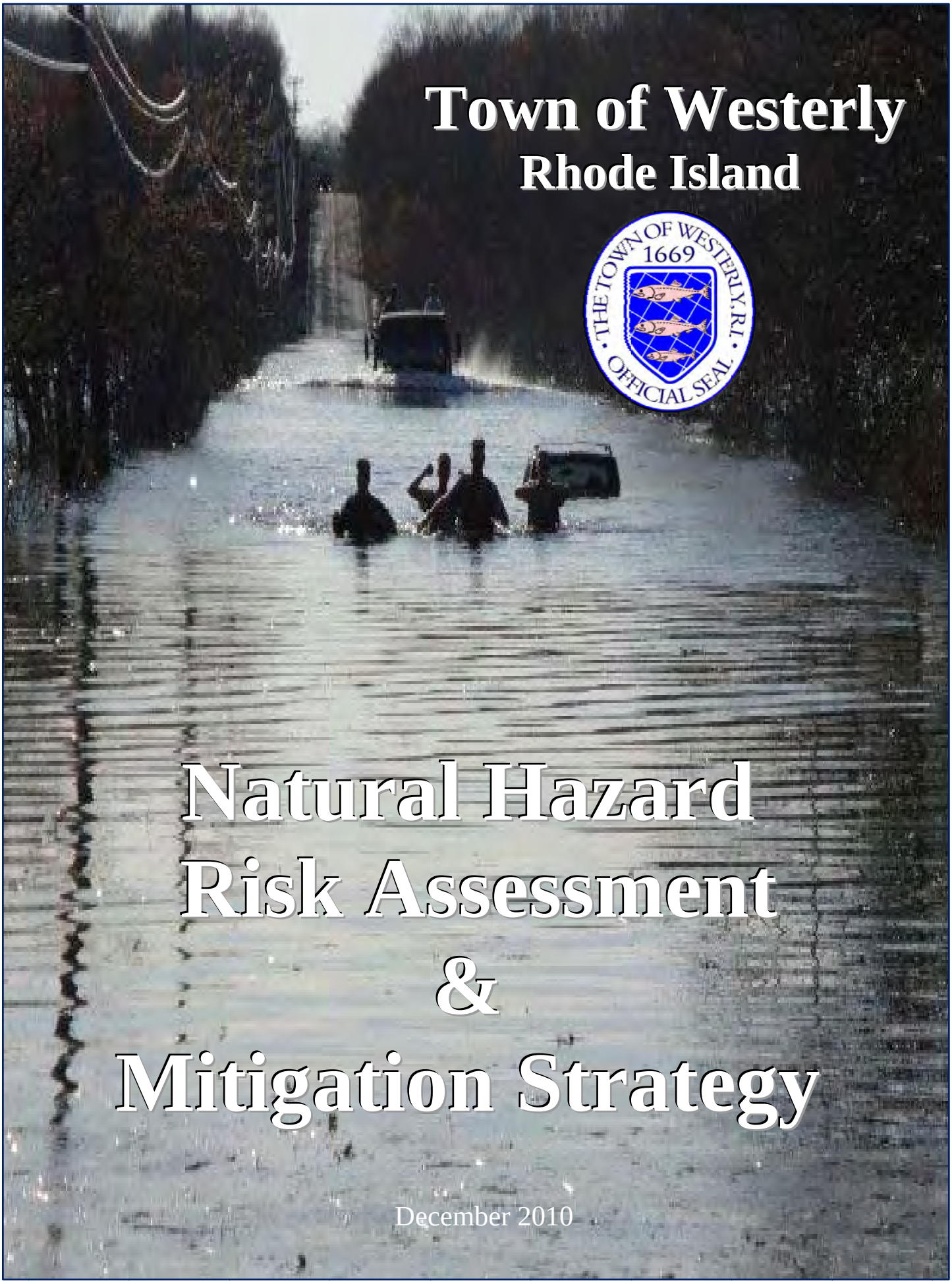
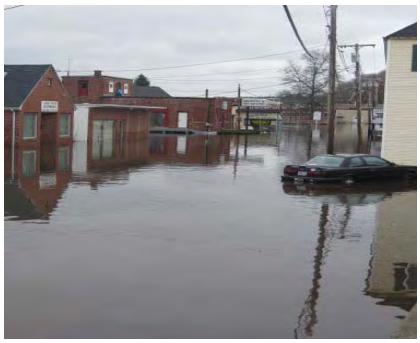


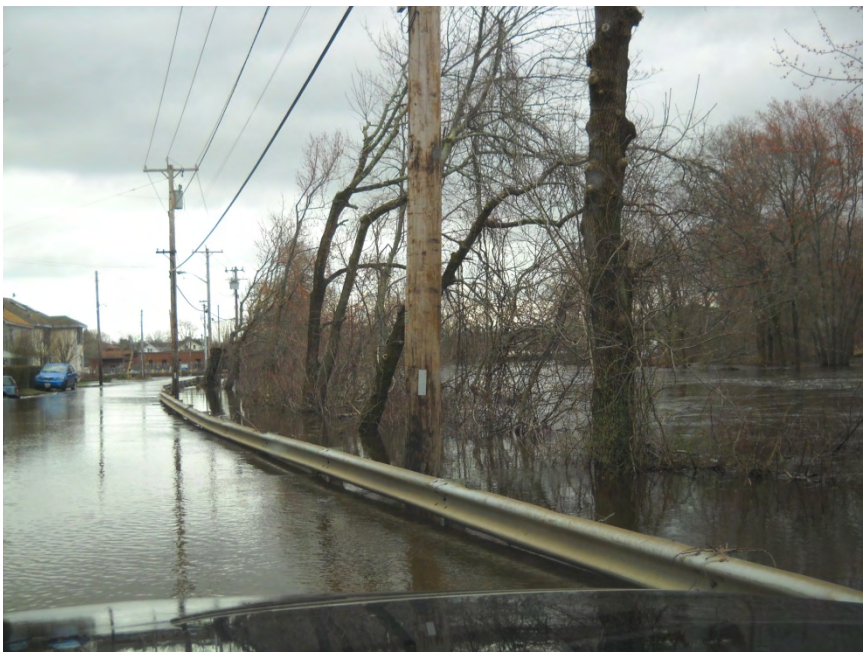
Town of Westerly
Rhode Island

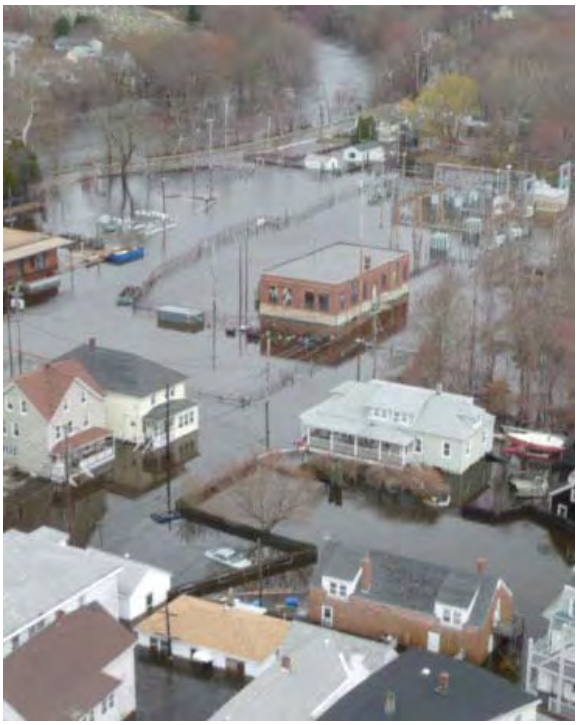
Natural Hazard Risk Assessment & Mitigation Strategy

December 2010


nationalgrid







Natural Hazard Risk Assessment & Mitigation Strategy Town of Westerly, Rhode Island

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Section 1: Introduction

What is Hazard Mitigation?

- *Hazard Mitigation*: Any sustained action taken to reduce or eliminate long-term risk to people and their property from the effects of natural hazards.[1]

- *Natural Hazard*: A threat to society stemming from the potential interaction between humans and extreme natural events.[2]

- *Emergency*: An emergency is a deviation from planned or expected behavior or a course of events that endangers or adversely affects people, property, or the environment.[3]

- *Disaster*: An event that has a large impact on society.[4] Disasters are characterized by the scope of an emergency. An emergency becomes a disaster when it exceeds the capability of the local resources to manage it. Disasters often result in great damage, loss, or destruction.[5]

- *Risk*: Risk is the potential or likelihood of an emergency to occur. For example, the risk of damage to a structure from flooding is high if the structure is located in an area susceptible to coastal flooding, whereas the risk of damage to a structure outside of a flood zone is low.[6]

Mission Statement

This *Natural Hazard Risk Assessment and Mitigation Strategy* focuses on natural hazards of primary importance to Westerly, including hurricanes, tropical storms, Nor'easters, and associated coastal and inland flooding. Other natural hazards addressed in this document include winter storms, thunderstorms and associated high winds, coastal erosion, wildfire, earthquakes, drought, heat waves, and dam failure.

The mission of this *Natural Hazard Risk Assessment and Mitigation Strategy* and town officials charged with overseeing its implementation is to minimize the impact of natural hazards on Westerly's residents and visitors, built environment and natural resources. This document evaluates the natural hazards and vulnerabilities specific to Westerly, assesses their associated risks, and identifies opportunities to mitigate their potential adverse impacts. Preparing for natural hazards before they occur will facilitate the Town's response and recovery efforts following a natural disaster.

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[1] Strategy for Reducing Risk from Natural Hazards in Charlestown, RI, September 1997.
[2] Tobin, Graham A. and Burrell E. Montz. 1997. Natural Hazards: Explanation and Integration. New York: The Guilford Press. p. 5.
[3] ESRI. "GIS for Emergency Management", July 1999.
[4] Tobin, Graham A. p. 6.
[5] ESRI.
[6] ESRI.

National Flood Insurance Program (NFIP)

Westerly, along with all of Rhode Island's other municipalities, participates in the NFIP. This program is a direct agreement between the Federal Emergency Management Agency (FEMA) and the town that flood insurance will be made available to home owners and businesses in exchange for community compliance with minimum floodplain management regulations. Communities participating in the NFIP must:

- Appoint a local NFIP Coordinator;
- Adopt Flood Insurance Rate Maps (FIRMs) dated October 16, 2010 as a local overlay zoning district;
- Require that all new construction or substantial improvement to existing structures in flood hazard areas and velocity zones be elevated or if non-residential, be flood proofed to the identified level on FIRM maps. The most recent CAV was held on August 13, 2008 where verification of compliance action through the building officials was shown to be in line with NFIP compliance requirements;
- Require design techniques to minimize flood damage for structures being built in high hazard areas, such as floodways or velocity zones. This is accomplished with the adoption of a new floodplain ordinance which is over and above NFIP compliance.

Because Westerly has adopted these standards, any structure is eligible for protection by flood insurance, which covers property owners from losses due to inundation from surface water from any source. NFIP participation by Westerly is essential to ensure that federally backed mortgages and loans can be used to finance flood prone property.

NFIP Community Rating System

FEMA's Community Rating System (CRS) encourages municipalities to voluntarily perform activities that exceed minimum standards of the NFIP described above. Westerly is in basic compliance with NFIP and is eligible to apply for participation in the CRS. Each flood mitigation-related activity conducted by the Town, including preparation of this plan, earns CRS credit points towards a rating for the community. Based on this rating, flood insurance premiums for residents and businesses may be reduced by 5 to 45 percent.

Eligibility for Federal Hazard Mitigation Grants

The Federal Disaster Mitigation Act 2000 (P.L. 106-390) requires local municipalities to adopt local mitigation planning requirements as part of a comprehensive hazard mitigation strategy, in order to continue to receive public disaster assistance. This natural hazard mitigation strategy will help Westerly qualify for federal grants, including Pre-disaster Mitigation (PDM) funds, Flood Mitigation Assistance (FMA) grants, and post-disaster Hazard Mitigation Grant Program (HMGP) grants that are provided by FEMA in partnership with the RI Emergency Management Agency (RIEMA). These grants, which generally require a 25 percent local cash or in-kind match, are specifically directed towards reducing future hazard losses, and can be used for projects protecting property from the damaging effects of hurricanes, floods, earthquakes, wind and other hazards.

Post-Disaster Assistance

In assessing requests for disaster-related assistance, FEMA and the Town of Westerly will use this plan for guidance in prioritizing short-term needs and long-term hazard mitigation measures, utilizing funding to be provided after a formal disaster declaration.

Section 2: Risk Assessment

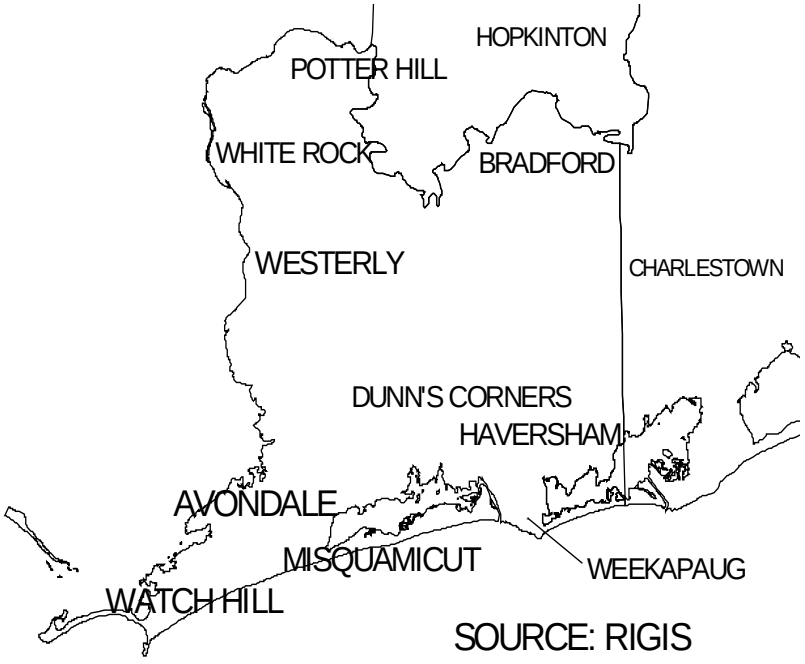
Westerly's Geography & Hazard Vulnerability

Westerly is a coastal community located in the southwest corner of Rhode Island that is bordered to the south by Block Island Sound and to the west and north by the Pawcatuck River. A key distinguishing feature of Westerly is its extensive system of Atlantic coast beaches, which for over a century has made the town a primary destination for tourists and seasonal residents.

Figure 1 – Westerly's Location

The official population of Westerly based on the 2000 Census is 22,966 – an increase of 6.3 percent from 1990 (2010 Census figures have not been released to date). However, this figure belies the fact that the Census only counts a person's primary residence. Many of the homes located in particularly vulnerable areas of the community – particularly Watch Hill, Misquamicut, Weekapaug and Shelter Harbor – are seasonally occupied during the summer, effectively doubling Westerly's year round population. These coastal villages are also the areas where much of the town's residential development is occurring, either as new construction or as substantial upgrades to existing structures.

Figure 2 – Westerly's Neighborhoods



Watch Hill, located in the southwestern portion of the town, is situated on an exposed peninsula bounded by the open ocean and Little Narragansett Bay. Further east, a series of brackish estuarine embayments – known locally as salt ponds – are separated from the ocean by narrow barrier beaches or spits, most of which have extensive commercial and / or residential development. The exposed position of this development creates unique challenges to hazard mitigation. For example, in an emergency, waterfront residents who ignore evacuation warnings could easily be cutoff from escape through excessive roadway flooding or bridge failure.

During a coastal storm such as a hurricane or a nor'easter, the Pawcatuck River is vulnerable to flooding from a combination of effects. Heavy rains in the watershed will result in higher water levels due to runoff, as documented by the flooding experienced from March 30 – April 2, 2010. Depending on the tides, a storm surge moving upriver from the coast could also raise the level of the river, as occurred during the 1938 hurricane, resulting in significant inland flooding as the Pawcatuck River exceeds its boundaries. This is a particular concern for Westerly's historic downtown, which has been designated by the National Trust for Historic Preservation as one of America's "distinctive destinations." Due to the town's economic dependence on tourism, key issues in the event of a hurricane include the evacuation of visitors that may be unfamiliar with Westerly, and the need for rapid recovery in order to sustain economic well-being.

> "As the pressure to develop the coastline increases it becomes even more important to identify high risk areas. Once these areas have been identified policies can be developed to avoid flood losses, particularly repetitive losses."

Westerly's total land area is approximately 30 square miles, of which about 2.5 square miles is protected open space; much of this protected land is located in areas subject to coastal or riverine flooding, and is owned by the State of Rhode Island or various non-profit land trusts. The town's overall density is 763 people per square mile; however, this density varies considerably by location. The most populated area is Census Tract 508.01, which encompasses the downtown and North End neighborhoods, with about 4,400 people per square mile. In contrast, Census Tract 510, encompassing Watch Hill, Misquamicut and Weekapaug, has a density of 326 people per square mile.[7] However, due to large numbers of seasonally occupied dwellings, population density in these coastal Census Tracts more than doubles during the summer months.

Some additional characteristics of the town deserve mention. Westerly is Washington County's major transportation center, featuring a railroad station located on Amtrak's Northeast Corridor and a state airport. Also, the town's thickly settled downtown center and busy coastal roadway network are vulnerable to traffic congestion particularly during morning and afternoon commutes throughout the year and on summer weekends. In the event of a natural disaster Westerly must coordinate interstate response and recovery efforts with the Connecticut border towns of Stonington and North Stonington, with a particular focus on maintaining these critical transportation links. Of particular concern are four bridges spanning the Pawcatuck River that are located in a FEMA-designated flood hazard zone that connect Westerly with these two towns.

Natural Hazard History in Westerly

Five intense hurricanes occurring in 1635, 1638, 1815, 1869, and 1938 have made landfall on the New England coast since European settlement. Historical records indicate that four of these hurricanes (1635, 1638, 1815, and 1938) and hurricane Carol, a strong category 2 storm in 1954,

[7] U.S. Census Bureau. 2000.

produced significant storm surges (>3 m) in southern Rhode Island. Storm surges of this magnitude can overtop barrier islands, removing sediments from the beach and nearshore environment and depositing overwash fans across back-barrier marshes, lakes, and lagoons. In a regime of rising sea level, accumulation of marsh, lake, or lagoon sediments on top of overwash deposits will preserve a record of overwash deposition. Hurricanes and their associated high winds and flooding pose the greatest natural hazard threat to Westerly, as evidenced by the following table summarizing significant hurricanes since 1935.

Table 1 – Significant Rhode Island Hurricanes from 1935 to 2001

Date	Name	Storm Category	Winds (Mph)	RI Property Damage ($ Million)	Deaths
September 21, 1938	New England	3	95	100	262
September 14, 1944	Great Atlantic	3	82	2	0
August 31, 1954	Carol	2	110	90	19
September 11, 1954	Edna	1	40	0.1	0
August 19, 1955	Diane	1	45	170	0
September 12, 1960	Donna	2	58	2.4	0
August 10, 1976	Belle	3	105	n/a	0
September 27, 1985	Gloria	2	81	19.8	1
August 19, 1991	Bob	2	63	115	0

The Great New England Hurricane of 1938

On September 21, 1938, the Great New England Hurricane came ashore with a storm surge of over 12 feet above the astronomically high tide that was occurring at the time of impact. This wind-driven storm surge wiped out all of Napatree Point and Fort Road in Watch Hill causing 24 deaths, heavily damaged or destroyed many of the vessels in Watch Hill Cove and the winds caused extensive damage to the hamlet. But the death and destruction was not limited to Watch Hill. Misquamicut took a very hard hit with over 50 deaths and 500 cottages destroyed as storm driven waves passed completely over the narrow barrier beach protecting normally tranquil salt ponds. Streams within the Pawcatuck River watershed were swollen by nearly seven inches of rainfall in three hours, and as the storm surge moving upriver met this floodwater, many downtown Westerly homes and businesses were flooded with water up to 8 feet deep. The high winds flattened trees, steeples, and telephone poles throughout the town. As a result of this storm, Sandy Point was severed from Napatree Point, and another breach way opened up in Weekapaug. The town as a whole was crippled for weeks on end due to this benchmark storm.

Figure 3 – Misquamicut Headland after Hurricane Carol in 1954. Note the houses damaged by storm surge several blocks inland.

Hurricane Carol (1954)

During the years following World War II, many structures were built on the shore in locations leveled by the 1938 hurricane. In 1954, on the heels of a post-war building boom, Hurricane Carol hit at the astronomical high tide, creating a storm surge of about 11 feet. Extensive damage resulted; however, due in part to the warning system which had been implemented by the National Weather Service after the 1938 storm, there were far fewer deaths associated with Carol.

Figure 4 – Breach in Misquamicut Barrier after Hurricane Carol in 1954. Note the houses in the salt marsh and pond.

Other Notable Hurricanes

The Great Atlantic Hurricane (1944), and Hurricanes Donna (1960), Belle (1976), Gloria (1985), and Bob (1991) all affected southern Rhode Island with heavy rains and high winds, but each came ashore at off tides and the physical damage caused was far less than those of 1938 and 1954. Most reported damage occurred in Misquamicut Beach, concentrated along the barrier spit separating the open ocean from the salt ponds.

Blizzard of 1978

The Blizzard of 1978 roared in and out of Westerly, leaving 24 inches of snow in its wake that had to be cleared away. The region was at a standstill for nearly one week, while heavy equipment cleared each street. The greatest impact was on municipal budgets and wear and tear on public works department vehicles.

Nor'easters

The Halloween Storm of 1991 was a strong extended nor'easter. This storm caused flooding in the tidal areas of the Pawcatuck River and over wash of the dunes along Atlantic Avenue in Misquamicut Beach during times of high tide. This in turn caused the flooding of up to one third of the residential area of Misquamicut and damage to many of the businesses in the area.

Spring Floods of 2010

The Spring Floods of 2010 dealt a devastating blow to the Town of Westerly and particularly the North End Neighborhood, Bowling Lane in Bradford, Bradford Dye Associates and Canal Street. These areas are major manufacturing hubs and are the most densely populated areas of Low-Moderate populations. In addition, the more rural areas of town around Chapman Pond, Newton

Marsh and Aguntaug Swamp were impacted along with the Town's animal shelter, DPW and landfill area. This storm event ranged from a 100-500 year storm event.

Property Damage & Flood Insurance Claims

Presently, one third of the National Flood Insurance Program repetitive loss claims in Rhode Island come from the four towns along the Rhode Island south shore including Westerly. Although the dollar values of property damage from weather events can be difficult to accurately measure, the following table summarizes the damage from some recent events in Washington County.

Table 2 – Property Damage from Recent Weather Events in Washington County

Date	Cause	Property Damage
January 7, 1994	Ice Storm	$500,000
August 24, 1996	ThunderstormWinds	$750,000
April 1, 1997	Heavy Snow	$700,000
February 18, 1998	Flash Flood	$400,000
June 11, 2001	Lightning	$10,000
March 6, 2003	Heavy Snow	$290,000
November 13, 2003	High Wind	$350.000
March 8, 2005	High Wind	$150,000
March 28, 2005	Flooding	$50,000
September 29, 2005	Flooding	$5,000
October 15, 2005	Flooding	$160,000
December 9, 2005	High Wind	$140,000
January 15, 2006	High Wind	$15,000
February 12, 2006	Heavy Snow	$70,000
October 28, 2006	High Wind	$15,000
October 28, 2006	Flooding	$2,000
April 16, 2007	High Wind	$15,000
April 16, 2007	Flooding	$10,000
February 18, 2008	High Wind	$3,000
March 8, 2008	High Wind	$5,000
December 19, 2008	Heavy Snow	$1,000
July 1, 2009	Flash Flood	$20,000
December 3, 2009	High Wind	$15,000
March 13, 2010	High Wind	$50,000
March 14, 2010	Flood	$40,000
March 29, 2010	Flood	$24,800,000
	Total Cost	**$28,566,000**

Source: National Climate Data Center

Flood insurance is required only if federally insured or guaranteed financing is used for structures located in FEMA-designated "A" or "V" flood hazard zones. However, the number of flood insurance policies and the value of the property covered in Westerly give an indication of the vulnerability of the community to flooding. Westerly ranks fourth in the state in number of total policies behind Warwick, Newport, and Narragansett. In terms of value of property covered, Westerly ranks third in the state, behind only Warwick and Narragansett. Since 1978, Westerly has accounted for over one-third of all claims made in Washington County. The following table summarizes flood insurance policy data for Westerly and its surrounding regions.

Table 3 – National Flood Insurance Summary
Program Activity (As of 9/30/2010)

	Total Policies	Total Annual Premiums	Claims Since 1978 (Amount paid)
Town of Westerly	1,193	$287,484	441 ($6,765,251)

Source: Federal Emergency Management Agency – National Flood Insurance Program

Within Westerly, the amount of property damage is most commonly reflected by the number of repetitive loss insurance claims filed under the NFIP. Most structures that are located within designated flood hazard zones are protected by coverages available under the National Flood Insurance Program. This insurance reimburses all covered losses up to $250,000 for homeowners and $500,000 for non-residential buildings including businesses.

When two or more claims within 10 years are made on a specific property that exceeds $1,000 per claim, such damage is categorized as a repetitive loss. Repetitive losses are one indication of vulnerable areas in the community. According to FEMA, Westerly had 38 repetitive loss properties, primarily residential, that have made 130 claims this year, with 441 since 1978, primarily in the vicinity of Atlantic Avenue.

Section 3: Natural Hazard Assessment

Important Definitions

100-Year Flood

The term "100-year flood" is misleading, since it implies that a flood event of this magnitude will occur like clockwork, precisely every 100 years. Rather, this term refers to a flood event that has a 1-percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time; also, depending upon the characteristics of natural topography or a particular storm, it may occur in one portion of the community but not another. The 100-year flood, which is a standard measure adopted by federal and state agencies, is used by the NFIP as the standard for floodplain management and to determine the need for flood insurance. A structure located within a special flood hazard area shown on an NFIP map has a 26 percent chance of suffering flood damage during the term of a 30-year mortgage.[8]

Flood Insurance Rate Maps

The Federal Emergency Management Agency has issued Flood Insurance Rate Maps (FIRMs) for Westerly's coastal and inland areas. These maps indicate the generalized location of designated flood zones and can be used to determine the estimated likelihood of flooding for specific areas. There are nineteen such maps, also known as Panels, covering the Town of Westerly. The two northern most panels, which cover the Pawcatuck River watershed, were last revised in February 1986, while the two southern panels, which cover the coastal areas of Watch Hill, Misquamicut, Weekapaug and Shelter Harbor, were last revised in 1992, 1993, with the latest revisions adopted on October 19, 2010.

As shoreline erosion occurs, the location of flood zones and boundaries will change. For example, a house in Misquamicut Beach that was located in an "A" flood hazard zone when the FIRM map was developed, may be located in a "V" zone by the year 2015. Furthermore, as road pavement and impervious surfaces associated with development replace forests and fields, a house which is currently located out of the floodplain entirely, may be located within the 100-year flood hazard zone within 30 years.

The Government Performance Results Act and the Federal Office of Management and Budget both have performance guidance suggesting that the average age of FIRMs be seven years or less, whereas the age of Westerly's FIRMs is currently from 10 to 17 years. And because of their unusual scale (1 inch = 800 feet), FIRMs can be difficult to use with a high degree of accuracy. New digitized maps into a GIS format have been completed and will greatly enhance the usability of the FIRMs. Locally, Westerly has implementation a municipal GIS that will contribute to the accuracy of future risk assessments, since FIRM data could then be linked with individual property boundaries.

If a person believes that their property has been incorrectly included in a designated flood zone, a Letter of Map Amendment (LOMA) can be requested from FEMA. This will prompt a review of

[8] Federal Emergency Management Agency. National Flood Insurance Program. 2002. "Ask the Expert" website.

available data and may lead to a map alteration. The fact that there have been ten individual LOMAs issued in Westerly since 1980 indicates that some inaccuracies exist in Westerly's FIRMs.[9] The amendments that have been approved by FEMA will be incorporated into the updated set of maps.

Flood Zone Definitions

Flood zones utilize a letter classification system to categorize different floodplain areas. The various zones found in Westerly are summarized in the following table.

Table 4 – Westerly's Flood Hazard Zones

Zone	Explanation
A	Areas of 100-year flood, mapped by approximate methods; base flood elevations (BFEs) are not determined.
A1-A30	Numbered A zones in which the number represents the BFE.
AE	The base floodplain where base flood elevations are provided; replaces A1-A30 zones on new FIRMs.
AO	Areas of 100-year shallow flooding where depths are between one and three feet.
AH	Shallow flooding base floodplain; BFEs are provided.
V	Velocity Zone -- The coastal area subject to a velocity hazard (wave action) where BFEs are not determined.
V1-V30 VE	The coastal areas subject to a velocity hazard (wave action) where BFEs are provided on the FIRM.

Source: Federal Emergency Management Agency

Base Flood Elevations

Base Flood Elevation (BFE) as depicted on FIRMs, refers to the maximum height in feet above mean sea level (determined from the National Geodetic Vertical Datum of 1929) that a 100-year storm event is expected to reach at a particular location, either from a coastal storm surge or from inland stream or river flooding. With the revision to the FIRMs, new Base Flood Elevation (BFE) shall be determined using North American Vertical Datum 88 (NAVD88) rather than the current use of the National Geodetic Vertical Datum of 1929.

However, it is important to recognize that there is actually a range of floods, other than just the 100-year flood. For example, a house located close to a barrier beach might experience some level of flooding every 5 to 10 years, resulting in much greater risk to the structure than the 100-year flood. It is these more frequent events that generate the greatest amounts of repetitive loss flood insurance claims.

Rating Hurricane Intensity

As with other types of natural disasters, hurricanes are rated according to their intensity and potential damage, illustrated in the following table. The Saffir/Simpson Hurricane-Scale ranks the intensity of hurricanes, both in terms of wind speed and magnitude of storm surge, with a

[9] RIEMA. State Floodplain Manager.

Category 1 storm the least intense, and a Category 5 storm having the greatest intensity and capacity for damage.

Table 5 - Saffir/Simpson Hurricane-Scale Ranges

Scale Number (category)	Wind Speed (mph)	Storm Surge (ft.)	Potential Damage
1	74-95	4-5	*Minimal:* No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also, some coastal flooding and minor pier damage.
2	96-110	6-8	*Moderate:* Some roofing material, door, and window damage. Considerable damage to vegetation and unanchored structures. Flooding damages piers and small craft in unprotected moorings may break their moorings. Coastal and low-lying escape routes flood 2-4 hours before arrival of the hurricane center.
3	111-130	9-12	*Extensive:* Some structural damage to small residences and utility buildings. Mobile homes are destroyed. Flooding near the coast destroys smaller structures with larger structures damaged by floating debris. Terrain may be flooded well inland. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the hurricane center. Evacuation of low-lying residences within several blocks of the shoreline may be required.
4	131-155	13-18	*Extreme:* Extensive damage done to roofs, windows and doors, with some complete roof structure failure on small residences. Shrubs, trees, and all signs are blown down. Complete destruction of mobile homes. Extensive damage to doors and windows. Major erosion of beach areas. Terrain may be flooded well inland.
5	>155	>18	*Catastrophic:* Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas on low ground within 5-10 miles of the shoreline may be required.

Sources: Saffir-Simpson Hurricane Scale – National Weather Service; Schwab, Jim. 1998. Planning for Post-Disaster Recovery and Reconstruction. Chicago: American Planning Association.

Natural Hazards Affecting Westerly

Hurricanes & Associated Coastal Flooding

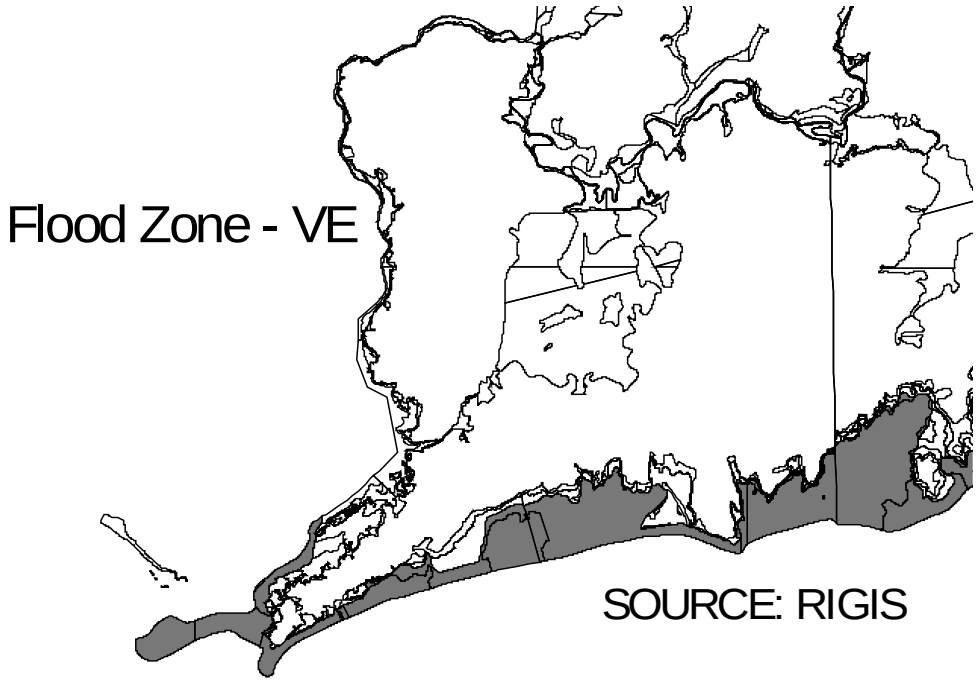
The east-west orientation of Rhode Island's south shore makes the area susceptible to hurricane damage. The hurricane track, scale and phase of the tidal cycle at landfall are critical to the amount and type of damage that is sustained. In the northern hemisphere, winds circle in a counterclockwise direction around a low-pressure center known as the eye. A storm with the eye tracking to the west of Rhode Island will result in the highest storm surges along the south shore. The forward momentum of the storm combined with the hurricane force winds circulating the eye pushes the ocean water mass onshore creating an elevated water surface. The most damaging storm surges occur when the hurricane landfall coincides with a monthly high tide.

When the eye passes to the east, the hurricane force winds blow in the opposite direction to the forward velocity of the storm. Storm surge is not so pronounced. However, the heaviest precipitation is usually associated with the western part of the storm so inland flooding is more

severe. Storm surge is the most damaging element of a hurricane. Defined as a wall of water made up of breaking waves, storm surge is caused by two forces. First, low pressure at the center of the hurricane elevates the water surface by about a foot for each inch drop of atmospheric pressure.[10] The second force – wind – pushes water against the shoreline, and is a key reason why storm surge is greater to the east of the eye. If hurricane landfall coincides with the time of high tide, the storm surge combines with the higher water level, resulting in greater devastation of the shore and inland areas. As indicated in the following figure, the velocity zone within which a storm surge could occur, potentially affects large numbers of coastal properties with elevations of less than 20 feet above sea level.

In Westerly, the coastal barrier beaches that separate the Maschaug, Little Maschaug, Winnapaug and Quonochontaug Ponds from Block Island Sound have all been designated "V" zones, as are lands located immediately north of the northern shorelines of these salt ponds. Other "V" zone locations include Napatree Point, Watch Hill Point, both sides of Atlantic Avenue in Misquamicut Beach, and portions of Weekapaug to the south of Wawaloam Drive and Ninigret Avenue. FEMA-designated "A" zones are much more expansive, and include low-lying portions of Watch Hill, portions of Misquamicut Beach located some distance inland from the ocean, and a large number of properties located between the north side of the salt ponds and Shore Road (Route 1A).

Figure 5 – Velocity (V & VE) Flood Zones in Westerly



[10] Monmonier, Mark. 1997. Cartographies of Danger: Mapping Hazards in America. Chicago: University of Chicago Press. p. 69.

Riverine Flooding

While riverine flooding in Westerly is a typical by-product of coastal storms and hurricanes, it can also occur during late winter due to melting snow, ice and persistent spring rain. The effect of such flooding includes retaining wall and building foundation damage, road damage, and ice or water-borne debris buildup against bridge structures.

The primary freshwater body in Westerly that is susceptible to flooding is the Pawcatuck River, whose watershed covers an area of 486 square kilometers, or 188 square miles.[11] It extends north into Rhode Island and west into Connecticut, encompassing all or part of twelve different municipalities. In 1978, 1982 and again in 2010 heavy rains caused the Pawcatuck River to flood its banks. These events caused road blockages along Route 91 between Westerly and Bradford, and along Canal Street, which included the complete failure of the National Grid substation that disabled power to the entire area, and Industrial Drive in the North End. Several businesses were flooded out and one building suffered a partial collapse. Many inland areas of Westerly subject to riverine flooding have been designated "A" zones, including low-lying areas along the Pawcatuck River (including portions of Downtown Westerly, the North End neighborhood, White Rock and Bradford), Mastuxet Brook, and Chapman Pond.

Westerly has several dams spanning the Pawcatuck River, constructed over a century ago to provide hydropower to adjacent textile mills. Each dam presents a varying degree of hazard, should it be overtopped or breached during flooding, with inundation areas potentially larger than the FEMA designated 100-year floodplain. It is recommended that Westerly develop Emergency Action Plans for these dams, which delineate the inundation areas and impacts to property should these dams fail or are overtopped. Such dam failures occurred in 2010 inundating the entire North End, Canal Street, and Industrial Drive.

Flood conditions are exacerbated by constriction of river waters that can occur when large amounts of ice or debris such as fallen trees, tree limbs pile up behind low-lying bridge decks or narrow bridge spans. There are nine bridges located on Westerly's section of the Pawcatuck River, several of which date to a period before structures were designed to pass floodwaters from a 100-year storm event. The collapse of one of these structures could cause a downstream catastrophe, as a flood surge laden with trees or buildings pile up against the next dam or set of bridge abutments.

Other than Westerly's downtown and adjoining neighborhoods, land use within the watershed consists primarily of forested, rural, or suburban residential areas. Several sizable areas are protected as open space, the largest being the Arcadia Management Area. However, southern Rhode Island is one of the fastest growing areas in New England, and intense development that is taking place throughout the watershed is increasing the amount of impermeable surface. Unless properly detained at the point where construction is taking place, the increased rates and amounts of storm water runoff will make the Pawcatuck River more prone to flooding during increasingly less significant storm events.

[11] Dillingham, Timothy P. 1993. The Pawcatuck River Estuary and Little Narragansett Bay: An Interstate Management Plan. Rhode Island Coastal Resources Management Council & Connecticut Department of Environmental Protection.

Nor'easters & Winter Storms

New England's "nor'easters", can at times be more destructive than hurricanes. This is due in part to their large size and slow speed, but also because they can form with little advanced notice, which limits time for preparedness. Typically occurring between November and March, nor'easters bring high winds and heavy prolonged precipitation.[12] These storms can also lead to severe weather conditions including heavy snowfalls, ice buildup, tree damage and power outages. However, not all of these storms will strike Westerly directly, and the storms will vary in intensity. The following table summarizes recent severe storms affecting Westerly and surrounding towns.

Table 6 – Recent Severe Storms

Date	Type	Storm Name
February 1, 1969	Winter Storm	n/a
February 2, 1976	Winter Storm	Groundhog Day Storm
February 1, 1978	Winter Storm	Blizzard of '78
January 1, 1987	Winter Storm	n/a
October 31, 1991	Nor'easter	Halloween Storm
December 11, 1992	Nor'easter	n/a
March 13, 1993	Winter Storm	Super storm
December 23, 1994	Winter Storm	Christmas Weekend
January 7, 1996	Nor'easter	n/a

Westerly is also susceptible to heavy amounts of snowfall, which can restrict travel and damage power lines and trees, effectively paralyzing the region. The following table summarizes the dates and snowfall amounts of recent significant storms in Washington County.

Table 7 – Recent Significant Snowstorms in Washington County

Date	Snowfall (Inches)
February 7, 2003	6-12
February 17, 2003	15
March 6, 2003	6-10
December 5, 2003	10-20
December 26, 2004	6-10
January 22, 2005	15-25
February 12, 2006	9-14
December 19, 2008	8-112
December 31, 2008	4-10
March 1, 2009	7-12

Source: National Climate Data Center (NCDC)
Note: NCDC began reporting snowstorm data in 1994

[12] Monmonier, Mark. Pg. 72.

Coastal Erosion & Sea Level Rise

Coastal erosion threatens both waterfront property and fragile shoreline habitats, and can affect Westerly's shoreline even during moderate coastal storms. In addition, the predicted increase in global sea-level rise will exacerbate coastal erosion as lower intensity storms cause greater amounts of damage and flooding than their historic counterparts. [13]

Global warming refers to the rise in the Earth's temperature, which has warmed by about 1 degree F over the past 100 years, and is expected to increase an additional 2 to 6 degrees F over the next one hundred years. As global temperatures rise, sea level rise rates are expected to increase, both because the ocean will get warmer and more ice will melt. Accelerated sea level rise estimates for Rhode Island project a rise of 18 inches by the year 2100.[14] This is a major concern for Rhode Islanders because of potential adverse impacts such as more common flooding of coastal areas, saltwater intrusion into drinking water supply, extreme weather events and damage to local crops. Due to global warming, water shortages may become more frequent, leading to more restrictions on local water usage. Homes along the coast may be threatened by sea level rise and an increase in storm intensity.[15]

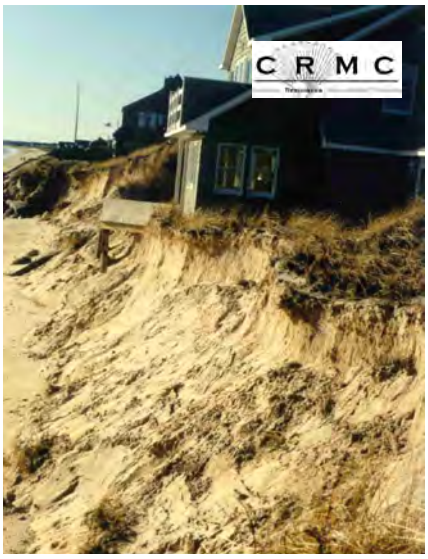


Figure 6 – Dune erosion after 1991 Nor'easter.

> "Today's coastline is of economical, social, cultural, and environmental value to communities and to nations. However, shorelines are dynamic and ephemeral places where erosion trends tend to dominate. Development along the shore places the desires of man (to have a safe and stable home) in direct opposition to the natural trends of nature (to erode, transport, and deposit coastal lands)."
>
> Joan Pope, U.S. Army Corps of Engineers

Of the six shoreline types found in Rhode Island, beaches and barrier spits are the most susceptible to erosion. About seven of Westerly's nine miles of coastline are comprised of these unconsolidated sediments (exceptions are rocky headlands located at Watch Hill Point and Weekapaug Point). The RI Coastal Resources Management Plan (CRMP) includes shoreline change maps for the Rhode Island south shore that span the time period from 1939 to 1985, based on a chronological sequence of aerial photographs taken after the hundred year storm of record, the 1938 hurricane. These have been used to create coastal erosion maps that depict predicted future changes to the shoreline – principally an inland movement of the high water

[13] RICRMC. April 12,1999. Rhode Island's Salt Pond Region: A Special Area Management Plan (Maschaug to Point Judith Ponds.(Still in force)

[14] Boothroyd, J. C., Klinger, J. P. and Galagan, C. 1998. Coastal geologic hazards on the south shore of Rhode Island *in* Guidebook to field trips in Rhode Island and adjacent regions of Connecticut and Massachusetts: 1998 New England Intercollegiate Geological Conference, 90th Annual Meeting, University of Rhode Island, Kingston, RI.

[15] Rhode Island Department of Environmental Management. Fact Sheet: Global Warming/Greenhouse Gases.

line – for the years 2020 and 2100. Copies of the seven CRMP maps for Westerly are found in the Appendix. Since 1985, however, several major winter storms, less severe hurricanes (Category 2) and tropical storms have impacted the Rhode Island south shore. Consequently, the shoreline change rates currently used for Westerly may be underestimated.

A key mitigation measure against coastal erosion and flooding is the adherence to CRMC's established coastal buffer zones and setbacks when siting new residential or commercial development[16]. Other mitigation measures include acquisition of property that is susceptible to erosion by the Town or by community land trusts, and managing the property as open space. Such land purchases, coupled with dune restoration and/or the planting of native coastal vegetation, can reduce coastal erosion by stabilizing soil along the shore. CRMC now requires dune restoration as part of any land development project along the ocean side of Atlantic Avenue.

Dam Failure

Although such an event has never occurred in Westerly, extreme flooding conditions or the sudden build up of flood borne debris has the potential to cause dam failure. The spring rains of 2010 caused the failure of Blue Pond Dam in Hopkinton. This dam failure caused a surge of water that incapacitated the National Grid substation on Canal Street and flooded the Canal Street manufacturing district and the North End Neighborhood. Of concern to Westerly are three dams spanning the Pawcatuck River that were constructed to provide hydropower to textile mills. Characteristics of these three dams are outlined in the following table.

Table 8 – Pawcatuck River Dams in Westerly

Name	Date Built	Length (ft.)	Height (ft.)	Drainage Area (Sq. mi.)	Owner	Hazard	Spillway Height (ft.)	Spillway Width (ft.)
Bradford Pond	unk.	200	9.5	219	Bradford Dyeing Assoc.	Low	6	80
Potter Hill	1903	112	10	204	Unknown	Low	8	81
White Rock	1930	438	8	292	Griswold Textiles	Low	6.5	113

Source: Rhode Island Department of Environmental Management

The RI Department of Environmental Management (RIDEM) manages the state's Dam Safety Program. The hazard classification of Westerly's Pawcatuck River dams as "low" indicates that their failure would result in no apparent loss of life and only minimal property damage. Dams classified as low hazard are not subject to routine safety inspections; however, RIDEM will conduct an inspection upon request of the owner, the town, or any property owner subject to potential damage stemming from failure of the dam.[17] Dam owners are ultimately responsible for the safety of their dams.[18]

[16] RICRMC. 1996. The State of Rhode Island Coastal Resources Management Program.
[17] State of Rhode Island, Department of Environmental Management. 2001. Annual Report to the Governor on the Activities of the Dam Safety Program.
[18] State of Rhode Island, Department of Environmental Management. 2001. Governor's Task Force on Dam Safety and Maintenance, Final Report.

Thunderstorms & Tornadoes

Thunderstorms, with their accompanying heavy rains and high winds can cause damage such as drainage system failure and localized flooding, downed tree limbs and power outages. Associated microbursts and hail are a particular threat. In 1989, a microburst occurring during a severe thunderstorm blew the roof off of a building in Watch Hill. Eleven months later another microburst flattened a small motel in the Misquamicut area, damaged a house on Shore Road, and lifted the roof off a sports complex in Dunn's Corners. Other structures received minor damage and many trees were either damaged or knocked down along the system's path. This single event caused about $250,000 in damage.

Another potential effect from thunderstorms is hail. Since this is considered a random event, Westerly is subject to the same risk from hailstorms as is Rhode Island as a whole. The following table summarizes recent hailstorms in Washington County.

Table 9 – Recent Hailstorms in Washington County

Date	Magnitude (Size in inches)
June 30, 1998	2.75
May 24, 2000	0.88
May 23, 2004	0.75
July 18, 2006	1.00
June 24, 2008	1.75

Source: National Climate Data Center (NCDC)
Note: NCDC began reporting hailstorm data in 1956

Eight reported tornadoes touched down in Rhode Island between 1950 and 1994, resulting in 23 injuries and nearly $2 million in damage. However, these statistics rank Rhode Island among the lowest in the United States in terms of tornado frequency and intensity. In addition, none of the reported tornadoes occurred in Washington County. Since tornadoes strike at random, the entire town of Westerly is at an equal risk of experiencing the effects of a tornado.

Current Rhode Island building design requirements use a design wind speed of 120 mph., (Category 3 hurricane) is considered effective in preserving structures from less severe categories of tornadoes and all but the most severe microbursts. However, the likelihood tornado or microburst remains too low to warrant specific additional mitigation measures actions.

Heat Wave

A heat wave is defined as three or more consecutive days on which the maximum shade temperature reaches or exceeds 90 degrees. The potential effects of heat waves include increased wildfire hazard, increased demand on water supply, and electricity brown outs. In addition, heat waves can result in loss of life due to overheating; the elderly are particularly susceptible to heat-related illnesses. The primary mitigation measure against heat waves is an alert system to warn residents of the potential threat. Residents at risk of heat-related illnesses should be advised to seek cooler environments in extreme conditions.

Drought

A drought is defined as a period in which rainfall is significantly below normal for a given area. Based on this description, the state of Rhode Island has experienced a severe drought approximately once every forty years, the last occurring in the 1960's.[19] Droughts are particularly critical to Westerly since the entire community relies on groundwater resources for its water needs, and a lack of rainfall threatens the availability of this source. Westerly's Superintendent of Utilities cooperates with the RI Water Resources Board (RIWRB) to determine if water restrictions are necessary to conserve water. Rainfall levels for a six-month period and water levels within community water supply wells are measured when determining the need for water restrictions. To ensure enforcement, such restrictions are put into the form of an ordinance enacted by Westerly Town Council.

Urban-Wildland Interface Fire

An urban-wildland interface fire is an uncontrolled wildfire in a geographical area where structures and other human development meet or intermingle with vegetative fuels, possibly consuming structures in its path. Wildfires are fueled by both native and non-native species of grasses, brush, and trees.[20] The vegetative fuels found in Westerly are classified as Light based on the National Fire Danger Rating Fuel Model Map.[21] However, severe and prolonged droughts increase the likelihood of wildfires regardless of the area vegetation.

Fires in New England exhibit a behavior very different from those occurring in the western United States, in that they are of much shorter duration and cover smaller areas. Specifically in Rhode Island, portable pumps and forestry hose are used to successfully attack a wildfire directly at its location. This approach differs from a strategy of containment often employed in the West, consisting of mechanical firebreak construction and back burning.

The likelihood of fire varies based on a number of weather-related factors. Drought leads to increasing dryness, which affects how deep in the vegetation the fire will burn. Wind speed influences direction and speed of the spread of wildfire. Both temperature and humidity affect the likelihood of wildfire; warmer and dryer weather can result in increased fire danger. Locations in Westerly most vulnerable to wildfire include the Woody Hill Management Area and the Town Forest that are inaccessible to motor vehicles. Other critical areas are the coastal grasslands in vicinity of Avondale, Watch Hill and the salt ponds. While these grassland areas are relatively small in size, the real danger associated with wildfire is the potential for its spread to nearby structures. While coastal grasslands are generally accessible to fire apparatus, they may be located some distance from hydrants, necessitating the transport of water to burning vegetation.

In Westerly, many of the areas most susceptible to wildfire are owned by land trusts dedicated to the preservation of open space. Wildfire response efforts would be enhanced by having each

[19] "Is Rhode Island Facing a Drought?" Rhode Island Statewide Planning Program Quarterly Progress Report. Number 403. January – March 2002.
[20] FEMA. State and Local Mitigation Planning how-to guide: Understanding Your Risks.
[21] USDA Forest Service. 1999. NFDR Fuel Model Map. http://www.fs.fed.us/land/wfas/fuels/fdfuel.gif.

land trust formally adopt a wildfire management policy in concert with the appropriate local fire district.

A specific problem in rural areas faced by fire fighters is inadequate posting of street addresses for residential properties. Without property markers, emergency response personnel may waste valuable time when trying to find direct access to a fire. This is especially true when residential properties are setback some distance from the road and hidden behind vegetation. This is easily remedied by requiring property owners to post address numbers that are visible from the street.

Earthquakes

The sudden motion or trembling that is associated with an earthquake can come without any warning and its effects can be experienced some distance from its epicenter. In April 2002, an earthquake occurred centered near Plattsburg, New York, tremors from which were felt as far away as Rhode Island.

All but the northeast corner of Rhode Island has been classified by USGS as an area with a peak acceleration of 3%g, or three percent of acceleration due to gravity with ten percent likelihood that this peak will be exceeded in a fifty-year period.[22] While this constitutes a relatively low hazard, Rhode Island does have a history of earthquakes. The largest recent earthquake in Rhode Island was on March 11, 1976, an event centered in Newport.[23] Based on the continuing possibility of effects from an earthquake, Rhode Island building codes enforce higher seismic requirements for buildings which have a substantial public hazard, based either on their occupancy or their use.

Tsunami

A large destructive traveling ocean wave caused by an underwater earthquake or another movement of the Earth's surface is the phenomenon called a tsunami**.** Underwater volcanic eruptions and landslides can also generate tsunamis. In the deep ocean, their length from wave crest to wave crest may be a hundred miles or more but with a wave height of only a few feet or less. In deep water, the waves may reach speeds exceeding 500 miles per hour.

Tsunamis are a threat to life and property to anyone living near the ocean. Large tsunamis have been known to rise over 100 feet, while tsunamis 10 to 20 feet high can be very destructive and cause many deaths and injuries.

Rhode Island's chance of a tsunami is small but the threat does exist.

[22] USGS. 1996. Peak Acceleration (%g) with 10% Probability of Exceedence In 50 Years. http://geohazards.cr.usgs.gov/eq/hazmaps/050pga.gif.

[23] National Earthquake Information Center, USGS Earthquake Hazards Program. Largest Earthquake in Rhode Island. http://neic.usgs.gov/neis/eqlists/USA/1976_03_11.html.

Section 4: Risk Assessment & Vulnerability

Risk Assessment

In order to assess Westerly's vulnerability to identified hazards, NOAA's Community Vulnerability Assessment Tool was used to determine the frequency, area of impact and potential damage magnitude of each hazard. Evaluating the number of times that a certain category of natural hazard has impacted Westerly in the past provides a measure of the likelihood of the event occurring again in the future.

Table 10 – Natural Hazard Frequency Score

Approx. Recurrence (years)	Approx. Annual Probability	Subjective Description	Frequency Score
1	100.0%	Frequently recurring hazards, multiple recurrences in one lifetime	5
50	2.0%	Typically occurs at least once in lifetime of average building	4
100	1.0%	60% chance of occurring at least once in lifetime of average building	3
250	0.40%	25% chance of occurring at least once in lifetime of average building	2
500	0.20%	10% chance of occurring at least once in lifetime of average building	1
1000	0.10%	Highly infrequent events, like maximum considered earthquake	0

Source: David Odeh, Odeh Engineers, North Providence, Rhode Island and Pam Pogue, RI Emergency Management Agency

A second criteria used in evaluating Westerly's natural hazard vulnerability is to determine the impact, or size of the area affected by the disaster. Some hazards impact only a small area, while others can affect the entire region. The area of a single event's impact is assigned a rank, with higher scores for larger affected areas. Again, historical data is used to investigate damage and loss records of previous hazard events to develop an estimate of where expected impacts or the amount of property damage may occur from future events.

Table 11 – Area of Impact Score

Mean Affected Area (sq. miles) Per Event	Description	Area Impact Score
500	Regional impact (e.g. statewide)	5
100	County scale impact	4
50	Town scale impact	3
10	Single zip code impact	2
1	Highly localized (city block scale)	1

Magnitude criteria are used to determine the range of the severity of damage (from minor to devastating) expected from a single event. Previous damage reports and other historical data

(e.g., newspaper articles, personal accountings, video clips, etc.) are used to determine relative magnitudes.

Table 12 – Magnitude Score

Severity Score	Earthquake MMI	Hurricane SSI	Average Flood Elevation
5	12	5	18
4	9	4	15
3	7	3	12
2	5	2	8
1	4	1	4
0	3	0	0

Based on the results of the cumulative scores for frequency, area of impact, and magnitude, the following formula is used to prioritize the potential threat each hazard poses to Westerly.

(FREQUENCY + AREA OF IMPACT) X POTENTIAL DAMAGE MAGNITUDE = TOTAL SCORE

Table 13 – Risk Score for Westerly, Rhode Island

Rank	Hazard	Frequency	Area Impact	Magnitude	Total
1	Hurricane	4	3	3	21
2	Flooding	4	2	3	18
3	Storm Surge	4	2	3	18
4	High Winds	4	3	2	14
5	Snow/Ice Storm	4	3	2	14
6	Wildfire	2	1	4	12
7	Thunderstorm	3	2	2	10
8	Hail	2	2	2	8
9	Tornado	1	1	4	8
10	Earthquake	1	3	2	8
11	Drought	4	3	1	7
12	Dam Failure	2	1	2	6

A growing population and growing value of insured property increases Westerly's vulnerability to natural hazards. Since the highest ranked hazard – a hurricane -- cannot be prevented from occurring, the forces accompanying this hazard such as storm surge, wind, coastal erosion and flooding, can result in significant damage and destruction. However, much of the built environment's vulnerability can be attributed to inappropriately designed, built and/or located structures that result from not using the best available construction knowledge and practices.[24] Almost every planning and development decision made at the local level has implications for the vulnerability to, and impact of, a natural hazard event.

[24] Heinz Center for Science, Economics, and the Environment. 2000. The Hidden Costs of Coastal Hazards: Implications for Risk Assessment and Mitigation. Washington, D.C.: Island Press.

Vulnerability Assessment

Threats to the Built Environment & Future Development Trends

A vulnerability assessment of Westerly's built environment consists of a determination of property at risk, including the number and type of structures in flood hazard areas and potential loss estimates. The following table summarizes the land area, number of buildings, and assessed value of the buildings located in Westerly's flood hazard zones.

Table 14 –Buildings in Flood Zones

Flood Zone	
A / AE / AH / AO	647
VE	198

For the past 20 years, the bulk of Westerly's new growth and development has occurred inland along the Route 1 commercial corridor and on former agricultural lands that may be dominated by second-growth forest. Areas that are of greatest risk to natural hazards, including coastal and riverine flood zones, are generally built out or have been set aside as protected open space, with most construction in these areas focusing on rehabilitation of existing buildings, tear-downs for new construction, or the construction of single-family dwellings on building lots platted decades ago. These latter activities often take place along Atlantic Avenue or in vicinity of the coastal salt ponds, in designated "V" zones. In addition, the demolition and reconstruction of buildings and residential properties are built to FEMA standards, local flood hazard standards, and also incorporates requirements for stormwater management promulgated by RIDEM in December 2010. Since the majority of development has been in areas with low risk and vulnerabilities, and with the rehabilitation of existing buildings, risks for the Town of Westerly have decreased since the previous plan.

Existing hazardous material storage and handling facilities raise other concerns. If extensive flooding were to occur, hazardous materials stored on commercial; properties in Westerly's North End could potentially spread to the surrounding area if containment facilities were breached. These conditions occurred during the spring flood of 2010 where large quantities of debris; stockpiled inventory and manufacturing based hydrocarbons where released into the Pawcatuck River.

Public Infrastructure & Utilities

Damage or destruction of public infrastructure such as transportation, water and sewer or communications facilities can result in enormous economic, social, and general functional disruptions to Westerly. A flooded road or collapsed bridge can have major implications including general loss of productivity; disruption of physical access preventing residents from getting to work or back to their homes, prevent emergency vehicles from reaching their destinations, and pose difficulties in obtaining important lifeline supplies such as food and other deliveries to the community.[25]

[25] Heinz Center.

Damaged or destroyed utility lines and facilities – electricity, computer and satellite links, natural gas, sewer, and water services – can cripple a region after a disaster. High winds or an ice storm can down power lines, resulting in the loss of power for days or weeks. Fortunately, Westerly's municipal water and sewer systems have auxiliary back-up power generators at numerous locations, powered by either diesel or natural gas. Collectively, these back-up generators are capable of pumping 6,100,000 gallons of water per day (GPD), which exceeds the town's total water storage capacity by 1,580,000 GPD. Furthermore, all of the town's water storage towers work by gravity discharge without any need for electrical power. Westerly's wastewater treatment facility also has auxiliary power generation, as do most of the sewer system's pump stations. Additionally, Westerly does not have any combined stormwater / sewer lines, which greatly reduces the risk of untreated waterborne pathogens reaching the Pawcatuck River or its tributaries.

More critical are areas of Westerly not served by municipal water, where homes and businesses instead must rely on private wells. These properties are generally located in eastern portions of the Town near the border with Charlestown. Unless individuals have purchased portable electrical generators, the loss of power will render well pumps inoperable. People in these areas may have to boil water collected from other sources to eliminate potential waterborne pathogens.

Westerly's bridges, particularly those crossing the Pawcatuck River or the Winnapaug Pond breachway, are also at risk due to flooding or storm surge. The bridges listed in the following table are considered particularly vulnerable due to their location in flood zones. These structures, as well as other bridges not listed here that serve the Route 78 bypass or cross over Amtrak's rail lines, could also be damaged during an earthquake.

Table 15 – Critical Bridges in Westerly Crossing Water Features

Bridge Location	Water Feature Crossed	Year Built	Utilities	RIDOT Sufficiency Rating
Amtrak RR Bridge (Ston. Town Line)	Pawcatuck River	unk.		Unknown
Boom Bridge Rd (No. Ston. Town Line)	Pawcatuck River	unk.		Unknown
Potter Hill Road (Hop. Town Line)	Pawcatuck River	2002		100.0 (RI)
Rt. 1 / Pawcatuck Bridge (Broad St.)	Pawcatuck River	1932	Water/Gas	75.5 (RI)
Route 3 (Hopkinton Town Line)	Pawcatuck River	1924		67.8 (RI)
Route 91 (Chapman Pond Bridge)	Aguntaug Brook	1925		80.3 (RI)
Route 91 (Cottrell Bridge)	McGowan Brook	1923	Gas	36.2 (RI)
Route 91 (Hop. Town Line - Bradford)	Pawcatuck River	1930		84.1 (RI)
Stillman Avenue (Ston. Town Line)	Pawcatuck River	unk.	Water	Unknown
Weekapaug Bridge (Atlantic Ave.)	Scheduled for replacement		Water	49.9
Weekapaug Inn Bridge (over Cove)	Weekapaug Inlet	1936	Water	(Unknown)
White Rock Rd. (Ston. Town Line)	Pawcatuck River	1996	Water	93.7
Amtrak RR Bridge (Bradford)	Pawcatuck River	1996	Water	95.4(RI)

(RI) = RIDOT Ownership & Maintenance

Vulnerable Historical Assets

Many of Westerly's historical buildings are potentially at risk from natural hazards. The following table shows properties in Westerly listed on the National Register of Historic Places. The individually listed Flying Horse Carousel, much of the Watch Hill National Historic District are particularly vulnerable to hurricanes and coastal storms, while portions of the Main Street and Downtown National Historic Districts and the North End Neighborhood are susceptible to Pawcatuck River flooding. In particular, river flooding during Hurricane Gloria partially undermined the foundation of a commercial building fronting on High Street, resulting in costly repairs.

Table 16 – National Register Listed Properties in Westerly

(A) = Flood Hazard Zone; (V) = Velocity Zone; (N/A) = Non-flood Zone Location

Name	Address
Babcock-Smith House (N/A)	124 Granite St.
Bradford Village Historic District (N/A)	Roughly, Bowling Lane from Pawcatuck River to Vars Lane & Main St. from Bradford Bridge to Church Ave.
Downtown Historic District (A)	Railroad Ave., High, Canal, Broad, Union, and Main Sts.
Flying Horse Carousel (V)	Bay Street in Watch Hill
Former Immaculate Conception Church	119 High St.
Main Street Historic District (A)	113-132 Main St., 7-13 School St., 3-4 Maple St.
North End Neighborhood	High Street/Route 3 and RT-78, the Downtown Circulator , the Pawcatuck River and the fringes of Downtown and the railroad.
US Post Office (N/A)	High and Broad Streets
Watch Hill Historic District (A + V)	Roughly bounded by Breen, Watch Hill & E. Hill Roads, Block Island Sound, Little Narragansett Bay, & Pawtucket River
Westerly Armory (N/A)	Railroad Ave., west of downtown Westerly
Wilcox Park Historic District (N/A)	Roughly bounded by Broad, Granite, High Sts. and Grove Ave. and including Elm St.

Economic Vulnerability

To isolate economic vulnerability to one segment of the seasonal economic engine of the town would not give the total representation of the complete economic blow the community and labor force would be stricken with. Low lying cottages in the beach communities rent for anywhere from $1,500 to $8,000 per week which calculate into huge losses in seasonal housing options. Condo rentals, timeshares, hotels, motels and Bed and Breakfast establishments provide great variety in lodging choices, all of which are vulnerable during a major storm event. In an

emergency, local budgets would be strained by additional and/or unanticipated costs from the following sources:

Table 17 – Economic Costs	**Economic Losses**
Emergency Services	Compromised Evacuation Routes
Debris Disposal	Compromised Food Supply
Disrupted Water and Sewer Service	Loss of Inventory – all types
Disrupted Electric Power	Structural Destruction
Contamination Clean-up	Loss of Jobs
Hospitalization of Injured	Loss of Life
Housing Displaced People	Beach & River Erosion
Housing Displaced Pets	Loss of Communication
Increased Crime	Loss of Personal Property
Evacuation of Shut -ins	Loss of seasonal income

Such losses would need to be calculated on a per storm event basis to determine the full scope and impact to the residents and the municipality.

Social Vulnerability

Hurricanes, storms, and other natural events become "hazards" when they affect human society in adverse ways. Communities are vulnerable to these hazards to the extent that they are subject to potential damage to, or disruption of, normal activities. Impacts to the social environment include injuries, deaths, long-term health problems and emotional issues arising from the event itself and its aftermath. Losses such as baby books, mementos, and photo albums cannot be measured in dollars.

> "Natural hazards become disasters once they have resulted in the loss of lives and injuries, caused damage to property and interrupted the normal operations of government, community and businesses within those communities."
>
> Heinz Center, The Hidden Cost of Coastal Hazards

Social vulnerability is directly linked to disruptions in public infrastructure, such as a loss of electric power, that can interrupt business activity and cause stress to affected families, particularly if they are forced to evacuate their residences, cannot find basic supplies, or temporarily lose jobs. If destruction of the infrastructure causes additional damage (e.g., property destroyed by fires caused by gas line breaks as occurred during the 1938 Hurricane), then this additional vulnerability needs to be taken into account. One also has to consider the exposure of residents and tourists to each hazard type and the potential number of fatalities and injuries to different socioeconomic groups.

The following critical facilities map depicts portions of Westerly subject to evacuation prior to hurricane landfall. As seen from Table 18, over 22 % of Westerly's year round population and 70% of the Town's seasonal population resides in these areas.

Total Year Round Population (2000 Census)	Total Seasonal Population (Estimate)	Evacuation Zone Year Round Population	Evacuation Zone Seasonal Population	Evacuation Zone Total Population
22,966	4,250	5,168	2,980	8,140

Table 18 – Population living within Hurricane Evacuation Areas

Environmental Vulnerability

Westerly's environmental assets include sensitive natural habitats, particularly barrier beaches, salt marsh and salt ponds that are susceptible to the effects of coastal erosion and sea level rise. The Rhode Island Department of Environmental Management (RIDEM) has classified several of these areas, including Weekapaug Inlet, Winnapaug and Maschaug Pond, and Napatree Point, as noteworthy natural communities of rare and endangered species of plants and/or animals. Inland from the coast, RIDEM has highlighted Chapman Pond and its surrounding wetland areas, including McGowan Brook, although here, there should be minimal long-term adverse environmental impact from flooding.

The Flood Insurance Rate Maps denote specific sites in Westerly classified as Coastal Barrier Resources System Areas (CoBRA) by FEMA. Although development in CoBRA locations is not restricted directly by federal regulations, no federal financial support (including flood insurance) is available for new development. Privately-financed development is not restricted. In Westerly, areas subject to these restrictions are located in the following areas: Napatree Beach and Napatree Point, Watch Hill Cove area, Maschaug Pond and Little Maschaug Pond areas, the western end of Winnapaug Pond, and the vicinity of Quonochontaug Pond.

Mitigation Strategy Matrix

The following risk assessment matrix identifies specific locations and physical elements that are vulnerable to natural hazards. This matrix associates categories of vulnerabilities with the specific natural hazards that pose the greatest threat of damage. The location of each site or facility at risk is described, along with the types of natural hazards that would cause the greatest damage. The matrix also lists the primary effects of damage from natural hazards, as well as the benefits of carrying out mitigation measures capable of preventing or limiting damage.

Risk Map

The map that follows this matrix graphically depicts locations where such hazards exist, with particular emphasis on FEMA designated A and V flood hazard zones, locations of repetitive flood damage, and critical infrastructure such as highway bridges and dams.

Section 5: Natural Hazard Mitigation Strategy

There are three pre-disaster phases to Westerly's natural hazard mitigation strategy – planning, mitigation and preparedness, which in the aftermath of a natural disaster enhance the Town's response and recovery efforts. Each is described below:

Phase I – Planning

Planning consists of analyzing and documenting the possibility of an emergency or disaster, and the potential impacts upon life, property, and the natural environment. This includes an assessment of hazards and risks, and the determination of mitigation, preparedness, response and recovery needs. This Natural hazard mitigation strategy is a critical step in this process. Its usefulness, however, requires continual maintenance and improvement through the following procedures.

- The plan should be monitored for accuracy and relevance, based on the most recent and comprehensive information available regarding the threat of natural hazards and Westerly's vulnerability levels. Prioritization and progress of recommended mitigation projects will be updated over time as circumstances change or various projects are completed. This is a quarterly effort that is conducted by the Task Force where changes are noted and mitigation may occur provided there is appropriate funding to make corrective actions. Due to the flood of March 2010, priorities changed, new issues were realized, and the plan priorities were revised accordingly. This event allowed for interest in revisions to the Land Development and Subdivision Regulations and Zoning Ordinance revisions to deal with all related stormwater issues in an effort to contain as much stormwater on private property as opposed to pipe and convey to the waters of the United States.

- Recommended mitigation actions should be implemented as funding becomes available. This plan can be used as a tool to justify the Town's grant applications to various state and federal agencies that distribute funds for local hazard mitigation.

> "The success of the hazard mitigation plan is measured by the degree to which actions are accomplished. Without the implementation and maintenance of the plan, the previous components have merely been an effort in research void of any practical application."
>
> Tennessee Emergency Management Agency

Updates to this plan (and to Westerly's Emergency Operations Plan) should involve continued public involvement, and revised versions of the plan should be distributed to appropriate organizations. Increased public awareness renders the community as a whole more prepared for the potential effects of natural hazards.

In addition, other local plans developed by the Town also play a role in both pre-disaster planning and post-disaster recovery. These include:

▪

- Emergency Operations Plan
- GASB-34 Fixed Asset Inventory
- Phase II Stormwater Management Plan
- Zoning Ordinance & Subdivision Regulations
- Canal Street Infrastructure Improvement Plan
- Dune Restoration on Town owned properties

Comprehensive Plan Amendments

Hazard mitigation should be incorporated into appropriate elements of Westerly's comprehensive plan. The following recommended text changes to these elements recognize the impact of natural hazard events and provide guidance on what can be done to protect life, property, natural resources, and the economic health of Westerly.

- Land Use Element – Incorporate natural hazard mitigation strategies into review standards established for the evaluation of commercial development plans and residential subdivisions.

- Housing Element – 1) Consider the risks and vulnerability of natural hazards on housing when developing new land use regulations and/or redefining the zoning map, 2) Identify and assess natural hazard risks when evaluating plans for residential subdivisions, and 3) Provide information to contractors and homeowners on the risks of building in flood prone areas, and the benefits of flood proofing.

- Economic Development Element – Identify and assess natural hazard risks when evaluating commercial and industrial development plans.

- Natural and Cultural Resource Element – Incorporate natural hazard mitigation measures, such as retrofitting buildings, to preserve and adaptively reuse properties listed on or eligible for inclusion in the National Register of Historic Places.

- Services and Facilities Element – Critical public facilities should be designed, retrofitted and/or located to account for natural hazard risks including flooding, high wind, drought and earthquake (See Appendix A for proposed text amendment).

- Open Space & Recreation Element – Investigate use of flood-prone areas as open space.

- Circulation Element – Functional components of Westerly's transportation system should include emergency evacuation routes and safe (flood proof and seismically designed) bridges.

Hazard Mitigation – The town has recently adopted a new Comprehensive Plan. Although this is not included in the current plan it is expected that it will be incorporated into the next 5-year update of 2016. The 2012 updated hazard mitigation plan will be utilized where appropriate into other existing planning mechanisms as listed above. The HMP will be referenced when these plans are updated if it is applicable to the plan. The HMP may also be incorporated into mutual

aid agreements, evacuation plans, storm water management plans, and/or zoning ordinances. The above mentioned plans are available for incorporating the mitigation requirements of the HMP.

The previous plan has not been incorporated into any other planning mechanisms. The process for incorporation of plan elements into existing planning mechanisms will be according to the rules and regulations of the Town. Typically, the Emergency Manager will meet with and support the staff of the department responsible for drafting the plan document or conducting the planning program to ensure the relevant elements of this plan are taken into consideration.

Multi-jurisdictional Mitigation Strategy

No agency or organization should plan for disasters in isolation from other organizations whose efforts are required to make plans work. Consequently, Westerly's continuing efforts to improve hazard mitigation must include coordination with the Town's fire districts, state and federal agencies as well as neighboring municipalities. This natural hazard mitigation strategy itself is an example of such communication, since it was prepared with the guidance and support of the Rhode Island Emergency Management Agency and FEMA. This plan and any future updates shall be submitted to neighboring municipalities in Rhode Island to keep them informed of Westerly's hazard mitigation plans, as well as to invite comments and suggestions.

Phase II – Mitigation

Mitigation consists of actions that reduce the risk and vulnerability to a disaster, resulting in saved lives and reduced property damage. It may include long-term activities such as open space acquisition on barrier beaches or enforcing building restrictions in flood zones. Recommended mitigation activities are listed in the Mitigation Strategy Matrix, and as described below.

What is Mitigation?

"Mitigation is the sustained actions taken to reduce or eliminate the long-term risk to human life and property from hazards."

Pre- and Post-Disaster Mitigation

The purpose of mitigation is to build a *disaster-resistant community* that promotes significant steps and measures to reduce vulnerability to hazards, when after a major disaster, there is minimal loss of life, limited interruption of public services, timely resumption of business operations, and rapid recovery to pre-disaster conditions. Most of the burden of disaster recovery will fall squarely on the shoulders of local government, and a severe disaster can bring extraordinary hardship to Westerly's economic base and quality of life for many years. A disaster also creates pressure for local officials to act – and to act quickly. But actions taken in haste to rebuild and return the community to normalcy should not ensure that the same destruction and hardship only repeats itself in future disasters.

Mitigation opportunities abound immediately after a disaster, with the sudden influx of grant funding providing a significant window of opportunity for recovery. However, there is no rationale to rebuild Westerly to exactly as it was prior to the disaster; it is far better to use such funds to reduce future risks. Consequently, a key purpose of this mitigation strategy is to ensure proper utilization of both pre- and post-disaster mitigation funds according to an agreed-upon strategy.

Flood Hazard Overlay Zoning District, Building Codes & Subdivision Design

The Town of Westerly's zoning ordinance contains a "Flood Hazard Overlay District," which corresponds geographically to both A and V flood zones as depicted on FIRM maps. This ordinance states that: "No use shall be approved which would adversely affect the capacity of any drainage facility or system or would involve alteration of sand dunes, barrier beaches, and other natural protective barriers." A Flood Hazard Permit is necessary for most activities located within a flood zone that require a building permit. The purpose of this permit, which is subject to a review by both the Zoning Official and Building Official, is to ensure flood damage potential is minimized through the proper design of sanitary facilities, flood proofing of buildings, and assuring that spaces below a building's established flood elevation are not blocked in order to allow the passage of water and, thus, capable of resisting hydrostatic and hydrodynamic load effects of buoyancy.

Westerly's building codes define how structures are built to enhance their ability to survive nature's wrath. These rules work best with new construction and with existing buildings that

undergo extensive remodeling. However, it must be recognized that there are many older buildings in flood prone areas that are clearly in need of retrofit that will not benefit from these regulatory tools since their owners are not proposing any changes or modifications that require local permit approvals.

Since state and federal regulations are periodically updated, a periodic review of Westerly's zoning ordinance, subdivision regulations and building codes should be made to ensure they continue to conform to state and federal requirements. An excellent publication available in the Westerly Planning Office is *Subdivision Design in Flood Hazard Areas (Planning Advisory Service Report No. 473)*, produced jointly by FEMA and the American Planning Association. This book discusses site-specific measures to minimize flood damage and preserve natural functions of floodplains, including coastal high hazard areas and low lying areas near rivers.

Building Relocation & Demolition

Alternatively, consideration may be given to relocating a structure to a safer portion of a property. If there is room on its current parcel, a structure might be a candidate to be relocated within its lot to increase the distance from a known hazard. For example, moving a house that is directly on a beach or atop a foredune to a new location behind the dune will enhance its protection from storm surge and coastal erosion.

In certain circumstances, demolition of a structure may be warranted, particularly when there is a history of repetitive loss insurance claims. The property would then be a candidate for open space designation to prevent future development. However, such actions may constitute a taking of private property, and conversion of a developed lot to open space is expected to occur only at very specific locations, and only when state or federal grant funding has been earmarked for this purpose.

Open Space Acquisition

> "Greenspace mitigates the risk to life and property posed by natural hazards. Coastal barrier beaches, coastal barrier ponds, and the wetlands and lowlands surrounding them are the state's front-line defense against the assaults of hurricanes and 'northeasters' on the coastline. Where undeveloped, these features absorb and dissipate the energies of wave and wind attack, affording a measure of protection to inland areas."
>
> RI State Guide Plan, Element 155

Land conservation efforts of the Watch Hill Conservancy, Westerly Land Trust, and the Weekapaug Foundation for Conservation have often focused on low-lying areas adjoining the ocean, salt ponds and the Pawcatuck River. Recent key acquisitions include property adjacent to Atlantic Avenue in Misquamicut Beach that has been acquired by the Town, and nearly 500 acres acquired by Westerly Land Trust from a private mill owner adjoining the Pawcatuck River near Bradford and 306 acres on Chapman Pond and 40 acres on Crandall Swamp Preserve. These efforts should be encouraged in the future, since it reduces the potential for development in flood prone areas subject to the adverse effects of hurricanes, coastal storms and riverine flooding. Sources of open

space funding used by Westerly include open space bonds administered by RIDEM, and FEMA hazard mitigation grant funds. If property owners convey land to an IRS-registered 501(c)(3) non-profit land trust, it may be possible to obtain a tax deduction for such property.

Construction of Flood Control Structures

Manmade structures intentionally constructed to prevent flood damage may consist of floodwalls, dikes, levees, inlet controls, breakwaters or dune replenishment. Most of these structures tend to be large and expensive, requiring federal financing and intervention. Adding to their cost is the need to address ancillary effects on the natural environment and surrounding unprotected properties. For instance, a breakwater built on a beach may affect shoreline sand replenishment, while a levee may simply redirect floodwaters into locations outside the protected area with no prior history of flooding.

In 1994 the U.S. Army Corps of Engineers studied the feasibility of installing dike-type structures to surround developed portions of Misquamicut Beach. This study was prompted by significant shoreline storm damage from severe winter storms in December 1992 and March 1993. The Army Corps analyzed a number of different types of structural storm damage prevention measures, and concluded that each alternative would be cost prohibitive relative to the benefits to be gained, with estimated project costs from $11 to $28 million.[26] In other words, it was deemed less expensive to replace damaged properties than building a wall to surround them. Fiscal constraints at all levels of government will continue to be an obstacle to construction of large-scale flood control structures in Westerly.

However, not all physical improvements come at a high cost relative to the benefits gained. After Hurricane Bob in 1991 the Misquamicut Fire District secured funds through FEMA to assist in replenishing primary sand dunes near Misquamicut Beach. This project allowed the District to build up the height of several of the dune areas to 11 feet above the mean high water. Also, beach grass was planted on several miles of dune within the District to help stabilize the remaining dunes. A similar dune reconstruction effort was completed in the late 1990's by RIDEM in front of Misquamicut State Beach. In addition, the Town of Westerly created a new dune and planted American Beach grass in the spring of 2007 at one of the two town owned beaches on Atlantic Avenue.

Dune replenishment will continue to be the flood control measure of choice. There may be opportunities in the future for Westerly to take advantage of various state or federally-funded projects, such as the Army Corps of Engineers' proposal to dredge shoaled-in portions of Winnapaug and Quonochontaug Ponds. When such plans are presented to the Town for review and comment, Westerly should seek surplus dredged sand for primary dune reconstruction in coastal areas at risk from storm surge.

Improved Floodplain Drainage

A well designed and maintained drainage system can more efficiently direct the flow of stormwater to points where the impacts of flooding will be minimized, thus lessening the after-effects of a storm event. The Town of Westerly has an ongoing effort to improve stormwater

[26] U. S. Army Corps of Engineers, New England Division. 1994. Shore Protection and Flood Damage Reduction, Reconnaissance Report, Misquamicut Beach, Westerly, Rhode Island.

drainage infrastructure in flood prone areas, driven by the need to comply with the RI Nonpoint Source Pollution Management Plan and the RI Pollutant Discharge Elimination System regulations. Both riverine and coastal flooding can be relieved through drainage projects implemented to address these regulations, and by adherence to a regular maintenance schedule to ensure that such systems are functioning properly.

In the mid-1990s, the Town initiated discussions with RIDEM to construct a new storm water drainage system in Misquamicut Beach. This project, was built, and pumps excess stormwater runoff from the neighboring streets into a discharge point in Winnapaug Pond. This effort has improved the ability of the storm water drainage system to handle heavy rains and flooding in this low-lying area.

To maintain the capacity of natural flood water drainage systems, the Town's subdivision, development plan and special use permit review procedures should insure that unnecessary filling and encroachment into wetlands and FEMA designated flood hazard areas does not occur.

Debris Management Plan for Bridges & Dams

Westerly's flood mitigation strategy must anticipate problems associated with debris such as trees and buildings collecting behind bridges and dams located along the Pawcatuck River. From a long-term perspective, the best solution is to reconstruct bridges to conform with RIDOT regulations, which include design standards that accommodate the 100-year flood event. Following these standards, deck spans for new bridges tend to be wider and provide greater clearance beneath them. The recently replaced Potter Hill Road bridge and Whiterock/Bridge Street bridge both have wider spans between abutments, allowing for the passage of larger quantities of flood debris.

However, older structures including the West Broad Street Bridge and Boombridge Road bridge can act as a weir, and collect large amounts of river borne debris. Rising floodwaters behind these structures could jeopardize the foundations of these structures or cause great amounts of upstream flooding. Consequently, Westerly's public works forces and/or equipment should be pre-positioned prior to an anticipated flood event in order to remove flood debris as it is accumulating. As evidence of this, the Boombridge Road bridge is out after the intense rain event on July 1, 2009.

Siting of Municipal Facilities & Infrastructure

In 2001, Westerly's Department of Public Works updated its Water Supply Management Plan to focus on emergency management. This plan describes actions to be taken in the event of an earthquake, flooding or high winds, focusing on the inspection of critical components of the water supply distribution system. Specific responses to problems that may be discovered during this post-disaster inspection are detailed in the plan.

A vulnerability analysis conducted as part of Westerly's Water Supply Management Plan update indicates that none of the water pumping facilities or reservoir tanks are located in FEMA flood hazard zones. A review of wastewater pumping station locations suggests that only one – the Old Canal Pump Station – is located within an A flood hazard zone, while the balance are in B or

C zones. This proactive policy of flood zone avoidance should be followed in the future as Westerly expands its water supply distribution and wastewater collection systems.

Consideration should also be given to flood hazard zone avoidance when siting municipal facilities such as a new police department, emergency operations center or public works garage -- to prevent the isolation of a facility due to flooding, it is recommended that they be sited near designated evacuation routes since these roadways will permit access throughout much of the community without threat of inundation. A review of Westerly's zoning map and zoning ordinance is warranted, such that elderly housing, nursing homes and assisted living facilities should be sited outside of FEMA flood hazard zones.

Since an earthquake could potentially damage or break water mains, Westerly's capital improvement budget process should allocate funds for interconnecting exiting water distribution systems in order to maintain steady water pressure throughout the service delivery area. As new subdivision streets are constructed in portions of Westerly served by public water supply, opportunities for looped and interconnected systems should be explored. Construction of additional water towers disparate locations will also help to maintain water pressure should there be a need to replace water mains damaged due to an earthquake.

Drought Management

The Town of Westerly's Department of Public Works has the primary responsibility for managing the town's water supply distribution system, and for ensuring that it can provide sufficient water to meet public health and safety needs of its customers. The Rhode Island Water Resources Board (RIWRB) issues notices regarding drought conditions in the state, and the Drought Management Element of the State Guide Plan (www.planning.ri.gov/landuse/dmp.htm) controls state policy relative to long-term drought response. The following five phases are used to classify existing drought conditions:

1. Normal
2. Advisory
3. Watch
4. Warning
5. Emergency

Based upon local water supply conditions, Westerly can initiate its own actions ranging from voluntary water use restrictions to declarations of local water emergencies. Information-sharing between state and local officials is essential in assessing drought situations. The local water entity must provide the specific information about its own circumstances to RIDEM, which is responsible for assessing the broader situation faced by Washington County as a whole. Similarly, state drought levels and information must be provided to water suppliers should prompt action be required of local communities.

The Town has the lead role in preparing for and managing all stages of drought at the community level. Drought preparedness measures are included in Westerly's Water Supply Management Plan, which stress policies that promote water conservation wherever possible, including a provision for local ordinances to ensure that established regulations and procedures can respond

to drought conditions. The following water supply alert phases are based upon monitored groundwater levels during periods of drought, focusing on well drawdown levels:

- Drought Watch / Advisory Phase 70% normal depth
- Conservation Phase 65% normal depth
- Expanded Restriction Phase 60% normal depth
- Emergency Phase 55% normal depth

Emergency powers are conferred upon the chief elected municipal official pursuant to *Rhode Island General Laws, 30-15-12,* which enables Westerly to plan for and declare a drought emergency. Local government's most visible role in Westerly may be educating the public on the drought status and in the development and enforcement of local regulations should the situation worsen.

Wildfire Loss Prevention

Urban-wildland interface fires tend to be more damaging than urban structural fires, are often more difficult to control, and behave differently from structural fires. When these fires erupt, people and structures must take priority, often at a devastating expense to natural resources. People who live in heavily forested portions of Westerly have little understanding of wildfire cycles and danger since it occurs so infrequently in Rhode Island. Consequently, homes and other structures are often built and maintained in a manner that leaves them and their occupants vulnerable.

Since Westerly is susceptible to prolonged drought, which increases the risk of wildfire, homeowners can protect themselves via a well-maintained landscape, reduction of woody vegetation and brush around the perimeter of the property, a fire-resistant roof, and a good access driveway with a turn around area.

Table 19 – The Three R's of Wildfire Loss Prevention

Removal	This technique involves the elimination of entire plants, particularly trees and shrubs, from the site. Examples include removal a dead tree or the cutting out of a flammable shrub.
Reduction	The removal of plant parts, such as branches or leaves, constitutes reduction. Examples include pruning dead wood from a shrub, removing low tree branches, and mowing dead grass.
Replacement	Replacement is the substitution of less flammable plants and vegetation. For example, removal of a dense stand of flammable shrubs and planting an irrigated, well maintained flower bed would be a type of replacement

Public/Private Partnerships

The purpose of public-private partnerships is to maintain and quickly restore the community's well-being. The Greater Westerly-Pawcatuck Area Chamber of Commerce, in a cooperative effort with the Westerly Emergency Management Agency, has surveyed its member's heavy

construction equipment and supplies in an effort to improve the town's emergency response capability. This list should be revisited at least annually both to ensure that it remains up-to-date, and to serve as a reminder to private businesses of their important role in post-disaster clean up. Furthermore, it is imperative that owners of individual businesses assess which natural hazards and risk factors may affect them, and make plans to minimize anticipated impacts.

Increased opportunities for volunteer involvement should be explored. As an example from another Rhode Island community, volunteers were employed to secure bookshelves to walls in local childcare centers as a safety measure. This type of activity will serve to supplement large-scale mitigation measures at a minimal cost.

Phase III – Preparedness

Preparedness activities are necessary to address impacts of natural hazards that cannot be prevented by mitigation measures alone. In the preparedness phase, governments, private organizations, and individuals develop plans to save lives and minimize disaster damage (e.g., compiling inventories of equipment to be used in post-disaster clean-up, installing early warning systems, and predetermined emergency response forces). Preparedness measures also seek to enhance disaster response operations (e.g., stockpiling vital food and medical supplies, performing training exercises, and mobilizing emergency response personnel on standby).[27]

The success of Westerly's effort to remain prepared for natural hazards depends on widespread dissemination of this hazard mitigation plan and similar documents to appropriate town agencies and organizations. Also, the following types of activities will contribute to the overall preparedness of the community:

- Public Information Activities
- Community Involvement & Volunteer Activities
- Training Exercises
- Community Warning & Alert Systems

Emergency Shelters

Emergency shelters play an important role during hazard response and recovery. They provide temporary shelter, sanitary facilities and food service during a local emergency. They can also serve as a focal point for distribution of food and clothing for people who choose not to use the shelter for temporary accommodation. Short-term occupancy, two to three days duration, is typically adequate for hurricane conditions; to establish a sense of community normalcy after a disaster, it is important that the schools be used for shelter only for a very short period, enabling them to revert to educational activities as quickly as possible. The Westerly Armory would be used as a staging area for emergency volunteers and National Guard troops. The following table lists the shelters and their locations and individual occupancies.

[27] ESRI.

Table 20 – Emergency Shelters Serving Westerly

Name	Location	Available Space (SF)	Short-term Occupancy	Long-term Occupancy
Dunn's Corner School	9 Plateau Rd.	7,700	383	191
Spring Brook School	39 Spring Book Rd.	8,800	437	219
Westerly Armory	6 Dixon Street	8,800	200	150
Westerly Senior Center	39 State Street	12,400	250	175
Total Shelter Occupancy			*1270*	*735*

Shelters approved by the American Red Cross (ARC) must meet the following criteria: control by the Town of Westerly, have adequate parking, not be located in a flood zone or storm surge area, and be structurally sound. The decision to open a shelter is not made by ARC; rather, it is made by local officials who then notify the ARC. The Red Cross will provide meals, basic first aid and counseling as needed, provided that the Town provide security, consisting of one policeman and one firefighter at each shelter.

Emergency Evacuation Areas & Evacuation Routes

In 1995 the Army Corps of Engineers established a set of evacuation zones considered vulnerable to hurricane surge that are recommended for evacuation prior to a hurricane's landfall. Two distinct evacuation areas have been delineated in Westerly.

- *Evacuation Area A* -- Located closest to the shore and recommended for evacuation prior to the landfall of hurricanes regardless of approach speed or category.

- *Evacuation Area B* -- Consists of additional locations that should be evacuated prior to the arrival of any Category 4 or 5 hurricanes. Additionally, Evacuation Area B should be evacuated if a Category 3 hurricane is approaching with a forward speed greater than 21 miles per hour, or if a Category 1 or Category 2 hurricane is approaching faster than 41 miles per hour.

Emergency evacuation routes have been established by the Westerly Police Department, as depicted on the Critical Facilities Map. These routes are intended primarily to evacuate people from low-lying areas subject to hurricane-induced storm surge or flooding. It is essential that designated evacuation routes be publicized BEFORE an event occurs, including posting of maps in motel rooms situated in flood hazard areas for tourists who may be unfamiliar with the local road system.

Most routes begin near the shoreline, and lead inland to areas of higher elevation. The primary routes leading north away from the shore are Watch Hill Road, Winnapaug Road, Weekapaug Road, and Noyes Neck Road. Critical east-west routes in Westerly are Post Road (Route 1) and Shore Road (Route 1A). Route 78 and Bradford Road can be used to travel inland towards the Interstate Highway System. Based on the current policy of the Westerly Police Department, an evacuation notice is issued prior to the arrival of any storm with wind speeds above 60 miles per hour. The evacuation notices issued by the Chief Elected Official as specified in the Town Charter typically include the area south of Shore Road (Route 1A) to the coast, and the area west

of Watch Hill Road and Beach Street (Route 1A) to the Pawcatuck River. An evacuation zone of this size includes approximately 3,300 households.

It must be noted that portions of Shore Road, Watch Hill Road are themselves subject to coastal flooding during the 100-year storm event, while portions of Canal Street, Beach Street, Main Street, and Route 91 between downtown Westerly and Bradford are subject to riverine or inland flooding. Consequently, the use of these roads for emergency evacuation is beneficial only during the hours immediately before a storm hits the shoreline.

To reduce or eliminate looting, police checkpoints should be established to prevent unauthorized people from entering areas of Westerly damaged by hurricanes or flooding. Upon presenting a valid identification at the Westerly Police Department demonstrating residency within "off limits" zones, people would be issued a written pass permitting access to their dwelling.

Phase IV -- Response & Recovery

In the days, weeks and even years following a natural disaster, Westerly will engage in a variety of different response and recovery efforts. *Short-Term Recovery* strategies are outlined in Westerly's Emergency Operations Plan (EOP), a copy of which is located in the Town Manager's office and the Police Department. The EOP outlines emergency and other urgent measures to open roads, restore power and telephone service, and support shelter operations. Short-term recovery lasts for a couple of days to a few weeks.

Long-Term Recovery may consist of debris clearance, and replacement of destroyed or damaged municipal facilities and infrastructure. This process can take several months or even several years after a disaster, and focuses on resumption of services to normal, pre-disaster levels, and large-scale repair and reconstruction of public and private property. A list of potential sources of post-disaster funding can be found in the Appendix.

Short-Term Recovery Priorities

Certain requirements necessarily take a higher priority during the initial stages of recovery, related to the nature of the disaster and continuing threats to safety and property. Short-term priorities include:

- **Search and Rescue.** Accounting for the whereabouts of everyone is one of the first priorities. Shelter counts and occupant names should be reviewed to identify missing persons. Buildings and collapsed structures must be searched.

- **Opening of Supply Lines.** Shelter occupants and people remaining in their homes must be supplied with water and food. The need is especially critical if normal supplies and services have been shut off or damaged. Decisions on how and where to open supply lines can have overriding logistical and political considerations.

- **Public Information.** People need to know everything from how to get their clothes clean to methods for preventing injury and disease. They will expect government to have the answers.

- **Restoration of Essential Services.** Local officials will have to decide which services are essential and which are not.

Rapid Damage Assessment

Rapid damage assessment is a critical component of emergency response operations, short-term recovery and long-term redevelopment. In all likelihood, local government will be on its own when conducting this initial post-disaster situation assessment. Damage information must be promptly collected, thoroughly analyzed, and accurately reported to local decision-makers and to state and federal agencies. This information permits the prompt preparation of a Presidential Declaration, which can lead to additional aid after a major natural disaster.

- **Department of Public Works.** Condition of water, sewer and stormwater drainage infrastructures, roads, bridges and dams.

- **Fire Districts.** Inventory residential and commercial buildings within their assigned portions of Westerly; identification of life-threatening situations requiring search & rescue or danger to emergency responders.

- **Building Official.** Condition of public buildings, schools, Westerly Hospital and nursing homes.

- **Town Planner & Tax Assessor.** Townwide fly-over; compilation of damage reports.

The goal of Rapid Damage Assessment is to determine the magnitude of damage, specify needed resources, prioritize response efforts, and initiate requests for state and federal aid. Three broad categories are used to describe the magnitude of damage: 1) buildings destroyed; 2) buildings with major damage (>50% destroyed); 3) buildings with minor damage (<50% destroyed). Contents of the initial Rapid Damage Assessment report include a description of the event, a quantification of resultant damage, identification of life-threatening situations, and requirements for needed additional non-local resources.

Organizational Roles in Response & Recovery

- Local government has the lead role.
- Private sector/volunteer groups provide needed resources.
- State provides assistance upon Governor's emergency proclamation.
- Federal agencies provide assistance upon Presidential disaster declaration.

In the weeks and months that follow a natural disaster, there will be more detailed evaluations of building safety and infrastructure damage. A key element of detailed evaluation is the rating of buildings as either safe, potentially dangerous (i.e., limited entry), or unsafe. This may be followed by an engineering evaluation, typically including detailed reconnaissance, mapping of building damage, preparation of structural calculations, and a quantitative

assessment of the strength of a building. A structural engineer retained by building owners conducts this type of study.

Documentation of Financial Aid in Recovery & Mitigation

Proper and detailed documentation must be maintained at a time when response and recovery operations are ongoing, and when local officials and emergency responders themselves may be over worked and exhausted. However, the temptation to make undocumented emergency purchases must be avoided, and FEMA's disaster record keeping and accounting procedures must be adhered to – in terms of reimbursement, if it is not documented, it did not happen! Under the Stafford Act, federal assistance is generally 75% of mitigation and recovery costs, with the state or local government picking up the remaining 25% cost-share, and can cover such items as debris removal, emergency protective measures, permanent restoration of government facilities, and replacement of damaged equipment and supplies.

In the period immediately after a disaster, the Town of Westerly must have the in-house capacity to:

- Pay the local cost-share (generally, 25% of all mitigation and recovery costs);
- Handle financial and material donations;
- Conduct emergency procurement, including the ability to do so without electrical power or without the ability to communicate with banks.

It is recommended that the Town provide training on post-disaster expense approval and documentation procedures, focusing on special purchasing procedures, and identifying personnel who will have purchasing authority. Even with outside financial assistance, Westerly will itself incur significant costs and it is likely that many items approved during the Town's normal capital improvement budget process will be cancelled or suspended as funds are reallocated towards disaster mitigation.

Table 21. Short-Term Post-Disaster Financial Issues Requiring Documentation for Stafford Act Reimbursement

Daily operations of local government	Emergency worker overtime & lodging
Disaster contract development & oversight	Equipment repairs and rental equipment
Donations storage & distribution	Crisis management counseling
Building inspections & damage surveys	Warehousing and staging of donated goods
Shelter operations and feeding	Debris management and disposal
Emergency engineering services	Wire/wireless telecommunication

Perimeter Security & Re-Entry Procedures

Immediately after a hurricane has passed, people will naturally want to return to the homes and businesses they have evacuated. Determining who should be allowed re-entry is essential in order to prevent a rush to the shoreline by potential looters and sightseers. The perimeter of designated evacuation areas must remain secured while search and rescue operations are still ongoing, and when there is danger of downed power lines or natural gas leaks causing additional injury. After a severe hurricane, local landmarks may be completely obliterated, and it may be

necessary for DPW crews to clear blocked roadways and even post temporary name signs at street intersections whose familiar landmarks have been destroyed. There will be tremendous pressure placed on local elected officials to re-open evacuated portions of Westerly, but this should be resisted until local emergency responders and public utility crews have determined that it is safe to do so.

Debris Management

The management of debris after a major disaster is an intense, long-term, and very expensive operation, with Westerly's DPW acting as lead agency. When private contracts are used in any phase of debris management, close supervision and monitoring are necessary in order to prevent fraud. After a Presidential Declaration, federal financial assistance may be available to offset costs of local debris operations. Accurate records must be kept of all activities and related costs. These records establish the basis for reimbursement, and may be audited two or three years after the storm event. The cost of debris removal can be tremendous – after Hurricane Hugo, North Charleston, SC spent $3 million to remove one million cubic yards of debris, which consumed an estimated 20 years of available landfill space. Key steps in debris management include:

- Forecasting/estimating volume of debris as part of Rapid Damage Assessment.
- Cutting and clearing debris from public roadways, bridges, dams, etc.
- Identification of temporary debris storage sites, designating certain areas for hazardous vs. non-hazardous wastes.
- Debris removal from public and private property.
- Debris reduction and removal from temporary storage sites.

Two temporary debris storage sites are identified in this plan, reflecting geographical areas of Westerly where the greatest amount of damage is expected to occur in a major storm event:

- Gingerella Recreation Complex – White Rock Road
- Misquamicut State Beach – Atlantic Avenue

It is not recommended that Westerly's transfer station on Rt. 91 be used for debris storage, because normal solid waste and recycling operations must still take place in the days and weeks that follow a natural disaster. All household waste should still be directed towards the transfer station, and not be accepted at the temporary debris storage sites.

It is recommended that DPW develop and publicize a waste reduction strategy before a hurricane strikes, focusing on burning, chipping and recycling. While burning may be less costly than other methods, issues include air quality and ash residue disposal. Chipping and grinding pose significantly fewer environmental concerns, but these methods are more expensive and time-consuming, producing a large volume of wood chips that may have to be burned. Recycling is another option, with separation of metals, concrete, lumber and other construction materials that would otherwise have to be land filled; again, the disadvantage is cost and time associated with separating materials. Finally, it is essential that the temporary alterative debris storage sites be publicized before a hurricane strike. This will reduce the number of informal and illegal dumpsites that pose health and safety threats to the community.

Donations Management

In the days following a natural disaster, the management of donations may become one of the more monumental tasks, and is something best delegated by local government to others. In Westerly, Bradford Johnnycake Center and the WARM Shelter are experienced donations managers, whose expertise can be tapped. In terms of a central donations clearinghouse, it is recommended that portions of the open quadrangle between Ward High School and Babcock School be set aside for this, with assistance provided by library staff, who because of their experience with the old manually-operated Dewey-Decimal System, understand how to maintain an inventory in the absence of electrical power. Finally, not all donations should be accepted by Westerly simply because they are "free". For example, after a late summer hurricane, a truckload of winter coats may be unnecessary and can legitimately be turned away. In Westerly, during the spring flooding of 2010, local business owners offered loading docks and vacant commercial storefronts for temporary staging areas for donated material such as bedding, appliances and clothing.

Permits for Building Reconstruction

Section 180 of the RI Coastal Resources Management Program deals with Emergency Assents. CRMC's post hurricane and storm permitting procedures impose a temporary 30-day moratorium on reconstruction after a disaster has been declared in order for municipalities to assess damages, determine changes that may have occurred to the coastline, and identify mitigation opportunities. During this moratorium, CRMC grants priority approval to the reconstruction and/or replacement of public facilities such as bridges, roads and public infrastructure. After the moratorium has passed, CRMC gives highest priority to applications for reconstruction of private dwellings and structures that were physically damaged or destroyed 50 percent or more by storm-induced flooding, wave or wind damage.

Business Recovery Strategies

A number of small locally-owned businesses are concentrated in flood prone areas along the Pawcatuck River, and in Watch Hill and Misquamicut Beach. While business owners should educate themselves as to available post-disaster state and federal assistance programs, they should also conduct a realistic economic analysis of their market and customer. "Open for Business" information produced by the Institute for Business and Home Safety is an excellent tool for educating business owners on disaster effects and preparedness needs (www.ibhs.org). Businesses need to know:

- How the disaster affects their customer base (who is left, and what they can afford);
- The relative demand for their goods and services in a post-disaster setting;
- How the disaster affects their key suppliers;
- Competitive advantages that other areas not subject to flooding possess, and the likelihood of market-share shifting elsewhere as a result;
- New opportunities in the post-disaster setting that can be maximized by the small business; and
- How the government's short-term and long-term recovery plans for the area as a whole might support their particular business.

Recovering for the Long Haul

Recovering from a major natural disaster can be a long-term proposition, and should include environmentally and economically sustainable land use and design decisions. While recovery will take place as a series of small increments, goals and policies formulated prior to the natural disaster should be implemented over time via appropriate land use regulations and procedures. The bottom line goal is to implement a recovery program that avoids re-creating the same pre-disaster scenario that was susceptible to serious damage or destroyed by the natural disaster. Since no amount of planning can fully anticipate all of the adverse impacts, the key to a sustainable disaster recovery is to ensure that "lessons learned" become part of the solution.

Mitigation Strategy Risk Matrix

There are two types of mitigation – structural and non-structural. Structural mitigation measures are typically preceded by engineering studies, and have high dollar costs, while non-structural measures focus on policy changes intended to promote better land use decision-making. The following mitigation strategy matrix constitutes an action plan that prioritizes needs specific to Westerly. Mitigation measures are categorized by one or more of the following types:

- Infrastructure Improvement
- Land Improvement & Property Protection
- Enhancing Natural Resources
- Planning & Management
- Regulatory Change
- Education & Training

In this matrix, potential mitigation measures are listed for each site or element that is considered at risk. Financing options, estimated costs, and project priority can also be found in the matrix. Mitigation actions listed in this matrix should be considered for grant funding as it becomes available in an effort to make Westerly more resistant to the effects of natural hazards. The matrix for this 5-year update has changed. The flood of 2010 was a contributing factor to change priorities to serve urgent need areas as well as moving completed tasks to the bottom of the matrix. After much public input, new areas for improvement were adding to existing categories already in the matrix.

Critical Facilities Map

The map that follows this matrix graphically depicts public infrastructure that must be relied on in the event of an emergency, including the town hall, police and fire stations, and temporary shelters for residents that have been evacuated from their homes. This map also depicts hurricane evacuation areas (principally along the shoreline and low lying areas adjacent to the Pawcatuck River), and designated evacuation routes leading away from these areas.

Section 6: Implementation, Evaluation & Revision of Hazard Mitigation Strategy

Evaluating the plan

The Hazard Mitigation Committee and other local officials will meet annually or after a disaster to ensure that the mitigation actions are being implemented in accordance with the assigned time frames. They will monitor and document progress**.** Progress will be reviewed with the public every two years at advertised public hearings held by the Hazard Mitigation Committee. The designated Hazard Mitigation Coordinator will be responsible for coordinating the annual meeting with the Committee. The group will reconvene in the first quarter of each year. Prior to the meeting, each of the participating departments will gather data to assess progress toward meeting plan objectives and goals. The evaluation will assess whether:

- Goals and objectives address current and expected conditions.
- The nature or magnitude of the risks has changed.
- Current resources are appropriate for implementing the plan and if different or additional resources are now available.
- Actions were cost-effective.
- Schedules and budgets are feasible.
- Implementation problems, such as technical, political, legal or coordination issues with other agencies are present.
- Outcomes have occurred as expected.
- Changes in Town resources impacted plan implementation (e.g., funding, personnel, and equipment).
- Changes in programming or government structures warrant changes to the plan.
- New agencies/departments/staff should be included.

Specifically, the Committee will review the mitigation goals, objectives, and activities using performance-based indicators, including:

- Project completion
- Percent complete versus percent of resources allocated
- Under/over spending
- Achievement of the goals and objectives

- Resource allocation (e.g., If there had been more money would the activity have been more successful)

Additionally, the group will review the mitigation implementation strategy using performance-based indicators including:

- Timeframes
- Budgets
- Lead/support agency commitment
- Resources (funding, personnel [have people been reassigned or left?])
- Feasibility (Is it still an appropriate measure?)

Finally, they will evaluate how other programs and policies have conflicted, or augmented, planned or implemented measures. Other programs and policies can include those that address:

- Sustainability
- Economic development
- Water quality management
- Environmental protection
- Historic preservation
- Redevelopment
- Health and/or safety
- Recreation
- Land use/current and comprehensive planning
- Transportation
- Public education and outreach

6.1.3 Updating the plan

The mitigation plan will be updated every five years and will reflect the results of the annual plan evaluations. The Task Force will initiate the next revision process for the plan during its annual review meeting in 2017. Following an update of the mitigation plan, the plan will be distributed for public comment. After all comments are addressed, the plan will be revised and distributed to all Steering Committee members, to each city department, and to the State Hazard Mitigation Officer.

The Westerly designated Mitigation Coordinator is responsible for coordinating the plan evaluation portion of the meeting, soliciting feedback, collecting and reviewing the comments, and ensuring their incorporation in the 5-year plan update as appropriate. Members of the Committee will assist the Coordinator, as necessary.

6.1.4 Implementation

The planning committee realizes that assigning a time frame to each recommended mitigation action is important so that activities can be coordinated with other important governmental functions, such as committee meetings and budget hearings. Assigned time frames also provide inputs to a project plan used for tracking the progress of all activities.

Formal adoption and implementation of this hazard mitigation plan will help make steps for the Town to become a part the Federal Emergency Management Agency's (FEMA) Community Rating System (CRS) program, which provides discounts on National Flood Insurance Program (NFIP) flood insurance premiums for residents of communities that voluntarily participate in this program. In addition, the adoption of this mitigation strategy increases the Town's eligibility for federal grants for hazard mitigation, which include FEMA's Pre-Disaster Flood Mitigation Assistance (FMA) program, Pre-Disaster Mitigation Program (PDM) and post-disaster Hazard Mitigation Grant Program (HMGP).

> "The success of the hazard mitigation plan is measured by the degree to which actions are accomplished. Without the implementation and maintenance of the plan, the previous components have merely been an effort in research devoid of any practical application"
>
> Tennessee Emergency Management Agency

Comprehensive Plan

To establish the authority and accountability for this plan's implementation, amendments will be made to Westerly's Comprehensive Plan that appropriately address the theme of natural hazard mitigation. Additionally, this plan has prioritized natural hazard risks facing the community – focusing principally on hurricane caused wind, flooding and storm surge damages – and has prioritized its recommendations in a mitigation strategy matrix that addresses these events, as well as natural disasters of lesser frequency, including ice storms, tornadoes, earth quakes and wildfire. The RI General Assembly voted in 2011 that all town Comprehensive Plans at the 5-year update stage shall incorporate a new element to the local comprehensive plans for Hazard Mitigation. For the Town of Westerly this will take place in 2016.

Capital Improvement Program

A well thought out Capital Improvement Program (CIP) – which includes recommendations of this natural hazard mitigation strategy -- assists the Town of Westerly develop and acquire municipal facilities and equipment necessary to provide services that are needed both now and in

the future. The CIP is a list of anticipated "big ticket" items that are deemed necessary for the town to acquire over a multi-year timeframe, with particular emphasis placed on the Capital Budget, which outlines needs for the upcoming fiscal year. Multi-year budget planning helps forecast the fiscal impact of capital projects taking several years to complete.

The Town Manager, Planning Board, Finance Board and Town Council all review the CIP on an annual basis following an established budget calendar. During this process, new projects are added while prior year projects that have been completed or are no longer warranted are eliminated. Some capital projects identified in previous years may be shifted within the schedule according to changing needs or funding availability.

Annual Performance Review & Plan Maintenance

It is recommended that Westerly's Local Hazard Mitigation Committee (LHMC) publicly advertise and meet quarterly to ensure that recommended mitigation actions are being implemented in accordance with this plan, and that this strategy is updated as conditions warrant. The Greater Westerly Pawcatuck Area Chamber of Commerce and other local business associations should be given a "heads up" about this meeting, and asked to invite their members to participate and provide feedback on plan maintenance. A status report will also be given to the Westerly Planning Board and Town Council. Modifications to the local mitigation strategy approved by Town Council will be submitted to RIEMA to ensure that the State Hazard Mitigation Strategy also remains current.

Natural disasters provide a good opportunity to assess how effective mitigation activities have been, and to modify the original strategy, implementation schedule and budget based on actual performance and community feedback. Hence Westerly's LHMC will meet after each actual natural disaster event to identify "lessons learned," and to evaluate and update this local mitigation strategy. Again, changes made to this strategy will be approved by Town Council and submitted to RIEMA for final approval.

Post-Incident Analysis & After-Action Reports

Post-incident evaluations are a key component of successful disaster recovery, in that they will identify items that need corrective action. Documentation after a major disaster provides a foundation to improve daily operations and interagency cooperation, especially when new partnerships were formed during the disaster, since Westerly may again be in contact with these organizations when the next big event occurs. The after-action/follow-up report should contain:

- Chronology of the event.
- Major actions taken by each participating agency and functional department.
- Identification of future disaster training needs.
- Discussion of budgetary concerns, record keeping and procurement protocols.
- Record of "lessons learned".
- Supporting documentation in the event of post-disaster lawsuits.

An analysis of after-action reports nationwide indicates a consistent deficiency in the following areas, which Westerly should take into account when developing its disaster recovery strategy:

- Need for clearly defined organizational roles and responsibilities of emergency responders.
- Improved stocking of shelters with equipment and supplies.
- Inadequate number of electrical generators for shelters and emergency services buildings.
- Physical integrity of public buildings to withstand more severe hurricanes.

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Appendix A – Amendment to Comprehensive Plan

Services & Facilities Element -- Goals and Policies

Emergency Management

Emergency management for the Town of Westerly is shared among a number of municipal departments, and state and federal counterparts that are involved in hazard mitigation and emergency relief and response. Depending on the nature and severity of the emergency, staff from public works, police, planning, building and school departments, and from the various fire departments and ambulance corps, will act in accordance with Westerly's Emergency Operations Plan.

Natural Hazard Mitigation

Westerly's *Natural Hazard Risk Assessment and Mitigation Strategy* focuses on natural hazards of primary importance to the community, including hurricanes, tropical storms, torrential rains, Nor'easters, and associated coastal and inland flooding. Other natural hazards addressed in this document include winter storms, thunderstorms and associated high winds, coastal erosion, wildfire, earthquakes, drought, heat waves, and dam failure.

The mission of this *Natural Hazard Risk Assessment and Mitigation Strategy* and town officials charged with overseeing its implementation is to minimize the impact of natural hazards on Westerly's residents and visitors, built environment and natural resources. This document evaluates the natural hazards and vulnerabilities specific to Westerly, assesses their associated risks, and identifies opportunities to mitigate their potential adverse impacts. Preparing for natural hazards before they occur will facilitate the Town's response and recovery efforts following a natural disaster.

GOAL:

To conduct proactive planning to prevent loss of life, and to prevent or reduce damage to the built environment and natural resources, by reducing vulnerability to natural hazards. This will be accomplished through proper planning and preparedness, and by programmed response and recovery efforts after a natural disaster occurs.

POLICIES:

A. Westerly must do its utmost to secure public safety and prevent loss of property and life in the event of a natural or man-made emergency.

B. Provide regular updates to Westerly's *Emergency Operations Plan*, *Natural Hazard Risk Assessment & Mitigation Strategy*, and *Hazardous Materials Response Plan*.

C. Provide for well-planned and effective emergency response through coordination with the Rhode Island Emergency Management Agency, the Federal Emergency Management Agency, adjacent municipalities, Westerly's various fire districts and Ambulance Corps, and the business community.

D. Design, retrofit and locate critical public facilities to account for natural hazard risks including flooding, high wind, drought and earthquake.

E. Participate in FEMA's National Flood Insurance Program and Community Rating System.

F. Adopt the *Natural Hazard Risk Assessment & Mitigation Strategy* as a supporting element of Westerly's Community Comprehensive Plan.

Appendix B – Hazard Mitigation Assistance Sources

State of Rhode Island Resources

Coastal Resources Center
University of Rhode Island
Narragansett Bay Campus
Narragansett, RI 02882
Phone: (401) 874-6224

Coastal Resources Management Council
Stedman Government Center
4808 Tower Hill Road
Wakefield, RI 02879
Phone: (401) 783-3370

Department of Environmental Management
235 Promenade Street
Providence, RI 02908
Phone: (401) 222-6800

Department of Transportation – Bridge Engineering
Two Capitol Hill
Providence, RI 02903
Phone: (401) 222-2053

Rhode Island Emergency Management Agency (RIEMA)
645 New London Avenue
Cranston, RI 02920
Phone: (401) 946-9996

Rhode Island Builders Association
450 Veterans Memorial Parkway, #301
East Providence, RI 02914
Phone: (401) 438-7400

RI Public Utilities Commission
89 Jefferson Blvd.
Warwick, RI 02888
Phone: (401) 941-4500

Statewide Planning Program -- Department of Administration
One Capitol Hill
Providence, RI 02908
Phone: (401) 222-9701

State Fire Marshal's Office
24 Conway Avenue
Quonset / Davis
North Kingstown, RI 02852
Phone: (401) 294-0861

Federal Government Resources

U.S. Army Corps of Engineers
New England District
696 Virginia Road
Concord, MA 01742
(978) 318-8111

Economic Development Administration
Curtis Center, Suite 140 South
Independence Square West
Philadelphia, PA 19106
(215) 597-7883

Environmental Protection Agency
Region I - JFK Federal Building
Government Center
Boston, MA 02203
(617) 918-1111

Federal Emergency Management Agency
Mitigation Division
Region I Office
J.W. McCormack POCH, Room 462
Boston, MA 02109
(617) 223-9561
(www.fema.gov)

Federal Insurance & Mitigation Administration
(Branch of FEMA administering National Flood Insurance Program)
500 C Street, SW
Washington, D.C. 20472
(202) 566-1600

National Weather Service

Forecast Office
445 Myles Standish Boulevard
Taunton, MA 02780
(508) 823-2262

Natural Resources Conservation Service

60 Quaker Lane, Suite 46
Warwick, RI 02886
(401) 828-1300

Small Business Administration – Disaster Loans
360 Rainbow Boulevard South, 3rd Floor
Niagara Falls, NY 14303
(716) 282-4612 or (800) 659-2955

Other Resources

Association of State Floodplain Managers (ASFPM)
Professional association with a membership of almost 1,000 state employees that assist communities with the NFIP. ASFPM has developed a series of technical and topical research papers and a series of proceedings from their annual conferences. Many mitigation "success stories" have been documented through these resources and provide a good starting point for planning. (www.floods.org)

Floodplain Management Resource Center
Free library and referral service of the ASFPM for floodplain management publications. Co-located with the Natural Hazards Center at the University of Colorado in Boulder, website users can use keywords to identify useful publications from the more than 900 flood-related documents in the library. (www.colorado.edu/hazards/)

Institute for Business and Home Safety (IBHS)
An insurance industry-sponsored, nonprofit organization dedicated to reducing losses -- deaths, injuries, and property damage -- resulting from natural hazards. IBHS efforts are directed at seven specific hazards: hurricane, flood, tornado, hail, earthquake, freezing weather and wildfire. Through its public education efforts and information center, IBHS communicates the results of its research and statistical gathering, as well as mitigation information, to a broad audience. (www.ibhs.org)

National Fire Protection Association (NFPA)
NFPA's mission is to reduce the worldwide burden of fire and other hazards on the quality of life by developing and advocating scientifically based consensus codes and standards, research, training, and education. (www.nfpa.org)

New England Floodplain and Stormwater Managers Association (NEFSMA)
NEFSMA's mission is to promote sound floodplain and stormwater management practices through workshops, conferences, and a newsletter to membership and interested individuals and companies. (www.nefsma.org)

New England States Emergency Consortium (NESEC)
NESEC conducts public awareness and education programs on natural disaster and emergency management activities throughout New England. Brochures and videotapes are available on such topics as earthquake preparedness, mitigation, and hurricane safety tips. (www.serve.com/NESEC)

Volunteer Organizations
Organizations such as the American Red Cross, Salvation Army, Habitat for Humanity, Interfaith, and the Mennonite Disaster Service, are often available to help after disasters. Service organizations such as the Lions, Elks, and VFW may also be available. These organizations have helped others with food, shelter, clothing, money, etc. Offices of individual organizations can be contacted directly, or the FEMA Regional Office may be able to assist. A good resource is "National Voluntary Organizations Active in Disaster." (www.nvoad.org)

Donated Flood Relief Funds
After a disaster, local businesses, residents, and out-of-town groups often donate money to local relief funds. They may be managed by the local government or local churches. No government disaster declaration is needed. It is recommended that local officials not award these funds until an applicant demonstrates they have exhausted all sources of public disaster assistance. Doing so allows the funds to be used for mitigation and other projects that cannot be funded elsewhere.

Appendix C -- Public Participation in Natural Hazard Mitigation Plan Preparation

The first draft of Westerly's *Natural Hazard Risk Assessment & Mitigation Strategy* was prepared in the summer of 2003 by intern Samuel Eisenbeiser, who at that time was a student in University of Rhode Island's planning program. Additional contributions to the draft plan were made by Assistant Town Planner Marilyn Shellman and Larry Steadman, Westerly's Deputy Civil Defense Director. The principal author and editor was Westerly Town Planner William Haase.

Westerly's 5-year update of the *Natural Hazard Risk Assessment & Mitigation Strategy* was distributed in July 2010 to the following individuals for review and comment, with responses received from many of these people over the subsequent two weeks (* = Westerly Emergency Management Task Force Member). Task Force members are residents of Westerly or are employed by the Town of Westerly with the business community being represented by the Westerly Chamber of Commerce. The general public will be invited to provide comment on the 5-year update at the Public Hearing with the Westerly Town Council on February 20, 2012. Copies are available for public review on the Town Website Homepage, at www.townofwesterly.com, with hard copies available in the Westerly Planning Office and the Westerly Public Library. The Westerly Planning Board conducted two public hearings August 16, 2011, September 20, 2011 to solicit input from the board and the public. Other meetings were held at the local community centers, Bradford Johnnycake (our local food bank) to work with the public in the affected areas.

In addition, The March flood of 2010 gave the task force and other town personnel a unique opportunity to learn of the impact the flooding on private and public properties that were not of high priority to the town because most of the storm events in Westerly occur in coastal areas. This event exposed the vulnerability of real property and business district within our riverine and wetland and contributing wetland areas. Due to this, many of the priority ranking was changed in the matrix due to the urgent need in this area.

- Steven T. Hartford, Town Manager and Director of Emergency Management*
- Westerly Town Council
- Donna Giordano, Town Clerk
- Marilyn Shellman, Town Planner
- Blanche Higgins, Assistant Town Planner
- David Murphy, Building Official
- Jonathan Pratt, Town Engineer
- Paul Corina, Water and Sewer Superintendent
- Roy Seitsinger, Superintendent of Schools*
- David Panciera, Planning Board Chairman
- Chief Ed St. Clair, Police Department*
- Lt. Michael Turano, Emergency Management Director*
- Chief Jay Sullivan, Bradford Fire District*

- Chief Michael Frink, Dunn's Corner Fire District*
- Chief Louis Misto, Misquamicut Fire District*
- Chief Scott Harold, Watch Hill Fire District*
- Chief John MacKay, Westerly Fire District*
- Kevin Flynn, Chief, RI Statewide Planning Program
- MG Kevin McBride, RI Emergency Management Agency
- Michelle Burnett, NFIP State Coordinator
- Westerly Public Library
- David Trebisacci, NFPA International (Public Fire Protection)*
- Ashley Hahn-Morris, Town Planner, Town of Charlestown
- James Lampher, Town Planner, Town of Hopkinton
- Charles S. Kinney, CEO, Westerly Hospital

5-year update draft copies were sent to RIEMA's Michelle Burnett, the NFIP State Coordinator, Emily Pysh, State Hazard Mitigation Officer, and to FEMA, Region I in Boston, December 2010. Very rigorous and extensive commentary was received from FEMA Region 1 in July of 2011 on the draft document. The draft 5- year update is posted on the Town of Westerly's website for public review prior to the public hearing. In addition, the draft has been distributed to the Town Council, the Planning Board and member of the Task Force for review and comment. A public hearing will be held in September 2011 at the discretion of the Town Council. Any revisions to the plan as a result of the public hearing will be incorporated in the final version of the plan with no further public hearings. The Westerly Planning Board also conducted a public hearing

On October 15, 2012, Westerly Town Council unanimously adopted the following resolution:

> WHEREAS, the Federal Disaster Mitigation Act of 2000 (P.L. 106-390) calls on all municipalities to prepare and adopt a Natural Hazard Risk Assessment and Mitigation Strategy in order to save lives and to minimize the impact of natural disasters on the built environment and natural resources; and
>
> WHEREAS, the adoption of such plan is essential for communities to receive future pre-disaster hazard mitigation grants, flood mitigation assistance, and post-disaster recovery funding from various state and federal agencies; and
>
> WHEREAS, the Westerly Planning Department in concert with local civil preparedness managers, the Federal Emergency Management Agency, and the RI Emergency Management Agency, has prepared a plan that prioritizes natural hazards that may occur in Westerly, and outlines a strategy for mitigation, preparedness, response and recovery; now therefore, be it
>
> RESOLVED: that the Town Council hereby approves and adopts the 5-year update of Natural Hazard Risk Assessment and Mitigation Strategy, October 2012, for the Town of Westerly, Rhode Island.

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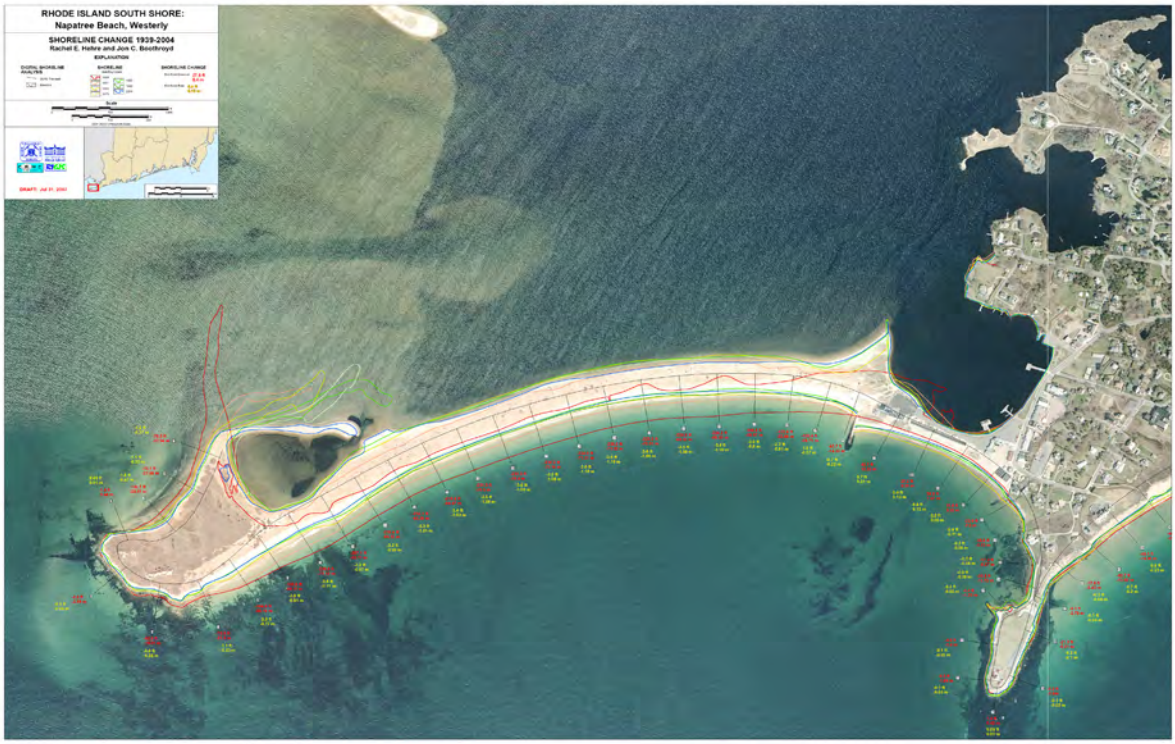
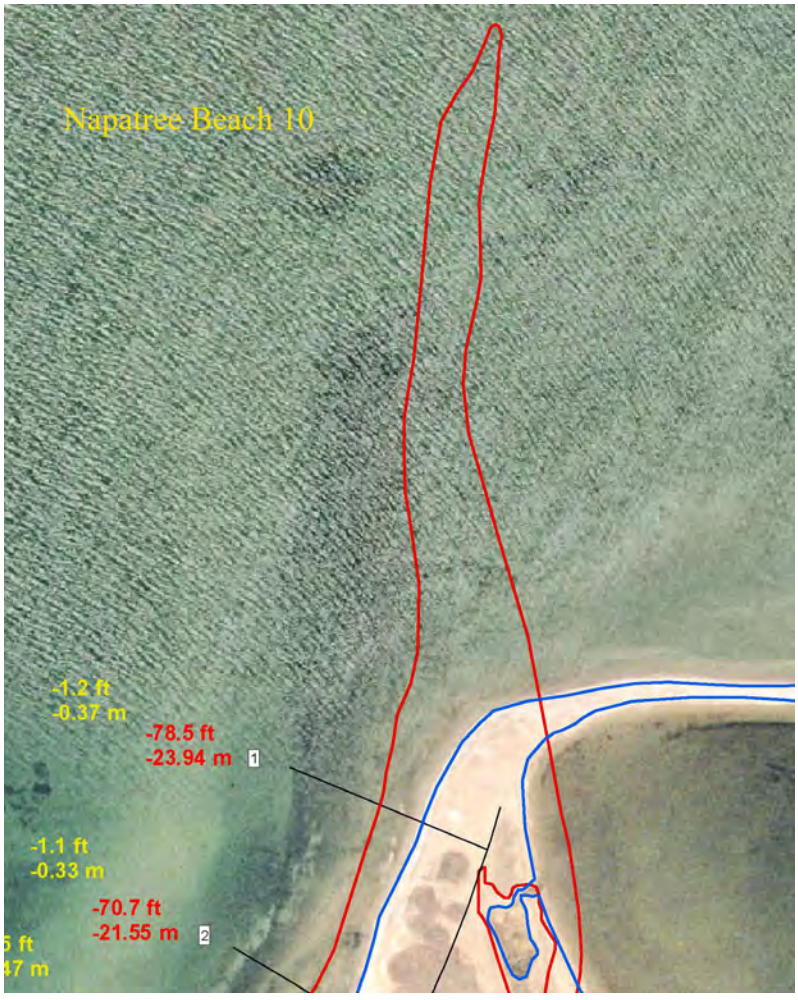
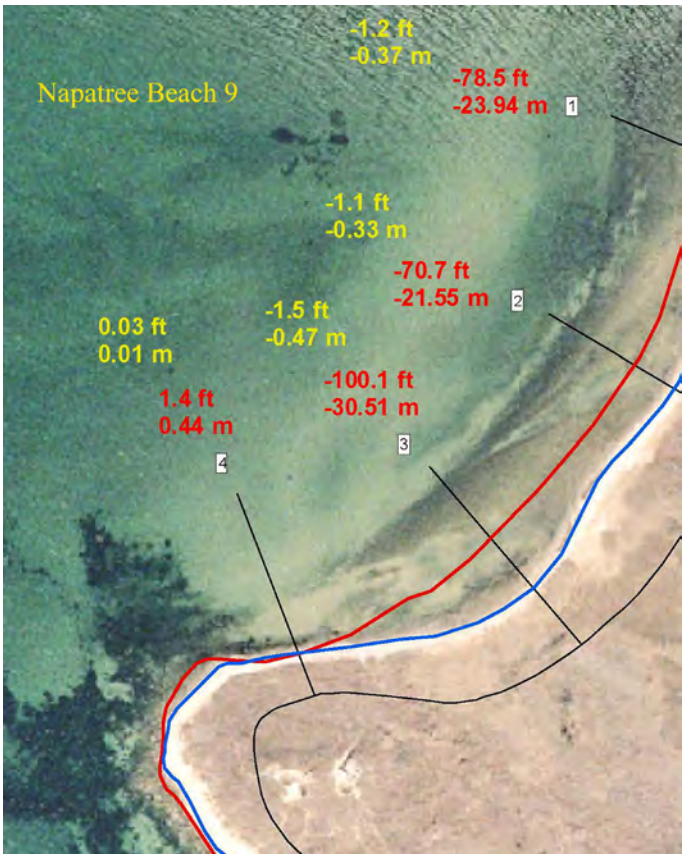
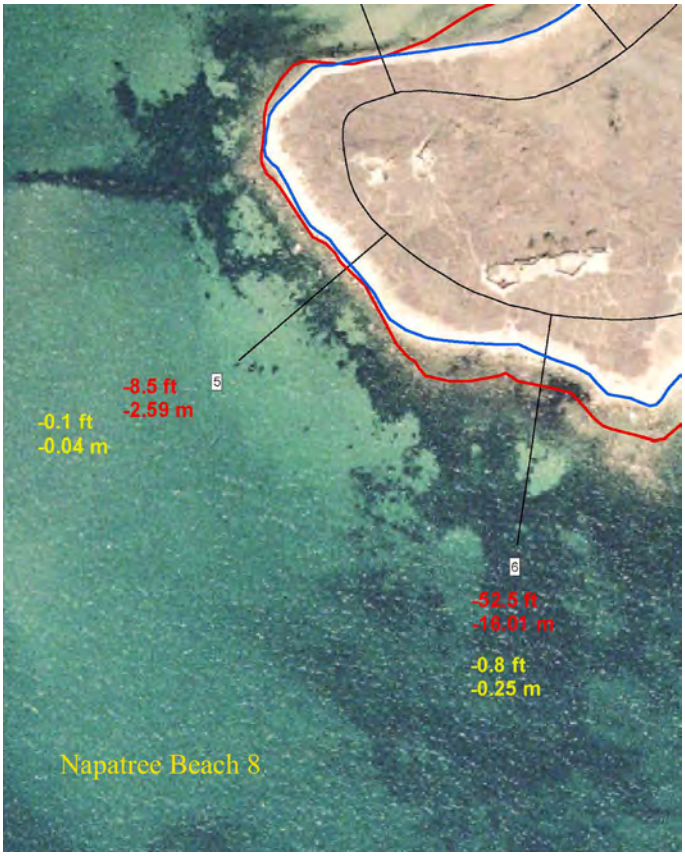
Appendix D – Coastal Erosion Maps for Westerly

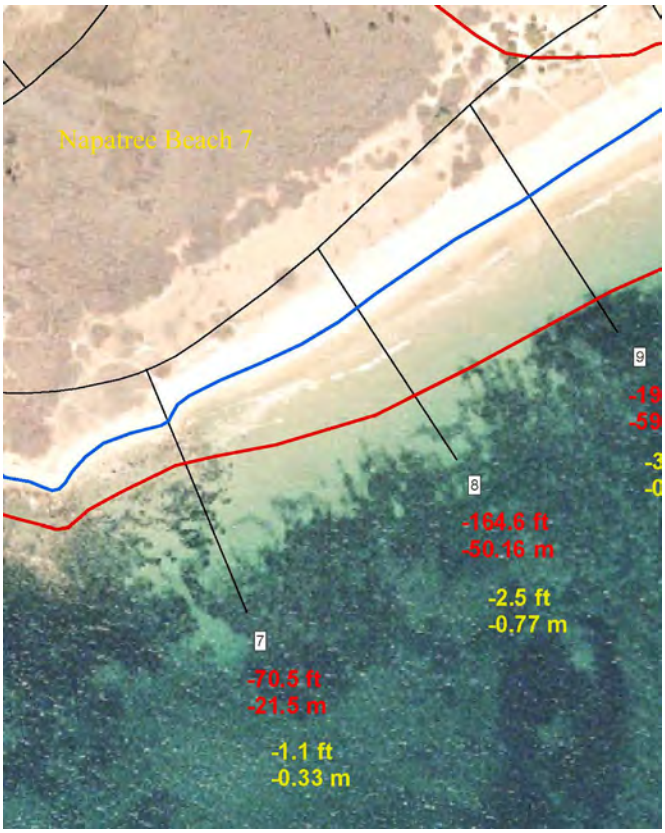
The following seven shoreline change maps show the annual rate of change in the position of the high water line (HWL) as measured from vertical aerial photographs dating back to 1939. Negative values indicate landward movement of the HWL, and positive values denote seaward displacement. Also shown are the transect lines defining the shoreline segments for which measurements were made, the locations of the long-term beach profiles, the projected HWL positions for the years 2020 and 2100, and the boundaries between barrier beaches and rocky headlands.

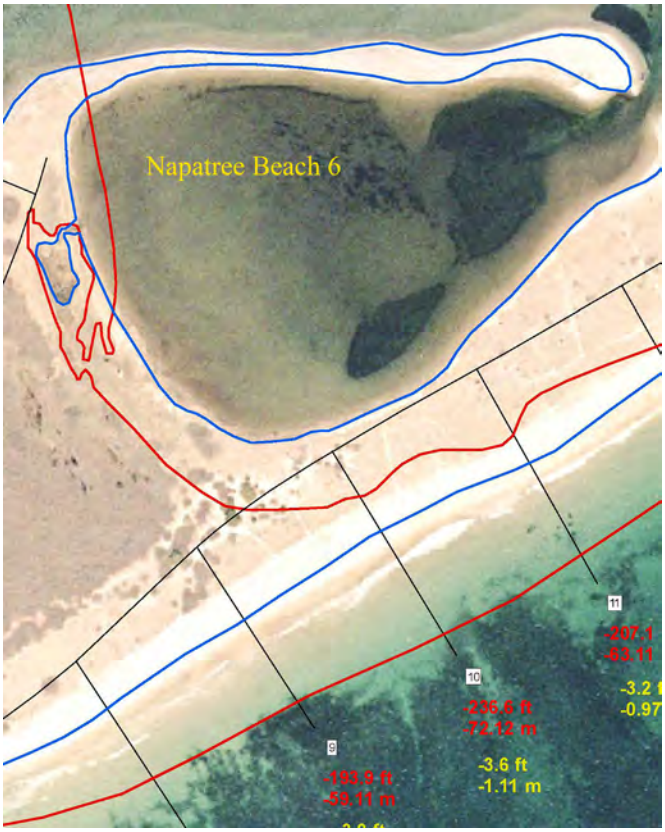

RHODE ISLAND SOUTH SHORE:
Napatree Beach, Westerly
SHORELINE CHANGE 1939-2004
Rachel E. Hehre and Jon C. Boothroyd
EXPLANATION

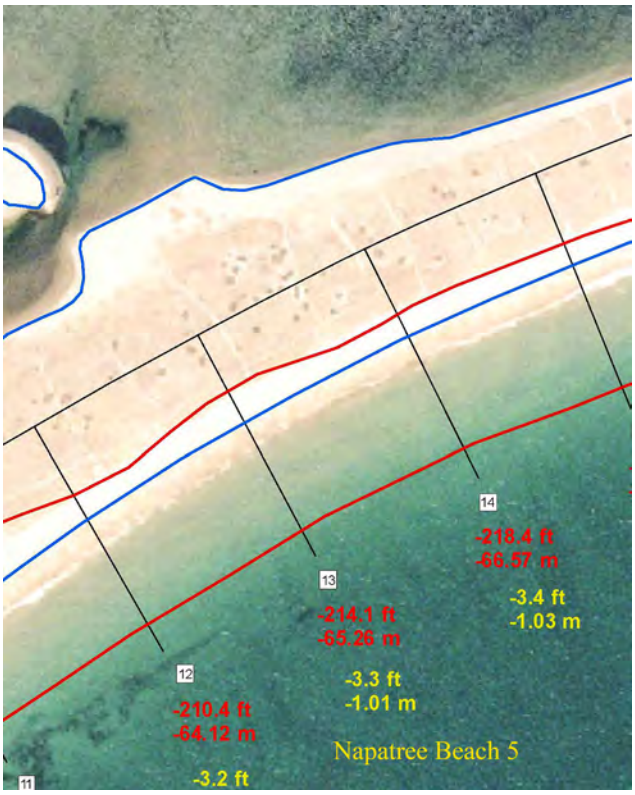

Napatree Beach 10
-1.2 ft
-0.37 m
-78.5 ft
-23.94 m
1
-1.1 ft
-0.33 m
-70.7 ft
-21.55 m
2

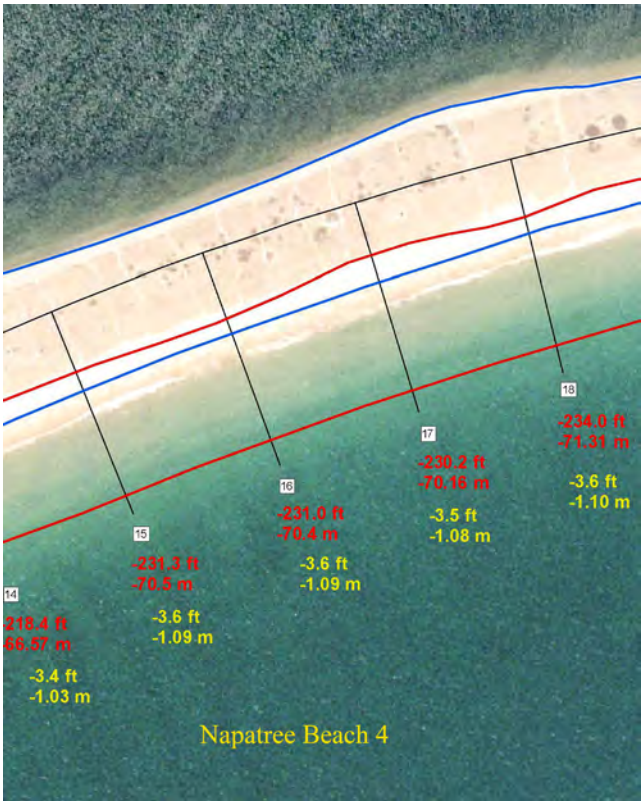

-1.2 ft
-0.37 m
Napatree Beach 9
-78.5 ft
-23.94 m
1
-1.1 ft
-0.33 m
-70.7 ft
-21.55 m
2
-1.5 ft
-0.47 m
0.03 ft
0.01 m
-100.1 ft
-30.51 m
1.4 ft
0.44 m
3
4

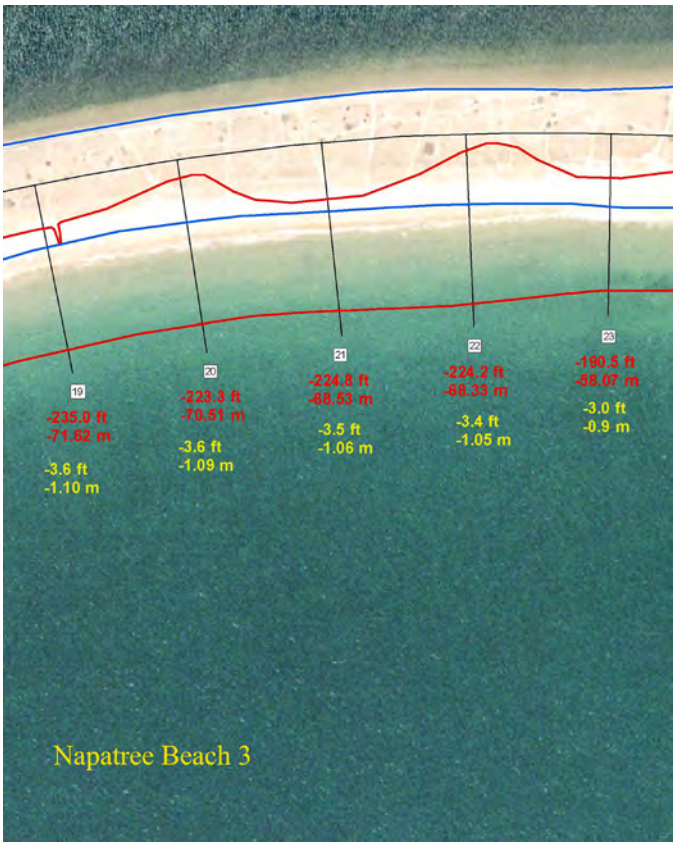

-8.5 ft
-2.59 m
5
-0.1 ft
-0.04 m
6
-52.5 ft
-16.01 m
-0.8 ft
-0.25 m
Napatree Beach 8

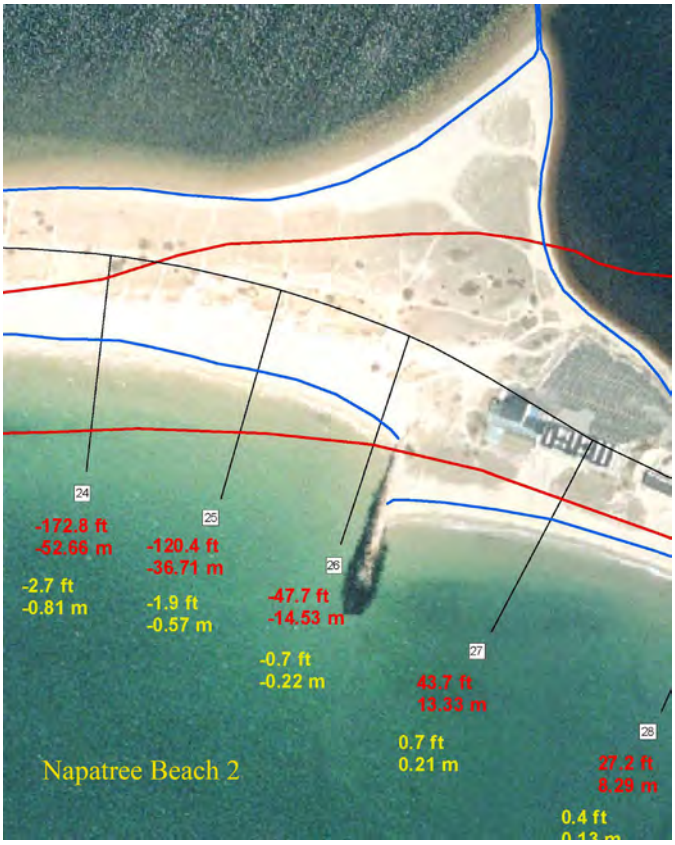

Napatree Beach 7
9
8
-164.6 ft
-50.16 m
-2.5 ft
-0.77 m
7
-70.5 ft
-21.5 m
-1.1 ft
-0.33 m

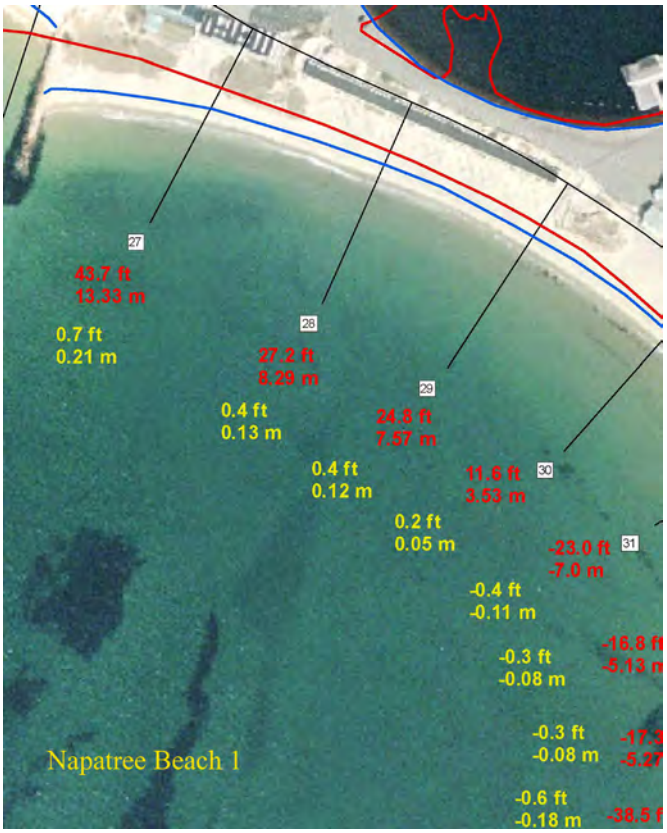

Napatree Beach 6
11
-207.1
-63.11
10
-236.6 ft
-72.12 m
-3.6 ft
-1.11 m
9

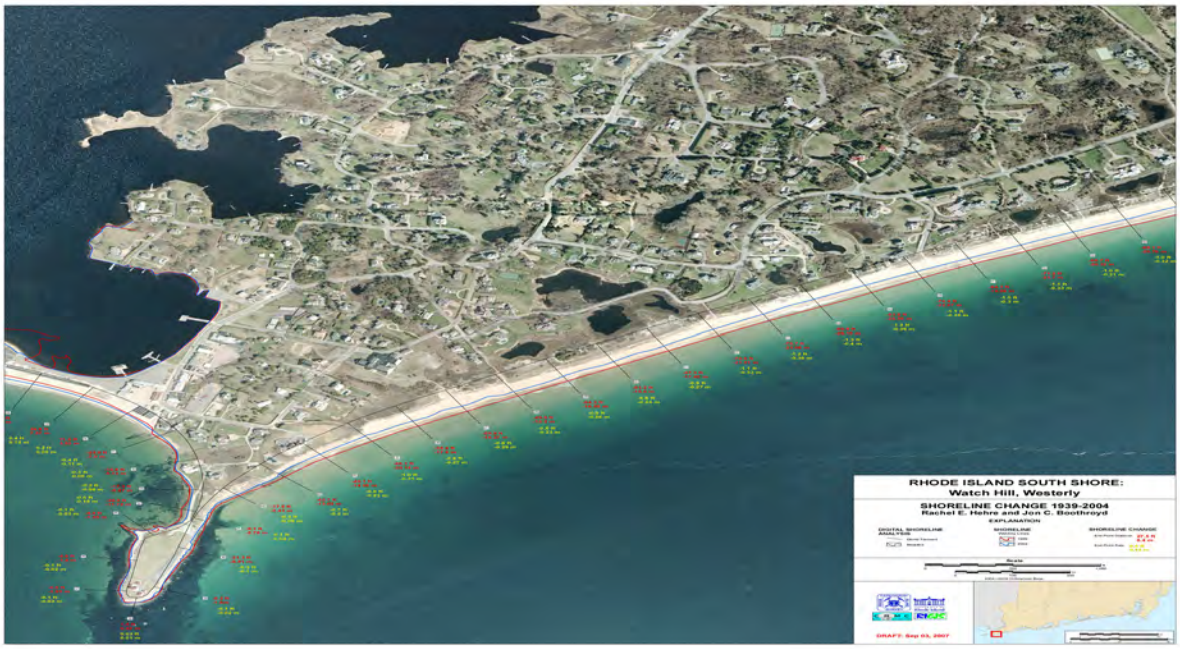

14
-218.4 ft
-66.57 m
-3.4 ft
-1.03 m
13
-214.1 ft
-65.26 m
-3.3 ft
-1.01 m
12
-210.4 ft
-64.12 m
-3.2 ft
11
Napatree Beach 5

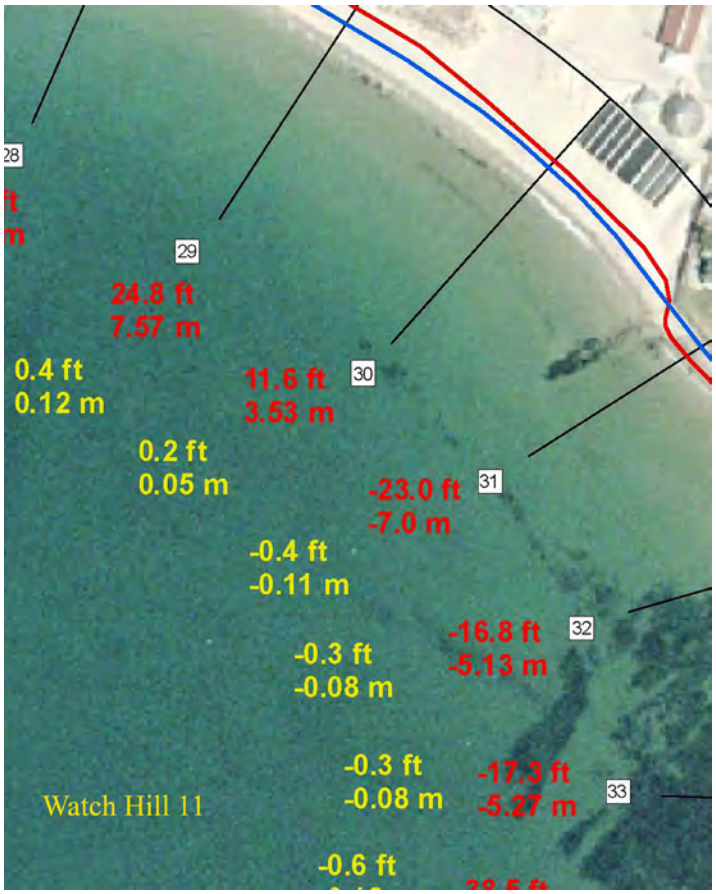

18
-234.0 ft
-71.31 m
-3.6 ft
-1.10 m
17
-230.2 ft
-70.16 m
-3.5 ft
-1.08 m
16
-231.0 ft
-70.4 m
-3.6 ft
-1.09 m
15
-231.3 ft
-70.5 m
-3.6 ft
-1.09 m
14
-218.4 ft
-66.57 m
-3.4 ft
-1.03 m
Napatree Beach 4

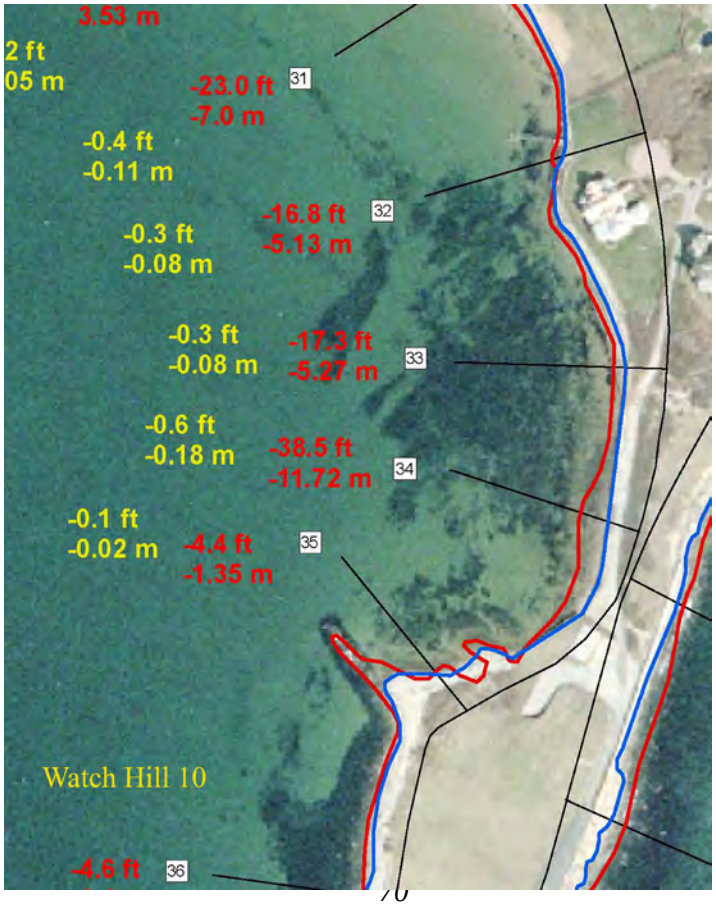

19
-235.0 ft
-71.62 m
-3.6 ft
-1.10 m
20
-223.3 ft
-70.51 m
-3.6 ft
-1.09 m
21
-224.8 ft
-68.53 m
-3.5 ft
-1.06 m
22
-224.2 ft
-68.33 m
-3.4 ft
-1.05 m
23
-190.5 ft
-58.07 m
-3.0 ft
-0.9 m
Napatree Beach 3

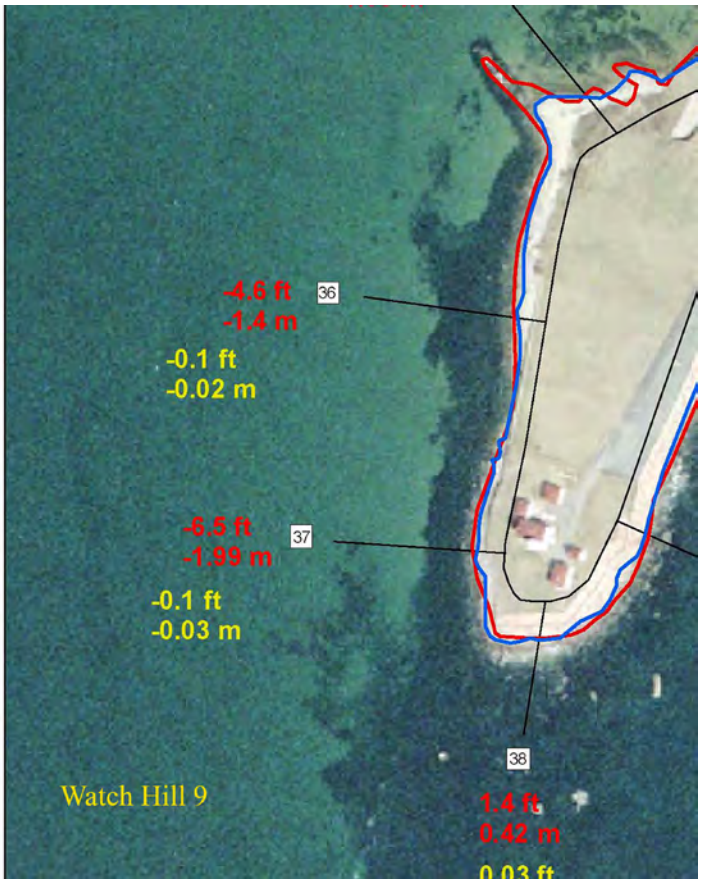

24
-172.8 ft
-52.66 m
-2.7 ft
-0.81 m
25
-120.4 ft
-36.71 m
-1.9 ft
-0.57 m
26
-47.7 ft
-14.53 m
-0.7 ft
-0.22 m
27
43.7 ft
13.33 m
0.7 ft
0.21 m
28
27.2 ft
8.29 m
0.4 ft
Napatree Beach 2

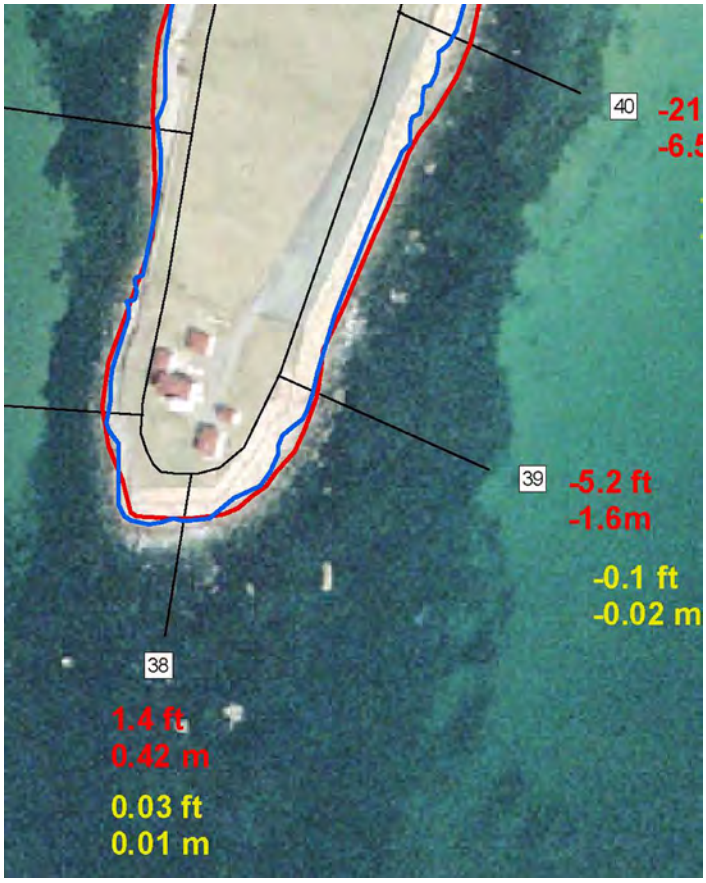

27
43.7 ft
13.33 m
0.7 ft
0.21 m
28
27.2 ft
8.29 m
0.4 ft
0.13 m
29
24.8 ft
7.57 m
0.4 ft
0.12 m
11.6 ft
3.53 m
30
0.2 ft
0.05 m
-23.0 ft
-7.0 m
31
-0.4 ft
-0.11 m
-0.3 ft
-0.08 m
-0.3 ft
-0.08 m
-0.6 ft
-0.18 m
Napatree Beach 1

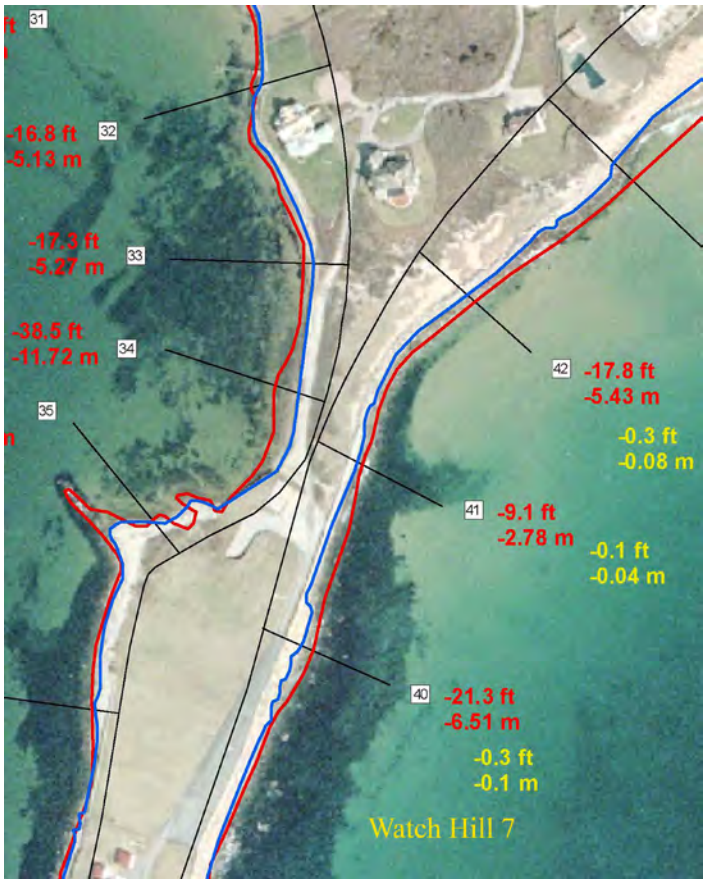

RHODE ISLAND SOUTH SHORE:
Watch Hill, Westerly
SHORELINE CHANGE 1939-2004
Rachel E. Hehre and Jon C. Boothroyd
EXPLANATION

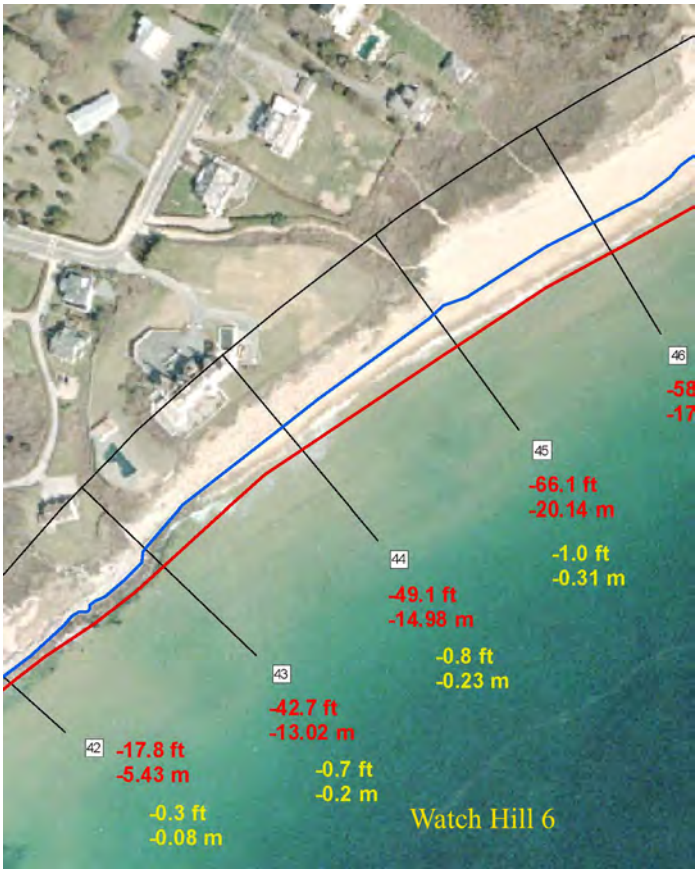

28
29
24.8 ft
7.57 m
0.4 ft
0.12 m
11.6 ft
3.53 m
30
0.2 ft
0.05 m
-23.0 ft
-7.0 m
31
-0.4 ft
-0.11 m
-16.8 ft
-5.13 m
32
-0.3 ft
-0.08 m
-0.3 ft
-0.08 m
-17.3 ft
-5.27 m
33
Watch Hill 11
-0.6 ft

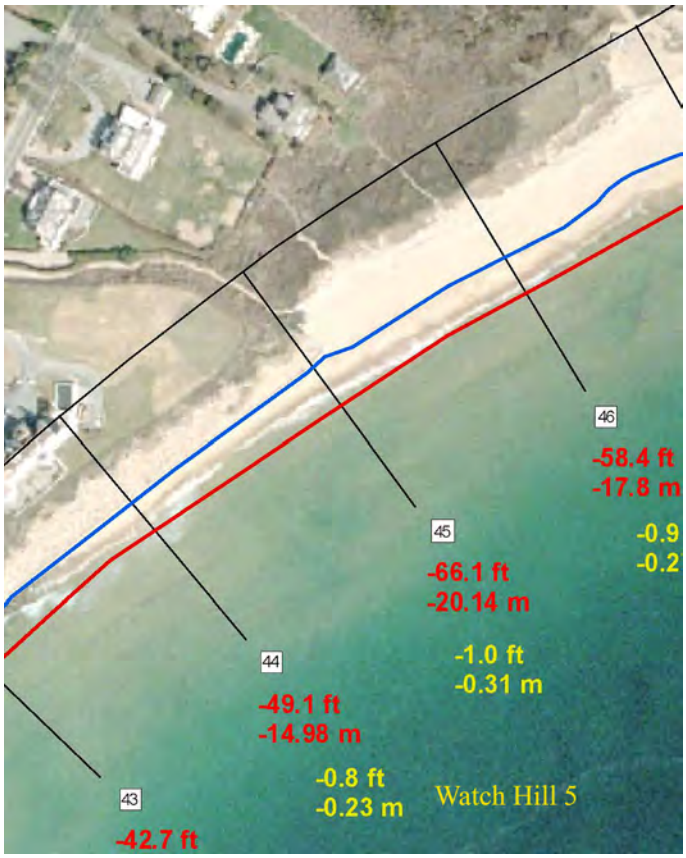

3.53 m
2 ft
05 m
-23.0 ft
-7.0 m
31
-0.4 ft
-0.11 m
-16.8 ft
-5.13 m
32
-0.3 ft
-0.08 m
-0.3 ft
-0.08 m
-17.3 ft
-5.27 m
33
-0.6 ft
-0.18 m
-38.5 ft
-11.72 m
34
-0.1 ft
-0.02 m
-4.4 ft
-1.35 m
35
Watch Hill 10
-4.6 ft
36

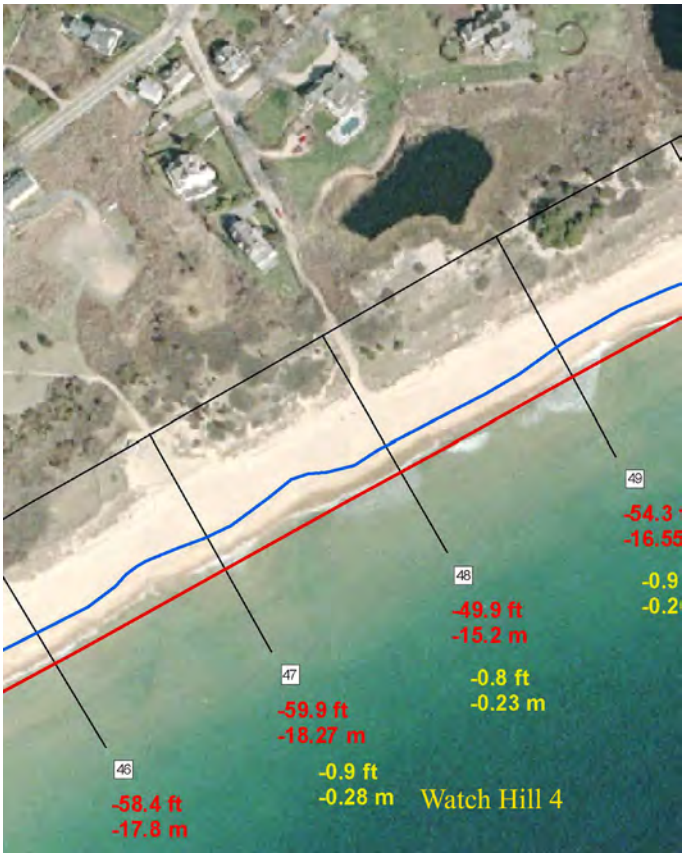

-4.6 ft
-1.4 m
36
-0.1 ft
-0.02 m
-6.5 ft
-1.99 m
37
-0.1 ft
-0.03 m
38
Watch Hill 9
1.4 ft
0.42 m
0.03 ft

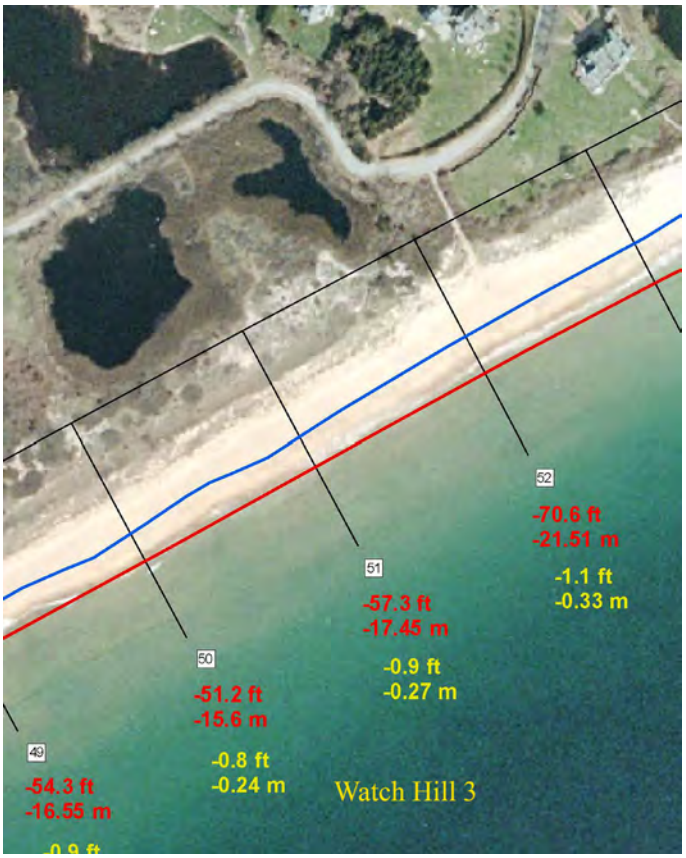

40
-21
-6.5
39
-5.2 ft
-1.6m
-0.1 ft
-0.02 m
38
1.4 ft
0.42 m
0.03 ft
0.01 m

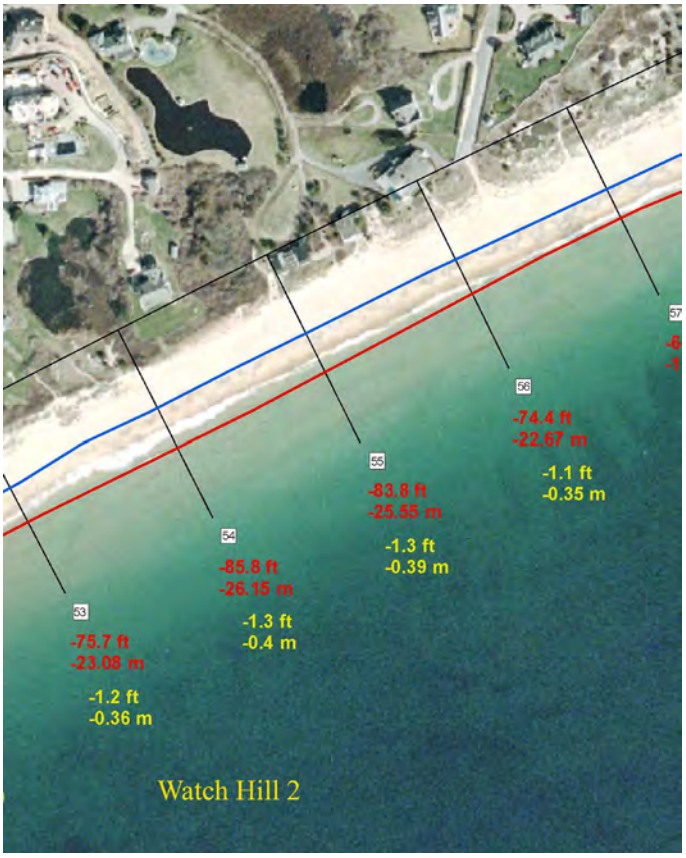

31
-16.8 ft
-5.13 m
32
-17.3 ft
-5.27 m
33
-38.5 ft
-11.72 m
34
35
42
-17.8 ft
-5.43 m
-0.3 ft
-0.08 m
41
-9.1 ft
-2.78 m
-0.1 ft
-0.04 m
40
-21.3 ft
-6.51 m
-0.3 ft
-0.1 m
Watch Hill 7

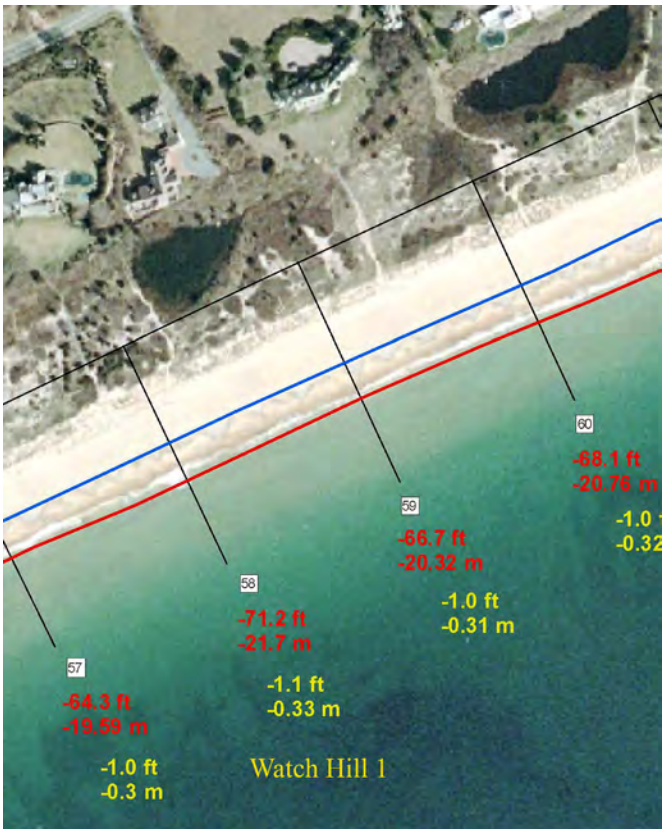

46
45
-66.1 ft
-20.14 m
-1.0 ft
-0.31 m
44
-49.1 ft
-14.98 m
-0.8 ft
-0.23 m
43
-42.7 ft
-13.02 m
-0.7 ft
-0.2 m
42
-17.8 ft
-5.43 m
-0.3 ft
-0.08 m
Watch Hill 6

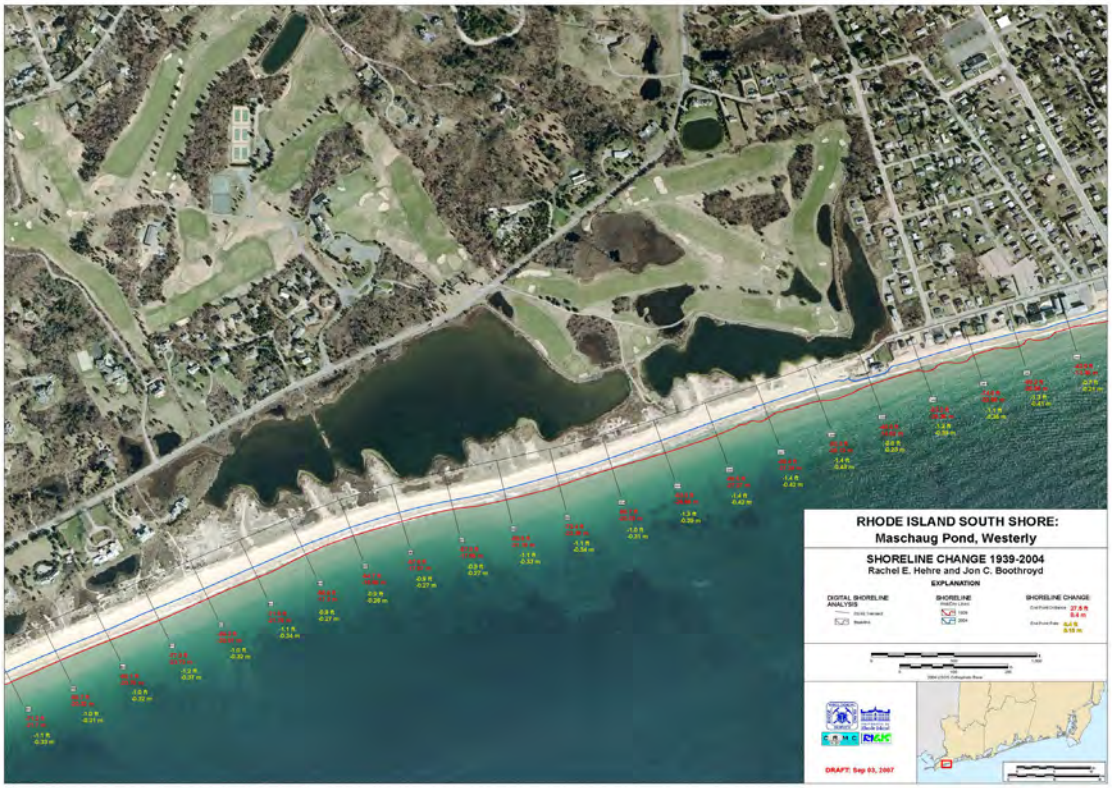

46
-58.4 ft
-17.8 m
-0.9
-0.2
45
-66.1 ft
-20.14 m
-1.0 ft
-0.31 m
44
-49.1 ft
-14.98 m
-0.8 ft
-0.23 m
Watch Hill 5
43
-42.7 ft

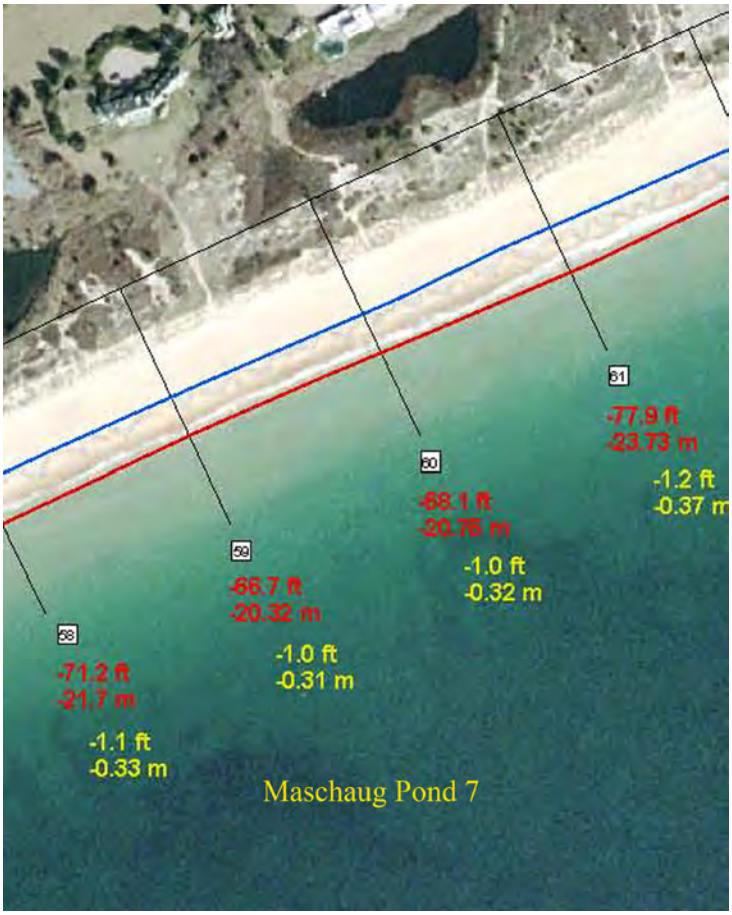

49
-54.3
-16.55
-0.9
-0.2
48
-49.9 ft
-15.2 m
-0.8 ft
-0.23 m
47
-59.9 ft
-18.27 m
-0.9 ft
-0.28 m
Watch Hill 4
46
-58.4 ft
-17.8 m

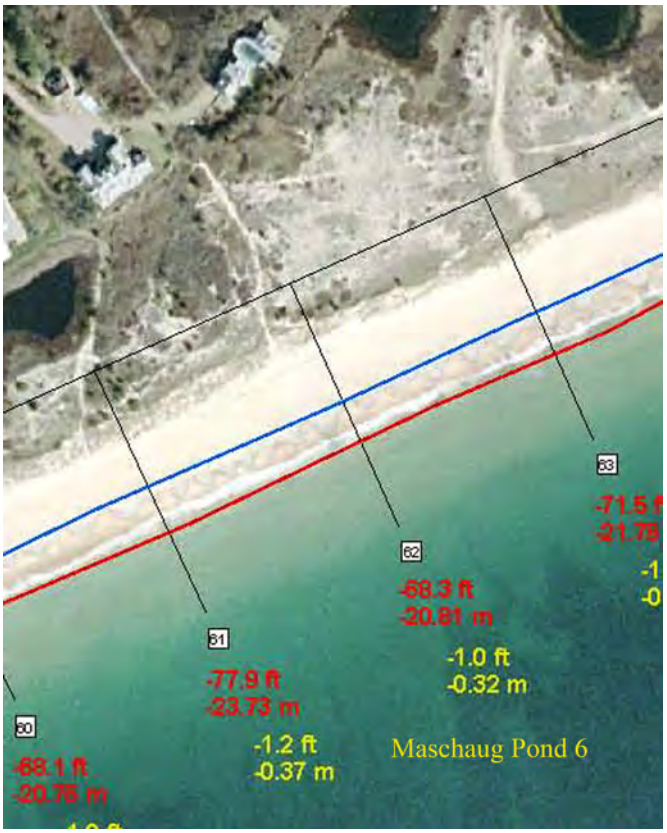

52
-70.6 ft
-21.51 m
-1.1 ft
-0.33 m
51
-57.3 ft
-17.45 m
-0.9 ft
-0.27 m
50
-51.2 ft
-15.6 m
-0.8 ft
-0.24 m
49
-54.3 ft
-16.55 m
Watch Hill 3

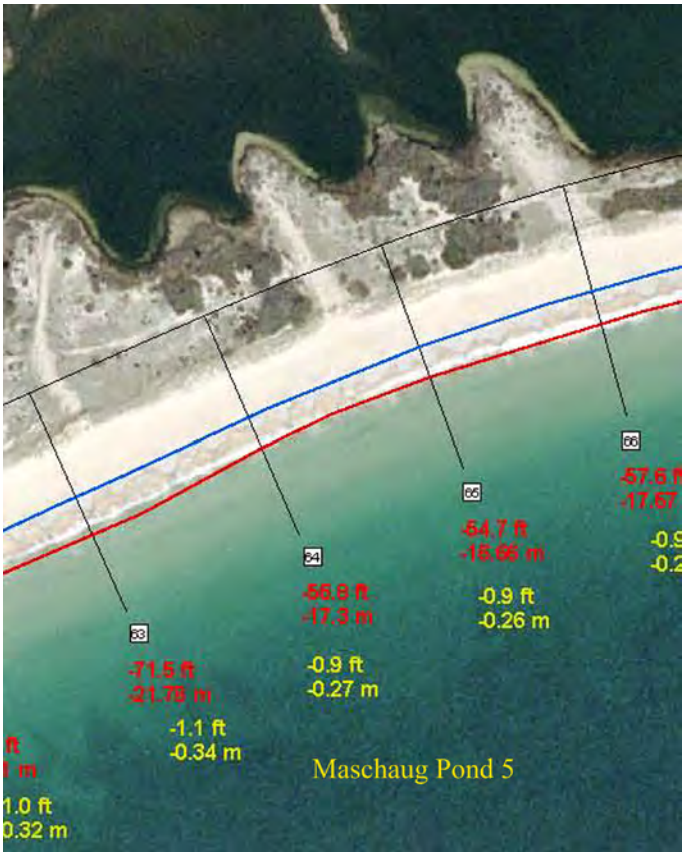

57
56
-74.4 ft
-22.67 m
-1.1 ft
-0.35 m
55
-83.8 ft
-25.55 m
-1.3 ft
-0.39 m
54
-85.8 ft
-26.15 m
-1.3 ft
-0.4 m
53
-75.7 ft
-23.08 m
-1.2 ft
-0.36 m
Watch Hill 2

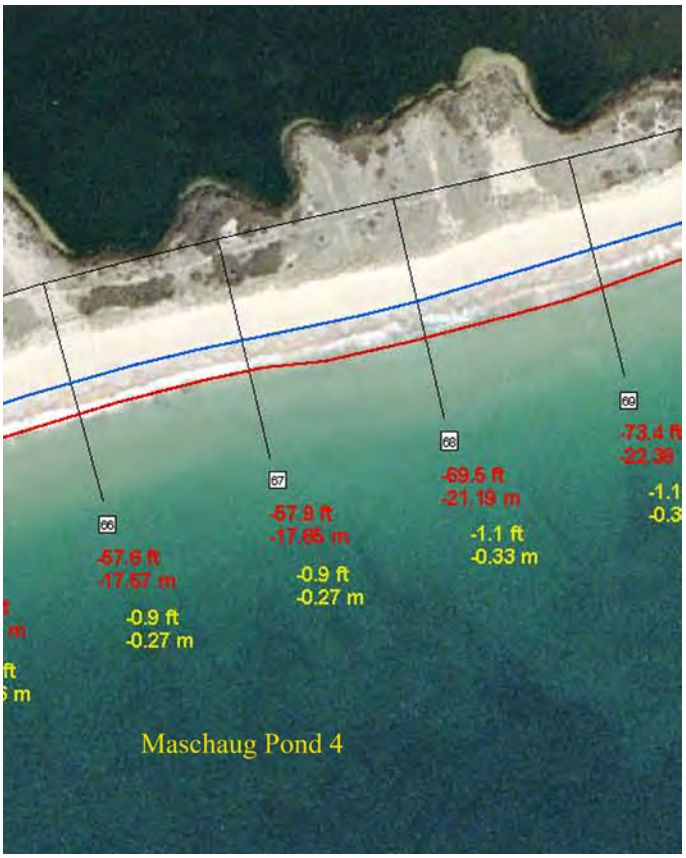

60
-68.1 ft
-20.75 m
-1.0
-0.32
59
-66.7 ft
-20.32 m
-1.0 ft
-0.31 m
58
-71.2 ft
-21.7 m
-1.1 ft
-0.33 m
57
-64.3 ft
-19.59 m
-1.0 ft
-0.3 m
Watch Hill 1

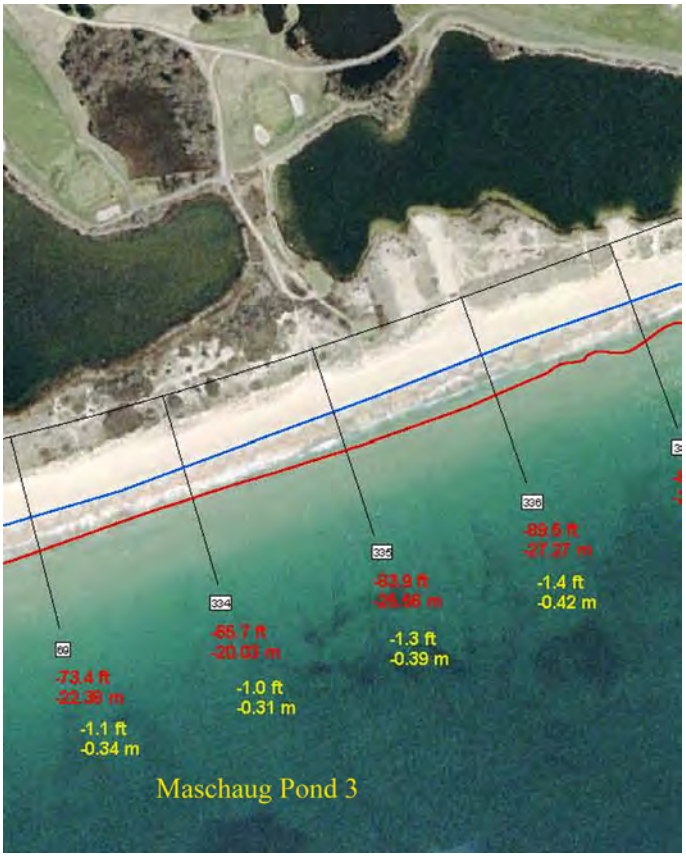

RHODE ISLAND SOUTH SHORE:
Maschaug Pond, Westerly
SHORELINE CHANGE 1939-2004
Rachel E. Hehre and Jon C. Boothroyd
EXPLANATION
DIGITAL SHORELINE ANALYSIS
SHORELINE
SHORELINE CHANGE
DRAFT: Sep 03, 2007

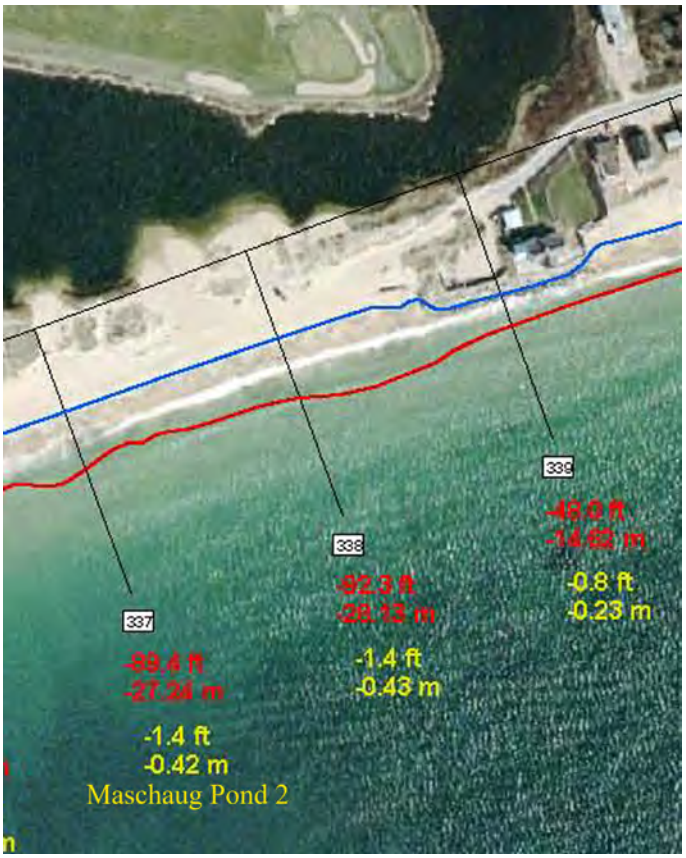

51
-77.9 ft
-23.73 m
-1.2 ft
-0.37 m
50
-68.1 ft
-20.76 m
-1.0 ft
-0.32 m
59
-66.7 ft
-20.32 m
-1.0 ft
-0.31 m
58
-71.2 ft
-21.7 m
-1.1 ft
-0.33 m
Maschaug Pond 7


63
62
61
60
-68.3 ft
-20.81 m
-1.0 ft
-0.32 m
-77.9 ft
-23.73 m
-1.2 ft
-0.37 m
Maschaug Pond 6


66
65
64
63
-64.7 ft
-0.9 ft
-0.26 m
-0.9 ft
-0.27 m
-71.5 ft
-1.1 ft
-0.34 m
Maschaug Pond 5


66
-57.6 ft
-17.57 m
-0.9 ft
-0.27 m
67
-57.9 ft
-17.65 m
-0.9 ft
-0.27 m
68
-69.5 ft
-21.19 m
-1.1 ft
-0.33 m
Maschaug Pond 4


69
-73.4 ft
-22.36 m
-1.1 ft
-0.34 m
334
-65.7 ft
-20.03 m
-1.0 ft
-0.31 m
335
-1.3 ft
-0.39 m
336
-1.4 ft
-0.42 m
Maschaug Pond 3

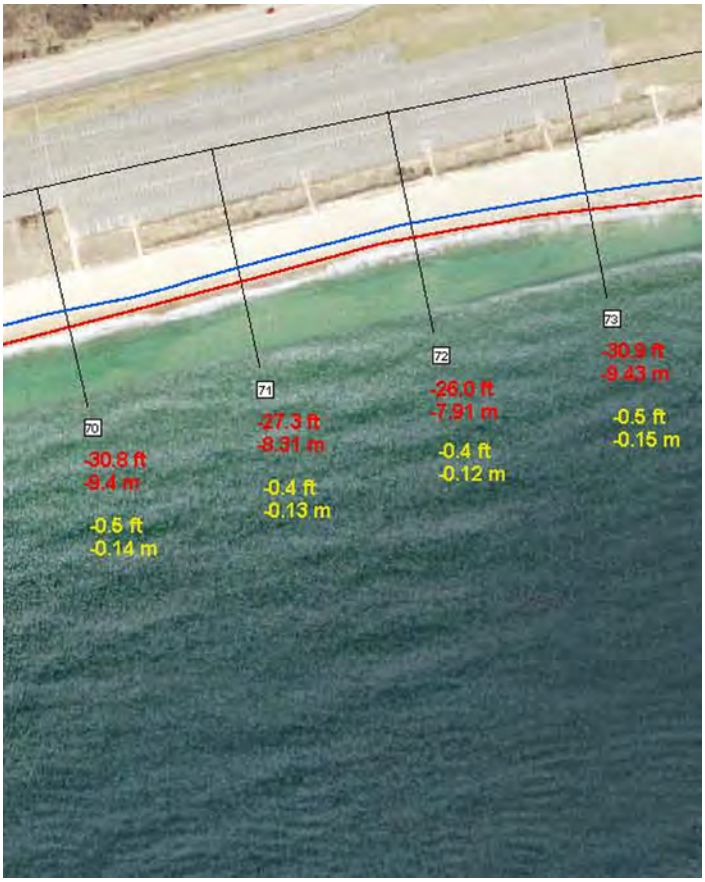

339
-46.0 ft
-14.02 m
-0.8 ft
-0.23 m
338
-92.3 ft
-28.13 m
-1.4 ft
-0.43 m
337
-89.4 ft
-27.24 m
-1.4 ft
-0.42 m
Maschaug Pond 2

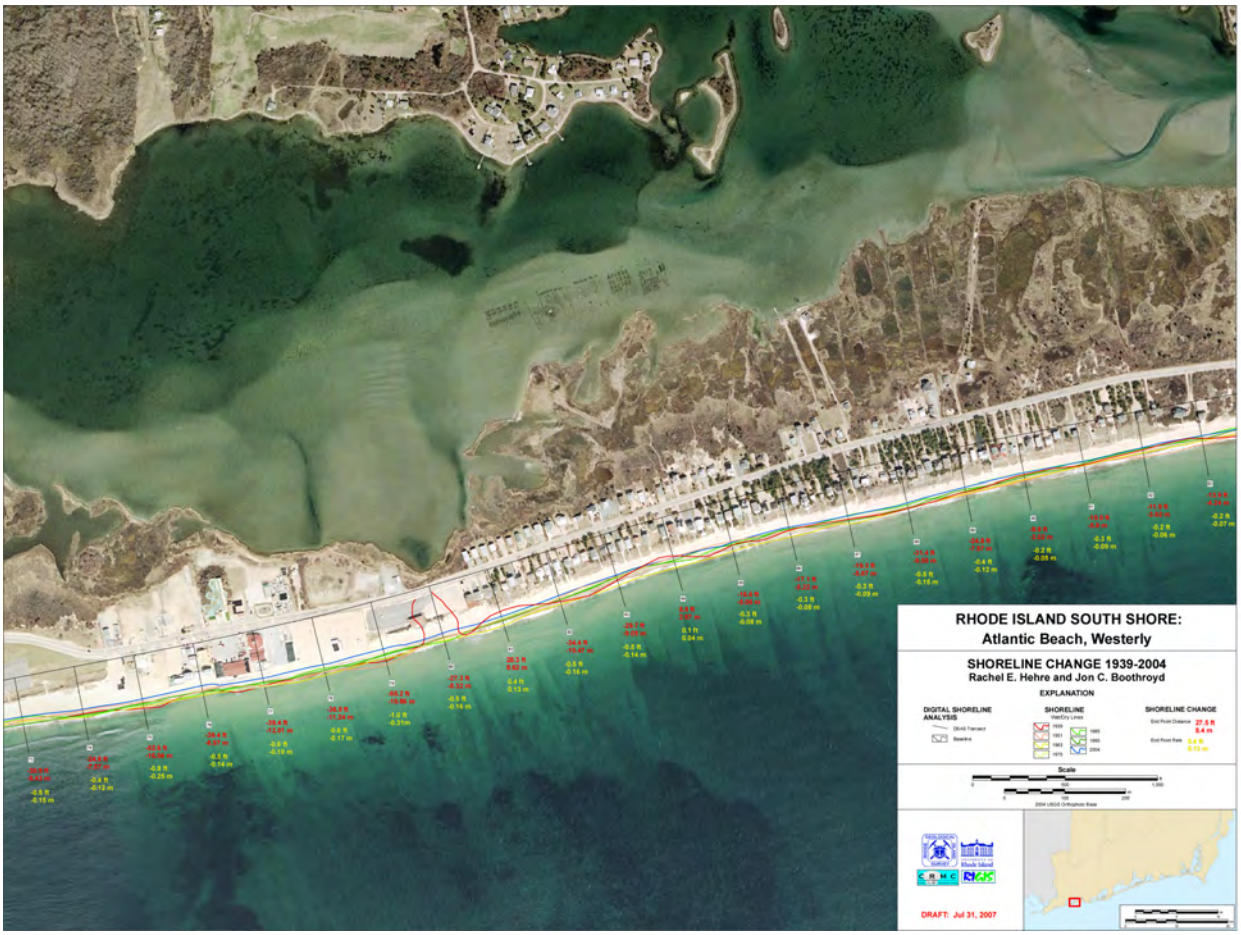

343
-43.9 ft
-13.38 m
-0.7 ft
-0.21 m
342
-89.2 ft
-27.09 m
-1.3 ft
-0.41 m
341
-74.0 ft
-22.56 m
-1.1 ft
-0.35 m
340
-83.2 ft
-25.36 m
-1.3 ft
-0.39 m
Maschaug Pond 1

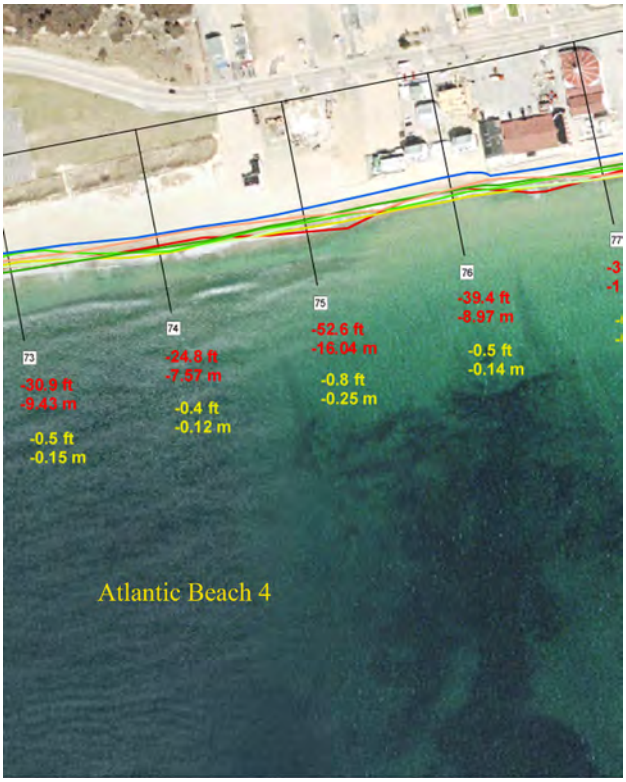

RHODE ISLAND SOUTH SHORE:
Misquamicut Headland, Westerly
SHORELINE CHANGE 1939-2004
Rachel E. Hehre and Jon C. Boothroyd
EXPLANATION

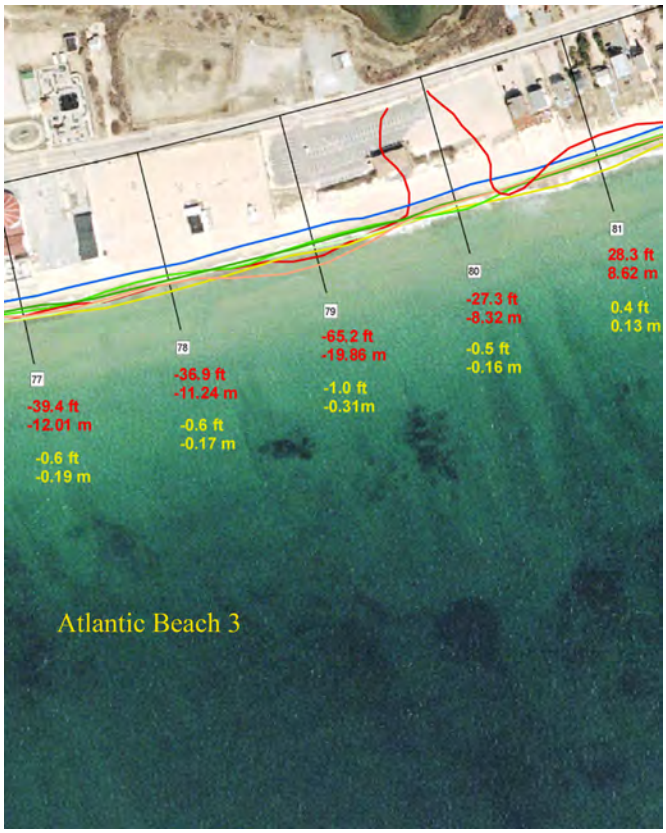

340
-93.2 ft
-28.36 m
-1.3 ft
-0.39 m
339
-46.0 ft
-14.02 m
-0.8 ft
-0.23 m
338
-92.3 ft
-28.13 m
-1.4 ft
-0.43 m
Misquamicut Headlands 5

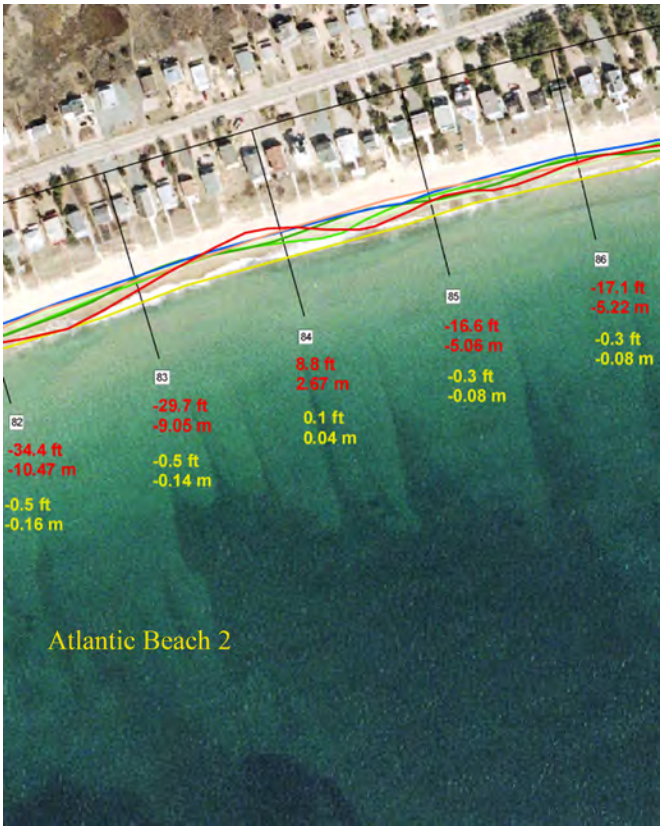

341
342
343
342
-74.0 ft
-22.56 m
-1.1 ft
-0.35 m
-1.3 ft
-0.41 m
-0.7 ft
-0.21 m
-1..0 ft
-0.31 m
Misquamicut Headlands 4

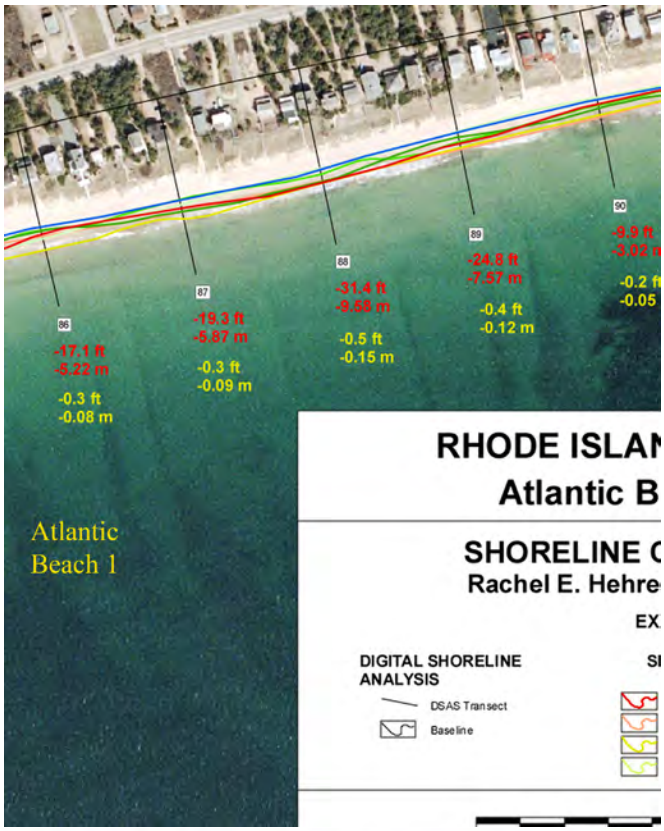

70
-30.8 ft
-9.4 m
-0.5 ft
-0.14 m
71
-27.3 ft
-8.31 m
-0.4 ft
-0.13 m
72
-26.0 ft
-7.91 m
-0.4 ft
-0.12 m
73
-30.9 ft
-9.43 m
-0.5 ft
-0.15 m


RHODE ISLAND SOUTH SHORE:
Atlantic Beach, Westerly
SHORELINE CHANGE 1939-2004
Rachel E. Hehre and Jon C. Boothroyd
EXPLANATION
DIGITAL SHORELINE ANALYSIS
SHORELINE
SHORELINE CHANGE
Scale
DRAFT: Jul 31, 2007

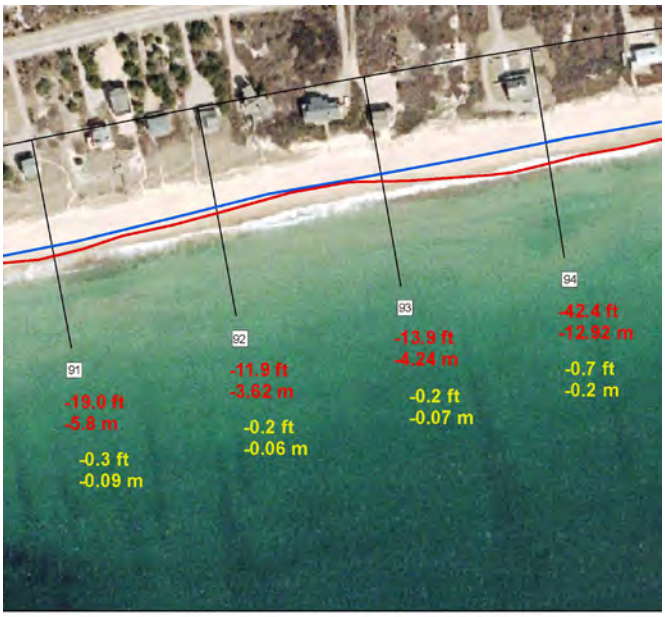

73
-30.9 ft
-9.43 m
-0.5 ft
-0.15 m
74
-24.8 ft
-7.57 m
-0.4 ft
-0.12 m
75
-52.6 ft
-16.04 m
-0.8 ft
-0.25 m
76
-39.4 ft
-8.97 m
-0.5 ft
-0.14 m
Atlantic Beach 4


77
-39.4 ft
-12.01 m
-0.6 ft
-0.19 m
78
-36.9 ft
-11.24 m
-0.6 ft
-0.17 m
79
-65.2 ft
-19.86 m
-1.0 ft
-0.31m
80
-27.3 ft
-8.32 m
-0.5 ft
-0.16 m
81
28.3 ft
8.62 m
0.4 ft
0.13 m
Atlantic Beach 3


82
-34.4 ft
-10.47 m
-0.5 ft
-0.16 m
83
-29.7 ft
-9.05 m
-0.5 ft
-0.14 m
84
8.8 ft
2.67 m
0.1 ft
0.04 m
85
-16.6 ft
-5.06 m
-0.3 ft
-0.08 m
86
-17.1 ft
-5.22 m
-0.3 ft
-0.08 m
Atlantic Beach 2


86
-17.1 ft
-5.22 m
-0.3 ft
-0.08 m
87
-19.3 ft
-5.87 m
-0.3 ft
-0.09 m
88
-31.4 ft
-9.58 m
-0.5 ft
-0.15 m
89
-24.8 ft
-7.57 m
-0.4 ft
-0.12 m
90
-0.2 ft
-0.05
Atlantic
Beach 1
RHODE ISLA
Atlantic B
SHORELINE C
Rachel E. Hehre
EX
DIGITAL SHORELINE
ANALYSIS
DSAS Transect
Baseline


RHODE ISLAND SOUTH SHORE:
Weekapaug Breachway, Westerly
SHORELINE CHANGE 1939-2004
Rachel E. Hehre and Jon C. Boothroyd
EXPLANATION

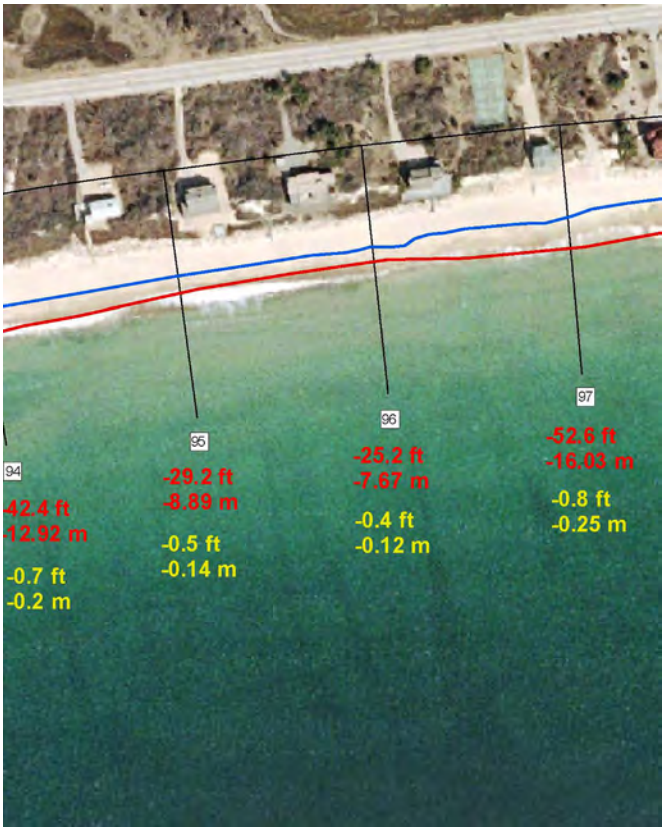


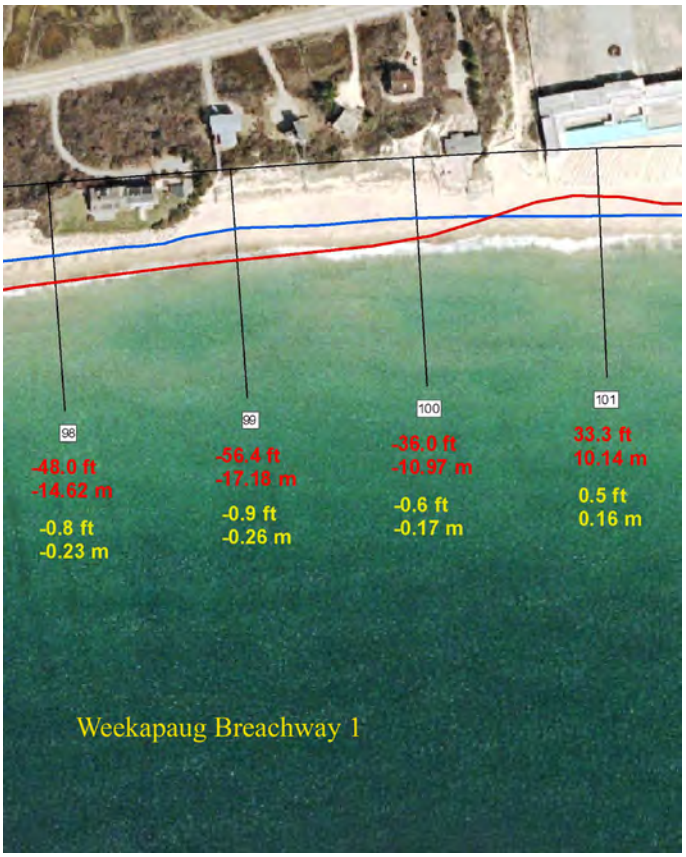
RHODE ISLAND SOUTH SH

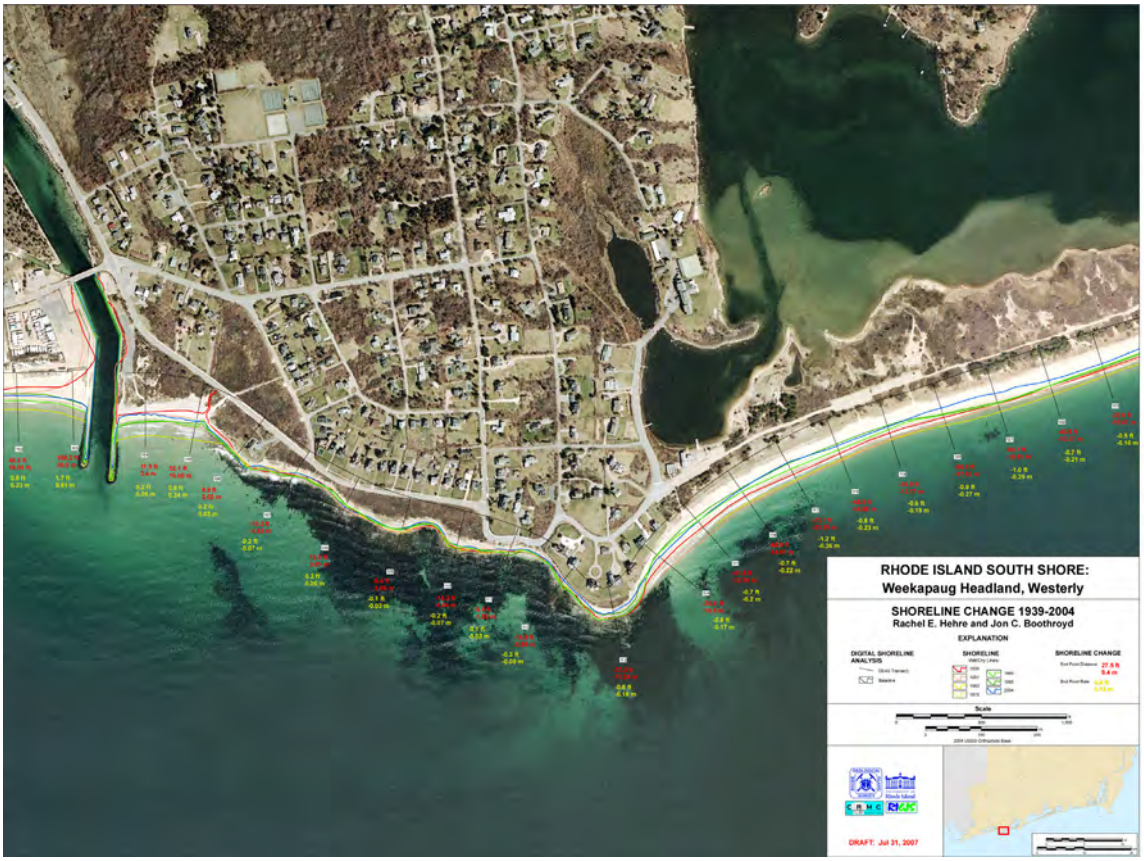
Weekapaug Breachway, We

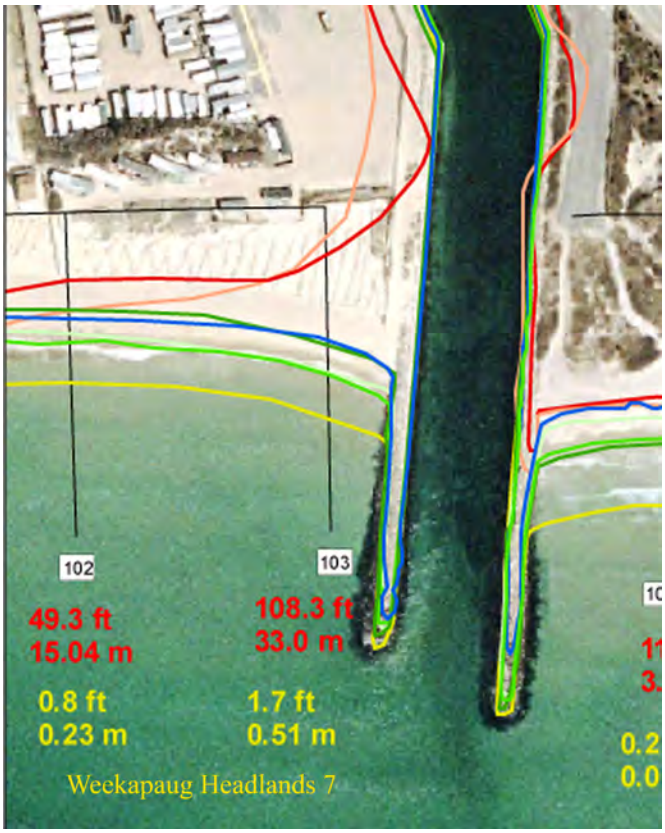
SHORELINE CHANGE 1939-2

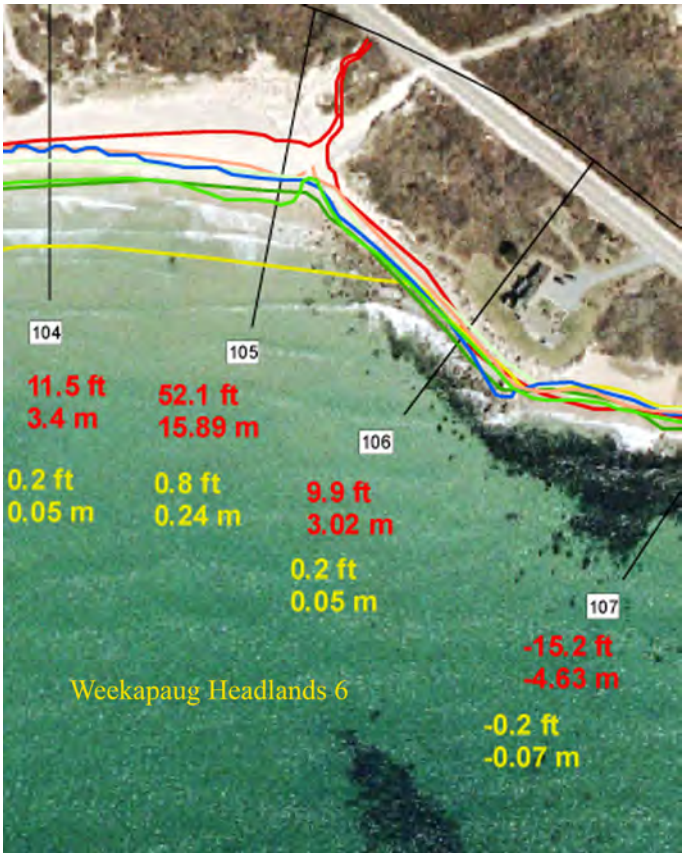
Rachel E. Hehre and Jon C. Booth

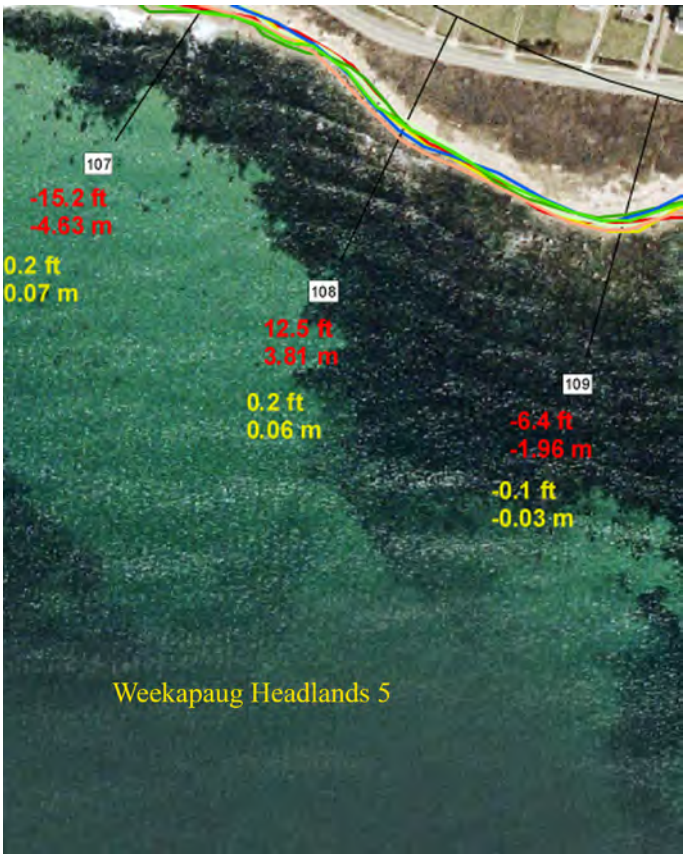


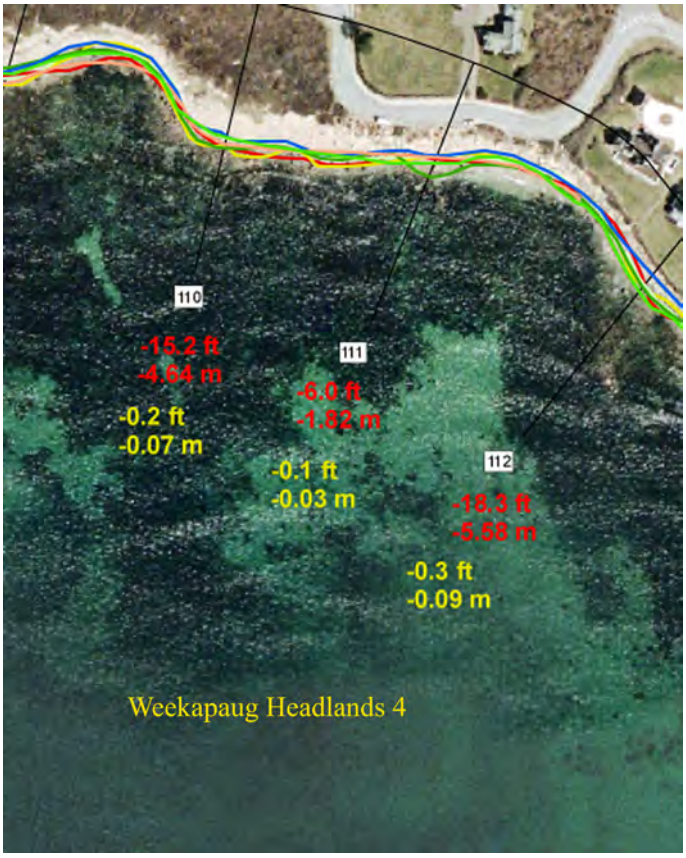

98
-48.0 ft
-14.62 m
-0.8 ft
-0.23 m
99
-56.4 ft
-17.18 m
-0.9 ft
-0.26 m
100
-36.0 ft
-10.97 m
-0.6 ft
-0.17 m
101
33.3 ft
10.14 m
0.5 ft
0.16 m
Weekapaug Breachway 1

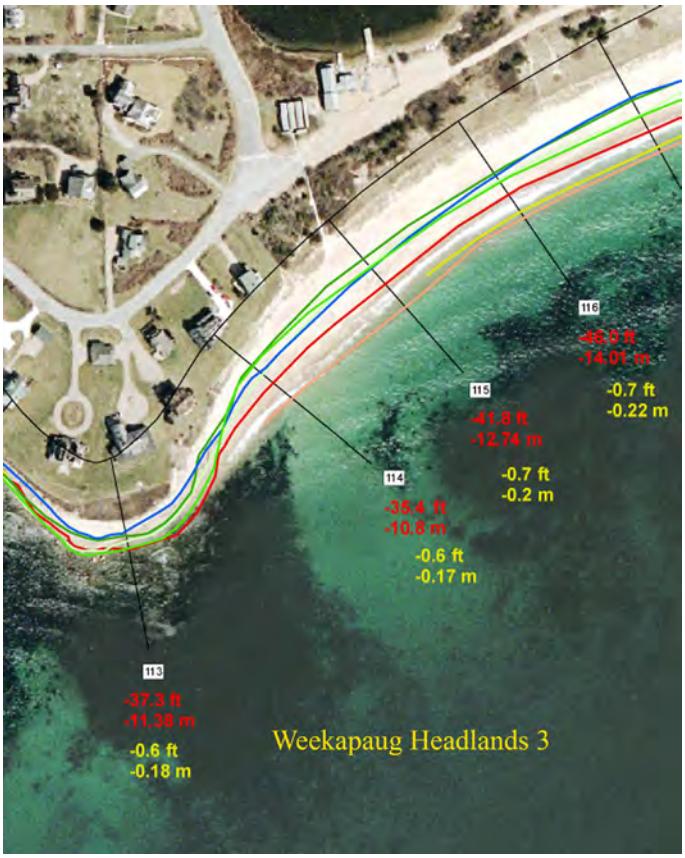

RHODE ISLAND SOUTH SHORE:
Weekapaug Headland, Westerly
SHORELINE CHANGE 1939-2004
Rachel E. Hehre and Jon C. Boothroyd
EXPLANATION
DRAFT: Jul 31, 2007

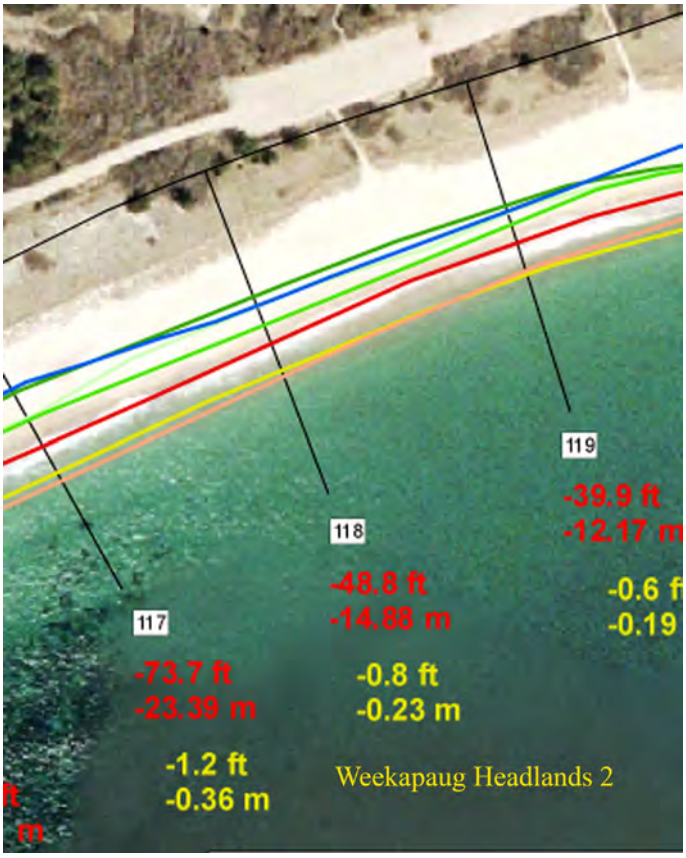

102
103
49.3 ft
15.04 m
108.3 ft
33.0 m
0.8 ft
0.23 m
1.7 ft
0.51 m
Weekapaug Headlands 7

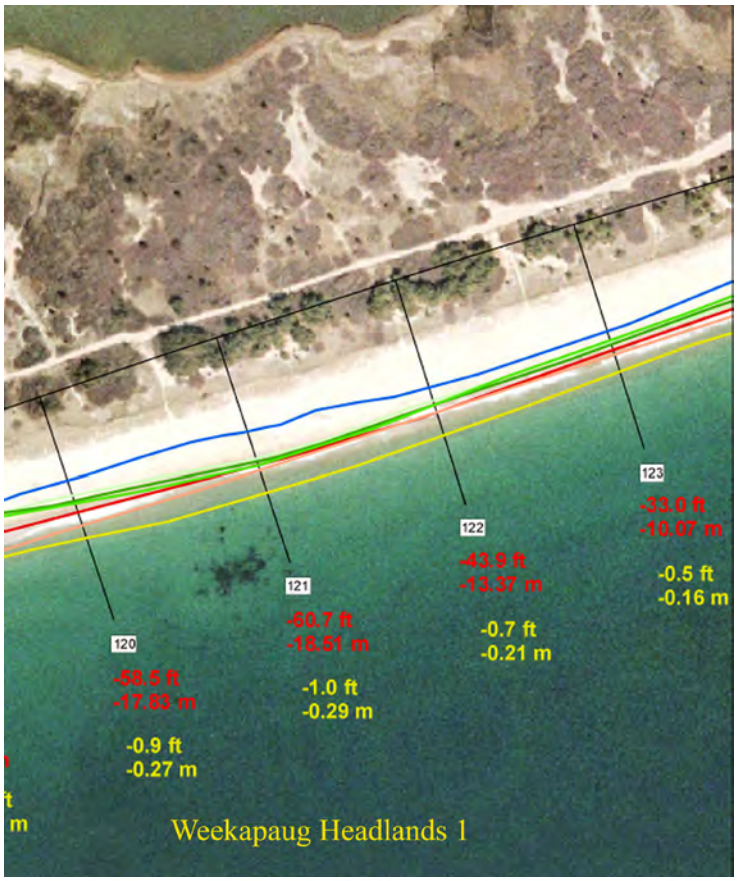

104
105
106
107
11.5 ft
3.4 m
52.1 ft
15.89 m
0.2 ft
0.05 m
0.8 ft
0.24 m
9.9 ft
3.02 m
0.2 ft
0.05 m
-15.2 ft
-4.63 m
-0.2 ft
-0.07 m
Weekapaug Headlands 6


107
-15.2 ft
-4.63 m
0.2 ft
0.07 m
108
12.5 ft
3.81 m
0.2 ft
0.06 m
109
-6.4 ft
-1.96 m
-0.1 ft
-0.03 m
Weekapaug Headlands 5


110
-15.2 ft
-4.64 m
-0.2 ft
-0.07 m
111
-6.0 ft
-1.82 m
-0.1 ft
-0.03 m
112
-18.3 ft
-5.58 m
-0.3 ft
-0.09 m
Weekapaug Headlands 4

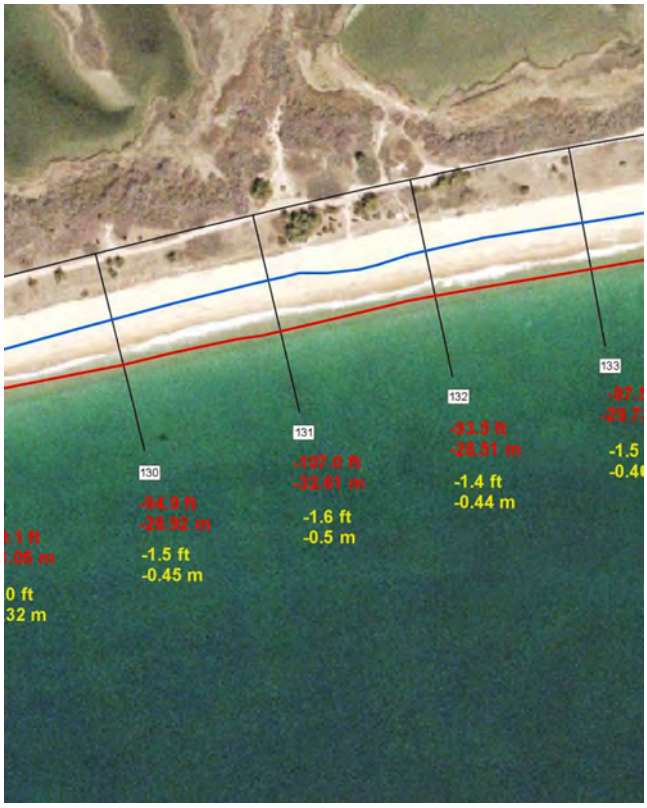

116
-46.0 ft
-14.01 m
-0.7 ft
-0.22 m
115
-41.8 ft
-12.74 m
-0.7 ft
-0.2 m
114
-35.4 ft
-10.8 m
-0.6 ft
-0.17 m
113
-37.3 ft
-11.38 m
-0.6 ft
-0.18 m
Weekapaug Headlands 3

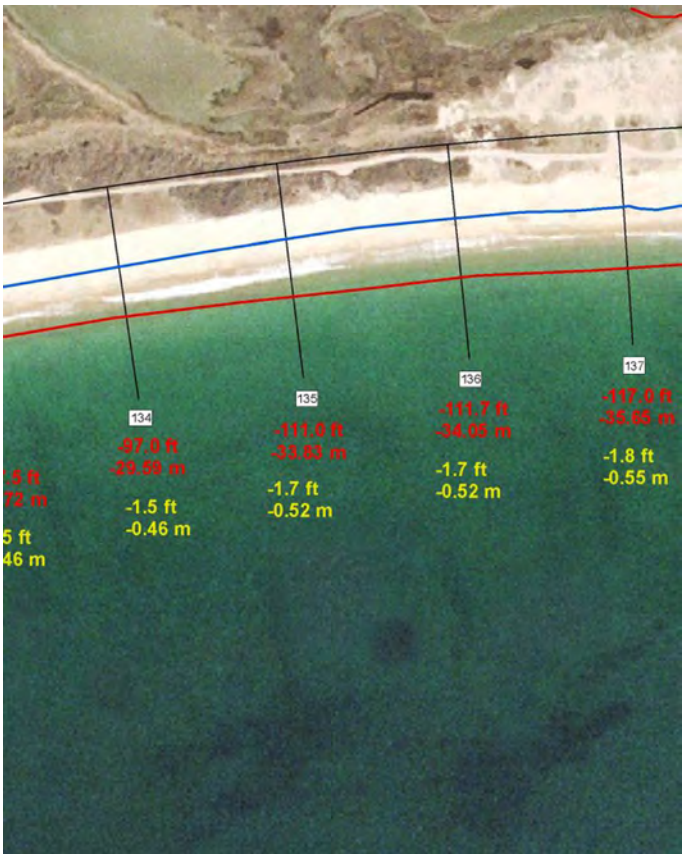

119
-39.9 ft
-12.17 m
-0.6 f
-0.19
118
-48.8 ft
-14.88 m
-0.8 ft
-0.23 m
117
-73.7 ft
-23.39 m
-1.2 ft
-0.36 m
Weekapaug Headlands 2

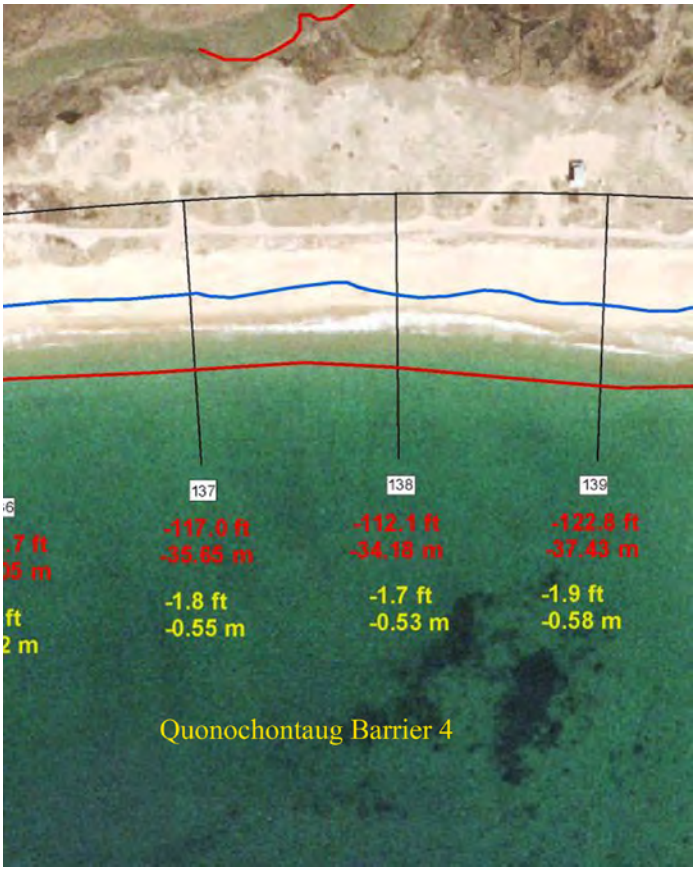

120
-58.5 ft
-17.83 m
-0.9 ft
-0.27 m
121
-60.7 ft
-18.51 m
-1.0 ft
-0.29 m
122
-43.9 ft
-13.37 m
-0.7 ft
-0.21 m
123
-33.0 ft
-10.07 m
-0.5 ft
-0.16 m
Weekapaug Headlands 1

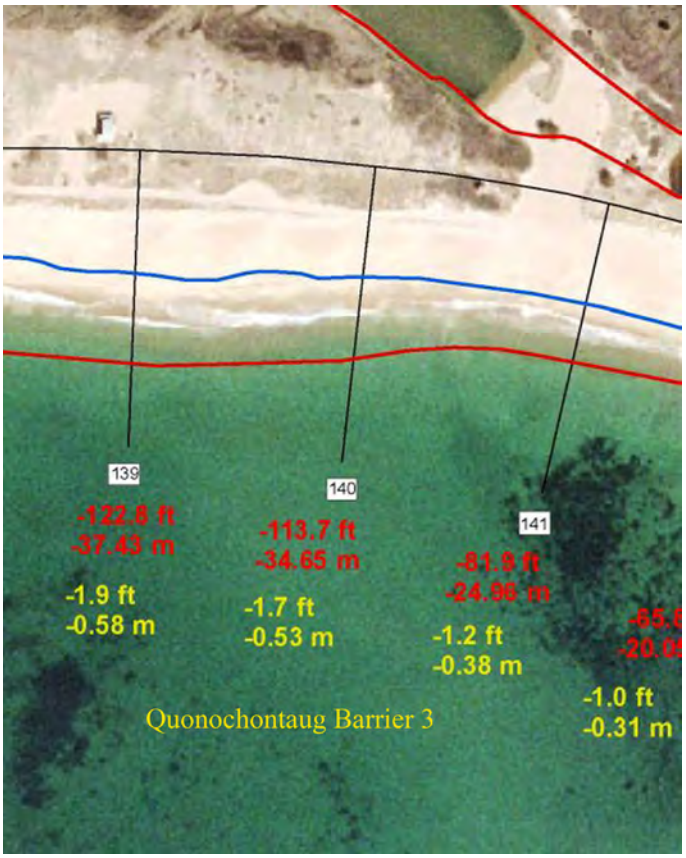

RHODE ISLAND SOUTH SHORE:
Quonochontaug Barrier, Westerly
SHORELINE CHANGE 1939-2004
Rachel E. Hehre and Jon C. Boothroyd
EXPLANATION

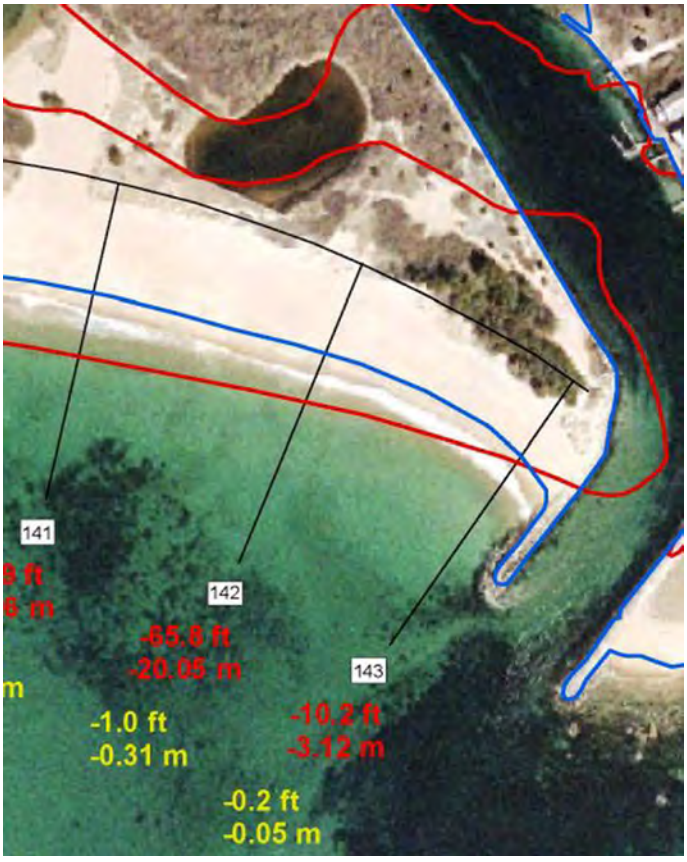

126
-66.0 ft
-20.13 m
-1.0 ft
-0.31 m
127
-73.2 ft
-22.3 m
-1.1 ft
-0.34 m
128
-60.7 ft
-18.51 m
-1.0 ft
-0.29 m
129
-69.1 ft
-21.05 m
-1.0 ft
-0.32 m
130


130
-94.9 ft
-28.93 m
-1.5 ft
-0.45 m
131
-107.0 ft
-32.61 m
-1.6 ft
-0.5 m
132
-93.5 ft
-28.51 m
-1.4 ft
-0.44 m
133


134
-97.0 ft
-29.59 m
-1.5 ft
-0.46 m
135
-111.0 ft
-33.83 m
-1.7 ft
-0.52 m
136
-111.7 ft
-34.05 m
-1.7 ft
-0.52 m
137
-117.0 ft
-35.66 m
-1.8 ft
-0.55 m


137
-117.0 ft
-35.65 m
-1.8 ft
-0.55 m
138
-112.1 ft
-34.18 m
-1.7 ft
-0.53 m
139
-122.8 ft
-37.43 m
-1.9 ft
-0.58 m
Quonochontaug Barrier 4


139
140
141
-122.8 ft
-37.43 m
-113.7 ft
-34.65 m
-81.9 ft
-24.96 m
-1.9 ft
-0.58 m
-1.7 ft
-0.53 m
-1.2 ft
-0.38 m
-1.0 ft
-0.31 m
Quonochontaug Barrier 3


141
142
143
-65.6 ft
-20.05 m
-1.0 ft
-0.31 m
-10.2 ft
-3.12 m
-0.2 ft
-0.05 m


144
186.5 ft
56.83 m
2.9 ft
0.88 m
Quonochontaug
Barrier 1
145
-19.6 ft
-5.98 m
-0.3 ft
-0.09 m


COMING
10 Affordable


03/31/2010

Natural Hazard Risk Assessment
&
Mitigation Strategy