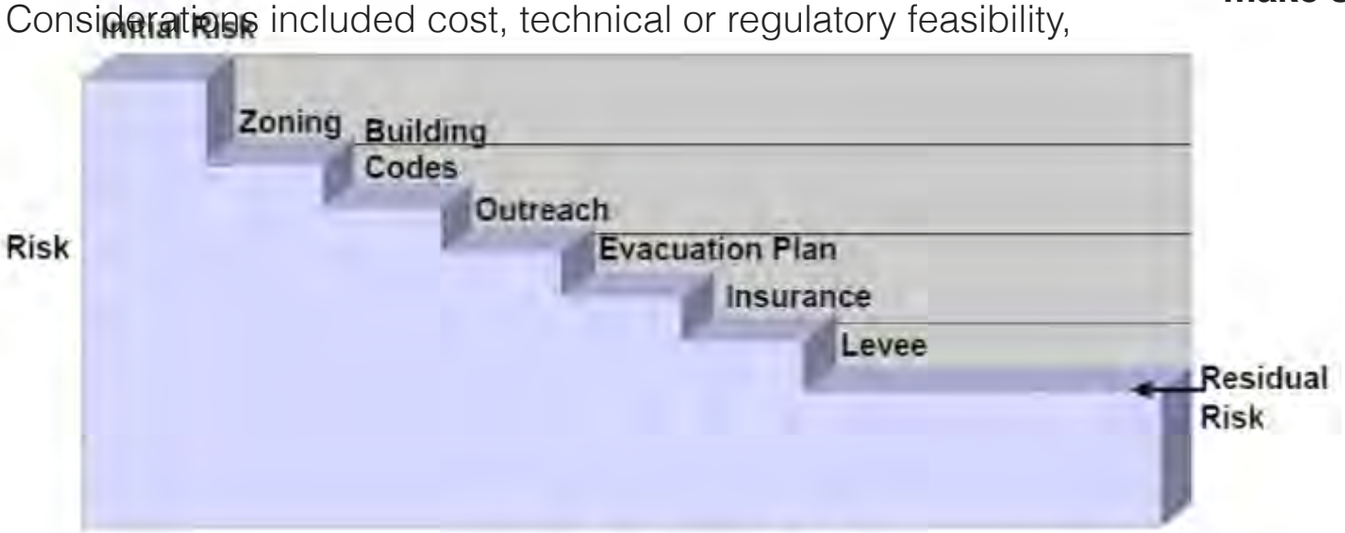
bottom right: Housing built to accommodate floodwaters in lowest floor, Waterrijk, Netherlands.

The Multiple Lines of Defense Strategy to Sustain Coastal Louisiana. *Lopez, John A., Lake Pontchartrain Basin Foundation, Metairie, LA January 2006*


Indeed, it was apparent that a high degree of coordination between strategies would be needed to enhance resilience of the entire Village. This is consistent with the Multiple Lines of Defense Strategy developed in Louisiana and elsewhere that emphasizes the need to employ complementary, sequential strategies that help create a more “fail-safe” system (see figure above).

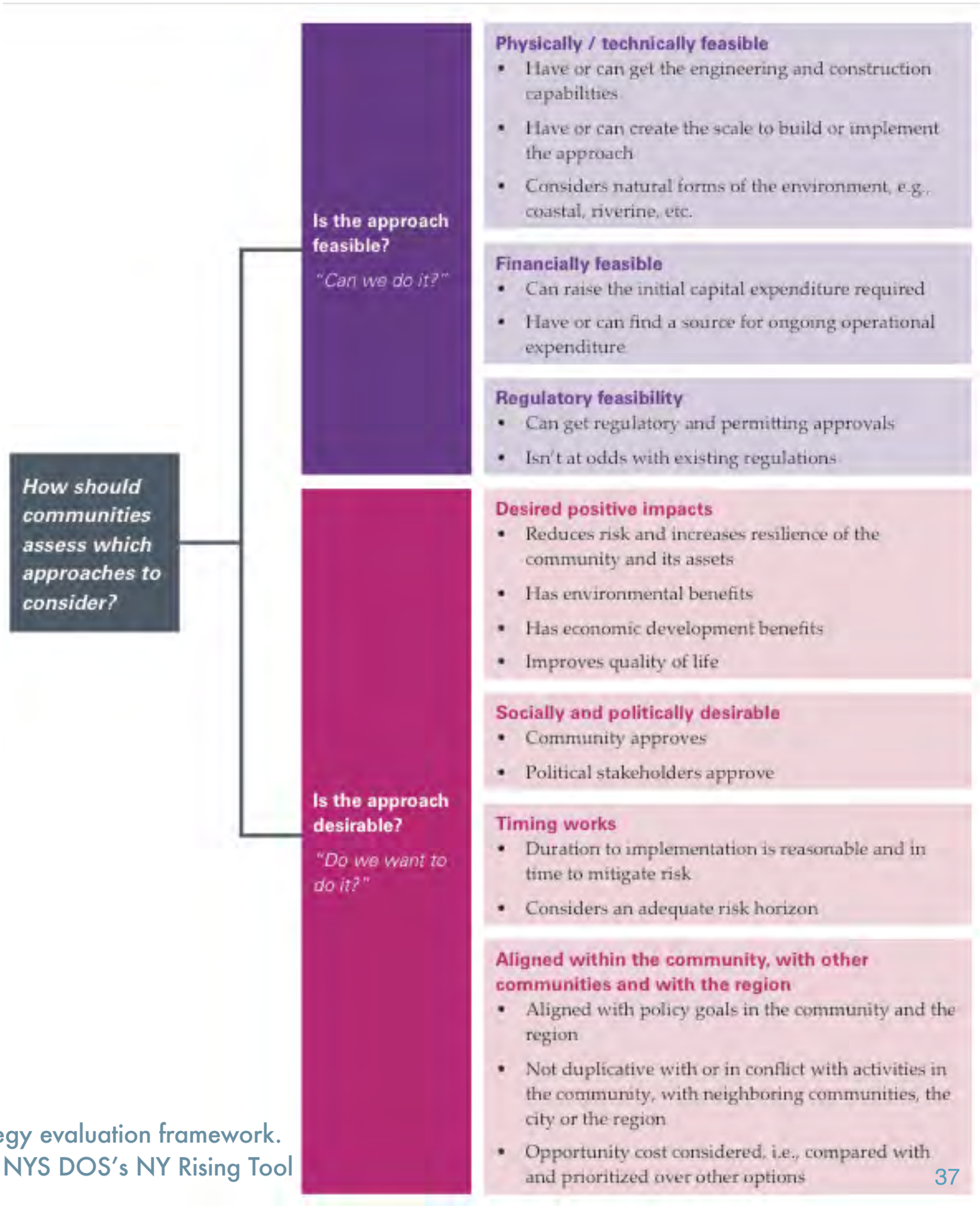
The Waterfront Resilience Task Force recognized that no single adaptation is perfect for all situations, and in examining different adaptation types sought to evaluate their applicability . Considerations included cost, technical or regulatory feasibility, social/political desirability, fairness, environmental impact, and implementation timeframe. Another important consideration for any adaptation type is its residual risk- the risk incurred if the adaptation fails to mitigate the hazard. Some of the adaptation strategies considered during this project, such as floodwalls, had high protective value but also high residual risk, as they could be overtopped or breached with potentially catastrophic consequences.

**How should communities assess which adaptation strategies make sense for them?**




Graphic of risk level following sequential implementation of risk reduction tools (zoning, outreach, etc.), with residual risk remaining after all tools.

The resilience visions and principles compiled by the Task Force are an essential set of guideposts for Piermont's current and future discussions about which kinds of adaptation strategies are best for the Village's unique character and circumstances. Also useful to consider are questions about technical, financial and legal feasibility, and whether strategies achieve the desired outcomes of reductions of risk and increases in resilience. During its deliberations, the Task Force referred to a framework created by NY Department of State that helps evaluate whether strategies are feasible, advisable, and desirable.




Strategy evaluation framework.
From NYS DOS's NY Rising Tool

# RECOMMENDATIONS

The Task Force presents the Village with the following recommendations for proactive steps toward a safer, vibrant waterfront and a more resilient Piermont, both for the next storm event and for a future of rising seas. The recommendations target a broad spectrum of Piermont's physical, natural and social fabric and are focused on actions that tie immediate recovery needs to long-term adaptation goals. Most importantly, these recommendations comprise an integrated set of actions that will make substantive contributions to the wellbeing of the community and its residents.

The recommendations are grouped into  the following categories:

1. Emergency Management & Communications
2. Reducing Risk to Critical Infrastructure
3. Planning and Codes
4. Municipal operations
5. Outreach and Collaboration
6. Site-based recommendations

These recommended actions are intended to be implemented immediately, (in the next 12 months), in the near term (1-2 years) and in the medium term (2-5 years). Additionally, the Task Force recognizes that for the Village to remain flexible and responsive to climate change over this century, long-range planning and adaptation considerations will be an ongoing dialog within the community, with new recommendations emerging over time. For each recommendation, lead implementers have been identified so that lines of responsibility are as clear as possible.



# Emergency Management & Communications

The Village of Piermont should ensure the efficiency and effectiveness of emergency management strategies to promote the safety of residents, limit damage to infrastructure and properties, and enable rapid recovery from significant emergency events.

## Immediate Actions

1. **Improve emergency communications:**

   - Inform residents of nixle.com, which is used to communicate emergencies in Rockland County.
   - Organize neighborhood networks for emergency communications, and preparedness training and planning.
   - Implement a more robust alert/communication system, including capacity for communications during emergencies with power outages.

LEAD IMPLEMENTER: **Fire and Police departments**

2. **Develop a comprehensive emergency management plan (CEMP).** This should include:

   - An evacuation plan
   - Designated upland parking areas
   - Procedures for securing loose floating assets (docks, watercraft)
   - Procedures for debris removal (from storm drains, bridges, streets)
   - Procedures/plans for providing human services
   - Procedures for shutoff and restoration of gas service
   - Emergency communication systems
   - Emergency backup power (e.g., generators, solar power charged batteries)
   - Framework for staff and volunteer training and drilling exercises (take advantage of training opportunities from federal, state and local partners)
   - Regular notification to owners and residents in current and projected future floodplains regarding risks to their properties and the availability of preparedness resources.

LEAD IMPLEMENTER: **Fire department, Police department, Department of Public Works, Rockland County Department of Fire and Emergency Services, Village Clerk, Floodplain manager**

# Reducing Risk to Critical Infrastructure

The Village of Piermont should ensure that critical infrastructure and services are robust and resilient - able to function during and after major events with minimal damage or downtime.

## Immediate Actions

3. **Work with local utilities, in particular electric, gas, water, sewer, and telecommunications, to improve resilience.** Make known Piermont village needs and understand/inform the utilities' plans in relation to communication protocols and infrastructure's operational and physical resilience to future storms and floods in Piermont. Include in these discussions the protocols for utility shutoffs and turn-ons before, during, and after storm events. Also, explore the possibility of timing upgrades to subsurface infrastructure (sewer, water, telecommunications) and relocating overhead utilities to underground during adaptive construction activities (e.g. filling, raising buildings, major structural upgrades) by the Village or private property owners in the village.

Lead implementer: **Village Board to initiate meetings between Fire Department, other Village officials and utilities**

4. **Advocate and coordinate with Rockland County and Orangetown to increase infrastructure, access, and stormwater resilience.**

   - Sewer operations and maintenance issues and further storm-proofing of the pump station
   - Exploring emergency access routes to and from the village
   - Reducing stormwater flow through Piermont (watershed management)

Lead implementer: **Village Board, with assistance of Chamber of Commerce and other local organizations to solicit community support**

5. **Conduct a risk and engineering review to analyze adaptation, relocation, building and decommissioning options for municipal infrastructure, including the Fire Station (emergency shelter), DPW storage facility, Fire Dept. boathouse, pump station, and roads.**

Lead implementer: **Village Board (via commissioning of a consultant)**

## Near-Term Actions

6. **Work through the Rockland County Multi-Jurisdictional Natural Hazard Mitigation Plan to position Piermont for resiliency actions and funding opportunities:**

   - Update to include climate change impacts, including sea level rise, as hazards in the Rockland County Multi-Jurisdictional Natural Hazard Mitigation Plan (in 5-year update)
   - Incorporate findings from the Piermont Waterfront Resilience Task Force into the plan (in annual update)
   - Invite the coordinator of the plan to speak to village planners about the update process and applications of the plan

LEAD IMPLEMENTER: **VILLAGE PROPOSAL WRITER AND ENGINEER**

Flooding on the Sparkill Creek.

# Planning and Codes

The Village of Piermont should plan for resilient land use patterns and encourage safe, resilient structures in the waterfront area through planning, zoning, permitting and building codes.

## Immediate Actions

7. **Establish a permanent Flooding and Storm Resilience committee.** This committee will work to ensure implementation of Task Force recommendations, support long-range planning, and track and publicize the village's progress toward meeting the goals of the recommendations.

LEAD IMPLEMENTER: **VILLAGE BOARD TO APPOINT MEMBERS AND APPROVE COMMITTEE'S RECOMMENDATIONS/INITIATIVES**

8. **Proceed with application to the National Flood Insurance Program's Community Rating System (CRS) and evaluate other options to reduce the impact of increasing flood insurance rates on the community.** Participating in the CRS can reduce insurance rates for residents and businesses, but requires the Village to take specific, concrete actions to reduce risks. The Village should also formalize its process for tracking repetitive loss properties (a requirement of CRS).

LEAD IMPLEMENTER: **VILLAGE BOARD**

9. **Create and implement a Floodplain Management Plan.** This is an important framework for establishing and coordinating preventive and corrective measures to reduce the risk of current and future flooding, resulting in a more resilient community. Elements of the plan could include the updates to zoning, building codes, or floodplain ordinances that are part of the Task Force's other recommendations. There are substantial resources available from FEMA's Floodplain Management Branch and the Association of State Floodplain Managers for creating and implementing this plan.

LEAD IMPLEMENTER: **VILLAGE ENGINEER (FLOODPLAIN MANAGER)**

**10. Incorporate findings/recommendations of the Piermont Waterfront Resilience Task Force into the new Local Waterfront Revitalization Program, including.**

- Describe coastal and climate hazards relevant to Piermont, incorporate FEMA flood mitigation strategies, and set goals for flood resilience
- Review and identify which and how local regulations can be modified to foster increased resilience and adaption to future storms and account for sea level rise. Possibilities include:
- Revise zoning to more specifically address flood risk areas;
    - encourage growth/replacement of lost tax base in safer areas;
    - allow opportunities for tidal habitat migration
    - incorporate form-based zoning consistent with adaptation strategies
- Revise local code to:
    - match or exceed the state's 2-foot freeboard requirement;
    - require property owners in flood-prone areas to include additional flood-proofing and adaptive measures for new, substantially damaged or substantially improved* buildings above the FEMA standard;
    - support amphibious/floating homes where feasible and other building resiliency measures, and coordinate them with utility requirements;
    - promote the use of green shoreline infrastructure (nature-based solutions)
    - regulate floating/potentially floating assets (e.g. boats, docks, tanks) that may pose a hazard during flood events
- Promote the long-term persistence of the Piermont Marsh as a natural storm buffer
- Encourage the use of natural buffers and green shoreline infrastructure to reduce flood risk and erosion and conserve natural resource functions
- Plan for continued long-term availability of public parks, walkways and waterfront access
- Promote best stormwater management practices and green infrastructure to alleviate upslope erosion, overland flooding, flash flooding and mud flows

LEAD IMPLEMENTER: **LWRP UPDATE COMMITTEE**

*"Substantially improved" generally refers to rebuilding, renovating or expanding structures at a cost of 50% or greater of pre-event value.

11. **Identify properties which may be of high priority for acquisition/relocation in long-term resiliency plans (e.g. waterfront and flood zones, repetitive loss properties, upland relocation areas), and implement a fund to acquire such properties upon their availability.**

LEAD IMPLEMENTER: **VILLAGE BOARD AND FLOODING AND STORM RESILIENCE COMMITTEE**

12. **Continue exploring long-range adaptation possibilities for the Village of Piermont, including structurally and economically viable solutions that offer a long-term pathway and can help guide wise near-term investments.** This process can build on the long-term adaptation visions developed through the formal Waterfront Resilience Task Force discussions, as well as other ideas and questions generated as part of the broader conversation within the Task Force and with the public. Possible areas of investigation include:

    - Actively seek collaboration with innovative and forward-thinking private investors and academic institutions to promote resilient projects in the village
    - Develop a plan for continued long-term availability of public parks, walkways and waterfront access
    - Identify receiving areas for new development to provide safer or replacement neighborhoods
    - Investigate the feasibility of harbor improvements such as breakwaters, oyster reefs or other structural and nature-assisting approaches that will reduce flood risks along the Piermont shoreline

LEAD IMPLEMENTER: **FLOODING AND STORM RESILIENCE COMMITTEE**

13. **Create a Municipal Village Master Plan that incorporates flood resilience, adaptation planning, and other land use issues into a long-range vision for the Village.**

LEAD IMPLEMENTER: **VILLAGE BOARD**

# Municipal Operations

Village operations, spending and decision-making should strive to reduce vulnerability to flooding and increase resilience.

Village boards, committees, and staff responsible for the management and regulation of resources, infrastructure and vulnerable populations should consider the impacts of flooding, sea level rise and climate change in all relevant decision making, including long-term planning, programming, permitting, regulation, emergency response, and funding and capital-expenditure decisions.

## Immediate Actions

14. **Adopt the sea level rise and flood projections recommended by New York State and FEMA, and used by the Task Force for municipal decision making and planning purposes.**

    Adopt official projections to inform all Village planning and decision making, recognizing both the inherent uncertainty in long-term climate projections and the need to adapt to conditions that may occur if meaningful steps are not taken to reduce greenhouse gas emissions. Ensure there is a mechanism in place to regularly re-evaluate and update these sea level rise and flood projections, using new information released by the state, and to incorporate updated projections into planning and decision making.

Lead implementer: **Village Board**

15. **Train all municipal staff and emergency managers in the use of the Task Force's risk and vulnerability assessments, sea level rise projection maps, as well as changing coastal hazards risks such as storm surges.**

Lead implementer: **Village Board to determine who will coordinate/lead trainings**

16. **Research financing options for supporting flooding adaptation, mitigation and protection measures.** Possible financing mechanisms may include grants, bonds, tax cap waivers, property sales and transfers fees, and fund-raising events.

Lead implementer: **Flooding and Storm Resilience Committee, with Village Proposal Writer**

## Near-Term Actions

17. **Integrate departmental budget requests into a village-wide Capital Improvement Plan.** This will allow the Village to integrate and prioritizes the needs of all departments, along with phased adaptation of infrastructure to flooding and sea level rise.

Lead implementer: **Village Board, with recommendations from Flooding and Storm Resilience committee**

18. **Consider cost-benefit analyses and long-term flood risk due to sea level rise and stronger storms in asset design and the prioritization of strategies to manage key municipal assets.**

Lead implementer: **Flooding and Storm Resilience Committee**

19. **Initiate Climate Smart Communities actions and participate in the program's new certification program.** The Village has joined the Climate Smart Communities program – active participation will allow the Village to receive free technical assistance and eligibility for future grant applications. Work through the program's framework to reduce Piermont's Greenhouse Gas emissions and contributions to sea level rise, address watershed management issues, and adapt to climate change by strongly encouraging green architecture, infrastructure and energy use.

Lead implementer: **Flooding and Storm Resilience Committee**

# Outreach and Collaboration

The Village should engage the community through public outreach in order to raise public awareness of the risks of flooding, coastal hazards and sea level rise, and give community members the tools and information they need to reduce their vulnerability. Collaborating with the organizations and citizen groups in the Village, as well as neighboring communities, is an opportunity to broaden outreach, pool resources, and learn from other local adaptation successes.

## Immediate Actions

20. **Post flood preparedness, flood-resilient building, and hazard mitigation resources on village website.** These should include, but are not limited to:
    - Base Flood Elevation (BFE) map, with guidance on its interpretation and updates
    - Link to elevation map and related information that indicates the elevation of properties and structures
    - Links to FEMA resources including the Coastal Construction Manual, National Flood Insurance Program, and the Community Rating System
    - Links to resources on flood resilient building practices
    - Link to nixle.com, which is used to communicate emergencies in Rockland County
    - Task Force final public presentation and other materials
    - Include a notice on the webpage encouraging users to obtain appropriate professional advice when using these reference materials to make building/investment plans, due to the complexity and shifting nature of regulatory requirements and issues. If possible, regularly remind village residents of the website and notify them of updates.

Lead implementer: **Flooding and Storm Resilience Committee to provide content, Mayor to approve addition of page, Village Clerk (Webmaster)**

21. **Provide presentations and public training opportunities to inform the public of flood-related issues and solutions.** Invite FEMA and other agencies or experts to regularly present information on their programs and strategies, including flood mitigation strategies, the Community Rating System, and FEMA's coastal construction manual.

Lead implementer: **Flooding and Storm Resilience committee**

**22. Design and install high-water-mark signs throughout the 100/500 year floodplain areas to educate the community about flood risk and refer interested residents/property owners to additional sources of flood preparedness information.**

LEAD IMPLEMENTER: **VILLAGE BOARD**

## NEAR-TERM ACTIONS

**23. Share the findings of the Piermont Waterfront Resilience Task Force and collaborate with other waterfront communities to improve understanding of and planning for coastal hazards such sea level rise and storm surge.**

LEAD IMPLEMENTER: **VILLAGE BOARD**

**24. Advocate to the state on climate change and flooding resilience issues. These may include:**

- The provision of funding and support for resilience-promoting planning and implementation
- Adoption of statewide regulations requiring notification to potential buyers/developers whenever a property in current or projected future floodplain and flood hazard areas is listed on the real estate market

LEAD IMPLEMENTER: **VILLAGE BOARD AND FLOODING AND STORM RESILIENCE COMMITTEE**


# Neighborhood-Based Recommendations

The Village should consider the uniqueness of each stretch of its waterfront, as well as its connections to other stretches, in determining the best options for flood adaptation.

As a means to understand the Piermont waterfront more deeply and plan at a more site specific level, the Task Force delineated 9 Adaptation Neighborhoods - segments of the waterfront united by their physical conditions, uses, assets and populations. Each of these neighborhoods present challenges and opportunities for positive transformation toward resiliency.

Below are considerations or concepts for adapting each waterfront neighborhood. Some of these actions can be addressed in the near-term, and some might be appropriate several decades from now. As a whole, they are possible components of the longer-term adaptation plan for the Village.

## North Piermont Avenue

- Waterfront residences and businesses are particularly vulnerable to damages from storm surge, wave action, and sea level rise. Adaptation pathways to consider include wet and dry floodproofing structures, elevating structures, converting structures to be amphibious or floating, constructing offshore breakwaters or a levee, or a managed retreat of residences to safer locations in the village. Note that the latter would not be possible for several water-based businesses currently located along this stretch of waterfront.
- Research the cost and feasibility of various breakwater designs, which would alleviate damage from wave action and enable a conversion of the waterfront to a floating (wharf or pier based) residential and commercial area.
- Survey waterfront owners to gauge opinion (including risk tolerance, impacts to water views and access) about adaptation options whose efficacy depends on uniformity and participation across private properties, such as a uniform shoreline floodwall or levee.
- To keep pace with rising sea levels, raise low sections of Piermont Avenue, consider eventually transforming the road into a pier (in conjunction with a pier-based rebuilding of the waterfront), or explore the feasibility of an alternate access route.

## Flywheel

- Elevate low-lying road sections to keep pace with sea level rise.
- Encourage wet floodproofing of vulnerable buildings.

## Commercial Core

- Encourage elevation of buildings in the northeastern portion of this area (between Piermont Avenue and the river) and wet or dry floodproofing other buildings.
- Explore the possibility of using fill to elevate the low lying area east of Piermont Avenue, to maintain a land connection to the Flywheel area, the Condominiums, and The Pier over the long-term.
- Consider possibilities for long-term redevelopment of the commercial core, which can include allowing/facilitating marsh expansion in a north-south pattern through its center (between Piermont Avenue and Roundhouse Road), along with esplanades along business fronts on both sides and bridges (walking and driving) to cross the marsh.

## Condominiums

- Consider fortifying (e.g. fill, walls, deployable floodgates) low-lying areas between buildings on the south side of the pier where floodwater incursions have occurred in recent storm events, along with elevating portions of Ferry Road to keep pace with sea level rise.
- Examine the possibility of adding green infrastructure or applying sustainable shoreline treatments to the built north shore.
- Encourage wet-floodproofing of residences and commercial buildings.
- Research the feasibility of a removable floodwall, to surround the condominium and Flywheel areas (the entire base of the pier).

## The Pier

- Evaluate the benefits of The Pier's current (and potential) uses and hydrologic impacts on Piermont Marsh (i.e., modifications to water flow in the Hudson which likely support the marsh's persistence). Compare these benefits to the cost of maintaining the Pier's elevation over the long-run, in order to make informed decisions about future public investments towards this asset.

## Bogertown and the Patch

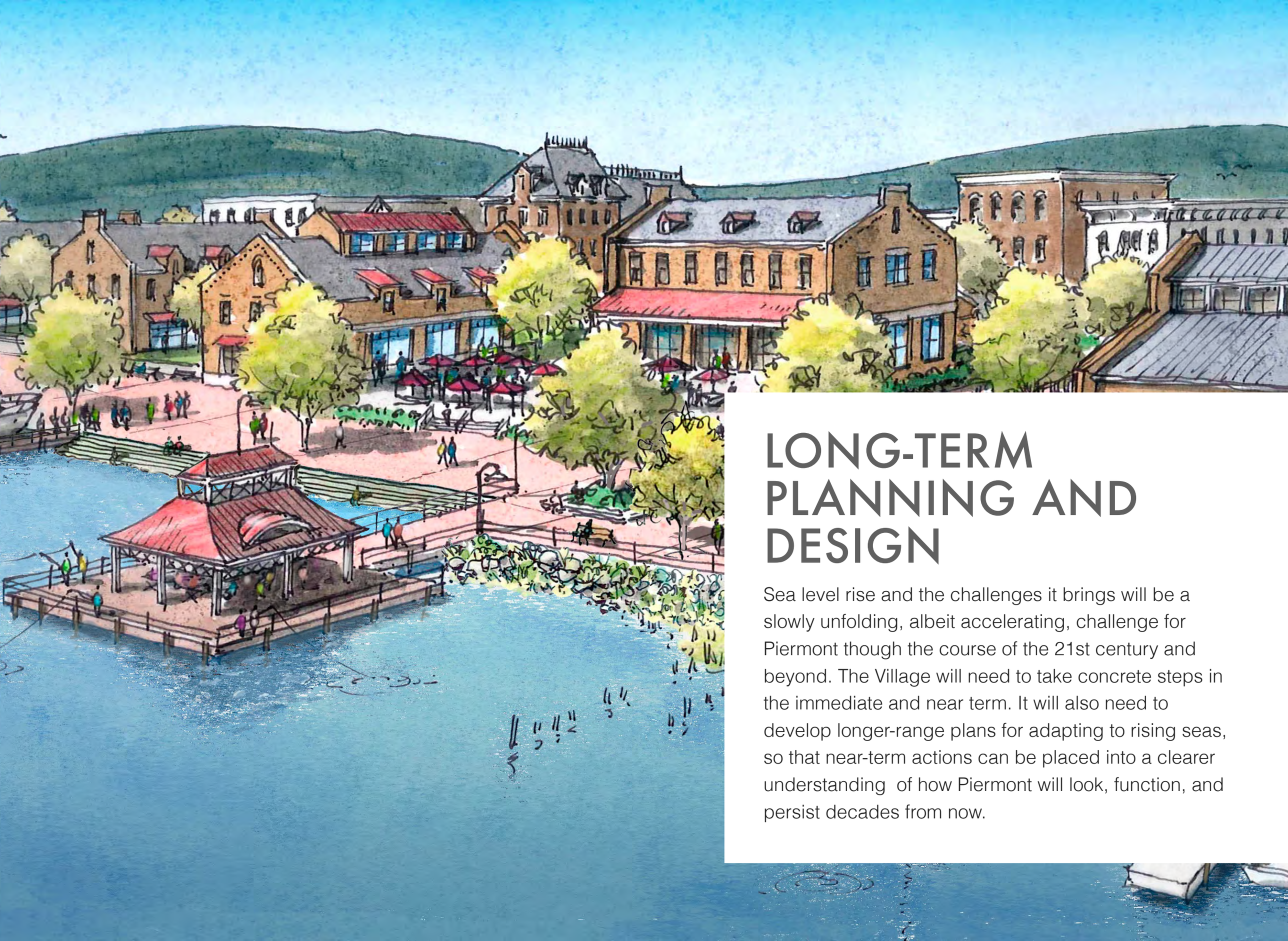
- Consider ways to fund or incentivize investments to elevate residences above flood hazard zones (including conversions to amphibious or floating structures) or encourage adaptive rebuilding.
- Explore the neighborhood community's interest in buy-out or rolling easement options, and seek safer locations within the village that may serve to receive relocated residents.
- Find an alternate location for parking and storage of the Department of Public Works' vehicles/equipment and other materials.
- Consider elevating Paradise Avenue to function as a protective levee for The Patch and other landward neighborhoods.

## Sparkill Creek Corridor

- Advocate to the Town of Orangetown for storm-proofing and any other necessary upgrades to the pump station, to ensure its continued functioning during flooding events.
- Work with the Town of Orangetown, Rockland County, and any relevant watershed groups to improve stormwater management in the Sparkill Creek watershed, in order to alleviate and prevent a future exacerbation of flooding driven by stormwater runoff.
- Consider possible adaptations for flood-vulnerable residences and other buildings along both sides of the creek, including wet or dry floodproofing, elevating, or relocation.
- Raise low sections of Piermont Avenue to keep pace with rising sea levels or explore the feasibility of an alternate access and through route to the Commercial Core along a higher elevation west of Piermont Avenue. The latter would be coupled with adaptation or relocation of uses currently along the road.

## Piermont Marsh

- Evaluate ways to enhance the flood-buffering characteristics of Piermont Marsh and to protect the existing marsh area from degradation.
- Research the need for and feasibility of assisted marsh adaptation (e.g. through assisted accretion, engineering the outer edge for reduced erosion, etc.).



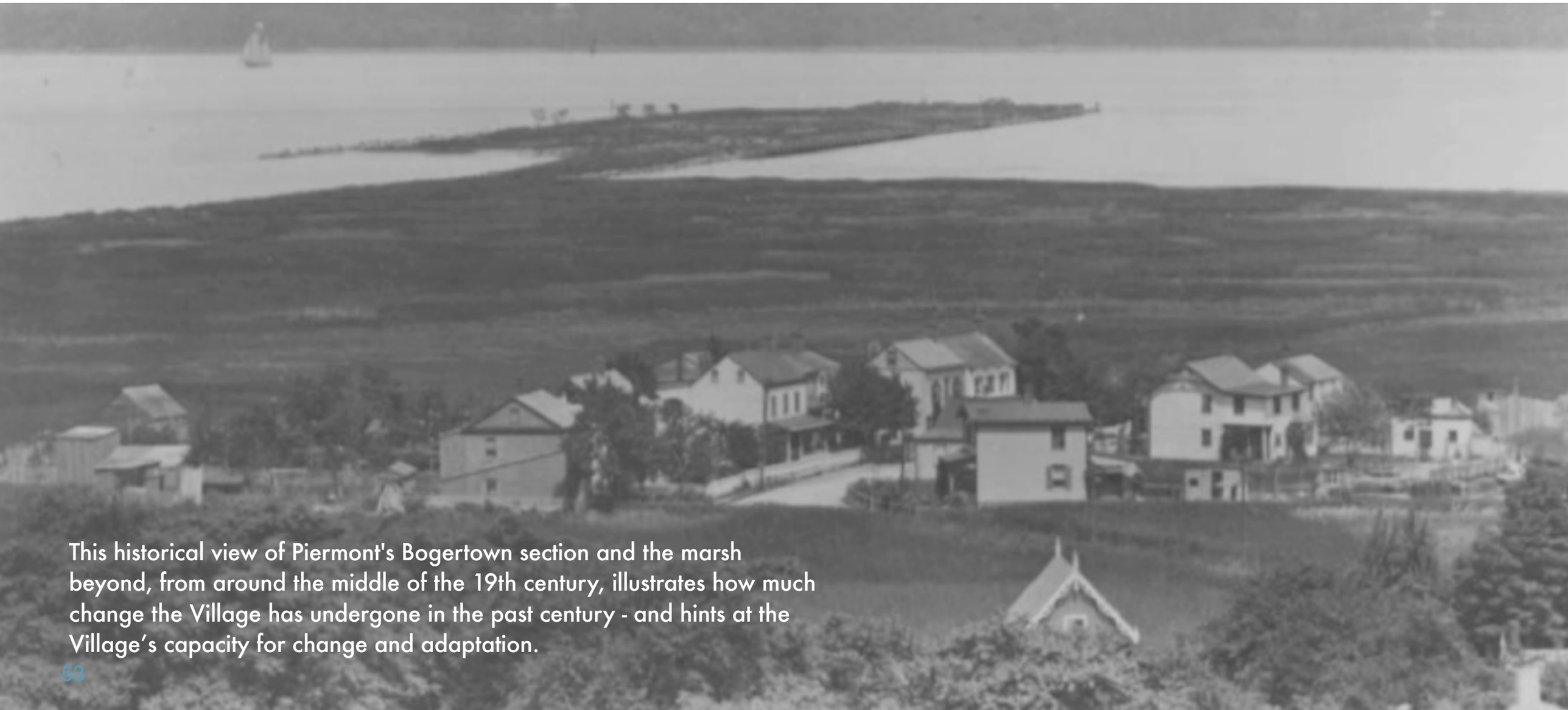
# LONG-TERM PLANNING AND DESIGN

Sea level rise and the challenges it brings will be a slowly unfolding, albeit accelerating, challenge for Piermont though the course of the 21st century and beyond. The Village will need to take concrete steps in the immediate and near term. It will also need to develop longer-range plans for adapting to rising seas, so that near-term actions can be placed into a clearer understanding  of how Piermont will look, function, and persist decades from now.

Developing consensus around Piermont's long-range adaptation destination will be a topic of a civic dialog in the Village for the foreseeable future. It will require sustained public engagement, detailed study and considerable creativity.

The Task Force worked to launch the process of planning and designing a more resilient waterfront, not to complete it. Task Force members learned about the range of conceptual, architectural, and regulatory approaches to adaptation currently in practice or development in other coastal areas in the United States and abroad. Armed with this broader perspective, the Task Force developed a portfolio of "Adaptation Alternatives" - competing scenarios for how a specific neighborhood or the entire Village might be adapted to reduce risks and achieve the vision statements and principles. A few examples of these Adaptation Alternatives are provided here. (The full set of Adaptation Alternatives are in Supplemental Materials.)

These alternatives are "sketches" of potential approaches, illustrative of strategies the Task Force sought to learn from - not recommendations or endorsements of desirability, feasibility, etc. Indeed, there are myriad other possible alternatives, many of which might be worthy of consideration or adoption.



This historical view of Piermont's Bogertown section and the marsh beyond, from around the middle of the 19th century, illustrates how much change the Village has undergone in the past century - and hints at the Village's capacity for change and adaptation.


Overhead view of Piermont showing the extent of the levee and recreational park.


Cross-section of the levee and recreational park along the north side of the Condominium neighborhood.

## Example Adaptation Alternative : Multi-Neighborhood Levee, Marsh and Greenway Construction

This Alternative sought to provide protection to the central areas of the Village, while enhancing recreational and environmental benefits.

*Pros*:

- Effective in providing protection for a time determined by the height of the levee
- Potentially an environmentally beneficial approach to protecting Piermont
- Provides recreation and tourism opportunities

*Cons*:

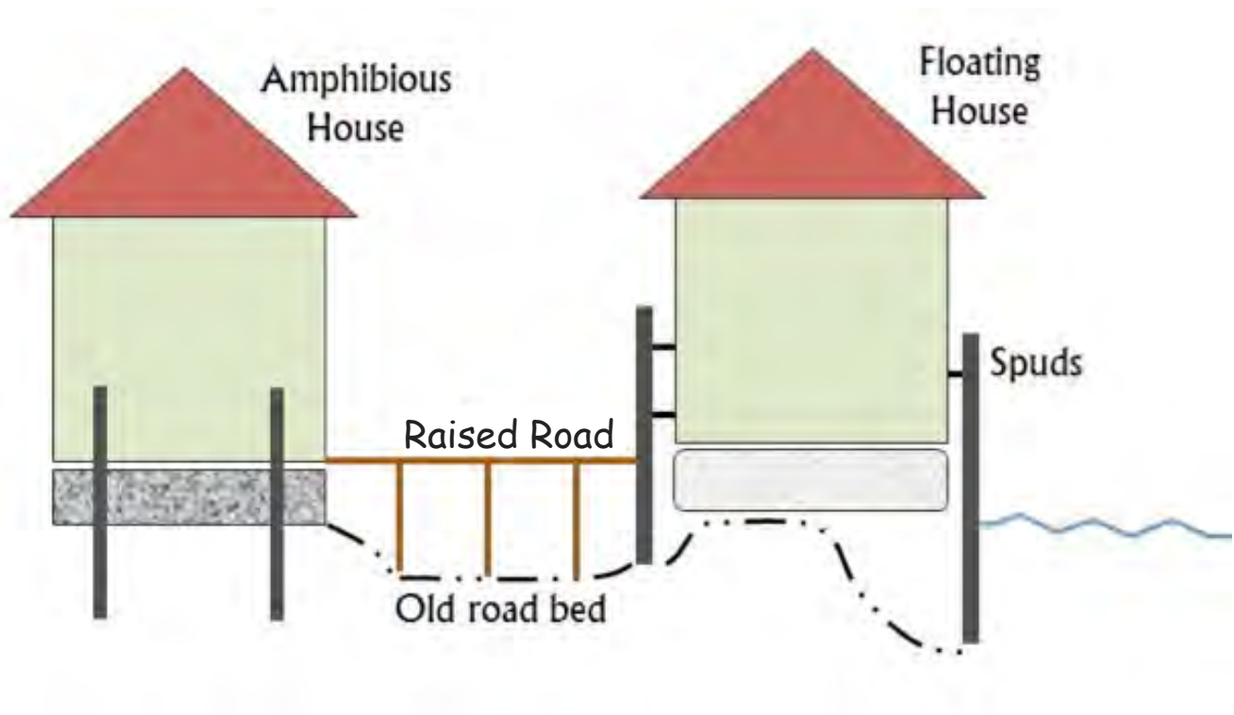
- Becomes less effective over time as sea level rises, or requires continued investment
- Likely an expensive option
- Residual risk of significant or catastrophic loss if levee is overtopped during a storm event

*Notes: The levee may be designed to allow for maintenance or upgrades, but potentially at a high cost. Also, to minimize risks, this strategy would need to be combined with other strategies such as floodproofing of structures and installing a pumping system to drain runoff behind levees. Impacts to village character and feasibility of this strategy were not known or assessed.*

Photo-simulation of the levee, marsh and recreational park along the north side of the Condominium neighborhood.


## Example Adaptation Alternative: Maintaining Piermont Avenue Access and Adapting Structures

This Alternative sought to preserve access along Piermont Avenue in the face of more frequent flooding and  maintain homes' and marina's intimate connection with the Hudson River in a safer way. The scenario integrates amphibious homes (which rest on the ground but are capable of floating during flood events), permanently floating homes, elevated roadway, and breakwaters (to provide wave attenuation needed by the floating homes).




Overhead (left) and cross-section (above) illustrating the integration of raised roads, amphibious or floating structures, and breakwaters.

The Task Force made the following observations about this Adaptation Alternative:

*Pros*:

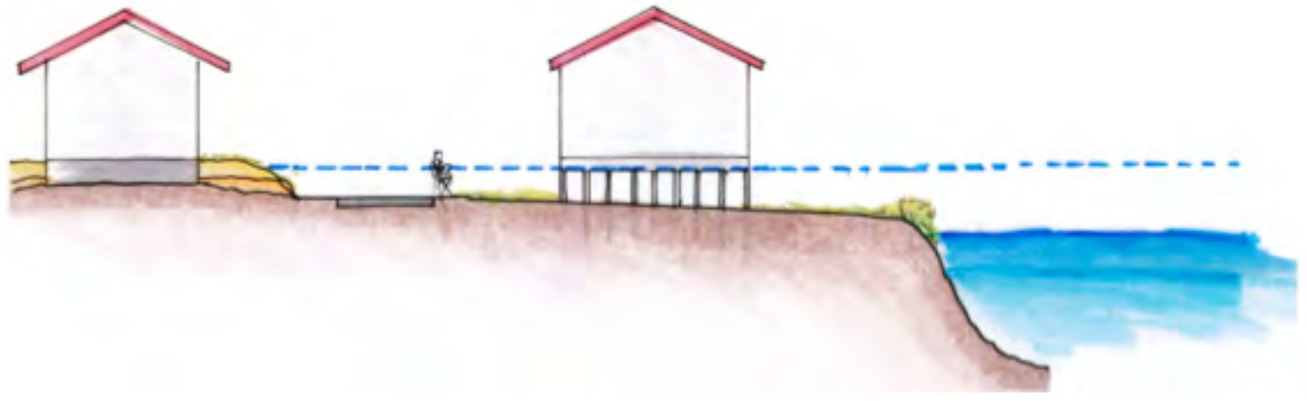
- This approach could be effective in making the structures more resilient, potentially for an unlimited time horizon because the floating structures cannot be overtopped or flooded regardless of sea level rise.
- This approach preserves the residential uses in the neighborhood.

*Cons*:

- This approach requires universal homeowner buy-in to the concept of road elevation.
- The feasibility of floating or amphibious structures in this coastal area is not fully known.
- Breakwaters, or other structures to reduce wave action would probably be required, to facilitate floating structures.
- Some loss of existing residential investments is likely and costs may be high.
- Waterfront uses may be impacted (though this is not a given).

*Notes: This approach may face regulatory hurdles and would require coordination with the State. It would also require significant coordination between public and private investments to ensure that changes to roads and structures, and costs of adaptations, are well-timed and equitable. Impacts to village character or feasibility of this strategy were unknown.*

Photosimulation of floating homes along Piermont Avenue. Raised roads are represented by the black bars, but are not to scale. (Note: each of these illustrated homes are actual floating homes from elsewhere.)



# BENEFIT-COST ANALYSIS CASE STUDIES: COAST MODELING OF ADAPTATION ALTERNATIVES

To further advance the information available to the Village for long-range resilience planning, the Task Force developed three highly-detailed Adaptation Alternatives and worked with Catalysis Adaptation Partners to investigate their potential economic costs and benefits relative to avoiding damages from flooding events.

These case studies were intended to explore a range of hypothetical approaches to increasing Piermont's waterfront resiliency using specific strategies and to begin understanding their physical, social, environmental and economic implications.

The Task Force considers these case studies to be illustrative of the adaptation planning process and believes that they may be informative to the Village as it considers the future of the waterfront. These case studies are not intended as recommendations, nor does the Task Force endorse any of these specific strategies for implementation without further study and public input.

COAST (COastal Adaptation to Sea level rise Tool) can be used to calculate a Benefit-Cost ratio for various adaptation types, using projected dollar figures for economic vulnerability over time (see pages 27-28), projected avoided damages, and estimated costs of adaptation. The larger the Benefit-Cost ratio, the more damage is avoided relative to adaptation costs. Ratios smaller than 1 result when the costs are higher than the avoided damages. The generalized methodology of COAST produces estimates only, and the resulting Benefit-Cost ratios are intended to be used in conjunction with non-economic considerations to guide communities in evaluating which adaptation options they may wish to study further. All estimates in the COAST analysis for Piermont were based on the three sea level rise projections chosen by the task force for all their planning exercises (see page 20).

# CASE STUDY 1: PROTECT PIERMONT

## GOAL: TO MAINTAIN CURRENT LAND USES AND ACCESS, PRESERVE THE VILLAGE'S CONNECTION TO THE RIVER, AND PROTECT AGAINST A 100-YEAR STORM UNTIL THE YEAR 2100

### ADAPTATION OVERVIEW

This adaptation scenario emphasizes a fortification strategy designed to protect a large part of the village waterfront from the damages of 100-year storms and sea level rise for the remainder of the century. The infrastructure for a removable floodwall would be installed around the pier and extending along Piermont Avenue on both ends, and the removable wall itself would be erected and dismantled as needed prior to high flood events. Roads along the floodwall would be raised in two phases to remain above daily high tides, securing access while also serving as a low fortification structure for lesser flood events. All structures between the floodwall and the river would be adapted to elevate above flood levels.

### ADAPTATION ELEMENTS

- Raise all sections of roads shown in red now, to a height of 6.75 feet, which roughly equals today's high tide (2.31 feet), plus 29 inches of sea level rise, plus 2 feet of freeboard.

- Raise all sections of roads shown in yellow and red in the year 2055, to a height of 10.3 feet (an additional 3.55 feet above the initial raising), which is equal to today's high tide (2.31 feet), plus 72 inches of sea level rise, plus 2 feet of freeboard.

- Elevate all buildings on parcels shown in purple now, so that their base floor elevation is at 14.5 feet, which is roughly the total of the 100-year advisory base flood elevation (10 feet), two feet of freeboard, and an additional 29 inches to account for sea level rise.

- Install a removable floodwall along the green line, the top of which would be set at 20 feet in elevation, which roughly equals today's high tide (2.31 feet), plus the height of a 100-year flood with two feet of freeboard (12 feet), and an additional 72 inches to account for sea level rise.

## BENEFIT-COST ANALYSIS

- The total costs of all adaptation elements would be approximately $76.48 million by the year 2100 (or $61.37 million in time-adjusted, or discounted, dollars).
- Avoided damages (benefits) from flood events would total approximately $188.88 million (or $52.85 million in discounted dollars) by the end of the century.
- The resulting Benefit-Cost ratio would be 2.47 (or 0.86 if calculated using discounted dollars) by 2100.

## INTERPRETATIONS AND LEARNINGS

Floodwalls and other fortification measures are the first adaptation that comes to many people's minds when considering protection from floods. Piermont's waterfront has some existing fortified sections of shoreline, and the Task Force wished to examine the economic feasibility of expanding these to a large, coordinated fortification throughout the village. As conceived here, the protective structures could be effective at preventing significant losses from the 100-year flood for the rest of the century.

A removable floodwall was deemed more feasible if installed along uniform waterfront sections and roadways, necessitating that some structures be left outside of the wall. These unprotected structures could employ more water-accommodating elevation adaptations, which would vary depending on local conditions but could include elevating on pilings and amphibious or floating structures.

In constant dollars this planning exercise resulted in a positive Benefit-Cost ratio (greater than 1:1) – meaning that avoided damages were projected to exceed the costs of installing this adaptation – although it was not positive if using discounted dollars. The ratio was brought down by the high cost of extending the floodwall far to the north and south of the commercial core, while not protecting large numbers of structures for each additional section of floodwall. In other words, protecting long linear areas with relatively few assets behind the protective structure is likely to be less cost effective than protecting compact, densely built areas.

Important issues identified for consideration included:

- high residual risks remain, from the possibility of catastrophic overtopping and worsened risk from upland flooding
- the social equity/fairness of the floodwall's cost, location and protective benefits
- the feasibility of operating and storing a removable floodwall with Piermont's small staff and municipal spaces.

Photosimulation of elevated seawall and removable flood wall installed along the Condominiums neighborhood waterfront.

# CASE STUDY 2: RAISE PIERMONT

GOAL: EMPHASIZING AN ACCOMMODATION APPROACH, MAINTAIN CURRENT LAND USE AND ACCESS PATTERNS BY ADAPTING BUILDINGS AND ROADS WHILE ALLOWING FLOODWATERS TO MOVE INTO THE WATERFRONT, AND MINIMIZE DAMAGES FROM A 100-YEAR STORM UNTIL THE YEAR 2100.

## ADAPTATION OVERVIEW

This case study scenario emphasizes an accommodation approach, allowing floodwaters to move onto the waterfront while adapting buildings to minimize damages and maintaining current access patterns. Largely residential portions of the village that are highly vulnerable would adapt by elevating structures, while the village's commercial core and the less vulnerable residences on the pier would be flood-proofed. A phased elevation of the roads would maintain access throughout the village across the century.

## ADAPTATION ELEMENTS

- Raise all sections of roads shown in red now, to a height of 6.75 feet, which roughly equals today's high tide (2.31 feet), plus 29 inches of sea level rise, plus 2 feet of freeboard.

- Raise all sections of roads shown in yellow and red in the year 2055, to a height of 10.3 feet (an additional 3.55 feet above the initial raising), which is equal to today's high tide (2.31 feet), plus 72 inches of sea level rise, plus 2 feet of freeboard.

- Elevate all buildings on parcels shown in purple now, so that their base floor elevation is at 14.5 feet. In the year 2055 elevate them an additional 3.5 feet (roughly the difference between 29" and 70" sea level rise projections) to 18 feet.

- Adapt all buildings on parcels shown in orange now, so that their first floors are modified either to:

    1. Allow flood waters to flow through without major damage (wet flood-proofing) by limiting uses in lower portions of the structures; or,

    2. Equip all buildings to be able to seal all openings in their first floors with water-tight doors, windows, vents, or other mechanism (dry flood-proofing).

## BENEFIT-COST ANALYSIS

- The cost of the 2-phased road and building elevation, combined with wet- and dry-floodproofing measures, would total approximately $172.31 million by the year 2100 (or $105.98 million in discounted dollars).
- Avoided damages (benefits) from flood events would total approximately $179.63 million (or $51.84 in discounted dollars) by the end of the century.
- The resulting Benefit-Cost ratio would be 1.04 (or 0.49 in discounted dollars) by 2100.

## INTERPRETATIONS AND LEARNINGS

The Task Force was keen to examine a scenario in which accommodation types of adaptation were applied throughout the village, as a way to illustrate a “living with the river” approach. This was recognized as an important long-term scenario as it would allow many existing uses in the village to endure, thus maintaining the character of this waterfront community. However, this design does not account for the heterogeneity of structure types in certain village areas, and their mixed ability to adapt in the illustrated ways. This approach also does not account for potential dislocation and loss of tax base if individual property owners were not fiscally able to finance these adaptations.

The Benefit-Cost ratio in constant dollars is barely over 1, meaning that recovering from repeated damages would roughly equal the cost of the adaptations. In discounted dollars the Benefit-Cost ratio is unfavorable, implying that from a purely economic standpoint it would not be cost effective to adapt in this way. There are, however, important non-economic implications to enduring repeated damages, including increased safety risks, dislocation during storm events, and emotional stress that could cause owners to abandon their investments.

Residence currently under construction in Piermont, elevated on pilings to reduce flood exposure.

# CASE STUDY 3: PIERMONT MARSHWAY

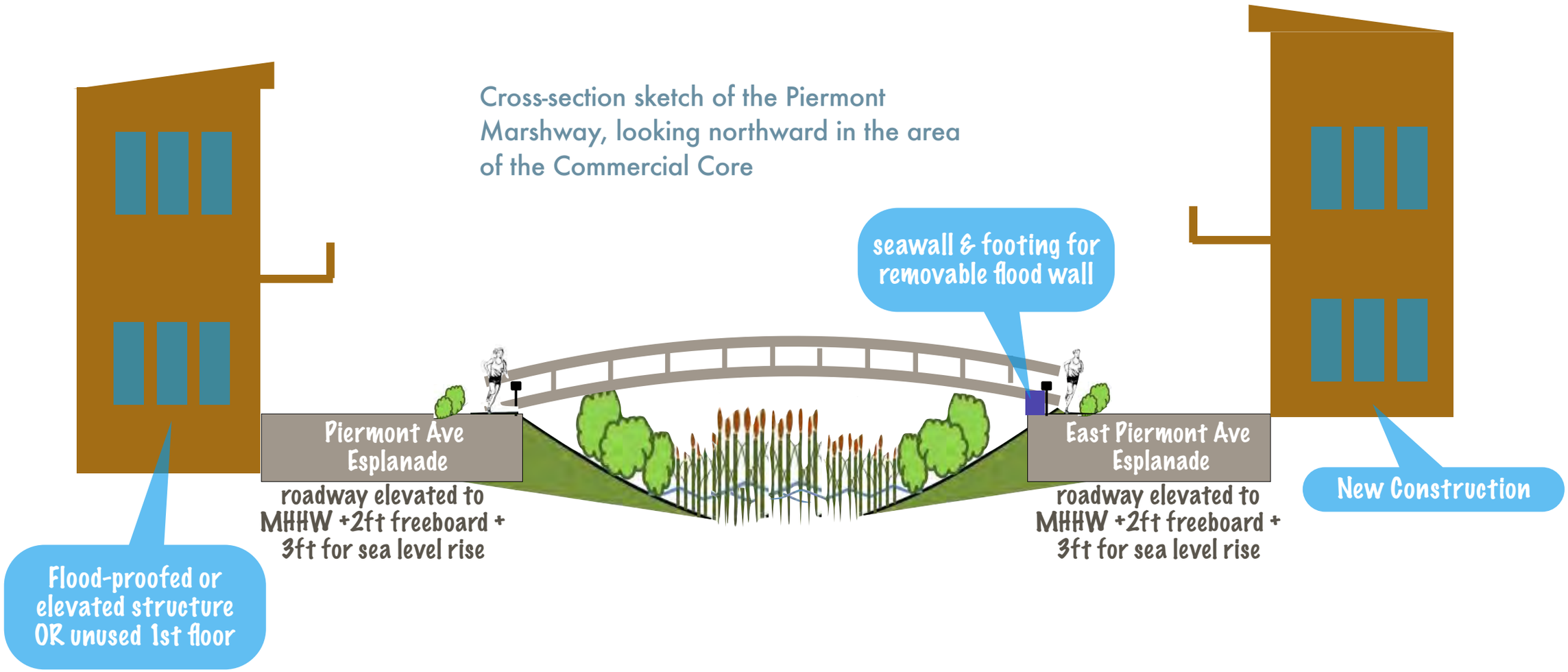
GOAL: REDESIGN THE VILLAGE TO BALANCE ECONOMIC VITALITY, ECOSYSTEM HEALTH AND PUBLIC SAFETY, WHILE PROTECTING AGAINST A 100-YEAR STORM UNTIL THE YEAR 2100.


## ADAPTATION OVERVIEW

The “Piermont Marshway” scenario mixes fortification, accommodation, and strategic relocation approaches to re-vision the village and its commercial core. The already higher base of the pier (e.g. the condominium and Flywheel areas) would be fortified with a removable floodwall, while businesses and residences along Piermont and Ferdon Avenues would elevate and floodproof. The lowest elevation, highest risk areas would undergo a strategic relocation to allow tidal habitat to expand into the heart of the village. A simultaneous redevelopment of the commercial core along this new marshway would showcase this natural feature and create a unique downtown experience.

## ADAPTATION ELEMENTS

- Raise all sections of roads shown in black now, to a height of 6.75 feet, which roughly equals today’s high tide (2.31 feet), plus 29 inches of sea level rise, plus 2 feet of freeboard. In the year 2055, raise them further to a height of 10.3 feet (an additional 3.55 feet above the initial raising), which is equal to today’s high tide (2.31 feet), plus 72 inches of sea level rise, plus 2 feet of freeboard.
- Elevate all buildings on parcels shown in light purple now, so that their base floor elevation is at 14.5 feet.
- Adapt all buildings on parcels shown in dark purple now, so that their first floors are modified either to:
    - Allow flood waters to flow through without major damage (wet-floodproofing) by limiting uses in lower portions of the structures; or
    - Equip all buildings to be able to seal all openings in their first floors with water-tight doors, windows, vents, or other mechanism (dry-floodproofing).
- Install a removable floodwall along the dashed blue line,  the top of which will be set at 20 feet in elevation, which roughly equals today’s




high tide (2.31 feet), plus the height of a 100-year flood with two feet of freeboard (12 feet), and an additional 72 inches to account for sea level rise.

- Install new bridges at locations shown in orange, to cross over areas allowed to transform into tidal marsh as sea level rises.
- Buy out vulnerable properties shown in tan in 2025 and those shown in pale green in 2055, through a voluntary program.
- Construct esplanades along new marsh, shown in yellow dashed lines, in 2055.

## BENEFIT-COST ANALYSIS

The total costs of all adaptation elements would be approximately $117.03 million by the year 2100 (or $76.58 million in discounted dollars).

Avoided damages (benefits) from flood events would total approximately $173.57 million (or $45.32 in discounted dollars) by the end of the century.

The resulting Benefit-Cost ratio would be 1.48 (or 0.59 in discounted dollars) by 2100.

## INTERPRETATION AND LEARNINGS

Recognizing that in reality there will likely be a mix of fortification, accommodation, and strategic relocation approaches in any viable long-term adaptation of Piermont, the Task Force sought to examine the benefits and costs of one such possible case. The three categories of adaptation were assigned to particular geographies based on a combination of current risk (e.g. most at risk areas assigned to relocation) and land use (e.g. esplanades would be an appropriate investment for the commercial core only). Once again, the true heterogeneity of construction types and land uses in the village is not fully captured by this design. There would also be issues of equity and burden of costs with the mixing of these different approaches. The strategic relocation assumed that all residents chose to participate, and would relocate within the village so that no net impact to the tax base was incurred. There were other considerations that were not addressed here, such as replacement of parking and residential areas in upland sites if necessary.

In constant dollars this planning exercise resulted in a positive, if somewhat low, Benefit-Cost ratio. In discounted dollars the Benefit-Cost ratio was unfavorable, implying that from a purely economic standpoint it would not be cost effective to pursue it. The most compelling reasons for examining such a strategy were the desire to find a safe and feasible alternative for those most at risk, include adaptations for all parts of the village waterfront, incorporate ecologically sound and beneficial adaptation, and enable the tourism and commerce of the village to continue its growth by creating a visually appealing downtown commercial center.

A view of the west side of Piermont Avenue, which would become the edge of the Piermont Avenue Esplanade in this scenario.

# MOVING TO IMPLEMENTATION

The recommendations for action presented in this document are meant to serve as a roadmap to the process of achieving and maintaining a resilient Piermont. However, it is the journey guided by this roadmap that will lead to actual change. While the roadmap will likely  be revisited and updated in the future based on new information and conditions, implementation of numerous recommendations can begin immediately following the adoption of this report.

The PWRTF has taken several steps to encourage implementation of its recommended actions. One has been to identify the most likely and effective lead implementer and the implementation timeframe (immediate-, near-, and medium/long-term) for each recommendation. This should facilitate timely action with defined leadership for each item.

The Task Force recognizes that the Village of Piermont, with its small staff and reliance on volunteer leadership, may be unable to simultaneously implement all of the recommended actions in any given time frame. To address this, the Task Force has prioritized the following recommendations as the most strategic to tackle first. Note that while these are considered priorities for immediate action, some of them also set the Village on a path to addressing its longer-term goals. Please refer to recommendations section of this report (page 38) for full descriptions of these items.

1. Establish a permanent Flooding and Storm Resilience Committee to follow up on implementing the Task Force recommendations
2. Improve emergency communications
3. Incorporate Task Force findings/recommendations into the Local Waterfront Revitalization Program (LWRP) update
4. Develop a Comprehensive Emergency Management Plan
5. Work with local utilities to improve resilience
6. Identify financing options, including grants, for supporting flood adaptation, mitigation and protection measures

The establishment of a permanent village committee tasked with addressing issues of flooding and storm resilience may be crucial for implementing the other 23 recommendations of the PWRTF. Not only would the committee be the lead implementer for several of the recommendations, but it would also serve to track progress on all recommendations and to foster continued planning for Piermont's long-term resilience.

The vision of a prosperous, safe, and resilient Piermont is shared by the community, and this report can serve as an initial guiding document to achieve that vision. We hope the Village Board of Trustees will soon formally accept this report as a guiding document to achieve this vision.  Once endorsed by the Village Board, this report should be made available through various village outlets (e.g. website, library, Village Hall). The Task Force also encourages village residents and business owners to become active participants in following and updating this roadmap to resilience.

# APPENDICES

# RECOMMENDATIONS BY SECTOR

| | | Sector | | | | |
|---|---|---|---|---|---|---|
| | | **Emergency Management & Communications** | **Reducing Risk to Critical Infrastructure** | **Planning & Codes** | **Municipal Operations** | **Outreach & Collaboration** |
| **Time frame** | **Immediate (next 12 months)** | 1. Improve emergency communications | 3. Work with local utilities to improve resilience | 7. Establish a flooding and storm resilience committee | 14. Adopt the sea level rise and flood projections recommended by NYS and FEMA for use in municipal planning | 20. Post flood preparedness, flood-resilient building, and mitigation resources on village website |
| | | 2. Develp a comprehensive emergency managemnt plan (CEMP) | 4. Advocate and coordinate with Rockland County and Orangetown | 8. Proceed with application to the NFIP Community Rating System (CRS) | 15. Train all municipal staff and emergency managers in the use of data and tools | 21. Provide presentations and training opportunities on flood-related issues |
| | | | 5. Conduct a risk and engineering review to analyze options for municipal infrastructure | 9. Create and implement a floodplain management plan | 16. Research the financing options for supporting flooding adaptation, mitigation, and protection measures | 22. Design, install and maintain high-water-mark signs in the floodplain areas |
| | | | | 10. Incorporate the findings/recommendations of the PWRTF into the new Local Waterfront Revitalization Program (LWRP) | | |
| | **Near-Term (1-2 years)** | | 6. Work through the Rockland County Multi-Jurisdictional Natural Hazard Mitigation Plan | 11. Identify key properties for long-term resiliency plans and implement a fund for their acquisition | 17. Integrate departmental budget requests into a village-wide Capital Improvement Plan | 23. Share the findings of the PWRTF and collaborate with other waterfront communities |
| | | | | | 18. Consider cost-benefit analyses and long-term flood risks in managing key municipal assets | 24. Advocate to the state on climate change and flooding resilience issues |
| | | | | | 19. Initiate Climate Smart Communities actions and participate in the new certification program | |
| | **Medium-Term (2-5 years)** | | | 12. Continue exploring long-range adapation possibilities for the Village | | |
| | | | | 13. Create a Village Comprehensive Plan | | |

# GLOSSARY

**Accommodation**, the use of strategies that allow the continued use of vulnerable lands, but that do not attempt to prevent flooding or inundation with shoreline flooding protection.

**Adaptation**, adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

**Base flood**, the flood that has a one percent chance of being equaled or exceed in any given year, also known as the "one-percent" or "100-year flood.

**Base flood elevation**, the computed elevation to which floodwater is anticipated to rise during the base flood, shown on flood insurance rate maps.

**CEMP**, comprehensive emergency management plan.

**Climate Smart Resilience Planning**, a planning evaluation tool for New York State communities.

**Community Rating System (CRP)**, a voluntary incentive program of the National Flood Insurance Program (NFIP) that encourages communities to adopt floodplain management activities that exceed the NFIP requirements.

**Conservation Easement**, a power invested in a qualified private land conservation organization (often called a "land trust") or government (municipal, county, state or federal) to constrain, as to a specified land area, the exercise of rights otherwise held by a landowner so as to achieve certain conservation purposes.

**DEM**, digital elevation model, a digital or 3-dimensional representation of a terrain's surface.

**FEMA**, Federal Emergency Management Agency.

**Fortification**, traditional coastal hardening techniques such as seawalls, and beach nourishment that attempt to maintain a static shoreline position.

**FIRM**, flood insurance rate maps, official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community.

**FIS**, flood insurance study (survey), A flood insurance survey is a compilation and presentation of flood risk data within a community. When a flood study is completed, the information and maps are assembled into a flood insurance study report, which contains detailed flood elevation data in flood profiles and data tables.

**Freeboard**, a factor of safety usually expressed in feet above a flood level for purposes of floodplain management. Often used to describe the height of a structure’s first floor over the base flood elevation.

**GIS**, geographic information system, a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.

**Hazard**, a dangerous phenomenon or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

**LiDAR**, light detecting and ranging radar, a remote sensing technology used to make high-resolution maps.

**MHHW**, mean higher high water, the average of the higher high water height of each tidal day.

**NFIP**, National Flood Insurance Program.

**NYHOPS**, New York Harbor Observing and Prediction System, a model operated by the Stevens Institute to provide ocean and weather information for the Port of New York and New Jersey.

**NYSDEC**, New York State Department of Environmental Conservation.

**NYSDOS**, New York State Department of State.

**PWRTF**, Piermont Waterfront Resilience Task Force

**Relocation**, moving development out of harm's way in a planned and controlled manner using techniques such as abandonment, relocation, avoidance.

**Resilience (*also* Resiliency)**, the capacity of an individual, community, or institution to dynamically and effectively respond to shifting climate impact circumstances while continuing to function and prosper.

**Risk assessment**, a process to analyze both the probability of an event and the consequences.

**Rolling Easement**, a special type of easement placed along the shoreline to prevent property owners from holding back the sea but allowing any other type of use and activity on the land. As the sea advances, the easement automatically moves or "rolls" landward, and tidal lands become public.

**SLR**, sea level rise, an increase in the mean level of the ocean.

**Special Flood Hazard Area**, the land area covered by the floodwaters of the base flood, as designated on NFIP maps.

**USGS**, United State Geoglogical Survey.

**Vulnerability**, the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes, or susceptible attribute or resource.

# RESOURCES LIST

The following resources were either used or referred to during the Piermont Waterfront Resilience Task Force's work.

**Resilient and Adaptive Waterfront Strategies**

Coastal Climate Resilience, Urban Waterfront Adaptive Strategies, prepared by New York City Department of City Planning. (2013)
http://www.nyc.gov/html/dcp/pdf/sustainable_communities/urban_waterfront_print.pdf

Coastal No Adverse Impact Handbook. Chapter 5: Mitigation. (2007)
http://www.floods.org/NoAdverseImpact/CNAI_Handbook/CNAI_Handbook_Chapter5.pdf

Georgetown Climate Center Adaptation Tool Kit: Sea Level Rise and Coastal Land Use, How Governments Can Use Land-Use Practices to Adapt to Sea Level Rise. Jessica Grannis. (2011)
http://www.georgetownclimate.org/resources/adaptation-tool-kit-sea level-rise-and-coastal-land-use

Incorporating Sea Level Change Scenarios at the Local Level.
NOAA. (2012)
http://www.csc.noaa.gov/digitalcoast/_/pdf/slcscenarios.pdf

Revitalizing Hudson Riverfronts: Illustrated Conservation & Development Strategies for Creating Healthy, Prosperous Communities. Eisenman, R. J. Anzevino, S. Rosenberg, and S.Spector (eds.), Scenic Hudson, Inc. (2010)
http://www.scenichudson.org/ourwork/riverfrontcommunities/publications

**Flooding and Stormwater Management, Flood Maps, and Flood Insurance**

FEMA Brochure on Flood Insurance Changes: Build Back Stronger-What you need to know.
http://www.fema.gov/library/viewRecord.do?id=6712

FEMA Map Services Center.
https://msc.fema.gov/portal

Scenic Hudson Sea Level Rise Mapper.
www.scenichudson.org/slr/mapper

**New York Climate Change Reports and Resources**

New York State 2100 Commission: Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure. (2013)
http://www.rockefellerfoundation.org/blog/nys-2100-commission-report-building

ClimAID: Responding to Climate Change in New York State. (2011)
http://www.nyserda.ny.gov/climaid

New York State Sea Level Rise Task Force Report. (2010)
http://www.dec.ny.gov/docs/administration_pdf/slrtffinalrep.pdf

New York State Climate Action Plan Interim Report. (2011)
http://www.dec.ny.gov/energy/80930.html

NYSDEC Climate Change, New Yorkers are Working on Many Fronts.
http://www.dec.ny.gov/energy/44992.html

NYSDEC Hudson River Estuary Program & Climate Change.
http://www.dec.ny.gov/lands/39786.html

Hudson River Sustainable Shorelines Project.
http://www.hrnerr.org/hudson-river-sustainable-shorelines

## Village of Piermont Studies and Plans

http://www.piermont-ny.gov

## COAST: COastal Adaptation to Sea Level Rise Tool

Summary of COAST.
http://catalysisadaptationpartners.com/uploads/3/1/4/8/3148042/coast_summary_111012.pdf

COAST in Action: 2012 Projects from New Hampshire and Maine. New England Environmental Finance Center. Series Report #12-05. Merrill, S., P. Kirshen, D. Yakovleff, S. Lloyd, C. Keeley, and B. Hill. Portland, Maine. (2012)
http://catalysisadaptationpartners.com/uploads/3/1/4/8/3148042/cre_coast_final_report.pdf

Valuing Mitigation Strategies: A GIS-based approach for climate adaptation analysis. Merrill, S., D. Yakovleff, S., Holman, D. Cooper, J., and P. Kirshen Arc Users. (2012)
http://www.esri.com/news/arcuser/1010/files/coast.pdf

# SUPPLEMENTAL MATERIALS AND ANALYSIS

Over the course of the Task Force project, a wide range of analysis, mapping and additional materials were developed. The results of this work, listed below, separately and *in toto* represent a foundation of quality information that may be used in current and future efforts by the Village to increase community resilience. The materials include:

1. Sea Level Rise and Flood Zone Project Maps
2. Department of State Coastal Risk Assessment: Results and Maps
3. Climate Smart Resilience Planning: Results and Recommendations
4. COAST Analysis: Results and Maps
5. Agendas and Summaries of Task Force Meetings
6. Adaptation Alternatives - Full Set Developed by the PWRTF

# PHOTO CREDITS

Jeff Anzevino - cover, pg 6, 7, 9, 14, 33, 38, 62, 65,

NOAA - 27

NYS DEC Hudson River Estuary Program - pg 35

Piermont Historical Society - pg 53

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