



**BUILDING ECOLOGICAL SOLUTIONS TO COASTAL COMMUNITY HAZARDS (BESCCH)**

# Township of Greenwich

## Municipal Coastal Vulnerability Assessment

### May 2016

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for the Township of Greenwich  
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# Township of Greenwich Coastal Vulnerability Assessment Report

## I. Introduction

### Municipal Coastal Vulnerability Assessment

The Municipal Coastal Vulnerability Assessment (CVA) is both a process and tool to help communities make incisive and sound decisions on near and long-term coastal management, reconstruction and resiliency measures. The CVA categorizes the degree to which a community’s assets (e.g. built, natural, social, etc.) will be impacted by projected sea level rise and storm events, and analyzes the consequences those vulnerabilities pose to the community. By accounting for vulnerability and consequence factors associated with future flood events, local officials will be better informed to make critical decisions regarding land use planning, mitigation, adaption measures and public investments. The CVA was developed through the New Jersey Resilient Coastal Communities Initiative (RCCI), a post-Sandy, multi-partner project funded by the National Oceanic and Atmospheric Administration (NOAA), and managed by the NJ Department of Environmental Protection’s Office of Coastal and Land Use Planning. The tool was created in response to the need for municipalities to be better prepared for the increasing rate of sea level rise and extreme storm events.

## II. Municipal Background

### Location and Demographics

Greenwich is a historic Delaware Bay community located on the banks of the Cohansey River in western Cumberland County. The Township is roughly 18 square miles with over 63 miles of coastline along the Delaware Bay. Greenwich is a rural community with a population of just over 800, and the majority of its land area in farmland, woodland or wetland. Approximately 5% of the community is surface water.

### Future Flooding

Greenwich is faced with a new set of challenges as sea level continues to rise and the intensity and frequency of storms and precipitation persist. Figure 1 shows past and future trends in monthly mean sea level rise using data from Cape May tide gauge station in Cape May, NJ. Additional data and maps regarding future flood projections, precipitation and climate change are available at Climate Central (<http://www.climatecentral.org>); NJAdapt (<http://www.njadapt.org>); and the NJ Climate Adaptation Alliance (<http://njadapt.rutgers.edu>).

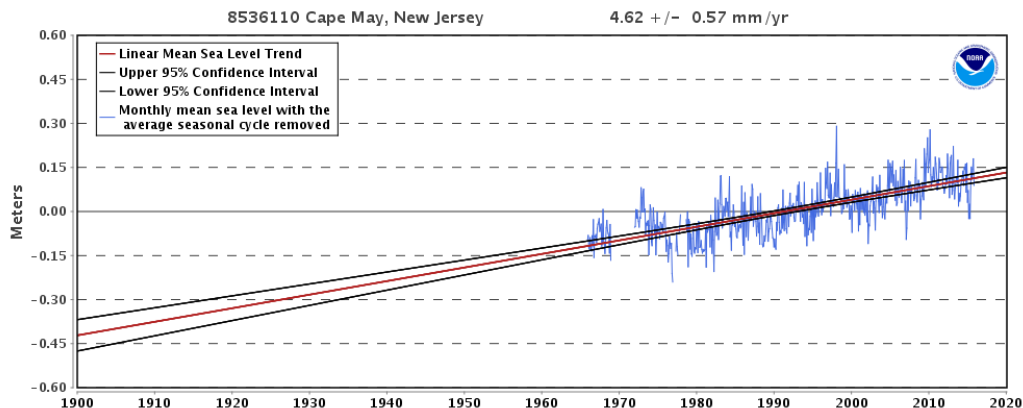


Figure 1. Mean Sea Level Trend at Cape May, NJ (NOAA, 2015)

### III. Municipal Coastal Vulnerability Assessment – Methodology

The CVA process is a methodical, step-by-step approach for conducting a comprehensive vulnerability assessment of coastal flooding hazards. It identifies the vulnerability of community assets (identified by the municipality) to a series of future flood hazard scenarios, and the associated consequences to the community. The CVA goes beyond a simple analysis of flooding extent and duration by also examining how flooding will affect the functional capacity of buildings, services, infrastructure, businesses, ecological systems and residents. The three key steps of the CVA are described below:

✓ *Identify and map community assets and selected coastal flood hazard scenario(s)*

Geographical Information Systems (GIS) maps are the most effective way of locating and analyzing community assets and flood hazards. Community assets are identified among four categories - Critical Facilities & Infrastructure Systems, Community Resources & Amenities, Natural Resources & Ecosystems, and Districts, Neighborhoods, & Population Clusters – and plotted using GIS. Flood hazard scenarios are selected and are also mapped. Communities are encouraged to use both future sea level rise (daily high tide) and storm surge levels for at least 2050, and, preferably, 2030 and 2100, if available.

✓ *Evaluate the vulnerability of community assets.*

Vulnerability is the predisposition of a community asset to be adversely affected by a hazard—in this case, coastal flooding. Vulnerability is measured by the anticipated degree of *exposure* and *sensitivity*.

*Exposure* is the extent to which community assets may be flooded, measured by magnitude and depth. The magnitude of exposure incorporates the frequency of occurrence (e.g. for high tide, the occurrence would be daily), and the depth of floodwater during the occurrence.

*Sensitivity* is measured by the extent to which the flooding will impact the following features of the asset<sup>1</sup>:

- Durability of the structure or asset (materials, elevated structure, flood mitigation measures, etc.)
- The ability of an asset to continue to provide its key benefits and operations in the aftermath of a storm event
- The ability to move quickly from harm’s way.

Each asset is assigned a single vulnerability rating based on the adverse impacts due to exposure and sensitivity to each hazard. A Vulnerability Rating Key provides guidance in the assignment of these ratings. (See Appendix C).

✓ *Evaluate the overall consequences to the community*

Consequence is the degree of impact on the entire community if an asset will be lost or damaged, or if the asset’s function is impaired. The degree of impact is measured by eight topic areas that can potentially impact the community. The topic areas include: property damage, population displacement, delivery of services, typical operations / daily life, environment, emergency response, hazardous materials, and municipal budget. The Consequences Rating Key in Appendix D provides guidelines for identifying and rating consequences.

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<sup>1</sup> Sensitivity also includes the natural coping capacity of individuals to move out of harm’s way. However, contrary to some definitions, it does not include adaptive capacity since by its inherent definition adaptive capacity is a likely future condition that requires action, e.g. elevating structures. The CVA evaluates sensitivity based on the assets’ current conditions.



## IV. Findings: Vulnerability and Consequences of Community Assets

Greenwich initially identified 57 assets to be included in the vulnerability and consequences assessment, but only those assets shown to be impacted by sea level rise and/or a Category 1 Hurricane in 2050 (10 assets in total) were included in the final assessment. The assets were identified under four broad categories of potential community assets: Critical Facilities & Infrastructure Systems, Community Resources & Amenities, Natural Assets & Ecosystems, and Districts, Neighborhoods, & Population Clusters. While the majority of assets were assessed individually, some of them were assessed as part of “systems” to ensure the functionality and consequence if one component or asset failed. For example, Greenwich’s Historic District, which includes a large number of historic homes and structures located along Ye Greate Street were assessed as a single asset because they impacted by many of the same issues including high groundwater levels, septic tank failures, and the historic nature of the buildings themselves.

The flood hazards scenarios used for this assessment were projected sea level rise and hurricane Category 1 storm surge for 2050, both provided by the NJ Department of Environmental Protection. The sea level rise projections are based on a 2013 study by New Jersey climate scientists,<sup>2</sup> and use the 2050 mid-range projections in that study, or 1.3 feet of sea level rise. The sea level rise maps show the additive layers of the projections and the mean higher high water (MHHW) mark, determined by NOAA calculations. The storm surge maps were developed using NOAA’s SLOSH (Sea, Lake, and Overland Surge from Hurricanes) model, combined with the sea level rise projections. The approximate depth of water is based on LiDAR data.<sup>3</sup>

The community assets were assessed for their vulnerability (exposure and sensitivity) to the above two hazard scenarios, and then for the consequences to the community if the asset was damaged or destroyed. The complete set of data on vulnerability and consequences are included in the CVA Matrix (Appendix A) and summarized in Table 1. Since sea level rise is more likely to occur than a Category 1 hurricane, the Township should particularly focus its attention on the assets with high consequences in the sea level rise column. There are also other considerations for interpreting the data in the Matrix and Table 1. The flood hazard maps are based on the latest technology and most readily available data, both of which will continue to be updated as new data is generated and technology advances. Additionally, there may be existing topographical features or mitigation measures in place that the assessment did not pick up, which could lower the vulnerability rating of an asset. For these reasons, the matrix should be used for general planning purposes and not for specific site planning or design, unless site conditions are field verified. More considerations on the use of the data and recommendations are offered in Section V.

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<sup>2</sup> Miller et al. December 2013. “A geological perspective on sea-level rise and its impacts along the U.S. mid-Atlantic coast.” [http://onlinelibrary.wiley.com/doi/10.1002/2013EF00\\_0135/pdf](http://onlinelibrary.wiley.com/doi/10.1002/2013EF00_0135/pdf)

<sup>3</sup> Note that the projected flood events used in this assessment were generated by several models prepared by state and national agencies and professionals, and are suitable for planning purposes. However, due to the uncertainty of projections and accuracy of certain types of data, the maps should not be the sole resource for conducting site specific analyses.

**Table 1. Summary of Township of Greenwich Coastal Vulnerability Assessment Matrix**

Asset Name	Asset Description	Asset Function	Vulnerability Rating		Consequences Rating	
			SLR	CAT1	SLR	CAT1
<b>Constant &amp; Lydia Waithman House c. 1690-1700</b>	Historic Structure	One of the oldest homes in Cumberland County.	NA	Low	NA	Low
<b>John and Elizabeth Bacon House c. 1700-1730</b>	Historic Structure	One of the oldest homes in Cumberland County.	NA	Low	NA	Moderate
<b>Hancock's Marina and Bait Box</b>	Marina	Hancock's Marina is a private marina and boat storage yard, used by local residents and tourists who bring recreational watercrafts to the area. The Bait Box is a restaurant with the only liquor license in the township and may begin to be opened year round. The property brings in approximately \$50,000 in property taxes annually.	Moderate	High	High	High
<b>Greenwich Boat Works &amp; Ship John</b>	Marina	Greenwich Boat Works is a private marina and boat storage yard, used by local residents and tourists who bring recreational watercrafts to the area. The property includes numerous abandoned and decrepit boats around the property. Ship John is a closed-down restaurant in disrepair. The restaurant is not likely to reopen. The property brings in approximately \$45,000 in property taxes annually.	Moderate	High	High	High
<b>Pier House</b>	Historic Structure	One of the oldest structures in Cumberland County.	NA	Low	NA	Low
<b>Bacon's Neck School</b>	Historic Structure	One of the oldest structures in Cumberland County.	NA	High	NA	High

**Table 1. Summary Township of Greenwich Coastal Vulnerability Assessment Matrix (Continued)**

Asset Name	Asset Category	Asset Function	Vulnerability Rating		Consequences Rating	
			SLR	CAT1	SLR	CAT1
<b>Bridgeton Road (County Road 607)</b>	State Designated Evacuation Route	Bridgeton Road is the only designated evacuation route out of Greenwich during an emergency. Although, there are other local routes out of the community. Part of Bridgeton Road consists of a land bridge across the impoundment of the confluence of Wheaton Run, Mill Run and Mounce Creek, and wetlands, water passing under the road via one culvert.	Low	High	Low	Moderate
<b>Bridgeton Dike</b>	Man-Made Dike	The dike was constructed to help keep floodwater and tidal water from the wetlands out of the drained farmland. The dike also helps to protect additionally developed areas from flood waters.	Moderate	High	High	High
<b>Wetlands Complex</b>	Wetlands Complex	The township has a significant amount of wetlands that buffer the community from the Delaware Bay and the Cohansey River.	High	High	High	High
<b>Market Lane (County)</b>	County Road & Dike	Market Lane is a county road. A low-lying dike/land bridge runs across multiple streams and associated wetlands. The dike includes a culvert with back flow prevention stop tidal waters from flowing upstream of Market Lane, which helps protect properties and structures.	Moderate	High	High	High
<b>Bacons Neck Road</b>	County Road & Dike	Bacons Neck Road is a county road. A low-lying dike/land bridge runs across the intersection of Pine Mount creek and a tributary and associated wetlands. The dike includes one culvert with back flow prevention structure to help prevent tidal flow north of Bacons Neck Road from high tide and storm events, which helps protect farm lands.	Moderate	High	High	High

**Table 1. Summary of Township of Greenwich Coastal Vulnerability Assessment Matrix (Continued)**

Asset Name	Asset Category	Asset Function	Vulnerability Rating		Consequences Rating	
			SLR	CAT1	SLR	CAT1
<b>Ye Greate Street Residents</b>	Residential Area	The largest concentration of residential homes in Greenwich is along Ye Greate Street, the main street of the township. The entirety of Ye Great Street is within a National Historic District, with several homes and other structures also being designated historic structures. The homes rely on septic systems as no sewer service is currently available in Greenwich.	Moderate	High	High	High
<b>Ye Greate Street</b>	Main Street & Local Evacuation Route	Ye Greate Street is the main street in Greenwich, and along which the largest concentration of residents live. The street includes stormwater infrastructure (stormdrains, culverts and outlets) used to drain water from the street and back into the wetlands to southwest of the street to reduce flooding on the street and residential homes.	Low	High	Low	High

## V. Recommendations

This section offers key steps that the township should consider following the vulnerability assessment, and discusses the long-term planning process that is integral to risk reduction and adaptation planning and implementation.

### Considerations

#### 1. Coordinate community outreach and education on flood risks

In order for Greenwich to better prepare for the future impacts of sea level rise and hurricane events, it is important to have an engaged and informed community. The results of this report should be shared with the community either at a public meeting or workshop, but at a minimum by posting it on the municipal website. The township should also consider special outreach to residents, business owners, and property owners in the most vulnerable areas of Greenwich. Educating these stakeholders about future flood vulnerabilities and working together to find solutions will protect Greenwich at large and keep the fabric of the neighborhoods intact and the businesses operating.

2. *Share the results of the Coastal Vulnerability Assessment with owners and managers of vulnerable and at-risk non-residential properties and work together to develop mitigation and adaptation strategies.* Many of Greenwich’s at-risk assets are owned and managed by private businesses and industries, and public and quasi-public entities. These property owners may be aware of additional risks and vulnerabilities that were not identified in this CVA or perhaps have already launched efforts to prepare for future risk reduction. Greenwich is encouraged

to reach out to these property owners to discuss the results of this report and future steps that may be taken individually and collectively to protect the properties from future flood hazards.

#### Suggestions

- Consider convening a workshop or meeting with at-risk non-residential property owners and operators to discuss opportunities to collaborate on adaptation strategies to minimize risks and potential damage to future flood hazards.
- When working with flood-risk private industries in development proposals, redevelopment or other activities, promote the importance of emergency management planning site remediation and the safe storage of toxic materials.

*3. Incorporate the results of the Coastal Vulnerability Assessment into the municipal master plan with short-term and long-term strategies for protecting and adapting the community assets and vulnerable areas.* Community flood risks are influenced largely by land use and development patterns that are grounded in local master plan policies. The master plan should identify areas in the community that will likely be impacted by future flood hazards, and offer measures for mitigation and adaptation strategies to protect the community's assets and properties and minimize their exposure to flooding.

#### Suggestions

- Include maps of projected sea level rise and future storm events in the land use plan and conservation plan elements of the municipal master plan.
- Identify natural resources that serve as protective flood mitigation measures (e.g. wetlands), and provide recommendations for maintenance and management in the conservation plan element.
- Identify planning policies for mitigation and adaptation strategies to protect properties from future flooding, including sea level rise and extreme storm events, in the land use plan element.

*4. Cross-reference the Coastal Vulnerability Assessment in relevant sections of the floodplain management plan and all hazards mitigation plan.* Hazard mitigation plans and flood mitigation plans provide strategies to reduce the community's flood risks, but are sometimes stand-alone documents that do not relate to each other or the community's master plan. This disconnect can result in conflicting policies and undermine the progress and effectiveness of mitigation and adaptation. Integrating the coastal vulnerability assessment (and related subsequent studies) into all local policy documents ensures a coordinated, complementary approach to mitigation, and avoids potential conflicts from competing goals and interests.

#### Resources

- *Integrating Hazard Mitigation Into Local Planning, Case Studies and Tools for Community Officials*, FEMA, 2013

*5. Consider wetland education and outreach campaign on the importance of Greenwich's Bay Shore wetland complex.* Wetlands serve an important role in flood hazard mitigation. These systems dampen wave height and energy, decreasing the destructive power of a storm surge entering the wetlands of the Bay Shore. Community education and outreach will raise awareness of the benefits these systems provide to the community both daily and during a storm event. An education and outreach campaign could include brochures for the boating community or citizen scientist wetland assessment program. In addition, the municipality may benefit from a more in-depth assessment of the health of the wetlands by consulting with a wetland ecologist from academia or the non-profit community.

### Resources

- Paddle for the Edge, Barnegat Bay Partnership <http://bbp.ocean.edu/pages/380.asp>
- [Partnership for Delaware Estuary](#)

### *6. Consider the use of living shorelines to protect community assets against shoreline erosion*

Living shorelines are a shoreline stabilization practice that address erosion and attenuate wave energy using a hybrid approach of strategically placed plants, stone, sand fill and other structural or organic materials. Living shorelines typically have other co-benefits such as the protection of flora and fauna habitats, flood mitigation, improved water quality and attractive, natural appearances. These practices are an alternative to the traditional hard or “gray” infrastructure (e.g. bulkheads, revetment walls, etc.), which are especially vulnerable to sea level rise and extreme flood events.

### Resource

- The Nature Conservancy. [Coastal Restoration Explorer Mapping tool](#).

### **Adaptation: A Long-Term Planning Process<sup>4</sup>**

Planning for the predicted increase in the frequency and severity of flood hazards is a complex and challenging task. Adaptation to these flood hazards requires a longer planning timeframe for which most municipalities are not accustomed to. Incremental steps are key to ensuring progress and minimizing public investments on projects that may be compromised by flooding in the near to distant future. This vulnerability assessment is an important first step in planning for these future hazards. The above recommendations provide key steps immediately following the vulnerability assessment to further identify and confirm vulnerabilities and consequences, and to begin thinking about adaptation. This section frames a strategic approach to identifying, assessing, and implementing long-term solutions to reducing flood risks. The process will need to be repeated periodically to respond to new data, changes in the physical environment and the long-term horizon.

### *Identify plans, studies and activities that are needed prior to identifying adaptation strategies*

The Township should re-convene the CVA committee or any other local flood management committee that includes a similar representation of multiple disciplines, e.g. municipal engineer, floodplain manager, planner, public works official, governing body representative, planning board representative, conservation planner, floodplain manager and emergency management official. This group should determine if there are data gaps or ambiguities in the CVA that need to be addressed to get a complete picture of vulnerability. For example, the community may want to field-verify certain sites or assets to determine if topography or adaptation measures may exacerbate or attenuate the projected flood impacts. If studies or plans are deemed necessary, the committee should identify who might take the lead. Also, the vulnerability and consequence ratings in this assessment should be compared with other current mitigation and planning documents to determine if there are any conflicts that should be addressed. Finally, the committee should determine which of the CVA recommendations will be implemented, if not all, and who should take the lead.

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<sup>4</sup> The term “adaptation” in this document refers to all measures to minimize flood risks, including “mitigation” projects and strategies, a term which is traditionally used by emergency managers and engineers.

### *Identify adaptation strategies*

Given that the CVA's purpose is to identify vulnerabilities, not pose solutions, the critical next step is to identify and evaluate potential solutions. Using this vulnerability assessment and other pertinent data and reports (e.g. the hazard mitigation plan, beach nourishment program, flood management reports) the first step is to identify the broadest range of possible solutions to reduce flood risks. Depending upon the magnitude of the vulnerabilities and consequences, the community may need to consult with coastal engineers outside of the community to fully realize this broad range of adaptation measures. DEP and other agencies and organizations may be available to provide workshops or host consultation meetings. This process of identifying adaptation strategies could take several months or more to fully understand the options available to the community.

The township should also determine whether a regional approach to an adaptation project is appropriate, and, if so, arrange for multi-jurisdictional meetings. The county or NJDEP Office of Coastal and Land Use Planning may be able to assist in scheduling or facilitating these meetings.

Once the broad list of adaptation options is created, the committee should select the most desirable projects and strategies to pursue, along with associated timeframes, funding options and project/task leads. This step might be preceded, or accompanied, by a cost-benefit analysis. Most adaptation projects will need to be reviewed by the NJ Department of Environmental Protection to ensure they meet permitting requirements. Projects that cannot be approved or funded at this time should be noted and discussed in future iterations of this process.

### *Engage the community*

Host community meetings to discuss and solicit feedback on the recommended adaptation strategies while also educating the participants about flood risk.

*Seek funding opportunities for adaptation planning and mitigation projects.* Below is a short list of potential grant programs:

- [NJ Department of Community Affairs \(DCA\) planning assistance grants](#)
- [NJDEP Office of Coastal and Land Use Planning](#)
- [NJDEP Office of Flood Hazard Risk Reduction Measures](#)
- [FEMA Hazard Mitigation grants](#)
- [FEMA Pre-Disaster Mitigation grants](#)
- [FEMA Flood Mitigation Assistance grants](#)
- [US Army Corps of Engineers](#)
- Other Federal grant programs – see the Appendix of the [NOAA Adaptation Guide](#)

### *Develop an implementation strategy*

Adaptation strategies should be integrated into the local hazards mitigation plan, capital improvement plan, master plan and ordinances to coordinate all related land use and adaptation policies and projects in the community. Key individuals and municipal departments should be assigned to lead and/or implement each of the adaptation strategies, along with proposed timeframes and funding options.

### *Schedule annual meetings*

Unfortunately, there may not currently be sufficient resources to address all of the community's identified vulnerabilities. Federal and state programs for coastal resiliency are still evolving, and grants, technical assistance, best practices and models, will inevitably become available. The committee should flag the issues for which solutions cannot be found and revisit them in the next adaptation planning process. Key staff should be charged with signing up for state and federal email lists that share grant and program information. The committee should continue to meet at least once a year, even after all current options for making progress have been exhausted, to consider if new programs or solutions have become available.



Appendix A - Greenwich Township Coastal Vulnerability Assessment Matrix

Asset Name	Asset Description	Asset Function	2050 Depth Projections (ft)		Exposure	Sensitivity	2050 Vulnerability Rating		Consequences	2050 Consequences Rating	
			Sea Level Rise	CAT1 Hurricane			Sea Level Rise	CAT1 Hurricane		Sea Level Rise	CAT1 Hurricane
Constant & Lydia Waithman House c. 1690-1700	Historic Structure	One of the oldest homes in Cumberland County.	NA	0-0.5	No impact from sea level rise. Building in the back of property may see minor inundation during a CAT1 event.	Historic structures in the area were built in the 18th-19th century and thus are not built to current construction codes that can withstand major storm events. Structure's utility infrastructure (electrical, water, and heating) is found in the basement, when flooded utility infrastructure is completely destroyed. Aesthetic materials found on the outside and inside of home are made of historic and original materials which are susceptible to damage.	NA	Low	Construction material that meets requirements of historic preservation code can be difficult and expensive to obtain in a timely manner. Moving utility infrastructure out of basements can be difficult under historic preservation code and modern construction code. However, the level of inundation above ground will likely be minimal.	NA	Low
John and Elizabeth Bacon House c. 1700-1730	Historic Structure	One of the oldest homes in Cumberland County.	NA	1-3.5	No impact from sea level rise. May see several feet of flooding during a CAT1 event.	Home-owners may be cut off and unable to leave home, basement in home may see water, from groundwater raising up. The structure is elevated 18th century. During storms septic or cess pools are being emptied.	NA	Low	Construction material that meets requirements of historic preservation code can be difficult and expensive to obtain in a timely manner. Moving utility infrastructure out of basements can be difficult under historic preservation code and modern construction code. Increasing renovation costs, scarcity of materials, and code requirements can cause homeowners to sell and/or walk away from the property. Loss or damage to historic residents can undermine the social and historic character of the township, reducing property values and property tax collections.	NA	Moderate
Hancock's Marina and Bait Box	Marina	Hancock's Marina is a private marina and boat storage yard, used by local residents and tourists who bring recreational watercraft to area. The Bait Box is a restaurant with the only liquor license in the township and may begin to be opened year round. The property brings in approximately \$50,000 in property taxes annually.	0-1.5	3-6	May see minor inundation throughout property during high tide due to sea level rise. May see major inundation during a CAT1 event.	Projected inundation during high tide could cause daily issues for access and use of the property and its current operational layout. A major storm event could severely damage and/or destroy structures and buildings on the property. Boats not removed or properly tied down could become a debris hazard. The Bait Box is raised (approximately 3-4 feet) above the ground level. The level of the structure may protect it from major damage, however the structure would still suffer some damage.	Moderate	High	Daily access issues will create operational and use issues for the marina and restaurant and may result in watercraft users going elsewhere. Substantial damage from a major storm event to marina and restaurant would result in possible bankruptcy of the commercial business. Improperly stored boats may cause debris hazards that can damage area properties and structures. Loss of the business would be a loss of a ratable for the township and would decimate the local tourism economy.	High	High
Greenwich Boat Works & Ship John	Marina	Greenwich Boat Works is a private marina and boat storage yard, used by local residents and tourists who bring recreational watercraft to area. The property includes numerous abandoned and decrepit boats around the property. Ship John is a closed-down restaurant in disrepair. The restaurant is not likely to reopen. The property brings in approximately \$45,000 in property taxes annually.	0-3	4-8	May see several feet of inundation throughout property during high tide due to sea level rise. May see major inundation during a CAT1 event.	Projected inundation during high tide could cause daily issues for access and use of the property and its current operational layout. A major storm event could severely damage and/or destroy structures and buildings on the property. Boats not removed or properly tied down could become a debris hazard.	Moderate	High	Daily access issues will create operational and use issues for the marina and restaurant and may result in watercraft users going elsewhere. Substantial damage from a major storm event to marina would result in possible bankruptcy of the commercial business. Improperly stored boats may cause debris hazards that can damage area properties and structures. Loss of the business would be a loss of a ratable for the township and would decimate the local tourism economy.	High	High
Pier House	Historic Structure	One of the oldest structures in Cumberland County.	NA	0-0.5	No impact from sea level rise. May see upwards of half a foot of inundation surrounding the structure.	Historic structures in the area were built in the 18th-19th century and thus are not built to current construction codes that can withstand major storm events. Structure's utility infrastructure (electrical, water, and heating) is found in the basement, when flooded utility infrastructure is completely destroyed. Aesthetic materials found on the outside and inside of home are made of historic and original materials which are susceptible to damage.	NA	Low	Construction material that meets requirements of historic preservation code can be difficult and expensive to obtain in a timely manner. Moving utility infrastructure out of basements can be difficult under historic preservation code and modern construction code. However, the level of inundation above ground will likely be minimal.	NA	Low

Asset Name	Asset Description	Asset Function	2050 Depth Projections (ft)		Exposure	Sensitivity	2050 Vulnerability Rating		Consequences	2050 Consequences Rating	
			Sea Level Rise	CAT1 Hurricane			Sea Level Rise	CAT1 Hurricane		Sea Level Rise	CAT1 Hurricane
Bacon's Neck School	Historic Structure	One of the oldest structures in Cumberland County.	NA	0-3	May see inundation on edges of property along wetlands during high tide due to sea level rise. May see several feet of inundation during a CAT1 event.	(see Constant Lydia Waithman House)	NA	High	Substantial damage could occur from hurricane storm surge. Loss or damage to historic residents can undermine the social and historic character of the township, reducing property values and property tax collections.	NA	High
Bridgeton Road (County Road 607)	State Designated Evacuation Route	Bridgeton Road is the only designated evacuation route out of Greenwich during an emergency. Although, there are other local routes out of the community. Part of Bridgeton Road consists of a land bridge across the the impoundment of the confluence of Wheaton Run, Mill Run and Mounce Creek, and wetlands, water passing under the road via one culvert.	0-1.5	0-7	May see minor inundation during high tide due to sea level rise. May see major inundation during a CAT1 event.	Access route may be cut off daily during high tide. Increasing high tides may contribute to erosion along the land bridge. During a storm event the route would be entirely cut off for access out and emergency services coming into the township.	Low	High	Bridgeton Road flooded and may be cut off access however, there are other smaller local roads that will still be accessible for travel in and out of the township. Continued erosion of the land bridge will require increasing maintenance, repairs, and possiblerequire the road to be elevate. The cost of maintenance and elevation will be expensive.	Low	Moderate
Bridgeton Dike	Man-Made Dike	The dike was constructed to help keep floodwater and tidal water from the wetlands out of the drained farmland. The dike also helps to protect additional developed areas from flood waters.	0-3	1-7	May see several feet of inundation during high tide due to sea level rise. May see major inundation during a CAT1 event.	Increasing high tides in the future will contribute to erosion of the dike structure. Major storm events will increase erosion and major damage to the dike structure. Past events and surge have cut deep gouges into the dike, which have come close to breaching. Local residents often go out onto the dike prior to major storm events to sandbag and reinforce weak points on the dike to keep it from failing.	Moderate	High	Erosion of the dike will require increasing maintenance and repair costs, and if not properly maintained the dike will eventually fail especially during a major storm event. A dike failure will result in the possible permanent inundation of Bridgeton Road, homes, structures, and large areas of farmland just north of the dike.	High	High
Wetlands Complex	Wetlands Complex	The township has a significant amount of wetlands that buffer the community from the Delaware Bay and the Cohansey River.	0.5-3	0-8	May see several feet of inundation during high tide due to sea level rise. May see major inundation during a CAT1 event.	Without a more detailed study it is difficult to predict whether the wetlands and marshes will be able to survive the saltwater intrusions from sea level rise and hurricane storm surge.	High	High	Due to the extreme importance of the wetlands (and marshes) as a flood mitigation measure, any loss could mean serious flooding throughout the community and a grave consequence.	High	High
Market Lane (County)	County Road & Dike	Market Lane is a local County road. A low-lying dike/land bridge runs across a multiple streams and associated wetlands. The dike includes a culvert with back flow prevention stop tidal waters from flowing upstream of Market Lane, which helps protect properties and structures.	0-2.5	4.5-8	May see couple feet of inundation during high tide due to sea level rise. May see major inundation during a CAT1 event.	Increasing high tides in the future will contribute to erosion of the dike structure. Major storm events will increase erosion and major damage to the dike/land bridge structure, which could result in a failure of the structure. A storm event would likely overwhelm the roadway and allow further flooding north of the road.	Moderate	High	Erosion of the dike will require increasing maintenance and repair costs, and if not properly maintained the dike will eventually fail especially during a major storm event. A dike failure will result in the possible permanent inundation of homes, structures, and large areas of farmland just north of the dike. A failure of the Market Lane road will put additional pressure on other roads and dikes north of the roadway. The loss of the road may limit access in the surrounding area for residents and emergency services.	High	High
Bacons Neck Road	County Road & Dike	Bacons Neck Road is a local County road. A low-lying dike/land bridge runs across the intersection of Pine Mount creek and a tributary and associated wetlands. The dike includes one culvert with back flow prevention structure to help prevent tidal flow north of Bacons Neck Road from high tide and storm events, which helps protect farm lands.	0-5	1-10	May see several feet of inundation during high tide due to sea level rise. May see major inundation during a CAT1 event.	Increasing high tides in the future will contribute to erosion of the dike structure. Major storm events will increase erosion and major damage to the dike/land bridge structure, which could result in a failure of the structure. A storm event would likely overwhelm the roadway and allow further flooding north of the road.	Moderate	High	Erosion of the dike will require increasing maintenance and repair costs, and if not properly maintained the dike will eventually fail especially during a major storm event. A dike failure will result in the possible permanent inundation of large areas of farmland, a few homes and other structures, north of the dike. The loss of the road may limit access in the surrounding area for residents and emergency services.	High	High

Asset Name	Asset Description	Asset Function	2050 Depth Projections (ft)		Exposure	Sensitivity	2050 Vulnerability Rating		Consequences	2050 Consequences Rating	
			Sea Level Rise	CAT1 Hurricane			Sea Level Rise	CAT1 Hurricane		Sea Level Rise	CAT1 Hurricane
Ye Greate Street Residents	Residential Area	The largest concentration of residential homes in Greenwich are along Ye Greate Street, the main street of the township. The entirety of Ye Great Street is within a National Historic District, with several homes and other structures also being designated historic structures. The homes rely on septic systems as no sewer service is currently available to Greenwich.	NA	NA	No direct impact from sea level rise. No direct impact during a CAT1 event.	The scenarios, sea level rise and CAT1 Hurricane, used in this assessment do not show inundation to any of the homes along Ye Greate Street. However, Greenwich has an issue with high groundwater levels which cause issues for stormwater drainage off of Ye Greate Street. Residents in the area already experience basement flooding and septic system failures during minor storm events. The flooding issues require homes to employ sub-pumps and frequent cleanouts of septic systems during storm events. Most resident's electrical, water, and heating systems are located in the basement. Sea level rise and major storm events will increase the flooding issues in the area.	Moderate	High	Frequent flooding in basements can cause major structural and utility issues for residents. As the majority of the homes are historic, relocating utilities above flood elevations can be difficult, especially with complying with historic zoning and building codes. Increasing flooding and failure of septic systems require ever increasing costs to home owners. Increased flooding and associated issues can force home owners to sell and/or walk away from the property.	High	High
Ye Greate Street	Main Street & Local Evacuation Route	Ye Greate Street is the main street in Greenwich, and along which the largest concentration of residents live. The street includes stormwater infrastructure (stormdrains, culverts and outlets) used to drain water from the street and back into the wetlands to southwest of the street to reduce flooding on the street and residential homes.	NA	NA	No direct impact from sea level rise. No direct impact during a CAT1 event.	The scenarios, sea level rise and CAT1 Hurricane, used in this assessment do not show inundation on Ye Greate Street. However, Greenwich has an issue with high groundwater levels which cause issues for stormwater drainage off of Ye Greate Street. The stormwater infrastructure along Ye Greate Street does not include back flow prevention. When minor or major storm events occur, in combination with high ground water levels, the systems frequently back up, flooding the street.	Low	High	Frequent flooding on the road ways can create problems for general access and evacuation for local residents, as well as emergency access for health and safety. Flooding on the roadway will also increase flooding issues in the basements of homes located along Ye Greate Street.	Low	High

## Appendix B – Vulnerability Rating Key

<b>Vulnerability Rating Key</b>	
<b>Level</b>	<b>Vulnerability Rating Given Hazard Exposure and Sensitivity</b>
Insignificant	<p><i>Exposure to Flooding:</i> This community asset is located out of harm’s way.</p> <p><i>Physical/Structural Damage:</i> No physical/structural damages expected.</p> <p><i>Disruption/Impairment:</i> No disruption in function, accessibility, or development and delivery of basic services and supplies. No apparent impacts to services provided by, typical operations, routine or daily life.</p> <p><i>Accessibility:</i> Key staff able to access facilities or locations without interruption.</p>
Low	<p><i>Exposure to Flooding:</i> The majority of this community asset is located out of harm’s way.</p> <p><i>Physical/Structural Damage:</i> Minor physical/structural damages expected.</p> <p><i>Disruption/Impairment:</i> Limited disruption in function, accessibility, or development and delivery of basic services and supplies. Limited impacts to typical operations, routine or daily life, if any.</p> <p><i>Accessibility:</i> Key staff able to access facilities or locations with minimal interruption.</p>
Moderate	<p><i>Exposure to Flooding:</i> A significant portion of this community asset is located in harm’s way.</p> <p><i>Physical/Structural Damage:</i> Moderate physical/structural damages sustained.</p> <p><i>Disruption/Impairment:</i> Moderate level of disruption to accessibility or mobility of asset, amenity or population. Moderate level of interruptions to development and delivery of basic services and supplies. Typical operations, routine or daily life moderately affected by flood hazard scenario.</p> <p><i>Accessibility:</i> Secondary evacuation and access routes available for use if/when primary systems fail.</p>
High	<p><i>Exposure to Flooding:</i> The majority of this community asset is located in harm’s way.</p> <p><i>Physical/Structural Damage:</i> Severe level of harm (destruction on property or degradation of function and/or injury) is expected, resulting in a high degree of loss. Asset, amenity or population is unable to withstand flood impacts.</p> <p><i>Disruption/Impairment:</i> Severe, potentially irreparable challenges faced requiring significant changes to asset functioning, community’s daily life or "new normal." Production, provision of services or daily routine expected to sustain a high degree of disruption. Significantly reduced operational capacity of community assets and amenities; long term or permanent relocation of asset, amenity or population.</p> <p><i>Accessibility:</i> Severe disruptions to the accessibility of asset, amenity or population or the disruption of this assets causes accessibility issues to other community assets. Key individuals, material supplies, core operating systems and functioning interrupted or unavailable.</p>

## Appendix C – Consequences Rating Key

<b>Consequences Rating Key</b>	
Level	Given Vulnerability of Assets, Rate the Magnitude or Severity of Consequences
1	<p style="margin: 0;"><i>Property Damages:</i> Only minor property damage.</p> <p style="margin: 0;"><i>Typical Operations/Daily Life:</i> No impacts or disruptions to typical operations, routine or daily life.</p> <p style="margin: 0;"><i>Environment:</i> No lasting environmental degradation.</p> <p style="margin: 0;"><i>Emergency Response:</i> No adverse effects on emergency response.</p> <p style="margin: 0;"><i>Hazardous Materials:</i> No increase or change in community/ecosystem exposure to toxics or hazardous materials.</p> <p style="margin: 0;"><i>Municipal Budget:</i> Negligible operational costs.</p>
2	<p style="margin: 0;"><i>Property Damages:</i> Limited property in narrow affected area damaged or destroyed.</p> <p style="margin: 0;"><i>Typical Operations/Daily Life:</i> Limited disruption to typical operations, routine or daily life.</p> <p style="margin: 0;"><i>Environment:</i> Minor damage or loss to habitat and species or functioning of the systems as a component of “coastal green infrastructure” of the community. Small loss of natural resource base. Increased, but tolerable stress on ecosystem.</p> <p style="margin: 0;"><i>Emergency Response:</i> Slight decrease in emergency response times and effectiveness</p> <p style="margin: 0;"><i>Hazardous Materials:</i> Limited hazardous materials spill, manageable clean-up and remediation.</p> <p style="margin: 0;"><i>Municipal Budget:</i> Additional but tolerable operational costs.</p>
3	<p style="margin: 0;"><i>Property Damages:</i> Substantial property in affected area damaged or destroyed.</p> <p style="margin: 0;"><i>Population Displacement:</i> Long-term population displacement over a broader segment of the population.</p> <p style="margin: 0;"><i>Typical Operations/Daily Life:</i> Daily life is affected such that only redundant systems can be used for an extended duration.</p> <p style="margin: 0;"><i>Environment:</i> Major damage or loss of habitat or functioning of the systems as a component of “coastal green infrastructure” of the community that may be permanent with adverse impacts.</p> <p style="margin: 0;"><i>Emergency Response:</i> Emergency response is strained resulting in significant degradation of response effectiveness and times.</p> <p style="margin: 0;"><i>Hazardous Materials:</i> Large hazardous material spill with significant risk to humans and ecosystems.</p> <p style="margin: 0;"><i>Municipal Budget:</i> High operational costs straining local budgets</p>
4	<p style="margin: 0;"><i>Property Damages:</i> Majority of property in affected area damaged or destroyed</p> <p style="margin: 0;"><i>Population Displacement:</i> Permanent and widespread population displacement.</p> <p style="margin: 0;"><i>Delivery of Services:</i> Long-term interruption of supply and services.</p> <p style="margin: 0;"><i>Typical Operations/Daily Life:</i> Majority of community operations, daily life patterns intensely impacted for an extended period.</p> <p style="margin: 0;"><i>Environment:</i> Permanent degradation of habitat or functioning of the systems as a component of “coastal green infrastructure” of the community.</p> <p style="margin: 0;"><i>Emergency Response:</i> Need for emergency services exceeds full capacity and/or services are degraded and not functioning.</p> <p style="margin: 0;"><i>Hazardous Materials:</i> Hazardous material spill that requires multi-year clean-up and poses significant health or ecosystem risk.</p>

## Appendix D – Municipal CVA Committee

### Municipal CVA Committee

Greenwich convened a diverse group of municipal representatives and community leaders to participate in the CVA process facilitated by Sustainable Jersey. The meetings were held on April 21, 2016 and December 11<sup>th</sup>, 2015 at the Greenwich Township Hall. The meeting attendees are shown below.

Participant	Title	Affiliation
Mark Werley	Township Committeeman	Township of Greenwich
Michael Ivanick	Planning Board Vice-Chair	Township of Greenwich
Penny Watson	Planning Board Chair	Township of Greenwich
Michael Henry	Planning Board member	Township of Greenwich
Mark Showers	Environmental Commission member	Township of Greenwich
Richard E. Domduco	Environmental Commission member	Township of Greenwich
Rick Brown	Planner	NJ Department of Environmental Protection
Jack Heide	Resiliency Manager	Sustainable Jersey

## Appendix E – Greenwich Coastal Vulnerability Assessment Maps

### Table of Maps

- Map 1. Township of Greenwich Community Assets
- Map 2. Township of Greenwich (North) Community Assets
- Map 3. Township of Greenwich (South) Community Assets
- Map 4. Township of Greenwich (North) 2050 Sea Level Rise
- Map 5. Township of Greenwich (South) 2050 Sea Level Rise
- Map 6. Township of Greenwich (North) 2050 CAT1 Hurricane
- Map 7. Township of Greenwich (South) 2050 CAT1 Hurricane





Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

# Greenwich Coastal Vulnerability Assessment 2050 Sea Level Rise

- Municipal Boundary
- Local Roads
- Evacuation Route

**Asset Categories**

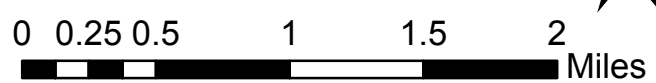
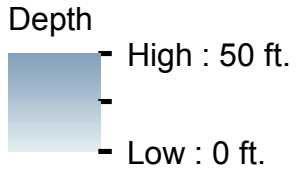
- Asset\_Cate**
- Community Resources & Amenities
  - Critical Facilities & Infrastructure Systems

**Community Assets**

**Number, Name**

- |  |  |   |
|--|--|---|
| 1, Aunt Betty's Kitchen & U.S. Post Office | 12, Dr. Thomas Ewing House                     | 32, Old Stone School                      |
| 2, Bacon's Adventure                       | 13, Edward & Hannah Harding House              | 33, Old Stone Tavern                      |
| 3, Bacon's Neck School                     | 14, Fire Hall                                  | 34, Pier House                            |
| 4, Bacon Sheppard Hancock House            | 15, Gabriel Davis House                        | 35, Pirate House                          |
| 5, Baptist Church                          | 16, Gibbon House                               | 36, Prehistoric Museum                    |
| 6, Benjamin & Rachel Reeve House           | 17, Gibbon Tenant House (White House Farm)     | 37, Presbyterian Church                   |
| 7, Bethel AME Church                       | 18, Greenwich Boat Works & Ship John           | 38, Reeve Sheppard House                  |
| 8, Buttonwood Farm                         | 19, Greenwich Landing Service Building         | 39, Sheppard's Mill Manor                 |
| 9, Constant & Lydia Waitman House          | 20, Haggerty House                             | 40, Sheppard's Mill Manor                 |
| 10, Darke-Ward House                       | 21, Hancock's Marina & Bait Box                | 41, Sheppard Tenant House                 |
| 11, Dixon Sheppard House                   | 22, John & Bethsheba Brick House               | 42, Swedish Granary                       |
|  | 23, John & Elizabeth Bacon House               | 43, Teaburner Farm                        |
|  | 24, Joseph Dennis House (Silk House)           | 44, Thomas & Mary Maskell House           |
|  | 25, Lecture Room (John DuBois Maritime Museum) | 45, Thomas Brown House (Bull's Eye House) |
|  | 26, Lewis & Mary Mulford House                 | 46, Township Hall & EOC                   |
|  | 27, Lower Friends Meeting House                | 47, Upper Friends Meeting House           |
|  | 28, Lummis Genealogical Library                | 48, William & Elizabeth Stewart House     |
|  | 29, Maskell Store                              | 49, William Watson's Tavern               |
|  | 30, Morris Goodwin Elementary School           | 50, Wood's Store                          |
|  | 31, Noah's Arcade                              | 51, Wood Mansion                          |

**2050 Sea Level Rise**



Prepared by Sustainable Jersey for the  
Township of Greenwich, August 2016





Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

# Greenwich Coastal Vulnerability Assessment 2050 CAT1 Hurricane

- Municipal Boundary
- Local Roads
- Evacuation Route

**Asset Categories**

- Asset\_Cate**
- Community Resources & Amenities
  - Critical Facilities & Infrastructure Systems

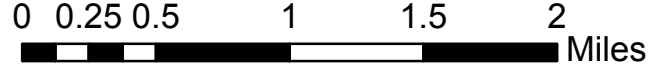
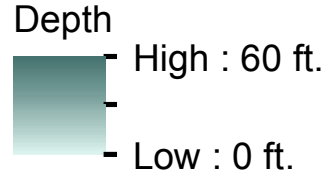
**Community Assets**

- Number, Name**
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  - 2, Bacon's Adventure
  - 3, Bacon's Neck School
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- 50, Wood's Store
- 51, Wood Mansion

**2050 CAT1 Hurricane**



Prepared by Sustainable Jersey for the Township of Greenwich, August 2016





Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

# Greenwich Coastal Vulnerability Assessment

## Community Assets

- Municipal Boundary
- Local Roads
- Evacuation Route

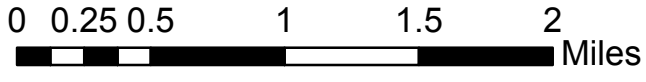
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Prepared by Sustainable Jersey for the Township of Greenwich, August 2016





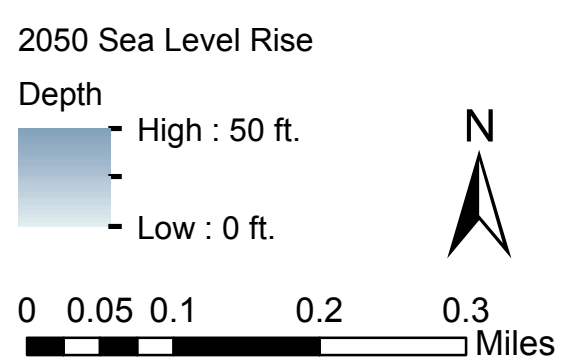
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

# Greenwich (Ye Greate) Coastal Vulnerability Assessment 2050 Sea Level Rise

- Municipal Boundary
- Local Roads
- Evacuation Route
- Asset Categories**
- Asset\_Cate**
- Community Resources & Amenities
- Critical Facilities & Infrastructure Systems
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Prepared by Sustainable Jersey for the  
Township of Greenwich, August 2016





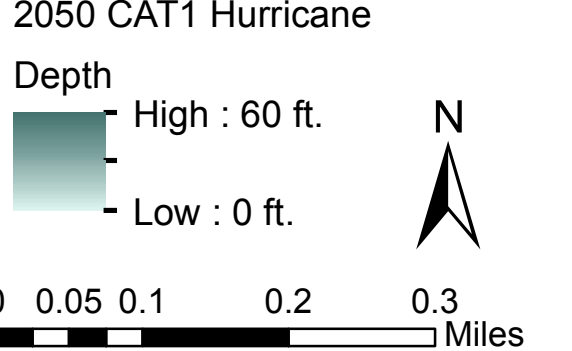
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

# Greenwich (Ye Greate) Coastal Vulnerability Assessment 2050 CAT1 Hurricane

- Municipal Boundary
- Local Roads
- Evacuation Route
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- Critical Facilities & Infrastructure Systems
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Prepared by Sustainable Jersey for the Township of Greenwich, August 2016





Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

# Greenwich (Ye Greate) Coastal Vulnerability Assessment

## Community Assets

- Municipal Boundary
- Local Roads
- Evacuation Route

### Asset Categories

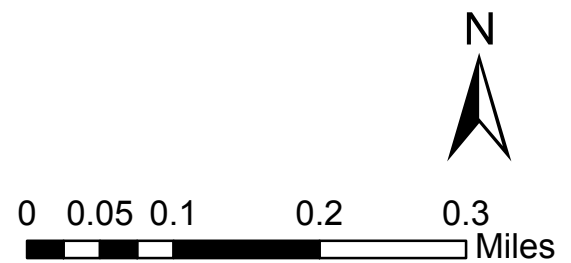
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- 21, Hancock's Marina & Bait Box
- 22, John & Bethsheba Brick House
- 23, John & Elizabeth Bacon House
- 24, Joseph Dennis House (Silk House)
- 25, Lecture Room (John DuBois Maritime Museum)
- 26, Lewis & Mary Mulford House
- 27, Lower Friends Meeting House
- 28, Lummis Genealogical Library
- 29, Maskell Store
- 30, Morris Goodwin Elementary School
- 31, Noah's Arcade

- 32, Old Stone School
- 33, Old Stone Tavern
- 34, Pier House
- 35, Pirate House
- 36, Prehistoric Museum
- 37, Presbyterian Church
- 38, Reeve Sheppard House
- 39, Sheppard's Mill Manor
- 40, Sheppard's Mill Manor
- 41, Sheppard Tenant House
- 42, Swedish Granary
- 43, Teaburner Farm
- 44, Thomas & Mary Maskell House
- 45, Thomas Brown House (Bull's Eye House)
- 46, Township Hall & EOC
- 47, Upper Friends Meeting House
- 48, William & Elizabeth Stewart House
- 49, William Watson's Tavern
- 50, Wood's Store
- 51, Wood Mansion



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