THE RHODE ISLAND COMPREHENSIVE PLANNING STANDARDS
GUIDANCE HANDBOOK SERIES

GUIDANCE HANDBOOK #12:

PLANNING FOR NATURAL HAZARDS & CLIMATE CHANGE

Revised June 2018

The plan must include an identification of areas that could be vulnerable to the effects of sea-level rise, flooding, storm damage, drought, or other natural hazards. Goals, policies, and implementation techniques must be identified that would help to avoid or minimize the effects that natural hazards pose to lives, infrastructure, and property.

The Rhode Island Comprehensive Planning and Land Use Regulation Act, RIGL subsection 45-22.2-6(b)(10)

ACKNOWLEDGEMENTS

The Rhode Island Comprehensive Planning Guidance Handbook Series is the result of over twenty-four months of cooperation and coordination among state agencies, local planners, and other professionals interested in helping cities and towns craft better comprehensive plans. The guidance development process was overseen by the Comprehensive Planning Advisory Committee, a dedicated group of planning, land use, legal, and community professionals who worked diligently to develop content on the comprehensive planning process and to review topical content as it was developed. Without this group the manual would not have become reality.

Additionally, the topical content for the guidance handbook series was developed in conversation with numerous experts. These knowledgeable individuals are the reason that the manual is helpful, user-friendly, and thorough.

The guidance handbook series was prepared by Chelsea Siefert, Principal Planner. Ms. Siefert was guided by Karen Scott, Assistant Chief and Kevin Nelson, Supervising Planner, and assisted by Caitlin Greeley, Principal Planner.

COMPREHENSIVE PLANNING ADVISORY COMMITTEE

Sheila Brush, former Director of Programs, Grow Smart RI

Bill DePasquale, Director of Planning, City of Warwick

Ann-Marie Ignasher, former Town Planner, Town of Foster

Nancy Letendre, Principal Planner, Mason & Associates, Inc.

Sue Mara, Assistant Director of Planning and Redevelopment, City of Pawtucket

Martha Matchnik, former Director of Healthy Aging, YMCA of Greater Providence

Krista Moravec, Environmental Planner, Horsley Witten Group, Inc.

Bonnie Nickerson, Director of Planning and Development, City of Providence

Fred Presley, City Manager, City of West Warwick

Pam Sherrill, former Town Planner, Town of Johnston

TOPIC EXPERTS

Angela Ankoma, RI Department of Health

Ken Ayars, RI Department of Environmental Management

Jim Boyd, RI Coastal Resource Management Council

Meredith Brady, RI Department of Transportation

Paige Bronk, Town of North Kingstown

Michelle Burnett, RI Emergency Management Agency

Kathleen Crawley, RI Water Resources Board

Teresa Crean, URI Coastal Resources Center/RI Sea Grant

Steve Devine, RI Department of Transportation

Joe Dias, RI Department of Environmental Management

Lauren Faria, RI State Council on the Arts

John Flaherty, Coalition for Transportation Choices

Elizabeth Francis, RI Council for the Humanities

Rupert Friday, RI Land Trust Council

Grover Fugate, RI Coastal Resources Management Council

Scott Gibbs, Economic Development Foundation of RI

Julia Gold, RI Department of Health

Rick Greenwood, formerly of RI Historical Preservation and Heritage Commission

June House, RI Office of Housing and Community Development

Paul Jordan, RI Department of Environmental Management

Lorraine Joubert, URI Nonpoint Education for Municipal Officials

Nate Kelly, Horsley Witten Group

Meg Kerr, Watershed Counts

Sarah Kite, RI Resource Recovery Corporation

Tom Kravitz, Town of Burrillville

Eliza Lawson, RI Department of Health

Mike McGonagle, RI Resource Recovery Corporation

Danny Musher, RI Office of Energy Resources

Bill Patenaude, RI Department of Environmental Management

Ken Payne, RI Agricultural Partnership

Amy Pettine, RI Public Transit Authority

Nicole Pollock, formerly of RI Department of Environmental Management

Leo Pollock, formerly of Southside Community Land Trust

Dan Porter, RI Airport Corporation

Lisa Primiano, RI Department of Environmental Management

Amy Rainone, Rhode Island Housing

Randy Rosenbaum, RI State Council on the Arts

Pam Rubinoff, URI Coastal Resources Center/RI Sea Grant

Rachel Sholly, RI Office of Energy Resources

Malcolm Spaulding, University of Rhode Island

Jan Reitsma, formerly of Governor Chaffee's Office

Jonathan Stevens, former State Historic Preservation Officer

Jessica Stimson, RI Emergency Management Agency

Elizabeth Stone, RI Department of Environmental Management

Valerie Talmage, Preserve Rhode Island

Michael Tondra, RI Office of Housing and Community Development

David Tremblay, RI Department of Labor and Training

David Vallee, National Oceanic and Atmospheric Administration

Marcel Valois, Commerce RI

Bob Vanderslice, formerly of RI Department of Health

Mike Walker, Commerce RI

Scott Wolf, Grow Smart RI

Art Zeman, RI Department of Environmental Management

TABLE OF CONTENTS

INTRODUCTION ii

SECTION 1. GENERAL INFORMATION ON PLANNING FOR NATURAL HAZARDS & CLIMATE CHANGE 1

WHAT ARE NATURAL HAZARDS & CLIMATE CHANGE? 3
WHY INCLUDE NATURAL HAZARDS & CLIMATE CHANGE? 4
A NOTE ON THE RELATIONSHIP TO THE LOCAL HAZARD MITIGATION PLAN 4
RELEVANT STATE GOALS AND POLICIES 5
OTHER RELEVANT DOCUMENTS 6
STAKEHOLDERS TO INCLUDE 6
MAKING CONNECTIONS THROUGHOUT THE PLAN 7
A NOTE ON ASSESSING IMPACTS AND VULNERABILITY 8
A NOTE ON THE APPROPRIATE PLANNING HORIZON 8

SECTION 2. FULFILLING THE STANDARDS 9

STANDARD 12.1 11
STANDARD 12.2 13
STANDARD 12.3 15
STANDARD 12.4 17
STANDARD 12.5 19

SECTION 3. CRAFT A BETTER PLAN 23

RECOMMENDATION 12.6 25

SECTION 4. ADDITIONAL RESOURCES 27

OVERVIEW OF A CHANGING CLIMATE IN RHODE ISLAND 29
GUIDANCE FOR MUNICIPALITIES IN THE CONSIDERATION OF PROJECTED FUTURE CHANGES TO RIVERINE FLOODPLAINS 35
U.S. ARMY CORPS OF ENGINEERS SEA LEVEL RISE PROJECTIONS 36
SAMPLE PROCESS FOR CONDUCTING A PRELIMINARY COMMUNITY VULNERABILITY ASSESSMENT . . 37
SAMPLE MATRICES AND TOOLS FOR CONDUCTING A PRELIMINARY COMMUNITY VULNERABILITY ASSESSMENT 43

INTRODUCTION

This handbook is meant to be an accompaniment to the Rhode Island Comprehensive Planning Standards Manual ("the Standards Manual"), providing additional information on the natural hazard and climate change-related standards contained within the manual, as well as general guidance on planning for natural hazards and climate change. The Rhode Island Comprehensive Planning Standards Manual and the other guidance handbooks in the series can be found online at www.planning.ri.gov/statewideplanning/compplanning/.

This manual is split into four sections. Section 1 - General Information on Planning for Natural Hazards and Climate Change provides general information, including the purpose of doing so, relevant documents to review and ways to connect natural hazards and climate change and the other topical areas. Section 2 - Fulfilling the Standards provides information on satisfying the specific requirements presented in the Rhode Island Comprehensive Planning Standards Manual. Section 3 - Craft a Better Plan provides additional recommendations for addressing housing within a comprehensive plan that are not required for State approval but would strengthen the plan's overall efficacy. Section 4 - Additional Resources provides more information about how the climate is changing and tools for assessing community vulnerability.

NOTES

In some cases, this guidebook presents "notes" that are relative to the content being discussed. Each note that occurs within the text will be tagged with a symbol to alert the reader to the note's purpose, as shown below.


This symbol is used to identify references to the Rhode Island General Laws (RIGL). Blue text within this note provides a link to the actual RIGL citation.


This symbol alerts the reader to something that is required for State approval.


This symbol alerts the reader to potential data sources.


The text following this symbol provides additional suggestions to enhance comprehensive plans.


This symbol alerts the reader to sample goals, policies and actions that would fulfill the requirements.


This symbol indicates general information that is secondary to the main point of the text, but could be helpful to the municipality.


This symbol alerts the reader to a cross-reference within the guidebook series. If a concept is mentioned in the text area and more information on the concept is available elsewhere in the guidebook series, this note will point the reader to where to find it.

This handbook includes standards for complying with the requirements of the Comprehensive Planning Act. A standard may: 1) reiterate a requirement found in the Act; 2) provide specifics to clarify a requirement of the Act; 3) describe processes that if followed will help ensure State approval; or 4) identify information that while not specifically required by the Act, has been identified as vital to supporting the intents of the Act. Those standards that describe processes or information not *required* by the Act are listed as recommendations.

SECTION 1. GENERAL INFORMATION ON PLANNING FOR NATURAL HAZARDS & CLIMATE CHANGE

WHAT ARE NATURAL HAZARDS & CLIMATE CHANGE?

A "natural hazard" is an event or series of events caused by forces of nature that has a negative impact on people, infrastructure or the environment. Natural hazards cannot be prevented but must be planned for in order to avoid or minimize impacts to lives, infrastructure and property.

Planning for natural hazards within a comprehensive plan must also include planning for the impacts of climate change. It is projected that current natural hazards will be worsened by the effects of climate change and that, in some areas, new hazards may arise due to the changing climate. In general, long-term climate change is likely to cause the following impacts in Rhode Island:

- Expedited sea level rise, which will also cause more extreme high tides and greater areas of saltwater intrusion in storm events;
- Increased storm surge levels and stronger, more frequent coastal storm events, which may lead to more frequent and farther reaching coastal flooding events, greater areas of saltwater intrusion, and increased coastal erosion;
- Heavier and more frequent precipitation events, which may cause more riverine and flash flooding events;
- Longer periods of drought, which may lead to more frequent wildfires and water availability concerns;
- Increasing air and water temperatures; and
- More frequent high heat days and heat waves.

Section 3 of this guidance handbook provides some additional information on the changing climate in the region. For more information about how the climate is changing in the Northeast United States, visit the National Climate Assessment website at http://nca2014.globalchange.gov/highlights/regions/northeast.

There are two ways to plan for natural hazards and climate change within a comprehensive plan, planning for adaptation to natural hazards and climate change impacts and planning for mitigation of climate change.

Mitigating climate change means implementing actions that seek to limit the magnitude or rate of long-term climate change. For a comprehensive plan, climate change mitigation relates primarily to energy, transportation and land use. Some examples of climate change mitigation techniques that are appropriate for a comprehensive plan include retrofitting public buildings to be more energy efficient and adopting a Future Land Use Map that increases the mix of uses, therefore reducing vehicle miles traveled and the associated vehicle emissions. Subjects related to climate change mitigation are covered in Guidance Handbook #9 - Planning for Energy, Guidance Handbook #11 - Planning for Transportation and Guidance Handbook #13 - Planning for Land Use.

This chapter focuses on natural hazard and climate change adaptation. Adaptation techniques seek to reduce the vulnerability of communities to the effects of natural hazards and climate change trends. As discussed throughout the chapter, natural hazards and climate change have the potential to affect all of the topical areas of a comprehensive plan and, by planning comprehensively, communities can reduce their vulnerability in all sectors.

WHY INCLUDE NATURAL HAZARDS & CLIMATE CHANGE?

Natural hazards and climate change impact many aspects of communities and their built environments, threatening public health, safety and welfare. The comprehensive planning process is an effective way to assess and plan for natural hazards, especially in considering the increasing risks resulting from climate change because it encompasses many of the areas likely to be impacted. Looking at natural hazards in the realm of the comprehensive plan allows communities to develop goals, policies, and implementation actions that stretch across the breadth of the topics covered within a comprehensive plan. For example, the impacts of natural hazards on the transportation network can be assessed and planned for and future land use patterns can be altered to account for particular vulnerabilities.

Also, addressing natural hazards within the comprehensive planning process allows communities to evaluate all of the plan's policies and implementation actions in light of the impacts of natural hazards. Many of the implementation strategies developed to support the plan's non-hazard related goals can be adjusted to further the goal of adaptation by assessing them through a natural hazard lens.

Local land use planning is an exercise of the state's police power, which has been delegated to the municipalities through the Rhode Island General Law. It is important for communities to explain the negative impacts to health, safety, and welfare caused by natural hazards and climate change within their comprehensive plans, so that the community has a solid foundation from which policy changes can be made.

The required content for related to natural hazards and climate change stems from the Rhode Island Comprehensive Planning and Land Use Regulation Act, RIGL subsections 45-22.2-6(b)(10) and 45-22.2-6(b)(12).

Municipalities should determine how they will include natural hazards in their comprehensive plans early in the drafting process. Some communities may choose to integrate these discussions within the other topical areas of the plan; others may craft stand-alone natural hazards chapters. Either way is acceptable for State approval.

A NOTE ON THE RELATIONSHIP TO THE LOCAL HAZARD MITIGATION PLAN

All communities that wish to avail themselves of Federal Emergency Management Agency (FEMA) money after a disaster occurs must adopt a local hazard mitigation plan, which is a different and distinct document from the local comprehensive plan. The purpose of a local hazard mitigation plan is to "identify policies and actions that can be implemented over the long term to reduce risk and future losses." While this is also one of the purposes of including natural hazards within a comprehensive plan, the local comprehensive plan is used to guide development and infrastructure decisions at the municipal level. Therefore, discussions of natural hazards and climate change impacts within a comprehensive plan must take a more holistic view and should align land use, transportation, infrastructure and other goals and policies with natural hazards considerations.

The comprehensive plan should consider different aspects of natural hazards and climate change than what is typically found in a local hazard mitigation plan. As you'll see throughout this handbook, there are some things that are typically found in a local hazard mitigation plan that the comprehensive plan doesn't need to discuss and there are some areas where a more detailed or thoughtful discussion of

vulnerabilities are warranted. **Therefore, simply inserting the local hazard mitigation plan into the comprehensive plan may not address all the requirements for State approval.** However, comprehensive plans and hazard mitigation plans can benefit each other. If your municipality has a hazard mitigation plan, the information contained within it can serve as the basis for addressing natural hazards in the comprehensive plan. Conversely, the goals, policies, and implementation program of the comprehensive plan can reinforce the strategies detailed within the hazard mitigation plan.

The American Planning Association, in its July/August 2009 Planning Advisory Service Memo, stated:

> *"Mitigation approaches can involve changes in zoning and subdivision codes to steer development to safer locations, applying stricter design standards in hazardous areas, providing economic incentives to owners for building retrofits, and undertaking improvements to public and critical facilities to make them safer and more resilient. [There has been] a long-standing tendency by local officials to assign the responsibility for such plans to emergency managers without realizing the degree to which local planning is integral to effective implementation. Many of the regulatory requirements for adequate local hazard mitigation plans entail skills for which planners are ideally suited, such as marshaling public input and involvement. Many of the most effective long-term solutions involve changes in land-use regulations such as zoning and subdivision codes."*

The options for referencing other municipal plans, such as the local hazard mitigation plan, within the comprehensive plan is discussed in Guidance Handbook #1 - The Comprehensive Plan 101 and Guidance Handbook #15 - The Comprehensive Planning Process.

For more information about the requirements for Local Hazard Mitigation Plans, contact the Rhode Island Emergency Management Agency at (401) 946-9996.

RELEVANT STATE GOALS AND POLICIES

Every comprehensive plan must be consistent with and embody the State's goals and policies for natural hazards and climate change as found in the State Guide Plan and the laws of the State. The goals and policies listed below represent the main themes of the State's goals and policies related to natural hazards and climate change and are intended to provide focus as to which aspects of the State's goals and policies are most important for local comprehensive planning.

See the Rhode Island Comprehensive Planning and Land Use Regulation Act, RIGL subsections 45-22 .2-6(b)(1) and 45-22 .2-9(d)(3) .

FROM THE STATE GUIDE PLAN

> *Guide development in a manner that will prevent encroachment on floodways, dunes, barrier beaches, coastal and freshwater wetlands, and other natural features that provide protection from storms, flooding, and sea-level rise.*

Land Use 2025: Rhode Island's State Land Use Policies and Plan, LUP 10, page 2-9

> *Strengthen regional economic resilience and harness opportunities for innovation.*

Rhode Island Rising: A Plan for People, Places and Prosperity, Goal 5, Policy 5, page 114

Minimize the effects of drought on public health and safety, economic activity, and environmental resources.

Rhode Island Water 2030, Policy WRM-1-6

Develop transportation and communication systems that serve Rhode Islanders and the region in the event of natural disasters, accidents, and acts of terrorism in a manner that minimizes injury, loss of life, and disruption to the economy; facilitates evacuation of people; and allows emergency response and recovery activities to occur.

Transportation 2035, Goal ER, page 5-15

FROM THE RHODE ISLAND GENERAL LAWS

The plan must include an identification of areas that could be vulnerable to the effects of sea-level rise, flooding, storm damage, drought, or other natural hazards. Policies and implementation techniques must be identified that would help to avoid or minimize the effects that natural hazards pose to lives, infrastructure, and property.

RI Comprehensive Planning and Land Use Regulation Act, RIGL subsection 45-22.2-6(b)(10)

OTHER RELEVANT DOCUMENTS

Before beginning assessment of existing conditions, needs and trends, and before developing goals, policies and actions, communities should review other state and local plans and other documents that are relevant to planning for natural hazards and climate change, including:

- The local Hazard Mitigation Plan;
- Any local Harbor Management Plans that may be available;
- The "State Hazard Mitigation Plan", available at http://www.riema.ri.gov/prevention/mitigation/index.php;
- The RI Climate Change Commission's "Adapting to Climate Change in the Ocean State: A Starting Point," available at http://www.crmc.ri.gov/climatechange/RICCC_2012_Progress_Report.pdf;
- Brown University's "Preliminary Assessment of Rhode Island's Vulnerability to Climate Change and its Options for Adaptation," available at http://envstudies.brown.edu/Summary- RIClimateChangeAdaptation.pdf;
- The RI Executive Climate Change Council's "A Resilient Rhode Island: Being Practical About Climate Change," available at http://www.planning.ri.gov/documents/climate/EC3ReportJune2014final.pdf; and
- Any of the RI Coastal Resources Management Agency's "Special Area Management Plans" that are applicable to the municipality, available at www.crmc.ri.gov/samps; and
- The RI Coastal Resources Management Agency's "Shoreline Change Maps," available at www.crmc.ri.gov/maps/maps_shorechange.html.

STAKEHOLDERS TO INCLUDE

In addition to the general public, when discussing how best to plan for natural hazards and climate change, municipalities may benefit from involving:

- Local emergency management officials;
- The local building official;
- The local emergency manager;
- The local floodplain manager;
- Local police, fire and/or emergency medical services personnel;
- The local Public Works Director;
- Residents who live within affected areas;
- Business owners who operate within affected areas;
- Representatives from the Rhode Island Emergency Management Agency;
- Representatives from the Coastal Resources Management Council;
- Representatives from the Department of Environmental Management;
- Representatives from the Office of Energy Resources;
- Representatives from the Department of Health;
- Representatives from the Division of Statewide Planning;
- Representatives from appropriate federal agencies, such as the United States Geological Survey, the Federal Emergency Management Agency, and the National Oceanographic and Atmospheric Administration.

MAKING CONNECTIONS THROUGHOUT THE PLAN

Though there are several specific topics that are required to be addressed within a comprehensive plan, it is important that municipalities not consider the topic areas in as segregated elements, but rather as pieces of a larger system. Everything within a community is connected in diverse and varied ways, all of which should be considered when crafting a comprehensive plan. The information provided below is intended to highlight a few of the ways that municipalities should think about the connected nature of the topic areas.

RELATIONSHIP TO LAND USE

One of the primary reasons for including this topic in a local comprehensive plan is to provide an opportunity for the community to make decisions about future land uses, infrastructure and the provision of services and facilities in light of the projected impacts of natural hazards and climate change. There are implications to allocating additional density and/or development, or intending that development continue, in vulnerable areas, which communities should recognize and discuss. Additionally, planning for natural hazards and climate change can save the community money in the long-term by allowing new development, facilities and infrastructure to be located and designed in a resilient way, instead of needing replacement or repair after hazard events.

When allocating future land uses, communities should consider the following guiding questions related to the implications of natural hazards and climate change:

- Will increasing density in a particular area cause more of the population, or any special segments of the population, to become more vulnerable to natural hazards impacts?
- How do current and projected future land use patterns increase or decrease community vulnerability?
- Are there areas not yet developed that should remain permanently undeveloped?
- Are areas designated institutional and/or public appropriately located to ensure continuity of services in the event of natural hazards?

Additionally, communities should consider whether to include policies and implementation actions that would assess the zoning ordinance, subdivison and land development regulations and other ordinances in light of natural hazards and climate change. Communities should spend time considering what mechanisms are available for controlling or limiting growth in exposed areas.

RELATIONSHIP TO ALL OTHER TOPIC AREAS

Natural hazard and climate change considerations should be seen as a lens through which all of the plan's goals, policies and implementation actions should be viewed. Therefore, there should be consistency between all of the plan's goals, policies, and implementation actions and the community's goals for natural hazards, even more so than with the other topical areas. Communities should review all of the plan's goals, policies and implementation actions to ensure that the entire plan is moving the community toward a more resilient future.

A NOTE ON ASSESSING IMPACTS AND VULNERABILITY

It is not expected that comprehensive plans include or be based on full, community-wide vulnerability assessments, or vulnerability assessments for the individual buildings, systems, etc. that exist within the community. A full vulnerability assessment is a complex endeavor which would require a large amount of time and/or resources to complete.

The purpose of including natural hazards and climate change within a comprehensive plan, as defined by the Comprehensive Planning and Land Use Regulation Act, is to adopt goals, policies, and actions that would minimize the impacts to lives, property, and infrastructure. Understanding this, while not required, **it is strongly recommended that the community determine the priority issues it would face in the event of future natural hazards and climate change trends and to propose goals, policies, and actions to address the identified issues.**

This handbook includes a recommended process for completing a preliminary community vulnerability assessment that will assist in identifying potentially significant issues, which can be found in Section 3. Guidance has been given to make this process as straightforward as possible, providing clear direction on each step in the preliminary vulnerability assessment process. It also attempts to identify the relevant data and expertise that will be needed to complete the assessment.

A NOTE ON THE APPROPRIATE PLANNING HORIZON

When assessing all future conditions and needs, a minimum 20-year planning horizon is required by the RI Comprehensive Planning and Land Use Regulation Act. However, when planning for natural hazards and climate change, it would be appropriate for municipalities to use a longer planning horizon. Although it may take longer than the 20-year comprehensive plan planning horizon for the impacts of climate change to be felt by municipalities, it is critical that communities be aware of and prepared for the long-term effects. S till, the community should determine the time period with which it is most comfortable, but the Division of Planning strongly recommends assessing climate change impacts over the entire design life of structures and infrastructure, which may be 50- or 100-years.

SECTION 2. FULFILLING THE STANDARDS

STANDARD 12.1 *(RECOMMENDATION)*

IDENTIFY THE PRIORITY NATURAL HAZARDS AND CLIMATE CHANGE TRENDS THAT ARE LIKELY TO IMPACT THE MUNICIPALITY.

To properly plan for natural hazard and climate change impacts, municipalities need an understanding of the natural hazards and climate change trends that are most likely to threaten the community in the future. For this assessment, communities should reflect on previous experiences and consider the ways in which the changing climate could amplify the effects of natural hazards.

When determining the priority hazards and trends that are likely to impact the municipality, municipalities should review the list of potential natural hazards outlined in Table 12-1. Types of Natural Hazards and Climate Change Trends and then consider the following guiding questions:

- What natural hazards has the municipality been historically subject to?
- How frequently have these hazards affected the municipality and surrounding areas?
- What types of natural hazards have had the most devastating or costly impacts?
- How are the impacts of natural hazards likely to change given the changing climate?
- How is/could the municipality's development pattern, especially the presence of impervious surfaces, amplify the effects of natural hazards and long-term climate change?

When considering which natural hazards present the greatest concern, municipalities must consider the impacts of climate change. (Explained in greater detail in Section 4. Additional Resources.) Specifically, municipalities must recognize that climate change is likely to amplify some effects of the natural hazards with which the community is already dealing, that climate change may quicken the onset of certain natural hazards, and that climatic changes may pose new threats to lives, infrastructure, and property.

Communities should also consider how their development patterns, especially the amount of impervious surface within the municipality, can amplify the effects of natural hazards and climate change. For example, wet springs are causing the loss of absorptive capacity in soils, which, coupled with more frequent and heavier precipitation, can lead to increased flooding. The effects of development patterns coupled with climate change could cause a natural hazard that may not otherwise be a priority for the municipality to become a priority.

Based on the answers to the above guiding questions, the consideration of likely climate change impacts and the onset of such impacts, the comprehensive plan must identify which natural hazards and climate change trends present the greatest concern.

TABLE 12-1. TYPES OF NATURAL HAZARDS AND CLIMATE CHANGE TRENDS

The natural hazards described within each community's comprehensive plan will depend on the history and context of the municipality, but could include:

FLOOD-RELATED HAZARDS

Riverine flooding

Coastal flooding

Flash, urban and stormwater-based flooding

Storm surge

Coastal erosion (with landslide) and shoreline change

Sea level rise

HEAT-RELATED HAZARDS

Drought

Wildfire

High heat days

Extreme heat waves

WIND-RELATED HAZARDS

Hurricanes

Tornadoes

Thunderstorms/wind storms

Hail

Lightening

WINTER-RELATED HAZARDS

Heavy snow

Ice storms

Blizzards

Extreme cold

EARTHQUAKES

The list of hazards presented here is categorized in the same way as the State Hazard Mitigation Plan to make it easy for municipalities to transfer the work of the comprehensive plan to their Local Hazard Mitigation Plan.

STANDARD 12.2

IDENTIFY THE AREAS OF THE COMMUNITY THAT COULD BE EXPOSED TO FLOODING, INCLUDING RIVERINE AND COASTAL FLOODING, SEA LEVEL RISE, AND COASTAL STORM SURGE BY INCLUDING:

a. One or more maps that illustrate the areas that would currently be inundated in the event of a 1% and 0.2% storm as they appear on the most recent Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs);

b. One or more maps that illustrate the areas that would be inundated in the event of Category 1 through 4 hurricanes; and

c. One or more maps that illustrate the areas that are projected to be inundated due to 1', 3', and 5' of sea level rise.

It is important to remember that vulnerability and exposure are not the same. "Exposure" to a natural hazard happens simply by being in the location where the natural hazard is occurring, while "vulnerability" indicates that the exposure has caused some type of harm.

Exposure to natural hazards and climate change impacts is generally the result of geographic location. There are some trends for which exposure will be limited to a specific geographic area of the community, such as riverine and coastal flooding and sea level rise. For other trends, such as drought, high heat, extreme cold, etc., though still geographically-based, the extent of the trends is so far-reaching that it will likely cover the entire municipality.

Identifying exposed areas allows communities to focus on those trends that will impact a specific area of the community. Comprehensive plans must identify areas of the community that could be vulnerable to the effects of flooding over the 20-year planning horizon. All types of flooding should be considered, including riverine flooding, tidal flooding, sea level rise, and flooding from storm surge.

Some options for mapping these requirements include:

- Show flood areas as layers on a "Natural Resources" or other map showing required data layers;
- Include flood areas as a separate map; or
- Develop a "Natural Hazards" map that includes a variety of information related to natural hazards, including floodplains and flood hazard areas, the other types of natural hazards listed below, evacuation routes, critical facilities, etc.

Flood Insurance Rate Maps are regulatory. All of the other required maps are intended for planning purposes only.

The 1% and .2% storms are named for the probability that such a storm will occur within a single year. These storms have also historically been known as 100-year and 500-year storms.

DATA SOURCES

See the NOAA website at http://www.nhc.noaa.gov/surge/slosh.php for more information on the hurricane surge maps.

For more information on mapping for comprehensive plans, please visit www.planning.ri.gov/publications/comprehensive-planning-materials.php

The following RIGIS data sets are recommended for this standard:

DATA SET NAME	DOWNLOAD LINK	ADDITIONAL NOTES
Flood Hazard Areas	flood hazard areas	This data set must be queried as follows: Select flood zone 'FLD_ ZONE' < > 'X' and 'FLD ZONE' < > 'X Protected by Levee'
Hurricane Surge (Worst Case) Inundation Areas	hurricane surge inundation areas	
Sea Level Rise: RIDOP	sea level rise: RIDOP	To get full coverage, this data set and the one listed below must both be used.
Sea Level Rise: RIDOP (Uncertain Areas)	sea level rise: RIDOP (uncertain areas)	To get full coverage, this data set and the one listed above must both be used

STANDARD 12.3 *(RECOMMENDATION)*

DISCUSS THE PRIORITY IMPACTS THAT THE MUNICIPALITY WOULD FACE IN THE EVENT OF FUTURE NATURAL HAZARDS AND LONG-TERM CLIMATE CHANGE, AS IDENTIFIED THROUGH A PRELIMINARY COMMUNITY VULNERABILITY ASSESSMENT, BY:

a. Stating the priority impacts that the municipality must address, as derived through a preliminary vulnerability assessment; and

b. Discussing the ways in which the municipality will address each priority impact, which may include undertaking more detailed vulnerability assessments for specific assets, populations, resources, etc.

If a municipality experiences a natural hazard, or the effects of long-term climate change, it is likely that resources, assets, infrastructure, and/or specific populations within the municipality will be impacted. Comprehensive plans should state the impacts that the community feels must be addressed as a priority, or the "priority impacts," and discuss the ways in which the municipality will address said impacts.

Priority impacts should be specific. Each "priority impact" should 1) be related to a specific resource, asset, piece of infrastructure, or population and 2) be linked to a specific natural hazard or climate change trend. See the example impact statements, below, where the resource, asset, piece of infrastructure, or special population is colored in blue and the natural hazard or climate change trend is colored in green.

Wickford Village will be impacted by sea level rise.

The wastewater treatment plant will be impacted by riverine flooding.

The community's elderly population will be impacted by high heat days.

It is likely that there are many resources, assets, pieces of infrastructure and populations within the municipality that are projected to be impacted by the impending natural hazards and climate change trends, but it is not necessary for the comprehensive plan to discuss them all. Comprehensive plans must only discuss and address those impacts which have been deemed a priority, meaning that they are likely to cause loss of life or threats to public health and safety, significant damage that is costly to repair, and/or disruption to important community functions.

However, to determine which impacts are a priority for the community, municipalities should perform a comprehensive assessment of all of the important resources, assets, infrastructure and populations within the municipality. This guidance refers to this type of assessment as a preliminary vulnerability assessment. A sample methodology for conducting a preliminary vulnerability assessment, along with helpful tools and matrices for completing the assessment, is located in the section called, Sample Process for Conducting a Preliminary Community Vulnerability Assessment. It is not required that municipalities follow the outlined process in order to receive State approval, however, it is highly recommended in order to get a full picture of the potential impacts that the community is facing.

Comprehensive plans must also provide some narrative regarding the priority impacts. To be most effective, this narrative should include discussion of the community functions and values that will be disrupted, any special populations that will be impacted and any work that is currently being done to address the impact.

Once the priority impacts have been established, the comprehensive plan should also discuss the ways in which the municipality will address each impact, and then include such measures as implementation actions within the Implementation Program, as discussed under Standard 12.5. Depending on what has been done to date, the extent of the impact and the data available, it may be most useful for the comprehensive plan to call for a more detailed vulnerability assessment on a specific piece of infrastructure, asset, resource, or population.

STANDARD 12.4

INCLUDE GOALS THAT EMBODY THE STATE'S GOALS REGARDING NATURAL HAZARDS AND CLIMATE CHANGE AND POLICIES TO SUPPORT EACH GOAL.

As a relatively new consideration, the more recent State Guide Plan elements have begun to explicitly address natural hazards and climate change considerations with goals and policies. However, the Rhode Island Comprehensive Planning and Land Use Regulation Act makes clear that identifying vulnerable areas and avoiding or minimizing the effects that natural hazards pose to lives, infrastructure, and property, is an important component of planning for a community's future.

Comprehensive plans must include goals that further the State's goals of protecting lives, infrastructure, and property and guiding development away from especially vulnerable areas, and policies to support each goal. Municipalities are encouraged to be proactive yet realistic in determining the goals and policies that are most appropriate for the community and should consider the following guiding questions:

- How does the community see itself adapting to the impacts of natural hazards and climate change in the future?
- How quickly will the municipality need to adapt to the impacts of natural hazards and climate change?
- Are there areas of the community where the only option is protection? Are there areas that can adapt? Are there areas where relocation might be necessary?
- How can the community become more resilient to the impacts of natural hazards?

For more information on the difference between goals, policies and implementation actions, see Guidance Handbook #1 - The Comprehensive Plan 101.

SAMPLE GOALS

- Our community will be resilient to natural hazards and climate change.
- Systems will be in place to minimize impacts from natural hazards in our vulnerable areas.

SAMPLE POLICIES

- Plan to accommodate a base rate of 3 to 5 feet rise in sea level by 2100 in the siting, design, and implementation of public and private coastal activities.
- Require municipal departments to incorporate climate change in all long-range planning and critical public infrastructure projects.
- Ensure that the local Hazard Mitigation Plan is up-to-date and utilizes the most recent available technical data for natural hazards and climate change.

- Ensure consistency between the Hazard Mitigation Plan, the Comprehensive Plan, SAMP plans, the city's land use regulations and the local Harbor Management Plan.
- Ensure that existing critical facilities are protected or otherwise improved to function in hazard and disaster situations.
- Ensure that new facilities are sited in areas that are not prone to flooding or other hazards.
- Improve the municipality's stormwater management system to enhance infiltration and expand stormwater retention areas.
- Ensure that there is adequate funding and administrative support to implement the recommendations in the local Hazard Mitigation Plan.
- Educate the public to better understand the concept of community resilience and the meaning of probabilities and risk, especially for stream and coastal flooding.
- When making improvements to parks, playgrounds and other open spaces, include improvements so that these areas can function as stormwater retention areas.
- Encourage stormwater drainage improvements that reduce runoff and increase the permeability of the built environment.
- Expand the tree canopy in urbanized areas of the community to reduce heat impacts.
- Continue to improve community resilience in order to qualify for the Community Rating System or improve or maintain the municipality's current Community Rating System score.
- Encourage reduction of carbon emissions in the municipality through improved transportation efficiency, reduction of traffic congestion, encouragement of alternative transportation options (rail, bike, pedestrian infrastructure), and implementation of an anti-idling ordinance for trucks, buses, and other vehicles.
- Ensure that public facility improvements necessary for increasing resiliency have priority placement on the municipal Capital Improvement Program.
- Ensure vulnerable coastal populations receive proper communications before, during, and after storms and are aware of evacuation procedures, location of shelters, and transportation options.

STANDARD 12.5

Include implementation actions within the Implementation Program that would help:

AVOID OR MINIMIZE THE EFFECTS THAT NATURAL HAZARDS POSE TO LIFE, INFRASTUCTURE, AND PROPERY

The implementation actions that the community chooses to include should be reflective of the impacts discussed under Standard 12.3. In order to effectively address the priority impacts identified through the assessment process, comprehensive plans must include implementation actions that make progress towards avoiding or minimizing the effects of the natural hazards that have been identified as priority concerns. For some municipalities, this will include actions that seek to conduct more in-depth vulnerability assessments of key infrastructure, resources and populations.

When determining the implementation actions, communities should consider the following guiding questions:

- Given the likely impacts, what policies should guide local development regulations and decisions?
- Given the likely impacts, what policies should guide investment in public infrastructure and facilities?
- What adaptation actions would be "win-win" for the community, in that they would be beneficial regardless of the occurrence of natural hazards?
- In exposed areas, what infrastructure and community facilities would cause the most community disruption if lost? How can these disruptions be mitigated?
- How can the community help to minimize the impacts to special populations?
- How can the zoning ordinance or subdivision and land development regulations be revised to better adapt to natural hazards and the changing climate?
- In exposed areas, are there currently undeveloped lands that could or should be permanently protected from development?

SAMPLE IMPLEMENTATION ACTIONS

- Define areas of the municipality that fall within these categories: **Protection Zones** that may be hardened to prevent or minimize floodwater intrusion; **Accommodation Zones** that are designed to be temporarily flooded with a high tide or storm event; **Retreat Zones** that have a master plan for managed retreat of structures and residents permanently out of the area; and **Preservation Zones** that have an established management plan for natural or cultural resource preservation.
- Provide incentives for achieving a higher level of flood protection when designing and constructing municipal infrastructure.
- Update the local Hazard Mitigation Plan on a minimum of every 5 years and as needed after natural hazard events.
- Complete vulnerability assessments of all municipal infrastructure to determine priorities for adaptation.

- Complete an assessment to identify the vulnerability of all critical public facilities such as police and fire stations, hospitals, schools, and other services.
- Develop a priority list of facilities that need to be hardened or otherwise improved and seek funding for improvements and coordinate this list with the local hazard mitigation plan
- Develop an acquisition strategy for properties in the municipality's most vulnerable areas, including determination of an appropriate funding source
- Revise local subdivision and land development regulations to require the incorporation of natural drainage systems, such as rain gardens and other small water management infrastructure, in private development.
- Design all new public buildings to include stormwater management best practices including the use of pervious materials, green roofs, and natural drainage systems.
- Undertake a study, working with the local land trust, to identify high priority water-adjacent land that could be designated as permanently protected open space.
- Review land uses in exposed areas to determine whether restrictions are necessary to prevent or lessen potential losses during large storm events.
- Develop design guidelines with examples of attractive design solutions for elevating existing buildings and for development of new elevated buildings.
- Develop and implement a street tree program in the municipality's most urbanized areas.
- Identify tree species that will be most resilient to climate change and use these species in public landscaping projects.
- Develop and disseminate an educational campaign for the public on reducing risks to private property.
- Create an Emergency and Disaster Preparedness section on the municipal website with information on minimizing risk to private property and on general preparedness.
- Work with the state and FEMA to make brochures and other information available on the City website, in the library, and at other city destinations, such as community centers.
- Hire a Community Rating System (CRS) coordinator to gain entrance into or to assist in implementing measures to increase the community's rating for the CRS program.
- Implement use restrictions within Special Flood Hazard Areas, as well as in all areas projected to be inundated by future sea level rise scenarios.
- Create a Sea Level Rise Overlay Zone in a defined area along the coast that restricts or prohibits development of new structures and outlines plans for managing parcels and properties after storm events (debris management, removal requirements of damaged/abandoned structures, etc.)
- Establish a process to reexamine the sea level rise projections and estimated timeframes for rise to maximize protection of assets and public safety within impacted areas.
- Coordinate with RI CRMC and RI DEM to establish clear and consistent setback requirements from boundaries of projected sea level rise scenarios or salt marsh migration areas.
- Ensure all high and significant hazard dams are maintained and in a safe condition.

- Explore the feasibility of structuring a Purchase of Development Rights and Transfer of Development Rights program specific to the Special Flood Hazard Areas to reduce density in the flood-prone areas of the community and the potential to offer qualified property owners a "buyout option".
- Require developers to present preliminary design plans illustrating they have accounted for sea level rise projections and required setbacks from the boundaries of these areas for any parcels proposed for development or redevelopment.
- Define a clear municipal review process for all developments proposed within the areas projected to be exposed to sea level rise.
- Evaluate options and conduct a feasibility assessment/cost-benefit analysis to phase out or downzone coastal properties most exposed or vulnerable to future sea level rise scenarios to reduce financial losses during storm events as well as volume of debris that could cause damage to adjacent properties or municipalities in Rhode Island.
- Provide property owners within the Special Flood Hazard Areas options and incentives for establishing voluntary recorded easements on their properties to dedicate the land on their property as "coastal migration areas."
- For areas of the municipality with municipal services that are vulnerable to sea level rise scenarios, consider the cost-benefit of maintaining this infrastructure and the feasibility of enacting a program of impact fees to cover cost of emergency response, future armoring, or otherwise flood-proofing these areas over the long term.
- Provide tax incentives for property owners who voluntarily implement measures for their parcel and/or structure to be more resilient to storm impacts and projected sea level rise.
- Establish a defined "Adaptation Action Area" special planning district within the municipality to focus adaptation best practices in areas most in need of early actions, and create a long-term master plan for this area.
- Evaluate the long-term viability of properties within projected sea level rise exposure areas and Special Flood Hazard Areas, contact the property owners and ensure they are notified of potential vulnerabilities, and establish procedures to apply long-term maintenance plans for their individual properties and related structures.
- Maintain a separate database of building permits for all properties within the Special Flood Hazard Areas and the projected sea level rise areas, or flag these properties as part of these zones.
- Implement an emergency permit process in the municipality to expedite permit approvals for predetermined repairs or reconstruction immediately following a storm event.
- Work closely with State agency partners to define, evaluate, and communicate rebuilding restrictions in exposed areas.
- Create incentives for homeowners to elevate their homes and offer clearly defined and enforceable height variances if the elevation of the structure will exceed the local height restriction.
- For new construction throughout the municipality, create incentives for builders to design and build structures that are resilient to storm impacts both within and outside of flood zones.

- Coordinate with the State Historic Preservation Officer and the local Historic District Commission to provide resources for owners of historic homes or homes within historic districts who may desire to elevate or otherwise flood-proof their property or structure, without being penalized or removed from the National Register of Historic Places.
- Coordinate with Rhode Island Emergency Management Agency (RIEMA) and owners of properties that are categorized as repetitive loss properties to consider long-term options for flood-proofing, elevating, or relocating the structures.
- Ensure Emergency Action Plans for all high and significant hazard dams are completed and submitted to RIEMA for review and approval.
- Review land uses and development in areas potentially inundated by the failure of high or significant hazard dams to determine whether restrictions are necessary to prevent or lessen potential losses.
- Offer property owners updates and training related to changes or amendments to the local Flood Insurance Rate Maps and the National Flood Insurance Program.
- Require the building official or other municipal staff become a Certified Floodplain Manager by the Association of State Floodplain Managers.
- Require the building official or other municipal staff become certified inspector/evaluator for a "Fortified" program that rates new construction projects based on techniques that result in improved resilience to hazards. (See www.disastersafety.org/fortified.)
- Require that municipal board and commission members participate in some form of annual training for hazard mitigation and coastal resilience to ensure continued implementation of hazard mitigation and climate adaptation actions.
- Evaluate the municipal development plan review procedures, site plan review process and zoning variance parameters related to properties within Special Flood Hazard and sea level rise areas to formalize adaptation strategies and implementation actions into local regulations.

SECTION 3. CRAFT A BETTER PLAN

RECOMMENDATION 12.6

Include implementation actions within the Implementation Program that:

WOULD HELP TO ACHIEVE A HIGH COMMUNITY RATING SYSTEM (CRS) SCORE

The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted community-wide to reflect the reduced flood risk resulting from the community actions. The comprehensive plan is a good place to set the framework for implementing the actions necessary to receive discounts through the CRS program as many of the actions relate to the built environment.

For more information on the actions that could be included in the comprehensive plan that would help to achieve a high Community Rating System score, visit http://www.fema.gov/national-flood-insurance-program/national-flood-insurance-program-community-rating-system or speak to the Floodplain Manager at the Rhode Island Emergency Management Agency by calling (401) 946-9996.

SECTION 4. ADDITIONAL RESOURCES

OVERVIEW OF A CHANGING CLIMATE IN RHODE ISLAND

Authors: ***David Vallee****, NOAA/National Weather Service, Northeast River Forecast Center, and* ***Lenny Giuliano,*** *Air Quality Specialist, Rhode Island Department of Environmental Management, State Climatologist, State of Rhode Island*

Rhode Island has experience a significant trend over the past 80 years toward a warmer and wetter climate regime. Trends are evident in annual temperatures, annual precipitation, and the frequency of intense rainfall events. Inland, these trends have combined to produce an increase in river flooding; some locations are experiencing more floods while other locations are seeing an increase in the severity of floods.

TEMPERATURE TRENDS

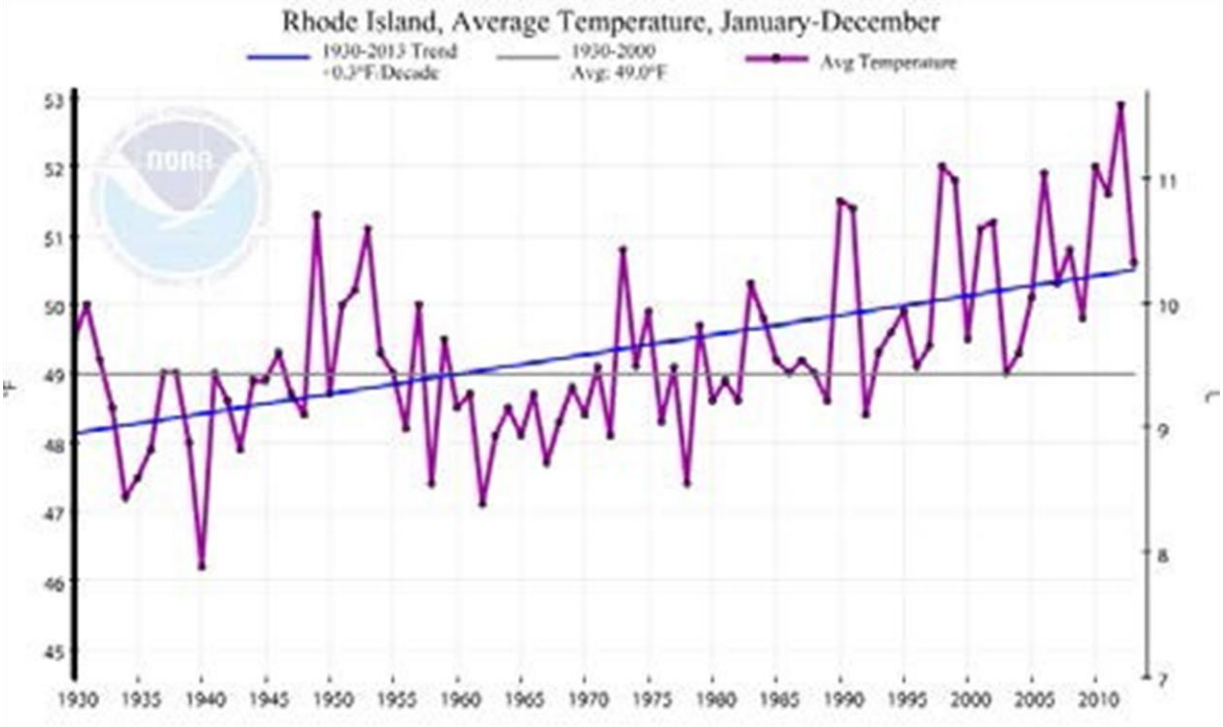
Temperatures have been steadily climbing in the ocean state since the early 1930s (Figure 1a). The average annual temperature for the state is currently increasing at a rate of 1 degree Fahrenheit every 33 years. What is most interesting is the inability for the state to sustain cold years. Notice the frequency of years with an annual temperature at or below 48 degrees prior to 1970 vs. after 1970. Only one year has produced an average annual temperature at or below 48 degrees since 1970. Similarly, notice the absence of years producing average annual temperatures warmer than 51 degrees compared to how frequently they have occurred over the past decade. See Figure 12-1 Average Annual Temperature for Rhode Island for the Period 1930 to 2013.

Further examination of the warming trend yields other significant indicators as to how the warming is playing out across the region. The frequency of days with high temperatures at or above 90 degree has increased while the frequency of days with minimum temperatures at or below freezing has decreased. Figure 12-2 provides an analysis since 1949 of the number of days per year in which maximum temperatures equaled or exceeded 90 degrees. Notice the upward trend in the frequency of 90 degree days since 1970; the average number of days expected in 1950 was about 7 while the new normal is 12. Similarly, Figure 12-3 provides an analysis since 1949 of the number of days per year in which minimum temperatures were equal to or colder than 32 degrees. Prior to 1980 experiencing minimum temperatures at or below freezing typically exceeded 120 days in the year. Since 1980, notice how infrequent this has become, and since 2000 not one year has experienced 120 or more days below 32 degrees. See Figure 12-2. Days Experiencing Maximum Temperatures of 90 Degrees or Greater for the Period 1949-2012, as Recorded at the National Weather Service Office T. F. Green State Airport.

PRECIPITATION

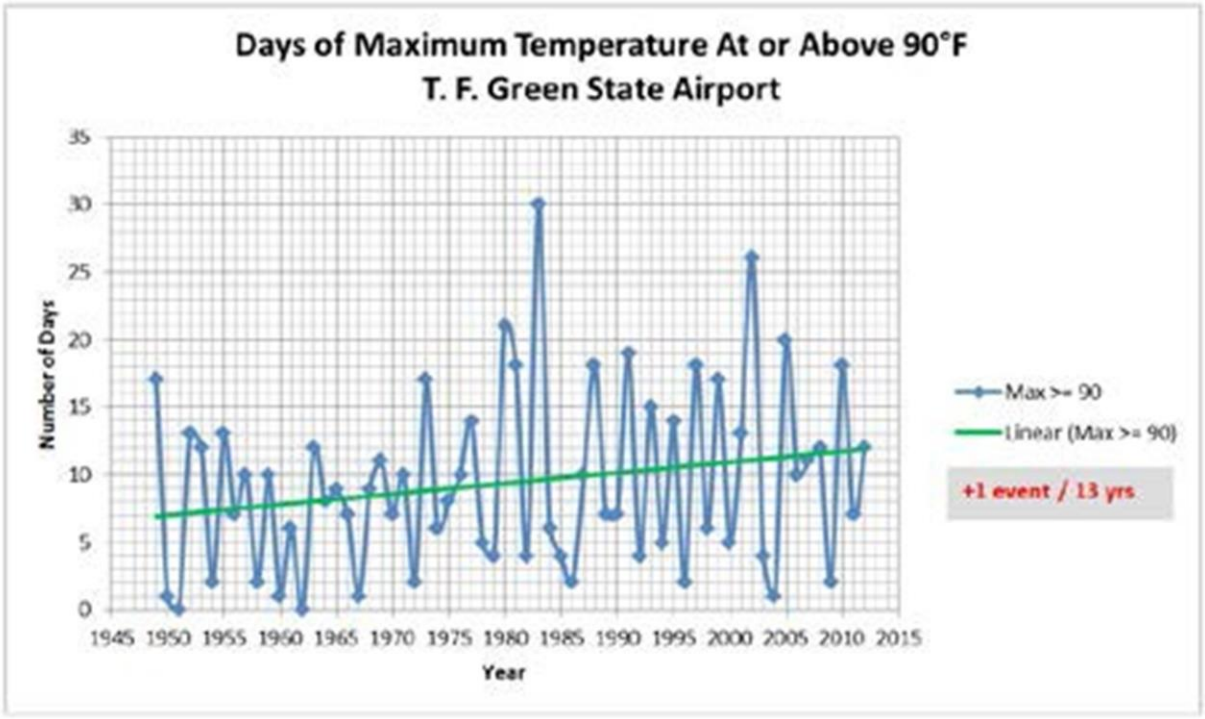
Equally as striking is the pronounced increase in precipitation from 1930 to 2013. Increased precipitation has occurred as a result of large, slow moving storm systems, multiple events in the span of a few weeks (such as the 2010 spring floods), as well as an increase in the frequency of intense rain events. The average annual precipitation for Rhode Island is increasing at a rate of more than 1 inch every 10 years. The frequency of days having one inch of rainfall has nearly doubled. Notice the striking absence of dry years with precipitation less than 40 inches and the increased frequency of years producing more than 55 inches of precipitation. See Figure 12-3. Days Experiencing Minimum Temperatures of 32 Degrees or Less for the Period 1949-2012, as Recorded at the National Weather Service Office T. F. Green State Airport and Figure 12-4. Average Annual Precipitation for Rhode Island for the Period 1930 to 2013.

FIGURE 12-1. AVERAGE ANNUAL TEMPERATURE FOR RHODE ISLAND FOR THE PERIOD 1930 TO 2013



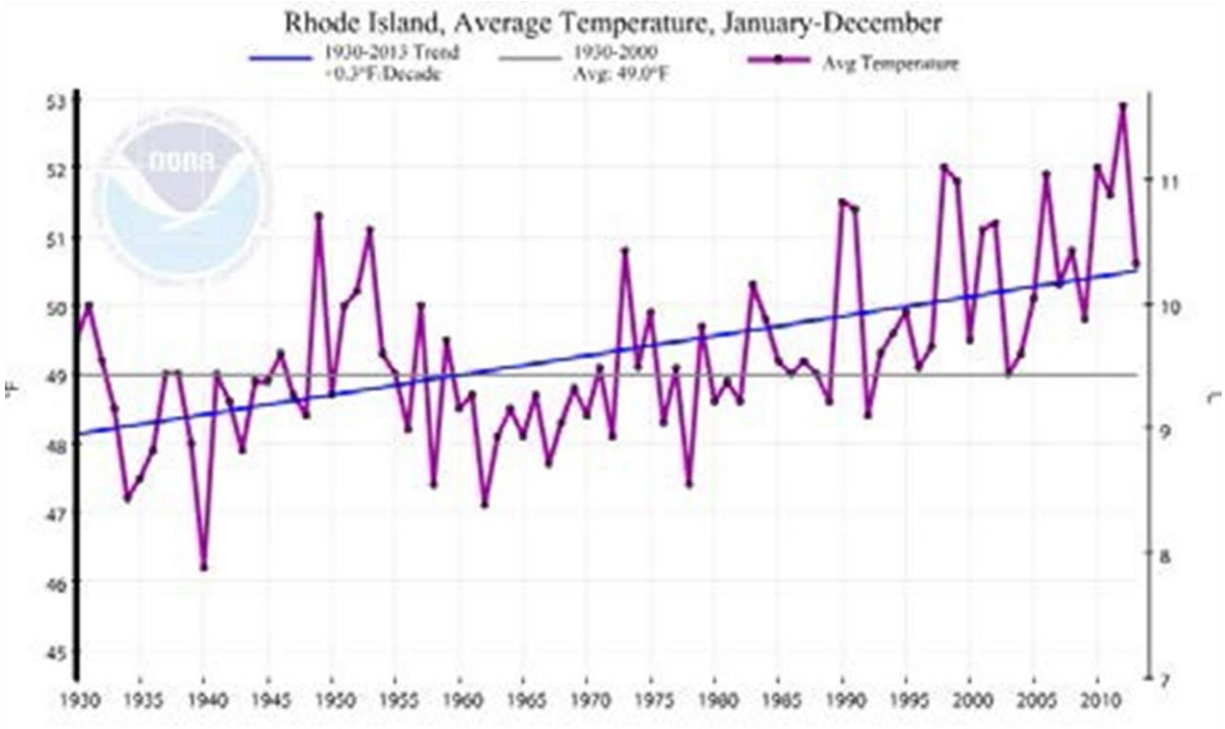
Data provided by the National Climatic Data Center at http://www.ncdc.noaa.gov/cag

FIGURE 12-2. DAYS EXPERIENCING MAXIMUM TEMPERATURES OF 90 DEGREES OR GREATER FOR THE PERIOD 1949-2012, AS RECORDED AT THE NATIONAL WEATHER SERVICE OFFICE T. F. GREEN STATE AIRPORT



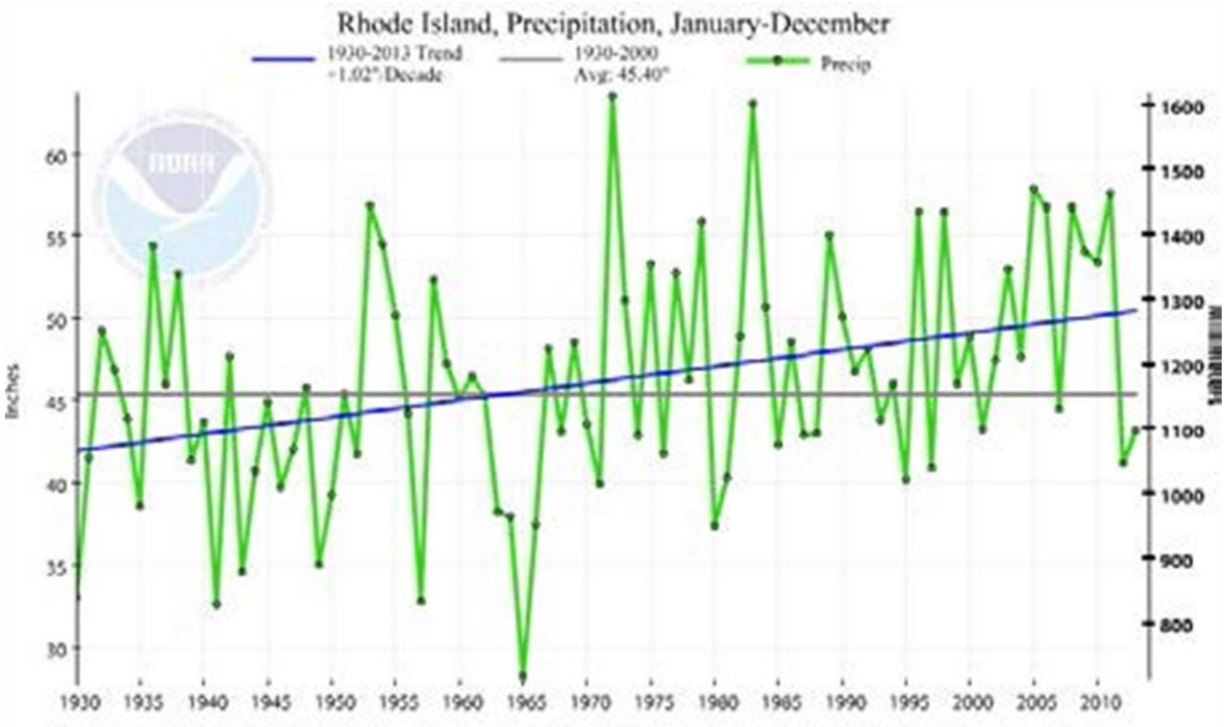
Analysis provided by the Northeast River Forecast Center

FIGURE 12-3. DAYS EXPERIENCING MINIMUM TEMPERATURES OF 32 DEGREES OR LESS FOR THE PERIOD 1949-2012, AS RECORDED AT THE NATIONAL WEATHER SERVICE OFFICE T. F. GREEN STATE AIRPORT



Analysis provided by the Northeast River Forecast Center

FIGURE 12-4. AVERAGE ANNUAL PRECIPITATION FOR RHODE ISLAND FOR THE PERIOD 1930 TO 2013



Data provided by the National Climatic Data Center at http://www.ncdc.noaa.gov/cag

RELATIONSHIP TO INCREASED FLOODING

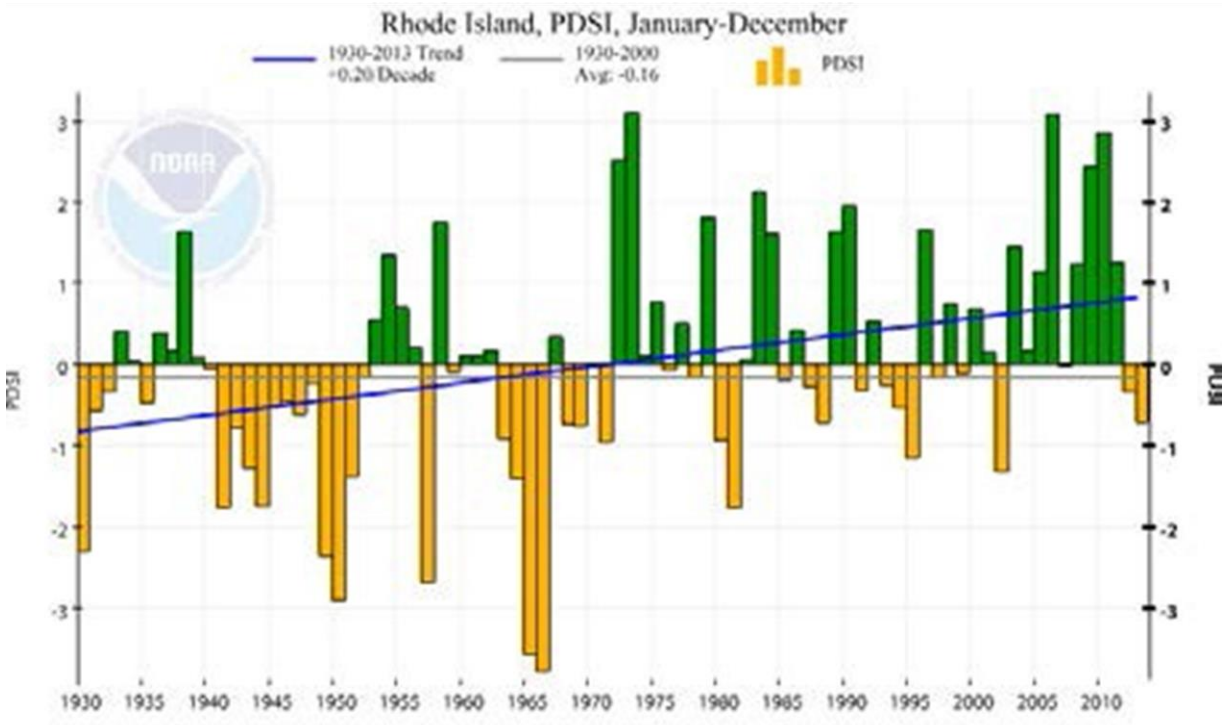
The increased amounts of precipitation since 1970 has resulted in a much wetter state to soil moisture and the ground's ability to absorb rainfall. One way of examining this is through the Palmer Drought Severity Index. The Palmer index tracks 6 to 18 month rainfall deficits in its calculation of drought severity. If one thinks of the soil as a sponge, shorter dry periods and more prolonged wet periods results in the sponge being full more frequently. This makes it less capable of handling additional rainfall which in turn increases the potential for flooding on the state's rivers and streams. Basins that have experienced considerable urbanization will have far less capacity to handle the additional runoff compared to a basin in which there remains considerable natural storage or less urbanization over time. Similarly, basins which may have flood control structures may not necessarily see an increase in the severity of flooding but may see in increase in the frequency of less severe floods. Rhode Island has a mixture of all of these types of issues. See Figure 12-5. Palmer Drought Severity Index for Rhode Island for the Period 1930 to 2013.

Rhode Island has seen the increase in precipitation and frequency of intense rainfall events play itself out in a variety of ways. The vast majority of the state's storm drainage infrastructure was designed based on rainfall frequencies that were derived in the early 1960s. In addition, considerable urbanization has taken place along much of the I-95 corridor in the past 40 years. The combined effects of urbanization and increased rainfall have resulted in increased urban and larger river system flooding. Urban areas are seeing increased issues with flash flooding in poor drainage areas where systems are likely undersized for the new rainfall amounts and intensities. The devastating floods of 2010 illustrated the challenges of the total wetter regime as multiple heavy rain storms impacted the state over the span of 5 weeks. The net result was some of the worst flooding in the state's history along rivers large and small, and in normally dry areas removed from stream channels as ground water levels rose to fill basements with water. Figure 4 is just one example for the Pawtuxet River at Cranston, RI, which illustrates just how dramatically flood frequency and flood magnitude have changed since the early 1940s. The lower portion of the Pawtuxet has experienced dramatic urbanization over the past 40 years.

The Blackstone River in Woonsocket is a basin with flood control projects in place at its headwaters in Worcester and by the West Hill Dam in Uxbridge. These structures were designed to retain runoff during high flow events and to release that water gradually after the flood wave has moved downstream. As depicted in Figure 5, in spite flood control projects established in the 1960s, this basin has also seen in increase in flood frequency but not necessarily magnitude. See Figure 12-6. Flood History at the USGS Gage Location in Cranston, RI on the Pawtuxet River.

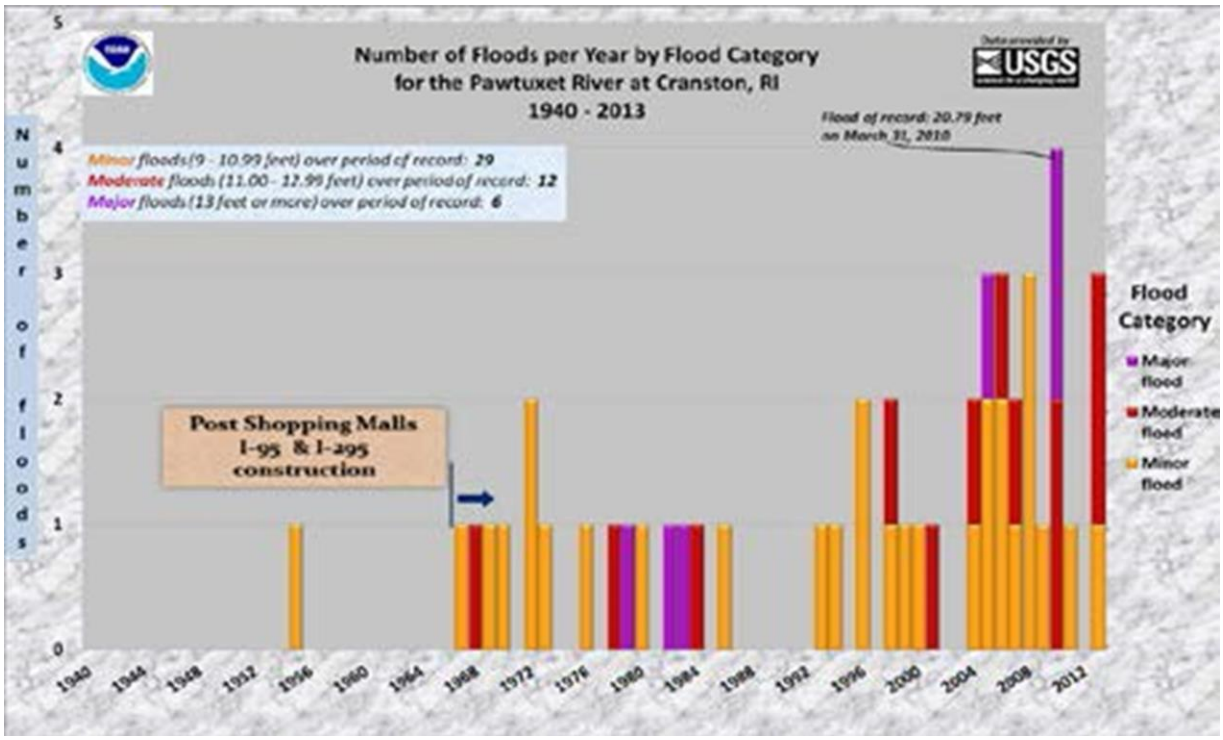
The Pawcatuck watershed is another unique and complex system with considerable natural storage through its eastern headwaters in the Wood River Junction area to the tidal affected lower reach through Westerly. Figure 12-7. Flood history at the USGS Gage Location in Wood River Junction, RI on the Pawcatuck River and Figure 12-8. Flood history at the USGS gage location in Westerly, RI on the Pawcatuck River provide an overview of the basin's flood history. At Wood River Junction, flood frequency increased dramatically after 1970 but has diminished again after 1986 with just one outstanding event; the record floods of 2010. This shift suggests perhaps water management practices were implement in this portion of the watershed that have resulted in a dampening of the climate signal. Westerly, however, is more representative of other rivers in the state, with an increase in the magnitude and frequency of flooding after 1970.

FIGURE 12-5. PALMER DROUGHT SEVERITY INDEX FOR RHODE ISLAND FOR THE PERIOD 1930 TO 2013



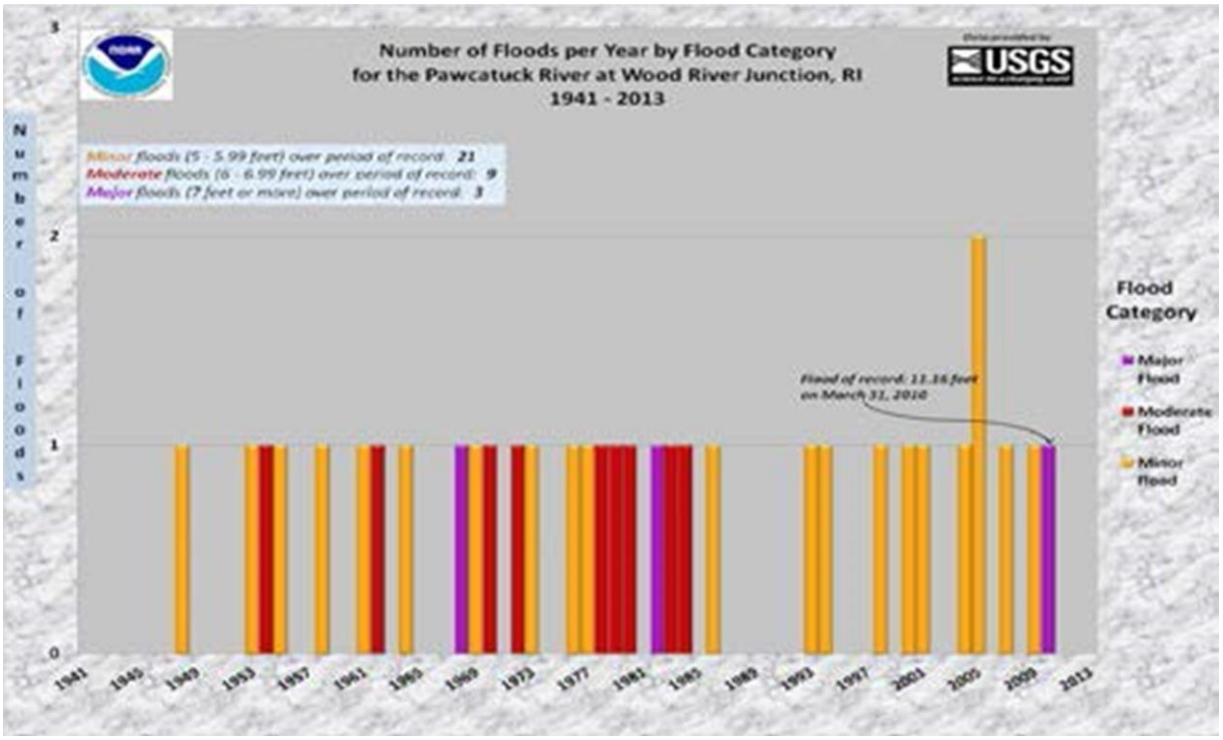
Data provided by the National Climatic Data Center at http://www.ncdc.noaa.gov/cag.

FIGURE 12-6 FLOOD HISTORY AT THE USGS GAGE LOCATION IN CRANSTON, RI ON THE PAWTUXET RIVER



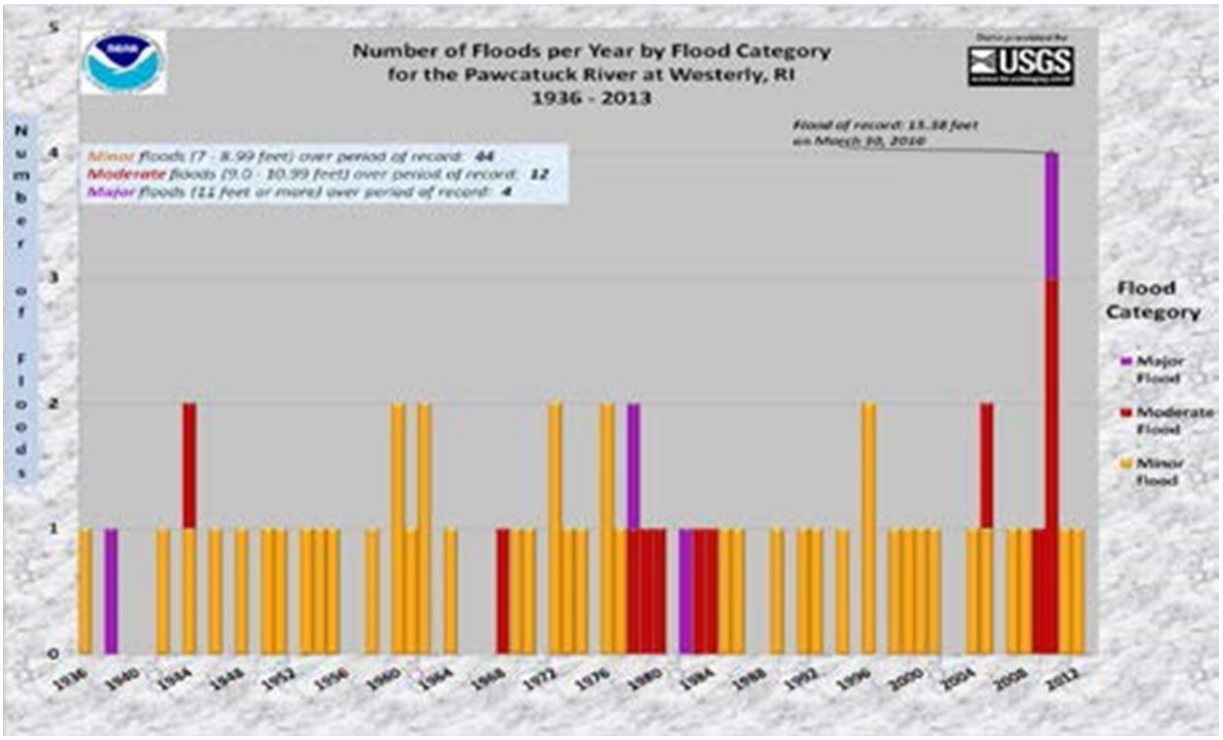
The color of the bar indicates the severity of the flood. Notice the dramatic increase in both frequency of flooding since the late 1960s, the frequency of multiple floods in a given year, and the severity of these floods. Floods in the major category approximate the 100 year base flood elevation based on the local FIRMS.

FIGURE 12-7. FLOOD HISTORY AT THE USGS GAGE LOCATION IN WOOD RIVER JUNCTION, RI ON THE PAWCATUCK RIVER



Color bars indicate the severity of flooding.

FIGURE 12-8 FLOOD HISTORY AT THE USGS GAGE LOCATION IN WESTERLY, RI ON THE PAWCATUCK RIVER



Color bars indicate the severity of flooding.

GUIDANCE FOR MUNICIPALITIES IN THE CONSIDERATION OF PROJECTED FUTURE CHANGES TO RIVERINE FLOODPLAINS

Author: ***Jim Boyd***, Coastal Policy Analyst, RI Coastal Resources Management Council

The State is already experiencing a rising trend in greater overall annual precipitation. This increase in rainfall has resulted in a greater frequency of riverine flooding within our communities, especially over the last two decades. The increase in flooding has dramatically risen as more frequent heavy rain storms impact the region. Consider that some communities are now seeing significant flooding problems occur on an annual basis, and in some cases even several times within the same year. See Figures 12-2 and 12-4 on of "Overview of a Changing Climate in Rhode Island."

As part of assessing vulnerability to flooding along streams and rivers, communities rely upon the regulatory FEMA Flood Insurance Rate Maps (FIRMs) that depict the extent of the designated floodplain for both the 1% and 0.2% annual chance flood events. These storms are also known as the 100 year and 500 year storm events. The floodplains that are shown on the FIRMs are based on hydrologic modeling using the precipitation that occurs during these large storms. However, the hydrologic modeling does not account for the increases in precipitation that are projected for the future. Thus, the current FIRMs may underestimate the extent of the 1% and 0.2% floodplains in the future. Since most community planning horizons are a minimum of 20 years or more, it will be important to examine estimated riverine and stream floodplains under future projected precipitation scenarios to assess the vulnerability of existing structures and plan for future community capital expenses.

The Rhode Island Department of Health contracted with Tetra Tech, Inc. to undertake an assessment of potential climate change impacts to Rhode Island drinking water utilities. See: http://www.health.ri.gov/healthrisks/climatechange. As part of their Phase 2 Report completed in December of 2012, Tetra Tech estimated hydrologic changes at the Pawtuxet River outlet (Pawtuxet Cove, Cranston) using eight climate scenarios for three time horizons of 2022, 2052, and 2084. The maximum peak flow from the 1% annual chance flood projected for these three time frames was an increase of 15.9%, 12.2%, and 6.2% respectively. Assuming that the future projected flow conditions for the Pawtuxet River may apply similarly to other watersheds in Rhode Island, it would be expected that the area of floodplains within the state may increase in the future. The result will be that areas within a current floodplain may experience deeper flood waters, while areas adjacent to these riverine floodplains that are not currently impacted by flood waters may be flooded in the future under the projected scenarios.

Tetra Tech developed a riverine flood hazard assessment that produced future floodplains for the 1% annual chance event by: (1) conducting a flood frequency analysis using the climate change model output; (2) extrapolating additional flow values for watersheds outside the pilot (Pawtuxet River watershed) area; and (3) using flow values in the HAZUS hydraulic model. The results are depicted in the map layer titled "Flooding Impacts to Rhode Island Utilities" as shown in Figure 40 of the Phase 2 report. The map shows the 1% annual chance floodplains for the years 2022, 2052 throughout the state. The 0.2% annual chance floodplain was not modeled due to insufficient historic data and the associated uncertainty with projecting such a floodplain. Nevertheless, in the interim communities can use the Tetra Tech generated future floodplains for the projected timeframes for planning purposes and to assess the vulnerability of structures within or in nearby proximity to these floodplains.

U.S. ARMY CORPS OF ENGINEERS SEA LEVEL RISE PROJECTIONS

The U.S. Army Corps of Engineers (USACE) has produced a three-scenario (low, intermediate, and high) sea level rise projection for the State of Rhode Island based on data collected by the Providence sea level gauge station. The USACE Low data is based on the historic rate of sea-level change. The USACE Intermediate data is computed from the modified NRC Curve I considering both the most recent IPCC projections and modified NRC projections with the local rate of vertical land movement added. The USACE High data is computed from the modified NRC Curve III considering both the most recent IPCC projections and modified NRC projections with the local rate of vertical land movement added.

The data below comes directly from the USACE website at www.corpsclimate.us/ccaceslcurves.cfm, using the RI - Providence gauge input. The numbers for each year are in feet, projecting the change in sea level from 1992 levels.

YEAR	USACE LOW	USACE INTERMEDIATE	USACE HIGH
2010	0.12	0.15	0.24
2015	0.15	0.20	0.35
2020	0.18	0.25	0.47
2025	0.22	0.31	0.62
2030	0.25	0.38	0.78
2035	0.28	0.45	0.97
2040	0.31	0.52	1.17
2045	0.35	0.60	1.39
2050	0.38	0.68	1.63
2055	0.41	0.77	1.88
2060	0.45	0.86	2.16
2065	0.48	0.95	2.45
2070	0.51	1.05	2.77
2075	0.54	1.16	3.10
2080	0.58	1.27	3.45
2085	0.61	1.38	3.82
2090	0.64	1.50	4.20
2095	0.68	1.62	4.61
2100	0.71	1.75	5.03

As illustrated by the data above, the low estimate for sea level rise by the year 2100 is approximately **8 1/2 inches**, while the intermediate estimate is **1 foot, 9 inches** and the high estimate is approximately **5 feet.** While this range is relatively wide, it benefits municipalities to be aware of all of the potential scenarios for sea level rise and to share these scenarios with the public during the comprehensive planning process.

SAMPLE PROCESS FOR CONDUCTING A PRELIMINARY COMMUNITY VULNERABILITY ASSESSMENT

The process outlined here seeks to determine possible impacts within the community. It is not expected that municipalities will undertake full vulnerability assessments for each building, system, etc. However, if any major impacts are identified, the comprehensive plan should call for the undertaking of a full vulnerability assessment.

STEP 1: IDENTIFY THE INFRASTRUCTURE, ASSETS, RESOURCES, AND POPULATIONS THAT MAY BE VULNERABLE

The first step in identifying the priority issues that the community may face in the event of future natural hazards and climate change is to determine the infrastructure, assets, resources and populations that may be vulnerable, both due to exposure (as discussed under Standard 12.2) and due to their general characteristics.

This portion of the preliminary assessment should look at all of the important pieces that make up a community - buildings and structures, public facilities and infrastructure, environmental resources, and special populations. A listing of various types of infrastructure, assets, resources and populations that should be assessed has been included in Table 12-2. Infrastructure, Assets, Resources, and Populations. Communities must determine which infrastructure, assets, resources, and populations are applicable for their context, with the understanding that not every community will have and/or discuss all of the items listed in Table 12-2.

To make this step of the preliminary assessment more manageable, communities should undertake it in two phases. First, communities should look at, or overlay, the maps of the areas that will be exposed to sea level rise and flooding with maps showing various components of the community to determine what lies within those areas, or what will be exposed and therefore potentially vulnerable. Second, communities should consider the full list of infrastructure, assets, resources, and populations outlined in Table 12-2 to determine if they are likely to be impacted by any other priority natural hazard and climate change trends. For example, businesses that rely on water for their economic activity may be specifically impacted by drought. Heavily forested areas may become more susceptible to forest fire with increased drought and/or heat waves. Populations without access to a private vehicle may be particularly impacted by any natural hazard that causes evacuation of their neighborhood.

A Preliminary Impact Evaluation Matrix has been included to assist in the second phase of this assessment. To use the matrix, list the natural hazards and climate change trends that are priorities for the municipality along the top (the columns) and list the pieces of the community to be assessed along the side (the rows). Then, mark off those components that seem likely to be impacted by the priority trends, based on previous experience, general knowledge of the community, exposure mapping, and any public input received.

STEP 2: ASSESS THE POTENTIAL EFFECTS OF PRIORITY NATURAL HAZARDS AND CLIMATE CHANGE TRENDS ON THE COMMUNITY

Once it is determined which components of the community will likely be impacted by priority natural hazards and climate change trends, the effects of such impacts on the community can be assessed.

TABLE 12-2. INFRASTRUCTURE, ASSETS, RESOURCES, AND POPULATIONS

BUILDINGS AND INFRASTRUCTURE

Residential neighborhoods and homes

Commercial areas and businesses

Industrial areas and businesses

Historic and cultural structures and sites

Public facilities and infrastructure

Emergency facilities, such as police and fire stations and emergency shelters

Healthcare facilities, nursing homes and assisted living facilities

Municipal buildings, such as city/town hall, other administrative or facility buildings

Schools and libraries

Major roads and evacuation routes

Public transportation routes or stops

Public transportation hubs

Rail lines and stations

Airports

Water supply infrastructure

Wastewater infrastructure

Stormwater drainage systems

Natural gas infrastructure

Electricity infrastructure

Energy production facilities

Marine facilities

Dams

Solid waste transfer stations

Telecommunications infrastructure

NATURAL RESOURCES

Parks and recreation facilities

Lakes, rivers and other water bodies

Reservoirs

Wetlands (coastal and freshwater)

Coastal barriers (dunes, marshes, coastal ponds)

Wildlife and endangered species

Forests

Undeveloped and/or conservation lands

SPECIAL POPULATIONS

Senior citizens

Young children

Low-income, unemployed or under-employed persons and households

Renters

Homeless persons and families

Seasonal residents

Students

Non-English speaking or limited English proficiency persons and households

Individuals with disabilities

Individuals with compromised immune systems or those who are chronically ill

Individuals with limited access to a personal automobile

Individuals uncertain about available resources because of citizenship status

Tourists

This evaluation will help communities determine which components of the community, if impacted by natural hazards and climate change trends, would cause the most disruption to the community, would have the greatest effect on quality of life, and/or would cause the most costly or irreparable damage.

Though primarily qualitative, this assessment should include a thoughtful analysis of each potentially impacted community component (identified as part of step 1) against each natural hazard and/or long-term climate change trend it will likely be exposed to or impacted by, in order to ascertain the severity of the impacts.

Assessment of the severity of impacts should be based on several considerations:

- The permanence of the impact (permanent, temporary, temporary until repaired, etc.);
- The number of people and/or businesses that will likely be affected by the impact;
- Whether any special populations will be unduly harmed by the impact; and
- Whether any community functions and/or values (e.g. public health and safety, education, tourism) will be impacted (see Table 12-3. Community Functions and Values for a list).

To assist in completing this assessment, an evaluation matrix, the Impact Severity Tool and an example of a completed evaluation matrix has been provided. The evaluation matrix is intended to be used to evaluate the impacts of each priority natural hazard or climate change impact on each potentially vulnerable piece of infrastructure, asset, resource, and population. To fill in the matrix, enter one potential impact into each row under the column heading, "impacts" as shown in the example. Then, under each subsequent column (except the last column), fill in the appropriate information. Use the last column to indicate whether overall impact severity seems to be high, medium, or low, based on the values entered for the remainder of the row.

Some aspects of community vulnerability that are not often considered, but may be of prime importance to the community are tree loss and erosion. Hurricane related winds and winter storms have the potential to cause massive losses related to tree damage, including large scale power losses, damage to structures, impassable roads, and extensive debris, which can all be added expenses for a municipality. Storms also drive erosion, which is an important consideration for both infrastructure and private development. The RI Coastal Resource Management Agency has developed Shoreline Change Maps (available at www.crmc.ri.gov/maps/maps_shorechange.html), which can help municipalities evaluate risk.

STEP 3: PRIORITIZE THE IMPACTS THAT THE MUNICIPALITY WOULD FACE IN THE EVENT OF FUTURE NATURAL HAZARDS AND LONG-TERM CLIMATE CHANGE

The steps of the preliminary vulnerability assessment outlined above will help the community understand what is likely to be vulnerable to natural hazards and climate change trends and how severe the likely impacts will be. To create a plan of action for minimizing the impacts, communities should also prioritize their needs so that money and effort can be expended toward the greatest effect. Prioritization of needs also allows communities to determine which impacts require immediate action, versus those that can be addressed at a later date.

For many communities, the identification of the most severe impacts will provide sufficient information to begin to determine priority. However, depending on the level of interest and time available, the community may wish to go through the full prioritization exercise described below.

TABLE 12-3. COMMUNITY FUNCTIONS AND VALUES

Some typical community functions and values that may be relevant to assess include:	
GOVERNMENT CONTINUITY	CONSERVATION
EMERGENCY SERVICES	MOBILITY AND TRANSPORTATION ACCESS
PUBLIC SAFETY	EDUCATION
PUBLIC HEALTH	QUALITY OF LIFE
BUSINESS CONTINUITY	SOCIAL SERVICES
HOUSING ACCESS	ECOLOGICAL FUNCTION
ECONOMIC ACTIVITY	TOURISM
EMPLOYMENT AND JOB ACCESS	RECREATION
FOOD SECURITY	

Prioritizing the impacts of natural hazards and climate change trends is a multi-step process. A sample Impact Prioritization Tool has been included to assist communities in the prioritization of natural hazard and climate change impacts. The Impact Prioritization Tool first combines the overall impact severity rating (high, medium, or low) from Step 2 with the adaptive capacity to determine the level of need (high, medium, or low). Then, the tool combines the level of need with the anticipated onset of the trends to determine priority (high, medium, or low). Each step in the process is described below.

Assessing Adaptive Capacity

Adaptive capacity refers to the current ability of a community to address a potential impact or to manage in the case of an impact. Assessment of adaptive capacity is subjective and highly variable depending on a number of factors. For example, if there is already a policy, program, institution or organization addressing a potential impact, or if there is another resource that could supplement the impacted community functions, the priority for addressing the impact may be less than the priority for addressing a different impact. However, it may also be the case that even though work is being done to address an impact, the severity of the impact is so high that it should still be a priority concern for the municipality. While some determinations of adaptive capacity may be straightforward, others may need more in-depth evaluation.

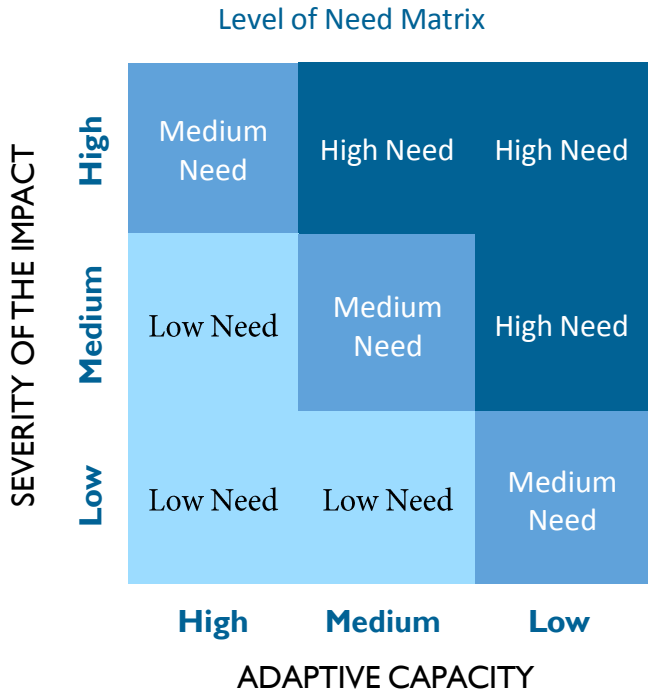
The community should assess the current level of adaptive capacity for each identified impact (high, medium, low). High adaptive capacity indicates that measures are already in place to address projected impacts; low adaptive capacity indicates that a community is generally unprepared. To determine adaptive capacity, communities should consider the following guiding questions:

- Generally, how prepared is the community to survive, recover and/or function if the resource is impacted?

- Are there currently actions in progress, planned, ready for implementation or being implemented to address the projected impact?
- If the actions are not being implemented, how long until implementation begins? What resources will be necessary for implementation?
- To what extent are the actions addressing the potential impact? Is it enough?
- Could the policy or program be strengthened to better address the potential impact or to address additional impacts?
- Is the community prepared to handle the impacts to populations and/or community functions and values in some other way?

Determining Need

When adaptive capacity is compared to the severity of the impact, a level of need can be determined. Generally, if something causes a high level of impact, but the capacity to adapt to the impact is also high, the need for additional action is low. Conversely, if the level of impact is high and the adaptive capacity is low, the need for additional action is high. The Level of Need Matrix to the right shows the relationship between adaptive capacity, impact severity and need. However, municipalities should feel free to put all actions to address all potential impacts, whether high or low need, within the Implementation Program of their comprehensive plans, if there is general support for undertaking them.



Assessing Onset

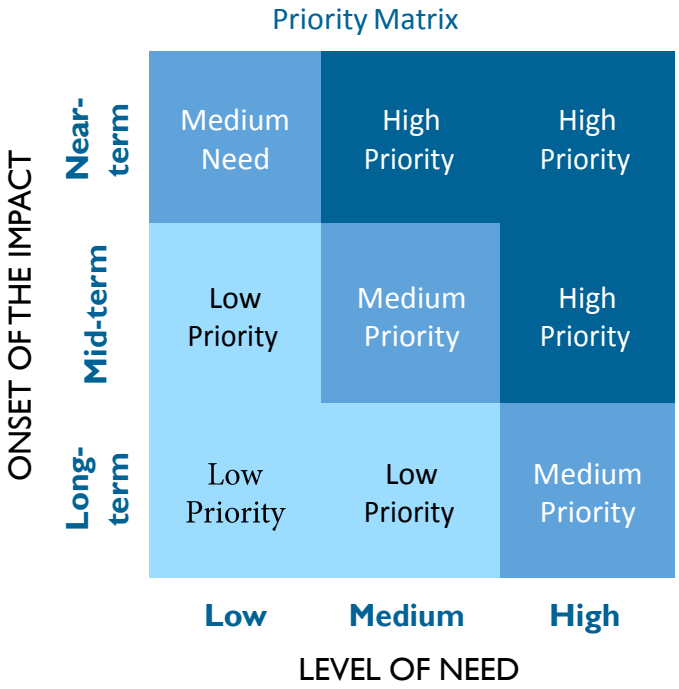
Onset refers to the time frame in which the community will likely feel the impacts of the natural hazard or climate change trends. Determining onset will assist in determining whether implementation actions should be near-, mid- or long-term. Table 12-4. Onset shows the general onset timeframes typically used in assessing vulnerabilities to natural hazards and climate change.

TABLE 12-4. ONSET

TIME FRAME	ONSET
Current – the community is feeling the impacts now or has felt the impacts in the past.	Near-term
Impacts likely between now and 2035	Near-term
Impacts likely between 2035 and 2065	Mid-term
Impacts likely between 2065 and 2100	Long-term

Determining Priority

To determine priority, the anticipated onset of the impact can be combined with the level of need. Generally, if something is near-term and high need, the priority will be high. Conversely, if something is long-term and low need, the priority will be low. The Priority Matrix on the next page shows the relationship between onset, need and priority.



STEP 4: INCLUDE DISCUSSION OF PRIORITY IMPACTS WITHIN THE COMPREHENSIVE PLAN

The steps of the preliminary vulnerability assessment outlined thus far will bring the community to understanding which potential impacts should be considered "high priority" for the municipality. To receive State approval, comprehensive plans must discuss the priority impacts and the ways in which the municipality will address the impacts, and include appropriate policies and implementation actions for addressing the impacts within the Implementation Program.

DATA SOURCES

To fulfill this standard, communities may want to use the GIS data sources listed under Standard 12.2 to determine exposure. The GIS data listed in all of the other handbooks can also be used to determine the locations of assets, resources and populations.

Communities may also wish to have discussions with the public, business owners, department heads and other community stakeholders.

SAMPLE MATRICES AND TOOLS FOR CONDUCTING A PRELIMINARY COMMUNITY VULNERABILITY ASSESSMENT

PRELIMINARY IMPACT EVALUATION MATRIX

RESOURCES/INFRASTRUCTURE/POPULATIONS	HAZARDS														COMMENT

PRELIMINARY IMPACT EVALUATION MATRIX - SAMPLE

RESOURCES/INFRASTRUCTURE/POPULATIONS	HAZARDS														COMMENT
	Sea Level Rise	*Storm Surge*	*Riverine Flooding*	*Extreme Cold*	*Heat Waves*	*High Heat Days*	*Drought*	*Hurricanes*	*Coastal Erosion*	*Flash Flooding*	*Heavy Snow*				
"The Point" Residential Neighborhood	X	X					X	X	X	X	X				*High density*
"Bayview Industrial Park"	X	X		X	X	X	X	X	X	X	X				
"River Landing" Town Center			X	X	X	X	X			X					
Police Station		X		X			X			X	X				*Needs insulation*
Fire Station 1	X	X		X			X	X	X						*Has new roof*
Fire Station 2			X				X								
Senior Center				X		X				X					*Flood prone area*
Elementary School				X	X	X									
Middle School				X	X	X									
High School				X	X	X									
Wastewater Treatment Facility	X	X					X	X	X						
Marinas	X	X					X	X	X						
Coastal Wetlands	X				X	X	X								
Spotted Owl Habitat					X	X	X								
Seniors				X	X	X	X	X							
Persons without Access to a Private Vehicle		X	X					X		X	X				
Limited English Speaking Residents		X	X	X	X		X	X		X	X				
"Bayfront Park"	X	X						X	X						
Rt 789 - Evacuation Route	X	X						X		X					

IMPACT SEVERITY TOOL

Impact Statement:_____

IMPACTS	PERMANENCE	POPULATIONS DISRUPTED	COMMUNITY FUNCTIONS/ VALUES DISRUPTED	OVERALL IMPACT SEVERITY *(high, medium, low)*

IMPACT SEVERITY TOOL - SAMPLE

Impact Statement: *"Bayfront Park" will be impacted by coastal erosion.*

IMPACTS	PERMANENCE	POPULATIONS DISRUPTED	COMMUNITY FUNCTIONS/ VALUES DISRUPTED	OVERALL IMPACT SEVERITY *(high, medium, low)*
Loss of bayfront walkway	*Permanent until fixed*	*All*	*Public health, quality of life*	*Medium*
Loss of fishing area	*Permanent until fixed*	*All*	*Quality of life*	*Low*
Interrupted use of only park in neighborhood	*Temporary*	*Neighborhood population*	*Public health, quality of life*	*Medium*

IMPACT PRIORITIZATION TOOL

Impact Statement: _____

IMPACTS	IMPACT SEVERITY *(high, medium, low)*	ADAPTIVE CAPACITY *(high, medium, low)*	LEVEL OF NEED *(high, medium, low)*	ONSET	PRIORITY *(high, medium, low)*

↑ List from Impact Severity Matrix

↑ Last column of Impact Severity Matrix

↑ See page 40 for guiding questions

↑ See Level of Need Matrix, page 41

↑ See Table 12-4. Onset on page 41

↑ See Priority Matrix, page 41

IMPACT PRIORITIZATION TOOL - SAMPLE

Impact Statement: *"Bayfront Park" will be impacted by coastal erosion.*

IMPACTS	IMPACT SEVERITY *(high, medium, low)*	ADAPTIVE CAPACITY *(high, medium, low)*	LEVEL OF NEED *(high, medium, low)*	ONSET	PRIORITY *(high, medium, low)*
Loss of bayfront walkway	*Medium*	*High*	*Low Need*	*Near-term*	*Low*
Loss of fishing area	*Low*	*Low*	*Medium Need*	*Near-term*	*High*
Interrupted use of only park in neighborhood	*Medium*	*Low*	*High Need*	*Near-term*	*High*
↑ List from Impact Severity Matrix	↑ Last column of Impact Severity Matrix	↑	↑	↑ See Table 12-4. Onset	↑ See Priority Matrix