Structural Shoreline Protection Measures:

Guidance for the Waterfront Property Homeowner

Shorelines are constantly changing, and Rhode Island coastal communities are increasingly experiencing the impacts. Storm waves can erode beaches and flood developed areas, while rising sea levels subsume land. Communities across the state are asking how they can protect people and property, as well as vital infrastructure such as drinking water supplies, utilities, and roadways.

The Rhode Island Coastal Resources Management Council (CRMC), in coordination with the University of Rhode Island, has prepared a plan to help find solutions to these problems, which are threatening communities in many areas along the state's coast. The ***Shoreline Change ("Beach") Special Area Management Plan (SAMP)*** *aims to improve the coastal resiliency of cities and towns throughout Rhode Island to the threats of erosion and flooding caused by storm events or sea level rise. Using up-to-date research and expertise from a wide range of public and private sectors, the Beach SAMP helps inform state and local policy and planning initiatives. Part of this partnership includes the maintenance of the Beach SAMP web site by Rhode Island Sea Grant.*

As one of the first coastal regulatory agencies in the U.S. to establish permit requirements addressing future risk from storm surge, coastal erosion, and projected sea-level rise, the CRMC hopes the Shoreline Change SAMP & guidance documents such as this one will serve as a model to other Rhode Island agencies, municipal governments, and homeowners on addressing future planning. The risks of coastal hazards extend beyond CRMC's jurisdiction – and likely outside currently-mapped Federal Emergency Management Agency's (FEMA) Special Flood Hazard Areas. Agencies embarking on state or regional projects will benefit from this process to ensure future conditions and flooding risk are evaluated so public dollars are spent wisely.

The CRMC believes that the process and tools outlined below will reduce impacts to coastal resources by protecting public health, safety, and welfare while minimizing damage and losses to infrastructure and property. Adapting to these ongoing and future conditions today will ensure Rhode Island builds resilient communities while preserving its strong coastal economy and environment tomorrow.

COASTAL RISK GLOSSARY

Risk- the potential for a hazard to occur, resulting in consequences for people and property. Coastal risk cannot be fully eliminated due to the uncertainties associated with coastal storms, but it can be managed and reduced through risk assessment and adaptation strategies.

Adaptation: a change or a process of change by which an organism, structure, or species becomes better suited to its environment. Adaptations options are measures and actions that can be implemented to improve adaptation to climate change.

Resilience: The capacity to recover quickly from difficulties; toughness. Resilience is related to adaptation in that resilience is the process and outcome of successfully adapting to changing climates, such as storm surge and sea level rise.

What are the Issues?

The terms seawall, revetment, and bulkhead are frequently used interchangeably, yet shouldn't be. A seawall is a hard, static, shore-parallel structure typically built out of concrete or stone. Seawalls vary widely in length; some protect one residential parcel while others may run the length of a beach or road. Seawalls are typically vertical structures. A revetment is also a hard shore-parallel structure, but is typically sloped rather than vertical, and is typically composed of materials like rock or rip rap. A bulkhead is a vertical structure, like a seawall, but in general is applied in commercial or industrial settings (e.g. a marina) solely to retain upland soils from sliding into the water.

Hardened structures are designed as protection strategies for adjacent upland properties and are typically constructed at the site scale, parallel to the shore. In some cases, structural shoreline protection measures are built-in to individual structures. Conceptually, these resilience methods can be applied to existing or new construction. Examples of "hard" shore-parallel shoreline protection structures include seawalls, revetments, and bulkheads. These concepts are designed to address flooding and coastal erosion as well as to reduce wave attack.

Such structural shoreline protection measures can have a broad range of negative impacts on adjacent beaches and properties, on the natural environment, and on shoreline public access.

Additionally, structural shoreline protection measures designed to protect adjacent structures are not sound adaptation measures to the issues of erosion and storm events. Although commonly used, structural shoreline protection measures must be considered with extreme caution. Like flood barriers, CRMC staff have found that structural shoreline protection measures are often either undersized or under-designed for the sources of coastal hazard risk they are intended to address. Further, they typically are not designed to be feasible means of protecting a site from storm surge and sea level rise given the latest sea level rise estimates. Structural shoreline protection measures can thus be a very costly adaptation measure with little return on investment.

The CRMC therefore prohibits new structural shoreline protection measures on barriers classified as undeveloped, moderately developed, and developed, as well as on all shorelines adjacent to Type 1 waters (see the RICRMP §1.3.1(G)(3)). Additionally, the CRMC favors non-structural methods of shoreline protection (see the RICRMP §1.3.1(G)(1)).

The reasons for non-structural methods of shoreline protection policies are because hardened shorelines cause serious environmental, ecological and public valuation impacts, and include: acceleration of sediment erosion (eventually leaving the face of the structure to serve as both low and high tide elevations); sediment impoundment (trapping sediment behind these structures actually removes that sediment from naturally nourishing beach areas of the shoreline); and, permanent impediments to lateral shoreline access.

Again, most structural shoreline protection measures are insufficient adaptation measures to respond to the latest sea level rise projections. Structural installation ideas has evolved through time, and the design of many seawalls & hardened revetments (i.e., wall height, stone size, etc.) is insufficient to protect against the intensifying storm conditions being projected for the future. Further, such structures are typically designed to protect adjacent land, and not necessarily the residential and other structures constructed on that land. For an in-depth discussion of these issues please see the Beach SAMP Chapter 4, Section 4.3.1.5, "Shoreline Protection Structures."

Potential applicants should consider these issues mentioned above when applying for Structural Shoreline Protection in applicable areas (i.e.: for maintenance of pre-existing SSP or under certain conditions/shoreline types adjacent to CRMC Water Types 2 through 6).

What Tools are Available to Better Understand These Matters?

The CRMC, with its partner the University of Rhode Island, has developed many tools, both educational and practical, to help the property owner (and municipalities) best address ways to manage their properties in light of rising sea levels and frequencies of storms.

The CRMC's "Suite of TOOLS"

STORMTOOLS **Overview**

STORMTOOLS is a mapping tool used to illustrate storm inundation, with and without sea level rise, for different types of storms that could occur along Rhode Island's coastline. There are two versions: STORMTOOLS for Beginners (a one-map stop for all residents of Rhode Island to better understand their risk from coastal inundation), and Advanced STORMTOOLS (a series of maps that illustrate what coastal flooding could look like in the future under different storm scenarios). The page also includes information about the STORMTOOLS data.

Coastal Environmental Risk Index (CERI)

An objective, quantitative assessment of the risk to structures, infrastructure, and public safety that coastal communities face from storm surge in the presence of changing climatic conditions, particularly sea level rise and coastal erosion. Uses state of the art modeling tools (ADCIRC and STWAVE, found here: https://www.erdc.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/476696/coastal-storm-modeling-system-features/) to predict storm surge and wave, combined with shoreline change maps (erosion), and damage functions to construct a risk index. The resulting model simulates atmospheric forcing, waves, nearshore dynamics, circulation and storm surge to create a physically accurate representation of inundation and flooding from extra-tropical storms and hurricanes.

STORMTOOLS Design Elevation (SDE) Maps

Base Flood Elevation (BFE) maps of coastal study area that explicitly include the effects of sea level rise. SDE maps can also be used in place of FEMA FIRMs for the design of structures and infrastructure design and are embedded in the CRMC risk based permitting system.

Map Journals

University of Rhode Island's Environmental Data Center (EDC) maps using simplified methods to estimate coastal inundation, a map tour of historic storms, and STORMTOOLS 101 apps.

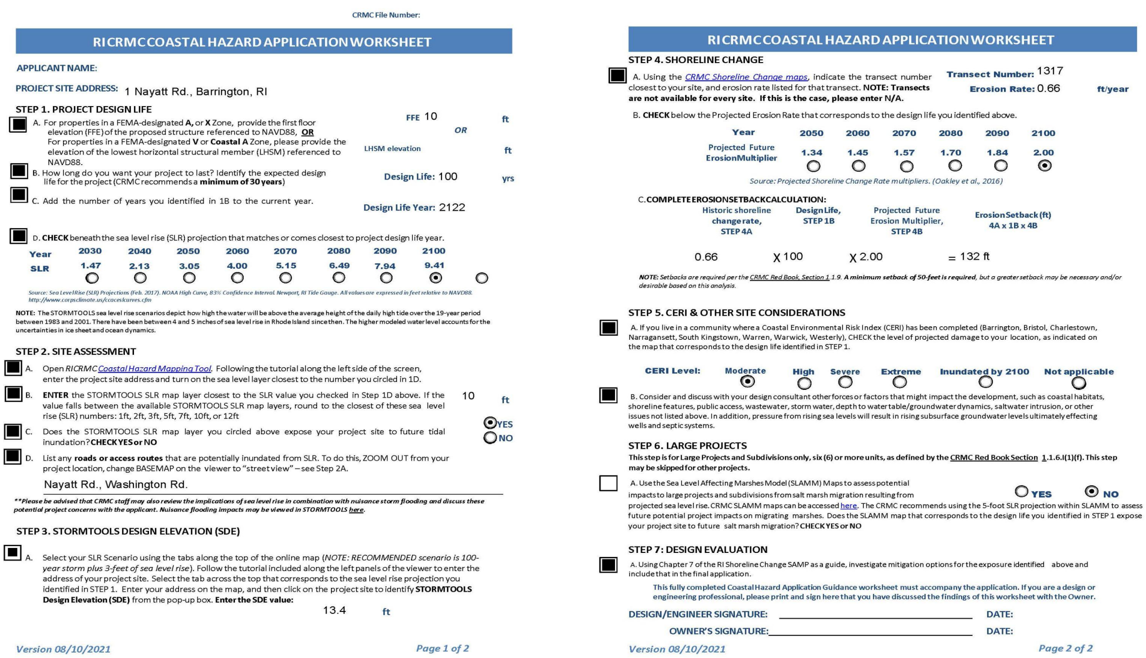
Rhode Island e911 Exposure Assessment

A summary of all exposed structures in each of the 21 coastal municipalities in Rhode Island within a variety of coastal flooding scenarios, and spreadsheets presenting the e911 structure type data sorted by coastal flooding scenario.

Coastal Hazard Application guidance (worksheet and viewer)

The primary purpose and use of the Coastal Hazard Application (CHA) Worksheet and Viewer is to notify applicants of potential coastal hazards - including sea level rise, storm surge, and associated flooding and erosion - that should be considered when planning shoreline development.

The CRMC's goal is to increase understanding and awareness of these potential hazards among the development community (property owners, builders, realtors, financial institutions and insurers) with the hope of guiding development and investment away from vulnerable areas. While the CHA is required for projects meeting specific thresholds, the CRMC encourages all applicants to consider using the CHA process to assess future risks to their proposed projects. Go to the CRMC website for a complete list of qualifying projects: http://www.crmc.ri.gov/coastalhazardapp.html



CRMC File Number:

RI CRMC COASTAL HAZARD APPLICATION WORKSHEET

APPLICANT NAME:

PROJECT SITE ADDRESS: 1 Nayatt Rd., Barrington, RI

STEP 1. PROJECT DESIGN LIFE

A. For properties in a FEMA-designated **A,** or **X** Zone, provide the first floor elevation (FFE) of the proposed structure referenced to NAVD88, **OR** For properties in a FEMA-designated **V** or **Coastal A** Zone, please provide the elevation of the lowest horizontal structural member (LHSM) referenced to NAVD88. — FFE 10 ft *OR* LHSM elevation ft

B. How long do you want your project to last? Identify the expected design life for the project (CRMC recommends a **minimum of 30 years**) — Design Life: 100 yrs

C. Add the number of years you identified in 1B to the current year. — Design Life Year: 2122

D. **CHECK** beneath the sea level rise (SLR) projection that matches or comes closest to project design life year.

Year	2030	2040	2050	2060	2070	2080	2090	2100
SLR	1.47	2.13	3.05	4.00	5.15	6.49	7.94	9.41

Source: Sea Level Rise (SLR) Projections (Feb. 2017). NOAA High Curve, 83% Confidence Interval. Newport, RI Tide Gauge. All values are expressed in feet relative to NAVD88. http://www.corpsclimate.us/ccaceslcurves.cfm

NOTE: The STORMTOOLS sea level rise scenarios depict how high the water will be above the average height of the daily high tide over the 19-year period between 1983 and 2001. There have been between 4 and 5 inches of sea level rise in Rhode Island since then. The higher modeled water level accounts for the uncertainties in ice sheet and ocean dynamics.

STEP 2. SITE ASSESSMENT

A. Open *RICRMC* Coastal Hazard Mapping Tool. Following the tutorial along the left side of the screen, enter the project site address and turn on the sea level layer closest to the number you circled in 1D.

B. **ENTER** the STORMTOOLS SLR map layer closest to the SLR value you checked in Step 1D above. If the value falls between the available STORMTOOLS SLR map layers, round to the closest of these sea level rise (SLR) numbers: 1ft, 2ft, 3ft, 5ft, 7ft, 10ft, or 12ft — 10 ft

C. Does the STORMTOOLS SLR map layer you circled above expose your project site to future tidal inundation? **CHECK YES or NO** — YES / NO

D. List any **roads or access routes** that are potentially inundated from SLR. To do this, ZOOM OUT from your project location, change BASEMAP on the viewer to "streetview" – see Step 2A.

Nayatt Rd., Washington Rd.

***Please be advised that CRMC staff may also review the implications of sea level rise in combination with nuisance storm flooding and discuss these potential project concerns with the applicant. Nuisance flooding impacts may be viewed in STORMTOOLS here.*

STEP 3. STORMTOOLS DESIGN ELEVATION (SDE)

A. Select your SLR Scenario using the tabs along the top of the online map (*NOTE: RECOMMENDED scenario is 100-year storm plus 3-feet of sea level rise*). Follow the tutorial included along the left panels of the viewer to enter the address of your project site. Select the tab across the top that corresponds to the sea level rise projection you identified in STEP 1. Enter your address on the map, and then click on the project site to identify **STORMTOOLS Design Elevation (SDE)** from the pop-up box. **Enter the SDE value:** 13.4 ft

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RI CRMC COASTAL HAZARD APPLICATION WORKSHEET

STEP 4. SHORELINE CHANGE

A. Using the *CRMC Shoreline Change maps*, indicate the transect number closest to your site, and erosion rate listed for that transect. **NOTE: Transects are not available for every site. If this is the case, please enter N/A.** — Transect Number: 1317 — Erosion Rate: 0.66 ft/year

B. **CHECK** below the Projected Erosion Rate that corresponds to the design life you identified above.

Year	2050	2060	2070	2080	2090	2100
Projected Future Erosion Multiplier	1.34	1.45	1.57	1.70	1.84	2.00

Source: Projected Shoreline Change Rate multipliers. (Oakley et al., 2016)

C. **COMPLETE EROSION SETBACK CALCULATION:**

Historic shoreline change rate, STEP 4A	Design Life, STEP 1B	Projected Future Erosion Multiplier, STEP 4B	Erosion Setback (ft) 4A x 1B x 4B
0.66	X 100	X 2.00	= 132 ft

***NOTE:** Setbacks are required per the CRMC Red Book, Section 1.1.9. **A minimum setback of 50-feet is required**, but a greater setback may be necessary and/or desirable based on this analysis.*

STEP 5. CERI & OTHER SITE CONSIDERATIONS

A. If you live in a community where a Coastal Environmental Risk Index (CERI) has been completed (Barrington, Bristol, Charlestown, Narragansett, South Kingstown, Warren, Warwick, Westerly), CHECK the level of projected damage to your location, as indicated on the map that corresponds to the design life identified in STEP 1.

CERI Level: Moderate / High / Severe / Extreme / Inundated by 2100 / Not applicable

B. Consider and discuss with your design consultant other forces or factors that might impact the development, such as coastal habitats, shoreline features, public access, wastewater, storm water, depth to water table/groundwater dynamics, saltwater intrusion, or other issues not listed above. In addition, pressure from rising sea levels will result in rising subsurface groundwater levels ultimately effecting wells and septic systems.

STEP 6. LARGE PROJECTS

This step is for Large Projects and Subdivisions only, six (6) or more units, as defined by the CRMC Red Book Section 1.1.6.I(1)(f). This step may be skipped for other projects.

A. Use the Sea Level Affecting Marshes Model (SLAMM) Maps to assess potential impacts to large projects and subdivisions from salt marsh migration resulting from projected sea level rise. CRMC SLAMM maps can be accessed here. The CRMC recommends using the 5-foot SLR projection within SLAMM to assess future potential project impacts on migrating marshes. Does the SLAMM map that corresponds to the design life you identified in STEP 1 expose your project site to future salt marsh migration? **CHECK YES or NO** — YES / NO

STEP 7: DESIGN EVALUATION

A. Using Chapter 7 of the RI Shoreline Change SAMP as a guide, investigate mitigation options for the exposure identified above and include that in the final application.

This fully completed Coastal Hazard Application Guidance worksheet must accompany the application. If you are a design or engineering professional, please print and sign here that you have discussed the findings of this worksheet with the Owner.

DESIGN/ENGINEER SIGNATURE: ______________________ DATE:

OWNER'S SIGNATURE: ______________________ DATE:

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Shown above are both pages of the CHA worksheet, filled out with an example address.

Solutions

The CRMC encourages non-structural shoreline protection where applicable and practicable instead of structural shoreline protection. It requires an administrative assent from the CRMC, which can be permitted in all water types, unlike new hardened shoreline structures, which are either prohibited or require a Category B assent, and which goes before the Council for a vote - https://rules.sos.ri.gov/regulations/part/650-20-00-1

Living Shoreline Solutions

What are Living Shorelines?

A living shoreline is a protected, stabilized coastal edge made of natural materials such as plants, sand or rock. Unlike a concrete seawall or other hard structure, which may impede the growth of plants and animals, living shorelines grow over time.

Living shorelines are created using natural elements and materials (sand, wetland plants, biodegradable materials, etc.) Living shoreline design often depends on specific site conditions, such as the slope of a shoreline, the tidal range, waves, and ice cover in the winter. Upfront costs for living shorelines are low compared to other shoreline stabilization options. However, they may require more maintenance over time.

Living shorelines are both beautiful and practical. They add attractive, low-maintenance green space and focal points for people to gather. Their services to the environment – which also benefit people – include purifying water, buffering floods, reducing erosion, storing carbon, and attracting wildlife to habitat.

Living shorelines tend to cost less than hard shorelines for both installation and maintenance. Installation fees vary from less than $1,000 to $5,000 per linear foot[1] Maintenance of living shorelines typically costs less than $100 per linear foot annually.

EXAMPLES OF LIVING SHORELINE SOLUTIONS

Natural Marsh Creation/Enhancement

Marsh vegetation can be planted along the shoreline. Roots help hold soil in place, and shoots will break small waves and increase sedimentation - vegetation projects such as this are a minimally invasive approach.

Materials: Native marsh plants appropriate for salinity and site conditions are best. Plugs of marsh grass can be planted to augment bare or sparse areas. Sediment may be necessary as well if the area needs to be filled to obtain appropriate elevations.

Habitat Components: Salt marsh; tidal buffer landward of the salt marsh; coastal beach; mud flat

Durability: Undisturbed growth of plants is essential; plants that die in early stages of growth or are removed must be replaced immediately. Ongoing maintenance of invasive species and runoff issues must be controlled for long-term success.

Ecological Services Provided: Increased water filtration, uptake of nutrients, filtration, denitrification and sediment retention. Additionally, a healthy salt marsh may reduce wave energy, provide essential habitat for many species, and provide natural shore erosion control, better water quality, recreation and education opportunities, as well as carbon sequestration.

DUNES[2]

Dune building projects involve the placement of compatible sediment on an existing dune, or creation of an artificial dune by building up a mound of sediment at the back of the beach. This may be a component of a beach nourishment effort or stand-alone

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[1] https://coast.noaa.gov/digitalcoast/training/living-shorelines.html

[2] http://www.northeastoceancouncil.org/wp-content/uploads/2018/12/Final_StateofthePractice_7.2017.pdf

project. The objectives of this project would be erosion control, shoreline protection, dissipation of wave energy, and enhanced wildlife and shorebird habitat.

Materials: Sediment brought in from an offsite source, such a sand and gravel pit or coastal dredging project. Planting the dune with native, salt-tolerant, erosion-control vegetation (e.g., beach grass *Ammophilia breviligulata)* with extensive root systems is highly recommended to help hold the sediments in place. Sand fencing can also be installed to trap windblown sand to help maintain and build the volume of a dune.

Habitat Components: Dunes plated with native beach grass can provide significant wildlife habitat.

Durability and Maintenance: The height, length, and width of a dune relative to the size of the predicted storm waves and storm surge determines the level of protection the dune can provide. To maintain and effective dune, sediment may need to be added regularly to keep dune's height, width and volume. The seaward slope of the dune should typically be less than 3:1 (base:height). Dunes with vegetation perform more efficiently, ensuring stability, greater energy dissipation, and resistance to erosion.

Design Life: Dunes typically erode during storm events. In areas with no beach at high tide, dune projects will be short-lived as sediments are rapidly eroded and redistributed to the nearshore. Designs should consider techniques that enhance or maintain the dune (i.e., sand fencing and/or vegetation to trap wind-blown sand).

Ecological Services Provided: The added sediment from dune projects supports the protective capacity of the entire beach system. Any sand eroded from the dune during a storm, supplies a reservoir of sand to the fronting beach and nearshore area. Dunes dissipate rather than reflect wave energy, as is the case with hard structures. Dunes also act as a barrier to storm surges and flooding, protecting landward coastal resources, and reducing overwash events.

CORE METRICS AND INDICATORS FOR MONITORING LIVING SHORELINE PROJECTS[3]

Site Use: What are the overall site conditions, the historical/cultural site considerations, current site use, and adjacent area use?

Biota: Presence of endangered or threatened species and special habitat

System: Shoreline change/position and tidal range

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[3] https://www.northeastoceancouncil.org/wp-content/uploads/2022/04/Living-Shorelines-Site-Characterization-and-Performance-Monitoring-Guidance-2022.pdf

Hydrodynamic: Wake/wave energy climate, storm impacts, ice impacts, and stormwater runoff

Geophysical: Site topography/elevation

Vegetation: Existing and historic vegetation, protected habitat areas, invasive plane species, vegetation structure/robustness, planting extent/area, final species planted, planting density, health and survival, herbivory impacts

Structure Condition: Created feature structural properties and stability, created feature anchoring integrity, material integrity, signs of erosion, material type used vs. proposed, fill quality used vs. proposed, and maintenance.

References

Losing Ground: Losing Ground: Coastal Erosion Coastal Erosion in Rhode Island http://www.crmc.ri.gov/climatechange/Losing_Ground_RISG_2012.pdf

Rhode Island Coastal Property Guide: What Coastal Property Owners, Renters, Builders and Buyers Should Know about Rhode Island's Shoreline
http://www.crmc.ri.gov/news/2014_0718_propertyguide.html

To understand how Communities can address Shoreline Management Issues in light of Erosion, Storms and Sea Level Rise, see:
http://www.beachsamp.org/wp-content/uploads/2015/11/muni_adaptation_strategy.pdf

The CRMC's Shoreline Change Maps - *shoreline rates of change to help best understand regulations and requirements*
http://www.crmc.ri.gov/maps/maps_shorechange.html

STORMTOOLS Risk and Damage Assessment App now available

Instructions for the CERI Risk and Damage App

Living Shorelines in New England State of the Practice