APPENDIX D: STATE AND DISTRICT OF COLUMBIA ANALYSES

NORTH ATLANTIC COAST COMPREHENSIVE STUDY:
RESILIENT ADAPTATION TO INCREASING RISK

STATE CHAPTER

D-2: Commonwealth of Massachusetts

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I. Introduction

The purpose of the North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk (NACCS) is to catalyze and spearhead innovation and action by all to implement comprehensive coastal storm risk management (CSRM) strategies. Action is imperative to increase resilience and reduce risk from, and make the North Atlantic region more resilient to, future storms and impacts of sea level change (SLC). The U.S. Army Corps of Engineers (USACE) and National Oceanic and Atmospheric Administration's (NOAA) Infrastructure Systems Rebuilding Principles defines resilience as the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies.

The goals of the NACCS are to:

- Provide a risk management framework, consistent with NOAA/USACE Infrastructure Systems Rebuilding Principles; and
- Support resilient coastal communities and robust, sustainable coastal landscape systems, considering future sea level and climate change scenarios, to reduce risk to vulnerable populations, property, ecosystems, and infrastructure.

The NACCS Main Report addresses the entire study area at a regional scale and explains the development and application of the NACCS CSRM Framework from a broad perspective. This State Coastal Risk Framework Appendix discusses state-specific conditions, risk analyses and areas, and comprehensive CSRM strategies in order to provide a more tailored Framework for the Commonwealth of Massachusetts. Attachments include the Commonwealth's response to USACE State Problems, Needs, and Opportunities correspondence.

II. Planning Reaches

Planning reaches for Massachusetts have been developed to offer smaller units than state boundaries from which CSRM and coastal resilient community decisions can be made. These planning reaches are based on natural and manmade coastal features including shoreline type, USACE CSRM projects, and the 1 percent floodplain (Figure 1).

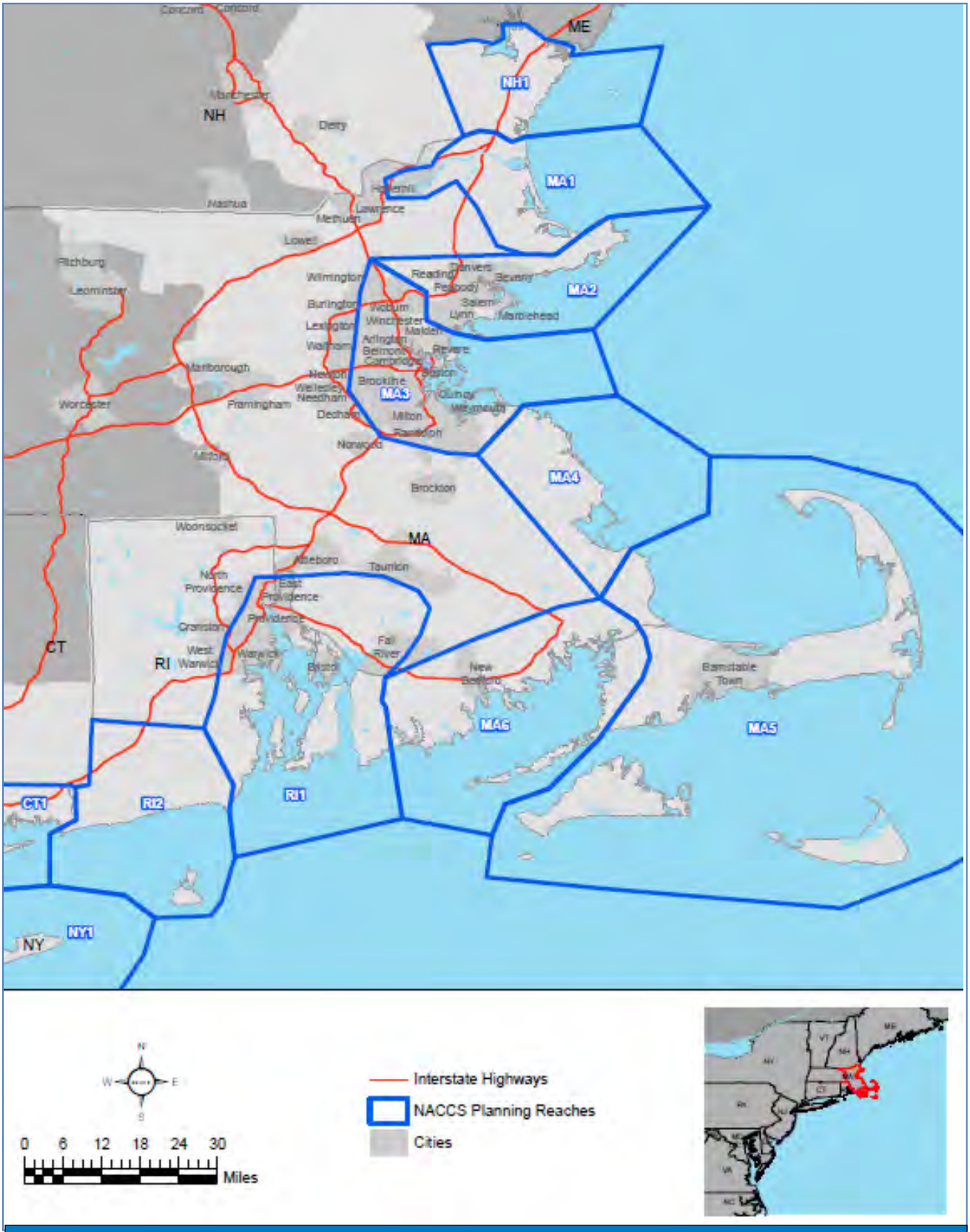


Figure 1. Planning reaches for the Commonwealth of Massachusetts

There are six planning reaches in Massachusetts, designated as MA1 through MA6. MA1 covers the area from the border with New Hampshire to Cape Ann and includes the Merrimack and Parker River estuaries and some significant barrier beaches. MA2 starts at Cape Ann and runs south to the Saugus River. This reach is dominated by rockier coastline. MA3 covers the Massachusetts Bay area in and around Boston to a point just south of Nantucket and is also dominated by rockier shore line. MA4 extends from Cohasset south to just below Plymouth. MA5 includes Cape Cod and the islands of Martha's Vineyard and Nantucket. This reach is contains many popular beaches. MA6 covers the area of Buzzards Bay down to the border with Rhode Island.

III. Existing and Post-Sandy Landscape Conditions

III.1. Existing Conditions

The existing conditions are the conditions immediately after the landfall of Hurricane Sandy. This existing conditions analysis includes consideration of the population, supporting critical infrastructure, environmental conditions, inventory of existing CSRM projects and associated project performance during Hurricane Sandy, Federal Emergency Management Agency (FEMA) and Small Business Administration response and recovery efforts, FEMA flood insurance claims, and shoreline characteristics that were vulnerable to coastal flood risk associated with Hurricane Sandy. Development of detailed existing conditions across the study area illuminates the vulnerabilities to storm damage that exist. This process helps to identify coastal risk reduction and resilience opportunities. The existing condition serves as the base against which all proposed risk reduction and resilience are compared. Further discussion of the existing conditions is provided in Appendix C – Planning Analyses.

Only the Charles River Dam in Boston, MA and the New Bedford Hurricane Protection Barrier in New Bedford, MA provide reliable risk management against storm surge. The existing conditions are discussed herein through an analysis of the population and supporting critical infrastructure affected by Hurricane Sandy within the study area. Figure 2 and Table 1 summarize pertinent information regarding population affected by Hurricane Sandy.

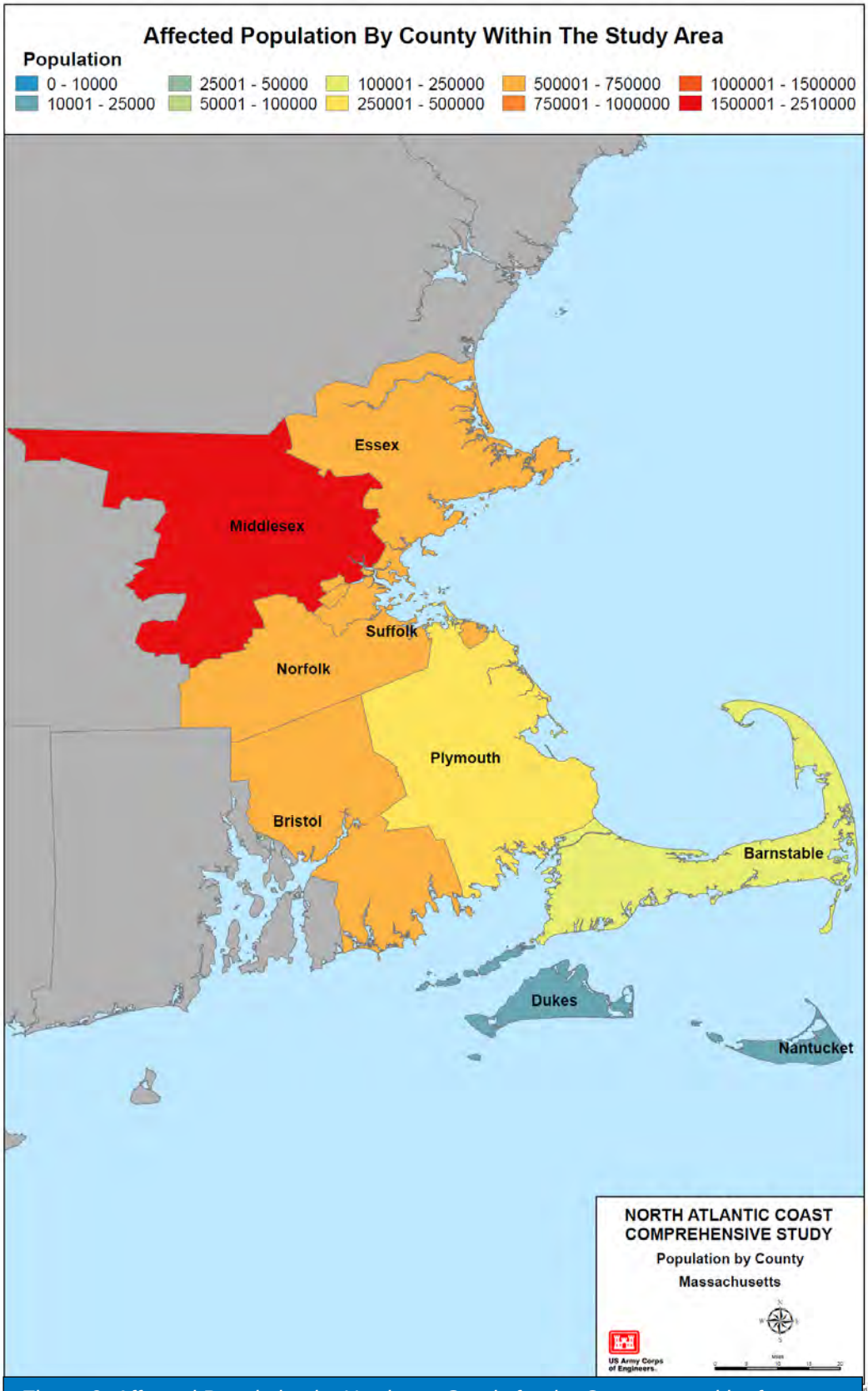


Figure 2. Affected Population by Hurricane Sandy for the Commonwealth of Massachusetts (2010 U.S. Census data).

Table 1. Affected Population by Hurricane Sandy for the Commonwealth of Massachusetts

County	Population
Nantucket	10,172
Dukes	16,535
Barnstable	215,888
Plymouth	494,919
Bristol	548,285
Norfolk	670,850
Suffolk	722,023
Middlesex	1,503,085
Essex	743,159
Total Population Affected	**4,924,916**

Figure 3 and Table 2 summarize pertinent information regarding infrastructure affected by Hurricane Sandy. Critical infrastructure elements include sewage, water, electricity, academics, trash, medical, and safety.

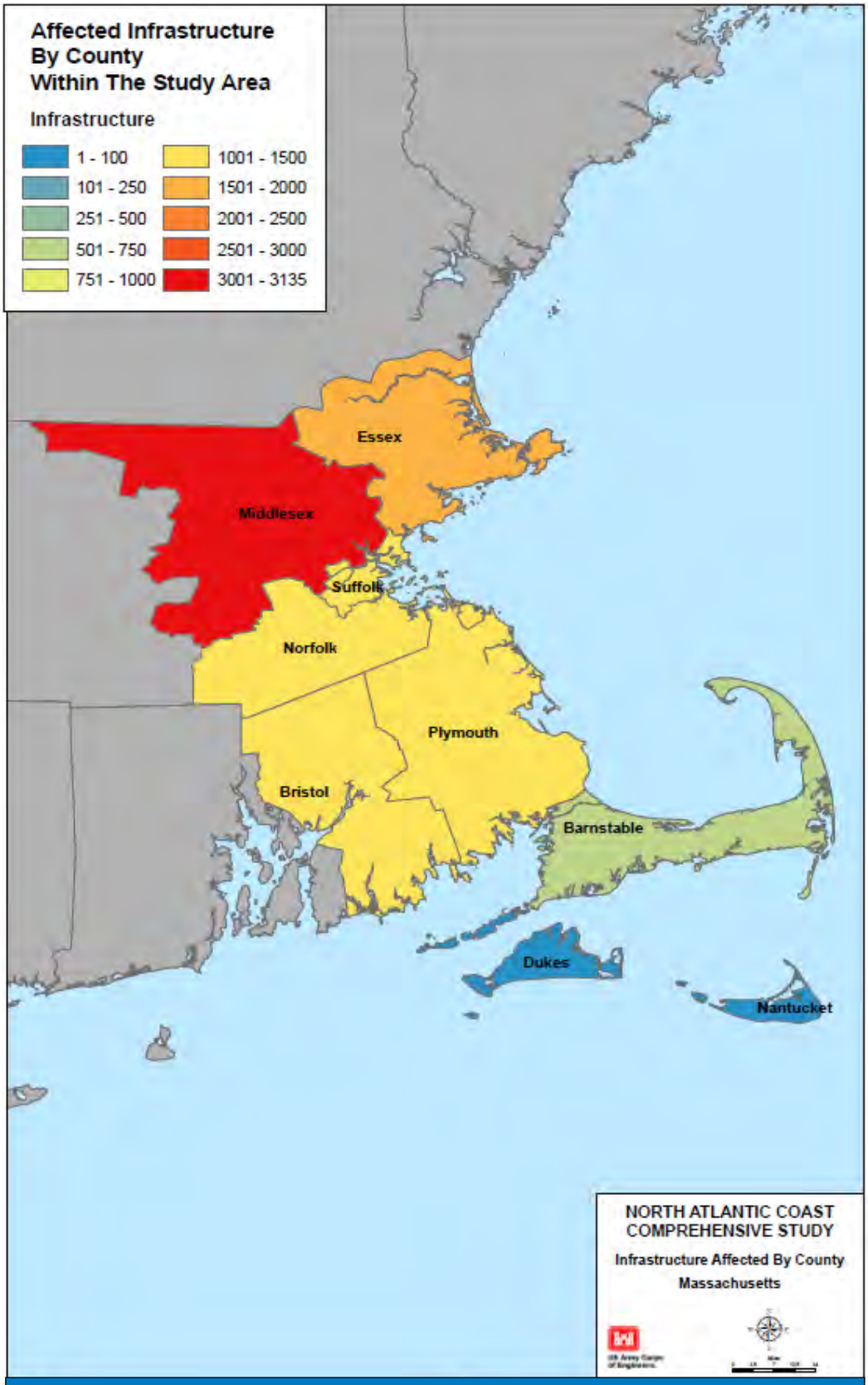


Figure 3. Affected Infrastructure by Hurricane Sandy for the Commonwealth of Massachusetts

Table 2. Affected Infrastructure elements by Hurricane Sandy	
County	**Infrastructure**
Barnstable	604
Bristol	1,436
Dukes	95
Essex	1,703
Middlesex	3,135
Nantucket	61
Norfolk	1,443
Plymouth	1,134
Suffolk	1,332
Total Infrastructure Affected	**10,943**

A detailed discussion of the environmental and cultural resources existing condition is provided in the Environmental and Cultural Resources Conditions Report.

III.2. Post-Sandy Landscape

The post–Sandy landscape condition is defined as the forecasted scenario or most likely future condition if no NACCS CSRM action is taken, and is characterized by CSRM projects and features, and socio-economic, environmental, and cultural conditions. This condition is considered as the baseline from which future measures will be evaluated with regard to reducing coastal storm risk and promoting resilience. A base year of 2018 has been identified when USACE projects discussed below will be implemented/constructed.

USACE has identified 67 Federal projects in Massachusetts that are included in the post-Sandy landscape condition; 17 of which are CSRM projects (1 under study) and 50 are navigation projects (NAV) (see Figure 4). A complete list of existing USACE projects within the entire study area is presented in Appendix C – Planning Analyses.

The post-Sandy landscape condition also includes active (at the time of the landfall of Hurricane Sandy) state and local/communities' CSRM projects in the Commonwealth of Massachusetts. Some of these projects may have been damaged during Hurricane Sandy. USACE understands that Massachusetts and the local communities have or are currently rebuilding and restoring the shoreline and damaged infrastructure and property to pre-Sandy conditions under emergency authorities and programs. Given this priority, and the apparent current lack of resources to commence new CSRM efforts at this time, USACE has made the assumption that the Commonwealth's most likely future condition will be the pre-Sandy condition. Massachusetts was queried with regard to the statement's accuracy in a May 23, 2013 letter. The Massachusetts Office of Coastal Zone Management (CZM) indicated via email correspondence (July 18, 2013) that the agency agrees with the statement's accuracy.

The Massachusetts CZM provided the USACE information regarding 1,064 CSRM projects: 627 were classified as seawalls/bulkheads, 427 were classified as revetments, and 10 were classified as dunes (see Figure 5). These are strictly publicly owned (municipal, state or Federal) projects. Structural height ranges (e.g. 0-5 feet, 5-10 feet, 10-15 feet, 15 feet or greater) were provided in the database. Roughly 59 percent of the structures identified had structural heights of 10 feet or less while 49 percent had a structural heights of 10 feet or greater. There was no other information available regarding the specific level of protection afforded by these projects. Reports are available that include detail regarding the

age, condition, and dimensions for each structure based on field inspections by coastal engineers. The reports also include photographs of each structure, estimates of the cost to repair the structure, and construction plans. These reports are available online at:
http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/seawall-inventory/

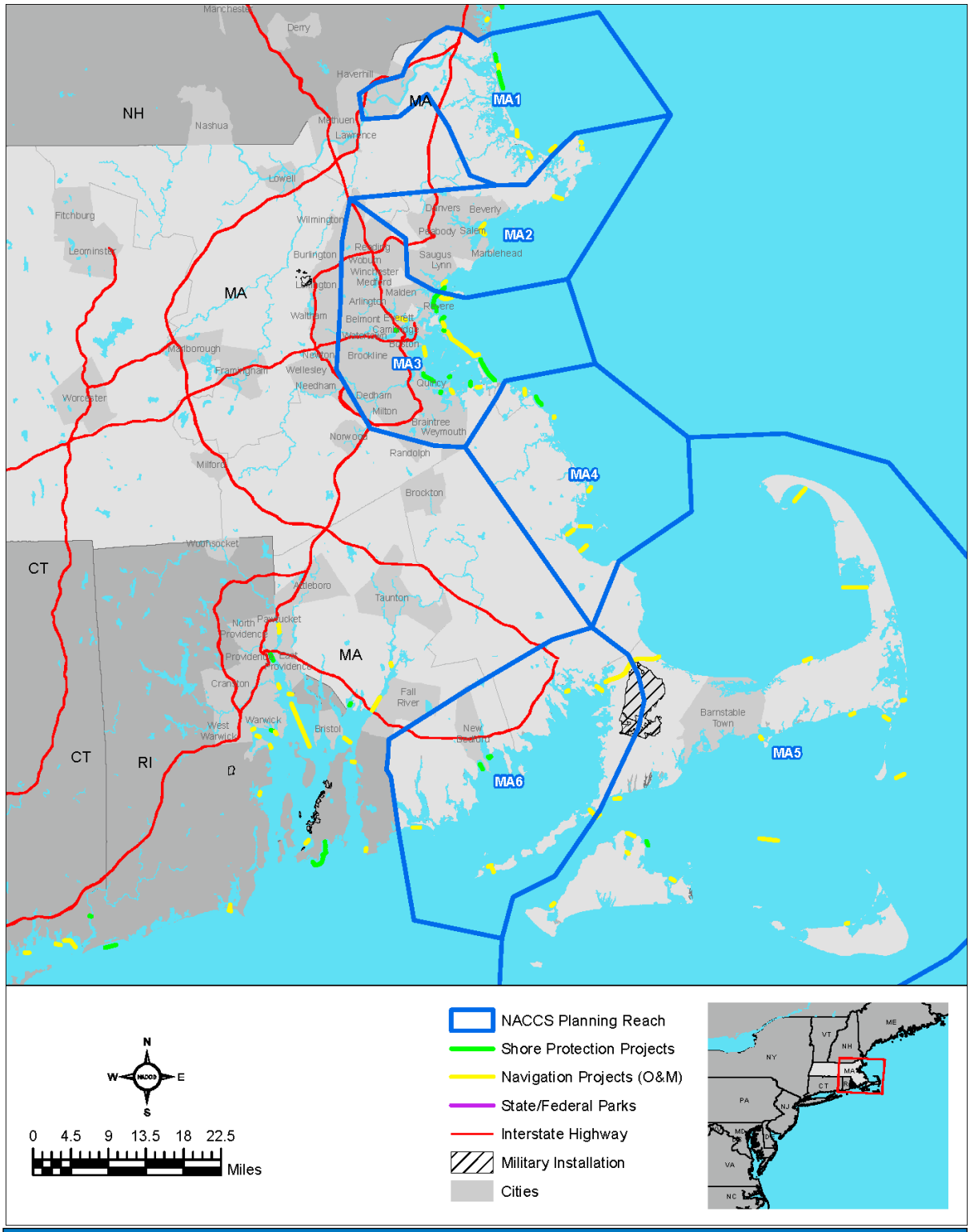


Figure 4. Federal Projects Included in the Post-Sandy Landscape Condition

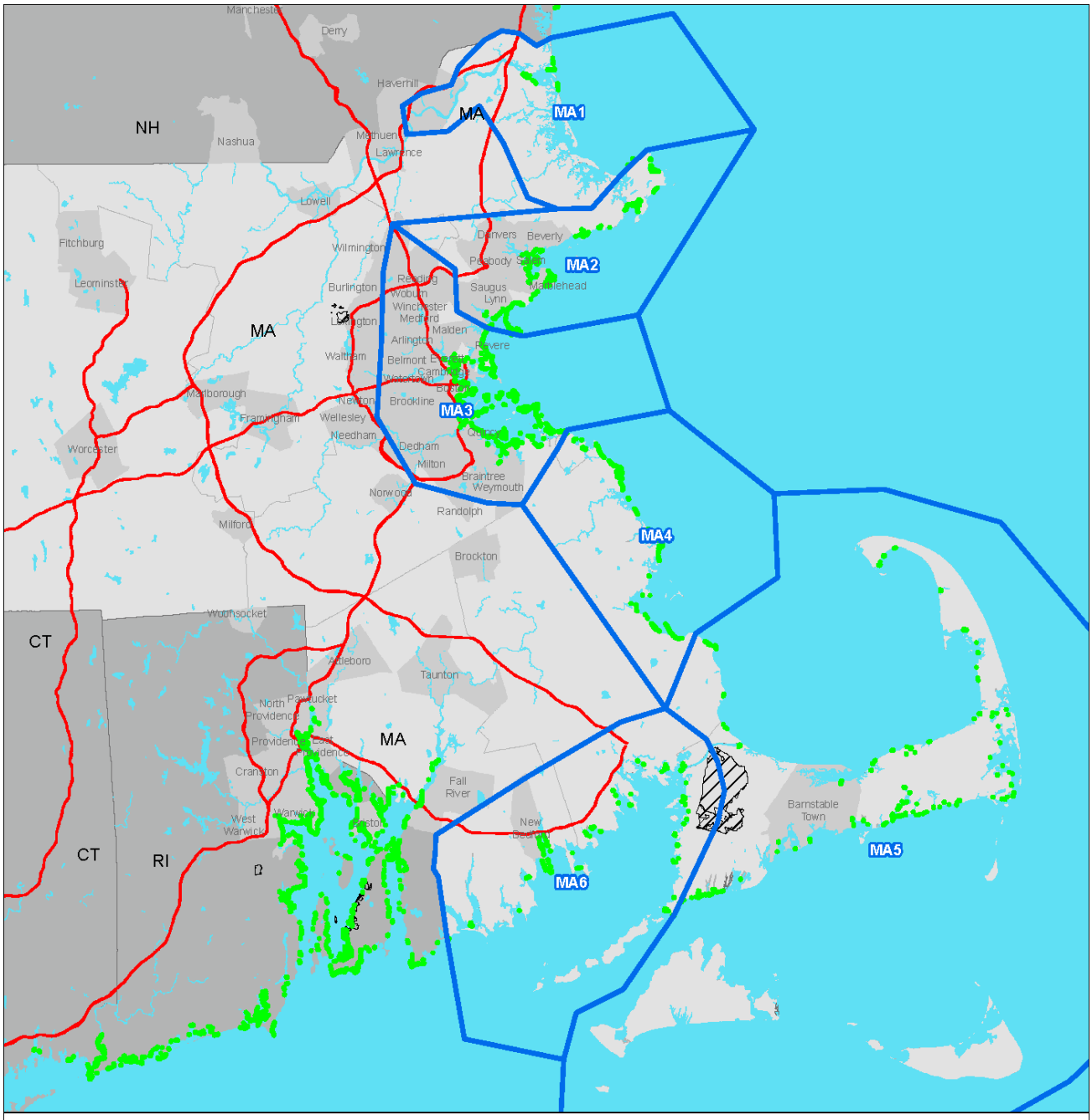


Figure 5. State Projects Included in the Post-Sandy Landscape Condition

Sea Level Change

The current USACE guidance on development of sea level change (USACE, 2013) outlines the development of three scenarios: Low, Intermediate and High (Figure 6). The NOAA High scenario (NOAA, 2012) is also plotted on Figure 6. The details of different scenarios and their application to the development of future local, relative sea level elevations for the NACCS study area are discussed in the NACCS Main Report.

The Commonwealth of Massachusetts has not officially adopted any SLC scenario.

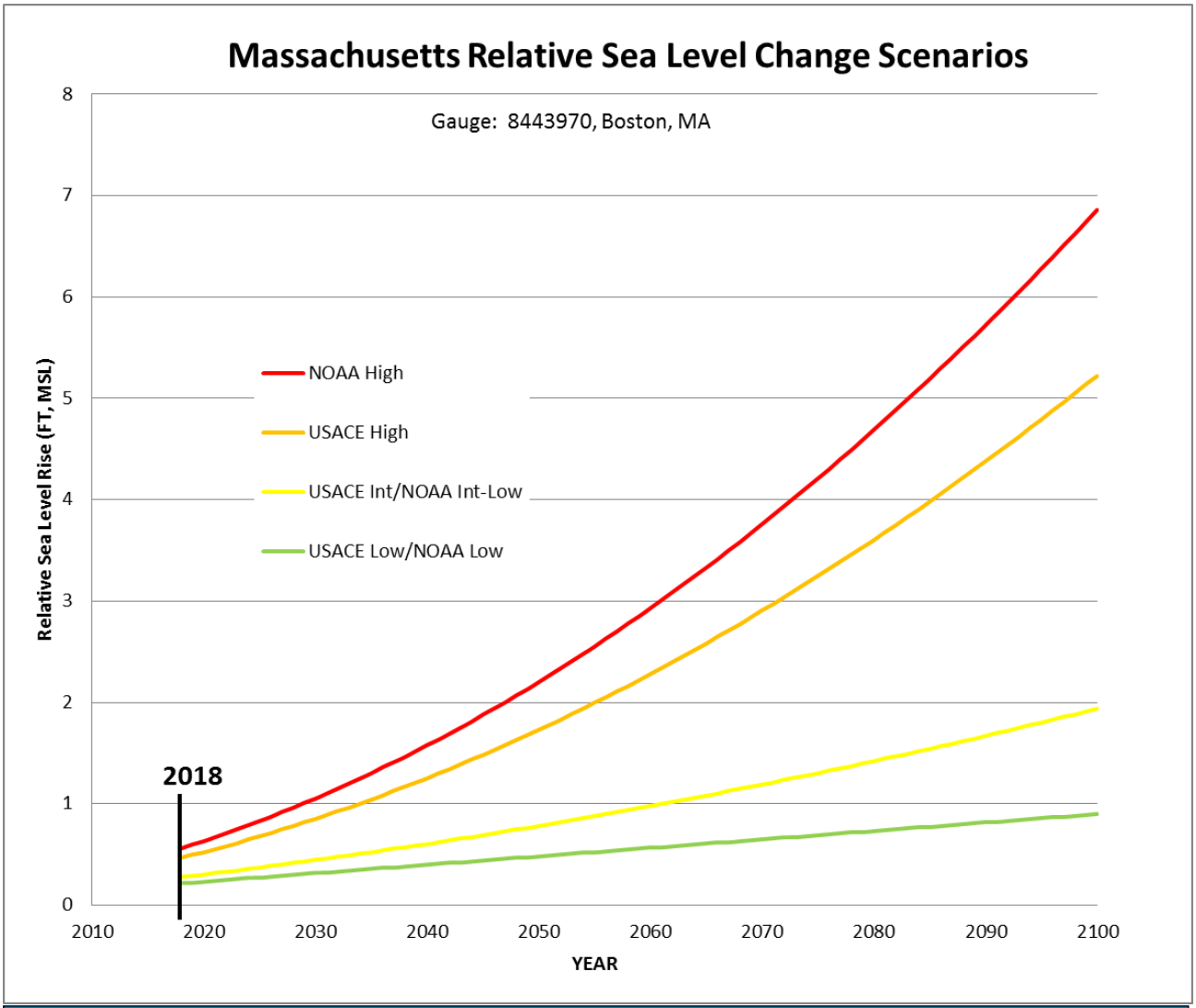


Figure 6. Relative Sea Level Change for Massachusetts for USACE and NOAA Scenarios

To consider the effects of SLC on the future landscape change, future SLC scenarios have been developed by the USACE (2013) and NOAA (2012). Figure 7 shows areas that would be below mean sea level at four future times (2018, 2068, 2100) based on the USACE High Scenario. A detailed discussion of mapping basis and technique for this and other mapping is provided in Appendix C – Planning Analyses.

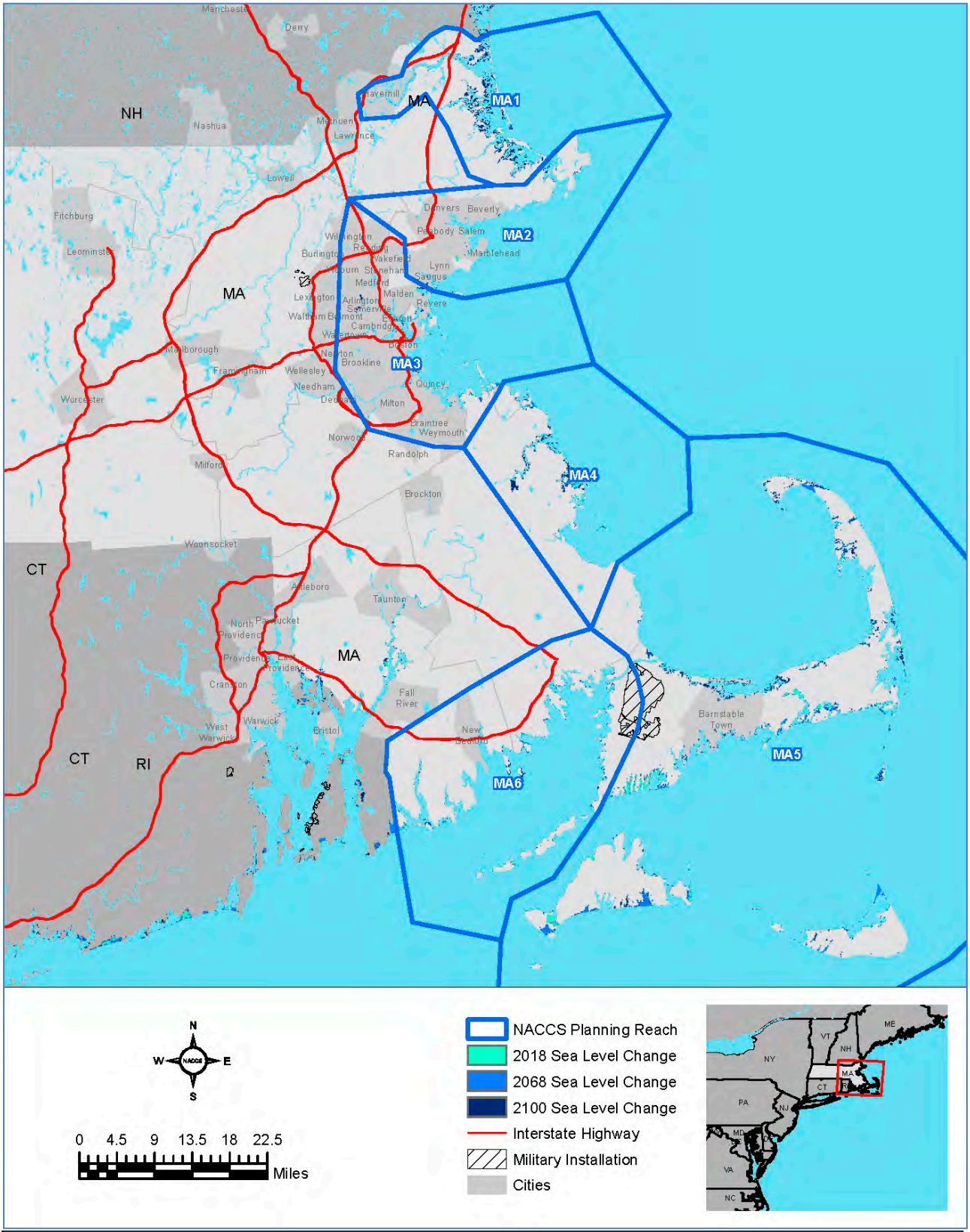


Figure 7. USACE High Scenario Future Mean Sea Level Mapping for the Commonwealth of Massachusetts

Forecasted Population and Development Density

Using information and datasets generated as part of the U.S. Environmental Protection Agency's (EPA) Integrated Climate and Land Use Scenarios (ICLUS), inferences to future population and residential development increases by 2070 were evaluated (USEPA, 2009). Figure 8 presents the USACE High scenario inundation and the forecasted increase in residential development density derived from ICLUS data for MD4. Changes to environmental and cultural resources and social vulnerability characteristics will not be considered as part of the overall forecasted exposure index assessment. Discussions of likely future impacts with respect to SLC on environmental and cultural resources will be considered in the Environmental and Cultural Resources Conditions Report. Additional information related to the forecasted population and development density is included in Appendix C – Planning Analyses.

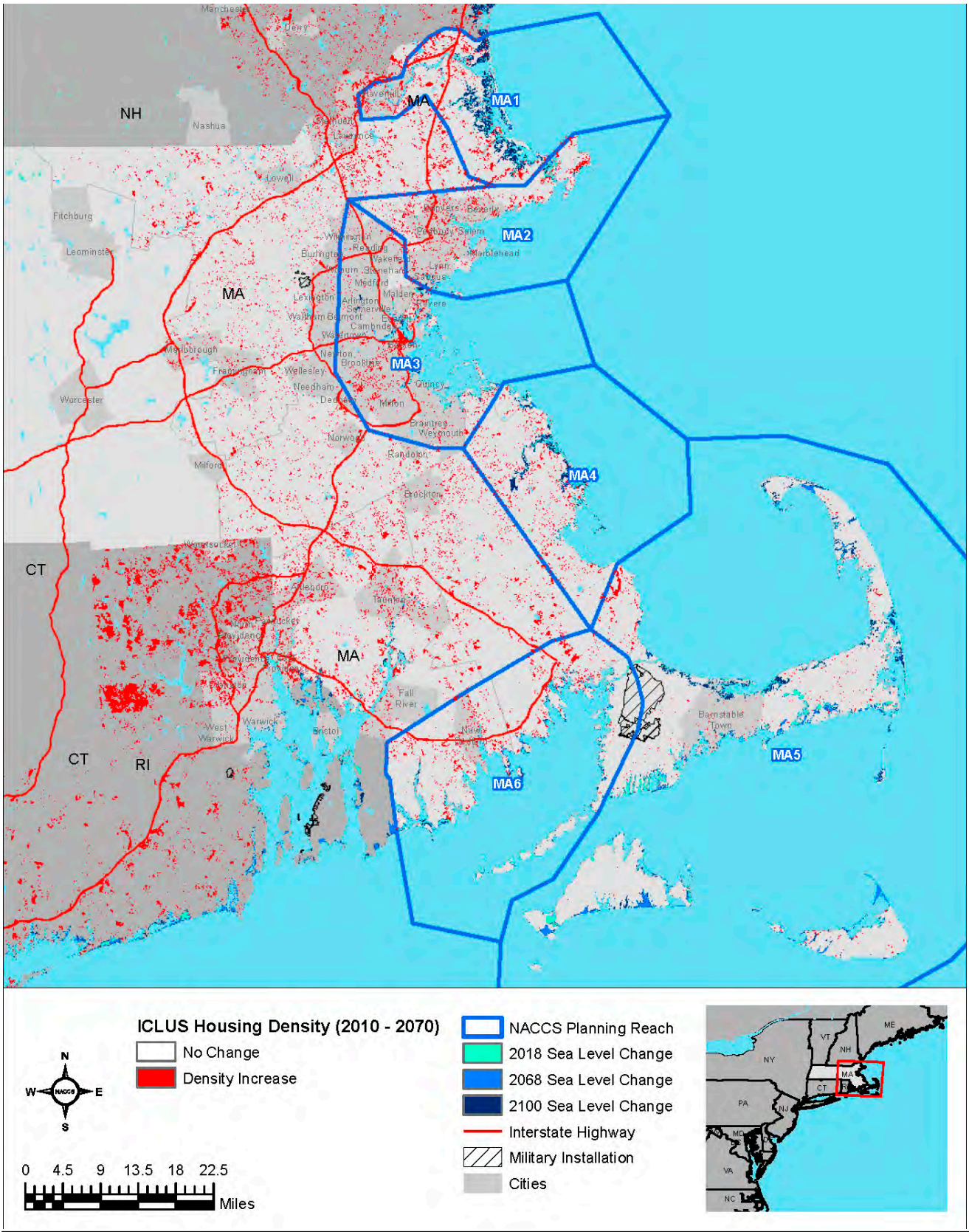


Figure 8. USACE High Scenario Future Mean Sea Level Inundation and Forecasted Residential Development Density Increase for the Commonwealth of Massachusetts

Extreme Water Levels

As part of the CSRM Framework, the extent of coastal flood hazard was completed by using readily available 1 percent flood mapping from FEMA, preliminary 10 percent flood values from the Engineer Research and Development Center (ERDC) extreme water level analysis, and the Sea, Lake, and Overland Surge from Hurricanes (SLOSH) modeling conducted by NOAA. The inundation zones identified by the SLOSH model depict areas of possible flooding from the maximum of maximum (MOM) event within the five categories of hurricanes by estimating the potential surge inundation during a high tide landfall. Although the SLOSH inundation mapping is not referenced to a specific probability of occurrence (unlike FEMA flood mapping, which presents the 0.2 percent and 1 percent flood elevation zones), a Category 4 hurricane making landfall during high tide represents an extremely low probability of occurrence but high magnitude event. In most cases it is only possible to provide risk reduction to some lower level like the 1 percent flood. Figure 9 presents the SLOSH hydrodynamic modeling inundation mapping associated with Category 1 through 4 hurricanes.

Figure 10 presents the approximate 1 percent flood plain plus 3 feet for the same area to illustrate areas exposed projected inundation levels which is closely aligned with the USACE high scenario for projected SLC by year 2068. Areas between the Category 4 and 1 percent plus 3-foot floodplain represent the residual risk for those areas included in the NACCS study area and Category 4 MOM floodplain.

Figure 11 presents the limit of the current 10 percent floodplain (an area with a 10 percent or greater chance of being flooded in any given year). The purpose of the 10 percent floodplain is to consider the possibility of surge reduction related to some natural and nature-based features (NNBF) management measures such as wetlands, living shorelines, and reefs.

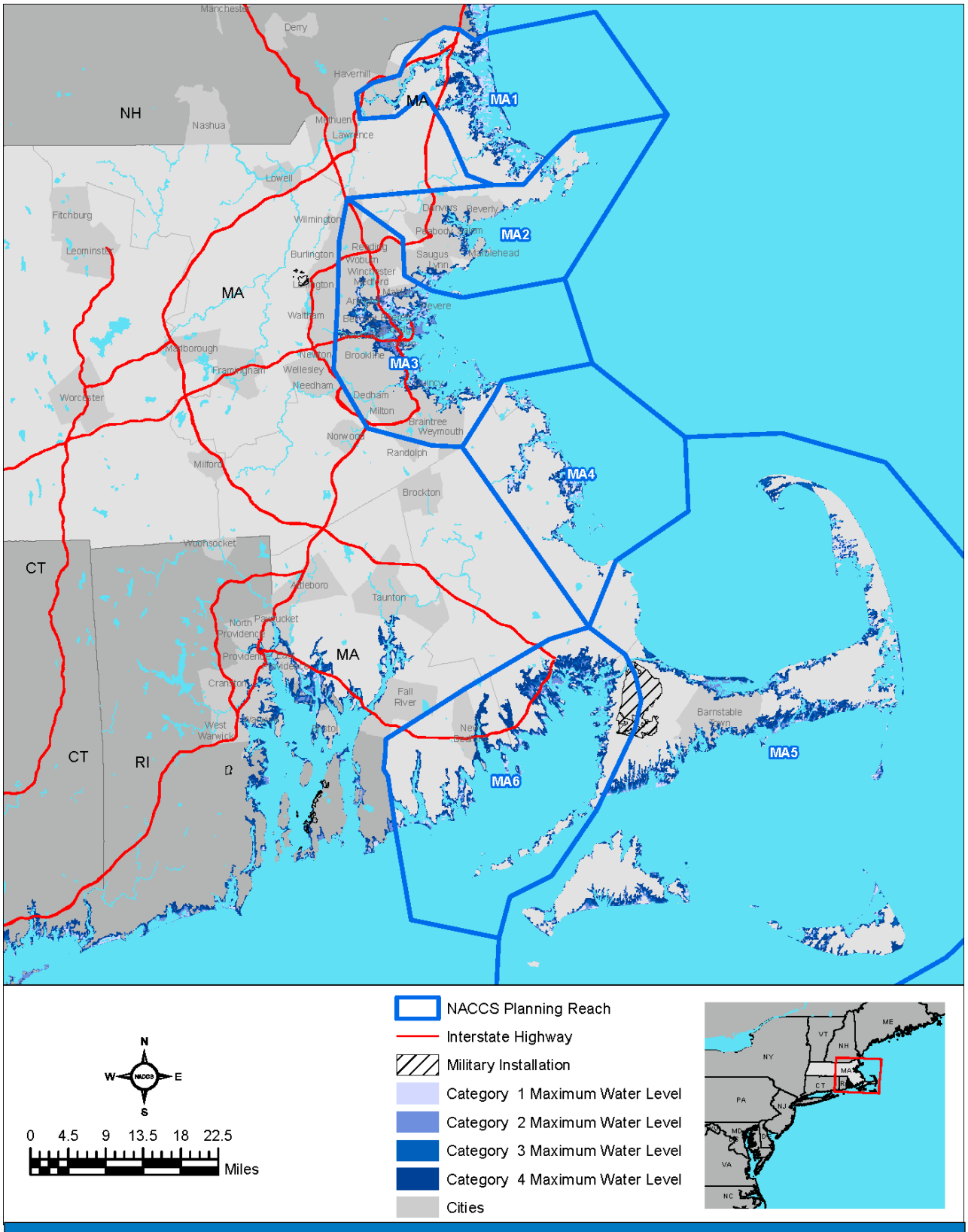


Figure 9. Impacted Area Category 1 - 4 Water Levels for the Commonwealth of Massachusetts

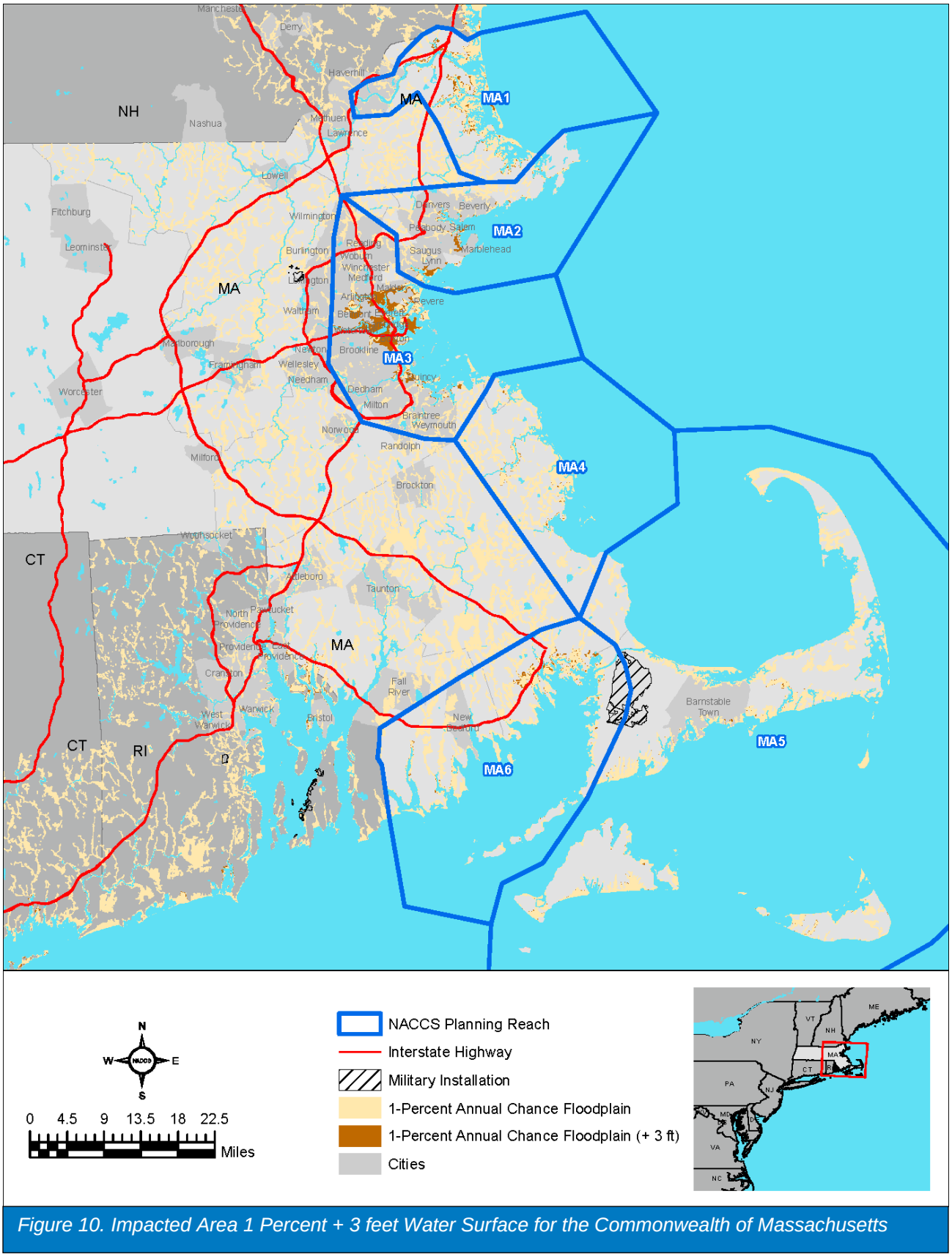


Figure 10. Impacted Area 1 Percent + 3 feet Water Surface for the Commonwealth of Massachusetts

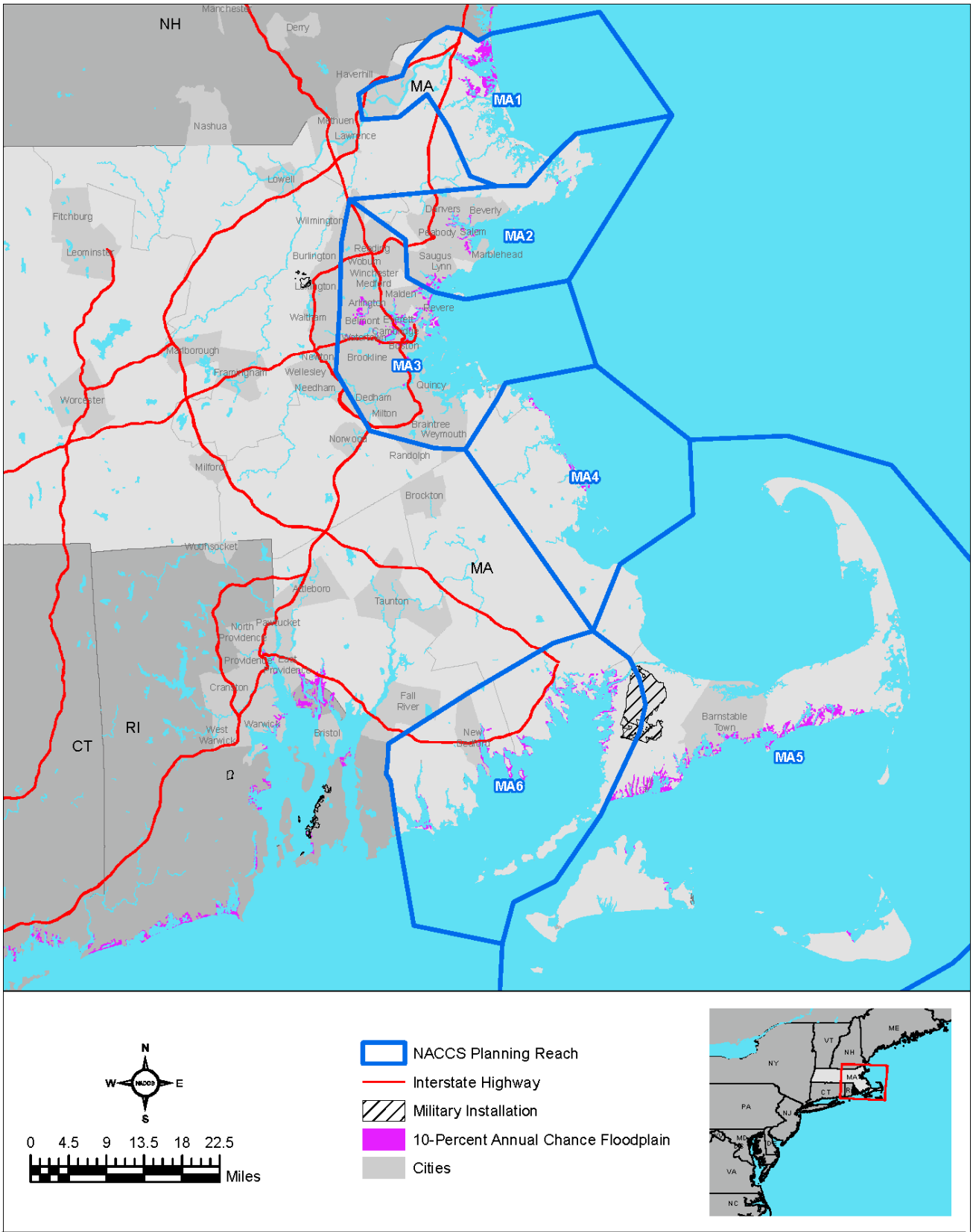


Figure 11. Impacted Area 10 Percent Water Surface for the Commonwealth of Massachusetts

Environmental Resources

Increased SLC is expected to threaten Massachusetts barrier beach and dune systems. Approximately 20 percent of Massachusetts' beach and dune habitat is adjacent to highly developed areas. Beaches and vegetated dunes provide an important buffer between coastal waters and infrastructure. Significant impacts to this buffer are predicted if nothing is done to protect this habitat.

It is expected that CSRM projects constructed by USACE would continue to receive renourishment for 50 years after initial construction. The remaining beaches and dunes that are not maintained by the state and local communities are at risk of damage from SLC. If beaches are armored, adjacent beaches will erode and sediments will not be available for natural replenishment of sediment in areas that are not supplemented with beach nourishment projects. The beaches serve as important habitat for horseshoe crabs, shorebirds such as nesting piping plovers, and numerous coastal species.

Massachusetts barrier beaches are dynamic features that respond in a generally predictable manner, migrating landward by storm overwash as the shoreline retreats due to erosion. If there is no room for migration, these barriers will suffer serious erosion and breaching.

Coastal wetlands have the potential to adapt and keep pace with SLC through vertical accretion and inland migration if there is space available at the same elevation relative to the tidal range and a stable source of sediment. Sea level change forces coastal wetlands to migrate inland causing upslope transitional brackish wetlands to convert to saline marshes and the saline marshes on the coastline to drown or erode. Coastal wetlands adjacent to human development or seawalls that block natural wetland migration paths will cause these wetlands to be inundated. In addition, these wetlands will generally be unable to accrete at a pace greater or equal to relative SLC, so critical coastal wetlands such as the North Shore's Great Marsh – the largest continuous stretch of salt marsh in New England, extending from Cape Ann to New Hampshire - are at risk as they will be unable to adapt and migrate as sea level rises and local land subsides. It is estimated by the National Marine Fisheries Service that 32 percent of the commercial fish and shellfish collected in New England are directly dependent on estuaries and salt marshes for various life stages, including spawning and early stage development.

Coastal freshwater and brackish wetlands in Massachusetts are sensitive to extreme high tides resulting from an increase in storm frequency or magnitude, and SLC; these high tides and SLC can carry salts inland to salt-intolerant vegetation and soils. If these coastal freshwater and brackish wetland communities are unable to shift inland, freshwater and brackish flora and fauna could be displaced by more salt-tolerant species.

Sea level change could result in the permanent inundation of tidal mud flats and low offshore islands that would result in the loss of critical nesting bird habitat for species such as roseate terns and common terns and as a feeding and resting area. Massachusetts is a valuable stopover for a wide variety of migratory species, particularly in the fall for species that breed throughout the tundra of Canada and Alaska and stop in Massachusetts and coastal New England to refuel before heading further south to the southern United States, Caribbean, and South America.

Although there is generally more room for wetlands to migrate in parks and refuges, these areas will still lose salt and freshwater marshes and dry land to open water as a result of the effects of SLC.

A more detailed explanation of these effects can be found in the Environmental and Cultural Resources Conditions Report.

IV. NACCS Coastal Storm Exposure and Risk Assessments

The extent of flooding, as presented in Figures 9 to 11, was used to delineate the areas included in the coastal storm risk and exposure assessments. An exposure index was created for population density and infrastructure, social vulnerability characterization, and environmental and cultural resources. In addition, the three individual indices were combined to create a composite exposure index. The purpose of combining individual exposure indices into a composite index was to provide an illustration of example values for features of the system, with population density and infrastructure weighted at 80 percent of the total index, and social vulnerability characterization and environmental and cultural resources weighted at 10 percent each. For the purpose of the Framework, the overall composite exposure assessment identified areas with the potential for relative higher exposure to flood peril considering collectively the natural, social, and built components of the system. Additional information related to the development of the NACCS risk and exposure assessments is presented in Appendices B – Economics and Social Analyses, and C – Planning Analyses.

IV.1. NACCS Exposure Assessment

The Tier 1 assessment first required identifying the various categories to best characterize exposure. Although a myriad of factors or criteria can be used to identify exposure, the NACCS focused on the following categories and criteria, as emphasized in Public Law (PL) 113-2.

Population Density and Infrastructure Index

Population density includes identification of the number of persons within an aerial extent across the study area; infrastructure includes critical infrastructure that supports the population and communities. These factors were combined to reflect overall exposure of the built environment. Figure 12 presents the population density and infrastructure exposure index. Figure 13 presents the percentages of infrastructure included within the population density and infrastructure exposure index.

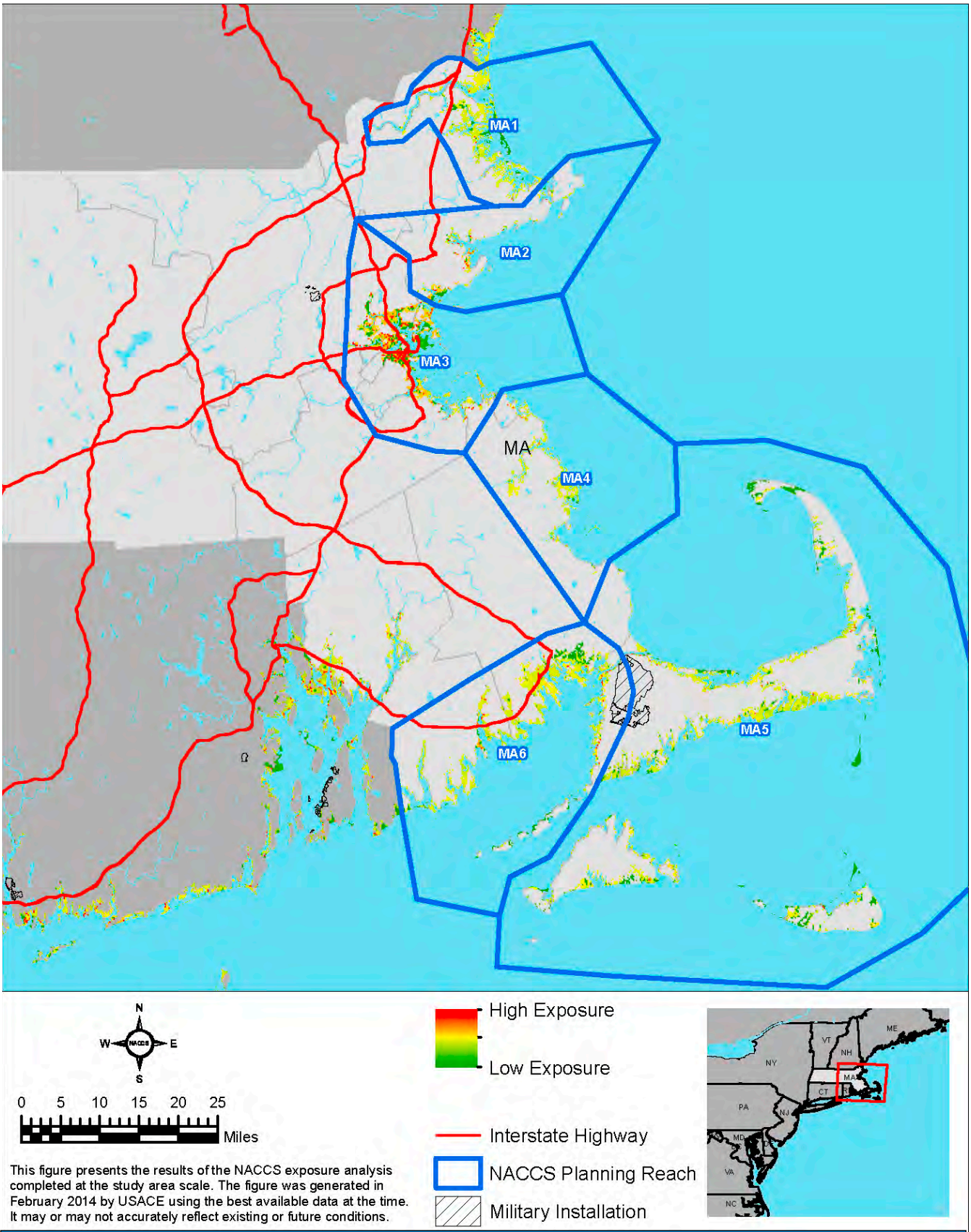


Figure 12. Population and Infrastructure Exposure Index for the Commonwealth of Massachusetts

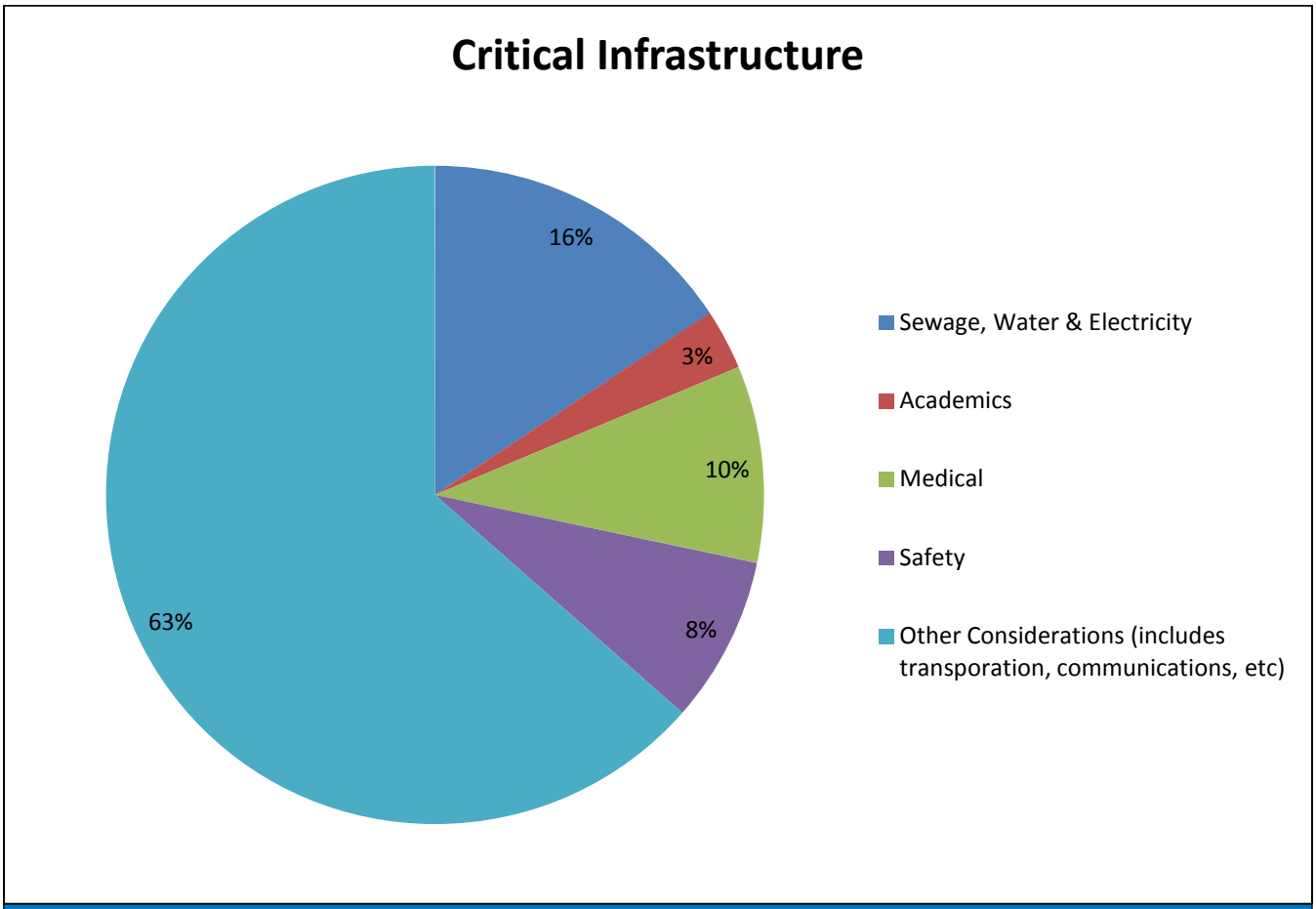


Figure 13. Vulnerable Infrastructure Elements Within the Category 4 MOM Inundation Area in the Commonwealth of Massachusetts.

*The information presented in this chart represents the critical infrastructure identified in the HSIP Gold data layer within the Category 4 MOM inundation area. At this scale, the information presented is intended to be approximate/illustrative and may not capture all critical infrastructure. Local data should be used in any follow on analyses.

Social Vulnerability Characterization Index

The social vulnerability characterization captures certain segments of the population that may have more difficulty preparing for and responding to natural disasters and was completed using the U.S. Census Bureau 2010 Census data. Important factors in social vulnerability include age, income, and inability to speak English.

Figure 14 presents the social vulnerability characterization exposure index for the Commonwealth of Massachusetts. Areas with relatively higher concentrations of vulnerable segments of the population are identified from this analysis.

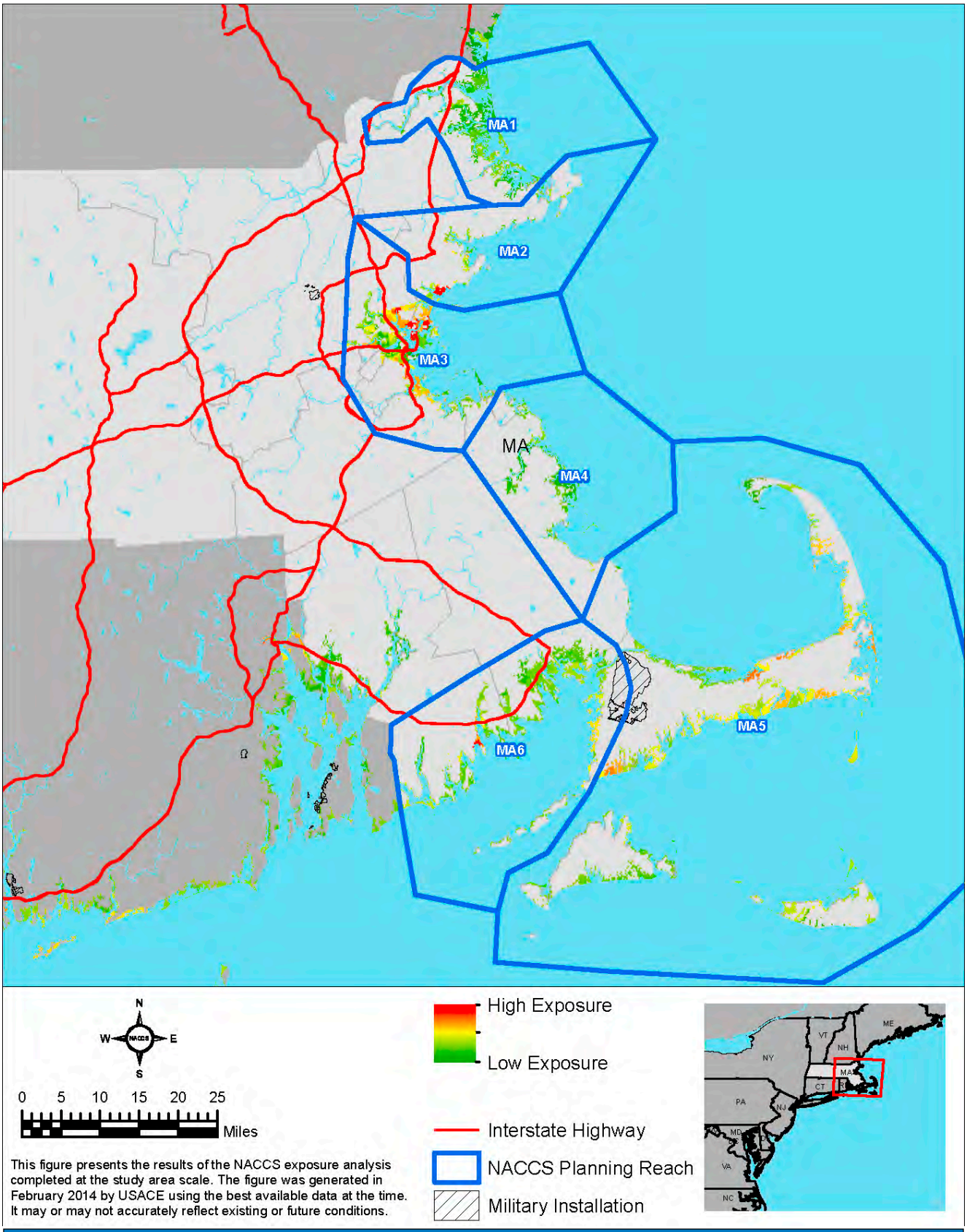


Figure 14. Social Vulnerability Index for the Commonwealth of Massachusetts

The identification of risk areas based on the social exposure analysis is provided below on a reach-by-reach basis for each of the planning reaches in the Commonwealth of Massachusetts.

MA1

Based on the social vulnerability analysis, no areas were identified within this reach as having relatively high social vulnerability (values above 70.0).

MA2

Based on the social vulnerability analysis, nine areas were identified within this reach as areas with relatively high social vulnerability. These areas were located within census tracts 2058, 2060, 2061, 2062, 2068, 2069, 2070, 2071, and 2072 (Essex County, MA). All of these areas were identified as vulnerable mainly due to a considerable percent of the population being non-English speakers. The areas identified within census tracts 2069, 2070, and 2072 also have a large percent of the population over 65 years old.

MA3

Based on the social vulnerability analysis, 51 areas were identified within this reach as areas with relatively high social vulnerability. These areas were located within census tracts 4178.02 and 4180.04 (Norfolk County, MA), 1606.01, 1707.02, 1605.01, 1401.06, 408.01, 4.01, 6.02, 402, 502, 503, 505, 506, 507, 512, 607, 610, 702, 803, 804.01, 805, 806.01, 808.01,812, 813, 821, 902, 903, 907, 913, 914, 916, 1001, 712.01, 9811, 104.03, 810.01, 704.02, 1602, 1604, 1601.01, 909.01, 611.01, 509.01, 501.01, 1605.02, 511.01, 921.01 (Suffolk County, MA), and 3412 and 3413 (Middlesex County, MA). The areas in census tracts 4180.04, 1606.01, 1707.02, 1605.01, 4.01, 502, 503, 505, 506, 507, 512, 607, 702, 813, 913, 916, 712.01, 704.02, 1602, 1604, 1601.01, 909.01, 611.01, 509.01, 501.01, 1605.02, 511.01, 921.01, 3412, and 3413 were identified as vulnerable mainly due to a considerable percent of the population being non-English speakers. The areas identified within census tracts 804.01, 806.01, 808.01, 812, 903, 9811, 104.03, 704.02, 909.01, and 611.01 have a large percent of the population below the poverty level. The area within census tract 1401.06 was identified mainly due to a large percent of the population under 5 years old. The areas within census tracts 4.01, 503, 505, 813, 104.03, 704.02, and 3412 have a large percent of the population over 65 years old.

MA4

Based on the social vulnerability analysis, no areas were identified within this reach as having relatively high social vulnerability (values above 70.0).

MA5

Based on the social vulnerability analysis, no areas were identified within this reach as having relatively high social vulnerability (values above 70.0).

MA6

Based on the social vulnerability analysis, ten areas were identified within this reach as areas with relatively high social vulnerability. These areas were located within census tracts 6525, 6512, 6519, 6520, 6518, 6509, 6527, 6526, 6524, and 6511 (Bristol County, MA). The areas in census tracts 6525, 6512, 6519, 6520, 6509, 6527, 6526, and 6524 were identified as vulnerable mainly due to a considerable percent of the population being non-English speakers. The areas in census tracts 6512

and 6519 also have a large percent of the population below the poverty level. And, the areas identified within census tracts 6520, 6518, and 6524 also have a large percent of the population over 65 years old.

Environmental and Cultural Resources Index

Environmental and cultural resources were also evaluated as they relate to exposure to the Cat 4 maximum inundation. Data from national databases, such as the National Wetlands Inventory and The Nature Conservancy Ecoregional Assessments; data provided from USFWS, including threatened and endangered species habitat and important sites for bird nesting and feeding areas; shoreline types; and historic sites and national monuments, among others were used in this analysis to assess environmental and cultural resource exposure. It should be noted that properties with restricted locations, typically archaeological sites, and certain other properties were omitted from the analysis due to site sensitivity issues.

Figure 15 depicts the environmental and cultural resources exposure index for the Commonwealth of Massachusetts. This exposure analysis is intended to capture important habitat, and environmental and cultural resources that would be vulnerable to storm surge, winds, and erosion. It should be noted though, that mapped areas displaying high exposure index scores (shown in red and orange) may not include all critical or significant environmental or cultural resources, as indexed scores are additive; the higher the index score, the greater number of resources present at the site. Impacts and recovery opportunity would vary across areas and depending on the resource affected.

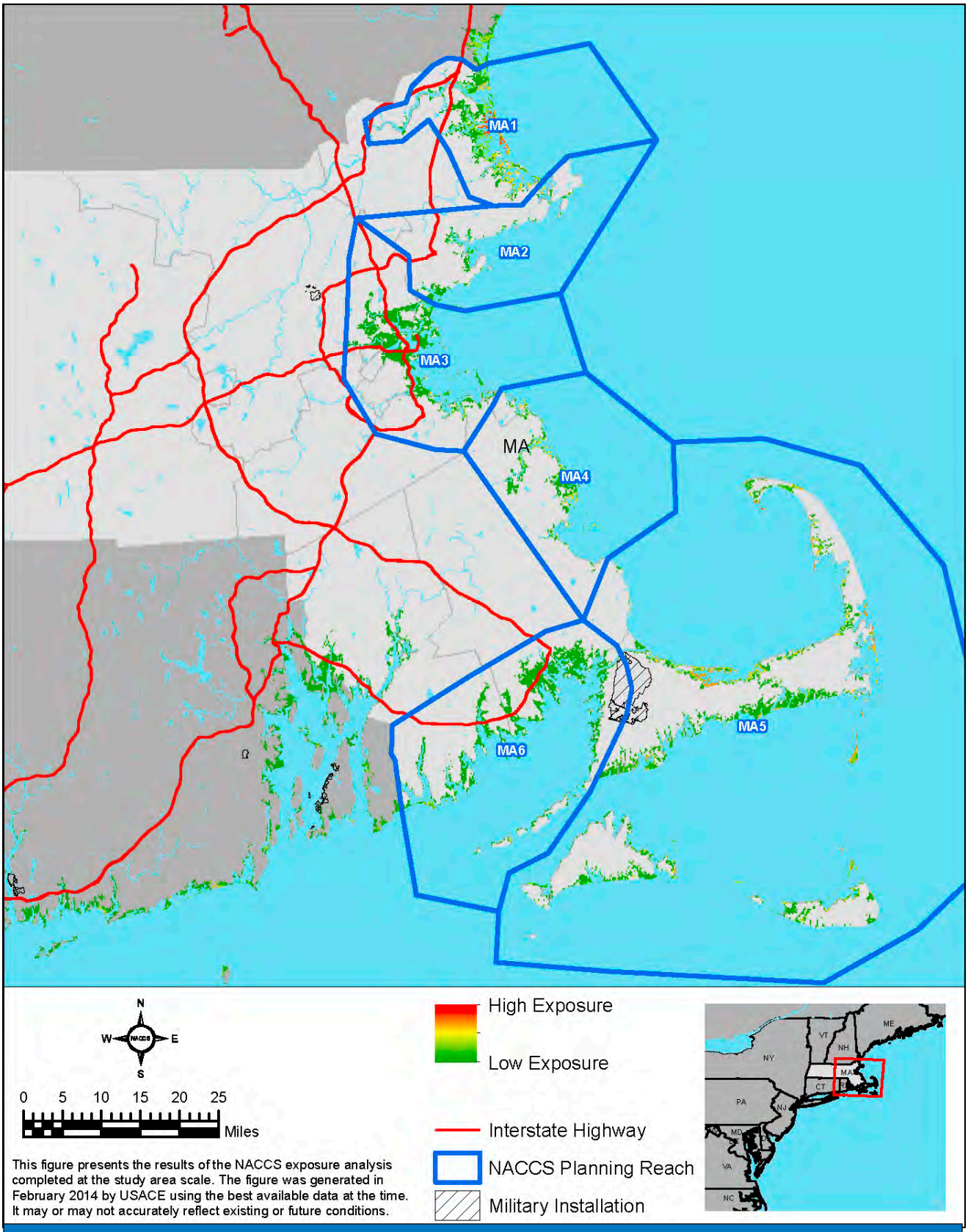


Figure 15. Environmental and Cultural Resources Exposure Index for the Commonwealth of Massachusetts

It should be noted that some regions that may be recognized as important in one category or another may not show up on the maps as a location identified as a High (red and orange) Environmental and Cultural Resource Exposure area. These areas may have met only one or just a few of the criteria used in the evaluation. Further, due to the minority contribution of cultural resources in the analysis (40 percent) and their general lack of proximity to key natural resource areas, historic properties may not be strongly represented.

A description of the High Environmental and Cultural Resource Exposure Areas for each planning reach is described below.

Reach: MA1

This analysis resulted in approximately 3,000 acres of high (red and orange) environmental and cultural resources exposure index area in planning reach MA1.

Castle Neck, Clark Pond, Plum Island and Salisbury Beach form about 2,900 acres of the Coastal Barrier Resources System (CBRS) in the high environmental and cultural resources exposure assessment area. Nearly 5,500 acres of these assessment areas are protected by the Parker River National Wildlife Refuge (NWR), as well as about 260 acres of habitat for the federally listed as threatened piping plover and the red knot, which is proposed to be listed as threatened. Nearly 3,000 acres of conservation areas considered priority by The Nature Conservancy (TNC) are included in these assessment areas. State parks larger than 10 acres covering nearly 140 acres are also considered in these high exposure index areas.

Over twice as much coarse grained (approximately 340 acres) as fine grained (approximately 160 acres) unconsolidated material compose the shoreline these assessment areas, while nearly two acres of the shoreline is rocky. Tidal emergent marshes make up about 2,300 acres, freshwater emergent marsh nearly 70 acres, and freshwater forested/shrub wetland about 2 acres of the wetlands in these exposure index areas.

There are approximately 3,000 acres of cultural resources buffer within the high environmental and cultural resources exposure index area in planning reach MA1.

Reach: MA2

This analysis resulted in approximately 30 acres of high (orange) environmental and cultural resources exposure index area in planning reach MA2.

Almost 20 acres of Wingersheek Beach comprises the CBRS in these assessment areas. Fifteen acres of habitat is available for the red knot and piping plover for nesting and foraging in these assessment areas. Nearly 30 acres of TNC priority conservation areas exist in these assessment areas, as well as 3 acres of state parks larger thanks 10 acres in size.

The shoreline in these exposure index areas is composed of nearly 20 acres of coarse grained (sand, gravel, and/or cobble) material. Slightly over 2 acres of tidal emergent marsh and less than a half of an acre of freshwater emergent wetland exist in this area.

There are roughly 26 acres of cultural resources buffer within the high environmental and cultural resources exposure index area in planning reach MA2.

Reach: MA3

This analysis resulted in approximately 130 acres of high (orange) environmental and cultural resources exposure index area in planning reach MA3.

Merrymount Park, Snake Island, and Wollaston Beach comprise about 90 acres of the CBRS, with the largest (70 acres) comprised by Merrymount Park. Almost 20 acres of habitat for the endangered roseate tern, piping plover, and red knot, and nearly 130 acres of TNC priority conservation areas are located within these assessment areas. City/county parks compose the largest number of acres (approximately 70 acres) of the approximately 80 acres of city/county and state parks in these high exposure index areas.

Almost 4 acres of fine-grained (mud, organic, flat) shoreline and 20 acres of coarse-grained shoreline, as well as about 80 acres of tidal emergent marsh border these assessment areas.

There is one National Monument within reach MA3 (includes Boston Metropolitan Area) within the MA3 high environmental and cultural resources exposure index area, the Boston National Historical Park which is home to the USS Constitution. Additionally, historic sites including the Moswetuset Hummock and Winthrop Parkway and Winthrop Shore Drive, both part of the Metropolitan Parkway System of Greater Boston were identified in this reach. There are roughly 130 acres of cultural resources buffer within the high environmental and cultural resources exposure index area in planning reach MA3.

Reach: MA4

This analysis resulted in approximately 90 acres of high (orange) environmental and cultural resources exposure index area in planning reach MA4.

Cohasset Harbor, Duxbury Beach, Plymouth Bay, Rexhame, and Rivermoor combine for approximately 80 acres of the CBRS. Over 58 acres of piping plover and red knot habitat, and nearly 87 acres of TNC priority conservation areas are located in these exposure areas.

All of the 50 acres of shoreline in the high exposure area is coarse-grained sand, gravel, and cobble. Slightly over 10 acres of tidal emergent marsh exist in this area.

There are nearly 90 of cultural resources buffer within the high environmental and cultural resources exposure index area in planning reach MA4.

Reach: MA5

This analysis resulted in approximately 8,200 acres of high (red and orange) environmental and cultural resources exposure index area in planning reach MA5.

Ballston Beach, Boat Meadow, Cape Poge, Center Hill Complex, Centerville, Chaplin Beach, Chatham Roads, Cisco Beach, Coatue, Davis Beach, Edgartown Beach, Eel Pond Beach, Esther Island Complex, Freemans Pond, Griffin/Great Islands Complex, Harthaven, Lewis Bay, Lieutenant Island, Mink Meadows, Muskeget Island, Namskaket Spits, Nauset Beach/Monomoy, Norton Point, Pamet Harbor, Popponesset Spit, Provincetown, Sandy Neck, Scorton, Sesachacha Pond, South Beach, Squaw Island, Town Neck, Tuckernuck Island, and Waquoit Bay form just over 8,000 acres under the CBRS. The Monomoy, Nantucket, Mashpee, and Nomans Land Island form almost 2,700 acres of

National Wildlife Refuges in the red and orange environmental and cultural resources exposure index areas. Over 3,700 acres of habitat is provided for roseate terns, piping plovers, red knots, and northeastern beach tiger beetle. Norton Point provides habitat for colonial nesting waterbirds in this exposure area. Approximately 8,000 acres of TNC priority conservation area exists in these exposure areas; as well as over 2,900 acres of city, county and state parks larger than 10 acres in size. City/county parks by far make the largest contribution with over 2,850 acres.

The vast majority of the shoreline is coarse-grained (approximately 1,600 acres), compared to the 14 acres of fine-grained shoreline (muds and organics) in these exposure areas. Nearly 70 acres of seagrass, 4,300 acres of tidal emergent marsh, 85 acres of freshwater emergent marsh, 85 acres of scrub-shrub, and 30 acres of freshwater forested/shrub wetlands can also be found in these exposure areas.

MA5 high environmental and cultural resources exposure index area includes the Cape Cod National Seashore, a Federal Park that includes the Marconi Wireless Site and numerous Native American and historic period archaeological sites. The Cape Cod National Seashore is 5,089 acres large. Other historic sites in the high exposure area include the Marconi Site and the Chatham Light Station, Highland Light Station, Wood End Light Lookout Station, and the Race Pont Life Station. Additionally, there are roughly 8,000 acres of cultural resources buffer within the high environmental and cultural resources exposure index area in planning reach MA5.

Reach: MA6

This analysis resulted in approximately 50 acres of high (orange) environmental and cultural resources exposure index area in planning reach MA6.

Buzzards Bay complex, Elizabeth Islands, Horseneck Beach, Little Beach, and West Sconticut Neck form nearly 50 acres of the CBRS in these exposure areas. Over 30 acres provide habitat for piping plovers and red knots. There are no TNC priority conservation areas in this planning reach. However, over 14 acres of state parks are located here.

Again, the majority of the shoreline material (>20 acres) in these exposure areas is composed of coarse-grained sands and gravels compared to the less than one acres of fine-grained (muds and organics) shoreline and less than one acre of rocky shores. Nearly 20 acres of tidal emergent marsh can also be found here.

There are approximately 50 acres of cultural resources buffer within the high environmental and cultural resources exposure index area in planning reach MA6.

Composite Exposure Index

All three of the exposure indices were summed together to develop one composite index that displays overall exposure. Figure 16 depicts the Composite Exposure Index for the Commonwealth of Massachusetts.

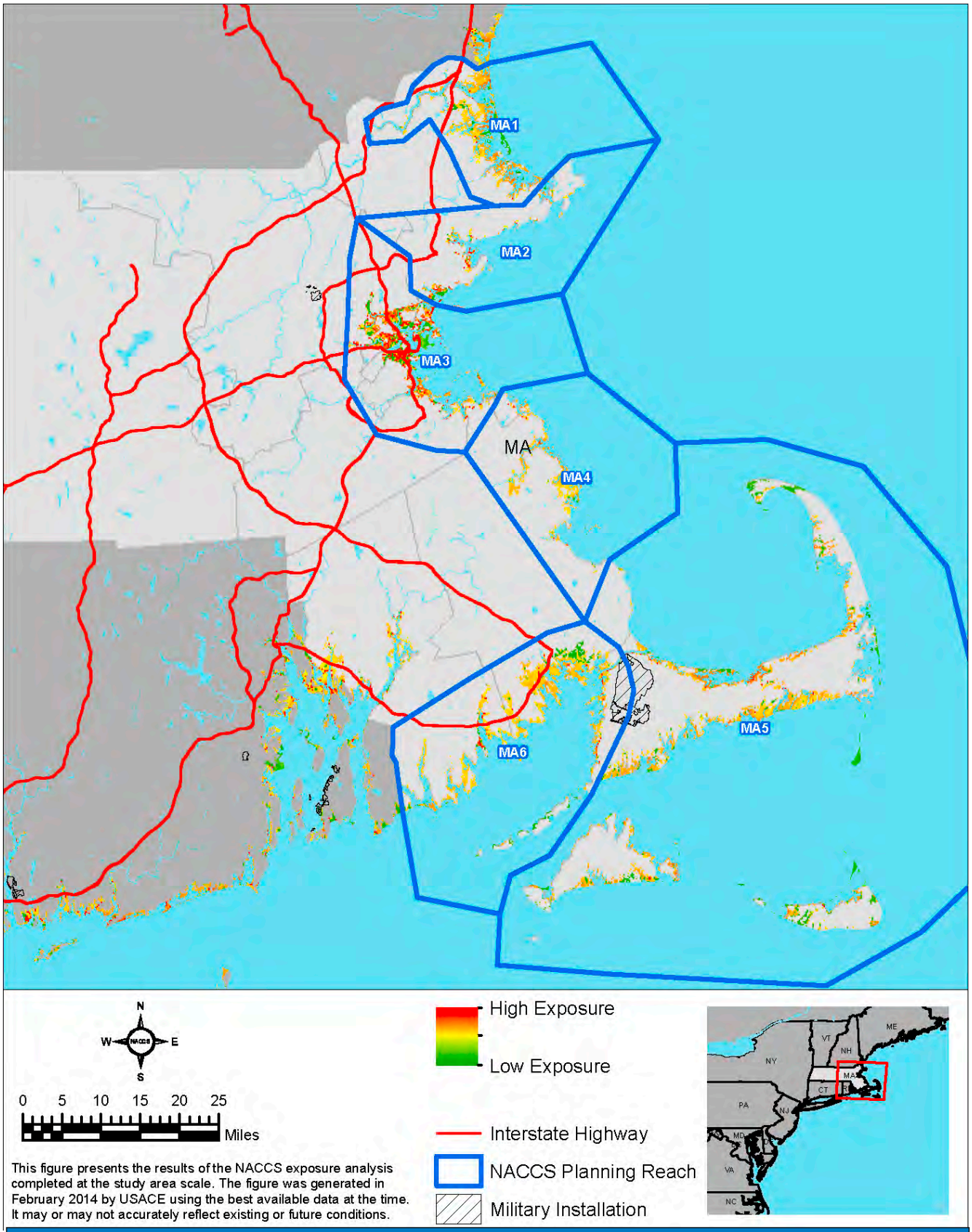


Figure 16. Composite Exposure Index for the Commonwealth of Massachusetts

IV.2. NACCS Risk Assessment

Exposure and coastal flood inundation mapping is used to identify the specific areas at risk. Once the exposure to flood peril of any area has been identified, the next step is to better define the flood risk. The Framework defines risk as a function of exposure and probability of occurrence. For each of the floodplain inundation scenarios, Category 4 MOM, 1 percent flood plus three feet, and the 10 percent flood, three bands of inundation were created. The bands correspond with the flooding source to the 10-percent inundation extent, the 10-percent to the 1-percent plus three feet extent, and the 1-percent plus three feet to the CAT4 MOM inundation extent. The 1-percent plus three feet extent was defined as the CAT2 MOM because at the study area scale there were areas that did not include FEMA 1-percent flood mapping. This process was completed for the composite exposure assessment in order to generate the NACCS risk assessment. The data was symbolized to present areas of relatively higher risk, which based on the analysis, corresponds with the three bands that were used in the analysis. Subsequent analyses could incorporate additional bands, which would present additional variation in the range of values symbolized in the figure. Figure 17 depicts the results of this risk assessment using the composite exposure data for the Commonwealth of Massachusetts.

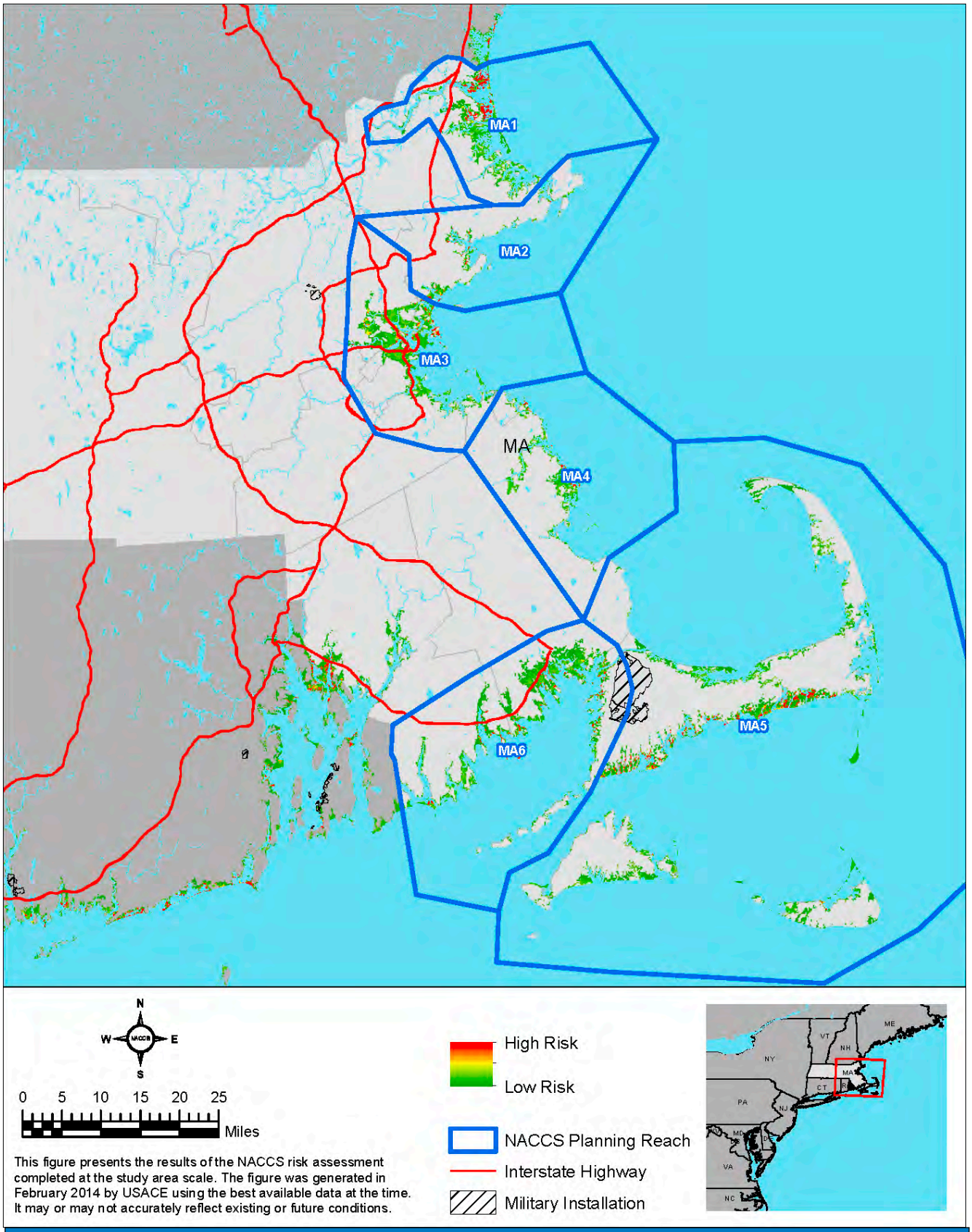


Figure 17. Risk Assessment for the Commonwealth of Massachusetts

IV.3. NACCS Risk Areas Identification

Applying the risk assessment to the Commonwealth of Massachusetts identified 14 areas for further analysis (Figure 18). These locations are identified on Figures 19 through 24 and are described in more detail below.

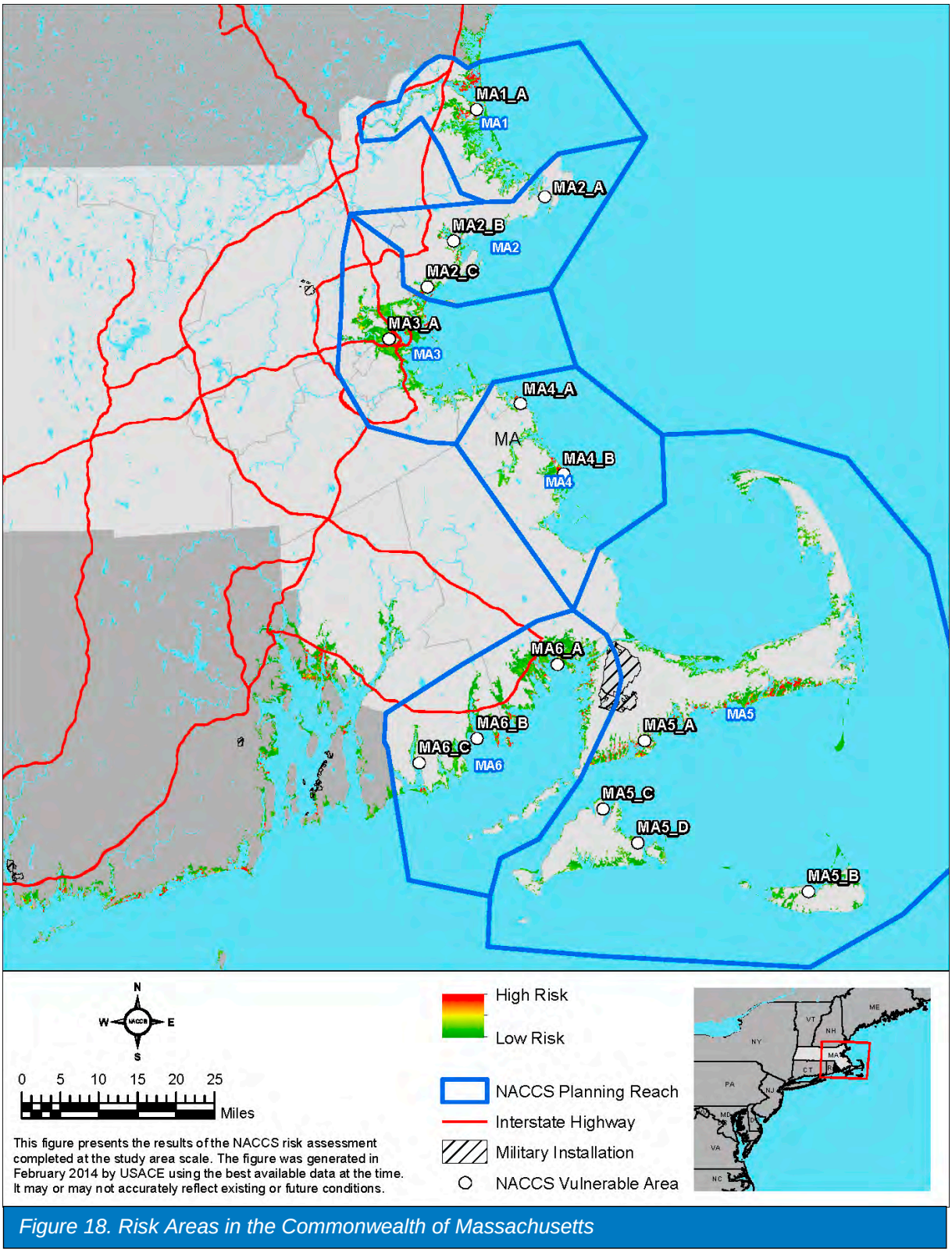


Figure 18. Risk Areas in the Commonwealth of Massachusetts

Reach MA1

The shoreline of Massachusetts Reach 1 (Figure 19) is characterized by sand/gravel/cobble shorelines fronting very large salt marsh areas. Some of the shoreline, on either side of the mouth of the Merrimack River in particular, has seen a fair amount of residential development. The reach contains a couple of USACE coastal flood risk management projects, and an extensive 1 percent floodplain.

One large exposure area was identified in this reach and is described in this section.

MA1_A: Merrimack River

This area of high exposure encompasses portions of the towns of Salisbury, Newburyport and Newbury; from the coast inland to almost as far as Route 95. A catastrophic surge event could inundate such highly populated areas as Plum Island, Salisbury Beach and the centers of each of the effected towns. Many residential and commercial properties (thousands) as well as state and municipal infrastructure would be affected. State routes 1, 1A, 113, 110 and the Plum Island Turnpike would be inundated cutting off significant portions of each town. Newburyport includes fairly developed commercial port facilities and a wastewater treatment plant that would be impacted.

Reach MA2

The shoreline of Massachusetts Reach 2 (Figure 20) is characterized by urban areas, wetlands and rocky shoreline. This reach has significantly more development than reach 1. The reach contains no USACE coastal flood risk management projects, but does include an extensive 1 percent floodplain in certain areas.

Three exposure areas were identified in this reach and are described in this section. The areas of high exposure center on the urban areas around Gloucester, Beverly, Salem, Peabody, Danvers, Saugus and Lynn.

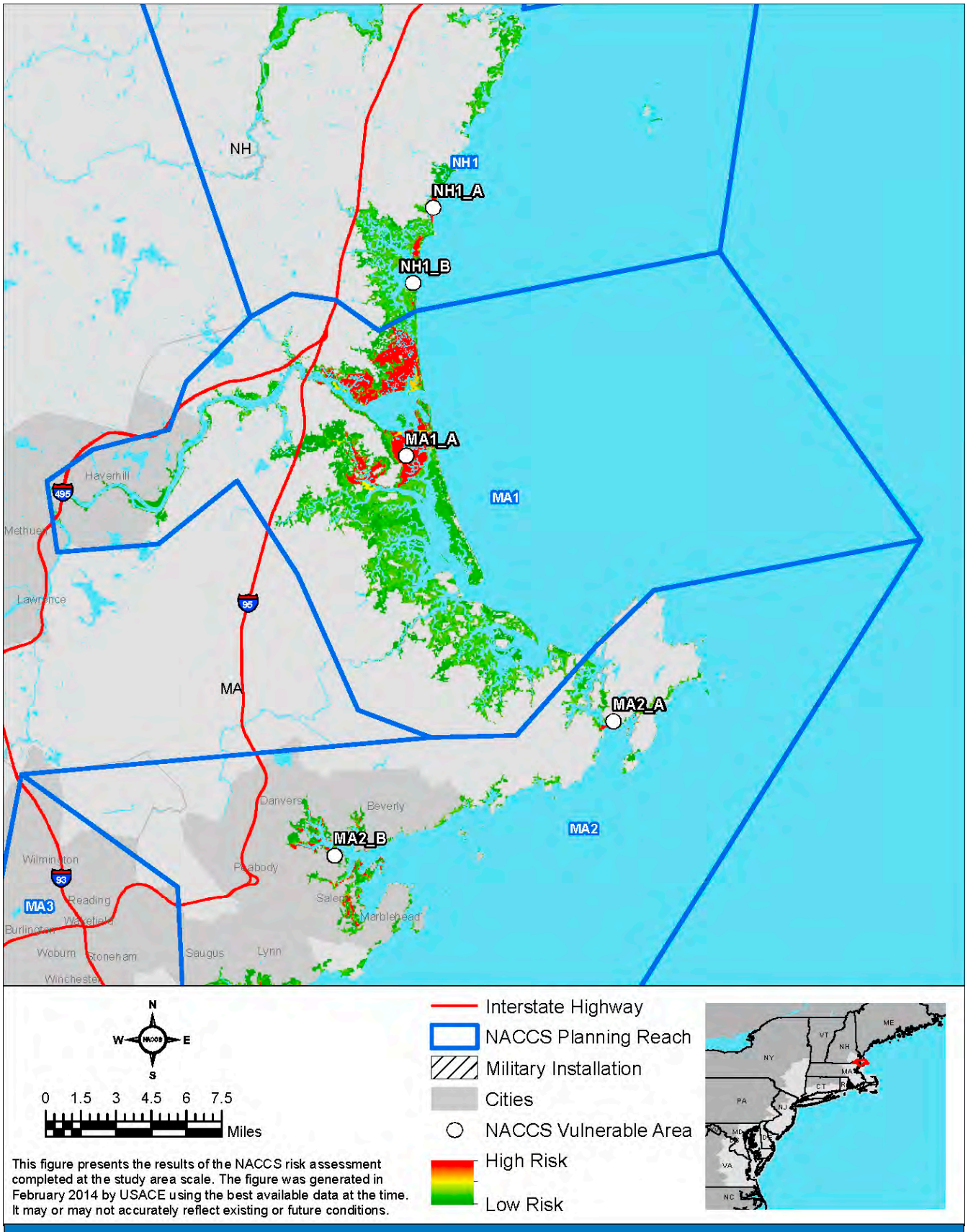


Figure 19. MA1 Reach Risk Areas

MA2_A: Gloucester Harbor

This area of high exposure begins at Smith Cove and wraps around the harbor; ending at Stage Fort Park on the west side of town. The exposure area extends in to the downtown area by about ½ a mile. Gloucester Harbor is home to a significant commercial fishing fleet. The harbor supports several fishing and boating related businesses. There are several hundred residential properties impacted in this area of high exposure including municipal infrastructure

MA2_B: Salem & Beverly Harbors

This area of high exposure is very large and encompasses the development surrounding these two harbors. It includes: the downtown area of Beverly along the harbor and the Bass River as far inland as Cabot Street; property adjacent to the Danvers, Porter, and Waters rivers as far inland as ½ mile past Route 128 in Danvers; properties along the North River in Salem and Peabody as far inland as Peabody Square; and all of downtown Salem. Hurricane surge in this area could impact thousands of residential and commercial properties, industrial facilities, water and wastewater treatment facilities, state and local roads and utilities, marinas and other water borne commerce. There is a regionally significant electrical power plant in Salem that is dependent on the harbor for importing fuel.

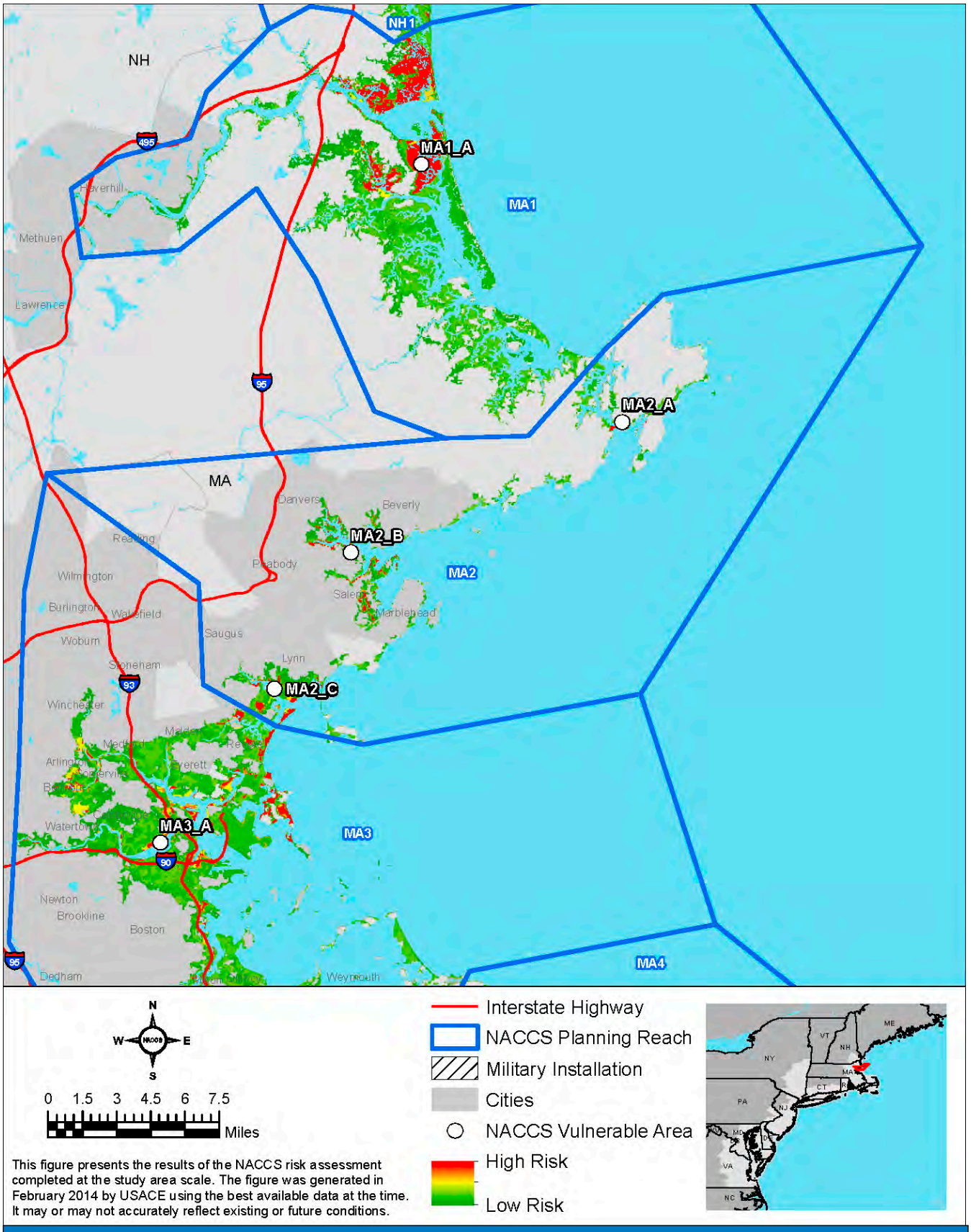
MA2_C: Saugus River

This area of high exposure actually begins in western Swampscott and includes part of downtown Lynn, West Lynn, the southeastern portions of Saugus that surround the Saugus River marshes and the Point of Pines neighborhood. Similar to the MA2_B area, many residential and commercial properties would be impacted. Majore traffic routes including routes 1, 1A, 129, 107 and the Nahant Road could be disrupted. Other notable impacts include wastewater treatment facilities, recreational and commercial boating at a couple of different harbors and the General Electric industrial complex.

Reach MA3

The shoreline of Massachusetts Reach 3 (Figure 21) is predominantly urban with a mixture of beaches, rocky shoreline, and small harbor islands. This reach by far is the most developed as Boston, Massachusetts' largest city, is at its center. The reach contains several USACE coastal flood risk management projects and an extensive 1-percent floodplain in certain areas.

One very large exposure area was identified in this reach and is described in this section.



This figure presents the results of the NACCS risk assessment completed at the study area scale. The figure was generated in February 2014 by USACE using the best available data at the time. It may or may not accurately reflect existing or future conditions.

Figure 20. MA2 Reach Risk Areas

MA3_A: Boston and Surrounding Cities

This area of high exposure includes significant portions of several low lying cities including Revere, Chelsea, Everett, Boston, Malden, Medford and Cambridge. Catastrophic storm surge would reach as far north as Malden center, as far west as the Watertown/Waltham city line, and as far south as parts of Dorchester. The area includes many thousands of residential and commercial structures. Boston is the capitol of the state and has a major international airport (Logan), government facilities, commercial centers, public transportation, highways, several major universities and colleges, and a major water treatment facility (Deer Island). Boston and Chelsea have some of the most significant harbor infrastructure in the region; importing and exporting oil, natural gas, shipping containers and bulk commodities. The Charles River and Mystic River dams provide low levels of protection to backshore communities during coastal surge events (< Category 2).

Reach MA4

The shoreline of Massachusetts Reach 4 (Figure 22) is characterized by urban and wetland areas with rocky shoreline to the north and beaches and bluffs to the south. The reach contains one USACE coastal flood risk management project and moderate areas of 1-percent floodplain.

Two exposure areas were identified in this reach and are described in this section.

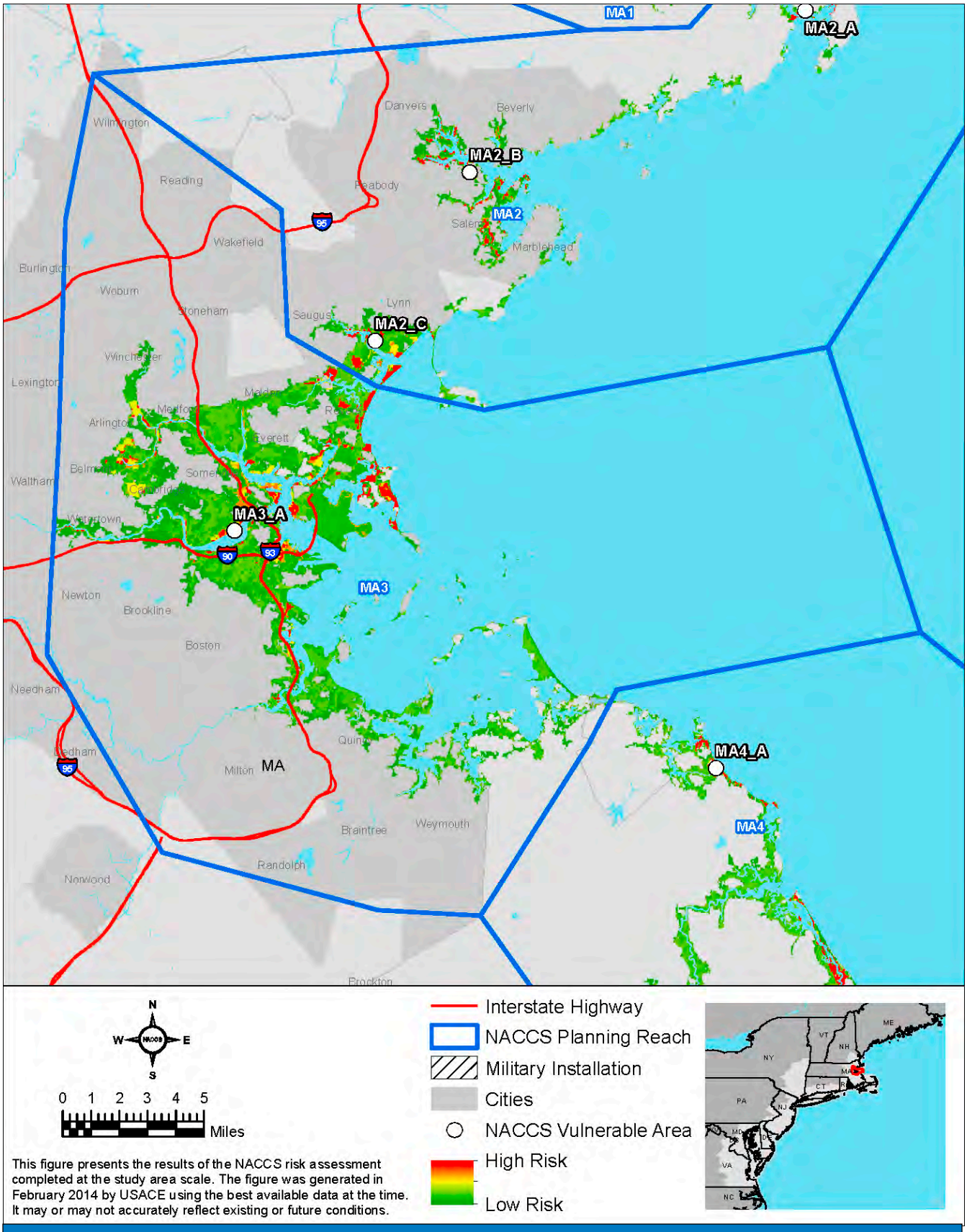


Figure 21. MA3 Reach Risk Areas

MA4_A: Scituate

This area of high exposure stretches from the Minot section of Scituate southeast to Scituate Harbor. It includes several fairly dense, low lying residential (year round and seasonal) areas extending about 1/3 of a mile inland. Included in this area are all of the local roads and utilities. This area has experienced significant coastal storm damage over the years.

MA4_B: Marshfield

This area of high exposure is encompassed by the Cliff Road to the north and Green Harbor to the south and includes all of the residential (year round and seasonal), commercial and municipal property between the shore and salt marsh behind it. This area has experienced significant coastal storm damage over the years.

Reach MA5

The shoreline of Massachusetts Reach 5 (Figure 23) is characterized by beaches, wetlands and some urban settings. The reach contains one coastal flood risk management project and an extensive 1-percent floodplain in many areas, especially across Cape Cod and the islands of Martha's Vineyard and Nantucket.

Four exposure areas were identified in this reach and are described in this section.

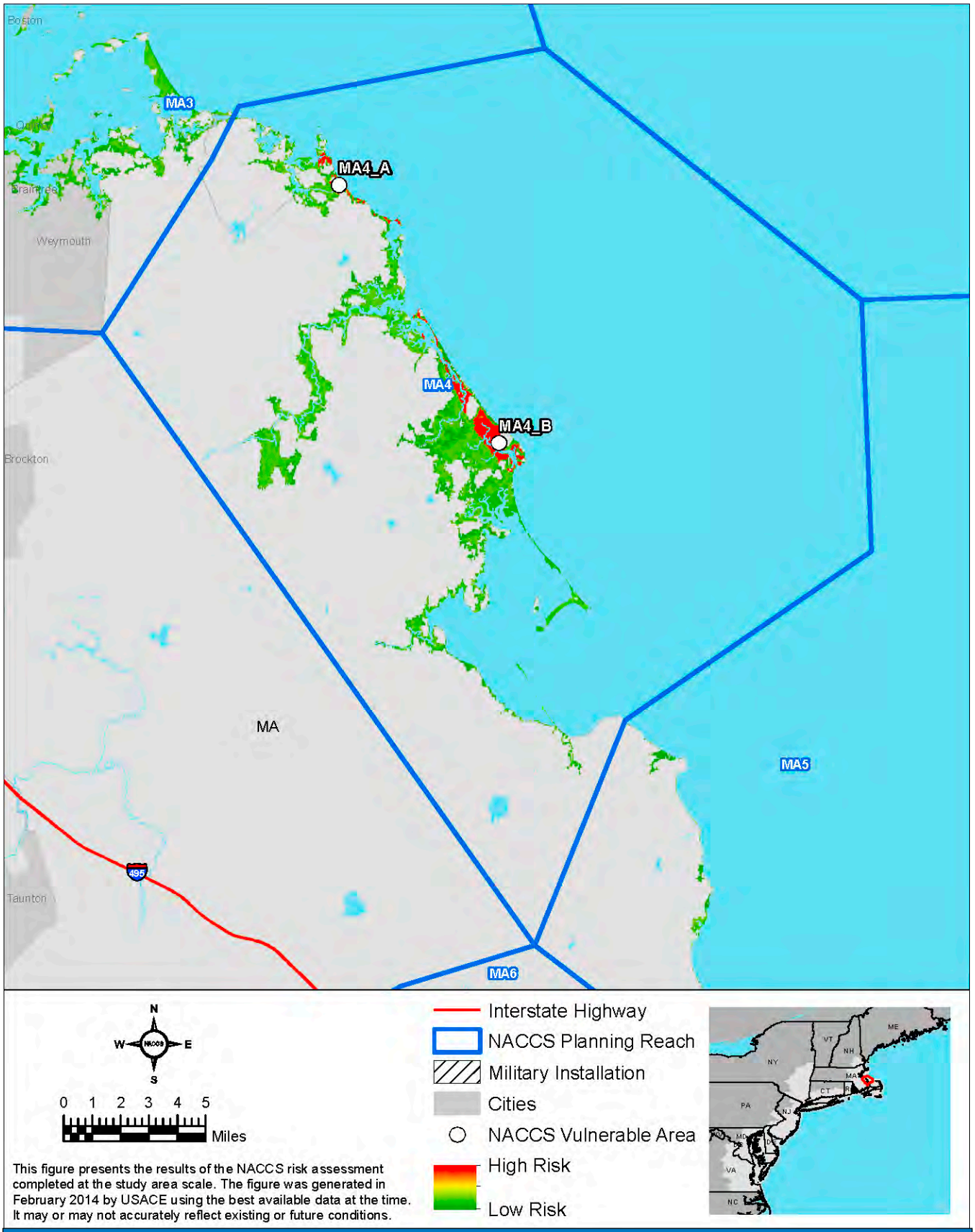


Figure 22. MA4 Reach Risk Areas

MA5_A: Southern Shore of Cape Cod

This area of high exposure extends along the southern shore of Cape Cod from Skinequit Pond in Harwich Port to Salt Pond in Falmouth. The area of catastrophic surge extends inland an average of 2 miles. Thousands of residential (year round and seasonal) properties are in this area. Commercial property is also included in the more developed portions of Harwich, Dennis, Yarmouth, West Yarmouth, Hyannis, Mashpee and Falmouth. Many local roads and Route 28, a major road for the Cape, are in the impact area. Hyannis is the Cape's largest port. Hyannis and Falmouth both provide critical ferry services to the island of Martha's Vineyard and Nantucket. Hyannis also contains the Cape's largest commercial airport. Recreational boating marinas and other related services are prevalent along the south Cape.

MA5_B: Nantucket

This area of high exposure is found on the west side of Nantucket Harbor and includes all of the port infrastructure and the downtown area. It extends nearly ¾ miles from the waterfront. Residential and commercial development in this area is quite dense. This is the only port to the island and is critical to supplying the year-round and seasonal populations.

MA5_C: Vineyard Haven (Martha's Vineyard)

This area of high exposure includes all of the residential, commercial and municipal property surrounding the immediate harbor. It extends about 1/3 mile away from the waterfront. The harbor is one of the ferry service access points to the island and is critical to supplying the island.

MA5_D: Edgartown (Martha's Vineyard)

This exposure area, similar to MA5_C, includes all of the residential, commercial and municipal property surrounding the immediate harbor, primarily on the west side. It extends about ½ mile inland.

Reach MA6

The shoreline of Massachusetts Reach 6 (Figure 24) is classified as a mixture of urban, wetlands, beaches, rocky shoreline and estuaries. The reach is naturally formed by Buzzards Bay. The largest city in the reach is New Bedford. Some of the larger towns include Falmouth, Bourne, Wareham, Marion, Mattapoiset and Fairhaven. The reach contains a couple of USACE coastal flood risk management projects and an extensive 1 percent floodplain in certain areas.

Three exposure areas were identified in this reach and are described in this section.

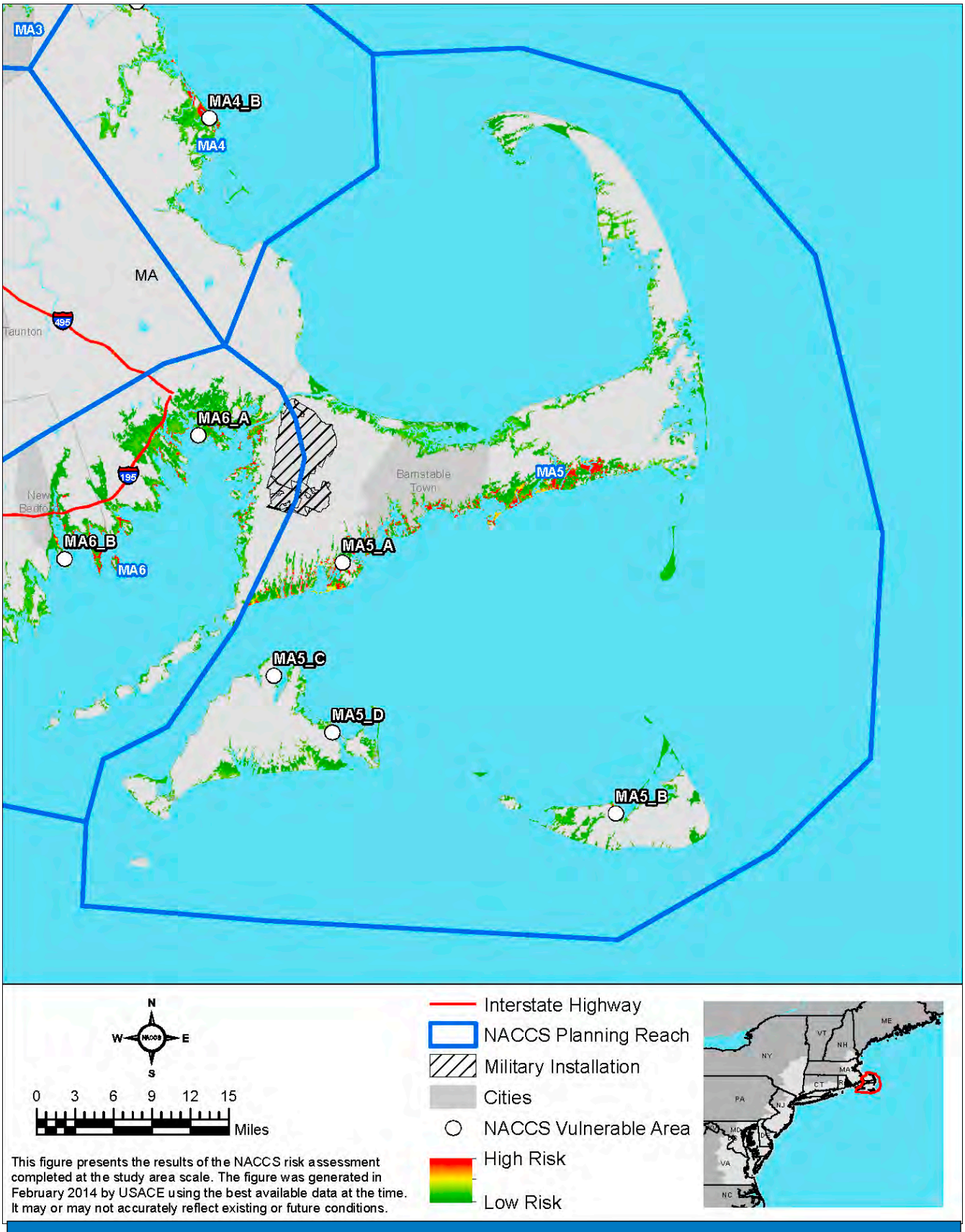


Figure 23. MA5 Reach Risk Areas

MA6_A: Upper Buzzards Bay

This area of high exposure begins in North Falmouth along Buzzards Bay, extends north into Bourne and Wareham, and finishes on the west side of the Bay in Marion. Inundation goes as far north as Route 25 and also impacts other state roads such as Route 28, 6 and Interstate 195. The area includes major areas (thousands of properties) of residential and commercial development, many local roads, the west end of the Cape Cod Canal, water and wastewater treatment facilities, and many marinas. The only train line accessing Cape Cod is also in this problem area.

MA6_B: Mattapoiset – New Bedford

This area of high exposure begins on the north side of Mattapoisett Harbor, extends south through New Bedford and ends in South Dartmouth. It reaches well inland in the low-lying areas north of Mattapoisett center and along the Acushnet River north of New Bedford. The exposure area encompasses much of the City of New Bedford, many residential and commercial properties, municipal and state infrastructure, utilities, commercial port facilities, and wastewater treatment facilities. Major roads impacted include state Route 6 and Interstate 195. New Bedford contains a hurricane barrier constructed and operated by the Corps (< Category 4 protection) and is home to New England's largest fishing fleet.

MA6_C: Westport

This area of high exposure is bound by the Horseneck Beach area to the south and extends north as far as Hixbridge Road in Westport. It includes all of the residential and commercial property adjacent to the East Branch of the Westport River. Several local roads and state Route 88 are in the impact area. Westport Harbor includes a modest fishing fleet and supporting boat yards.

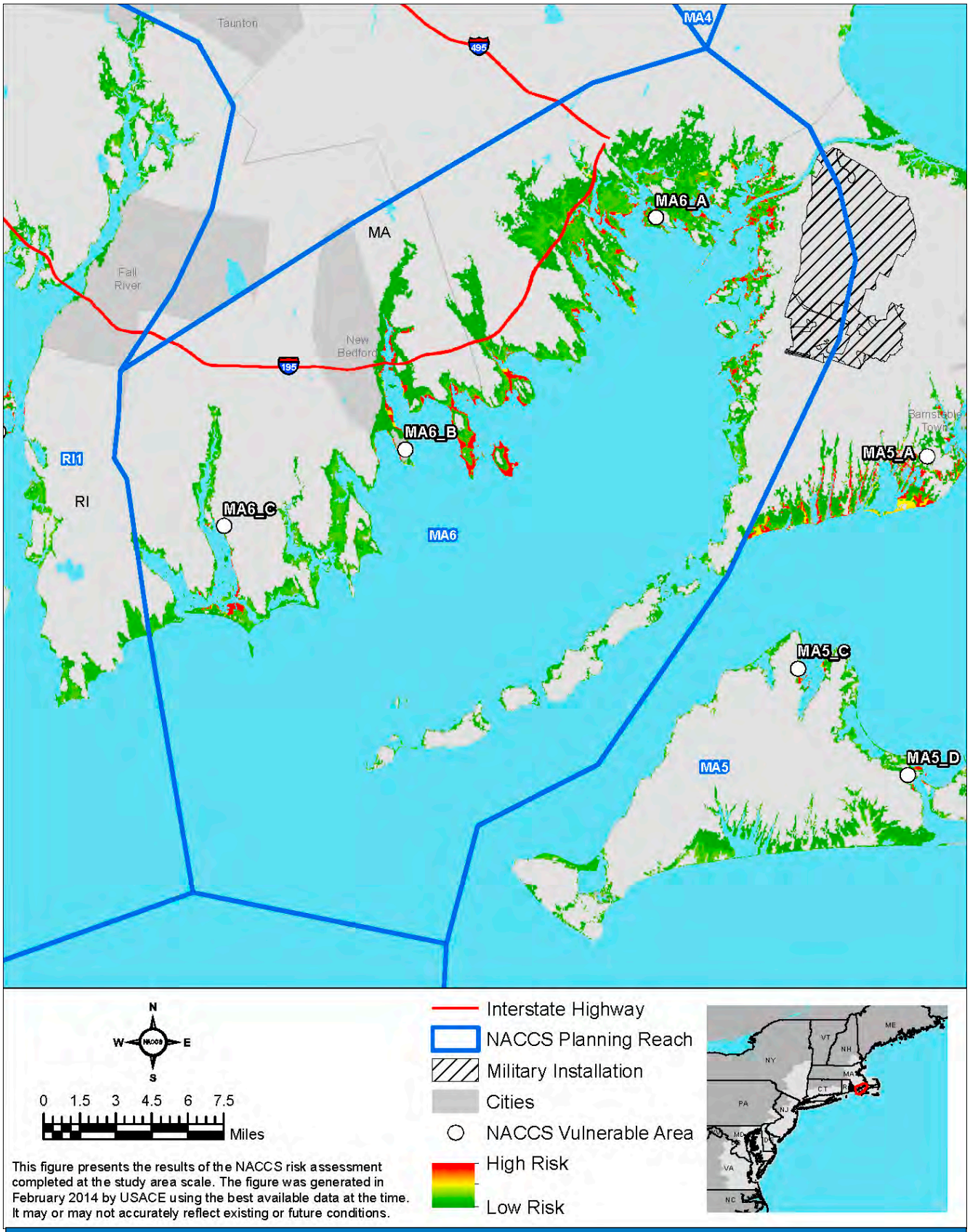


Figure 24. MA6 Reach Risk Areas

V. Coastal Storm Risk Management Strategies and Measures

V.1. Measures and Applicability by Shoreline Type

The structural and NNBF measures were further categorized based on shoreline type for where they are best suited according to typical application opportunities and constraints and best professional judgment (Dronkers et. al., 1990; USACE 2014). Shoreline types were derived from the NOAA Environmental Sensitivity Index Shoreline Classification dataset (NOAA, n.d.). Figure 25 presents the location and extent of each shoreline type in the Commonwealth of Massachusetts. Table 3 summarizes the measures applicability based on shoreline type. It is assumed non-structural measures could be considered in all geographic contexts, subject to further evaluation at a smaller scale.

Additionally, a conceptual analysis of geographic applicability of NNBF was completed, including beach restoration, beach restoration with breakwaters/groins, living shorelines, reefs, submerged aquatic vegetation, and wetlands. The GIS operations that were used for the NNBF screening analysis are described in the Use of Natural and Nature-Based Features for Coastal Resilience Report (Bridges et. al., 2015). In addition to the NOAA Environmental Sensitivity Index Shoreline Classification dataset (NOAA n.d.), other criteria that was considered was habitat type, impervious cover, water quality, and topography/bathymetry. Consistent with the theme of the Framework, further evaluation of the results would be required at a smaller scale and with finer data sets. Figure 26 presents the location and extent of NNBF measures based on additional screening criteria. Additional information associated with the methodology and results of the analysis is presented in the Planning Analyses Appendix. Table 4 displays a summary of shoreline type by length by reach for the Commonwealth of Massachusetts. Figures 27 through 32 display the shoreline type on an individual reach basis.

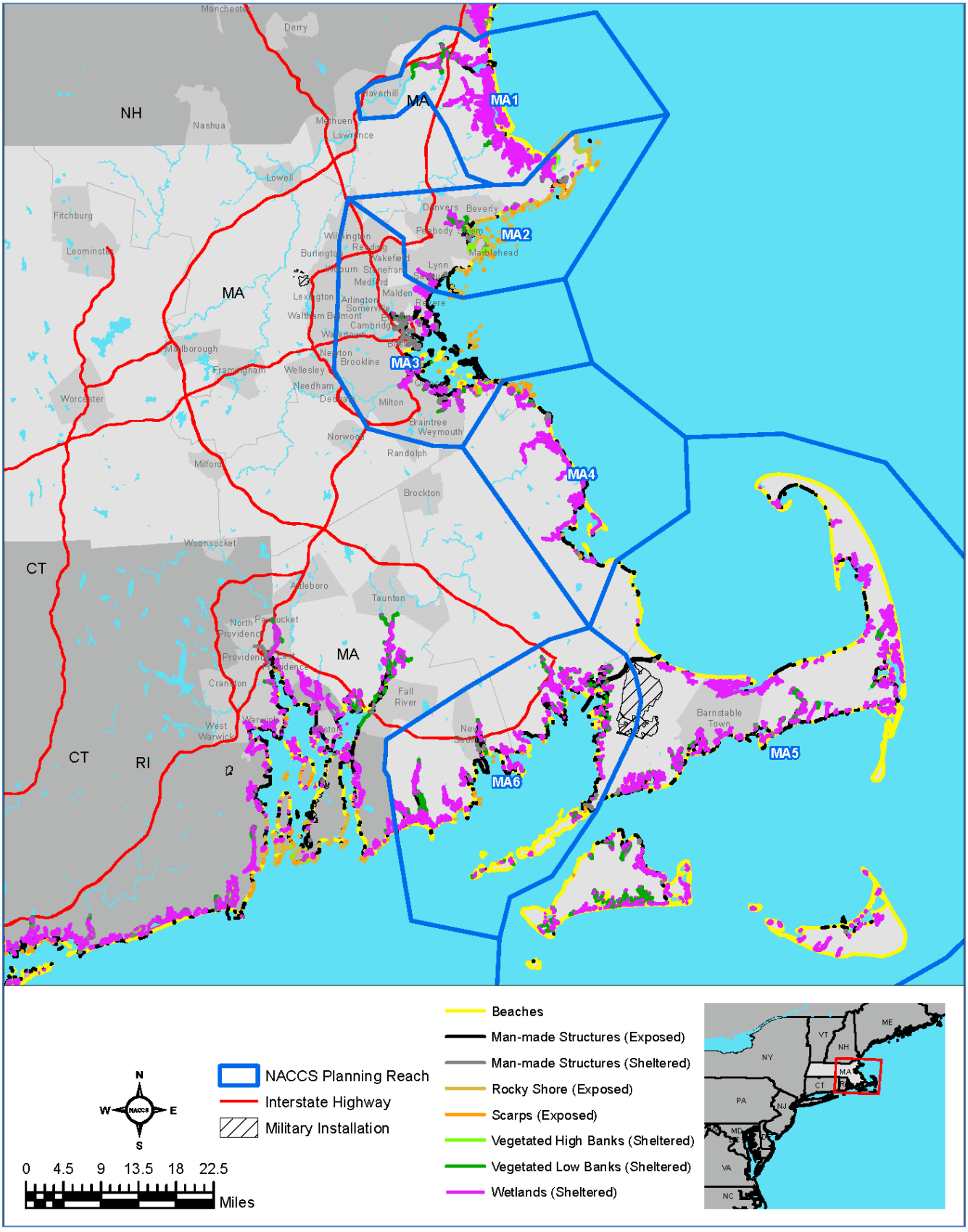


Figure 25. Shoreline Types for the Commonwealth of Massachusetts

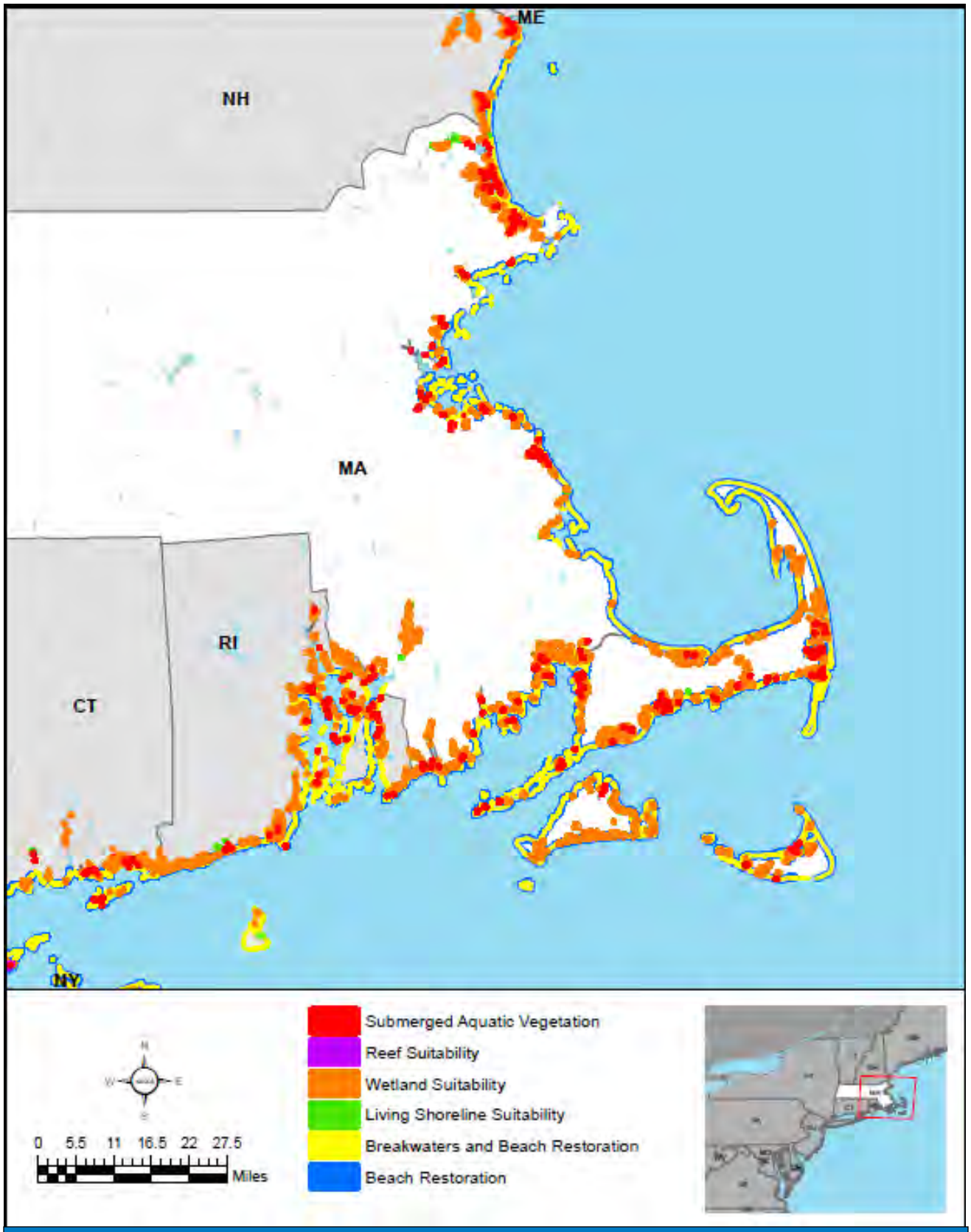


Figure 26. NNBF Measures Screening for the Commonwealth of Massachusetts.

Table 3. Structural and NNBF Measure Applicability by NOAA-ESI Shoreline Type

Measures	Rocky shores (Exposed)	Rocky shores (Sheltered)	Beaches (Exposed)	Manmade structures (Exposed)	Manmade structures (Sheltered)	Scarps (Exposed)	Scarps (Sheltered)	Vegetated low banks (Sheltered)	Wetlands/Marshes/ Swamps (Sheltered)
Structural									
Storm Surge Barrier[1]									
Barrier Island Preservation and Beach Restoration (beach fill, dune creation)[2]			x						
Beach Restoration and Breakwaters[2]			x						
Beach Restoration and Groins[2]			x						
Shoreline Stabilization						x	x	x	
Deployable Floodwalls					x				
Floodwalls and Levees		x			x			x	
Drainage Improvements	x	x	x	x	x	x	x	x	x
Natural and Nature-Based Features									
Living Shoreline						x	x	x	x
Wetlands							x		x
Reefs	x	x				x			x
Submerged Aquatic Vegetation[3]									x
Overwash Fans[4]									
Drainage Improvements	x	x	x	x	x	x	x	x	x

[1] *The applicability of storm surge barriers cannot be determined based on shoreline type. It depends on other factors such as coastal geography.*

[2] *Beaches and dunes are also considered Natural and Nature-Based Features*

[3] *Submerged aquatic vegetation is not associated with any particular shoreline type. Initially assumed to apply to wetland shorelines.*

[4] *Overwash fans may apply to the back side of barrier islands which are not explicitly identified in the NOAA-ESI shoreline database.*

Table 4. Shoreline Types by Length (ft) by Reach

Shoreline Types by Length (ft) by Reach
Sum of Shoreline Length in Feet

Row Labels	Beaches	Manmade Structures (Exposed)	Manmade Structures (Sheltered)	Marshes / Swamps / Wetlands (Sheltered)	Rocky Shore (Exposed)	Scarps (Exposed)	Vegetated High Bank (Sheltered)	Vegetated Low Bank (Sheltered)	Grand Total
MA1	**15,842**	**18,387**		**362,643**	**2,937**			**2,549**	**402,358**
MA1_A	15,842	18,387		362,643	2,937			2,549	402,358
MA2	**9,514**	**72,088**	**23,172**	**93,851**	**6,390**	**1,429**	**7,585**	**41,467**	**255,496**
MA2_A		7,602	6,254	954		478			15,288
MA2_B	6,548	36,909	13,458	31,914	5,265	951	7,585	35,543	138,173
MA2_C	2,966	27,577	3,460	60,983	1,125			5,924	102,035
MA3	**14,867**	**122,760**	**82,119**	**63,098**				**393**	**283,237**
MA3_A	14,867	122,760	82,119	63,098				393	283,237
MA4	**11,051**	**15,577**	**23,480**	**70,633**	**36**	**708**		**4,677**	**126,162**
MA4_A	3,216	10,177	8,680	7,701	36	708		4,677	35,195
MA4_B	7,835	5,400	14,800	62,932					90,967
MA5	**254,414**	**117,663**	**73,938**	**523,480**				**111,575**	**1,081,070**
MA5_A	229,407	110,096	64,557	513,860				110,407	1,028,327
MA5_B	4,490	2,078	2,554	245					9,367
MA5_C	9,074	5,057	2,518	4,900				1,168	22,717
MA5_D	11,443	432	4,309	4,475					20,659
MA6	**174,065**	**234,203**	**24,564**	**368,300**	**2,059**			**130,893**	**934,084**
MA6_A	120,808	135,221	15,504	208,422	1,057			100,812	581,824
MA6_B	43,401	86,629	9,060	85,227	31			7,850	232,198
MA6_C	9,856	12,353		74,651	971			22,231	120,062
Grand Total	**479,753**	**580,678**	**227,273**	**1,482,005**	**11,422**	**2,137**	**7,585**	**291,554**	**3,082,407**

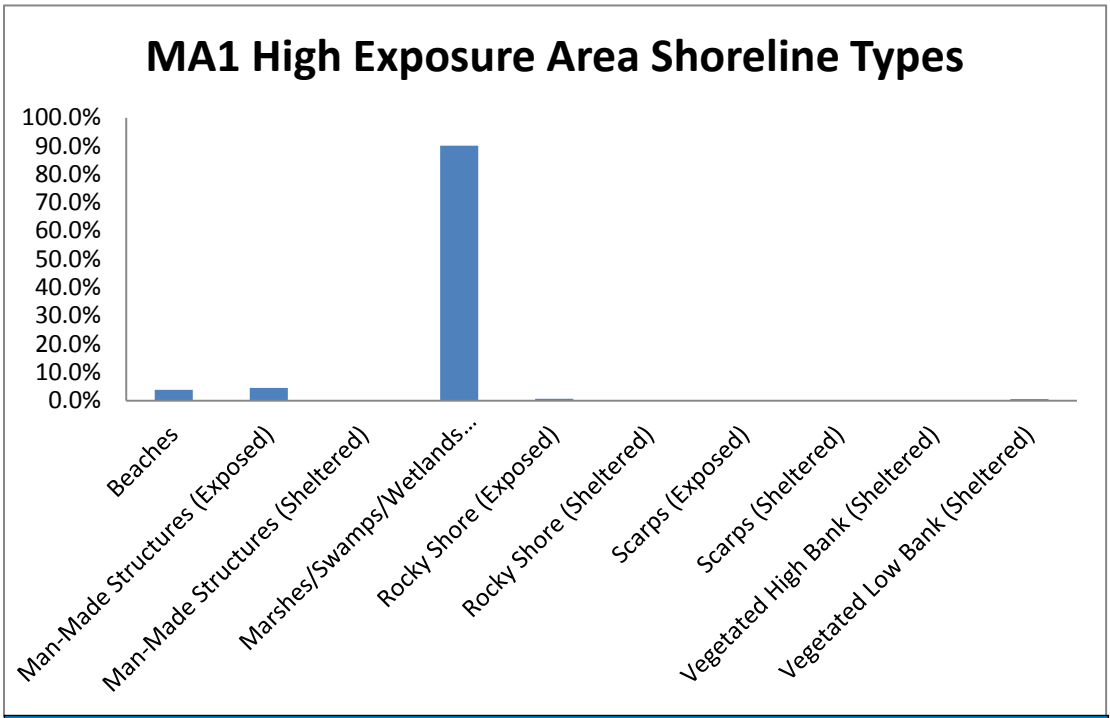


Figure 27. MA1 Shoreline Types

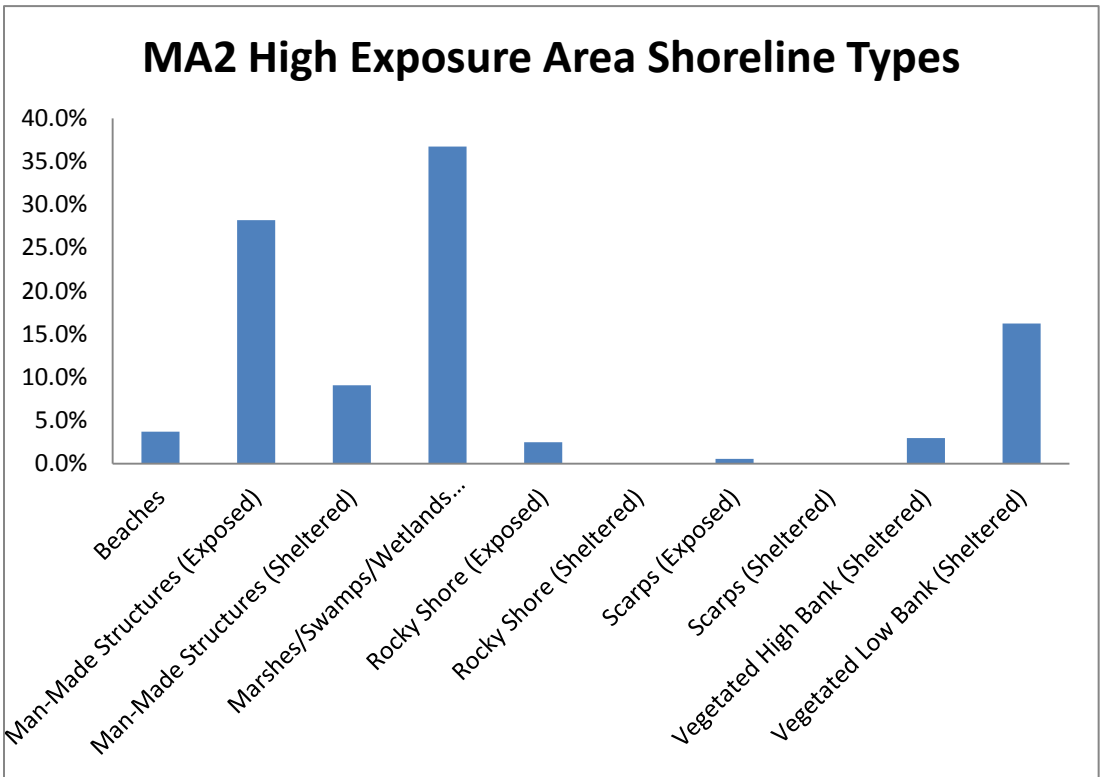


Figure 28. MA2 Shoreline Types

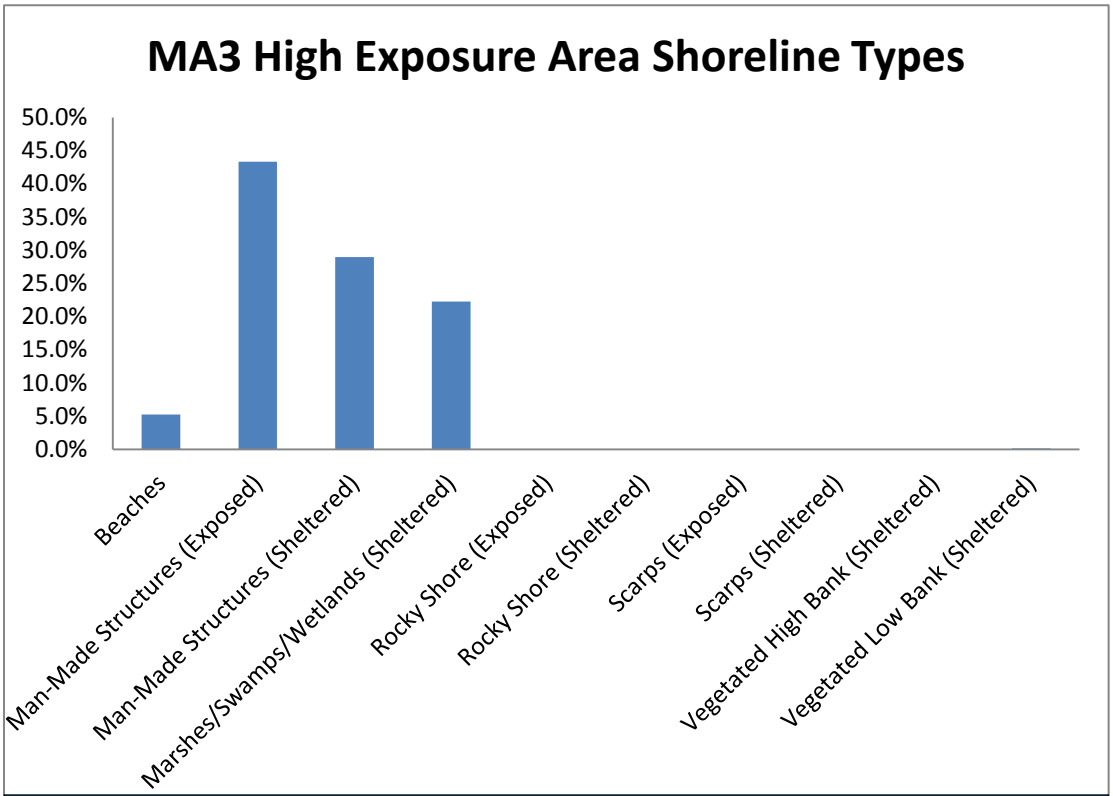


Figure 29. MA3 Shoreline Types

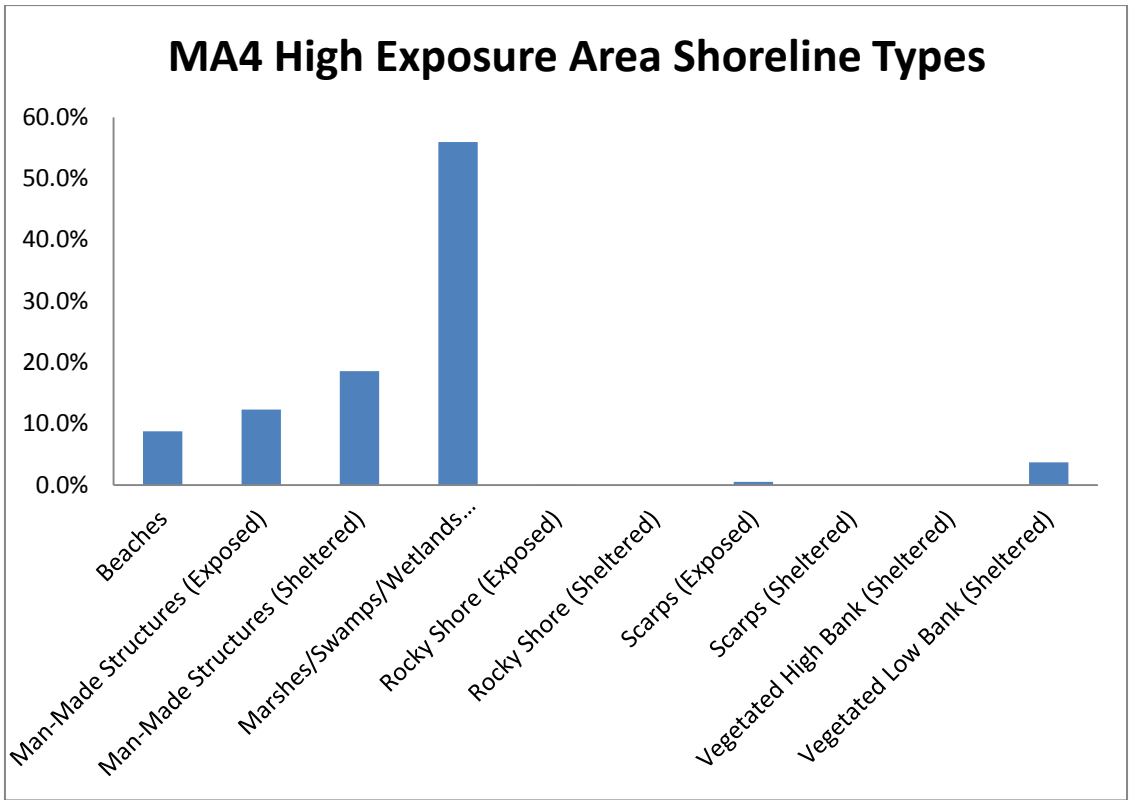


Figure 30. MA4 Shoreline Types

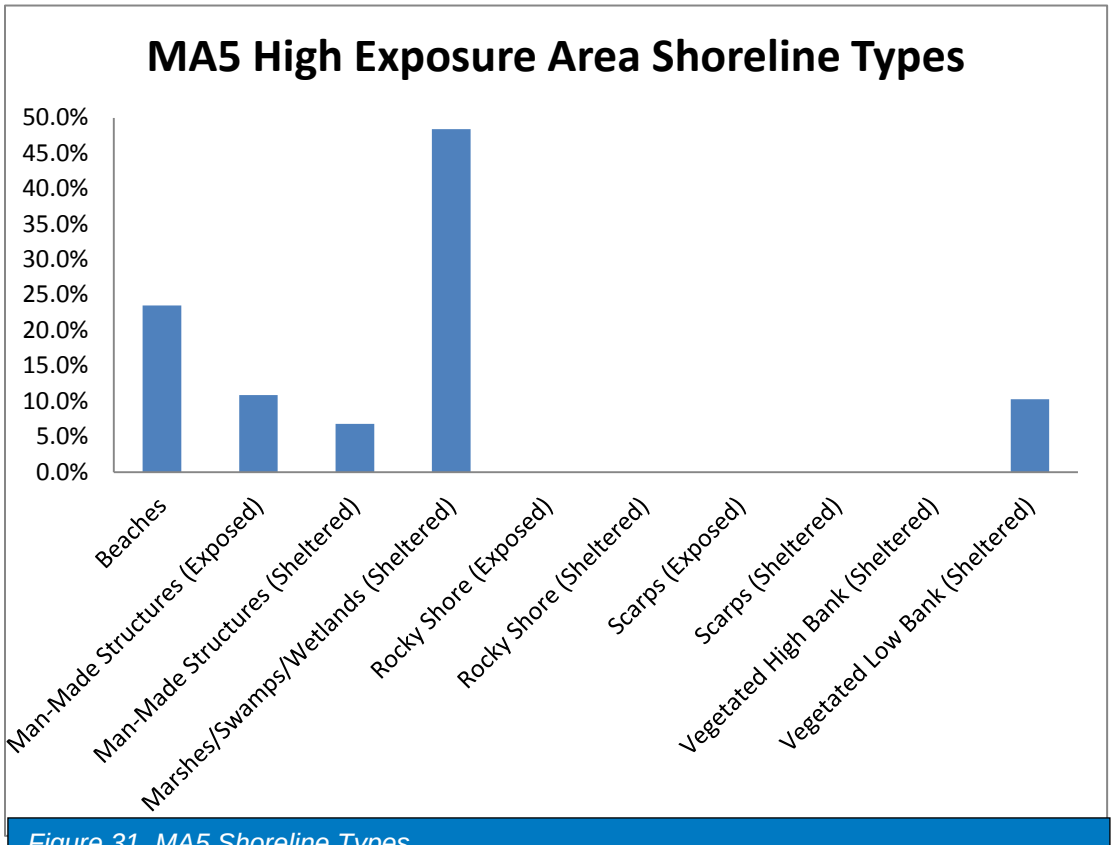


Figure 31. MA5 Shoreline Types

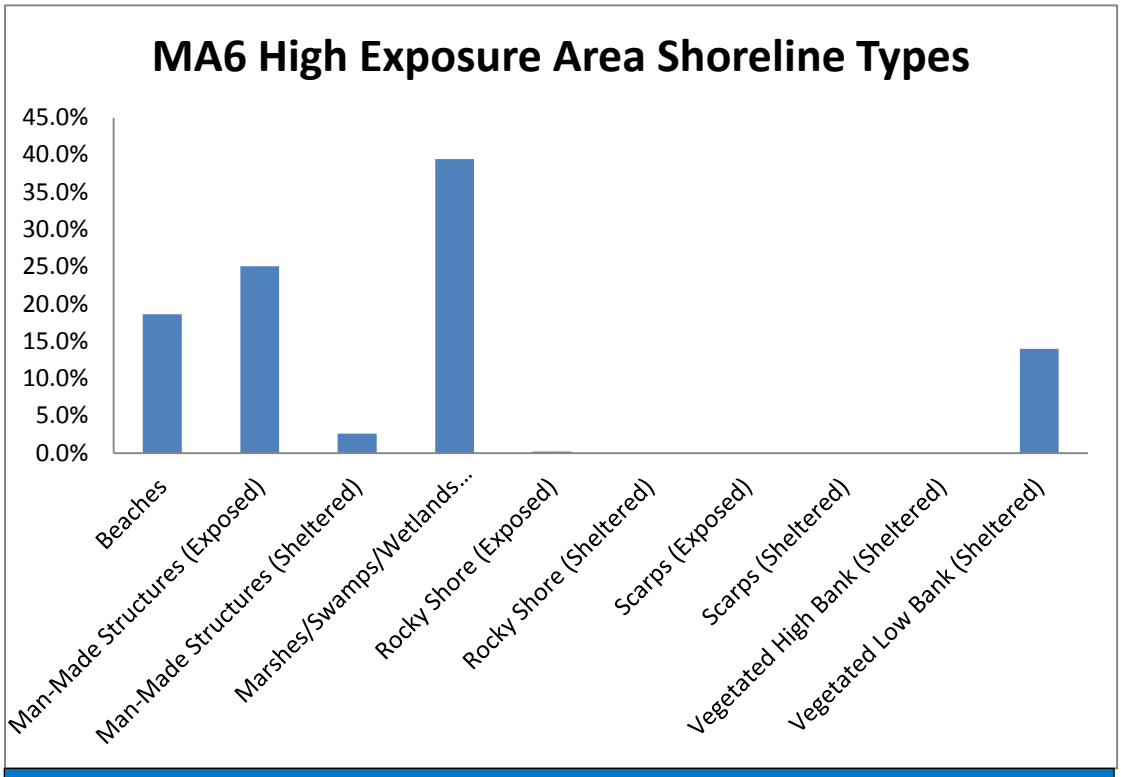


Figure 32. MA6 Shoreline Types

V.2. Cost Considerations

Conceptual design and parametric cost estimates were developed for the various CSRM measures were representative, concept designs were developed for each measure together with quantities and parametric costs (typically per linear foot of shoreline) based on a combination of available cost information for existing projects and representative unit costs for all construction items (e.g., excavation, fill, rock, plantings) based on historical observations. Additional information on the various measures is included in Appendix C – Planning Analyses.

VI. Tier 1 Assessment Results

Table 5 presents the results of the Commonwealth of Massachusetts risk areas and the comparison of management measures. The reference to the level of risk reduction in the table relates to the flooding attribute of the storm damage reduction and resilience storm damage reduction function presented in Table 1 of the overview section. The level of risk reduction (High or Low) is based on a 1 percent chance flood plus three feet (High) or 10 percent chance flood (Low) level. For each shoreline type within the risk area presented in Table 5, the numerical sequence of the measures for each shoreline type within the respective risk area relates to the change in risk and the parametric unit cost estimates for the applicable measures. Nonstructural measures could be considered in all geographic contexts, subject to further evaluation at a smaller scale. As a result, Table 5 only presents the change in risk and the parametric unit cost estimates for structural measures, including NNBF.

Table 5. Comparison of Measures within Massachusetts Risk Areas

Risk Areas	Shoreline	RR	Beach Restoration with Dunes	Beach Restoration with Breakwaters	Beach Restoration with Groins	Shoreline Stabilization	Deployable Floodwall	Floodwall	Levee	Living Shoreline	Wetlands	Reefs	SAV Restoration
MA1_A	Beaches	High	1	3	2								
MA1_A	Rocky Shore (Exposed)	Low										1	
MA1_A	Vegetated Low Banks (Sheltered)	High						2	1				
MA1_A	Vegetated Low Banks (Sheltered)	Low				2				1			
MA1_A	Wetlands (Sheltered)	Low								1	3	4	2
MA2_A	Manmade Structures (Sheltered)	High					3	2	1				
MA2_A	Scarps (Exposed)	Low				2				1			
MA2_A	Wetlands (Sheltered)	Low								1	3	4	2
MA2_B	Beaches	High	1	3	2								
MA2_B	Manmade Structures (Sheltered)	High					3	2	1				
MA2_B	Rocky Shore (Exposed)	Low										1	
MA2_B	Scarps (Exposed)	Low				3				1		2	
MA2_B	Vegetated Low Banks (Sheltered)	High						2	1				
MA2_B	Vegetated Low Banks (Sheltered)	Low				2				1			
MA2_B	Wetlands (Sheltered)	Low								1	3	4	2
MA2_C	Beaches	High	1	3	2								
MA2_C	Manmade Structures (Sheltered)	High					3	2	1				
MA2_C	Rocky Shore (Exposed)	Low										1	
MA2_C	Vegetated Low Banks (Sheltered)	High						2	1				

Risk Areas	Shoreline	RR	Beach Restoration with Dunes	Beach Restoration with Breakwaters	Beach Restoration with Groins	Shoreline Stabilization	Deployable Floodwall	Floodwall	Levee	Living Shoreline	Wetlands	Reefs	SAV Restoration
MA2_C	Vegetated Low Banks (Sheltered)	Low				2				1			
MA2_C	Wetlands (Sheltered)	Low								1	3	4	2
MA3_A	Beaches	High	1	3	2								
MA3_A	Manmade Structures (Sheltered)	High					3	2	1				
MA3_A	Vegetated Low Banks (Sheltered)	High						2	1				
MA3_A	Vegetated Low Banks (Sheltered)	Low				2				1			
MA3_A	Wetlands (Sheltered)	Low								1	3	4	2
MA4_A	Beaches	High	1	3	2								
MA4_A	Manmade Structures (Sheltered)	High					3	2	1				
MA4_A	Rocky Shore (Exposed)	Low										1	
MA4_A	Scarps (Exposed)	Low				3				1		2	
MA4_A	Vegetated Low Banks (Sheltered)	High						2	1				
MA4_A	Vegetated Low Banks (Sheltered)	Low				2				1			
MA4_A	Wetlands (Sheltered)	Low								1	3	4	2
MA4_B	Beaches	High	1	3	2								
MA4_B	Manmade Structures (Sheltered)	High					3	2	1				
MA4_B	Wetlands (Sheltered)	Low								1	3	4	2
MA5_A	Beaches	High	1	3	2								
MA5_A	Manmade Structures (Sheltered)	High					3	2	1				

Risk Areas	Shoreline	RR	Beach Restoration with Dunes	Beach Restoration with Breakwaters	Beach Restoration with Groins	Shoreline Stabilization	Deployable Floodwall	Floodwall	Levee	Living Shoreline	Wetlands	Reefs	SAV Restoration
MA5_A	Vegetated Low Banks (Sheltered)	High						2	1				
MA5_A	Vegetated Low Banks (Sheltered)	Low				2				1			
MA5_A	Wetlands (Sheltered)	Low								1	3	4	2
MA5_B	Beaches	High	1	3	2								
MA5_B	Manmade Structures (Sheltered)	High					3	2	1				
MA5_B	Wetlands (Sheltered)	Low								1	3	4	2
MA5_C	Beaches	High	1	3	2								
MA5_C	Manmade Structures (Sheltered)	High					3	2	1				
MA5_C	Vegetated Low Banks (Sheltered)	High						2	1				
MA5_C	Vegetated Low Banks (Sheltered)	Low				2				1			
MA5_C	Wetlands (Sheltered)	Low								1	3	4	2
MA5_D	Beaches	High	1	3	2								
MA5_D	Manmade Structures (Sheltered)	High					3	2	1				
MA5_D	Wetlands (Sheltered)	Low								1	3	4	2
MA6_A	Beaches	High	1	3	2								
MA6_A	Manmade Structures (Sheltered)	High					3	2	1				
MA6_A	Rocky Shore (Exposed)	Low										1	
MA6_A	Vegetated Low Banks (Sheltered)	High						2	1				
MA6_A	Vegetated Low Banks (Sheltered)	Low				2				1			
MA6_A	Wetlands (Sheltered)	Low								1	3	4	2
MA6_B	Beaches	High	1	3	2								

Risk Areas	Shoreline	RR	Beach Restoration with Dunes	Beach Restoration with Breakwaters	Beach Restoration with Groins	Shoreline Stabilization	Deployable Floodwall	Floodwall	Levee	Living Shoreline	Wetlands	Reefs	SAV Restoration
MA6_B	Manmade Structures (Sheltered)	High					3	2	1				
MA6_B	Rocky Shore (Exposed)	Low										1	
MA6_B	Vegetated Low Banks (Sheltered)	High						2	1				
MA6_B	Vegetated Low Banks (Sheltered)	Low				2				1			
MA6_B	Wetlands (Sheltered)	Low								1	3	4	2
MA6_C	Beaches	High	1	3	2								
MA6_C	Rocky Shore (Exposed)	Low										1	
MA6_C	Vegetated Low Banks (Sheltered)	High						2	1				
MA6_C	Vegetated Low Banks (Sheltered)	Low				2				1			
MA6_C	Wetlands (Sheltered)	Low								1	3	4	2

VII. Tier 2 Assessment of Conceptual Measures

As part of the NACCS Tier 2 analysis for the Commonwealth of Massachusetts and in coordination with the Massachusetts CZM, the Merrimack River estuary complex was selected as an example area to further evaluate flood risk as part of the CSRM Framework. Defined as Area MA1_A, the area includes the inundated shoreline of the towns of Salisbury, Newburyport and Newbury. The example area represents an area within the Commonwealth of Massachusetts at risk to coastal flooding. This area was selected for additional analysis due to increased coastal erosion issues and the overall need for enhanced coastal resilience to surrounding communities due to significantly developed waterfront areas.

As demonstrated in Table 6, this area of high risk was subdivided into eight subregions. Each subregion offers a unique set of CSRM measures which may act as an example for similar geomorphic settings in the Commonwealth of Massachusetts by state and local agencies, and non-profit organizations.

Table 6. Tier 2 Example Area Relative Cost/Management Measure Matrix for the Commonwealth of Massachusetts

Subregion Strategy MA1_A

Risk Management Strategies (MA)

					Preserve		***Accommodate***			***Avoid***	
	Existing Coastal Flood Risk Management Projects				Structural Measures (100yr + 3')	Regional/ Gates (500-yr)	NNBF (10-year)	Non-Structural (10-year)		Acquisition (10-year floodplain)	
Revised Polygon	Description	Existing Project - 2018 Post Sandy	Estimated LOP	Description	Cost Index	Description	Description	Description	Cost Index	Description	Cost Index
MA1_A_1	N/A	None	N/A	No. Very little property subject to flooding.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MA1_A_2	N/A	None	N/A	No property subject to flooding.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MA1_A_3	N/A	None	N/A	No. Developed property too spread out.	N/A	N/A	N/A	Floodproofing	N/A	Acquisition and Relocation	N/A
MA1_A_4	N/A	None	N/A	No. Developed property too spread out.	N/A	N/A	N/A	Floodproofing	0.36	Acquisition and Relocation	1.00
MA1_A_5	N/A	None	N/A	Beach fill/dune project along shore.	0.56	N/A	N/A	Floodproofing	0.31	Acquisition and Relocation	1.00
MA1_A_6	N/A	None	N/A	Seawall or bulkhead extensions along developed portions	1.00	N/A	N/A	Floodproofing	N/A	Acquisition and Relocation	N/A

				of river bank.							
MA1_A_7	N/A	None	N/A	No. Developed property too spread out.	N/A	N/A	N/A	Floodproofing	N/A	Acquisition and Relocation	N/A
MA1_A_8	N/A	None	N/A	Beach fill/dune project along shore.	1.00	N/A	N/A	Floodproofing	0.04	Acquisition and Relocation	0.09

Table 6 presents the results of the Tier 2 analysis. The Tier 2 analysis evaluates the relative costs associated with management measures included in the three primary avoid, accommodate and preserve strategies for CSRM for this particular area. For each of the areas identified, management measures were selected based on knowledge of the area and available data and analyses including shoreline type, topography, extent of development from aerial photography, sea level change inundation, extreme water levels, flood inundation mapping. Other information considered in the identification of measures includes existing CSRM projects, conceptual costs and the change in vulnerability associated with a combination of measures.

The risk reduction associated with the management measures corresponds to the qualitative evaluation of measures presented in Table 3, such as high for a 1-percent-annual-chance flood plus three feet and low for a 10-percent-annual-chance flood. The cost index was derived from parametric unit cost estimates divided by the highest parametric unit cost of all the management measure in the area. The higher the cost index the greater the relative costs. This enables the users to compare the measures associated with the risk management strategy in order to evaluate affordability and ultimately leading to an acceptable level of risk tolerance. The combination of measures leading to a selection of a plan as described in the NACCS Framework would further quantify risk reduction, and evaluate and compare the change in the risk based on the total cost of the plan. This would be completed at a smaller scale, Tier 3, which would be able to incorporate refined exposure and vulnerability, and evaluation of other risk management measures, as well as refined costs.

VIII. Focus Area Analysis Summary

No focus area analyses were prepared for Massachusetts.

IX. Agency Coordination and Collaboration

IX.1. Coordination

As part of PL 113-2, Federal agencies received appropriations for various purposes within the agencies' mission areas in response to Hurricane Sandy. As part of the NACCS authorizing language, the NACCS was conducted in coordination with other Federal agencies, and state, local, and tribal officials to ensure consistency with other plans to be developed, as appropriate. Extensive collaboration occurred as part of the NACCS, which is presented in the Agency Coordination and Collaboration Report.

Interagency points of contact and subject matter experts were asked in early 2013 to assist in preparing the scope for the NACCS and to be engaged in data gathering and development of analyses as part of the NACCS. This coordination complements the NACCS website located at http://www.nad.usace.army.mil/CompStudy.aspx and webinars for several coastal resilience topics.

The New England District requested feedback with respect to the preliminary problem identification and exposure mapping in a letter dated September 4, 2013. In a letter dated October 21, 2013 Massachusetts CZM provided a list of highly vulnerable areas for each sub-reach along the coast.

In response to further inquiries in April 2014 regarding problems and opportunities they are facing, the Massachusetts CZM responded by letter (May 15, 2014). Specifically, they stated that coastal erosion is due to reduced sediment supply due to armoring and depleted sediment sources. This can be addressed by beneficially using dredged sand from navigation projects and disposing it on nearby beaches and dunes. They also stated that Massachusetts shores are composed of a mix of sand, gravel, and cobble and that there is very little guidance available regarding the design of nourishment shore protection projects with mixed sediments. It would be helpful to several communities if the Corps could provide technical assistance in this area.

The Commonwealth of Massachusetts was the only New England state to provide additional plans or strategies for future coastal storm damage reduction. On January 10, 2013, the governor signed into law a bill that would make it easier to repair or remove unsafe dams and coastal infrastructure by providing funding and enhanced reporting and enforcement authority, An Act Further Regulating Dam Safety, Repair and Removal (H.4557). The law creates a loan and grant program, titled the "The Dam and Seawall Repair and Removal Fund", the will facilitate the repair or removal of unneeded dams and help finance repairs to structures aimed at controlling coastal flooding. The implementation guidance for this new program can be found at http://www.mass.gov/eea/air-water-climate-change/preserving-water-resources/water-laws-and-policies/water-laws/draft-regs-re-dam-and-sea-wall-repair-or-removal-fund.html. The expectation is that many of these projects will result in improved coastal structures that address storm damage while also improving natural resources and addressing the hazards of climate change impacts.

IX.2. Related Activities, Projects and Grants

Specific Federal, state and Non-Governmental Organization efforts that have been prepared in response to PL 113-2 are discussed below specifically for the Commonwealth of Massachusetts. Additional information regarding Federal, state and Non-Governmental Organization projects and plans applicable to all of the states in the NACCS Study Area are discussed in "Appendix D: State and District of Columbia Analyses", while additional information regarding the alignment of interagency plans and strategies is discussed in the Agency Collaboration and Coordination Report.

Federal Efforts

The Department of the Interior received $360 million in appropriations for mitigation actions to restore and rebuild national parks, national wildlife refuges, and other Federal public assets through resilient coastal habitat and infrastructure. In August 2013, the Department of the Interior (DOI) announced that USFWS and the National Fish and Wildlife Foundation (NFWF) would assist in administering the Hurricane Sandy Coastal Resiliency Competitive Grant Program which will support projects that reduce communities' vulnerability to the growing risks from coastal storms, SLC, flooding, erosion and associated threats through strengthening natural ecosystems that also benefit fish and wildlife (NFWF, 2013). The Hurricane Sandy Coastal Resiliency Competitive Grants Program will provide approximately $100 million in grants for 46 proposals to those states that were affected by Hurricane Sandy. States affected is defined as those states with disaster declarations as a result of the storm event. The grants range from $100,000 to $5 million and requests for proposal were due by January 31, 2014. More information on the program can be found at www.nfwf.org/HurricaneSandy, and the full list of projects can be found at http://www.nfwf.org/hurricanesandy/Documents/doi-projects.pdf. Table 7 presents the list of specific Federal projects and plans proposed for the Commonwealth of Massachusetts that have

been identified to date. Figure 33 presents proposed projects (including DOI grant projects that were not selected to receive grant funding because those that were not selected to receive grant funding represent an opportunity to potentially receive funding in the future) and other ongoing Federal actions using PL 113-2 funding.

Table 7. Post-Sandy Funded Federal Projects and Plans in Massachusetts

Agency	State	Proposal	Cost
USFWS/DOI	MA	Whittenton and West Britannia Dam Removals; Mill River, Taunton	$650,000
USFWS/DOI	MA	Round Hill Salt Marsh Restoration Project; Dartmouth, MA	$2,277,000
USFWS/DOI	MA	Muddy Creek Wetland Restoration Project; Chatham, MA	$3,762,000
USFWS/DOI	MA	Parker River Restoration Project	$3,718,000
USFWS/DOI	MA	Restoring resilience to the Great Marsh; Parker River NWR, MA	$340,000
USFWS/DOI	RI/MA/NH/ME	Protecting Property and Helping Coastal Wildlife: Enhancing Salt marsh and Estuarine Function and Resiliency for Key Habitats on Impacted Wildlife Refuges from Rhode Island to southern Maine	$4,150,000
DOI/NFWF	MA	Restore and enhance Great Marsh's wetlands and dunes. Local municipalities' vulnerability will be reduced through restoration projects, assessments, and coastal resilience plans.	$2,940,000
DOI/NFWF/MA DF&G	MA	Remove ten high risk fish barriers that cause flood damage within nine Massachusetts communities. Project will increase flood resilience, open 189 river miles for fish, and restore 90 acres of wetlands. Project will also identify, and develop concept plans for, ten additional high priority barriers.	$4,500,000
DOI/NFWF/Wampanoag Tribe	MA	Assess and restore over 230 acres of tribal habitat in Martha's Vineyard, Massachusetts. Management plans and multi-jurisdictional partnerships will support marine protection and habitat restoration.	$670,000
DOI/NFWF/DMF	MA	Reuse one million cubic yards of rock to create a protected Boston Harbor shoreline in Massachusetts. Project will reduce wave energy, protect transplanted eelgrass, and repurpose dredged rock.	$240,000

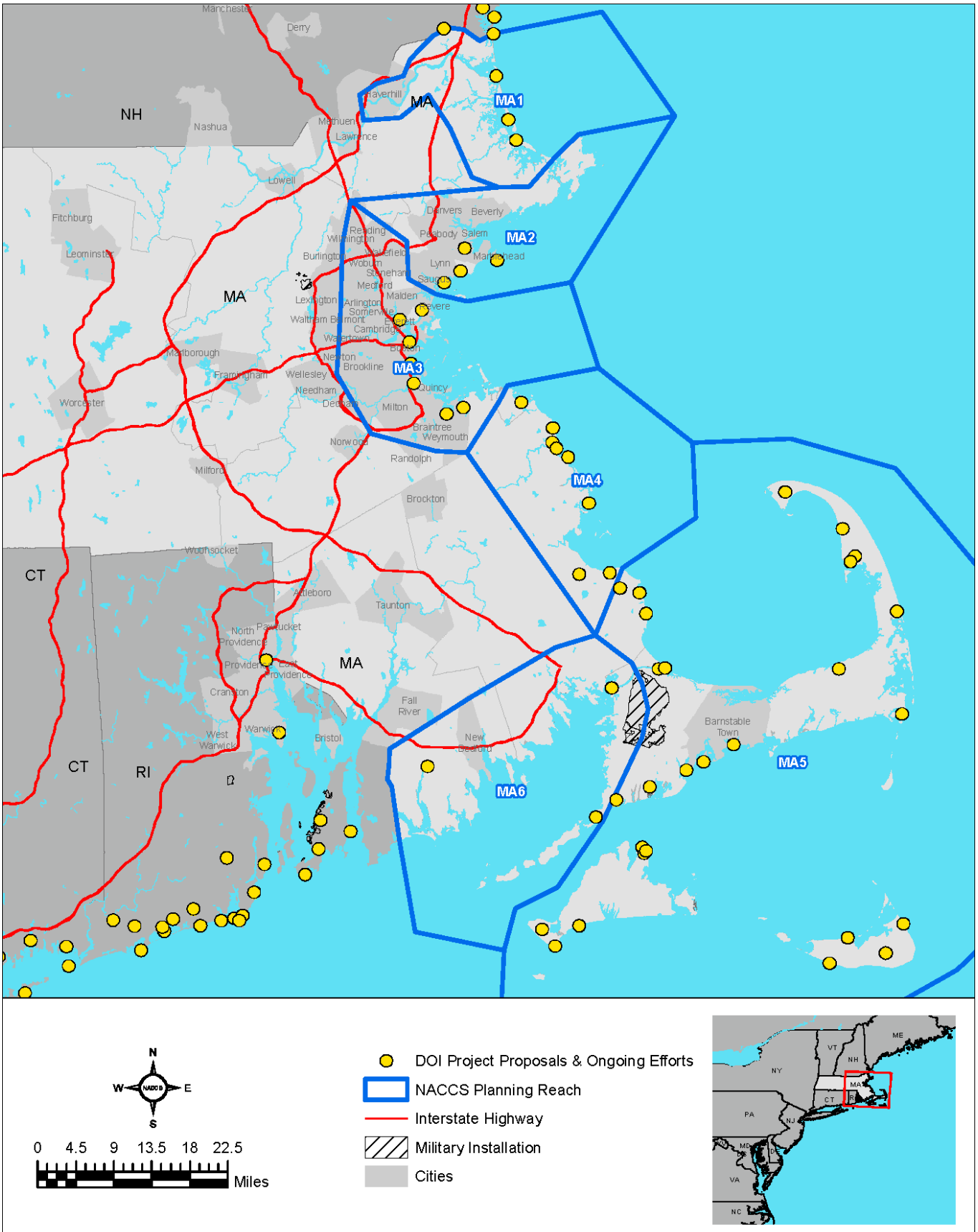


Figure 33. Department of the Interior Projects for the Commonwealth of Massachusetts

Other grant opportunities included in the Hurricane Sandy Coastal Resiliency Competitive Grants Program include other topographic surveys, storm tide monitoring, and other tools to assess habitat and opportunities to increase resilience along the North Atlantic Coast.

The USACE is working with several partners including NOAA, FEMA, The Nature Conservancy, The Conservation Fund and academic institutions such as University of Rhode Island, Virginia Institute of Marine Sciences and the University of New Orleans to institute the Systems Approach to Geomorphic Engineering (SAGE) Program. The goals of this program are to pursue and advance a large-scale comprehensive view of coastal landscape change and use integrated methods for coastal landscape transformation to slow/prevent/minimize mitigate impacts to coastal communities and shorelines through an innovative approach to coastal landscape resilience. The next steps for the SAGE Program are to establish regional communities of practice within each of the demonstration pilots, identify areas of need within the demo sites, and determine potential solutions for the areas of need within each of the demo sites.

NOAA is working to complete various data collections activities as part of the PL 113-2 funding allocations within the National Ocean Service, National Marine Fisheries Service, and the National Weather Service, including mapping, modeling resilience, and technical assistance (NOAA, 2013). Mapping activities include aerial photogrammetry surveys, hydrographic surveys, integrated ocean and coastal mapping LIDAR (in coordination with USGS and USACE), and fisheries survey. The National Weather Service also received funds to improve numerical hurricane forecast systems. Additionally, NOAA's Coastal Impact Assistance Program can provide tools and information to support recovery and planning efforts at regional, state, and community levels. More information on the ongoing work can be found at http://oceanservice.noaa.gov/hazards/sandy/.

As part of the Natural Resources Conservation Service Emergency Watershed Protection Program, the U.S. Department of Agriculture has acquired floodplain easements for approximately 750 acres in Connecticut (Old Field Creek, West Haven), New York (New Creek/West Branch, Staten Island), and New Jersey (Bay Point). The cost was approximately $19.2 million. The easement are intended to assist victims of Hurricane Sandy and also prevent future damages in flood prone areas. Additionally, not only do the easements reduce future exposure, the floodplain easements represent habitat conservation opportunities as part of natural features for floodplain storage and wave attenuation. Additional information on the easements can be found at
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1240996.pdf.

FEMA distributes public assistance funding to states and counties within various categories, including debris removal, protective measures, public buildings, public utilities, recreational, roads and bridges, state management, and water control facilities. Detailed distribution of funding within each category can be found here
http://www.recovery.gov/Sandy/whereisthemoneygoing/Pages/DisasterReliefPrograms.aspx.

The U.S. Department of Housing and Urban Development has allocated approximately $12 billion for recovery actions to rebuild areas affected by Hurricane Sandy through the Community Development Block Grant Program (CDBG). To be eligible to receive funds, each grantee must conduct a comprehensive risk assessment to address climate change impacts, changes in development patterns and population, and incorporate resilience performance standards identified in the Hurricane Sandy Rebuilding Strategy. More information can be found at

http://portal.hud.gov/hudportal/HUD?src=/sandyrebuilding. In Massachusetts, no CDBG funds were made available.

Region 1 of the EPA has developed a compilation of studies and projects that they and the New England states believe will advance emergency preparedness and resilience. The initiative is called the Region 1 Resiliency Portfolio "Advancing Resilient Communities and Water Infrastructure". Projects aimed at advancing resilience will result in long-term benefits, including reduction in emergency wastewater bypasses and boil water orders, less reliance on energy grids, and economic savings and public health benefits from expedited cleanups.

In addition to the Hurricane Sandy Rebuilding Task Force discussed in the Overview section of this State Appendix, the U.S. Housing and Urban Development (HUD) has allocated approximately $1 billion for recovery actions including Rebuild by Design to rebuild areas affected by Hurricane Sandy through the Community Development Block Grant Program (CDBG). The purpose of the Rebuild by Design initiative is to consider innovative and implementable solutions to address risk of future climate events. By creating a competition, the effort brings together experts from various fields to develop opportunities for resilience and innovation as part of the rebuilding process in areas with extensive impacts from Hurricane Sandy in Connecticut, New Jersey, and New York. Three geographical categories were identified: City, Shore, and Region. Ten projects were selected by HUD Secretary Shaun Donovan to proceed into a design phase. Final designs were shared with Federal and public stakeholders in April 2014. The winning design solutions will be selected by HUD in mid-2014. These solutions may be implemented with disaster recovery grants from HUD in addition to other sources of public and private sector funding. More information on the initiative and the various designs that were submitted for consideration for the competition are available at http://www.rebuildbydesign.org/.

Structures of Coastal Resilience (SCR) is a Rockefeller Foundation-supported project dedicated to studying and proposing resilient designs for urban coastal environments in the North Atlantic region. Four design teams from Princeton, Harvard, the City College of New York, and University of Pennsylvania are developing both general strategies and features for coastal protection and site specific design in the study regions: Narragansett Bay RI, Jamaica Bay NY, Atlantic City NJ, and Norfolk VA.

On February 4, 2013, the Federal Transit Administration (FTA) announced the availability of $2 billion in emergency aid funds to transit agencies affected by Hurricane Sandy, through its new Emergency Relief Program. The projects are being implemented with resilient features so that the infrastructure will not need to be replaced when the next storm occurs.

IX.3. Sources of Information

A review of Federal, state, municipal, and academic literature was conducted and various reports covering topics related to coastal resilience and risk reduction in Massachusetts were considered in the development of this state narrative and are listed in Table 8.

Table 8. Federal and Commonwealth of Massachusetts Sources of Information

Resource	Source/Reference	Subject	Key Findings Synopsis
MA Coastal Zone Management Policy Guide	http://www.mass.gov/czm/plan/czm_policy_guide.htm	CZM Policy	The Policy Guide provides the official program policies as administered by the Massachusetts CZM and includes information on the Federal Coastal Zone Management Act, the history and operation of the Massachusetts coastal program, federal consistency review, and the application of coastal policy in other state regulatory programs.
MA Hazard Mitigation Plan	http://www.mass.gov/dcr/stewardship/mitigate/plan.htm	Hazard Mitigation	The Massachusetts State Hazard Mitigation Plan provides both short-term and long-term strategies for implementing hazard mitigation measures by state agencies as well as local municipalities throughout the Commonwealth of Massachusetts. This plan accomplishes this by identifying actions that will lower the risks and lower the costs of natural hazards.
MA Storm Smart Coasts	http://www.mass.gov/czm/stormsmart/index.htm	Risk Reduction Measures	Suggested activities that communities can take to break the cycle of damage, rebuilding, and repeated damage.
US Census Bureau Quick Facts	http://quickfacts.census.gov/qfd/states/25000.html	Socioeconomics	A comparison of MA socioeconomics versus the national statistics.
MISER Population Projections	http://www.umass.edu/miser/population/miserproj.html	Population Projections	A University of Massachusetts based site that projects population growth through 2020. The data is somewhat dated having been last calculated in 2003.
MA CZM Plans and Reports	http://www.mass.gov/czm////publications.htm#plans	Strategic Plans	Various coastal related strategic plans are listed here for MA.
MA Shore Protection	http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/seawall-inventory/	Shore Protection Inventories	MA CZM developed a comprehensive list of publically owned and operated shore protection projects. It includes a 20 year prioritized list, including costs, of repair needs for the projects.
South Shore Coastal Hazards Characterization Atlas	http://www.mass.gov/czm/hazards/ss_atlas/atlas.htm	Coastal Atlas	MA CZM atlas of coastal hazards along the south shore of MA. Site includes insurance claim data, shoreline type and change rates, structures, etc.
MA Ocean Resource Information System (MORIS)	http://maps.massgis.state.ma.us/map_ol/moris.php	Coastal resources/population information/ maps	Interactive GIS based website to extract various data sets for the coastal region of MA.

Resource	Source/Reference	Subject	Key Findings Synopsis
How are Right Whales Affected by Climate Change?	http://www.neaq.org/conservation_and_research/climate_change/effects_on_ocean_animals.php	Natural Resources	Website highlighting the effects of climate change on various species.
Massachusetts Climate Change Adaptation Report. (September 2011)	http://www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf	Climate Change	Submitted by the Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee the framework assesses a suite of strategic, long-term solutions designed to enable neighborhoods and natural resources to adapt to climate change.
Atlantic Coast Joint Venture. (January 2005)	http://www.acjv.org/resources.htm	Coastal Resources	Map showing various coastal waterfowl focus areas in Massachusetts.

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http://www.umass.edu/miser/population/miserproj.html

http://www.mass.gov/czm////publications.htm#plans

http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/seawall-inventory/

http://maps.massgis.state.ma.us/map_ol/moris.php

http://www.mass.gov/czm/hazards/ss_atlas/atlas.htm

ATTACHMENT A

USACE State Problems, Needs, and Opportunities Correspondence with Individual State Responses

THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
OFFICE OF COASTAL ZONE MANAGEMENT
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(617) 626-1200 FAX: (617) 626-1240

May 15, 2014

John Kennelly,
Planning Chief
New England District
U.S. Army Corps of Engineers
696 Virginia Road
Concord, MA 01742

RE: North Atlantic Coast Comprehensive Study: State of Massachusetts Problems, Needs and Opportunities for Future Planning Initiatives

Dear Mr. Kennelly,

The Massachusetts Office of Coastal Zone Management (CZM) has received your request for input regarding the state's problem areas and needs related to future planning initiatives, and opportunities for the U.S. Army Corps of Engineers (USACE) to provide other technical services to meet the needs of the State. As a follow-up to our conference call with you and Chris Hatfield on May 7, 2014, we are providing you with a summary of our comments.

There are a significant number of areas along the coast that are vulnerable to damage and flooding in coastal storm events. CZM's comment letter dated October 21, 2013 (attached) provided feedback regarding the draft identification of vulnerable areas sent to us in the early phases of the North Atlantic Coastal Comprehensive Study (NACCS). The areas we identified, in addition to those already identified as part of the study, represent some of the areas most vulnerable to coastal storm damage and flooding.

Your letter also requested information regarding technical services the USACE could provide to meet the needs of the State. We offered the following comments and suggestions:

- A major contributing factor to coastal erosion along the Massachusetts coast is reduced sediment supply. This is a result of armoring and depleted sediment sources. One way to address this deficit is to place clean, beach compatible dredge sediments from nearby dredging projects on adjacent beaches and dunes. This is a cost-effective way of preventing sediment that has been trapped in navigation channels from being permanently lost from the longshore sediment transport system. Implementing this as a best practice for USACE Navigation Projects is a proactive technique that could be implemented to address some our sediment deficits.

- Many Massachusetts beaches are composed of a mix of sand, gravel, and cobble sized sediments. There is very little guidance available regarding the design of nourishment projects with mixed sediments. The beaches and dunes composed of this type of material behave differently than those composed of just sand. The coarser gravel and cobble size sediments tend to shift landward in storm events, forming berms that serve as energy dissipaters seaward of coastal engineering structures and as natural dunes. It would be helpful if the USACE could bring in technical staff from other USACE regions who have experience designing projects with mixed sediments to help inform the evaluation of these techniques in Massachusetts. For example, this expertise would be helpful to the Marshfield and Hull studies that are currently ongoing.
- The Massachusetts Coastal Hazards Commission, Infrastructure Working Group, undertook a project to inventory all publicly owned coastal engineering structures. The inventory was conducted by coastal engineers, who did visual inspections, took photographs to document existing conditions, rated the condition of each structure, made recommendations for repairs, and located original plans for the structures, where possible. One of the findings in the inventory reports for many of the older seawalls constructed in areas such as Scituate and Marshfield is that the landform in front of the structure (i.e. beach and nearshore) has eroded significantly, and is not adequate to provide protection during a major coastal storm event, threatening the stability of the structure. This is a significant problem for many areas along many areas of the south shore, where storm damage patterns are increasing in smaller storm events (e.g. 2013 February and March northeasters), seawalls are being undermined, and rates of overtopping and storm damage landward of the walls are increasing. There is a need for larger nourishment to protect homes, roads and other infrastructure in these areas. The summary coastal structures inventory report and detailed reports for each community are available online: http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/seawall-inventory/. CZM is currently working with the Department of Conservation and Recreation and private consultants to update these reports. We expect to have the new reports available in the next few months.

If you have any questions regarding our comments, please contact Rebecca Haney, CZM Coastal Geologist, at 617 626-1228 or rebecca.haney@state.ma.us.

Sincerely,

Bradford V. Washburn,
Assistant Director

cc: Rebecca Haney, CZM Coastal Geologist