Town of Guilford
Community Coastal Resilience Plan
Report of Options to Increase Coastal Resilience

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Prepared for

Town of Guilford
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In Association with

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Executive Summary

Utilizing The Nature Conservancy's web-based Coastal Resilience Tool, the Town of Guilford is undertaking The Nature Conservancy's Coastal Resilience Program. Coastal resilience is the ability to resist, absorb, recover from, or adapt to coastal hazards such as sea level rise, increased flooding, and more frequent and intense storm surges. The goal of the Coastal Resilience Program is to address the current and future social, economic and ecological resilience of the Town of Guilford to the impacts of sea level rise and anticipated increases in the frequency and severity of storm surge, coastal flooding, and erosion. The four basic steps of the Coastal Resilience Program are:

1. Generate awareness of coastal risk (already underway and largely complete);
2. Assess coastal risks and opportunities (complete);
3. Identify options or choices for addressing priority risks and vulnerabilities (current effort); and
4. Develop and implement an action plan to put selected options or choices into place (future effort).

The Town has drafted the subject report of options for increased coastal resilience as a step toward developing a Community Coastal Resilience Plan. This report has been funded through a grant from NOAA as part of the New England Municipal Resilience Initiative.

In the context of hazards, risk is the product or the sum of vulnerability and frequency. In the context of coastal hazards, risk will change over time because the frequency will increase. Coastal storms are believed to be increasing in frequency, and flooding will increase in frequency as sea level rises. Thus, even if coastal vulnerabilities in Guilford remain static, risks will increase. Therefore, Guilford is at a crossroads with regard to reducing risk. Vulnerabilities can remain static and risk can increase, or vulnerabilities can be reduced through adaptation to hold risk at bay. If vulnerabilities can be reduced even further, than risks could be lowered in the face of rising sea level and increased coastal storms, leading to increased resilience.

Many coastal resilience and adaptation strategies, measures, and actions have been described in the climate change literature since the late 1980s. Two decades ago, the primary options for adaptation that were considered viable were *protection, retreat*, and *accommodation*. However, we now understand that accommodation is rarely sustainable in the long term, and that protection and retreat are overly simplified terms that do not allow for the many strategies, measures, and actions currently available to communities. These strategies, measures, and actions have evolved over time and can typically be grouped into a number of broad categories that are separated by type of vulnerability addressed or proposed method of implementation.

The town of Guilford has organized its preferred adaptation strategies into four categories that are appropriate for the geography, population, and infrastructure found in Guilford. The four categories and their sub-categories are listed in the following table.

Options for Coastal Resilience in Guilford

Categories of Options	Possible Options
Management of coastal real estate and structures	Building codes (freeboard, V zone standards in A zones)
	Acquisition of damaged properties
	Zoning overlays
	Zoning amendments
	Coastal realignments through any of the above
Shoreline protection and management of coastal and near-shore lands	Hard shoreline protection
	Living shorelines
	Buffers for flood protection
	Land acquisition for tidal marsh migration
	Land conservation for tidal marsh migration
Roadway alterations	Elevation of roadways
	Abandonment of roads
	Re-evaluation of emergency routes
	Alternate egress
Protection or replacement of water supply wells and septic systems	On-site retrofits of septic systems
	Community wastewater systems
	Extension of sewer system
	Individual water treatment systems
	Community water systems
	Extension of water mains
	Vacate properties

Guilford's coastal neighborhoods are diverse and it is likely that each will be faced with a combination of vulnerabilities to sea level rise and the increased incidence and severity of coastal storms. A combination of adaptation measures will therefore be necessary in each neighborhood in order to reduce risks and increase resilience. Likewise, neighborhood-scale resilience planning will likely be important in Guilford. When this planning occurs, neighborhoods will be urged to evaluate individual adaptation measures and determine how comprehensive solutions can be developed and implemented for building coastal resilience.

1.0 INTRODUCTION

1.1 Review of Previous Efforts

Utilizing The Nature Conservancy's web-based Coastal Resilience Tool, the Town of Guilford is undertaking The Nature Conservancy's Coastal Resilience Program. Coastal resilience is the ability to resist, absorb, recover from, or adapt to coastal hazards such as sea level rise, increased flooding, and more frequent and intense storm surges. The goal of the Coastal Resilience Program is to address the current and future social, economic and ecological resilience of the Town of Guilford to the impacts of sea level rise and anticipated increases in the frequency and severity of storm surge, coastal flooding, and erosion.

In the context of hazards, risk is the product or the sum of vulnerability and frequency. In the context of coastal hazards, risk will change over time because the frequency will increase. Coastal storms are believed to be increasing in frequency, and flooding will increase in frequency as sea level rises. Thus, even if coastal vulnerabilities in Guilford remain static, risks will increase. Therefore, Guilford is at a crossroads with regard to reducing risk. Vulnerabilities can remain static and risk can increase, or vulnerabilities can be reduced to hold risk at bay. If vulnerabilities can be reduced even further, than risks could be lowered in the face of rising sea level and increased coastal storms, leading to increased resilience.

The four basic steps of the "Coastal Resilience Program" are:

1. **Generate awareness of coastal risk (already underway and largely complete);**
2. **Assess coastal risks and opportunities (complete);**
3. **Identify choices for addressing priority risks and vulnerabilities (current effort); and**
4. **Develop and implement an action plan to put selected choices into place (future effort).**

A risk and vulnerability report was completed in September 2012. Guilford faces several major categories of vulnerabilities to coastal hazards. The categories and some of the included vulnerabilities are as follows:

- Social – Residents, business community, and visitors.
- Economic – Residential Properties, commercial/industrial businesses, municipal resources, tourism, and future development.
- Infrastructure – Roads, bridges, railroads, stormwater, seawalls, tide gates, the marina, and municipal facilities.
- Utilities – Public and private water supplies, septic systems, telecommunications, and electricity.
- Emergency Services – Fire, police, medical, sheltering, evacuation/egress.
- Natural Systems – Tidal wetlands and other coastal landforms.

The relative importance of these vulnerabilities varies by location. Some of the notable geographic vulnerabilities are listed below:

- Branford Town Line to Island Bay – Old Quarry is already grappling with increased inundation of the main access to some 40 homes (Old Quarry Road). Sections of Route 146 are threatened.
- Island Bay to Trolley Road – Shell Beach Road and residential structures along the road are vulnerable to storm surges as well as future daily inundation. Homes located on Leetes Island are at risk of isolation. Marsh advancement is critical but may be challenging at the peripheries of Leetes Marsh, Great Harbor, and Lost Lake.
- Trolley Road to Vineyard Point – Some homes in the Trolley Road, Sachems Head, and Vineyard Point areas are vulnerable to inundation and storm surge.
- Vineyard Point to Tuttles Point – Indian Cove is increasingly vulnerable to a loss of egress at two key locations, and Tuttles Point Road is increasingly vulnerable to storm surges as well as future daily inundation.
- Tuttles Point to Guilford Point – Like Old Quarry Road, Chaffinch Island Road is already suffering from frequent flooding. Important facilities such as Brown's Boat Yard, Guilford Boat Yard, and the Guilford Yacht Club are vulnerable to inundation and storm surge.
- Guilford Point to Madison Town Line – Jacob's Beach is vulnerable to erosion whereas homes along Seaside Avenue are vulnerable to inundation and storm surges. The Town marina and the state's East River Boat Launch are critical facilities that are highly vulnerable given their waterfront locations.
- Guilford Center and Town Center South – Several important economic areas are vulnerable such as commercial plazas along the Boston Post Road, the Soundview Road commercial/industrial area, and the Whitfield Street corridor.
- Upper East River – Although land is vulnerable to flooding, the East River estuary is a key area of interest for identifying future zones for marsh migration.

1.2 Evolution of Options for Coastal Resilience

The Intergovernmental Panel On Climate Change (IPCC) published the landmark paper "Strategies for Adaptation to Sea Level Rise" in 1990. The preface states that "This report represents the first survey on a global scale of adaptive options for coastal areas in response to a possible acceleration of sea level rise and the implications of these options." This was one of the earliest reports to list the three traditional categories of adaptation "to protect human life and Property." Three basic types of adaptation were presented in the report. The following descriptions of these three types of adaptation are taken from the report:

- Retreat involves no effort to protect the land from the sea. The coastal zone is abandoned and ecosystems shift landward. This choice can be motivated by excessive economic or environmental impacts of protection. In the extreme case, an entire area may be abandoned.

- Accommodation implies that people continue to use the land at risk but do not attempt to prevent the land from being flooded. This option includes erecting emergency flood shelters, elevating buildings on piles, converting agriculture to fish farming, or growing flood or salt tolerant crops.

- Protection involves hard structures such as sea walls and dikes, as well as soft solutions such as dunes and vegetation, to protect the land from the sea so that existing land uses can continue.

Before the publication of the IPCC paper, James Titus with the U.S. EPA began authoring and co-authoring a series of papers about adapting to sea level rise and coastal hazards. The following is a list of some of the papers by Titus and his colleagues:

- Planning for sea level rise before and after coastal disaster (1984).
- Greenhouse effect, sea level rise, and coastal zone management (1986).
- Greenhouse effect, sea level rise, and coastal drainage system (1987)
- Greenhouse effect, sea level rise, and coastal wetlands (1988)
- An overview of studies estimating the nationwide cost of holding back the sea (1989)
- An overview of the Nationwide Impacts of Sea Level Rise (1989)
- Greenhouse effect, sea level rise, and barrier islands: Case study of Long Beach Island, New Jersey (1990)
- Greenhouse effect, sea level rise, and wetland policy: How Americans could abandon an area the size of Massachusetts at minimum cost (1991)
- Greenhouse Effect and Sea Level Rise: The Cost of Holding Back the Sea (1991)
- Rising Seas, Coastal Erosion, and the Takings Clause: How to Save Wetlands and Beaches Without Hurting Property Owners (1998)

"Mitigation" vs. "Adaptation"

In the context of climate change science, "mitigation" refers to efforts to decrease greenhouse gas emissions whereas "adaptation" refers to efforts to adapt to the effects of climate change. However, in the context of disaster resilience, "mitigation" refers to long-term efforts to reduce the effects of disasters. Thus, elements of a community's hazard mitigation plan may be similar to elements of a community's climate adaptation plan.

Many of these papers discussed possible options that fell into the three traditional categories of adaptation. Some of the papers focused on specific vulnerabilities such as drainage systems and wetlands, while some developed cost estimates for taking action or not taking action.

In 2002, a summary of transportation-related discussions was published in the report "The Potential Impacts of Climate Change on Transportation." The report discussed the particular vulnerabilities associated with roads, airports, and other transportation systems and networks.

Adaptation methods such as elevating roads, protecting systems with dikes, and retreat were discussed.

The report "Bracing for Climate Change in the Constitution State" was published by Environmental Defense in 2004. This report included a brief section on adaptation. Hard solutions, soft solutions, and retreat were mentioned but not explored in depth. The report noted that the time was ripe for developing specific methods of adaptation in Connecticut.

In 2010, NOAA's Office of Ocean and Coastal Resource Management published the manual "Adapting to Climate Change: A Planning Guide for State Coastal Managers." Chapter 5 is dedicated to a discussion of adaptation strategies and methods. According to the manual, NOAA's seven categories of "Climate Change Adaptation Measures" and their sub-categories are:

Impact Identification and Assessment

- Research and Data Collection – Predict possible social and economic effects of climate change on communities. Calculate cost-to-benefit ratios of possible adaptation measures. Encourage adaptation plans that are tailored to specific industries.
- Monitoring – A comprehensive monitoring program that incorporates multiple tools and considers a variety of systems and processes can provide input to the vulnerability assessment and adaptation strategy.
- Modeling and Mapping – Map which areas are more or less susceptible to sea level rise in order to prioritize management efforts.

Awareness and Assistance

- Outreach and Education – Create scientific fact sheets about climate change addressing community members, visitors, elected officials, businesses and industries. Use multiple forms of communication such as news media, radio, brochures, community meetings, social networks, blogs and websites.
- Real Estate Disclosure – The disclosure of a property's vulnerability to coastal hazards enables potential buyers to make informed decisions reflecting the level of impacts they are willing and able to accept.
- Financial and Technical Assistance – Provide flood insurance discounts for properties that exceed floodproofing standards by one or two feet. Encourage hazard mitigation by providing grants to areas that implement adaptation measures.

Growth and Development Management

- Zoning – Zoning can be used to regulate parcel use, density of development, building dimensions, setbacks, type of construction, shore protection structures, landscaping, etc. It can also be used to regulate where development can and cannot take place, making it an invaluable tool in efforts to protect natural resources and environmentally sensitive areas and guide development away from hazard-prone areas.

- Redevelopment Restrictions – Combining restrictions with acquisition/demolition/relocation programs provides safer options to property owners in the wake of the loss of or damage to their homes or businesses.
- Conservation Easements – A conservation easement is a legal agreement between a landowner and a land trust or government agency that can be used to restrict development in sensitive and hazard-prone areas.
- Compact Community Design – The high density development suggested by compact community design can allow for more opportunities to guide development away from sensitive and hazard-prone areas.

Loss Reduction

- Acquisition, Demolition, and Relocation – The most effective way to reduce losses is to acquire hazard-prone properties, both land and structures, demolish or relocate structures, and restrict all future development on the land.
- Setbacks – Setbacks can protect structures from hazards by keeping the structures away from a property's most vulnerable areas.
- Building Codes – Building codes that regulate design, construction, and landscaping of new structures can improve the ability of structures in hazard-prone areas to withstand hazard events.
- Retrofitting – Existing structures can be protected from hazards through retrofitting.
- Infrastructure Protection – Infrastructure protection entails fortification against the impacts of climate change.
- Shore Protection Structures – Shore protection structures protect existing development allowing it to stay in place. They often damage or destroy other valuable coastal resources and create a false sense of security; nevertheless in some cases, for the purposes of protecting existing development, there may be no other acceptable or practical options.

Shoreline Management

- Regulation and Removal of Shore Protection Structures – To protect the natural shoreline and the benefits it provides, regulations can be used to limit shoreline hardening as well as promote alternative forms of protection.
- Rolling Easements – Rolling easements are shoreline easements designed to promote the natural migration of shorelines. Typically, rolling easements prohibit shore protection structures which interfere with natural shoreline processes and movement, but allow other types of development and activities. As the sea rises, the easement moves or "rolls" landward, wetland migration occurs, and public access to the shore is preserved.
- Living Shorelines – Living shorelines can be effective alternatives to shore protection structures in efforts to restore, protect, and enhance the natural shoreline and its environment. Living shorelines use stabilization techniques that rely on vegetative plantings, organic materials, and sand fill or a hybrid approach combining vegetative plantings with low rock sills or living breakwaters to keep sediment in place or reduce wave energy.

- Beach Nourishment – Beach nourishment is the process of placing sand on an eroding beach, typically making it higher and wider, to provide a buffer against wave action and flooding.
- Dune Management – Dunes may be restored or created in conjunction with a beach nourishment project or may be managed as part of a separate effort.
- Sediment Management – Dredging and placing sediment, building shore protection structures and other structures that trap or divert sediment.

Coastal Ecosystem Management

- Ecological Buffer Zones – Ecological buffers are similar to setbacks (and may be included within setbacks) but are typically designed to protect the natural environment by providing a transition zone between a resource and human activities.
- Open Space Preservation and Conservation – Open space preservation and conservation can be accomplished through the management of lands dedicated as open space through a number of the measures previously discussed, such as zoning, redevelopment restrictions, acquisition, easements, setbacks, and buffers.
- Ecosystem Protection and Maintenance – In the context of coastal adaptation, ecosystem protection largely involves the protection of tidal wetlands and other ecosystems. The facilitation of wetland migration is an important aspect of this.
- Ecosystem Restoration, Creation, and Enhancement – Similar to the above, ecosystem restoration and creation can replace tidal wetlands that are lost to sea level rise.

Water Resource Management and Protection

- Stormwater Management – Drainage systems may be ill-equipped to handle the amount of stormwater runoff that will accompany the more intense rainfall events expected in the future, and those in low-lying areas will be further challenged by losses in elevation attributed to rising sea levels.
- Water Supply Management – Climate change will negatively affect both water quantity and quality, and coastal populations will continue to grow, so water supply managers must be prepared to respond to associated challenges to water supply.

Elements of *protection, retreat*, and *accommodation* are found in several of these categories and sub-categories of adaptation. For example, Growth and Development Management actions can be used to manage retreat or accommodation, whereas Shoreline Management may include methods of protection as well as removing protection. NOAA notes that these adaptation measures are organized into categories that describe their primary purpose, but in many cases, they serve multiple purposes and could fit into multiple categories (e.g., acquisition could fit under Growth and Development Management, Coastal and Marine Ecosystem Management, and Shoreline Management in addition to Loss Reduction).

The EPA publication "Rolling Easements" (Titus, 2011) provides the most current comprehensive description of rolling easements and all the adaptation measures found in this broad collection of techniques. As noted by Titus in this publication, *accommodation* is viable in many communities, but no longer considered sustainable for the long term; eventually *protection* or

retreat will be the default. This is an important concept because communities will need to understand that there is a limit to how far into the future accommodation will be practical. Many of the recent and current trends in adaptation planning (circa 2008 to the present) appear to be taking this into account. Recent planning efforts are described in the next chapter.

2.0 Recent Trends in Adaptation Planning and Coastal Resilience

2.1 Communities in Other States

The most progressive adaptation and coastal resilience planning in the United States appears to be occurring in the mid-Atlantic region where some of the most significant effects of sea level rise are anticipated. Active planning is also taking place in Florida communities. Two Maryland counties, one Delaware community, and one Florida county are described below.

Somerset County, Maryland

The State of Maryland has been encouraging local communities to plan for sea level rise for a decade or longer. Somerset County prepared its "Rising Sea Level Guidance" in 2008 using a grant from the Maryland Department of Natural Resources. The county's population is approximately 25,000 and much of the county lies at a very low elevation along Chesapeake Bay. Recommendations of the guidance are wide-reaching and include the following:

- Recognize increased flooding through 2050 by adopting a "floodplain planning zone" that uses the year 2050 projected inundation area as boundary.
- Re-delineate the landward boundary of Conservation Zone to coincide with the 2050 inundation area and reduce the allowed density.
- Require buildings in floodplains to be on higher foundations (two feet of freeboard is recommended).
- Adopt Coastal V Zone requirements in areas where waves may be 1.5 feet or higher, instead of just where waves exceed three feet.
- Modify on-site septic requirements to anticipate impaired performance as water table levels rise, for example:
    - For undeveloped lots within the predicted 2050 inundation area that meet current 'adequate treatment zone' (2 to 4 feet depth to aquifer) and normal septic field testing, require site plans to designate future location for retrofit system (mound or holding tank).
    - Require holding tanks to be designed for buoyancy conditions based on 2050 inundation depths.
    - Require, on lots where existing septic systems are failing, installation of mound systems or tanks.
    - Within the predicted 2050 inundation area, require proposed central package treatment systems to be designed and installed to recognize anticipated flooding and groundwater conditions.
- Require planning for certain roads to anticipate more frequent flooding, for example:
    - Based on the typical problems experienced by roads in low-lying areas that are frequently inundated, identify requirements for elevated roads or for low water crossings (i.e., design them to be low to avoid blocking drainage, but require owners to acknowledge access limitations).
    - Require more underdrains/crossdrains to allow for drainage.

- For elevated roads, if the intent is to improve bedding as groundwater levels rise, removal of more unsuitable material to bear the placement of thicker fill materials may be required.
- Develop site characteristics that will be used by the County to determine where elevated road beds will be required.

- ❑ Require stream/tributary buffers or conservation easements.
- ❑ Recognize that wetlands will migrate inland, groundwater levels will rise, and saltwater intrusion will increase.
- ❑ Anticipate that some buildings will be relocated, elevated on higher foundations, or abandoned.

The recommendations for freeboard and applying V zone standards in coastal A zones are progressive but have been cited in the literature for many years. Somerset County's re-delineation of the Conservation Zone and potential adoption of a floodplain planning zone based on a future inundation area (in this case, the year 2050) is very forward-thinking and demonstrates that it may be possible for consensus to emerge around selecting a planning horizon to make decisions. The county's recommendations for septic systems and roads are very detailed (relative to the recommendations typically seen for septic systems and roads) and demonstrate a thorough understanding of the problems that will be faced by these systems.

Dorchester County, Maryland

Dorchester County prepared its "Sea Level Rise Technical Guidance for Dorchester County" in 2008 using a grant from the Maryland Department of Natural Resources and NOAA. The county's population is approximately 33,000 and much of the county lies at a very low elevation along Chesapeake Bay. The cornerstone of the technical guidance is the recommendation to adopt a Sea Level Rise (SLR) Overlay District using a 25-year high inundation scenario as boundary. At a minimum, the following would be pursued in the overlay district:

- ❑ Prohibit new subdivisions
- ❑ Prohibit expansion of footprints on existing developed lots
- ❑ Restrict major renovations of structures to cosmetic repairs, re-roofing, and replacement of appliances
- ❑ Prohibit use of bermed infiltration ponds for development on unimproved lots
- ❑ Restrict septic disposal facilities to state of the art facilities whose integrity would not be compromised by storm surge
- ❑ Require all new and existing well heads to be raised above the base food elevation plus a height to accommodate wave action on storm surge
- ❑ Require a minimum two-foot freeboard above base flood elevation
- ❑ Until federal agencies can update their maps, assume the 100-year flood elevation to be equivalent to the Category Two storm surge elevation, which will vary depending on the waterway
- ❑ Provide for the closure of inundated roads where an alternate route exists

- ❑ Provide for the termination of maintenance for roads that serve only a few occupied residences
- ❑ Provide for the termination of maintenance on roads where the cost to maintain exceeds the Fair Market Value of the properties it serves
- ❑ Initiate participation in the NFIP Community Rating System; implement provisions for a buy-out program
- ❑ Identify properties for potential buy-out. Rank them in order of level of immediate risk.
- ❑ Assess losses forest and identify reforestation sites outside the sea level risk zone
- ❑ Assess wetland losses and identify suitable areas to accommodate sea level encroachment and conversion to new wetlands
- ❑ Strongly participate with Corps of Engineers projects to restore and/or create barrier islands which act as buffers to the wetlands and mainland behind them.
- ❑ Prohibit investment on new infrastructure in the SLR District
- ❑ Abandon, relocate, raise, or seal any infrastructure that will sustain damage by inundation

Similar to Somerset County, Dorchester County's adoption of a SLR overlay district based on a future inundation area (in this case, the 25-year scenario) is very forward-thinking. The three recommended actions to address roads and the recommendation to "prohibit investment on new infrastructure in the SLR District" demonstrate that the county is serious about decreasing expenditures on infrastructure that is increasingly vulnerable.

While the county understands that its zoning and subdivision codes would be used for much of the above, two additional chapters of the code are noted as potentially useful in the county's adaptation planning:

- ❑ Chapter 80: Economic Development Department. This section allows the department to assist businesses in strategic planning that would lay the groundwork for future economic development; to help companies improve their operations; aid in site searches; and, assist in revitalization. The guidance document notes that this department's activities could be expanded to work with companies in sea level risk areas toward relocation efforts.

- ❑ Chapter 96: Forest Conservation Standards. This section contains provisions that speak to the preference for preservation of habitat types, priority for planting site selection, and the establishment of a mitigation bank. The guidance document notes that these codes may be amended to include specific provisions for forest habitat that would manage the level of groundwater, serve as protective buffers to salt marshes and non-tidal wetlands, and prohibition of forest harvest on areas with high water tables that lie adjacent to salt marsh.

Lewes, Delaware

The City of Lewes participated with a number of stakeholders in the development of the "City of Lewes Hazard Mitigation and Climate Adaptation Action Plan." The plan was published in 2011 and serves as a unified hazard mitigation plan and climate adaptation plan. The city is relatively

small at a population of 2,700, but it sometimes increases to 10,000 in the summer due to the city's location on Delaware Bay.

Based upon results of significant public participation and a ranking exercise, as well as additional input from relevant City boards and departments, the following are the six actions recommended for implementation:

- ❑ Incorporate climate change concerns into the comprehensive plan and into future reviews of the building and zoning codes.
- ❑ Improve outreach and education particularly focused on successful behavior changes related to home building and retrofits.
- ❑ Ensure that aquifer information is integrated into all planning efforts.
- ❑ Use elevation data to determine road levels and evacuation risk.
- ❑ Evaluate the City and the Board of Public Works (BPW) infrastructure's flood vulnerability from direct flood impacts, as well as from indirect flood impacts to access routes.
- ❑ Improve the City's level of participation in the community rating system (CRS).

The Lewes plan focuses on providing guidance for implementation. Several categories of implementation are described:

- ❑ Inclusion into Planning and Zoning Strategies
- ❑ Education and Outreach Strategy
- ❑ Aquifer Information Integration Strategy
- ❑ Evacuation Route Assessment Strategy
- ❑ Infrastructure Analysis Strategy
- ❑ CRS Strategy

Among the six actions and the six implementation strategies, the following types of recommendations are included in the plan:

- ❑ Amend the zoning code to require freeboard, create strict floodproofing requirements for critical facilities, prohibit expansions of buildings in flood zones, and create floodplain setbacks
- ❑ Increase standards in the Floodplain, Drainage, Stormwater, and Erosion/Sediment Control sections of Zoning Code
- ❑ Provide financial incentives to build above code
- ❑ Allocate funds to capital improvements
- ❑ Consider stormwater utility
- ❑ Consider a beach nourishment tax district
- ❑ Create buffers zones for marsh migration

Lee County, Florida

The Southwest Florida Regional Planning Council prepared the "Lee County Climate Change Resiliency Strategy (CCRS) in 2010. Rather that providing a ranked or prioritized list of strategies, the report lists the following possible strategies that can be used across all departments and planning processes:

- Address climate change impacts in plans for working waterfronts.
- Strengthen building codes in coastal areas to provide additional protection for properties from wind and storm surges.
- Adopt soft defense strategies, such as establishing aquatic vegetation beds, using natural or artificial breakwaters, and beach nourishment, where appropriate (for example, shorelines that are more undeveloped and where a seawall would inhibit wetland migration and damage natural defense systems).
- Allow coastal wetlands to migrate inland in areas explicitly indicated.
- Allow shoreline hardening where appropriate.
- Allow beach nourishment where appropriate.
- Change the placement and design of infrastructure (for example, for water supply, wastewater treatment, power plants and other utilities, and transportation).
- Conserve land in coastal areas by removing or limiting development potential through acquisition, conservation easements, and the purchase and transfer of development rights.
- Consider sea level rise in infrastructure planning.
- Consider sea level rise in site design.
- Constrain locations for certain high risk infrastructure.
- Construct groins in appropriate areas.
- Create a regional sediment management plan.
- Create dunes to protect shorelines.
- Create marsh.
- Create natural buffers against sea level rise.
- Design new coastal drainage systems.
- Develop and adopt building design criteria to deal with the consequences of possible sea level rise.
- Ensure appropriate foundations for buildings.
- Establish early warning sites and baseline data.
- Establish rolling easements to maintain sediment transport.
- Expand planning horizons.
- Improve land use and management.
- Explicitly indicate in the Lee County Comprehensive Plans which areas will retain natural shorelines.
- Fortify dikes.
- Identify, protect and adapt protections of ecologically important areas/critical habitat.
- Improve flood pain management/regulation.

- Incorporate wetland protection into infrastructure planning data.
- Increase shoreline setbacks and exchange/purchase/acquisition.
- Land exchange programs.
- Encourage use of living shorelines in residential, commercial and institutional properties.
- Manage realignment of infrastructure.
- Prepare for more frequent storm events with associated erosion.
- Encourage natural breakwaters where appropriate.
- Plant submerged aquatic vegetation and other vegetation.
- Prohibit development or engineering "solutions" to block migration of wetlands.
- Prohibit development subsidies (federal flood insurance and infrastructure development grants) to estuarine and coastal shores at high risk.
- Promote wetland accretion by introducing sediment and prohibiting hard shore protection.
- Protect barrier islands that shelter beaches.
- Protect and restore natural defenses such as salt marshes, sand dunes, and natural vegetation.
- Purchase upland development rights or property rights.
- Redefine flood hazard zones.
- Regulate pumping near shorelines, especially for flood control.
- Remove hard protection or other barriers to shoreline retreat and replace shoreline armoring with living shoreline protections.
- Replicate habitat types in multiple locations to spread risks.
- Restrict/prohibit development in erosion/flood/damage prone areas.
- Relocate structures away from vulnerable/affected shoreline.
- Retreat from and/or abandon shore headland control.
- Retrofit roads and bridges, which may involve rebuilding roads and bridges at higher elevations and developing engineering techniques that allow them to float or withstand flooding.
- Revising port master plans to reflect the impact of sea-level rise.
- Use integrated coastal zone management.
- Use natural and artificial breakwaters to reduce wave energy.
- Wetland conservation/restoration accounting for climate change and human engineering such as canals, floodgates, levees, etc.

Lee County prepared a cost comparison for five different methods of adaptation. Table 1 provides the estimates.

Table 1
Comparison of Relative Costs for Various Adaptations

Alternative	**Estimated Cost (Billions)**
Rolling conservation easements (purchased)	$1.8 to $1.4
Bulkhead with fill to 4 feet	$40.6
Gradual sand filling to keep pace	$2.8

Elevating infrastructure	$36.5
Armored dike with pumping stations	$41.0

The appendix of the plan provides additional cost estimates that may be helpful. Unit costs are provided for different kinds of seawalls, bulkheads, riprap banks, and gabion boxes along the waterfront. Unit costs vary from $60 to $800 per linear foot.

In general, the Lee County plan lacks the specificity of recommendations that the Somerset County, Dorchester County, and City of Lewes plans provided. However, the cost estimates are helpful for understanding how different options may compare to one another.

2.2 Connecticut Communities

Town of Groton

A number of communities in Connecticut are undergoing coastal resilience planning at the same time. For example, the Town of Groton participated in an EPA-funded climate change planning process in 2010 and 2011. The process resulted in the report "Preparing for Climate Change in Groton, Connecticut: A Model Process for Communities in the Northeast" (April 2011). During the workshops held in Groton, workshop participants identified the following as climate related impacts likely to affect Groton:

- More frequent river and coastal flooding;
- Increased coastal erosion;
- Increased precipitation, flooding, drought, and erosion;
- More frequent flooding that could prevent access to and reduce function of Groton-New London Airport;
- Access to state parks such as Bluff Point and Haley Farm could be hampered by flooding;
- Docks and marina facilities could be damaged by flooding and sea level rise;
- Increased economic impacts related to infrastructure replacements, loss of employment hours, additional emergency service personnel, and others arising from no action scenarios;
- Sections of Amtrak railroad could flood under certain sea level rise and storm flooding scenarios;
- Mystic River bridge may experience additional openings for smaller boats as bridge clearance diminishes with sea level rise;
- Overall quality of life, aesthetics, and enjoyment of citizens may be reduced.

Numerous adaptation strategies were developed by workshop participants in Groton:

- Relocate/Elevate vulnerable roads and infrastructure – ensure emergency access and preservation of public safety during extreme events;
- Develop Memorandums of Understanding with state personnel regarding funding of local police costs incurred to protect safety along vulnerable state owned road infrastructure during and after storm, so that police can also monitor other hazardous areas;

- Stormwater runoff reduction program designed to control peak discharges and to require post- development rates of runoff to be no greater than pre-development conditions in most circumstances;
- Flood-proofing of existing buildings;
- Conversion of land upriver to wetlands in order to accommodate increased sea level rise;
- Creation of incentives for retreat zoning and/or zoning and redevelopment restrictions and building code changes or enforcement to prevent building in the most vulnerable locations;
- Educational programs that alert residents about climate change and vulnerable areas of the Town;
- Purchase of vulnerable land or land that will act as a buffer by Groton;
- More stringent building and engineering design standards that anticipate future climate conditions, as opposed to just existing conditions;
- Beach nourishment;
- Installation of flood/tide gates at locations such as Groton Long Point and Mumford Cove;
- Creation of a comprehensive watershed management plan for debris and culverts, in partnership with Amtrak and CTDOT;
- Improved road condition reports during extreme events, in order to help the school district and other agencies to identify the safest transportation routes;
- Identification of Town, State, and Federal funding available to make the improvements to infrastructure that is deemed highly vulnerable;
- Integrate climate preparedness into the Capital Planning process, Master Plan of Conservation and Development update process, the zoning regulations revision, and streetscape project; and
- Investigate the logistical challenges of incorporating climate change, adaptation, and preparedness into school curriculum.

While many of the strategies may be viable, some of them involve comprehensive planning and will be incorporated into the Plan of Conservation and Development and the Municipal Coastal Program. Others are related to funding mechanisms and planning.

Town of Old Saybrook

The Town of Old Saybrook adopted changes to its Zoning Regulations in 2012 that were moderate in terms of text involved yet very progressive for a Connecticut community. Quite simply, these amendments require one foot of freeboard and the application of V zone standards in coastal A zones. The revised Old Saybrook Floodplain Management Ordinance now states the following:

- Section 2.9: “VE Zone floodplain construction standards are applied to development, new construction and substantial improvements in the Coastal AE Zone.”
- Section 2.26: “The floodplain development and construction standards for VE Zones will be applied in the Coastal AE Zone.”

- Section 5.3.1: “New construction or substantial improvement of any residential structure shall have the lowest floor, including basement, elevated at least one foot above the base flood elevation.”
- Section 5.3.2.1: New construction or substantial improvement of any commercial, industrial, or non-residential structure located in Zone A or AE, shall have the lowest floor, including basement, elevated at least one foot above the base flood elevation; or
- Section 5.3.2.2: Non-residential structures located in all A and AE zones may be dry flood-proofed at least one foot above the base flood elevation in lieu of being elevated provided that together with all attendant utilities and sanitary facilities the areas of the structure below the required elevation are water tight with walls substantially impermeable to the passage of water, and use structural components having the capability of resisting hydrostatic and hydrodynamic loads and the effects of buoyancy.
- Section 5.3.4.2: All buildings or structures [in coastal high hazard areas] shall be elevated so that the lowest supporting horizontal member is located no lower than one foot above the base flood elevation and with all space below the lowest supporting horizontal member open so as not to impede the flow of water, except for breakaway walls as defined in Section 2.7.
- Section 5.3.7.1: New construction of critical facilities shall be elevated or dry flood proofed to one foot above the base flood elevation (100-year flood elevation).

Although freeboard can be found in other Connecticut communities, the application of V zone standards in coastal A zones is not typically found in Connecticut. Old Saybrook provides an excellent model for other coastal communities in Connecticut.

3.0 Outreach and Development of Options

3.1 Municipal Officials and Commissions

The Town of Guilford municipal department heads and commission chairpersons met on October 10, 2012 to hear a presentation of the many adaptation methods described in the publications listed in Section 1.2 and 2.0. NOAA's six categories of adaptation measures were used as the framework for the presentation. The three examples from Maryland and Delaware communities were described as well. The goal of the meeting was to educate attendees about all the various options that are available rather than focus on a group of options. Attendees included:

- George Kral – Guilford Town Planner
- Kevin Magee – Guilford Environmental Planner
- Hank Graver – Chairman, Guilford Marina Commission
- Brian McGlone – Guilford Economic Development Coordinator
- Rick Maynard – Guilford Parks and Recreation Director
- Mark Damiani – Guilford Assistant Town Engineer
- William Thody – Guilford Building Official
- Mary Jo Kestner – Plan of Conservation and Development Committee
- Dennis Johnson – Guilford Health Director
- Sidney Gale – Resident
- Joe Mazza – Guilford First Selectman

An active discussion followed the presentation. Meeting minutes are included in Appendix A. During this discussion, none of the possible adaptation measures were ruled out, although it was agreed that some may not be practical in Guilford. Instead, much of the discussion focused on how Guilford will make choices in the future. For example, potable water supply and wastewater disposal will become challenging in some of the coastal neighborhoods like Indian Cove, Mulberry Point, and Tuttles Point; this will necessitate further dialogue about whether water and wastewater infrastructure should be provided. The meeting also included a discussion about how future planning efforts may need to be divided into town-wide planning

and neighborhood-scale planning, which will be addressed during the development of the town's coastal resilience plan.

One important result of the discussion with municipal department heads and commission chairpersons was that it informed an organization of the possible coastal resilience and adaptation measures into a concise categorization that is considered appropriate for Guilford. The four categories and their sub-categories are listed in Table 2.

Table 2
Options for Coastal Resilience in Guilford

Categories of Options	Possible Options
Management of coastal real estate and structures	Building codes (freeboard, V zone standards in A zones)
	Acquisition of damaged properties
	Zoning overlays
	Zoning amendments
	Coastal realignments through any of the above
Shoreline protection and management of coastal and near-shore lands	Hard shoreline protection
	Living shorelines
	Buffers for flood protection
	Land acquisition for tidal marsh migration
	Land conservation for tidal marsh migration
Roadway alterations	Elevation of roadways
	Abandonment of roads
	Re-evaluation of emergency routes
	Alternate egress
Protection or replacement of water supply wells and septic systems	On-site retrofits of septic systems
	Community wastewater systems
	Extension of sewer system
	Individual water treatment systems
	Community water systems
	Extension of water mains
	Vacate properties

3.2 Public Participation

The options listed in Table 2 were presented to the public during a public meeting on November 26, 2012. A copy of the power point slide show is included in Appendix B of this report along with minutes of the meeting. Approximately 50 people attended the meeting, and an article was published in the Guilford Patch (www.patch.com) on the following day.

Because this was the first public meeting about coastal resilience subsequent to the passing of Hurricane Sandy in October 2012, Mr. Kevin Magee (Guilford's Environmental Planner) opened the meeting with a summary of the effects of Sandy on the Town of Guilford. Many roads were flooded and temporarily closed. Sandy's flood level was 5.33 feet as recorded at Seaside

Avenue. The two restaurants at the marina were flooded. However, the marina did not suffer as much damage as it did during Hurricane Irene in August 2011.

Professor Alex Felson and graduate student Tim Terway of the Yale Urban Ecology and Design Lab provided a survey to meeting attendees and presented a brief slide show to describe the results of prior surveys. These previous surveys revealed that the public believes that physical changes are needed to address sea level rise and increase coastal resilience, but that there are societal and institutional obstacles. These obstacles will need to be addressed in future coastal resilience planning efforts in Guilford.

Next, Dr. Felson and Mr. Terway moderated a live presentation of the web tool, traveling from west to east along the shoreline of Guilford. The Hurricane Sandy flood elevation was added to the display to help illustrate how future daily inundation scenarios could compare to Sandy's flooding. Heavy red lines were superimposed on roads that were flooded during Sandy.

A number of comments were received during the public participation component of the meeting. These are listed in the meeting minutes in Appendix B. In general, these comments can be grouped into the following four themes:

- Coastal resilience planning – and many of the solutions that are implemented – may be best accomplished at the neighborhood scale; and neighborhood planning groups may need to be organized to begin looking at appropriate solutions;
- The tax base associated with coastal properties would need to be preserved in the short term and then some of the tax base may need to be shifted in the long term;
- Education and technical assistance are needed and desired by homeowners, and education could also be accomplished in the schools;
- Comprehensive solutions will be needed such as: addressing water and wastewater at the same time in neighborhoods where these systems will struggle or fail; ensuring that roadway improvements in one location are effective because improvements are also made elsewhere in the transportation network; and working on coordinated roadway and railroad improvements.

The attractiveness of options listed in Table XX is that they can be applied on a neighborhood scale and can be used for comprehensive solutions. The next chapter of this report describes the options in more detail.

4.0 Description of Potential Coastal Resilience Options for Guilford

4.1 Management of Coastal Real Estate and Structures

Management of coastal real estate and structures may include phasing with coastal realignment strategies and may occur through zoning overlay districts or zoning amendments. This category will likely include strengthening building codes to require freeboard, applying V zone standards in A zones, and acquisition of property damaged by coastal hazards.

Strengthen building codes to require freeboard

Freeboard standards require structures to be elevated higher than the level that FEMA requires through the NFIP regulations. Application of freeboard standards to coastal flood zone elevations is typically viewed as more effective than applying freeboard standards to inland flood zones. When used alone, freeboard standards provide additional certainty that flood levels will not damage a structure. When use in combination with V-zone standards described below, freeboard standards can provide an additional level of flood damage prevention. Independent academic studies have found that freeboard is one of the most effective tools to reduce flood damages. A study of the CRS found that insured flood losses were reduced by almost $ 1 million in communities that require freeboard.

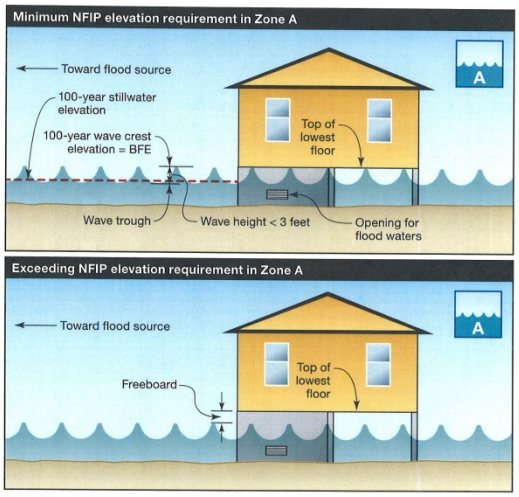


Figure 5-1.
Recommended elevation for buildings in Zone A compared to minimum requirements

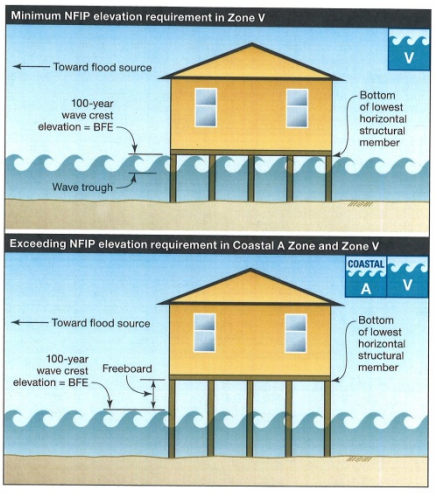


Figure 5-2.
Recommended elevation for buildings in Coastal A Zone and Zone V compared to minimum requirements

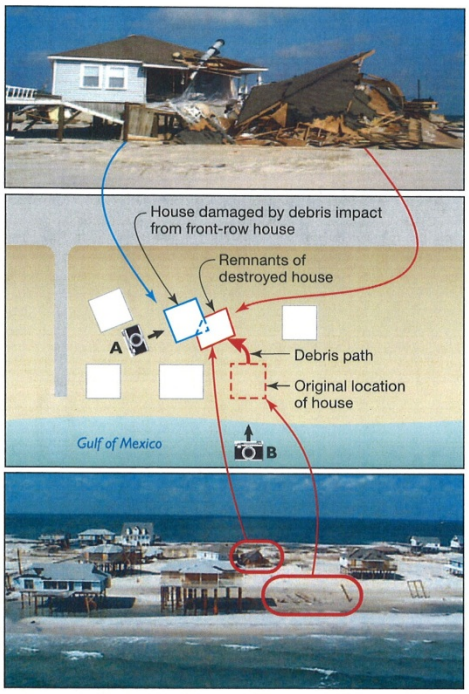
Freeboard standards can be found statewide in New York (where two feet of freeboard is required for new construction and substantial improvements) and a few other states, but it is not required by the State of Connecticut unless hazard mitigation grant funds are used for elevating structures. Municipalities in Connecticut are entitled to adopt freeboard standards.

Several communities in Connecticut require freeboard, although not all of them are coastal towns:

- Ansonia – 1 foot
- Norwich – 1.5 feet
- Waterford – 1 foot
- Meriden – 1 foot
- Old Saybrook – 1 foot

At 1.5 feet, the City of Norwich may have the most aggressive freeboard requirement in Connecticut.

Guilford's Municipal Coastal Program (2008) included the following Policy Recommendation: "Consider establishing freeboard standards that are more stringent than FEMA's minimum requirements, as other communities have done, so that new construction and substantial renovations will result in structures that can accommodate higher flood levels caused by sea level rise." Guilford's Hazard Mitigation Plan (2012) also recommended freeboard.



Applying V zone standards in A zones

As noted in Section 2.2, Old Saybrook requires the use of V zone standards in coastal A zones. The effect is to cause a greater level of protection to new construction and substantial improvements in coastal A zones as compared to the same structures in coastal A zones prior to the amendment. The application of more stringent codes not only protects a given structure; it also protects *nearby* structures from damage caused by collapsing or floating structures and debris.

Guilford's Municipal Coastal Program and Hazard Mitigation Plan both discuss the benefits of applying V zone standards in coastal A zones.

Acquisition of property damaged by coastal hazards

Immediately following coastal hazard events such as severe storms and damaging storm surge, Guilford may occasionally have opportunities to acquire damaged structures and their underlying properties rather than the owner electing to make costly repairs to continue living at risk. Even if properties are repaired, Guilford may have opportunities to acquire structures that

have suffered repeated damages. Subject to a successful demonstration of a benefit-cost ratio above 1.0, FEMA mitigation funds may be available for acquiring damaged properties using one of the five typical programs (Pre Disaster Mitigation, Hazard Mitigation Grant Program, Flood Mitigation Assistance, Repetitive Flood Claims, and Severe Repetitive Loss)[1].

Zoning amendments

Zoning amendments may be used at any time to require freeboard and application of V zone standards in coastal A zones. The attractiveness of these measures is that they would immediately apply to SHFAs delineated by FEMA, whether or not the town was to implement overlay zones.

Zoning overlay districts

Like the Maryland counties described in Section 2.1, Guilford may wish to adopt a zoning overlay district that is delineated using a line of future daily inundation or a future storm of a given hurricane category/intensity. Any of the planning periods used in the coastal resilience tool could be used (2020s, 2050s, or 2080s). Once adopted, the town could enact any number of requirements for development or redevelopment within the overlay, including freeboard and application of V zone standards in coastal A zones (if not already incorporated into Zoning Regulations) or more stringent freeboard such as two feet. Other possibilities may include variable setbacks and buffers or restrictions on what types of renovations or expansions may be permitted for existing buildings.

Coastal realignment strategies

Coastal realignment will ensure that wetlands and beaches migrate inland as buildings and roads are moved or removed. This is the central concept in the broad set of tools known as rolling easements. Rolling easements can be thought of as a combination of the circa-1990 principles of accommodation and retreat. Because it is unrealistic to prevent development of low-lying coastal lands that could eventually be submerged by a rising sea, an alternative is to allow development with the conscious recognition that land will be abandoned if and when the sea rises enough to submerge it. From now until the land is threatened, valuable coastal land can be put to its highest use; once the land is threatened, it will

> *"A rolling easement is a legally enforceable expectation that the shore or human access along the shore can migrate inland instead of being squeezed between an advancing sea and a fixed property line or physical structure. The term refers to a broad collection of legal options, many of which do not involve easements. Usually, a rolling easement would be either (a) a law that prohibits shore protection or (b) a property right to ensure that wetlands, beaches, barrier islands, or access along the shore moves inland with the natural retreat of the shore." (Titus, 2011)*

[1] These programs are described in the Hazard Mitigation Plan

convert to wetland or beach as if it had never been developed.

According to Titus (2011), there are more than a dozen approaches for ensuring that wetlands and beaches migrate inland as buildings and roads are moved or removed. The term rolling easement refers to legal options, although many of them do not involve easements.

Regulatory rolling easements include:

- Local zoning that restricts shore protection;
- Regulations that prohibit shore protection by state coastal or wetland programs, or require removal of structures standing on the beach or in the wetlands;
- Permit conditions that require public access along the dry beach in return for a building permit; and
- Permit conditions that require public access along the inland side of a new shore protection structure, in return for a permit to build such a structure.

If some lands must give way to the rising sea, the economic, environmental, and human consequences could be much less if the abandonment occurs according to a plan rather than unexpectedly. (Titus, 2011)

A "property rights approach" includes:

- Affirmative easements that provide the public with the right to walk along the dry beach even if the beach migrates inland;
- Conservation easements that prevent landowners from erecting shore protection structures or elevating the grades of their land;
- Restrictive covenants in which owners are mutually bound to avoid shore protection and allow access along the shore to migrate inland;
- Future interests that transfer ownership of land whenever the sea rises to a particular level;
- Migrating property lines that move as the shore erodes, enabling waterfront parcels to migrate inland so that inherently waterfront activities can continue.
- Legislative or judicial revisions and clarifications regarding the inland migration of public access along the shore and the rights of landowners to hold back the sea; and
- Transferable development rights that provide those who yield land to the rising sea the right to build on land nearby.

The particular details associated with implementing the above rolling easements are too varied to fully describe in this report of coastal resilience options. As planning continues, Guilford will need to determine whether rolling easements are the best methods of encouraging coastal realignment.

4.2 Shoreline Protection and Management of Coastal and Near-Shore Lands

Shoreline protection and management of coastal and near-shore lands differs from the management of coastal real estate and structures by focusing on the land itself. This group of measures may include hard shoreline protections, living shorelines, land acquisition and land

conservation practices for tidal marsh advancement, and tidal wetland buffers for near-shore flood protection.

Hard shoreline protection

According to Titus (2011), planners in the United States view shore protection as likely for 60% of the low-lying shoreline along the Atlantic coast if sea level rises three feet in the next century. Hard shoreline protection generally includes the following structures that are parallel to the shoreline:

- Seawalls are engineered barriers that protect land from waves and flooding
- Levees are engineered berms that protect land from flooding
- Bulkheads are engineered structures that retain soil and reduce erosion
- Riprap provides protection from erosion by dissipating wave energy

Hard protections that are not parallel to the shoreline may include jetties, groins, revetments, and the like.

In order to include hard shoreline protection in a community, it is often necessary to inspect coastal structures such as bulkheads and seawalls; determine which structures are deteriorating and need repair; prioritize repair of structures based on condition and ability to protect property; and assess privately-owned coastal structures. Guilford will continue to have areas that are protected by hard shoreline protection well into the future, including private properties and municipal facilities such as the marina. Maintenance of hard structures is a desired action that is discussed in the town's Hazard Mitigation Plan and the Municipal Coastal Program. In short, hard shoreline protection will always be an important tool for Guilford to maximize coastal resilience in discrete areas.

Living shorelines

Living shorelines use non-structural shoreline stabilization to provide erosion control and enhance natural habitat. These are often created through strategic placement of plants, stone, sand fill, and other structural and organic materials. Living shorelines are not compatible with high-energy waters but may be appropriate for different parts of the Guilford shoreline due to the somewhat protected nature of Long Island Sound.

Photo courtesy of Maryland Commission on Climate Change

The science surrounding living shorelines is young. In 2012, the Virginia Institute of Marine Science published the report "Ecological and Erosion Protection Functions of Chesapeake Bay Living Shorelines" in cooperation with NOAA, the Chesapeake Bay Trust, and the Maryland

Department of the Environment. This report provides a number of design criteria and lessons learned from living shoreline projects.

Recent changes in Connecticut's coastal management laws appear to make the use of living shorelines more permissible along the state's shoreline by excluding them from the definitions associated with hard structures. In the coming years, Guilford may wish to develop living shoreline projects to protect tidal wetlands that have been eroding. Control of tidal wetland erosion is a desired action that is discussed in the Hazard Mitigation Plan and the Municipal Coastal Program.

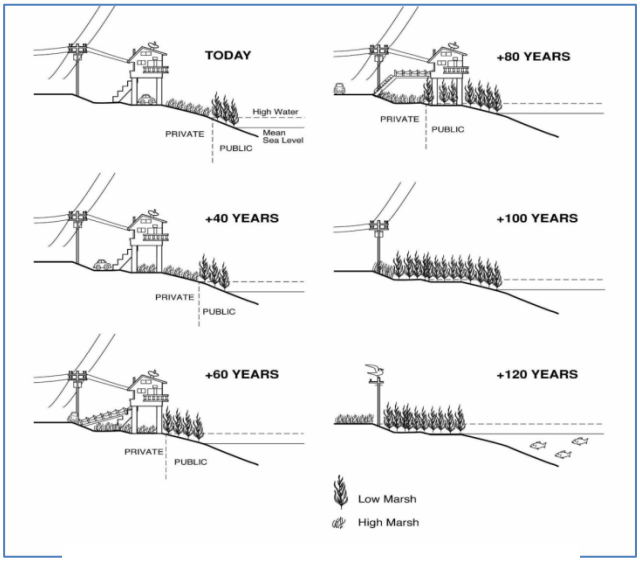
Buffers for near-shore flood protection

The use of buffers in Guilford is not a new concept. The Municipal Coastal Program recommended a system of variable buffers for shoreline properties, and the Planning and Zoning Commission often requires buffers in connection with development projects. Buffers may be associated with tidal wetlands although this is not necessary.

The appeal of buffers relative to coastal resilience is that they provide space for flood mitigation and wave attenuation between tidal waters and structures or infrastructure. While buffers may not stop water from reaching a structure, research of coastal storm damage in the United States has shown time and time again that storm surges are slowed and waves are attenuated when buffers are available. Setting aside buffers between water and structures or between water and infrastructure is viewed as an important tool for Guilford to increase coastal resilience.

Land acquisition for tidal marsh migration

The Municipal Coastal Program includes a lengthy discussion of the benefits of acquiring land for migration of tidal wetlands. Setting aside coastal land for marsh migration is also recommended in the Hazard Mitigation Plan. The benefits of acquisition are fairly obvious – if the appropriate land is acquired (in the best location and with optimal ground surface elevations), then tidal wetlands will have the best chance of adapting to sea level rise by migrating inland.



Graphic from Rolling Easements (Titus, 2011)

Land conservation for tidal marsh migration

If land cannot be acquired for tidal wetland migration, there may be opportunities to set aside the appropriate land through conservation easements and other arrangements. In some cases, this may occur through the

use of rolling easements. In other words, Guilford may not acquire private properties; instead, these properties would continue to remain in private ownership and tidal wetlands would be allowed to migrate inland as structures are removed. This concept is depicted in the graphic above.

4.3 Roadway Alterations

As noted in Section 1.2, a summary of transportation-related discussions was published in the report "The Potential Impacts of Climate Change on Transportation" in 2002. The report demonstrated that there are special vulnerabilities associated with roads, airports, and other transportation systems and networks. Adaptation methods such as elevating roads, protecting systems with dikes, and retreat were discussed in the report.

Guilford's Municipal Coastal Program and Hazard Mitigation Plan both address roads. The specific roadway vulnerabilities in Guilford were also documented in the risk and vulnerability report that preceded this report of options. In particular, the Municipal Coastal Program states that *"The Town should elevate key roadways to keep up with increasing coastal flood depths and sea level rise. Evacuation routes should be prioritized, and Route 146 should be the highest priority of the evacuation routes. Potential inundation areas at the West River, Long Cove, and Leetes Island must be elevated to maintain Route 146 as a viable evacuation route. In addition, Daniel Avenue, Indian Cove Road, and Tuttles Point Road should be improved as needed to ensure that Indian Cove residents can evacuate via Mulberry Point when access to Vineyard Point Road is flooded."*

Roadway alterations in Guilford may include elevation of roadways, abandonment of some roads, re-analysis of emergency access, and developing alternative egress for some areas.

Elevation of roadways

Roads can be elevated to remain viable while flood elevations increase. This has been done in many coastal communities along the east coast of the United States over the last century as sea level has been rising. The drawback to elevating roads is that private properties often remain at lower elevations and therefore remain flood-prone. A higher road surface can then impede drainage of floodwaters off properties. Cross culverts can be used to facilitate drainage under elevated roads. At significantly greater cost and effort, some roads can be elevated on piers or long bridges.

The elevation of roads will likely be an important coastal resilience tool used in Guilford. The town is already evaluating the feasibility of elevating sections of Old Quarry Road to improve access to and from the properties located in the Old Quarry neighborhood. Sections of Route 146 will be likely candidates for elevation in the coming years, as well.

Abandonment of some roads

Some communities may find it acceptable to abandon roads as the cost of elevating or maintaining a road becomes excessive. For example, Somerset County (Section 2.1) has explored the abandonment of certain roads. In Guilford, one potential example of a road that could be abandoned is the section of Tuttles Point Road that connects Tuttles Point to Mulberry Point. This section of road is already flood-prone. However, the road could not be abandoned unless an alternate mode of access was developed for Tuttles Point residents, such as a road further inland.

In some cases, complete abandonment may not be necessary, but Guilford may allow a lesser level of maintenance. An example can be found at Pebble Beach in Rockport, Massachusetts. After many years of repaving a road at Pebble Beach that is prone to frequent washover, the town now maintains the road as unpaved and simply clears the surface after washover events.

Re-analysis and evaluation of emergency access and routes

Some communities may abandon designated emergency access ways (without actually abandoning the associated road) while selecting a different route for emergency access or evacuations. In Guilford, one potential example is to leave Daniel Avenue at its existing grade and elevate West Lane so that Indian Cove residents may evacuate to the west instead of to the east. Daniel Avenue would not be abandoned, but it would no longer serve as a route that could be used for evacuation during a coastal flood event.

Developing alternative egress for some areas

Developing alternate egress would likely be used in connection with abandonment of roads and/or re-assignment of emergency access. In the Tuttles Point Road example described above, an alternate mode of access would be development further inland. In the Daniel Avenue example described above, West Lake would become the alternate egress.

4.4 Protection or Replacement of Water Supply Wells and Septic Systems

As noted in the risk and vulnerability report, some of Guilford's neighborhoods will face serious problems relative to water supply and sanitary wastewater disposal as sea level rises and groundwater rises accordingly. Adaptation methods may include on-site retrofits to septic systems, development of community water and wastewater disposal systems, extension of sewer and water systems, or – in extreme cases – vacating properties.

On-site retrofits

A small number of potential solutions may be available for property owners to continue generating sanitary wastewater on their properties. First and foremost, septic systems can be elevated to maintain an appropriate vertical separation between effluent leachfields and the surface of the groundwater table. Elevating a system will typically require building a mound of fill material over the new system, and the use of pumping equipment because gravity drainage will no longer be possible. If elevating a system is not possible, a suitable site for a new system may be found elsewhere on a property. However, the town of Guilford recognizes that this will be difficult for many of the small lots found in some of the shoreline neighborhoods where water supply wells are also present on lots.

In cases where the full area needed for renovation of wastewater is no longer available, property owners could attempt to install and maintain advanced sewage treatment facilities. While this may be feasible from an engineering viewpoint, it is unlikely that the average homeowner would have the time and financial resources available to constantly maintain these treatment systems in working order.

In cases where septic systems cannot be improved, it may be possible to install effluent holding tanks. The tanks would then be pumped out and sanitary wastewater would be delivered to a sewage treatment plant elsewhere in Connecticut. In practice, this is probably not feasible for most of Guilford's coastal neighborhoods. During the busy summer months, neighborhoods could face multiple pumpouts with trucks crowding the streets in densely populated neighborhoods.

Individual water treatment systems

As salt water intrusion allows brackish groundwater to flow into wells, residents may choose to remove dissolved solids (salt and other minerals) using small reverse osmosis treatment systems. These systems can also be used to remove nitrates that originate in nearby septic systems. Individual water treatment systems can be used for many years and are easily replaced when necessary.

Development of community systems

If the above options are not viable for a certain neighborhood, then community water systems and/or community wastewater disposal systems may be feasible for some parts of Guilford. Different sets of challenges would arise for each:

- Community water systems are strictly regulated by the Connecticut Department of Public Health (DPH). Community water systems in Guilford must be owned and operated by the Connecticut Water Company, which holds the exclusive service area in Guilford. Such systems can only be developed where the appropriate sanitary setbacks (established in the Public Health Code) around each well can be placed into the control of the water company; this typically requires several acres of land for well sites. It would be difficult to site wells with the appropriate sanitary setbacks and open space near Guilford's coastal

neighborhoods while maintaining a reasonably close distance to the neighborhoods in order to keep water transmission costs to a minimum. If water from new wells needs to be treated, then costs will increase.

- Community wastewater systems are currently undergoing feasibility studies in several shoreline towns in Connecticut such as Old Saybrook and Old Lyme where beach communities have struggled with septic system failures. Community systems are strictly regulated by the Connecticut Department of Energy and Environmental Protection (for flows exceeding 5,000 gallons per day [gpd]) or the DPH (for flows less than 5,000 gpd); along with the local health department. Like community water systems, it would be difficult to site community wastewater systems near Guilford's coastal neighborhoods while maintaining a reasonably close distance to the neighborhoods in order to keep transmission and pumping costs to a minimum.

Development of a community wastewater disposal system has been intermittently considered over the years in the Town Center South area, but the coastal residential neighborhoods have not explored this type of solution.

Extension of sewer and water systems

The Connecticut Water Company already owns and operates a public water distribution system in Guilford. The system is present in areas such as Sachems Head but it does not extend into coastal neighborhoods such as Indian Cove, Mulberry Point, and Tuttles Point. The Town of Guilford commissioned a feasibility study for extending the water system to these three neighborhoods and developed cost estimates for water main extensions. Following this exercise, Guilford residents voted against extending water mains to Indian Cove, Mulberry Point, and Tuttles Point. However, the town recognizes that over the long term, this may be one of the only viable means of providing a safe and reliable water supply to coastal neighborhoods.

Sanitary sewer systems are not presently located in Guilford's coastal neighborhoods. In order to provide sanitary sewer service in place of septic systems, the town would need to develop a new sewer system and identify a location for treating sewage. This could be a new sewage treatment plant in Guilford, or the town could pump sanitary wastewater to a nearby municipality with a treatment plant. In either case, this solution to wastewater handling in Guilford would cost many millions of dollars, if not more.

Vacating property when none of the above are feasible

In extreme situations where on-site solutions are not feasible for providing a potable water supply and disposing of sanitary wastewater, and community or townwide systems are not possible due to feasibility or expense, some properties may be rendered unusable. These properties will be vacated, possibly abandoned, and the town will lose the associated tax base.

4.5 Combining Options

Guilford's coastal neighborhoods are diverse and it is likely that each will be faced with a combination of vulnerabilities to sea level rise and the increased incidence and severity of coastal storms. A combination of adaptation measures will therefore be necessary in each neighborhood in order to reduce risks and increase resilience.

Seaside Avenue is a good example of a residential neighborhood where several adaptation measures from each of the four categories may be necessary:

- Homes along Seaside Avenue will be increasingly vulnerable to flooding and wave action during intense storms. Freeboard and the application of V zone standards will strengthen structures and make them more resilient (especially for those houses that have not yet been elevated to FEMA's base flood level).
- At the same time, access along Seaside Avenue will be compromised more frequently unless the road is elevated. Cross culverts will be needed to facilitate the passing of water from northwest to southeast (and vice versa) beneath the road.
- In order to maintain the wide buffer of tidal wetlands that these residents currently enjoy (between the road and the edge of Long Island Sound), the town may wish to develop living shorelines along the edge of the sound to reduce erosion.
- As groundwater rises and septic systems have a harder time functioning, or as frequent floods wash over septic systems, homeowners will need to build mounded septic systems.
- As some properties are damaged beyond reasonable repair, or as septic system failures require that properties be vacated, the town may acquire lots and set the land aside for migration of tidal wetlands.

Soundview Road offers an example of a non-residential area where several adaptation measures from each of the four categories may be necessary. Figure 1 depicts a generalized commercial building that is vulnerable to various aspects of sea level rise and increased incidence of coastal hazards, and one that has been adapted. The adapted building has an elevated septic system, a relocated well with wellhead located above future flood levels, a partially flood-proofed building, and elevated critical systems inside and outside the building such as IT and HVAC.

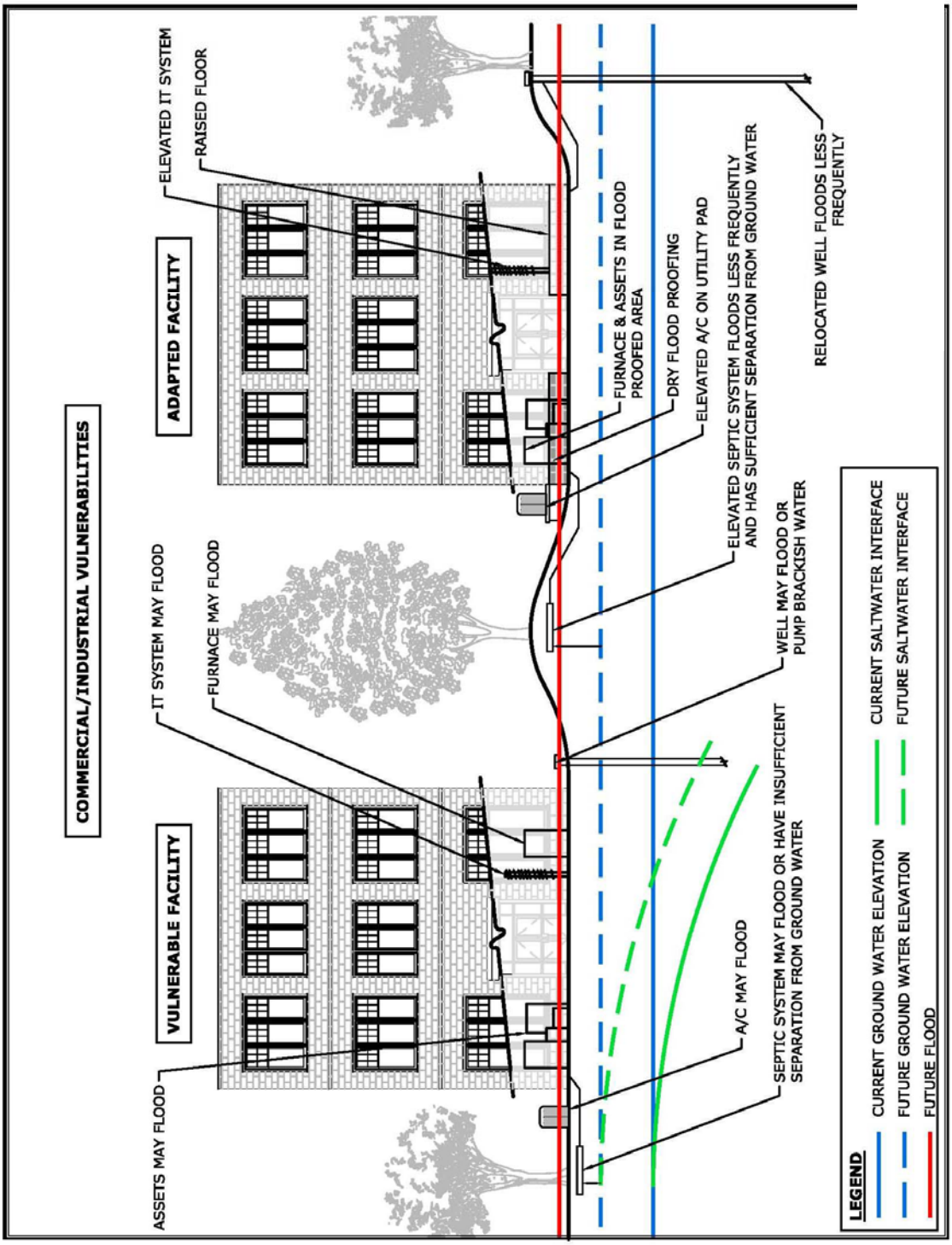
Some neighborhoods may be primarily focused on some of the adaptation measures more than others, depending on their vulnerabilities. For example, homes in Sachems Head are served by the public water system and many will have suitable space for septic system upgrades. However, the neighborhood is prone to isolation during storm surges that flood key sections of Route 146. Therefore, elevation of Route 146 will be critical to maintain evacuation routes from (and emergency access to) Sachems Head.

Neighborhood-scale resilience planning will be important in Guilford. When this planning occurs, neighborhoods will be urged to evaluate individual adaptation measures and determine

how comprehensive solutions can be developed and implemented for building coastal resilience.

Figure 1

Vulnerable and Adapted Commercial Facilities



Appendix A
Presentation and Meeting Minutes – October 10, 2012

Appendix B
Presentation and Meeting Minutes – November 26, 2012