Report on Coastal Vulnerability and Sea Level Rise

TMG
Turner Miller Group
planning consensus community

GREAT ecology
ENVIRONMENT + DESIGN

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Photo of Beach Road after Hurricane Sandy of 2012. Photo by: L. Konopko

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Introduction

In 2013, Stony Point was chosen for the New York Rising Community Reconstruction Program, that provided significant planning assistance as well as future project funding for recovery from Hurricanes Sandy and Irene and Tropical Storm Lee. This study builds upon that effort by considering coastal vulnerability of tidally influenced areas along the Town's Hudson River waterfront in light of future rising sea levels and increased storm severity.

The problem of sea-level rise, storm surge and flooding in the waterfront area of Stony Point has an impact on the homes and personal finances of its residents; the economic stability of current businesses; the environment; Town infrastructure including roads, sewer and water utilities; parkland; and potential future economic development of the area. In recent years, the Town of Stony Point has experienced an increase in damage caused by flooding along the riverfront and associated areas along tributary waterways.

Most recently, as a result of Hurricane Sandy, many homes and businesses on the banks of the Hudson River were devastated. Hurricane Irene had already impacted waterfront Town Parks and damaged many other facilities in 2011. In the aftermath of Hurricane Sandy, in November of 2012, it is estimated that the storm surge caused the Hudson River to rise to at least elevation[1] 10.25 feet in Stony Point, as evidenced by several inches of slime and sediment left on the floor of the Town's wastewater treatment plant. The existing Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) from 1982 show 100-year (1%) storm flood elevations at approximately 7 feet.

As a direct result of Sandy, over 100 homes and businesses experienced damage due to storm generated flooding. Of these at least five were immediately condemned, with several additional following in the weeks and months after. Additionally, buildings damaged beyond 50% of value are required to be reconstructed with a first floor above the base flood elevation - an enormous expense not always covered by FEMA insurance payouts.

The damage experienced in recent years is unprecedented in the history of Stony Point. Throughout the northeast, storm intensities have been increasing, which is leading to excessive amounts of rainfall. Rainfall that is taxing storm drains and creating many of the flooding problems that we see today. Changes in the overall climate of the planet are also creating the conditions for rapid development of storms similar to Super Storm Sandy.

The cost of Town infrastructure damage and clean-up following Hurricane Sandy is estimated at $2M. Private residential and commercial damage is estimated at several million dollars more. The Town is concerned about the

Severe Damage in the wake of Hurricane Sandy. Photos by : L. Konopko.

[1] All elevations are vertical datum NAVD88 unless otherwise noted.

residual effects of Sandy to waterfront residents and commercial property owners. In the wake of Sandy, FEMA proposed advisory base flood elevations (ABFEs) are as high as 11 feet making rebuilding and repairing existing structures even more costly.

Of particular concern are those residents of the Ba Mar mobile home park, who will have to raise the floors of their homes, in some cases by several feet, to meet not only the FEMA flood elevations but also the conditions established by the NYS Building Code. Waterfront landowners are also very concerned about decreasing property values as result of rising waters consuming usable land and new flood elevations increasing insurance costs.

The four active marina facilities along Stony Point's Waterfront are struggling with the current economic climate and with recent hurricane-related damages. Some are seeking additional and alternative uses, including new residential multifamily housing, that would also be affected by any future flooding. Shoreline erosion and siltation concerns in Stony Point Bay are also mounting and may further impact the future viability of the marinas. Recently, Penny Bridge Marina obtained approvals and permits for dredging in front of the bulkheads and mooring facilities along their property, but the other area marinas are facing similar costs.

The Town’s Local Waterfront Revitalization Plan is more than 20 years old. It reflects a different economic, fiscal and climate perspective, where storm severity and frequency and sea level was not recognized as a concern, and current economic development needs due to fiscal conditions were not as pressing. The more recent Master Plan update recognized the need for economic development, but was in its final adoption stages prior to Hurricane Sandy and was silent on storm resiliency issues.

It has become clear that increasing storm severity, global sea level rise and coastal vulnerability are continuously and increasingly becoming challenges to the Town's tidally influenced areas. In light of this, the Town sought to undertake an investigation into coastal vulnerability and sea level rise (CV-SLR).

Purpose

The Town has found it to be a challenge to bring all community stakeholders to the same table to deal with broad planning issues such as waterfront use in light of sea level rise concerns. The issue is further complicated by the fact that different government entities oversee the jurisdiction, maintenance and/or improvements to portions of the water front area. Some roads along the riverfront are County roads. Jurisdiction over the Hudson River and its estuaries fall under the New York State Department of Environmental Conservation, the Rockland County Drainage Agency, and the Army Corps of Engineers. CSX, a national rail company, owns a well-travelled right-of-way much of which is just above 1982 7-foot flood elevations that are at serious risk to sea-level rise (SLR) and recently sought approval and permitting for costly track improvements.

The purpose of this effort to assess coastal vulnerability based on sea level rise is to develop and implement a process to engage stakeholders, government representatives and consultants in open communication to identify specific waterfront problems and to find feasible solutions. Specifically objectives of the CV-SLR investigation are:

1. To organize a taskforce that includes local, county and state government representatives, the town engineer and planners, waterfront residents and business owners, and ecological and economic consultants;
2. Obtain input from taskforce members and consultants regarding the natural resources, assets and infrastructure at risk, and the priorities and possible solutions to the increasing problem of flooding along the shore of the Hudson River;
3. Assess the feasibility and cost-benefit ratio of potential solutions to SLR;
4. Evaluate the recommendations of the Final NYRCR Plan for Stony Point with regard to SLR;
5. Disseminate the results of the analysis and set up strategies for implementation.

New York Rising Community Reconstruction (NYRCR) Program

Shortly after the Town was awarded a grant by the New England Interstate Water Pollution Control Commission (NEIWPCC) and the New York State Department of Environmental Conservation (DEC) Hudson Estuary Program to help defray the cost of the CV-SLR effort, the Town was also chosen as a "New York Rising Community Reconstruction Program Community."

The NYRCR Program, announced by Governor Cuomo in April of 2013, was a $650 million+ planning and implementation process established to provide rebuilding and resiliency assistance to communities severely damaged by Hurricane Irene, Tropical Storm Lee, and Superstorm Sandy. The program provided professional consultant assistance to assemble a committee of local stakeholders, officials, and representatives to develop a Plan for storm recovery and resiliency. It allocated Stony Point $3 million to implement eligible projects identified in the Plan.

In light of the Town being chosen as a NYRCR community and in light of overlap between the NYRCR and CV-SLR work programs, DEC Hudson Estuary Program and NEIWPCC agreed to an amendment in the work program, that would allow the CV-SLR process to build upon the NYRCR process rather than duplicate it.

Stony Point's NYRCR process organized the taskforce and conducted a prioritization of resources, assets and infrastructure (objectives 1 and 2 of the CV-SLR). Additionally, several projects were identified to increase the storm resiliency of the Hudson River waterfront. These projects were detailed generally, and future sea level was not a significant consideration in these projects. Additionally, it is noted that the NYRCR effort was not constrained to the tidally-influenced areas of the Town. The geographic scope of the NYRCR planning area included all areas of the Town of Stony Point outside of Bear Mountain and Harriman State Parks. The topical scope of the NYRCR Plan also went beyond that of the CV-SLR addressing such topics as lack of emergency preparedness; uncertainty surrounding regional energy and infrastructure projects, and synergy between local and regional natural and cultural resources.

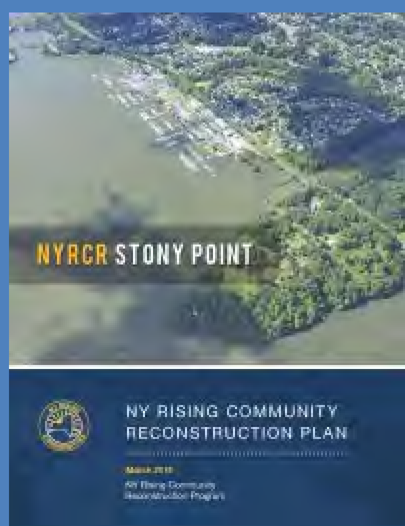
NYRCR Goals and Objectives

The goals and objectives of the NYRCR Plan include:

- Plan for better mobility and connectivity for people in cars, on foot, and with transit.
- Cooperate with other regional entities.
- Improve waterfront access and infrastructure.

Stony Point NYRCR Community Vision:

Stony Point is a vibrant and connected riverfront and hillside community. Our Vision is to preserve our town's history and protect our people and our natural resources while making the community more resilient in the face of future hazards and attracting visitors to ensure an ecologically sound and economically strong future for the people of Stony Point.



- Protect the watershed and strengthen stormwater management practices.
- Redevelop historic assets while maintaining neighborhood fabric.
- Foster emergency readiness.
- Revitalize downtown businesses.
- Develop design and construction standards for resilience.
- Enhance historical, natural, and cultural attractions for tourists.
- Retain and attract residents with a range of housing options.

Three public engagement meetings were held throughout the eight month planning process. These meetings provided the opportunity for Stony Point residents to learn about the NYRCR planning process, assets and projects, and provide input to help develop community-driven plans.

The committee first identified where the Town is vulnerable, where its critical assets are located and the risks those assets face. To address these specific vulnerabilities, a comprehensive needs and opportunities analysis was prepared through a combination of research, analysis, and feedback from the committee and the community.

The NYRCR Plan provides an overview of Stony Point and its risks, vulnerabilities, needs and opportunities. Strategies for reconstruction and resilience were developed as an approach to meet the identified needs and a way to put the related opportunities into action. To address the risks and respond to the needs, projects were developed to execute the reconstruction and resiliency strategies.

NYRCR Featured Projects

The following projects were identified and prioritized as needed resiliency projects related to tidally influenced areas of the Town.

1. Create a disaster recovery communications center;
2. Expand/develop shelters;
3. Harden wastewater treatment plant against future flooding including installing watertight doors and windows, raising electronics and replacing existing motors with sealed motors;
4. Rehabilitate wastewater interceptors along Beach Road and the Ba Mar sewer line;
5. Provide shoreline protection of Beach Road against erosion and wave action consisting of rehabilitation of sea walls and jetties as well as a non-disclosed physical wave attenuation infrastructure;
6. Provide shoreline protection of River Road against erosion and wave action consisting of rehabilitation of sea walls and jetties as well as well as groins for wave attenuation;
7. Rehabilitate Cedar Pond Brook interceptor sewer line;

Based on the final report of the NYRCR Plan it was determined that the best use of funds and effort in the CV-SLR investigation would be to focus attention on analyzing coastal vulnerability to sea level rise, which is something that was not given detailed consideration as part of NYRCR. Particular attention would be paid to the projects identified in the NYRCR Plan as identified above.

Global Climate Change, Sea Level Rise and Coastal Vulnerability

Due to a combination of climate change and regional subsidence, sea level in New York is rising at an average of approximately 2.77 mm/year (NOAA, 2014). Though the exact degree of expected sea level rise is uncertain, the New York Panel on Climate Change projects between 7 to 12 inches of SLR by the 2050s and 12 to 23 inches by the 2080s (not including rapid ice melt scenarios). Some global sea level rise models similar to those conducted by the IPCC predict sea levels can rise by as much as 6 feet by the year 2100. Increased water levels threaten infrastructure and public access to estuarine resources.

Residents of the Town and region have witnessed the impact of sea level rise locally over human time scales. Over the last 30 years observed average sea level at the Battery in New York has increased at a rate of 0.93 feet per century[2]. FEMA base flood elevations have increased 4 feet in 30 years, and the number of tropical cyclones hitting the eastern seaboard has increased significantly over the last 50 years. Nevertheless, respecting the various views on global climate change among local stakeholders required finding and relating consensus from well-respected authorities.

That consensus was built around a report entitled Global Sea Level Rise Scenarios for the United States National Climate Assessment[3], issued by the National Oceanic and Atmospheric Administration (NOAA) in partnership with the US Geological Survey (USGS), Department of Defense (DOD), Department of Energy (DOE), Environmental Protection Agency (EPA) and the US Army Corps of Engineers (USACE). This document, established a very clear recommendation for communities wishing to plan for sea level rise:

> *"We have very high confidence (>9 in 10 chance) that global mean sea level will rise at least 0.2 meters (8 inches) and no more than 2.0 meters (6.6 feet) by 2100.... Based on a large body of science, we identify four scenarios of global mean SLR ranging from 0.2 meters (8 inches) to 2.0 meters (6.6 feet) by 2100. These scenarios provide a set of plausible trajectories of global mean SLR for use in assessing vulnerability, impacts, and adaptation strategies. None of these scenarios should be used in isolation, and experts and coastal managers should factor in locally and regionally specific information on climatic, physical, ecological, and biological processes and on the culture and economy of coastal communities. Scientific observations at the local and regional scale are essential to action, and long-term coastal management actions (e.g. coastal habitat restoration) are sensitive to near-term rates and amounts of SLR. However, global phenomena, such as SLR, also affect decisions at the local scale, especially over longer time horizons. Thousands of structures along the US coast are over fifty years old, including vital storm and waste water systems. Thus, coastal vulnerability, impact, and adaptation assessments require an understanding of the long-term, global, and regional drivers of environmental change. "*

Rather than focus on debating different models and the science behind the models, the study considered a range of global sea level rise - 8 inches to 6.6 feet. When planning for short time horizons and low-cost infrastructure, it was

Excerpts from *Nasa - Earth Observatory* - *In a Warming World Storms May Be Fewer but Stronger, (Voiland, Adam & Simmon, Robert, 2013)*

<http://earthobservatory.nasa.gov/Features/ClimateStorms/page2.php>

NASA Goddard Space Flight Center

"Rainfall totals from tropical cyclones in the North Atlantic have risen at a rate of 24 percent per decade since 1988"

NOAA

"Twice as many extreme snowstorms between 1961 and 2010 as there were from 1900 to 1960."

Massachusetts Institute of Technology

"Atlantic hurricanes are about 60 percent more powerful than in the 1970s. Top wind speeds increased by 25 percent and storms last longer"

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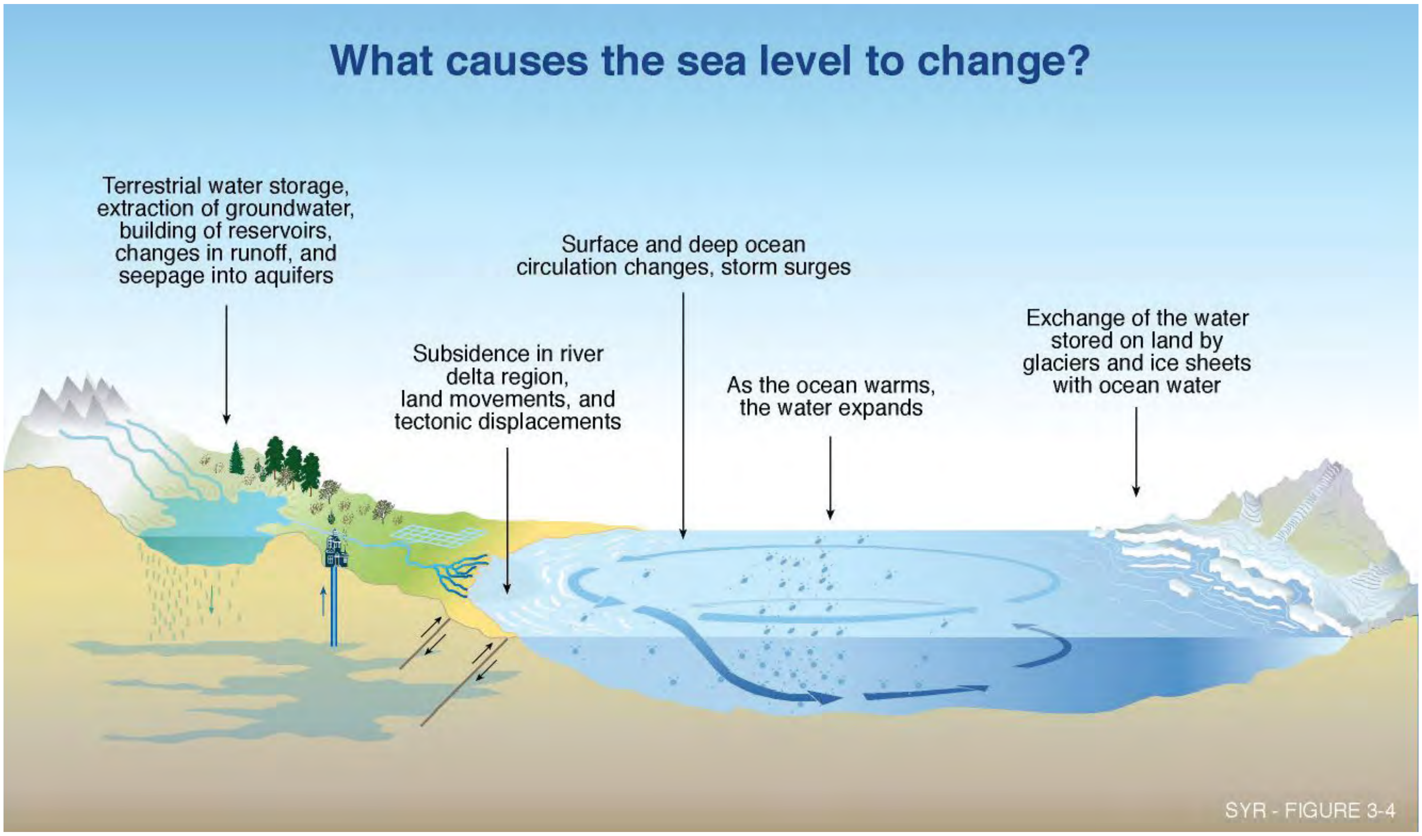
[2] National Oceanic and Atmospheric Administration, 2013. Tides and Currents Mean Sea Level Trends for the Battery, New York. <http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8518750>

[3] Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2012. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1. 37 pp.

satisfactory to look at the low-range scenarios. When planning for long-term or signficant infrastructure investment, consideration of a high-range scenario was appropriate.



Reasons for Sea Level Change Excerpted from *Global Sea Level Rise Scenarios for the United States Climate Assessment*[4]

Based on the needs to assess vulnerability on a range of scenarios, the consultant team developed a Coastal Vulnerability Index (CVI) model[5] to assess SLR impacts to the town of Stony Point, New York. The goal was to develop a tool that informed decision makers of where the Stony Point waterfront was most vulnerable to SLR and provide guidance on resiliency methods that could be employed to protect those areas. The CVI model evaluated SLR vulnerability based on 10 criteria: shoreline condition, slope, low-lying areas, natural habitats, FEMA flood zones, soil type, elevation, property value, population, and projected sea level rise. The CVI model utilized desktop-based GIS analyses to determine which sites are most at risk to SLR and storm surge.

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[4] ibid. p.5

[5] Tallis, H.T., Ricketts, T., Guerry, A.D., Wood, S.A., Sharp, R., Nelson, E., Ennaanay, D., Wolny, S., Olwero, N., Vigerstol, K., Pennington, D., Mendoza, G., Aukema, J., Foster, J., Forrest, J., Cameron, D., Arkema, K., Lonsdorf, E., Kennedy, C., Verutes, G., Kim, C.K., Guannel, G., Papenfus, M., Toft, J., Marsik, M., and Bernhardt, J. 2011. InVEST 2.2.2 User's Guide. The Natural Capital Project, Stanford.

Existing Geography, Shoreline and Land Use

Stony Point's Hudson Riverfront is widely varied and for much of its length rises steeply from the River. The West Shore Hudson River rail line owned by CSX Corp follows the river shore for most of Stony Point's length only gaining distance from the River south of Grassy Point Road.

Bear Mountain State Park and Iona Island

The Town's shoreline starts just north of the Bear Mountain Bridge (see figure 1). Through the first 4.5 miles, Bear Mountain State Park extends to the river and the shoreline is characterized by granite geology rising steeply out of the river. Iona Marsh and Iona Island extend out into the River approximately one mile south of the bridge and are owned by the New York State Department of Conservation and used as an estuarine sanctuary and research reserve. South from Iona Island, Bear Mountain State Park continues with a few enclaves of residential single-family development interspersed.

The River bends around Dunderberg Mountain, where the park ends and ownership of the Hudson River shoreline transitions to mostly private land holdings. The land continues to rise steeply from the River in this area and geology transitions from predominantly granite to marble[6]. Land use along the riverfront remains largely undeveloped with a few residential enclaves until 5.5 miles south of the bridge where the site of the former Lovett Power Generation Plant is currently being used as a barge landing and staging area for the Tappan Zee Bridge reconstruction project.

Central Shoreline

The former Lovett Plant site is owned by a private energy corporation and its shoreline is characterized by a mix of existing bulkheads and rip rap shoreline. There are no remaining landside structures on this site. There is some bluewater infrastructure to support the docking of barges and ships.

Three-quarter miles south of the former Lovett Plant site is a mine operated by Tilcon, New York. The mine drops well below the elevation of the River, but is divided by a 150-foot wide 30-50 foot high escarpment of the predominant Inwood Marble geology. The shoreline along this reach is comprised of a mix of sandy beach, rip rap or natural rock, and bulkheading for docking of barges in connection with mine activities.

South of the mine, Stony Point Battlefield State Historic Site juts into the Hudson River. This peninsula is also comprised of the Inwood Marble bedrock geology and shortly south of the battlefield, the geology transitions to softer shales and more organic soils. The Battlefield shoreline rises steeply from the River on all sides and is generally comprised of natural rock.

Beach Road Area

South of the Battlefield, the land use becomes much more varied. Hudson Drive and Beach Road provide access to the privately-owned land along this reach. At the southern end of Beach Road is the Town-owned Vincent Clark Park which provides a playground, pavilion, grills and picnic table as well as boat launch. Much of the shoreline is used for Marina uses, although there are a significant number of homes and private beaches and anchorages along both sides of Beach Road. Most of the marinas have bulkheads along the river, while the park and private residential lands tend to have a more natural shoreline of sandy soils. The western side of this area is demarcated by the elevated CSX rail line which rises approximately 20+ feet above the river. This sheltered area of the Hudson River is known as Stony Point Bay, but is also part of the larger widening of the river that is known as Haverstraw Bay. This

[6] Bonnell, S. M. 1990. Soil Survey of Rockland County, New York. USDA Soil Conservation Service in cooperation with Cornell University Agricultural Experiment Station. General Geology Map.

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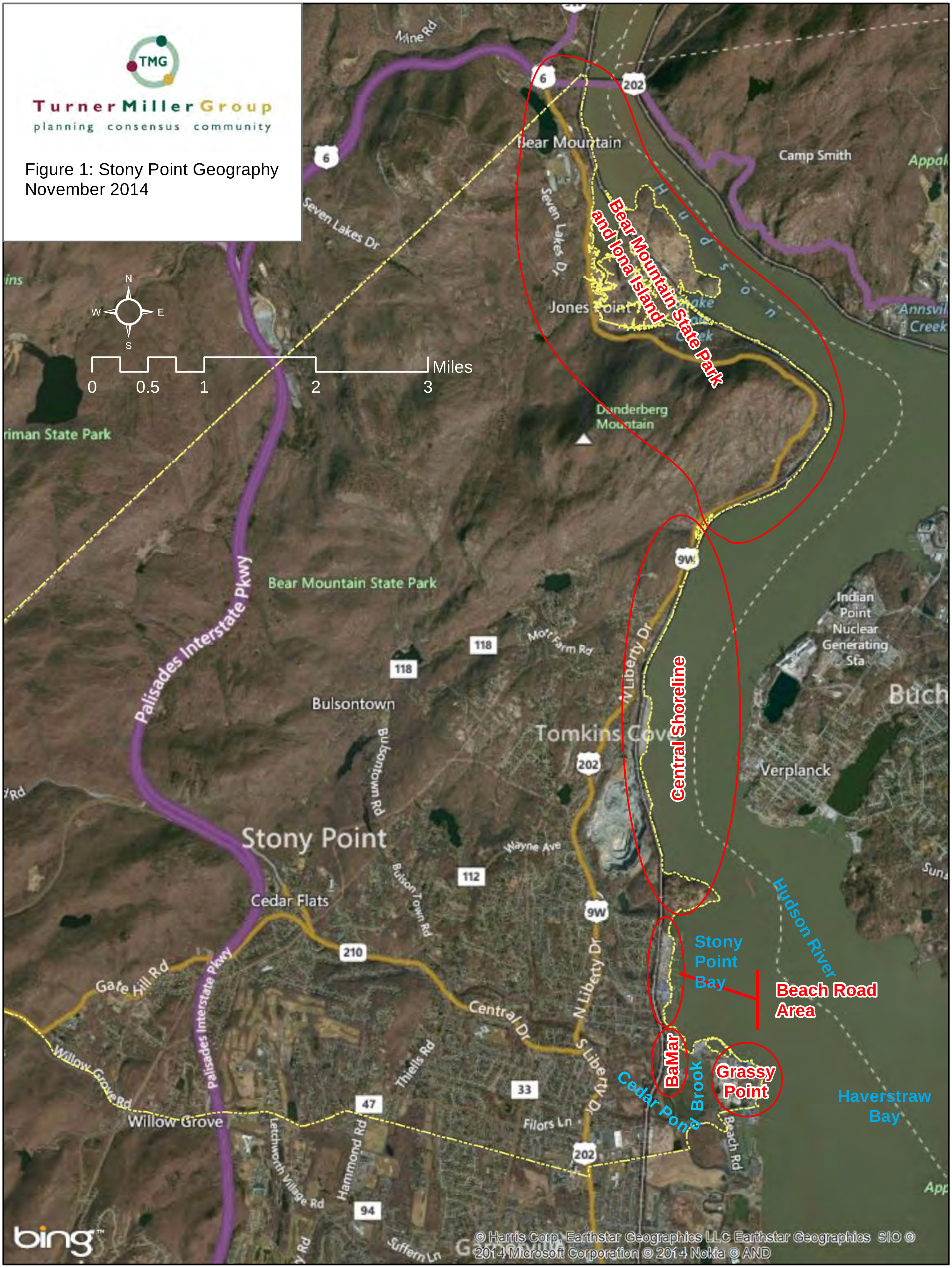
Figure 1: Stony Point Geography
November 2014



area between the Battlefield and Grassy Point Road and east of the rail line will hereafter be referred to as the "Beach Road area."

BaMar

South of the Beach Road Area, Grassy Point Road travels from east to west. Directly south of the intersection of Beach Road and Grassy Point Road is the BaMar Marina and Mobile Home Park. This facility contains more than 100 mobile homes arranged north and west of the Cedar Pond Brook estuary which flows north into the Stony Point Bay. The Cedar Pond Brook Estuary is mostly comprised of wetlands dominated by phragmites and is owned by Rockland County and categorized as open space parkland. The main sewer interceptor of the Town travels through this area from a railroad trestle to the south to Grassy Point Road where it heads east. The shoreline of the Cedar Pond Brook is comprised of bulkheads in the area of marina use and natural soil/rock shoreline in other areas. This area will hereafter be referred to as "BaMar."

Grassy Point

Heading east from BaMar and the Beach Road Area, Grassy Point Road crosses the Penny Bridge under which the Cedar Pond Brook (and Minisceongo Creek) flow into the Stony Point Bay. The area east of the Penny Bridge is referred to as Grassy Point and is a 100-acre "peninsula" between the Cedar Pond Brook Estuary and the Hudson River. It is connected to the main landmass by a small 50-foot wide spit of land in the south where another "Beach Road" enters into Stony Point from the Town of Haverstraw. Grassy Point Road bisects Grassy Point travelling east-west until it reaches the Hudson River, where it turns south and becomes River Road. The area north of Grassy Point Road is used for a marina, residential uses, a fuel-oil depot and the Town's Riverfront Park that contains a pavilion, volleyball courts, and benches and grills. The reach of shoreline used for marina and fuel-oil depot has bulkhead and riprap shoreline. The Town Park has a natural soil beach. The fuel-oil depot has bluewater facilities to receive waterborne deliveries.

South of Grassy Point Road, the majority of land is owned by the US Gypsum Corporation. An idling wallboard factory is located on the site and has not been in operation for more than five years. The factory maintains a railroad siding that travels north from the Town of Haverstraw and a conveyor that travels southeast to the Hudson River, where the company maintains bluewater infrastructure to support waterborne deliveries. US Gypsum maintains a naturalized shoreline with the Cedar Pond Brook estuary. East of US Gypsum, the Town of Stony Point has a wastewater treatment plant. East and north of the treatment plant is a neighborhood of small multifamily and single-family residences and a restaurant. East of River Road, the shoreline is comprised of natural sand beach with five groins extending into the River.

West of Grassy Point, and south of BaMar the Cedar Pond Brook flows in an easterly course under the CSX Rail line, at a 50-foot high trestle that was constructed in 1905. West of this trestle, Cedar Pond Brook remains tidal and influenced by the elevation of the Hudson River including during storms. The Town's main sewer interceptor travels through this section of the Cedar Pond Brook estuary which is comprised of phragmites-dominated wetlands. The water action of the tidal Cedar Pond Brook especially during storms has significantly undermined the soil berm that the pipe flows under. Additionally, this has exposed the wood post footings for the pipe, which are in poor condition.

Coastal Vulnerability Index

Coastal vulnerability index (CVI) modeling has been a popular method for evaluating a coastal community's vulnerability to sea level rise and storm surge for the past 15 years. The CVI method has become a very fast and cost effective tool for both regional and local planners to identify areas of their communities that are at risk to these threats.

The CVI was originally developed by Theiler and Hammar-Klose in 1999 and evaluated six physical parameters related to the coastline's vulnerability. There have been many modifications to the original model's method over the past decade that can now analyze socioeconomic parameters in addition to geophysical properties of the coast line. Great Ecology utilized the CVI method because of its flexibility in examining a number of different geophysical and socioeconomic variables, its cost effectiveness, and the abundant availability of third-party data that coincide with the data needs of the model.

CVI Methodology

The CVI model relied primarily on third party data sources such as federal and state agencies. Datasets utilized in creating the CVI model are described briefly in the following sections. Table 1 shows each dataset name and respective source.

Great Ecology assigned index scores of 1 to 5 to the variables of the CVI, where 1 indicates low coastal vulnerability and 5 indicates high coastal vulnerability. Scores were assigned using previous CVI models conducted by Gornitz and Theiler (see references). Great Ecology used the ArcGIS raster calculator (ArcMap 10.1, ESRI, Redlands CA) to combine the final variable values into a single index, and adding variable scores together where they overlapped spatially to derive the final CVI score. Site specific and regional recommendations were formulated for minimizing infrastructure risk and damage from SLR based on the findings from our CVI model this final report.

Sea Level Rise Intervals

Sea level rise data was downloaded from NOAA's Digital Coast web mapper (http://csc.noaa.gov/slr/viewer/). This raster dataset represents areas inundated by sea level rise at each 1-ft interval from 1 foot to 6 feet. Index values for SLR intervals were determined based on Gornitz and Theiler's models for coastal vulnerability.

Shoreline Condition

Great Ecology created the shoreline condition data set by tracing the shoreline of the project area into a vector shapefile. Each segment of the shoreline was assigned a different morphology type (i.e. reinforced, marsh, vegetated, etc.). These vectors were converted into a raster data set and expanded the associated CVI index value inland approximately 500 feet to account for the shoreline morphology's influence on near-shore areas.

Slope

Great Ecology used the Slope tool in the Spatial Analyst extension of ESRI ArcMap to develop a percent slope raster data set of the project area at a 3-meter resolution.

Low-Lying Areas

Data delineating low-lying areas was downloaded from NOAA's Digital Coast web mapper. These low-lying areas are most often areas contained behind levee systems, or depressions close to the shoreline that have no obvious surface hydrologic connection to a water body. This raster maps areas that would become inundated after each 1-foot SLR increment from 1 feet to 6 feet if a surface water connection existed.

Natural Habitats

Great Ecology utilized land use and land cover (LULC) data from the USGS to develop an index data set of currently existing habitat types.

Elevation

Great Ecology downloaded elevation data published by the USGS and hosted on the USDA Data Gateway website. This data set contains elevation data in meters at a 9 m^2 resolution.

Property Value

Due to delays in the provision of property value data from the Rockland County GIS department, property value data was not included in the final version of the CVI model.

FEMA Flood Zones

FEMA flood zone GIS data was downloaded from the National Flood Insurance Program Flood Hazard Mapper website to develop an index model layer of FEMA flood zones (http://www.fema.gov/national-flood-insurance-program-flood-hazard-mapping/national-flood-hazard-layer-nfhl).

Soil Type

Soil data was downloaded from the USDA Data Gateway (http://datagateway.nrcs.usda.gov/GDGOrder.aspx). The soil data was published by the USDA Natural Resources Conservation Service (NRCS) and contains soil drainage characteristics. These drainage characteristics were used to develop a CVI layer for inclusion in the model.

Population

2010 census data was downloaded from the US Department of Commerce (www.census.gov). This data set includes the population by census tract nationwide. The Rockland County data set was clipped to our project area for inclusion in the CVI model.

Town Boundary

A digital boundary of Stony Point was downloaded as a GIS layer to include in our model from the Rockland County Planning Department. This layer allowed us to clip other third party data sets with a common boundary to make integration of multiple data types and sources more efficient.

Storm Surge

Great Ecology utilized NOAA's Sea, Lake and Overland Surges from Hurricanes (SLOSH) storm surge model software (NOAA, 2008) to develop a raster data set representing areas inundated from a class 4 hurricane approaching Stony Point from the south with northeastern winds. This model outputs extremely coarse vector data which was not usable in the model. We took the mid-points of vector features from the model's outputs and interpolated them using the natural neighbor tool from the Spatial Analyst extension in ArcMap to develop a new raster data set with more evenly distributed values across our project area.

Table 1. Data Set Sources for CVI Model

Variable	Dataset Name	Source
Sea Level Rise Intervals	SLRmosiac.img	Derived from NOAA's Digital Coast database by Great Ecology
Shoreline Condition	shoreexpand2.img	Great Ecology
Slope	3mSlope.img	Derived from USGS 3-meter resolution elevation data by Great Ecology
Low-Lying Areas	LLAmosaic.img	Derived from NOAA's Digital Coast database by Great Ecology
Natural Habitats	LULC.img	USDA Data Gateway
FEMA Flood Zones	S_FLD_HAZ_AR.shp	FEMA
Soil Type	soilmu_a_ny087.shp	USDA Data Gateway
Elevation	ned03m41073b8 and c8.tif	USDA Data Gateway
Property Value	(Not yet acquired)	Rockland County GIS Department
Population	tabblock2010_36_pophu.shp	US Census Bureau
Town Boundary	CityTown.shp	NYS GIS Clearinghouse
Storm Surge	SLOSH_Output_Intersect.shp	NOAA National Weather Service - SLOSH data

Each dataset was evaluated before inclusion in the CVI model to ensure data quality and integrity. Evaluations included the following process:

1. Confirm GIS data is projected accurately and that its metadata entry for coordinate system matches the projection of the file.
2. Evaluate polygon and polyline shapefiles for extremely small features that may indicate errors in the dataset.
3. Identify if duplicate features exist, which may indicate errors in the dataset or its associated attribute table.
4. Ensure null features do not exist in the dataset.
5. Ensure raster datasets are of an appropriate resolution and do not contain null values (30m x 30m maximum cellsize.
6. Identify the variable type for all raster files.

Once Great Ecology approved the quality of a dataset, it was indexed based on the values summarized in Table 2. No datasets were discarded as a result of our approval process.

Table 2. CVI Index Values for Stony Point CVI Model

	Costal Vulnerability Index Values				
Variable	**Very Low (1)**	**Low (2)**	**Moderate (3)**	**High (4)**	**Very High (5)**
Sea Level Rise Intervals	5-6 ft	4-5 ft	3-4 ft	2-3 ft	0-2 ft
Shoreline Condition	Rocky or reinforced	Riprap	Vegetated	Marsh	Unconsolidated or lawn
Slope	Less than 7.19%	7.20 - 28.79%	28.80 - 53.99%	54.00 - 95.39%	Greater than 95.4%
Low-Lying Areas	5-6 ft	4-5 ft	3-4 ft	2-3 ft	0-2 ft
Natural Habitats	Shrub/scrub, mixed forest, deciduous forest, evergreen forest	Herbaceous, hay/pasture, woody wetlands	Barren land, emergent herbaceous wetlands, cultivated crops	Developed open space, developed low intensity	Developed medium intensity, developed high intensity, open water
FEMA Flood Zones[1]	X zones	A zones	AO zones	AE zones	VE zones
Soil Type	Excessively drained	Somewhat excessively drained	Moderately well drained, well drained	Poorly drained	Very poorly drained, open water, gravel pits, urban area
Elevation	Greater than 30 m	20 - 30 m	10 – 20 m	5 – 10 m	Less than 5m
Population	0-30	31-85	86-154	155-293	293 or greater
Storm Surge Inundation	0 ft	1 ft	2 ft	3 ft	4 ft or greater

[1]X zone: outside of Special Flood Hazard Area (SFHA).
A zone: areas subject to 1% annual chance flood event.
AO zone: areas subject to inundation by 1% annual chance shallow flooding (sheet flow).
AE zone: areas subject to inundation by 1% annual chance flood event.
VE zone: areas subject to inundation by the 1% annual chance flood with additional hazards due to storm-induced velocity wave action.

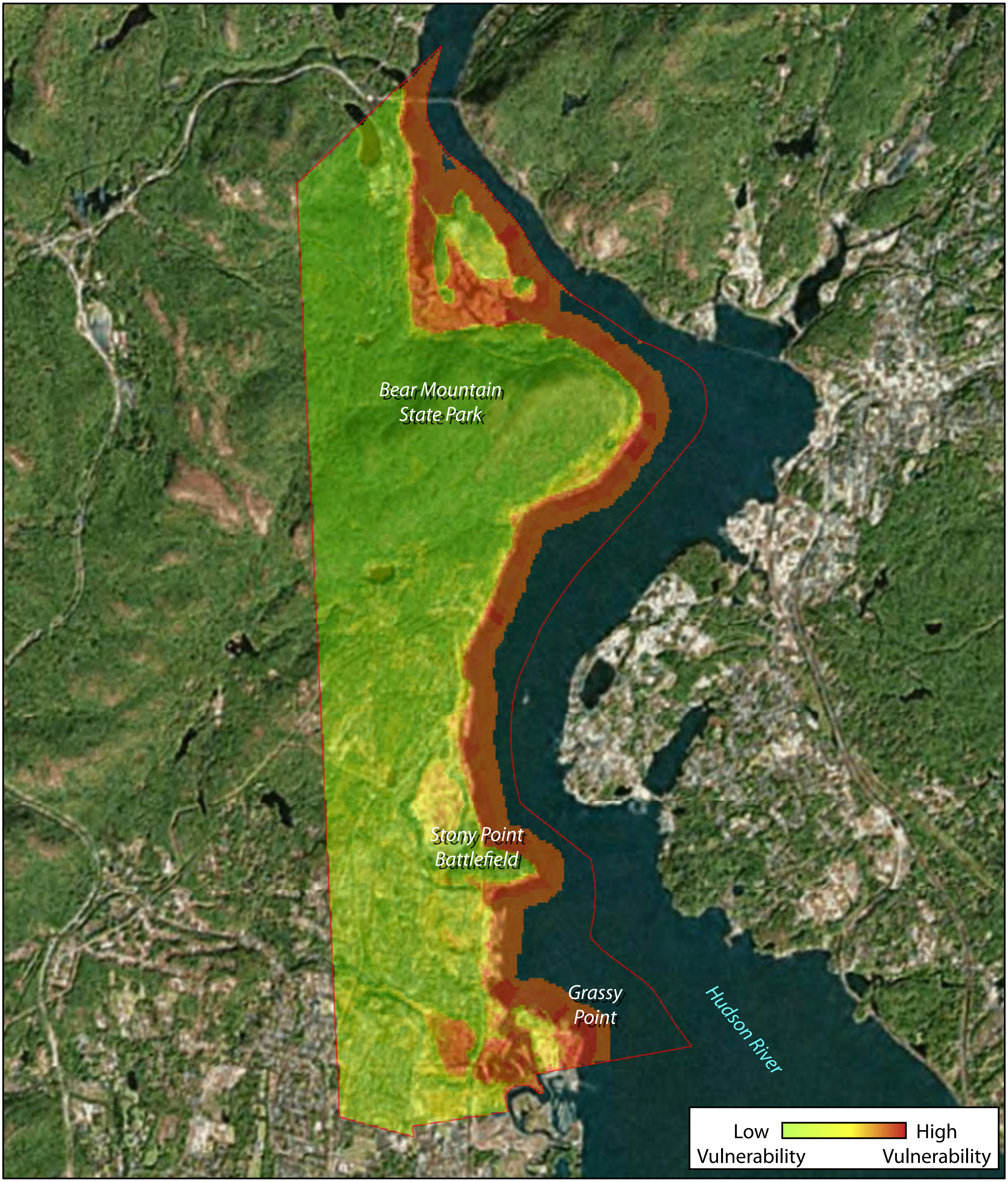
Each index raster dataset was then added together creating the final CVI model output raster dataset. The final CVI dataset's scores ranged from a theoretical low (not vulnerable) of 9 to a theoretical high (very vulnerable) of 45.

Figures 2-6 show the vulnerability of the various areas of the Town.

CVI Results and Discussion

The CVI model indicated the areas more vulnerable to sea level rise are the eastern half of Grassy Point, waterfront areas around the BaMar residential area, and Vincent Clark Park. CVI scores in the eastern portion of Grassy Point ranged from 36-45, some of the highest scores registered in the model. These areas scored higher than other neighboring areas due to their low elevation and unprotected shorelines. The areas around the US Gypsum Plant were typically less vulnerable as they were farther away from the exposed beach front along River Road. The BaMar area received scores between 30 and 36, with some areas scoring as high as 38, especially the most southerly area with southeasterly exposures.

Areas north of Grassy Point and Beach Road typically scored much lower than the southern portion of the study area. Much of the shoreline in the northern half of the study area are reinforced with riprap or consist of a rocky shoreline, making them much more resilient to storm events and less affected by sea level rise. While some of the small enclaves of residential property north of the Stony Point Battlefield show some vulnerability, these are generally, very small areas effecting a small number of properties.



STONY POINT COASTAL VULNERABILITY STUDY
CVI MODEL OUTPUT

FIGURE 2
1:55,000
NAD 1983 New York State Plane East FIPS 3101

0 0.25 0.5 1 MILES

NOVEMBER 12, 2014

GREAT ecology
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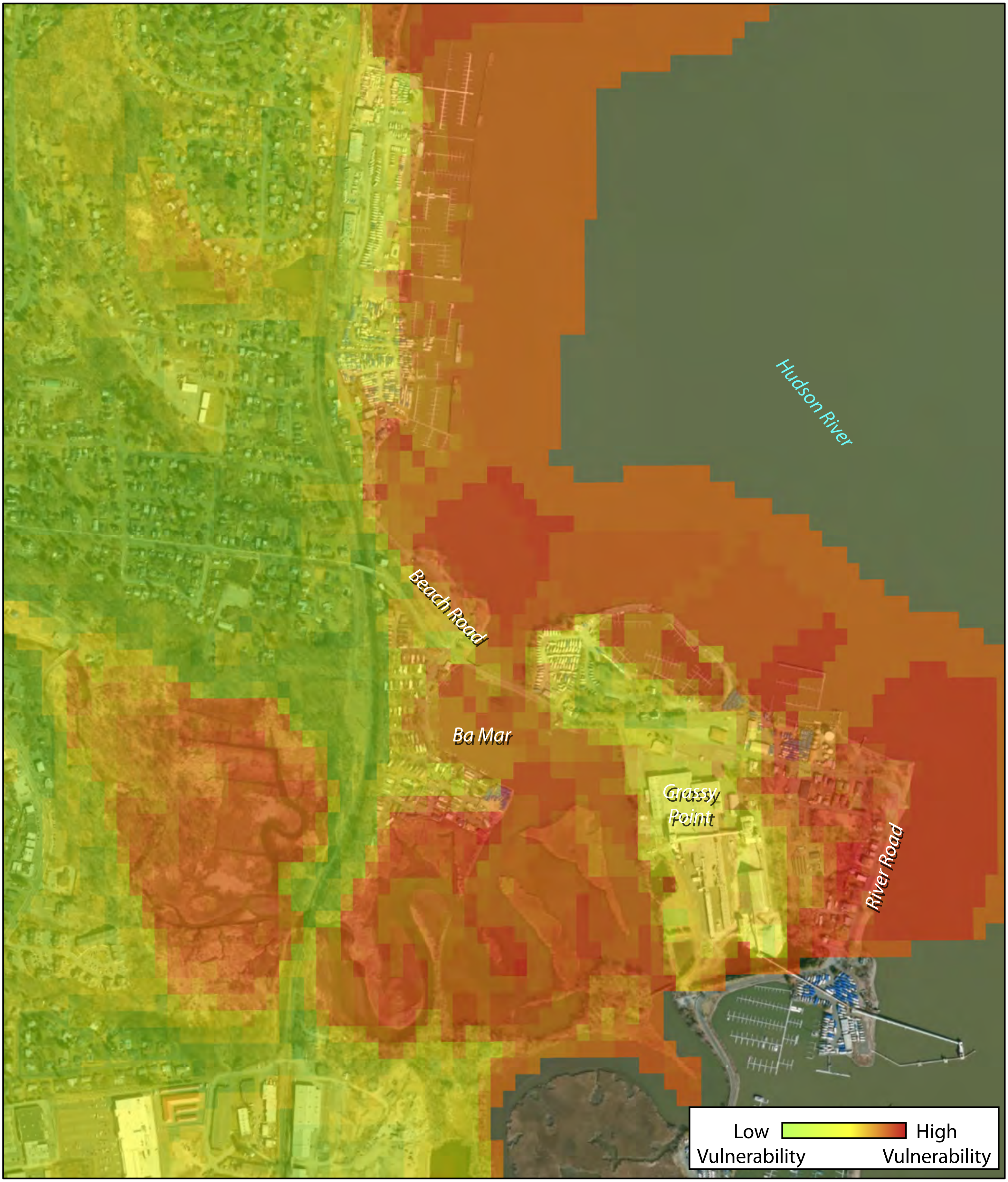
STONY POINT COASTAL VULNERABILITY STUDY
SOUTHERN WATERFRONT

FIGURE 3
1:10,000
NAD 1983 New York State Plane East FIPS 3101

GREATecology ENVIRONMENT + DESIGN

NOVEMBER 12, 2014



STONY POINT COASTAL VULNERABILITY STUDY
CVI MODEL OUTPUT

NOVEMBER 12, 2014

FIGURE 4
1:10,000
NAD 1983 New York State Plane East FIPS 3101

0 250 500 1,000 FEET

GREAT ecology
ENVIRONMENT + DESIGN

STONY POINT COASTAL VULNERABILITY STUDY
GRASSY POINT

FIGURE 5
1:6,000
NAD 1983 New York State Plane East FIPS 3101

0 125 250 500 FEET

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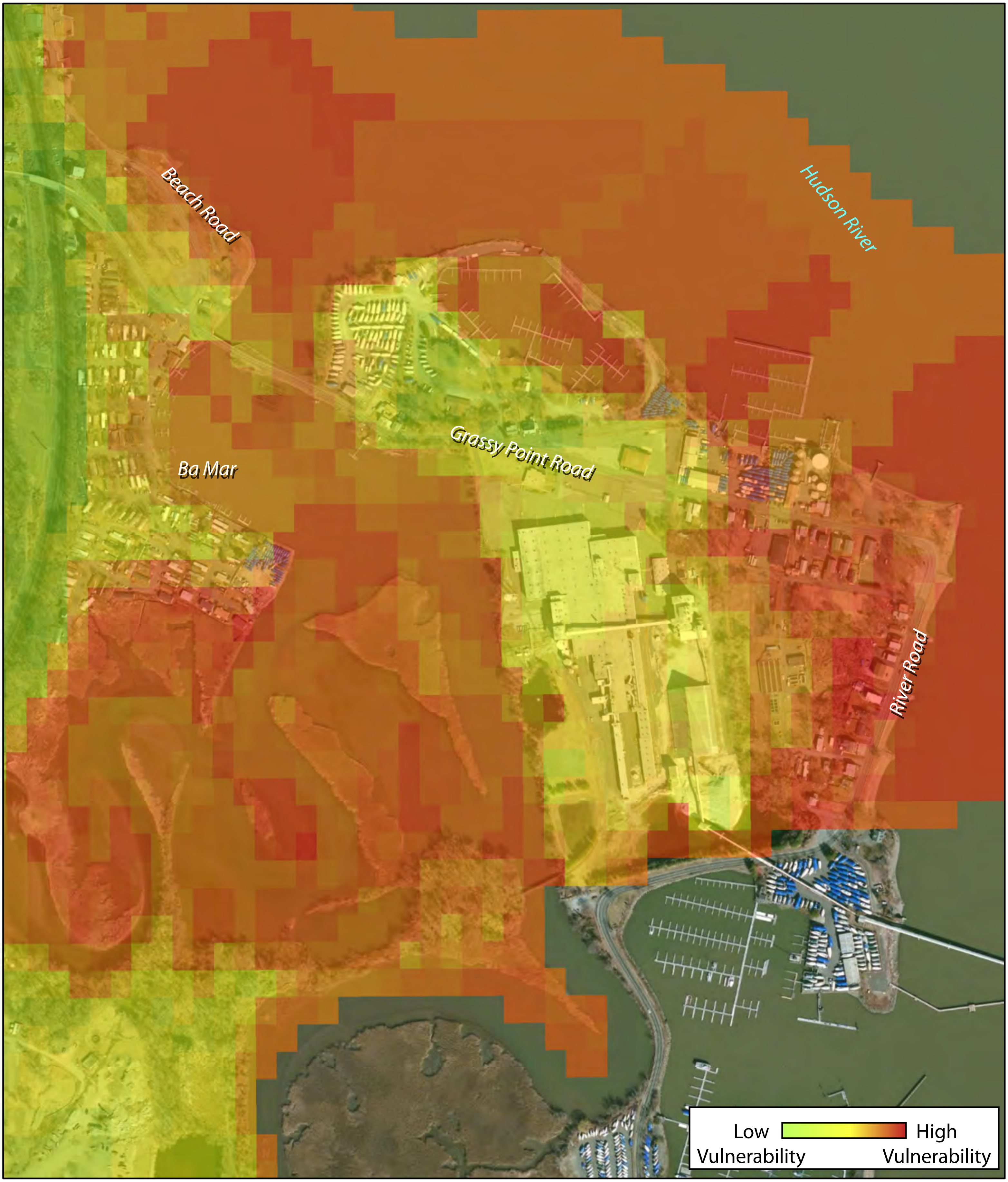
NOVEMBER 12, 2014



STONY POINT COASTAL VULNERABILITY STUDY
CVI MODEL OUTPUT

FIGURE 6
1:6,000
NAD 1983 New York State Plane East FIPS 3101

0 125 250 500 FEET

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Alternative Analysis

To insulate the Grassy Point area from future storm impacts, the NYRCR Plan recommended a project that included the construction of seawalls and groins (jetties) in order to dissipate wave energy east of River Road.

Great Ecology generated three proposed alternatives after reviewing the initial findings of the CVI model with the NYRCR Committee. The Committee agreed upon three alternative resiliency strategies for the waterfront and Great Ecology modeled the installation of those strategies to measure the decrease in coastal vulnerability as a result of each method.[7]

These alternatives included 1) the installation of rip rap groins at the current seawall elevation of 8 feet off the shore of the eastern beachfront of Grassy Point 2) installation of an artificial reef structures (reef balls) off the shore of the eastern beachfront of Grassy Point up to the high tide elevation (exposed at low tide - covered at high tide), and 3) construction of a dune to elevation 15 in front of exposed coastal homes in the Grassy Point residential area (chosen to based on four feet of sea level rise over existing 11-foot FEMA flood elevations).

Great Ecology simulated each alternative and altered the index values of the CVI variables according to the proposed alternatives method. For example for the dune creation alternative the elevation was increased to mimic that of the dune structure post-construction. The dune would also change the slope data set, storm surge data set, and shoreline geomorphology data set. The CVI model was then recalculated with these new CVI index values to determine the resiliency benefits associated with each alternative.

Groin and Artificial Reef Alternative

The CVI model is not specifically designed to model infrastructure that is submerged in a water body such as the Hudson River. As a result, the modeled groin and reef alternatives were very similar, both affecting above surface variables in identical ways. Therefore, the outcome of both alternatives was the same.

The average score of the Grassy Point area without any alternative method being applied to it was 34 (out of a possible 45). With the installation of the groins or reef structures off the shoreline east of River Road, the average score drops 4%, to approximately 32. More importantly, with the installation of groins or reefs, the number of cells scoring 38 or higher is greatly reduced from the original model output (from 101 cells to 22), signifying that the area has fewer areas that are extremely vulnerable.

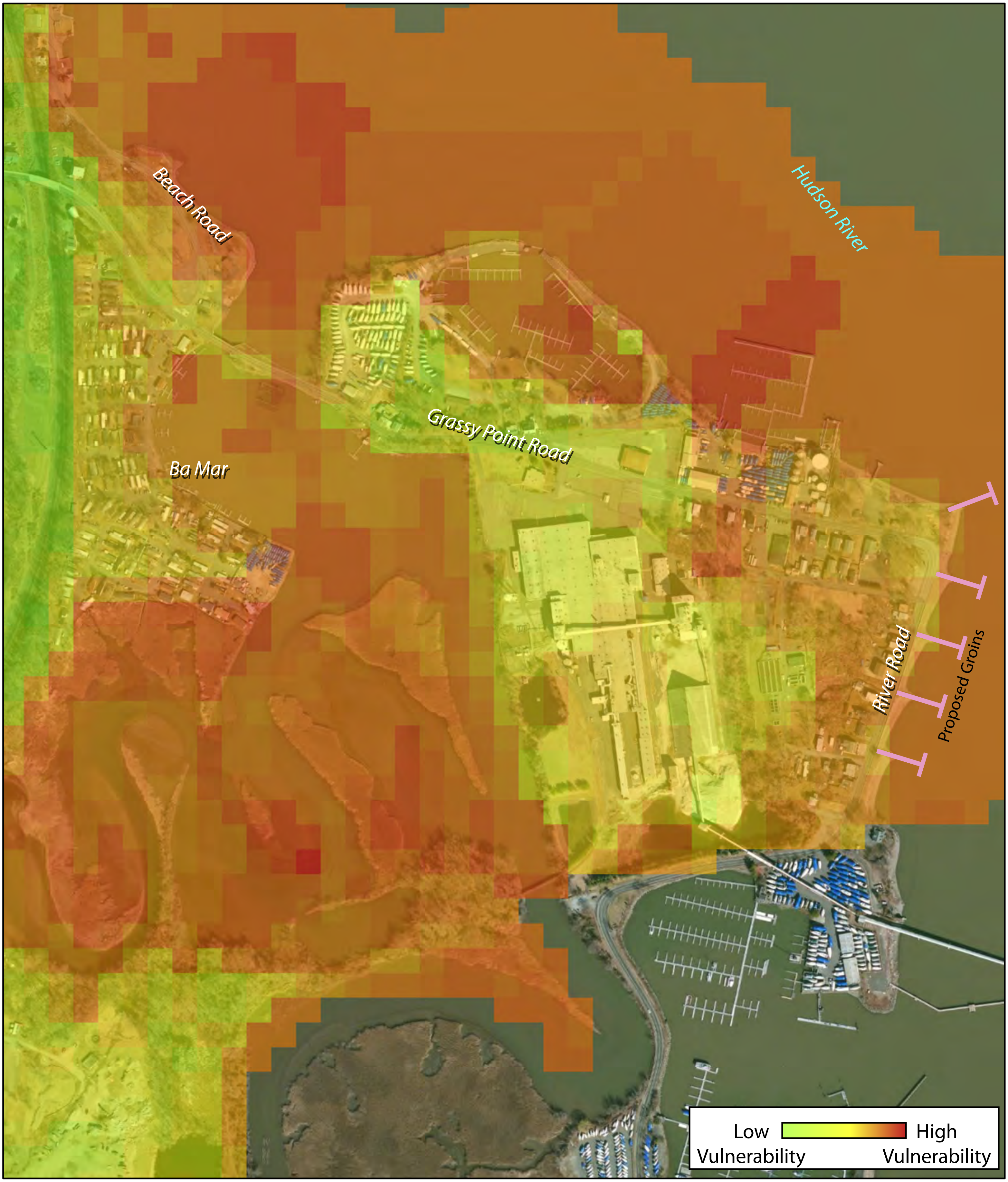
Dune Creation Alternative

The average score of the Grassy Point area with the installation of a 15-foot tall dune along the currently existing River Road was reduced from 34 to 31. Similar to the groin and reef alternative, dune creation saw a dramatic decrease in the number of cells that scored above 38.

Groin and reef structures also reduced coastal vulnerability at Grassy Point, but to a lesser degree. Subsurface structures like artificial reefs can only attenuate wave energies to a certain depth. Storm surge during major events like Hurricane Sandy would raise the water level high enough to effectively negate the reef's wave attenuation ability. Groins have the ability to attenuate wave action to a greater height than reefs and may be a better option for sea level rise resiliency in this area.

The reduction in coastal vulnerability with all three alternatives corresponds with the reduction of wave energy during coastal storms and their impact on area structures. Impacts from increased river flows will not be mitigated under any of these scenarios.

[7] The modelling conducted here is for planning purposes. Selection and design of resiliency projects should rely on more detailed hydraulic modelling.



STONY POINT COASTAL VULNERABILITY STUDY
GROIN/REEF ALTERNATIVE ANALYSIS OUTPUT

FIGURE 7
1:6,000
NAD 1983 New York State Plane East FIPS 3101

0 125 250 500 FEET

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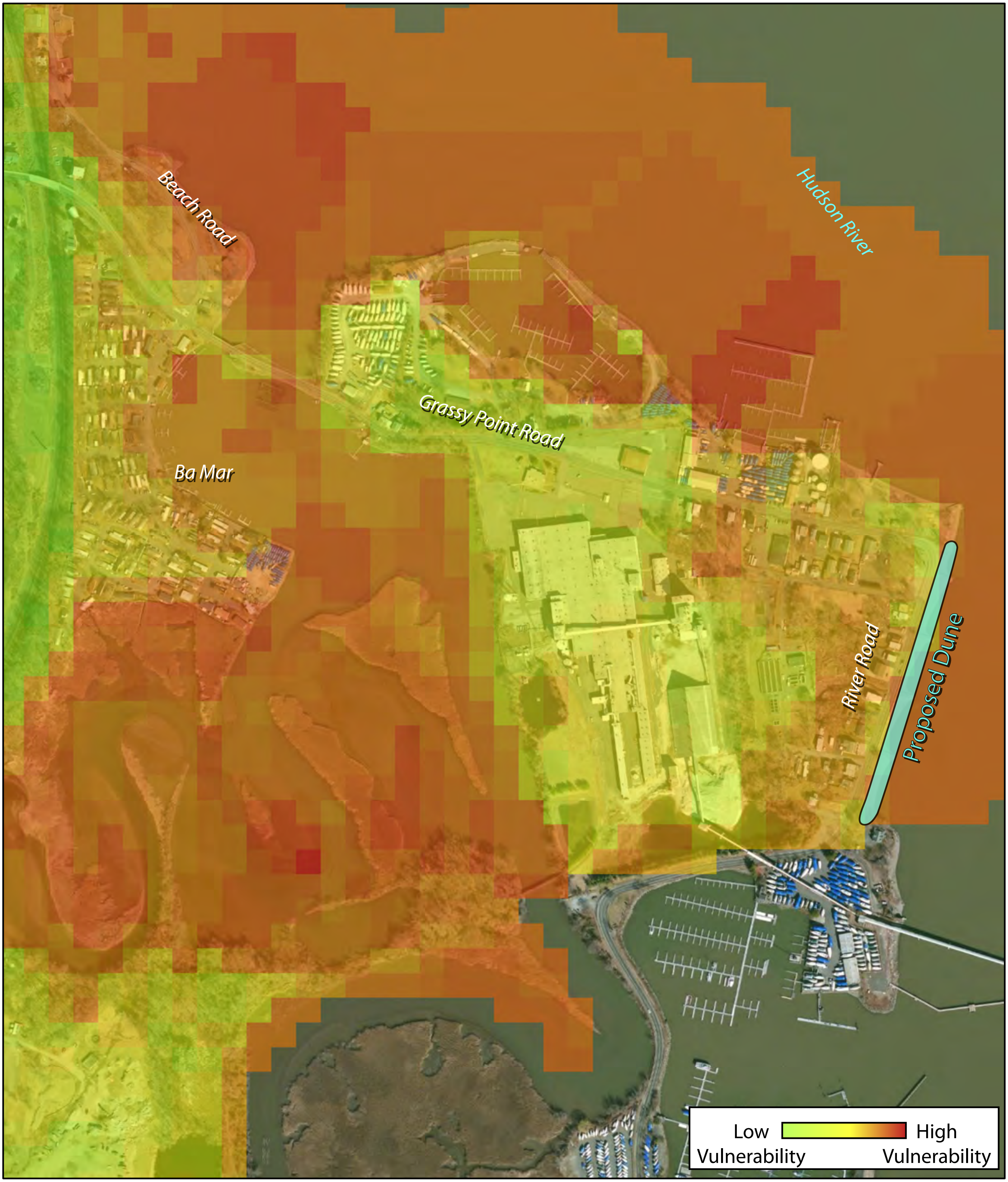
NOVEMBER 12, 2014



STONY POINT COASTAL VULNERABILITY STUDY
DUNE ALTERNATIVE ANALYSIS OUTPUT

FIGURE 8
1:6,000
NAD 1983 New York State Plane East FIPS 3101

0 125 250 500 FEET

NOVEMBER 12, 2014

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that the constructed dune would provide. It is noted that while the alternatives analyzed reduce impacts from coastal storms, they do little to reduce the impacts of future high river flows.

Quantitative Cost Comparison

Table 3. Quantitative Cost Comparison of River Road Shoreline Protection

	Alternative One - No Action	Alternative Two - Standard Jetty 3,000 linear feet rip rap jetty	Alternative Three - Reef Balls 5x300ft artificial reefs	Alternative Four - Dunes 1,500 foot dune construction
Project Soft Costs		$255,000	$100,000	$112,500
assumed %		10.0%	20.0%	10.0%
Project Hard Costs		$2,550,000	$500,000	$1,012,500
Total Project Costs	(existing infrastructure)	$2,805,000	$600,000	$1,125,000
Maintenance cycle	10	20	100	3
Maintenance costs	$1,000,000	50%	100%	20%
30 year maintenance cost	$3,000,000	$2,103,750	$180,000	$2,250,000
Total 30 year cost	$3,000,000	$4,908,750	$780,000	$3,375,000
Total Annual cost	$100,000	$163,625	$26,000	$112,500
Building Value Impacted				
Residential Neighborhood Full Value	$2,163,400	$2,163,400	$2,163,400	$2,163,400
Residential Neighborhood % Damage	75%	50%	50%	30%
Damage	$1,622,550	$1,081,700	$1,081,700	$649,020
Benefit	$0	$540,850	$540,850	$973,530
US Gypsum Building Value	$3,678,887	$3,678,887	$3,678,887	$3,678,887
US Gypsum % Damage	10%	10%	10%	5%
Damage	$367,889	$367,889	$367,889	$183,944
Benefit	$0	$0	$0	$183,944
Town Treatment Plant Depreciated Building Value	$12,000,000	$12,000,000	$12,000,000	$12,000,000
Treatment Plant % Damage	20%	15%	15%	5%
Damage	$2,400,000	$1,800,000	$1,800,000	$600,000
Benefit	$0	$600,000	$600,000	$1,800,000
One time total benefit	$0	$1,140,850	$1,140,850	$2,957,474
Annual Benefit	$0.00	$114,085	$114,085	$295,747.44
Annual Benefits less cost	-$100,000	-$49,540	$88,085	$183,247

The qualitative cost analysis is based on a number of assumptions. Town Engineer Kevin Maher, P.E. was consulted for assistance on construction costs, as well as information on labor expended after Hurricane Sandy. Based on consultation with the Town Engineer and Comptroller, the following assumptions were made:

- The labor costs to cleanup roadways, the costs of emergency services expended post-storm, as well as added expenses surrounding public safety, building inspection, and park and sewer infrastructure recovery following Hurricane Sandy totaled approximately $2M for the Grassy Point and Beach Road area.
- Based on the degree of destruction caused by wave action throughout the Grassy Point area during Hurricane Sandy, it was determined that all three alternatives would reduce these expenditures by approximately half by mitigating storm surge caused by high winds and wave action. Because of this, the cost of the no-action alternative was set at $1M per major storm loss event (similar to Sandy) as the difference between installing some type of shoreline protection for storm surge mitigation only and doing nothing at all.
- The cost analysis is based on increasing severity of tropical cyclones, and the cost of damage from these increasingly frequent storms is estimated to reach the cost of Hurricane Sandy every ten years over the next 100 years.[8]
- The percentage of damage is based on an approximation of the real-property and equipment damage incurred by the Grassy Point area during hurricane Sandy. It does not include damage to boats docked or stored on the marinas, as this is not included in the real property assessment values and may fluctuate significantly.
- The percentage of damage change for each scenario was determined based on the average benefit experienced under each scenario as well as the benefit to the most vulnerable areas. The percentages relative to the no-action alternative were discussed and subjectively determined based on consultation between the Turner Miller Group, Great Ecology and the Town Engineer.
- There was not a detailed proposed design with regard to the T-Head Groin Alternative in the NYRCR Plan. It was assumed that the five existing groins would be reconstructed by extending dry-laid riprap groins 200 feet from the existing sea wall and terminating in a 100-foot T-Head.
- Soft-costs for dune construction and groins is based on standard 10% rates. The reef-ball alternative was assumed to be two times higher based on the higher cost for DEC permitting.

[8] "The combined effects of storm climatology change and a 1 m SLR may cause the present NYC 100-yr surge flooding to occur every 3–20 yr and the present 500-yr flooding to occur every 25–240 yr by the end of the century" Lin, Ning; Emanuel, Kerry; Oppenheimer, Michael; Vanmarcke, Erik. Physically based assessment of hurricane surge threat under climate change. Journal Article - Nature Climate Change - vol 2, issue 6. 2012.

Dune Construction -
Photo by K Duhring -
<http://ccrm.vims.edu/livingshorelines>

Reef Balls
Photos by Reefball Foundation
<www.reefball.org>

T-Head Groin
Photo by Broward County
<http://www.broward.org/BeachRenourishment>

Based on these assumptions, the dune construction alternative provides the greatest net benefits to the community.

Dune Construction

The key benefit to the Dune construction is the significant benefits to the residential neighborhoods along River Road and Grassy Point Road as well as the benefits to the Town's wastewater treatment plant. The Town has identified hardening of the wastewater treatment plant as another NYRCR project. Another benefit is the reduced cost relative to the construction and maintenance of riprap groins and jetties. This approach is estimated to result in the reduction of property damage by almost $3M for a Sandy-scale storm.

Reef Balls

The installation of an artificial reef or reef balls provides the second most benefits to the Town by virtue of the fact that if built to be emergent, they can provide equal protection to the groins at a much lower construction and maintenance price. The installation of perforated concrete domes that are cast on site and then dropped in rows off shore and allowed to lie on the riverbed has the lowest construction and maintenance cost. Unfortunately the technology is not a currently accepted practice by DEC and soft costs to get the approach permitted may be higher. This approach is estimated to result in the reduction of property damage by more than $1.1M for a Sandy-scale storm.

Groin Structures

The installation of physical groin structures constructed of rip rap is the most costly. Turner Miller Group estimated a total construction cost of $2.8M with a requirement for major repair (50%) after two Sandy-scale storms. This is significantly in excess of the $1.7M initial construction cost estimated in the NYRCR Plan. If the actual costs are closer to those listed in the NYRCR plan, it is possible that this would be a much less costly resiliency approach. Like the artificial reef, the property damage decrease would be more than $1.1M for a Sandy-scale storm.

No-Action

The no-action alternative would be the most costly approach. The public cleanup costs are estimated to approach $100,000 annually with no benefit to private landowners in the area.

Qualitative Cost Analysis

Each alternative also has potential to impact or benefit a number of factors that are not expressible in dollar terms. This includes benefits to ecology, aesthetics, public safety, and quality of life.

Table 4. Qualitative Cost Analysis of River Road Shoreline Protection

	No Action	Groins	Reef Balls	Dunes
Ecology Costs (wildlife, wetlands, habitat, etc)	Debris and chemical contamination from flooded homes and oil tank farm	Temporary construction impacts to river	Temporary construction impacts to river	Temporary construction impacts to river
				Reduction in aquatic habitat if constructed on river side of sea wall
Ecology Benefits	None	Decreased post storm contamination (see no action ecology cost) Possible habitat value if designed properly	Decreased post storm contamination (see no action ecology cost) Aquatic habitat value	Decreased post storm contamination (see no action ecology cost) Possible habitat value (not certain for riverine ecology)
Aesthetic Costs (views, appearance of area)	Post-storm debris and abandoned/condemned homes	Temporary construction impacts to river views	Temporary construction impacts to river views	Temporary construction impacts to river views
				Potential blocked views
Aesthetic Benefits	None	Reduced post-storm damage(see no-action aesthetic costs)	Reduced post-storm damage(see no-action aesthetic costs)	Reduced post-storm damage(see no-action aesthetic costs)
Quality of Life Costs (health, comfort and happiness)	Disruption during storm from damaged structures	Noise and truck traffic impacts during construction	Noise and truck traffic impacts during construction	Noise and truck traffic impacts during construction
				Risk of sand erosion impacting neighboring properties if not maintained properly.
Quality of Life Benefits	None	Decreased disruption (see no-action quality of life costs) Recreational benefits - increased fish populations and possible fishing facility	Decreased disruption (see no-action quality of life costs) Recreational benefits - increased fish populations	Decreased disruption (see no-action quality of life costs) Recreational amenity - sandy beach
Public Safety Costs (risk of injury or death)	Significant risk to life during severe storms	Injury risk for persons climbing on rip rap	Risk to boaters when submerged	None
Public Safety Benefits	None	Decreased risk during storms (see no-action public safety costs)	Decreased risk during storms (see no-action public safety costs)	Decreased risk during storms (see no-action public safety costs)

In terms of qualitative impacts, the no-action alternative provides the least benefits, and the costs of doing nothing are well known to residents of the area. Unmitigated damage to real property will continue to present hazards and disruption to life, and post-storm aesthetic and contamination impacts. Any of the three alternatives would provide benefits by mitigating the impacts of severe storms.

Ecology

All three alternatives would result in temporary impacts to sea life during construction. Artificial reefs have the potential to enhance aquatic habitat value over the long-term and the dunes and groin alternatives could also provide habitat benefits if designed properly. While coastal dunes have significant habitat value for plant life, invertebrates and sea birds, it is not clear how valuable this habitat function would be in this stretch of the Hudson River. Additionally, there is currently limited room on the river side of the existing River Road sea wall. Construction of a dune in this location may require reduction of aquatic habitat which also may raise permitting difficulties and reduce flood storage. An alternative approach would be to re-route River Road through the Town's wastewater treatment plan property, which would make the current road bed available for constructing dunes. This would significantly increase the cost of the dune alternative to the point where it would become the most costly in terms of quantitative cost-benefit (assuming a road construction cost of approximately $2M), but would have the beneficial effect of increasing accessibility of the County road during severe storms since the elevation of the road would be increased.

Aesthetics

All three alternatives would result in temporary aesthetic impacts during construction. A 15-foot high dune would rise significantly above the existing 8-foot high sea wall and block views for motorists and existing waterfront residences.

Quality of Life

There would also be temporary quality of life impacts to local residents from noise and truck traffic during construction for all three alternatives. The dunes alternative also poses the threat of wind erosion carrying the sand onto adjacent properties if not properly maintained and stabilized. Dunes would provide a more substantial sandy beach amenity that is not available currently in the Town of Stony Point. Both reef balls and groins could increase fish population in the area resulting in a recreational benefit to fisherman. Groins, if appropriate designed, could also double as a fishing "pier" projecting into the river.

Public Safety

The groin alternative could result in potential injury risks to persons climbing over the rip rap. The artificial reef could result in potential hazards to boaters when submerged.

Public Outreach

Two public outreach meetings were held to engage the public and local stakeholders. The first was held on October 1, 2014 at 5:00PM at the Rho Community Center - 5 Clubhouse Lane - Stony Point, NY. Unfortunately, the first meeting was poorly attended. Key stakeholders including representatives of Rockland County Planning and Rockland County Fire and Emergency Services did attend.

The meeting opened with a presentation on general adaptation strategies to sea level rise, presented by Kristin Marcell of DEC Hudson Estuary Program. Several adaptation strategies were described to provide a general primer for later discussion by the Committee. Due to the poor attendance at the first public meeting the presentation was repeated at the second public meeting.

Zak Lehmann of Great Ecology then presented the results of the CVI Analysis. Following the presentation, Zak Lehmann opened the CVI software and analysis so that the results could be queried interactively to answer questions and inform discussion of the committee and public. Based on these discussions the committee determined that the project most likely to benefit most from further assessment of sea level rise was the shoreline protection of River Road. In addition to the NYRCR recommendation for construction of groins, the alternatives to be considered were the utilization of "reef balls" or similar artificial reef technologies and the consideration of dune construction.

The committee resolved to better advertise the next public meeting in order to achieve more robust stakeholder input.

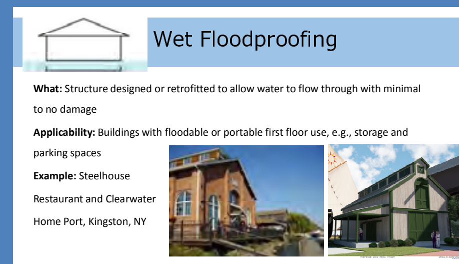
The second meeting was held on October 29, 2014 at 5:00 PM at the Rho Community Center. The Rockland County Times advertised the meeting in print and the Rockland Journal News included an announcement online. Additionally, the Town advertised the meeting on its Facebook page and on its website. Committee members were instructed to get the word out, and the second meeting was much better attended by approximately 30 local residents of the Beach Road Area, BaMar and Grassy Point.

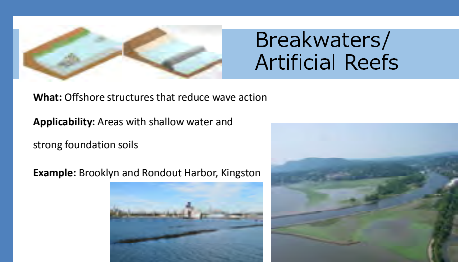
Max Stach of Turner Miller Group introduced some of the concepts of sea level rise and work that had already been undertaken. Kristin Marcell gave a presentation of general adaptation strategies and Zak Lehmann gave a presentation of results for Coastal Vulnerability Index analysis. In addition, Mr. Lehmann presented the results of the three alternatives analyzed for shoreline protection of River Road.

Max Stach presented a number of general recommendations on best practices for storm preparedness, and additional planning for sea level rise and climate change based on the Climate Smart Communities Planning Tool.

The attendees provided robust public input on the presented material. Generally public input indicated:

- A desire to maintain views of the Hudson River from private residences;
- Concern regarding the challenges for elevating brick structures and structures built on slabs;
- Frustration at the slowness of the NYRCR process in actually proceeding to construction phases;
- Concern that shoreline resiliency projects adequately protect inland structures;
- Concern about the impacts of raising Beach Road on the accessibility of area residences;
- Expression of the desire to continue to promote economic development despite challenges posed by sea level rise;





Samples of General Adaptation Strategies presented by K. Marcell of DEC Hudson Estuary Program based on Urban Waterfront Adaptation Strategies by NYC Department of City Planning.

- Consensus on the need to maintain accessibility to Grassy Point residences during flood events in a manner that does not impede normal access to neighboring lots (by raising road elevations for example);
- Concerns about the navigational impact of in-water structures;
- Interest and concern in the concept of relocating River Road;

Recommendations

Based on the analyses conducted on coastal vulnerability, public input, and the discussions and deliberations of the NYRCR Committee, the following recommendations are offered by the consultant team to make Stony Point more resilient to sea level rise.

The Beach Road/Stony Point Bay Area from the Battlefield Park to the Penny Bridge is at significant risk to sea level rise. Grassy Point helps to attenuate storm surge during storms with winds out of the southeast, so the impacts to this area are mostly from water elevation and shoreline composition as opposed to storm surge. Vincent Clark Park's exposed lawn shoreline makes the area at risk to erosion.

The current zoning proposal for mixed-use residential development at this location was discussed briefly at both meetings as was the Master Plan recommendation to promote economic development along this stretch of the waterfront. Height clearance at the Tomkins Avenue underpass is insufficient for emergency equipment - specifically firefighting equipment. The actual roadway at the Tomkins Avenue underpass is above existing flood elevations and is not particularly vulnerable to future SLR. South of the Tomkins Avenue underpass, Beach Road actually floods during current periods of tidal high water and this will be exacerbated by rising sea levels. Several solutions were discussed from raising Beach Road, which is difficult due to existing adjacent residences; building an overpass over the CSX rail line, which is likely cost prohibitive; and access through the Battlefield Park, which would likely still be exposed to storm surge. The Committee made it clear that economic development at the waterfront remained an important objective of the Town.

Recommendation 1: Plant emergent grasses and other deeply rooting vegetation along the shoreline of Clark Park to slow wave/wake energy and reduce shoreline erosion.

Recommendation 2: Allow flexibility in height regulations to allow any future waterfront development to measure height from the base flood elevation or current existing grade, whichever is higher. Require any residential waterfront development to provide a strategy for mitigating possible sea level rise increases including incorporating wet flood proofing strategies or adapting construction to facilitate easier post-construction height increase.

Recommendation 3: Require any future large-scale Hudson River waterfront residential development to creatively address and mitigate access restrictions of the Tomkins Avenue underpass and Beach Road (possibly by locating emergency service equipment on-site).

Penny Bridge was discussed as a resource that is clearly exposed during storm events. Although several approaches were discussed, the only clear solution was to raise the roadway/bridge and abutments if access was to be maintained in the future. Grassy Point Road is a county road.

Recommendation 4: Petition the County to raise the elevation of the Penny Bridge and Grassy Point Road from the Penny Bridge to the US Gypsum site to 14 feet. Look for opportunities to apply jointly for funding.

The Grassy Point Area is actually fairly well resistant to sea level rise on an elevation basis. The central area occupied by the US Gypsum Plant is not at significant risk to sea level rise. Most of the other areas, with the exception of 3rd, 4th and 5th street could also withstand 2 feet or more of rise. However, the east end of Grassy Point, specifically all of the area east of the US Gypsum Plant, including the Town's wastewater treatment plant is extremely vulnerable to storm surge.

This area of high exposure is proposed by FEMA for both V and A zones marking areas that will be inundated currently during 1% storms, with the area east of the wastewater treatment plant subject to significant wave action.

The NYRCR Plan recommended a project that included the construction of seawalls and groins (jetties) in order to dissipate wave energy. Multiple other approaches were discussed to this including reef balls and dune restoration. The possibility of relocating River Road to the east of the Town's wastewater treatment plant property were discussed with the benefit of increasing potential beach area and dune height. Grassy Point Road and River Road are County Roads.

The Town's wastewater treatment plant was discussed as to hardening the current treatment plant, or having Rockland County or the Haverstraw Joint Regional Sewerage Board take over the plant. In the last storm, the plant was not damaged and was operable. However, with moderate degrees of sea level rise, this may not be the case.

Also discussed was the isolation of this area as Grassy Point Road and River Road are flooded. The possibility of raising Grassy Point Road to projected long-term future flood elevations of between 14 and 17 feet was discussed in order to facilitate evacuation during a storm.

Recommendation 5: Seek funding for and construct a shoreline protection infrastructure east of River Road. Additional consideration should be given to the alternatives evaluated herein. The Town of Haverstraw and adjoining private marina should be contacted and given the opportunity to extend any shoreline protection south into the Town of Haverstraw providing additional protection as practicable.

Recommendation 6: Team with Rockland County to explore the re-routing of River Road through the Town's wastewater treatment plant property and out through the idling US Gypsum property. Such a route could be built to higher elevations and support better emergency access to the area during storm events. The additional land captured from the abandonment of the existing River Road could potentially support the construction of shoreline protection measures.

Recommendation 7: Any project to harden the wastewater treatment plant should account for flood elevations of 14 feet given the remaining usable life of the treatment plant.

BaMar Park Area is at risk from moderate levels of sea level rise. Currently, Local Law requirements[9] for damaged structures is to be built to elevation 13. Since these manufactured housing units have estimated useful lives of 25 to 30 years, the two-foot over current flood elevation probably allows for a practical high-end estimate of sea level rise over the next 30 years (two feet). However, there are areas of BaMar that are more exposed to sea level rise, that are generally characterized by the proximity to the Cedar Pond Brook as well as southeast exposures, specifically the areas around the site entrance as well as the most southerly homes on Dara, Kathy and Kim Lane. These areas are more exposed to storm surge flowing over the Cedar Pond Brook Estuary. Marsh reclamation in the estuary could help to combat wave energy during storm surge. However, these areas may be appropriate for planned retreat.

[9] Stony Point Local Law 1 of 2013 adopted FEMA's advisory base flood elevation of 11 feet as the Hudson River base flood elevation. New York State Building Code requires two feet of freeboard over base flood elevations.

Recommendation 8: The Town should consider new legislation requiring minimum setbacks from mobile homes to the mean high water line of any tidal waterbody. Consideration should be given to limiting grandfathering of this standard. The setback area could be used for alternative uses such as recreation or marina use. Additionally, the setback could support construction of a berm, which could allow the owner of the park to seek a map amendment from FEMA, thereby lowering insurance costs.

Recommendation 9: The Town should work with Rockland County and DEC to explore the possibility of restoring the Cedar Pond Brook Estuary with native emergent vegetation. Doing so would provide ecological benefit and reduce storm surge erosion and siltation if the estuary can support denser planting.

Recommendation 10: Consider a TDR Program that funds buyouts of homes in exchange for residential density elsewhere in the Town. The Town should consider allowing private developers to purchase homes and lots within FEMA "V-zones" and in exchange for dedication of the land or easements to the Town, to be able to apply this density to any zoning district in the Town except for the APRP and SR districts. Details of the program would have to be developed including the maximum increase in density allowed under this program, and minimum lot sizes required for buyout, but it could provide revenue that the Town can use to buy out highly vulnerable properties with owners willing to sell. .

The Cedar Pond Brook Interceptor located west of the CSX rail line was a project identified in the NYRCR final report proposed at an elevation of approximately 7 feet above mean high water with locking manholes and a snorkel at top elevation of 15 feet. This design would be topped during current 1% storms, and the snorkel elevation would be adequate for up to four feet of sea level rise.

Recommendation 11: Any design of improvements or relocation of the Cedar Pond Brook Interceptor should consider future flood elevations of up to 14 feet given the usable life of the interceptor. It is suggested that further study is required, but that this is a high priority given the potential impacts that a breakage could have on the Cedar Pond Brook estuary and Hudson River.

Climate Smart Communities

The Climate Smart Communities program is a program sponsored by several NY agencies including Departments of Environmental Conservation, Energy Research and Development Authority, Public Service Commission, Department of State, Department of Transportation and the Department of Health. The program provides recognition and support to communities wishing to reduce greenhouse gas emissions, promote energy conservation, and make their communities more resilient to climate change.

The first step to becoming a Climate Smart Community is to take the Climate Smart Pledge. The Town of Stony Point should review the program and determine whether or not it is a right fit for the Town. Regardless of whether the Town takes the Climate Smart Communities Pledge, the program provides an extremely useful self-assessment tool known as the *Climate Smart Resiliency Planning Evaluation Tool,* which allows a facilitator to answer several questions and identify planning that can be undertaken and steps that can be taken to make the community more resilient and reduce greenhouse gas emissions. Based on an initial completion of the tool by the Town Planner, the following recommendations are made:

Recommendation 12: Assign a Town staff member involved in an emergency management role to further facilitate and continuously update the *Climate Smart Resiliency Planning Evaluation Tool.*

Recommendation 13: Follow through on NYRCR recommendations for operations center and storm shelter investments.

Recommendation 14: Prepare a comprehensive update of the Town's Comprehensive Plan. Emergency Service Providers should be involved by inclusion on the Comprehensive Plan Committee. The Plan should specifically include consideration of sea level rise and identify coastal resiliency as a goal. Flood-prone areas should be considered for open space and recreation and measures of acquiring private flood-prone lands should be explored.

Recommendation 15: Become a FEMA Rated Community and seek to improve ratings. The program allows for reductions to individual flood insurance rates based on the actions of the local government. Some steps that could be taken to immediately improve the Town's score include: making FEMA maps available on the Town Website; tracking repetitive flood losses; training Town employees in FEMA's Hazus-MH a hazard mitigation tool; training Town employees in flood hazard risks; installing publically visible high-water markers; developing flood/storm preparedness materials (including emergency kits, family evacuation planning, etc. and making them available on the Town website (including bilingual publications) and advertising their availability in media; and developing public information plans for pre-storm activities.

Recommendation 16: Consider coastal vulnerability in the development of a capital improvement plan for Town Resources including parks, wastewater treatment plant, and other infrastructure. Vulnerable areas should be prioritized and infrastructure improvements should include consideration of tidal flood elevations 3 feet over current elevations.

Recommendation 17: Update the Local Waterfront Revitalization Plan (1994) and ensure it addresses sea level rise and coastal storms. The current Plan is dated both from a goal and from a resiliency standpoint. Updating the plan could make the Town eligible for additional public funding of resiliency infrastructure projects.

Recommendation 18: Plan for storm preparedness and recovery including becoming a NOAA Storm-ready community; developing a storm emergency response and short-term recovery plan; and developing a storm evacuation plan;

Recommendation 19: Consider developing a Climate Action Plan. The Town will receive benefits from increased energy and cost efficiency while doing its part to reduce the production of greenhouse gases.

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