



# Long-Term Community Resilience Exercise Resource Guide

Historical Reference Documents

November 2021



FEMA

The following series of Exercise Seminar Participant and Situation Manuals are being provided as historical reference to the November 2021 Long-Term Community Resilience Exercise Resource Guide (ERG). These documents are intended to show examples of climate adaptation exercise structure and content. As this reference cites past exercises, some information found within the manuals may no longer be current and internet links may no longer be functional. It should also be noted that certain names and addresses, not pertinent to the documents' role as ERG reference material, have been redacted.

Requests for further information about the Long-Term Community Resilience ERG, as well as questions and comments, may be sent to [NEP@fema.dhs.gov](mailto:NEP@fema.dhs.gov).



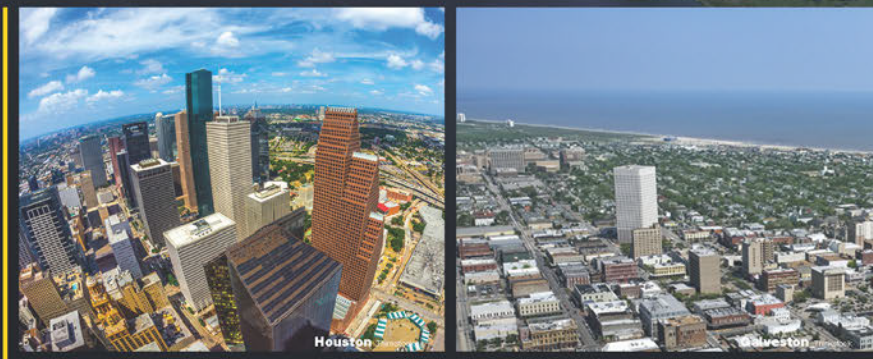
*"Climate change, once considered an issue for a distant future, has moved firmly into the present."*

– Third U.S. National Climate Assessment

Climate Change Preparedness and Resilience Exercise Series

# Houston Climate Change Preparedness and Resilience Workshop

October 6, 2014



**FEMA**

National Exercise Program  
The White House

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National Aeronautics and Space Administration (NASA) Johnson Space Center



October 6, 2014

8:30 a.m.–5:00 p.m. Central Daylight Time (CDT)

## **WORKSHOP SCHEDULE**

**Registration**

**Welcome and Opening Remarks**

**Overview and Administration**

**Video:** Coastal Chapter, Third U.S. National Climate Assessment

**Panel Session #1:** Science: National & Regional Perspective

**Break**

**Panel Session #2:** Action: Challenges & Opportunities

**Lunch**

**Panel Session #3:** Impacts: State & Local Perspectives

**Brief Introduction to the Tabletop Exercise**

**Tabletop Exercise**

**Participant Feedback / Hotwash**

**Closing Remarks**

**Adjournment**

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## INTRODUCTION

The Houston Climate Change Preparedness and Resilience Workshop is an element of the Climate Change Preparedness and Resilience Exercise Series sponsored by the White House National Security Council Staff, Council on Environmental Quality, and Office of Science and Technology Policy in collaboration with the Federal Emergency Management Agency (FEMA) National Exercise Division (NED). The Houston Workshop is one of three jurisdictional workshops being conducted in October 2014—additional workshops are being held in Fort Collins, Colorado and Anchorage, Alaska—with a goal of advancing the climate adaptation dialogue and identifying collaborative and sustainable approaches to community-based climate preparedness and resilience capabilities.

Hosted by Mayor Annise Parker, the City of Houston, and NASA’s Johnson Space Center, the Workshop is comprised of three moderated and interactive panel sessions and one facilitated tabletop exercise. The morning panel sessions reflect a diverse group of panelists and disciplines with focuses on climate science (from national, regional, and local perspectives), effects of climate change (from state and local perspectives), and associated challenges and opportunities (from a whole community perspective). These sessions set a foundation for the afternoon tabletop exercise discussions that will focus on planning, infrastructure systems (energy and chemical sectors along the Houston Ship Channel), natural resources and ecosystems, health and social services, and the economy within the Houston-Galveston area. Ultimately, workshop participants will address the question of “what can be done now, as a whole community, to collaboratively and sustainably prepare, plan for, or help mitigate future projected climate impacts on the Houston-Galveston area.”

In support of the desired outcome to improve collaboration with and between whole community partners, workshop participants include local, State, and Federal representatives as well as private sector, non-governmental, and academic partners who have roles, responsibilities, and expertise as they relate to climate adaptation, hazard mitigation, and resiliency planning efforts.

This Participant Handbook provides goals and objectives for the workshop, a detailed scenario with focus areas, and facilitator questions for discussion during the exercise.

### Workshop Goal

The goal of the workshop is to provide a forum for numerous stakeholders in the Houston-Galveston area to identify and refine climate change preparedness and resilience requirements and initiatives in collaboration with critical whole community stakeholders.

### Workshop Objectives

The workshop will have the following objectives:

1. Examine methods to better integrate existing and emerging scientific information and other requirements into current and future planning to manage and adapt to climate risks and vulnerabilities.

2. Identify collaborative and sustainable whole community approaches to advance and sustain local climate preparedness and resilience programs, policies, and strategies.
3. Examine investment opportunities and the development of coalitions between local, State, Federal, and private sector partners to support climate preparedness and resilience.
4. Examine relevant effects of climate change and hazard mitigation strategies for populations of disproportionate impact (vulnerable communities and populations).

## Workshop Outcomes

The workshop will focus on the following outcomes:

1. Improved collaboration with and between whole community partners on climate preparedness and resilience strategies.
2. Identification of new research, information, and capabilities that will support local preparedness, adaptation, and hazard mitigation planning.

## Workshop Output

Workshop outputs will include the following:

1. Workshop Summary Report that addresses key discussion points and identified climate preparedness and resilience information, innovations, and initiatives.
2. Potential climate change risks and vulnerabilities to be addressed in the local, State, and regional Threat and Hazard Identification Risk Assessment (THIRA) processes.

## Workshop Format

The workshop is a one-day facilitated event tailored for the specific needs of the City of Houston. The morning panel sessions are based on current scientific projections and climate preparedness and resilience efforts, while the afternoon is a facilitated scenario-driven tabletop exercise.

Scientific information describing observed climate trends and projected future climate conditions is derived primarily from the Third U.S. National Climate Assessment.<sup>1</sup>

The exercise scenario is tailored to examine specific jurisdictional effects based on the existing Third National Climate Assessment regional scenarios and includes a specific scenario event – increased risks from storm surge and heat waves in the mid-21<sup>st</sup> century—to allow participants to focus their discussions.

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<sup>1</sup> Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.



## Workshop Participants

Workshop participants include local, State, and Federal climate adaptation and hazard mitigation planners, emergency managers, and subject matter experts (SMEs) as well as identified stakeholders and partners from the private sector, non-governmental organizations, and academic institutions. Federal participants include both region-based Department and Agency representatives as well as select representatives from the National Capital Region (NCR).

### City of Houston

- Houston Advanced Research Center
- Houston-Galveston Area Council
- Port of Houston

### Additional Local Communities

- Galveston County
- Harris County
  - Flood Control District
  - Metropolitan Transit Authority

### Federal Departments/Agencies

- Federal Energy Regulatory Commission
- National Aeronautics and Space Administration
- U.S. Army Corps of Engineers
- U.S. Department of Agriculture
  - U.S. Forest Service
- U.S. Department of Commerce
  - National Oceanic and Atmospheric Administration
  - U.S. Economic Development Administration
- U.S. Department of Defense
- U.S. Department of Energy
- U.S. Department of Health and Human Services

- U.S. Department of Homeland Security
  - Federal Emergency Management Agency Region VIII
  - Office of Infrastructure Protection
  - U.S. Coast Guard
- U.S. Department of the Interior
  - U.S. Geological Survey
  - Fish and Wildlife Service
- U.S. Department of Transportation
  - Federal Highways Administration
  - Federal Transit Administration
- U.S. Environmental Protection Agency
- U.S. Global Change Research Program
- U.S. Small Business Administration
- White House
  - Council on Environmental Quality
  - Office of Science and Technology Policy
  - National Security Council Staff

**Private Sector**

- Centerpoint
- Lyondell Bassell
- NRG
- Shell
- Thermal Energy Corporation

**Non-Governmental Organizations**

- C40 Cities Climate Leadership Group
- The Nature Conservancy

- Galveston Bay Foundation
- Texas Medical Center

### Academic Partners

- Louisiana State University
- Rice University
- Texas A&M University
- Texas Sea Grant Program
- Texas Tech University
- University of Houston
- University of South Alabama
- University of Texas

### Workshop Scope and Assumptions

Exercises play a vital role in national preparedness by enabling whole community stakeholders to test and validate capabilities as well as identify potential capability shortfalls and planning requirements for improving preparedness. A well-designed exercise provides a low-risk environment to share understanding of requirements, familiarize personnel with roles and responsibilities, and foster meaningful interaction and communication across organizations. Exercises bring together and strengthen the whole community in its efforts to prevent, protect against, mitigate, respond to, and recover from all hazards. Overall, exercises are cost-effective and useful tools that help the nation practice and refine our collective capacity to build, sustain, and deliver the core capabilities needed to achieve climate preparedness and resilience.

Participants are encouraged to share their expertise, and the facilitator will ensure that participants have an opportunity to contribute. The scenario will integrate existing issues as identified through the planning process. Discussion questions aim to assist participants in achieving objectives of the workshop.

Participants should consider the following exercise ground rules to ensure that objectives are met in a reasonable amount of time and that the workshop runs smoothly:

1. Keep exercise objectives in mind throughout the workshop.
2. Participate openly and focus discussions on appropriate topics. Asking questions, sharing thoughts, and offering forward-looking, problem-solving suggestions will enhance the exercise experience.
3. Focus comments and consider time constraints.

In any exercise, assumptions are often necessary to complete play in the time allotted. During this exercise, the following assumptions apply:

1. The scenarios are plausible, and events occur as they are presented.
2. There are no “hidden agendas” or trick questions.
3. All players receive information at the same time.

## Workshop Evaluation

The workshop evaluation process aligns with requirements of the National Exercise Program (NEP) and is consistent with Homeland Security Exercise and Evaluation Program (HSEEP) doctrine. Evaluation efforts validate strengths and identify opportunities for improving climate resiliency among participating organizations by capturing key discussion points, identifying strengths and areas for improvement, and consolidating these discussion points within a Summary Report. This approach affords participating organizations an opportunity to revise, update, or modify current climate change adaptation and hazard mitigation plans and strategies, as needed.

The Summary Report will capture key discussion points to include the following:

1. Recommendations on integration of climate preparedness and resilience requirements and initiatives into current and future planning to manage and adapt to climate risks and vulnerabilities.
2. Suggestions on maintaining collaborative partnerships and building new coalitions across the whole community.
3. Areas where additional information and research are needed.
4. Effects of climate change on Houston-Galveston area missions, policies and strategies, and resources required given the workshop scenario.

The NED assigns evaluators to capture participant discussions. The evaluation team will then produce the Summary Report and deliver it to the NED within two (2) weeks of the workshop’s conclusion. The exercise planning team and key participants will be invited to participate in a virtual After-Action Meeting in November 2014 to review the draft Summary Report and validate and revise the findings and observations in order to produce a final Summary Report.

## Core Capabilities

The National Preparedness Goal, released in September 2011, defines what it means for the whole community to be prepared for all types of disasters and emergencies. It identified five (5) mission areas—Prevention, Protection, Mitigation, Response, and Recovery—which encompass 31 distinct critical elements (“core capabilities”) needed to achieve a secure and resilient Nation.

The workshop will focus on the Mitigation mission area, which is comprised of “the capabilities necessary to reduce the loss of life and property by lessening the impacts of disasters.”



Five (5) of the Mitigation core capabilities will be explored through the workshop:

1. Community Resilience
2. Long-Term Vulnerability Reduction
3. Operational Coordination
4. Planning
5. Risk and Disaster Resilience Assessment

Descriptions<sup>2</sup> for the core capabilities that will be examined during the workshop are as follows:

Core Capability	Description
<b>Community Resilience</b>	Lead the integrated effort to recognize, understand, communicate, plan, and address risks so that the community can develop a set of actions to accomplish mitigation and improve resilience.
<b>Long-Term Vulnerability Reduction</b>	Build and sustain resilient systems, communities, and critical infrastructure and key resources lifelines so as to reduce their vulnerability to natural, technological, and human-caused incidents by lessening the likelihood, severity, and duration of the adverse consequences related to these incidents.
<b>Operational Coordination</b>	Establish and maintain a unified and coordinated operational structure and process that appropriately integrates all critical stakeholders and supports the execution of core capabilities.
<b>Planning</b>	Conduct a systematic process engaging the whole community as appropriate in the development of executable strategic, operational, and/or community-based approaches to meet defined objectives.
<b>Risk and Disaster Resilience Assessment</b>	Assess risk and disaster resilience so that decision-makers, responders, and community members can take informed action to reduce their entity's risk and increase their resilience.

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<sup>2</sup> Department of Homeland Security. *National Preparedness Goal*. September 2011.

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## SCENARIO BACKGROUND: *Climate Information*

### Regional Changes in the Climate for the Southeast and along the Coast

The Texas Gulf Coast averages approximately three (3) tropical storms or hurricanes every four (4) years, generating coastal storm surge and sometimes bringing heavy rainfall and damaging winds hundreds of miles inland. The expected rise in sea level, as predicted in the Third U.S. National Climate Assessment, will result in the potential for greater damage from storm surge along the Gulf Coast of Texas.<sup>3</sup>

The State of Texas is part of the U.S. Great Plains Region, as identified in the Third U.S. National Climate Assessment. The Houston-Galveston area has much in common with the information outlined in the Third U.S. National Climate Assessment's U.S. Southeast and Caribbean Region and Coastal Zone Development and Ecosystems chapters. Therefore, we have included the relevant key findings below as background information for the scenario.

The U.S. Southeast and Caribbean<sup>4</sup> regional findings include:

- **Key Message 1: Sea Level Rise Threats.** Sea level rise poses widespread and continuing threats to both natural and manmade environments and to the regional economy.
- **Key Message 2: Increasing Temperatures.** Increasing temperatures and the associated increase in frequency, intensity, and duration of extreme heat events will affect public health, natural and manmade environments, energy, agriculture, and forestry.
- **Key Message 3: Decreased Water Availability.** Decreased water availability, exacerbated by population growth and land-use change, will continue to increase competition for water and affect the region's economy and ecosystems.

The U.S. Coastal Zone Development and Ecosystems<sup>5</sup> regional findings include:

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<sup>3</sup> Shafer, M., D. Ojima, J. M. Antle, D. Kluck, R. A. McPherson, S. Petersen, B. Scanlon, and K. Sherman, 2014: *Ch. 19: Great Plains. Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 441-461. doi:10.7930/J0D798BC.

<sup>4</sup> Carter, L. M., J. W. Jones, L. Berry, V. Burkett, J. F. Murley, J. Obeysekera, P. J. Schramm, and D. Wear, 2014: *Ch. 17: Southeast and the Caribbean. Climate Change Impacts in the United States: The Third U.S. National Climate Assessment*, J. M.

Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 396-417. doi:10.7930/J0NP22CB.

<sup>5</sup> Moser, S. C., M. A. Davidson, P. Kirshen, P. Mulvaney, J. F. Murley, J. E. Neumann, L. Petes, and D. Reed, 2014: *Ch. 25: Coastal Zone Development and Ecosystems. Climate Change Impacts in the United States: The Third U.S. National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, , 579-618. doi:10.7930/J0MS3QNW..

- **Key Message 1: Coastal Lifelines at Risk.** Coastal lifelines, such as water supply and energy infrastructure and evacuation routes, are increasingly vulnerable to higher sea levels and storm surges, inland flooding, erosion, and other climate-related changes.
- **Key Message 2: Economic Disruption.** Nationally important assets in vulnerable coastal locations, such as ports, tourism, and fishing sites, are increasingly exposed to sea level rise and related hazards. This threatens to disrupt economic activity within coastal areas and the regions they serve and results in significant costs from protecting or moving these assets.
- **Key Message 3: Uneven Social Vulnerability.** Socioeconomic disparities create uneven exposures and sensitivities to growing coastal risks and limit adaptation options for some coastal communities, resulting in the displacement of the most vulnerable people from coastal areas.
- **Key Message 4: Vulnerable Ecosystems.** Coastal ecosystems are particularly vulnerable to climate change because many have already been dramatically altered by human stresses. Climate change will result in further reduction or loss of the services that these ecosystems provide, including potentially irreversible impacts.
- **Key Message 5: The State of Coastal Adaptation.** Leaders and residents of coastal regions are increasingly aware of the high vulnerability of coasts to climate change and are developing plans to prepare for potential impacts on citizens, businesses, and environmental assets. Significant institutional, political, social, and economic obstacles to implementing adaptation actions remain.

### Local Background Information for the Houston-Galveston Area

The Houston-Galveston area is home to more than six (6) million residents,<sup>6</sup> making it the fifth-largest metropolitan area in the United States by population.<sup>7</sup> Key industries include energy, transportation, and manufacturing. It is a focal point of Texas' and the nation's economic activity as a major cargo hub, a crucial center of domestic energy production and security, and the location of numerous critical infrastructure sites. The U.S. Department of Energy (DOE), NASA, and the U.S Coast Guard (USCG) are some of the Federal Agencies that maintain major installations in the area.

Like many urban centers, the Houston-Galveston area depends on infrastructure—including water and sewage systems, roads, bridges, and power plants—that is aging and in need of repair or replacement. Rising sea levels, storm surges, heat waves, and extreme weather events will compound these issues, stressing and overwhelming these essential services.

Houston-Galveston area residents are particularly vulnerable to disruptions in essential infrastructure services from climate change, in part because many of these infrastructure systems

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<sup>6</sup> Based on 2013 census data of the 13 counties on the Houston-Galveston Area Council. [http://www h-gac.com/community/socioeconomic/census/documents/Estimates\\_Detail\\_Counties\\_Census.pdf](http://www.h-gac.com/community/socioeconomic/census/documents/Estimates_Detail_Counties_Census.pdf)

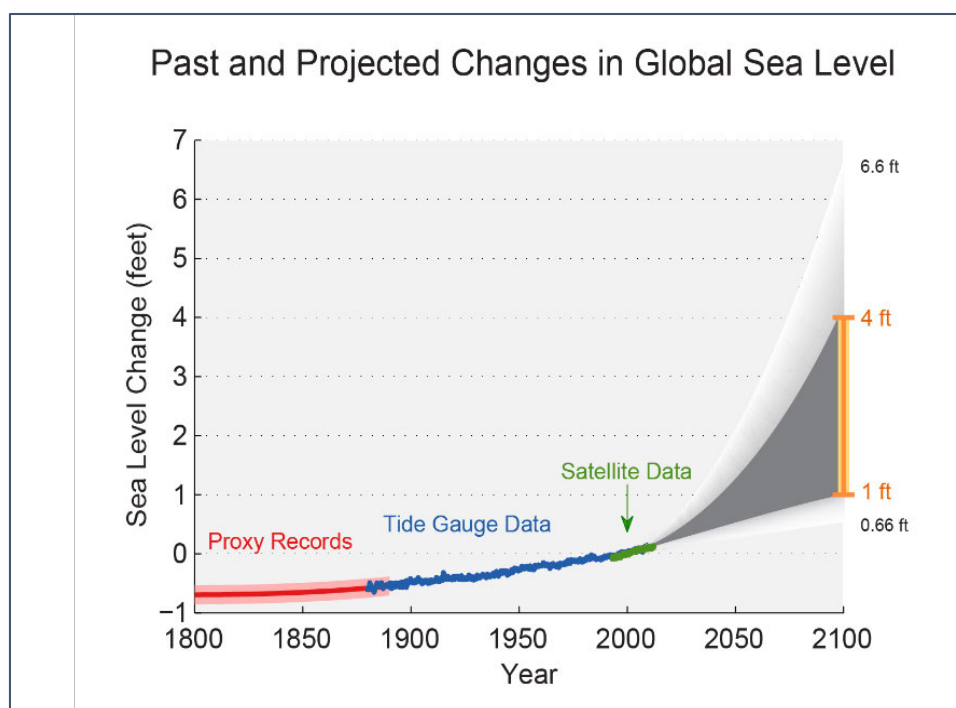
<sup>7</sup> "Houston now No. 5 in population, overtakes Philadelphia" April 5, 2012, <http://www.bizjournals.com/houston/news/2012/04/03/houston-ranks-no-5-by-metro.html>



are reliant on each other. For example, electricity is essential to multiple systems, and a failure in the electrical grid can affect water treatment, transportation services, and public health. These infrastructure systems are lifelines to millions of people and will continue to be affected by various climate-related events and processes.

### Observed Climate Change Trends for the Houston-Galveston Area

**Average annual temperature has increased.** Data from Liberty, TX indicate that the average annual temperature has risen approximately 1 degree Fahrenheit over the past century. Maintaining a humid subtropical climate, the Houston-Galveston area typically experiences more than 100 days per year of temperatures exceeding 90 degrees Fahrenheit. In 2011, Houston set a record for the most number of days recording temperatures of 100 degrees Fahrenheit or higher in its recorded history.



**Figure 1. Estimated, observed, and projected future global sea level rise from 1800 to 2100, relative to the year 2000 (source: Third U.S. National Climate Assessment, 2014).**

**Precipitation patterns are changing.** Extreme rainfall events (non-tropical/hurricane) are common throughout the year, especially those that occur in a one-day period, and can cause flash flooding. Flood events affect transportation infrastructure, making roads impassable and damaging transit systems, while also posing risks to public safety and community health.<sup>8</sup>

**Sea level is rising and the land is sinking.** Climate data collected over the past 100 years in the Houston-Galveston area demonstrate a long-term pattern of sea level and temperature rise. Long-term tide gauge data from Galveston show that the sea level has risen more than 26 inches during

<sup>8</sup> "Climate Impacts in the Great Plains." U.S. Environmental Protection Agency.

this same time period (0.26 inches per year), significantly greater than the global average.<sup>9</sup> This area is prone to high rates of land surface subsidence attributed to soil decomposition and compaction, deep fluid extraction, and the lack of sediment deposition. Because much of the region is exceptionally low-lying, with some areas only several feet above sea level, sea level rise and storm surge are pressing issues.

**Extreme weather events are occurring more frequently; in particular, tropical storms, coastal flooding, and drought.** As a humid, subtropical climate, the Houston-Galveston area typically experiences more than 100 days per year of temperatures exceeding 90 degrees Fahrenheit, which has increased the vulnerability of outdoor workers to heat-related health impacts and stressed infrastructure systems.<sup>10</sup> In August 2011, Houston had the most number of days reaching temperatures of 100 degrees Fahrenheit or higher in its recorded history (see **Figure 2**). Tropical storms in the region bring extreme rainfall, strong winds, and coastal flooding. The Houston-Galveston area is one of the nation's most hurricane-prone regions<sup>11</sup> (see **Figure 4**). In June 2001, Tropical Storm Allison caused more damage than any tropical storm in U.S. history, with estimates in excess of \$5 billion. Most of the damage, and 22 fatalities, occurred in Houston. Storm rainfall totals peaked at 36.99 inches in the Port of Houston.<sup>12</sup> In September 2005, Hurricane Rita prompted the evacuation of approximately two (2) million Houston-Galveston residents, resulting in massive traffic jams and at least 49 indirect fatalities, mostly due to excessive heat and a fire on an evacuation bus. Rita, a Category 3 storm by the time it made landfall near the Sabine Pass, did little physical damage to the Houston-Galveston area, but it stressed the region's infrastructure and evacuation systems.<sup>13 14</sup> In September 2008, Hurricane Ike resulted in storm surges between 10 and 20 feet and caused an estimated \$29.5 billion in damages to the Houston-Galveston area.<sup>15</sup> In the 12-months following the storm, the estimated economic losses stemming from Hurricane Ike totaled \$142 billion.<sup>16</sup>

### Projected Future Climate Conditions for the Houston-Galveston Area

**Average annual temperatures and extreme high temperatures are projected to increase.** Climate models project continued warmer temperatures in the region. The average temperature in the Gulf Coast region appears likely to increase by at least 2.7 degrees Fahrenheit  $\pm$  1.8 degrees Fahrenheit during the next 50 years. Extreme high temperatures are also projected to increase, with the number of days above 90 degrees Fahrenheit very likely to increase significantly across the study area. Within 50 years, the probability of experiencing 21 days per year with temperatures of 100 degrees Fahrenheit or above is greater than 50 percent. Projected

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<sup>9</sup> Ibid, page 3-20.

<sup>10</sup> Houston Advanced Research Center, "HARC Helps Houston Plan for Climate Change Impacts on Municipal Operations", November 21, 2013.

<sup>11</sup> *Top 5 Most Vulnerable U.S. Cities to Hurricanes*. Climate Central, June 6, 2012.

<sup>12</sup> NOAA Service Assessment Report, "Tropical Storm Allison, Heavy Rains and Floods, Texas and Louisiana, June 2001," September 2001

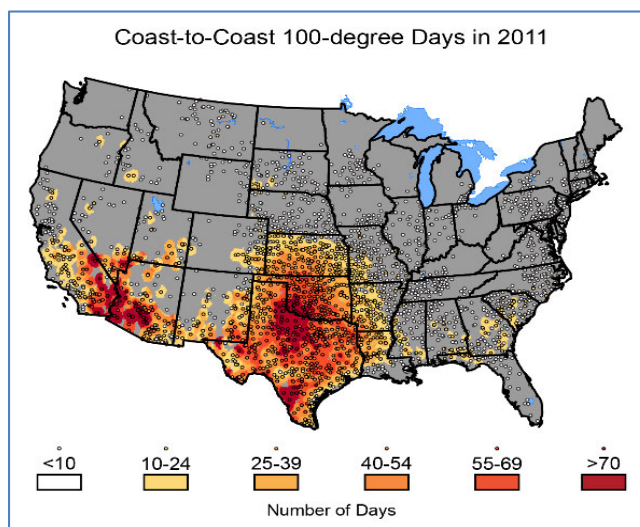
<sup>13</sup> 8 years ago, seemingly all of Houston evacuated ahead of Hurricane Rita." Houston Chronicle, September 24, 2013

<sup>14</sup> "Post-Tropical Cyclone Report: Hurricane Rita." National Weather Service, Houston/Galveston TX, November 30, 2005

<sup>15</sup> *Hurricane Ike Five Years Later: Photos Show Damage, and Recovery, in Houston and Galveston*. The Weather Channel, September 26, 2013.

<sup>16</sup> *Hurricane Ike Impact Report*. Texas Engineering Extension Service, August 15, 2011.

hotter summer temperatures will stress many aspects of the manmade environment, requiring more maintenance to sustain safe living and working conditions.<sup>17</sup>



**Figure 2.** Map displays the numbers of days with temperatures above 100°F during 2011 (source: Third U.S. National Climate Assessment, 2014).

**Precipitation changes are uncertain.** Data regarding future precipitation patterns in the Gulf Coast region are inconclusive. Some analyses, including the Global Climate Model results from this study, indicate that average precipitation will increase in this region, while others indicate a decline of average precipitation during the next 50 to 100 years. Although average annual rainfall may increase or decrease slightly, the intensity of individual rainfall events is likely to increase during the 21st Century.

**Sea level is projected to rise.** Climate models project continued sea level rise in the region. Relative sea level<sup>18</sup> along the Gulf Coast from Houston-Galveston to Mobile, Alabama is likely to increase at least one (1) foot across the region and possibly as much as six (6) to seven (7) feet in some parts of the Gulf Coast area during this century. The analysis of a “middle range” of potential sea level rise of two (2) to four (4) feet indicates that a vast portion of the Gulf Coast from Houston to Mobile may be inundated over the next 50 to 100 years. Sea level rise, coupled with storm surge, will continue to increase the risk of impacts to major coastal infrastructure, such as airports, ports and harbors, roads, rail lines, tunnels, and bridges. Increased coastal erosion, saltwater intrusion into aquifers and estuaries, changes in sediment transport and tidal flows, and more frequent flooding from higher storm surges are also likely.

<sup>17</sup> A Report to the Houston-Galveston Area Council. *Adaptation to Climate Change in the Houston-Galveston Area: Perceptions and Prospects*. The Bush School. Texas A&M University. 2009.

<sup>18</sup> Relative sea level rise (RSLR) is the combined effect of the projected increase in the volume of the world’s oceans (eustatic sea level change), which results from increases in temperature and melting of ice, and the projected changes in land surface elevation at a given location due to subsidence of the land surface.

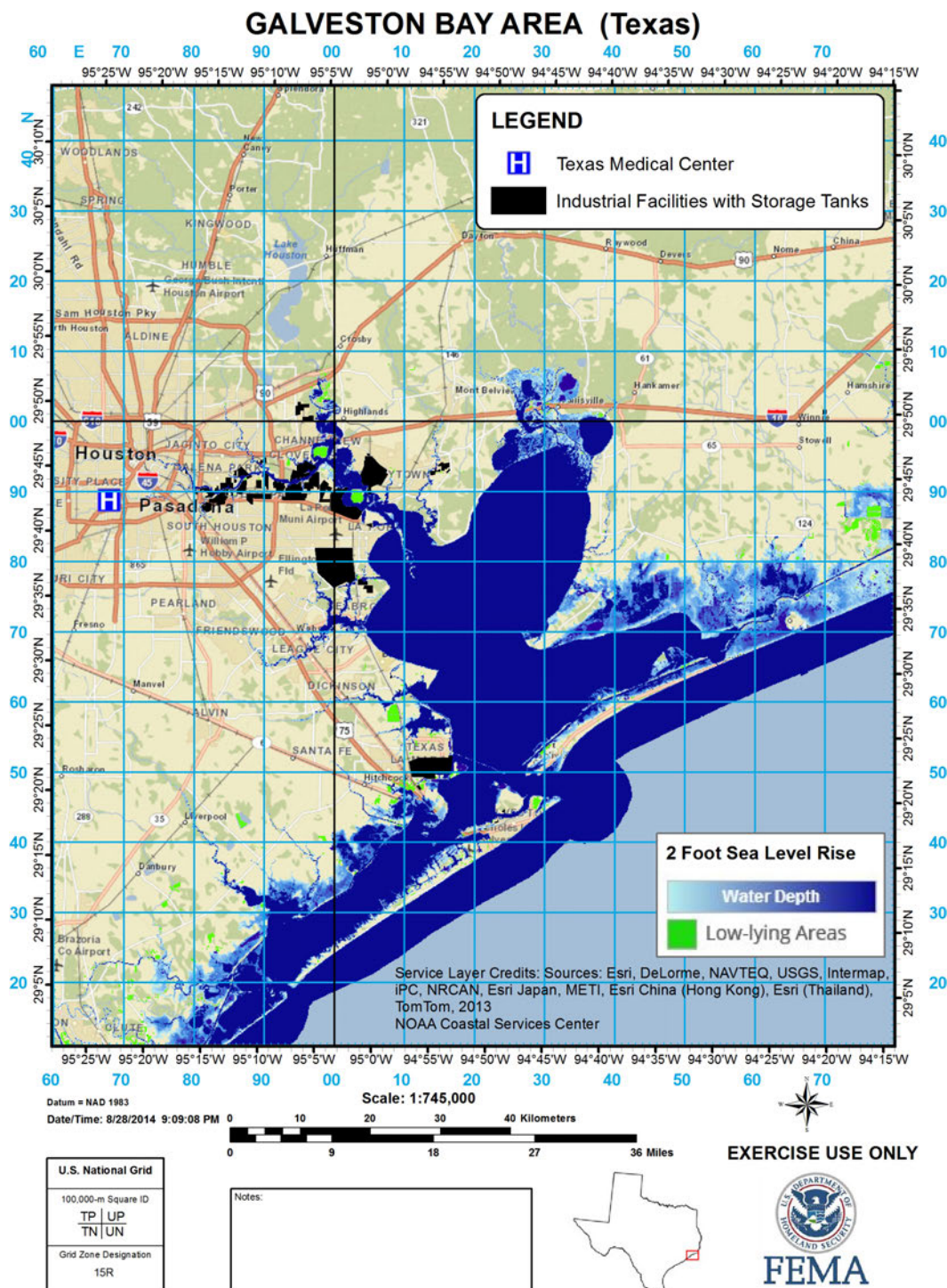


Figure 3. Projected impacts of two (2) feet of sea level rise in the Houston-Galveston area.

**Extreme weather events are projected to become more powerful.** Storm surge and sea level rise may be the greatest climate threats to the Houston-Galveston area. The region has always been subject to hurricanes and associated high winds, storm surge, and flooding. Rising sea level and land subsidence will increase the risk of catastrophic storm surge impacts on regional infrastructure assets, human capital, and natural resources. The Atlantic Ocean and Gulf of Mexico are getting warmer, making hurricanes more frequent and more powerful. Rising relative



sea level will exacerbate exposure to storm surge and flooding. Depending on the trajectory and scale of individual storms, facilities at or below 30 feet could be subject to direct storm surge impacts. Extreme floods and storms associated with climate change will also lead to increased movement of sediment and buildup of sandy formations in port channels. Projected changes in the frequency of extreme events (such as hot and cold days) may also lead to large impacts.

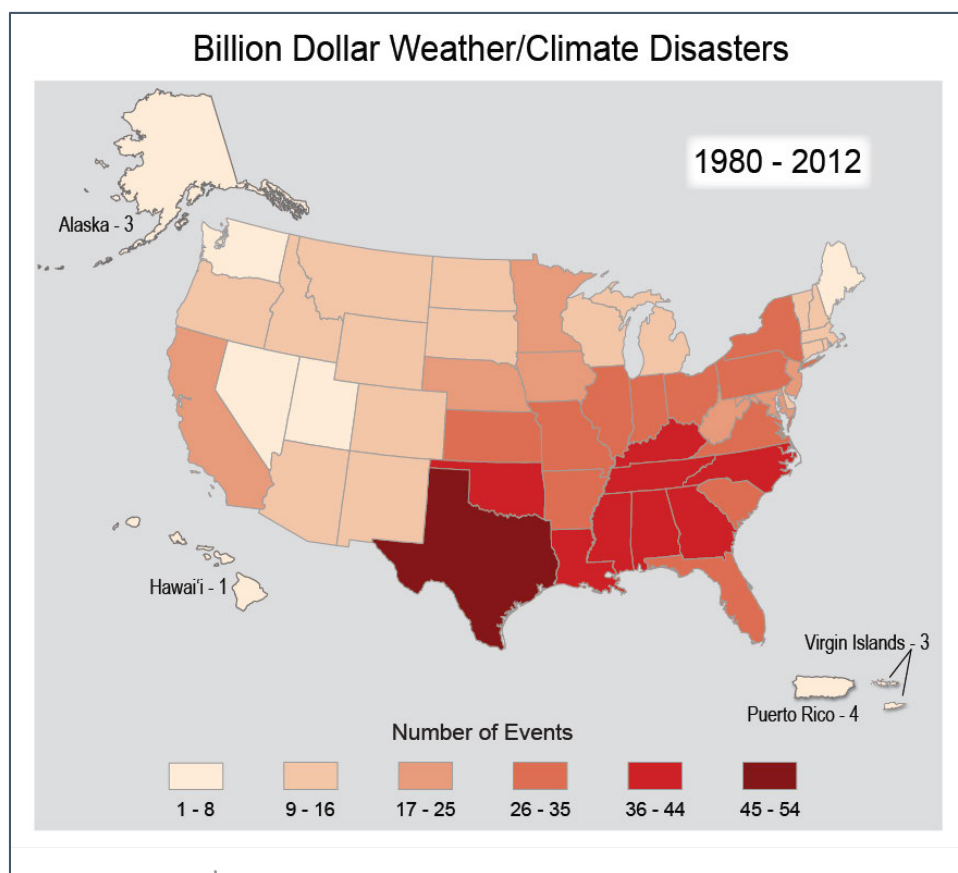
### Local Impacts in the Face of a Changing Climate for the Houston-Galveston Area

**Human health and well-being.** As urban areas develop, changes occur in their landscape. Buildings, roads, and other infrastructure replace open land and vegetation. Surfaces that were once permeable and moist become impermeable and dry. These changes cause urban regions to become warmer than their rural surroundings, forming an “island” of higher temperatures in the landscape.<sup>19</sup> Urban heat islands, combined with an aging population and increased urbanization, are projected to increase the vulnerability of urban populations to heat-related health effects in the future. Additionally, sea level rise and increased storm surge can contribute to saltwater contamination of freshwater supplies, urban flooding, sewer overflows, and other public health risks in the Houston-Galveston area.

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<sup>19</sup> U.S. Environmental Protection Agency. Basic Information—What is an Urban Heat Island? 2013. Online resource.





**Figure 4.** This map summarizes the number of times each state has been affected by weather and climate events over the past 30 years that have resulted in more than one (1) billion dollars in damages (source: Third U.S. National Climate Assessment, 2014).

**Essential infrastructure and economic activity.** The Port of Houston is one of the busiest ports in the nation and one of the most important in terms of energy supply and security. Current estimates place financial losses of Houston Ship Channel disruption at approximately \$300 million per day. Given the fact that the refining facilities around the Houston Ship Channel are responsible for nearly 12 percent of U.S. oil refining capacity, a disruption lasting longer than just several days can significantly affect U.S. energy supplies.<sup>20</sup>

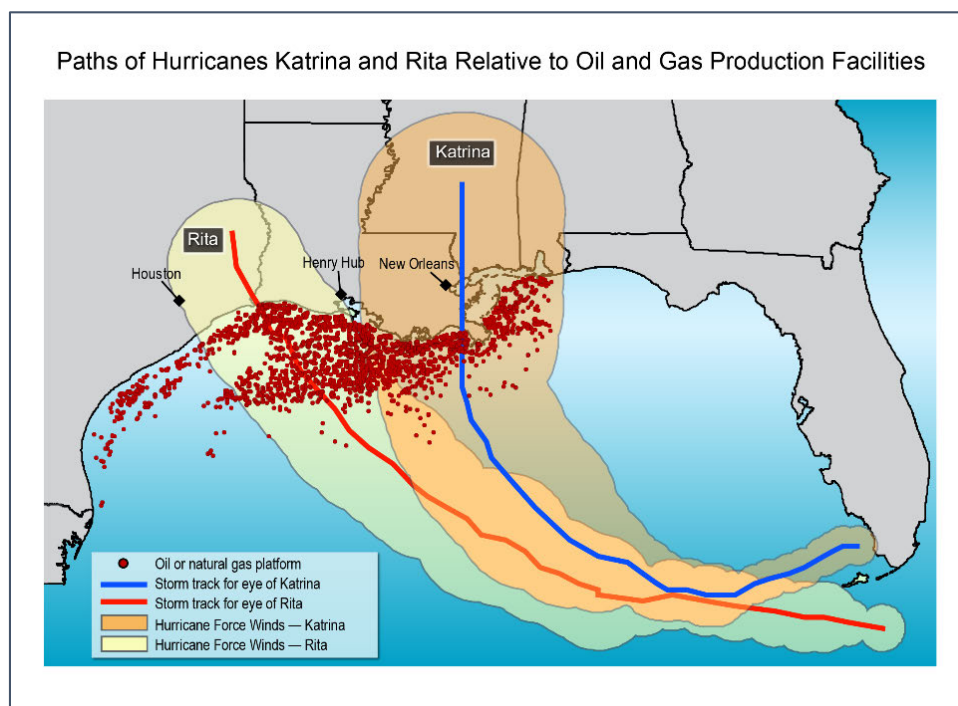
**Coastal lifelines.** The projected rise in sea level will result in the potential for greater damage from storm surge along the Gulf Coast of Texas. Approximately one-third of the Gross Domestic Product (GDP) for the State of Texas is generated in coastal counties.<sup>21</sup> According to a recent study co-sponsored by a regional utility, coastal areas in Alabama, Mississippi, Louisiana, and Texas already face losses that annually average \$14 billion due to hurricane winds, land subsidence, and sea level rise.<sup>22</sup> According to a recent study, projected sea level rise increases

<sup>20</sup> "Spill brings concerns of potential economic impact." Houston Chronicle, March 23, 2014.

<sup>21</sup> Houser, T., R. Kopp, S. Hsiang, R. Muir-Wood, K. Larsen, M. Delgado, A. Jina, P. Wilson, S. Mohan, D. J. Rasmussen, M. Mastrandrea, and J. Rising (2014). *American Climate Prospectus: Economic Risks in the United States*. New York, NY: Rhodium Group.

<sup>22</sup> America's Wetlands Foundation, Entergy Corporation, *Building a Resilient Energy Gulf Coast: Executive Report*. America's Energy Coast, October 2010.

average annual losses from hurricanes and other coastal storms. In Galveston, a typical single-family coastal home worth \$191,000 faces \$4,752 in average annual hurricane losses today that will likely grow by \$1,035 to \$1,392 by 2030 and \$2,488 to \$3,303 by 2050.<sup>23</sup>



**Figure 5. A substantial portion of U.S. energy facilities is located along the Gulf Coast and offshore in the Gulf of Mexico, where they are particularly vulnerable to storms, hurricanes, and sea level rise (source: Third U.S. National Climate Assessment, 2014).**

**Fresh water availability.** Rapid population growth places increasing demand on diminishing water supplies in Texas. Along the Texas Gulf Coast, climate change-related saltwater intrusion into aquifers and estuaries poses a serious risk to local populations. In 2011, many locations in Texas experienced more than 100 days over 100 degrees Fahrenheit, with the state setting new high temperature records. Rates of water loss were double the long-term average, which depleted water resources and contributed to more than \$10 billion in direct losses to agriculture alone.

**Ecosystem services.** The ecological effects of climate change to the Texas Gulf Coast are another critical issue confronting the Houston-Galveston area. Texas coastal marshes and wetlands are fertile breeding grounds for a wide variety of marine life, impede erosion, and help to block some types of inland flooding. Sea level rise threatens to reduce marsh and wetland areas, depriving the Texas Gulf Coast of these benefits. Higher water temperatures and shifting balances between fresh and salt water can negatively alter marine life habitats, creating problems for this region's large aquaculture economy. The Texas coastal agricultural economy, including livestock, rice, cotton, and citrus cultivation, is threatened by the combination of salt or brackish water from sea level rise and reduced freshwater levels from changes in temperature and

<sup>23</sup> Houser, T., R. Kopp, S. Hsiang, R. Muir-Wood, K. Larsen, M. Delgado, A. Jina, P. Wilson, S. Mohan, D. J. Rasmussen, M. Mastrandrea, and J. Rising (2014). *American Climate Prospectus: Economic Risks in the United States*. New York, NY: Rhodium Group.

precipitation.<sup>24</sup> Coastal ecosystems are particularly vulnerable to climate change because many have already been dramatically altered by human activity, which creates additional stresses. Climate change will result in further reduction or loss of the services that these ecosystems provide. Oil and chemical spills that require extensive clean-up efforts highlight these ecological and economic dangers. Moreover, these types of incidents may increase in frequency due to storm-surge induced accidents.<sup>25</sup>

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<sup>24</sup> University of Texas Bureau of Economic Geology, *Sea Level Changes and the Texas Coastal Environment*, accessed at [www.beg.utexas.edu](http://www.beg.utexas.edu) on September 22, 2014.

<sup>25</sup> Blackburn, J.B., P.B. Bedient, L.G. Dunbar. Severe Storm Prediction, Education, and Evacuation from Disasters (SSPEED) Center 2014 Report. Houston, TX: Rice University, 2014

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## SCENARIO EVENT: *Increased Risks from Storm Surge and Heat Waves in the Mid-Century*

### Summer 2044—Houston-Galveston Area

It is the year 2044. The model projections described earlier have occurred. Since 2008, average annual temperatures have increased by 2.5 degrees Fahrenheit. Houston is currently experiencing a 14-day stretch during which the heat index has exceeded 110 degrees Fahrenheit. Increased use of air conditioning and water cooling mechanisms is stressing aging energy supply and transmission systems as well as local water supply systems. Area healthcare systems are stressed by an increase in the number of elderly patients, those with access/functional needs, and other populations of disproportionate impact due to the extreme heat wave. Additionally, outdoor workers are experiencing heat injuries at much higher rates than normal (2.4 deaths per million workers compared to an average of 1.6 over the previous 50 years).

Extreme weather events, such as more-powerful hurricanes, longer and hotter heat waves, and more extensive flooding, have impacted area residents, infrastructure, and ecosystems as well as the Houston-Galveston economy over the past several years. A series of sub-tropical and tropical storms hit the area in previous years, and dredging operations to clear local shipping channels of excess silt are ongoing. The average sea level at the Port of the Houston has risen approximately 16 inches, due to the combination of eustatic sea level rise and land subsidence.

Tropical Storm Brandy, now 200 miles west of Miami, is expected to strengthen to a large Category 3 hurricane before making landfall in the Houston-Galveston area in three (3) days, bringing with it a potential 20-foot storm surge. Ocean temperatures in the Atlantic Ocean and Gulf of Mexico have increased, making hurricanes more powerful.

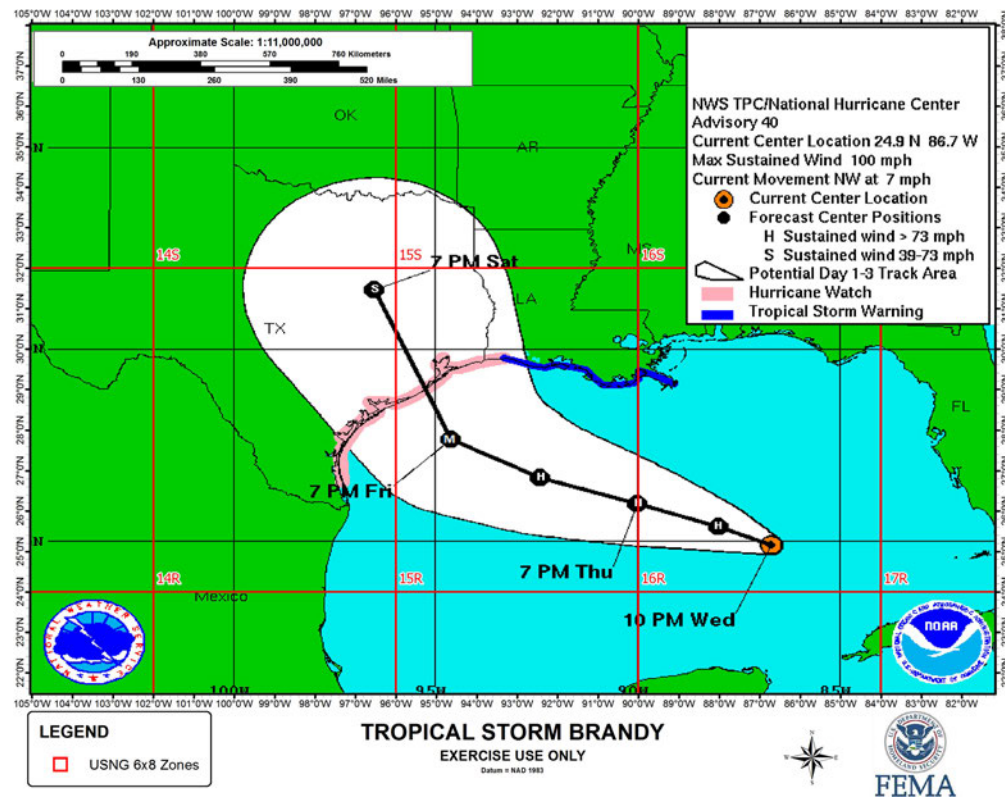
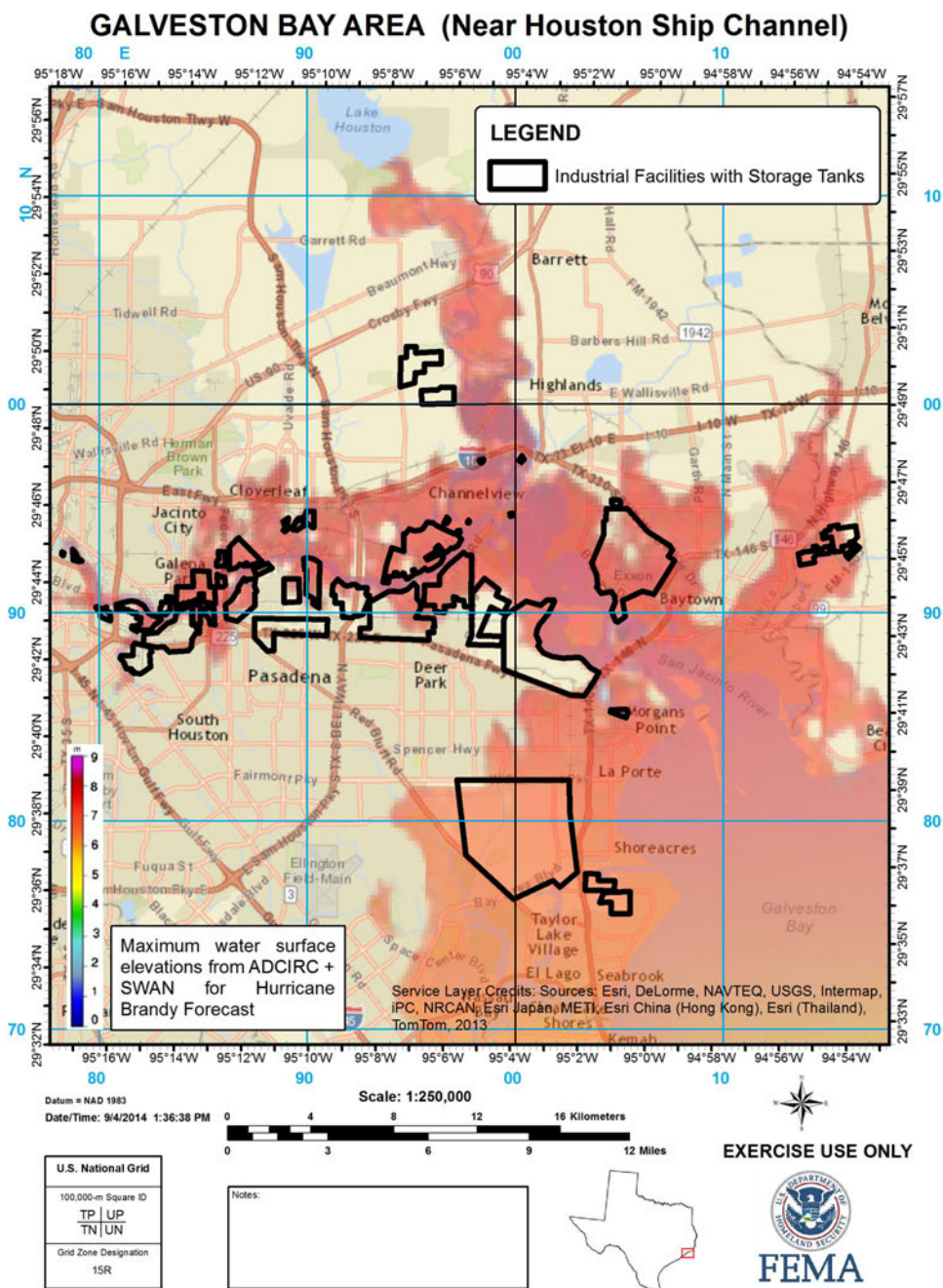


Figure 6. NOAA forecast map for Hurricane Brandy.

If Tropical Storm Brandy strengthens as expected and follows the forecast track, it will make landfall on the Texas coast at or near San Luis Pass. Previous modeling efforts for such a hurricane have forecast potentially devastating consequences for the Houston-Galveston area. Based on modeling conducted in the wake of Hurricane Ike (2008), and taking relative sea level rise into account, the storm surge could reach 34 feet in the Houston Ship Channel and along the west coast of Galveston Bay, in addition to expected heavy rains and 120-mph winds.

Storm surges of this magnitude will overwhelm existing barriers and bring devastating consequences, including the loss of homes, businesses, and livelihoods on Galveston Island, the Bolivar Peninsula, and the communities along the western edge of Galveston Bay.





**Figure 7. Potential Hurricane Brandy inundation in the Houston Ship Channel.**

Particularly vulnerable is the Houston Ship Channel, and the multitude of ports, refineries, and petro-chemical facilities located along it. Previous studies have indicated the potential for \$100 billion in damage to the manmade infrastructure along the channel, and estimates place financial losses due to ship channel disruption at approximately \$300 million per day.

The Houston Ship Channel is the location of approximately 12 percent of U.S. oil refining capacity; any disruption lasting longer than several days will negatively affect U.S. energy supplies. There are also 3,600 energy-related companies, including 600 exploration firms and 170 pipeline companies, in the Houston-Galveston area that would be impacted by such a storm. Relative sea level rise has already negatively affected many of these facilities, and caused many



others to be more susceptible to storm surge. A 2014 DOE pilot study on risks to energy facilities due to relative sea level rise indicates that 16 energy facilities in Houston will be inundated by 2050 (based on the Third U.S. National Climate Assessment intermediate-high and high emission scenarios).

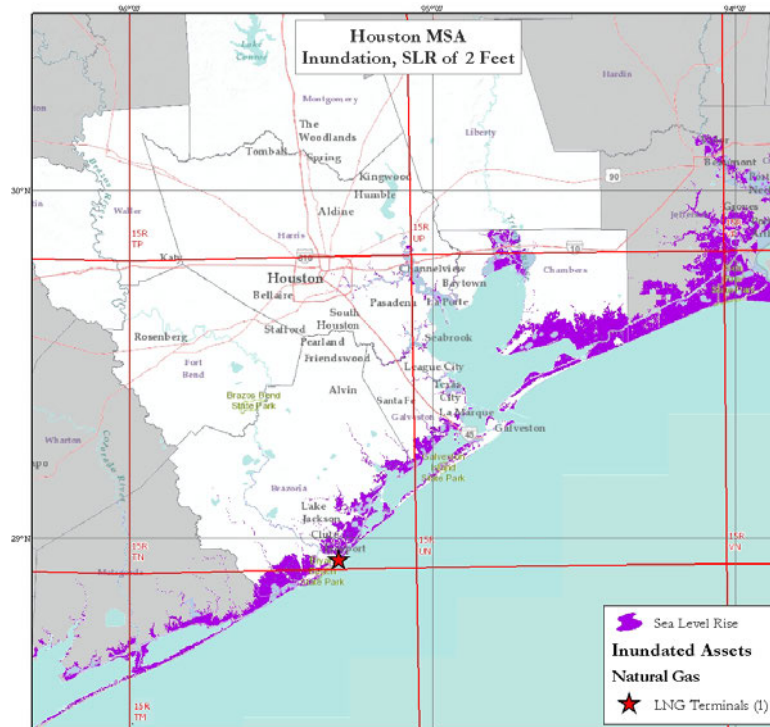
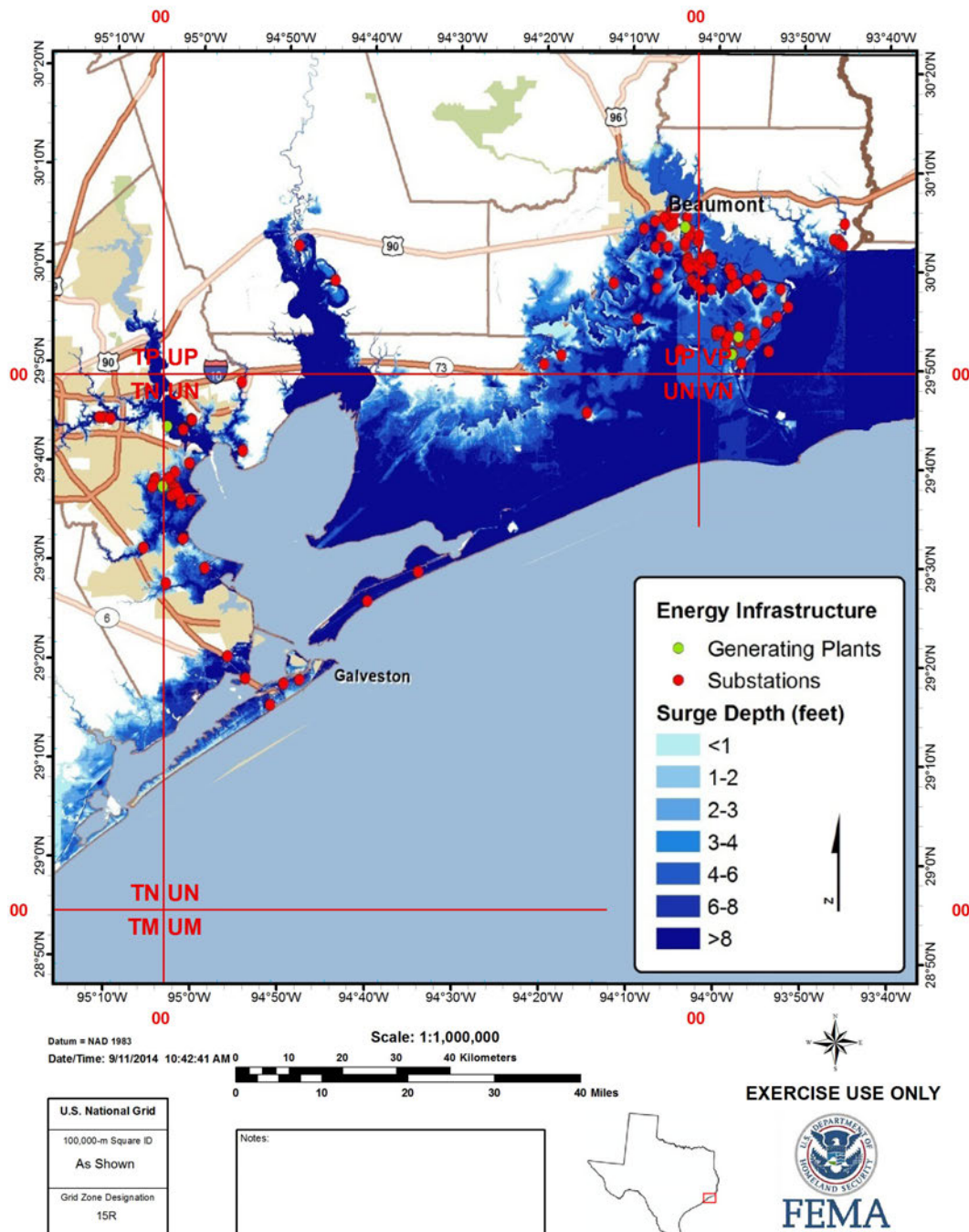
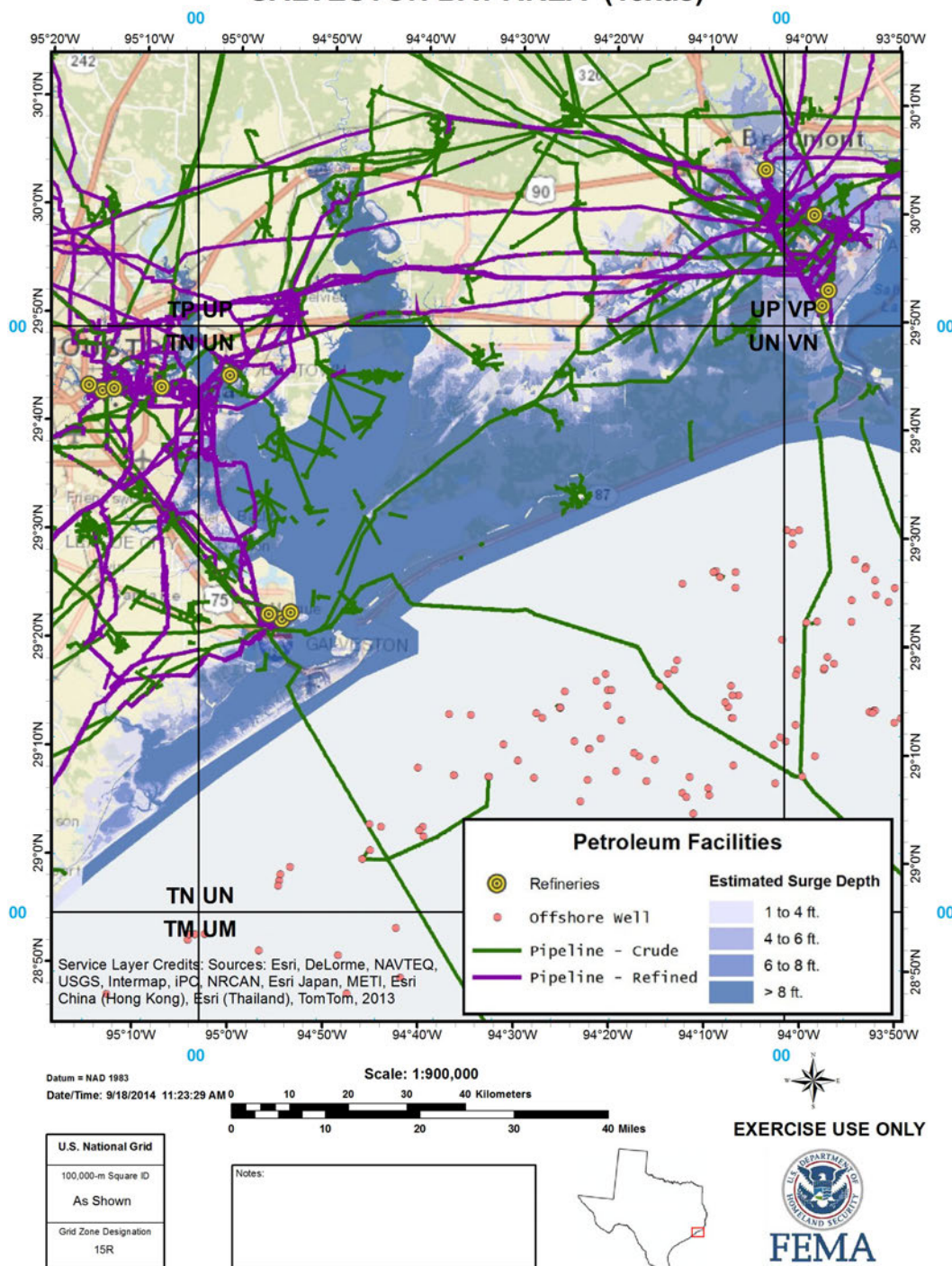


Figure 8. Inundation of energy infrastructure by relative sea level rise of 2 feet (top).

**GALVESTON BAY AREA (Texas)****Figure 9. Inundation of energy facilities by Hurricane Brandy storm surge.**

**GALVESTON BAY AREA (Texas)****Figure 10. Inundation of pipelines by Hurricane Brandy storm surge.**

The Houston Ship Channel is also the location of a large percentage of U.S. agrochemical (e.g., fertilizer and pesticides) production capacity; any disruption lasting longer than several weeks will negatively affect the food security of the United States and our trading partners.

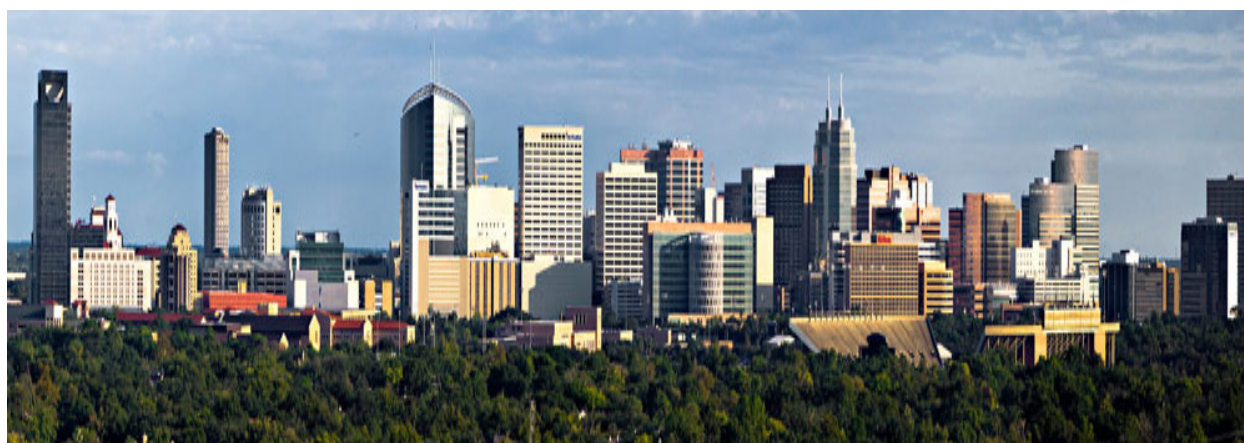
Additionally, there are 405 chemical plants employing 36,000 people in the Houston-Galveston area. These facilities are responsible for approximately 40 percent of the nation's capacity to



produce basic chemicals used by downstream chemical operations, and the area is a key production center for derivative chemicals and specialty chemicals as well. Relative sea level rise has already negatively affected many of these facilities, and caused many others to be more susceptible to storm surge.

Major damage to the petroleum and chemical processing facilities along the Houston Ship Channel could result in major releases of toxic materials into the waterways, creating both an acute environmental disaster and a long-term negative impact on the tourism and fishing industries in the area. Pollution of Galveston Bay and its marshlands could have long-term effects on the health of shrimp, blue crab, salmon, tuna, and other commercially valuable species on which the area's commercial fishing industry depends.<sup>26</sup> In addition to these potential toxic chemical releases, the natural environment of the Galveston Bay is at risk from the storm. Relative sea level rise and past storms have already claimed more than 200 square miles of low lying land area along Galveston Bay and inundated many fresh water marshes with salt water. This has altered the ecology of the area, increased the vulnerability of the coast to storm surge, and negatively affected the sport fishing and tourism industries.

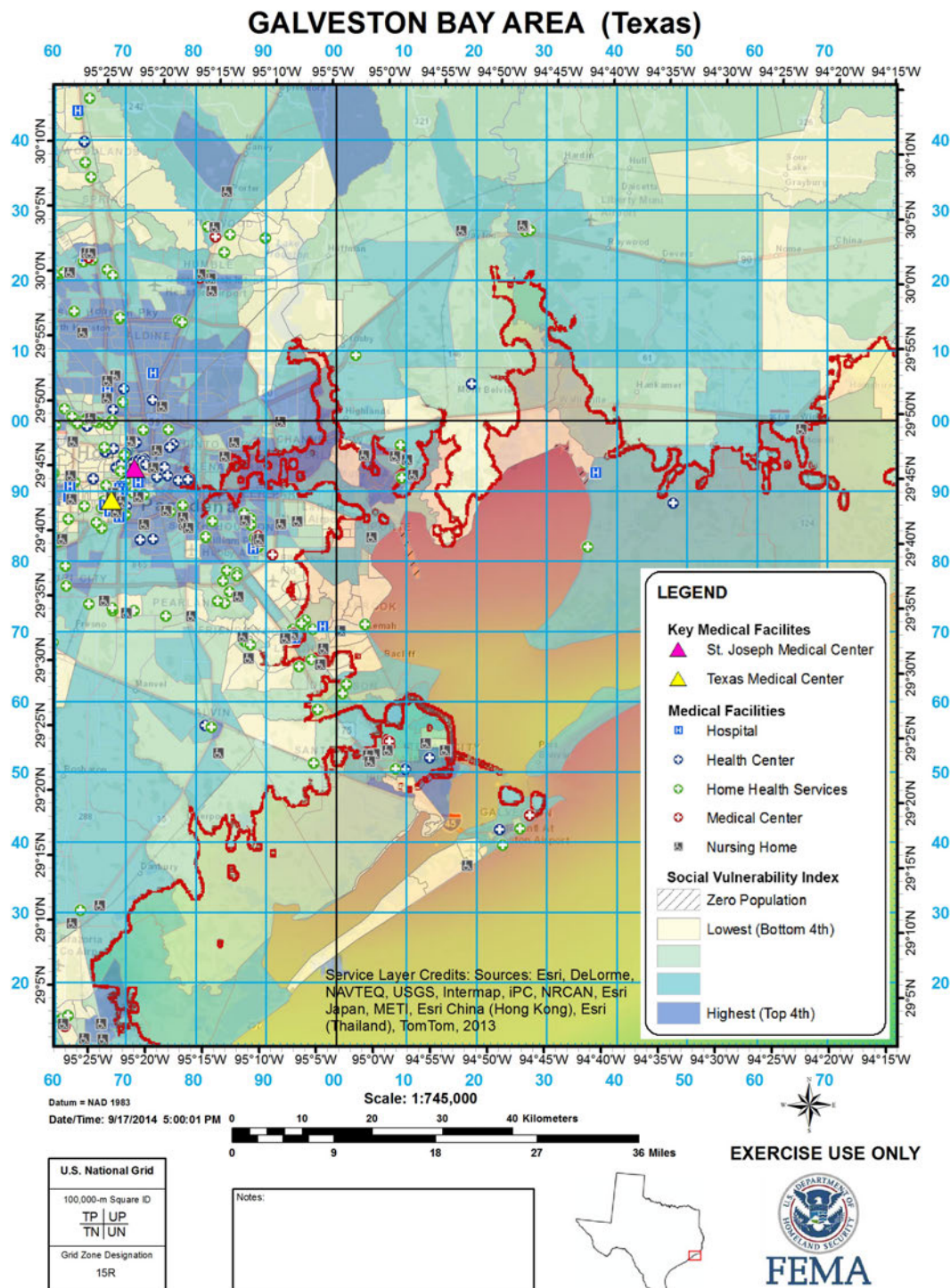
The Houston-Galveston area healthcare infrastructure is also at risk. The Texas Medical Center (2450 Holcombe Blvd #1, Houston, TX 7702 [29° 42.402'N, 95° 23.946'W; USNG 15R TN 67901 88694]) is the largest medical center in the world. It has one of the highest densities of clinical facilities for patient care, basic science, and translational research and receives an average of 3,300 patients per day. The center hosts 54 medicine-related institutions, which include the following: 21 hospitals; eight (8) specialty institutions; eight (8) academic and research institutions; three (3) medical schools; six (6) nursing schools; and schools of dentistry, public health, pharmacy, and other health-related practices. Located in Greater Houston adjacent to Brays Bayou, the Center has historically been subject to flooding during extreme rain events, regardless of the exact landfall point along the Texas coast.



**Figure 11. Texas Medical Center (© 2014 Texas Medical Center Corporation).**

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<sup>26</sup> "Oil Spill Threatens Galveston Bay's Fishing Industry." Texas Tribune, March 26, 2014.



**Figure 12. Inundation of Galveston Bay by Hurricane Brandy.** Graphic shows area healthcare facilities and the social vulnerability index of affected areas. Maximum extent of inundation is shown by the red line (i.e., areas south and east of the red line are inundated, except for circled areas).

The St. Joseph Medical Center (1401 St. Joseph Parkway, Houston, Texas 77002 [29° 44.881'N, 95° 21.958'W; USNG 15R TN 71201 93209]) is also at risk of flooding from Hurricane Brandy. This acute-care 792-bed facility, with a level III trauma center, serves populations of disproportionate impact in Houston.

## HOUSTON FACILITATOR DISCUSSION QUESTIONS

Given the observed climate trends and projected future conditions in the Houston-Galveston area, as well as the specific scenario event-increased risks from storm surge and heat waves in the mid-21<sup>st</sup> century, the following discussion questions will allow workshop participants to focus on the overarching question “what can be done now, as a whole community, to collaboratively and sustainably prepare, plan for, or help mitigate future projected climate impacts on the Houston-Galveston area.” Specific attention should be paid to planning, infrastructure systems (energy and chemical sectors along the Houston Ship Channel), natural resources and ecosystems, health and social services, and the economy within the Houston-Galveston area.

### Planning

1. What long-term planning efforts are underway in the Houston-Galveston area that would be affected by inclusion of either the heat wave or Hurricane Brandy?
  - a. Do these planning efforts take climate change—particularly sea level rise, temperature increases, variable but more intense precipitation, and stronger storms/higher storm surge—into account?
  - b. What local and State agencies are involved in these planning efforts?
  - c. How can the Federal government and, particularly, regional Federal partners best support these efforts?
2. How can Federal Departments and Agencies and, particularly, regional Federal partners collaborate to enhance their assistance to local and State planning efforts?
  - a. How can we increase communication and awareness between Federal Agencies, all with the same over-arching mission, and avoid duplicating efforts?
3. What additional actions must be taken now or in the near-term to avert mission failure or mitigate these risks?
  - a. What changes need to be made to your Department/Agency’s plans and policies?
  - b. How can emerging information be continuously integrated into planning efforts?
  - c. How is the Houston-Galveston area integrating climate considerations into the Threat and Hazard Identification and Risk Assessment (THIRA) process (examining how climate change potentially exacerbates existing threats and hazards)?
4. Are there currently coalitions being organized between local, State, Federal, and private sector partners to support adaptation planning for future storm surge and heat wave conditions as described in the scenario?
  - a. What would make it easier to build these coalitions?



- b. What governance structures are in place within the Houston-Galveston area and the State of Texas to support collaborative climate adaptation planning efforts and coalitions across the whole community?
5. What obstacles have your Departments and Agencies encountered that affect adaptation planning?
  - a. Are there specific barriers that discourage investment?
  - b. Are there changes that need to be made to local, State, Tribal, and Federal legal, regulatory, and policy frameworks to support adaptation and hazard mitigation strategies?
  - c. What are other innovative approaches to overcoming these obstacles?
  - d. What actions are you taking as a jurisdiction to make climate adaptation a priority consideration for resource planning support?
6. What incentives should we pursue to enhance local, State, Tribal, and Federal preparedness and resilience in the face of climate change risks?
7. How can Federal Agencies better serve the multitude of private companies at risk (in terms of both infrastructure and lives) in understanding the risks?
8. What public messaging/communications strategy are you developing or implementing to connect with the public on issues related to climate adaptation and hazard mitigation?
  - a. How can Federal Departments and Agencies best support local, State, and Tribal climate adaptation communications and outreach efforts?
  - b. What progress has been made in developing training and educational tools?

### **Infrastructure Systems**

1. Is there an existing inventory available of transportation infrastructure in the area? Utility infrastructure? Water/Sewer Systems?
  - a. Does that inventory include an assessment of the vulnerability of major infrastructure? Has functionally obsolete infrastructure been identified?
  - b. Are plans in place to address any weaknesses in basic infrastructure and/or update the infrastructure to the latest disaster resilient standards?
2. What long-term energy and chemical infrastructure development, modification, or re-engineering efforts are underway in the Houston-Galveston area, and in the Houston Ship Channel in particular, that would be affected by inclusion of either the heat wave or Hurricane Brandy?
  - a. Do these infrastructure development/modification/re-engineering efforts take climate change—particularly sea level rise, temperature increases, variable but

- more intense precipitation, and stronger storms/higher storm surge—into account?
- b. What local agencies are involved in these efforts?
  - c. How can the Federal government and, particularly, regional Federal partners best support these efforts?
  - d. How can whole community and, particularly, private sector partners best support these efforts?
3. How can Federal Departments and Agencies and, particularly, regional Federal partners collaborate to enhance their assistance to local, State, Tribal, and private sector infrastructure development/modification/re-engineering efforts?
  4. What are some of the most significant cascading affects from a major disruption to Houston-Galveston chemical and energy production capabilities at the local, State, and Federal levels?
  5. In the event that an intense tropical storm or hurricane results in severe disruption to Houston-Galveston chemical and energy supply chains (such as Tropical Storm Brandy, as described in the exercise scenario), what can local, State, and Federal planners—from both the public and private sectors—do today to mitigate the negative effects to national chemical and energy supplies?
  6. What interagency coordination is most needed today to ensure the survivability of chemical and energy supply chains in 2044? What are some the most significant barriers to that interagency coordination?
  7. Currently (2014), the Port of Houston has a \$499B annual economic effect (\$1.38B/day, \$57M/hour, \$1M/hour). How would these numbers compare in 2044 if the Port were devastated by a major hurricane and faced a lengthy closure?
  8. What can be done today, in terms of planning and infrastructure development, to ensure the sustainability of Houston Ship Channel operations in the wake of a major hurricane in the 2044 timeframe?
    - a. What interagency and public-private coordination is required?
    - b. What are the barriers to this coordination?
  9. What science information, data, or modeling capabilities exist to support decision-making requirements or investment decisions related to infrastructure systems?

### **Natural Resources/Ecosystems**

1. What long-term natural resources/infrastructure development or re-development efforts are underway in the Houston-Galveston area that would be affected by inclusion of either the heat wave or Hurricane Brandy?
  - a. Do these infrastructure development/re-development efforts take climate

- change—particularly sea level rise, temperature increases, variable but more intense precipitation, and stronger storms/higher storm surge—into account?
- b. What local and State agencies are involved in these efforts?
  - c. How can the Federal government and, particularly, regional Federal partners best support these efforts?
  - d. How can whole community partners best support these efforts?
2. How can Federal Departments and Agencies and, particularly, regional Federal partners collaborate to enhance their assistance to local, State, Tribal, and private sector infrastructure development/re-development efforts?
  3. Given the severe ecological effects likely from a hurricane (such as the one presented in the scenario), what can be done today to mitigate the ecological damage in the 2044 timeframe?
    - a. From a planning perspective?
    - b. From an engineering and infrastructure perspective?
    - c. From an economic and commercial perspective?

## Health and Social Services

1. How would health and social services in the Houston-Galveston area be affected by either the heat wave or Hurricane Brandy, given the expected rise in population and projected socio-economic conditions of the mid-21st Century?
  - a. In particular, what steps could be taken to better protect the Texas Medical Center and St. Joseph's Medical Center from storm-related flooding, electrical service interruptions, and supply chain disruptions?
  - b. What steps can be taken to better protect populations of disproportionate impact and those with access and functional needs from disruptions to area health and social services?
  - c. What local and State agencies are involved in these efforts?
  - d. How can the Federal government and, particularly, regional Federal partners best support these efforts?
2. How can Federal Departments and Agencies and, particularly, regional Federal partners collaborate to enhance their assistance to local, State, Tribal, and private sector health and social services planning efforts?
3. What can local, State, and Federal planners—from both the public and private sectors—do today to mitigate the effects of a forced evacuation of the Texas Medical Center due to structural damage, power outages, etc. in the 2044 timeframe?

4. What data or modeling capabilities exist to support decision-making requirements or investment decisions related to the provision of health and social services?

**Economy**

1. What short-term and long-term investments must be made to build and sustain capabilities to support adaptation planning?
  - a. How can local, State, Tribal, and Federal investments be leveraged to support multi-agency requirements and vice versa?
  - b. How can public-private partnerships be leveraged to support multi-agency requirements?

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## APPENDIX A: RESOURCES

### Useful Links:

#### WHITE HOUSE RESOURCES

- **Council on Environmental Quality:** <http://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience>
- **Office of Science and Technology Policy:** <http://www.whitehouse.gov/administration/eop/ostp>
- **White House Climate Data Initiative:** <http://www.data.gov/climate/>

#### FEDERAL RESOURCES

- **The U.S. Global Change Research Program:** [www.globalchange.gov](http://www.globalchange.gov).
- **Third U.S. National Climate Assessment:** <http://nca2014.globalchange.gov/>
- **Third U.S. National Climate Assessment Download Materials:** <http://www.globalchange.gov/nca3-downloads-materials>
- **The U.S. Global Change Research Program Adaptation Page:** <http://www.globalchange.gov/explore/adaptation>
- **The U.S. Global Change Research Program Federal Adaptation Resources Library:** <http://www.globalchange.gov/browse/federal-adaptation-resources>
- **Department of Transportation—Gulf Coast Study:** [http://www.fhwa.dot.gov/environment/climate\\_change/adaptation/ongoing\\_and\\_current\\_research/gulf\\_coast\\_study/index.cfm](http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/index.cfm)
- **Environmental Protection Agency—Region 6:** <http://www2.epa.gov/aboutepa/epa-region-6-south-central>
- **National Aeronautics and Space Administration—Johnson Space Center:** <http://www.nasa.gov/centers/johnson/home/>
- **Federal Emergency Management Agency—Region 6:** <http://www.fema.gov/region-vi-arkansas-louisiana-new-mexico-oklahoma-texas>
- **U.S. Coast Guard—Houston, TX:** <http://www.uscg.mil/nmc/recs/hou.asp>

#### REGIONAL RESOURCES

- **The State Climatologist:** <http://climatexas.tamu.edu/>
- **The Texas Sea Grant Program:** <http://texas-sea-grant.tamu.edu/>



- **Southern Regional Climate Center:** <http://www.srcc.lsu.edu/>
- **Southern Regional Climate Services**  
**Director:** <http://www.ncdc.noaa.gov/rcsd/southern>
- **National Weather Service—Southern**  
**Region:** <http://www.nws.noaa.gov/om/csd/index.php?section=programs#southern>
- **West Gulf River Forecast Center:** <http://www.srh.noaa.gov/wgrfc/>
- **National Estuarine Research—Mission-Aransas**  
**Reserve:** <http://www.nerrs.noaa.gov/Reserve.aspx?ResID=MAR>
- **U.S. Department of Agriculture’s Southern Plains Climate**  
**Hub:** [http://www.usda.gov/oce/climate\\_change/regional\\_hubs.htm](http://www.usda.gov/oce/climate_change/regional_hubs.htm)
- **South Central Climate Science**  
**Center:** <http://www.interior.gov/csc/southcentral/index.cfm>
- **Gulf Coast Prairie Landscape Conservation**  
**Cooperative:** <http://gulfcoastprairielcc.org/>
- **Harte Research Institute:** <http://www.harterresearchinstitute.org/>
- **Rice University’s Baker Institute for Public Policy:** <http://bakerinstitute.org/>
- **Texas Tech University:** <http://www.depts.ttu.edu/politicalscience/>

## **LOCAL RESOURCES**

- **City of Houston—Mayor’s Office of Sustainability:** [www.greenhoustontx.gov](http://www.greenhoustontx.gov)
- **The Houston Advanced Research Center:** [www.harc.edu](http://www.harc.edu)
- **Galveston Bay Foundation:** <http://www.galvbay.org/>
- **University of Houston:** <http://www.icas.uh.edu/>
- **Texas A&M University—Galveston Campus:** <http://www.tamug.edu/>

## **Attached Fact Sheets:**

1. Federal Highway Administration, Summary of FHWA Climate Adaptation Initiatives
2. U.S. Department of Transportation, *Draft* Hydraulic Engineering Circular No. 25 (Volume 2).

# Summary of FHWA Climate Adaptation Initiatives

(Available at: [http://www.fhwa.dot.gov/environment/climate\\_change/adaptation/ongoing\\_and\\_current\\_research/summary/index.cfm](http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/summary/index.cfm))

The Federal Highway Administration (FHWA) began to address the impacts of climate change near the beginning of the George W. Bush administration. Climate change impacts, such as more frequent and intense heat waves and flooding, threaten the considerable federal investment in transportation infrastructure. FHWA is partnering with state and local transportation agencies to increase the resilience of the transportation system to these impacts.

## Initial Efforts Focused on Impacts of Climate Change on Transportation Systems

FHWA's initial efforts focused on understanding the scope and scale of climate change impacts on transportation. DOT (with FHWA support) commissioned a [series of short papers](#) by researchers across government and convened a conference in 2002. FHWA then led the [Impacts of Climate Variability and Change on Transportation Systems and Infrastructure: Gulf Coast Study](#). Issued in March 2008, the report concluded that many critical transportation assets were extremely vulnerable. For example 19% of major roads and 5% of rail lines in the central Gulf Coast region could be affected if sea levels rise by just 2 feet, a conservative estimate of projected sea level rise in the region over the next 50 to 100 years. Hurricane Katrina further underscored this conclusion. FHWA's [Potential Impacts of Global Sea Level Rise on Transportation Infrastructure - Atlantic Coast Study](#) followed in October 2008. The impacts of climate change also began to arise as issues on a few highway projects, such as the Bonner Bridge replacement project along the Outer Banks of North Carolina.

From the initial projects, FHWA learned that climate change impacts threaten key goals of safety, system reliability, asset management, and financial stewardship. More frequent heat waves stress materials while heavier rainfall, rising sea levels, and stronger hurricanes cause flooding that damages roadways and disrupts traffic. FHWA also learned that, due to the global nature of climate models, the resulting climate projections were not well suited for making design decisions at the project-level. Transportation agencies needed climate projections at a fine enough scale to develop effective strategies to adapt to climate change at the project and systems level.

## Next Steps: Developed Tools and Information for States to Assess Vulnerabilities

FHWA then embarked on a series of efforts designed to gain experience applying climate information and to develop capacity in state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) (FHWA's main stakeholders).

- FHWA produced the report [Regional Climate Change Effects: Useful Information for Transportation Agencies](#) in May 2010. This report provided projections of temperature, sea level rise and precipitation over three different time periods out to 2100.
- To raise awareness of climate adaptation and resiliency, FHWA held several practitioner [peer exchanges](#) and conducted numerous [webinars](#).
- To help DOTs and MPOs better understand their vulnerabilities to climate change, FHWA produced a conceptual framework in 2009. Piloted in five locations in 2010 and 2011, FHWA updated it with feedback and examples from the pilots and released it in 2012 as the [FHWA Climate Change & Extreme Weather Vulnerability Assessment Framework](#).
- The updated Framework is being used by a second round of [demonstration projects at 19 different agencies](#) across the nation, including inland areas facing more severe droughts and flooding from heavier downpours. Many of these are analyzing adaptation options in addition to vulnerabilities. FHWA will update the framework again upon completion of the 19 pilots in 2015.

# Summary of FHWA Climate Adaptation Initiatives

(Available at: [http://www.fhwa.dot.gov/environment/climate\\_change/adaptation/ongoing\\_and\\_current\\_research/summary/index.cfm](http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/summary/index.cfm))

- To date, 24 state DOTs and 30 MPOs have assessed their vulnerability to climate change, as tracked for the FHWA Strategic Implementation Plan.

## Recent Efforts Analyze Strategies to Improve Resilience

FHWA's most recent efforts include research to help areas analyze adaptation strategies to increase resiliency. FHWA is conducting engineering analyses of adaptation options such as enlarging culverts, raising bridges, or using more heat resistant materials as part of three projects discussed below.

- To be completed in Fall 2014, the [Gulf Coast Phase 2 project](#) is assessing vulnerability and risk to multi-modal assets in Mobile, AL. The project is also producing transferable tools for using climate projections at the local level, assessing vulnerabilities, and analyzing adaptation options.
- As short-term recovery to Superstorm Sandy wrapped up, FHWA began working with the region to build long-term resilience to future storms. FHWA is now working with MPOs, DOTs and other owner/operators in the NY-NJ-CT region on [the Hurricane Sandy Follow-up, Vulnerability Assessment and Adaptation Analysis](#).
- The Engineering Strategic Initiative Adaptation Study will develop recommended engineering solutions to adapt to climate vulnerabilities for specific highway facilities around the country. Three additional Strategic Initiatives projects newly funded for 2014 will develop methods to incorporate changes in precipitation patterns in the highway design process, research climate impacts on geohazards, and conduct a watershed sensitivity study to help owners identify drainage assets at high risk.

## Integrating Climate Resilience into FHWA Programs

FHWA is integrating climate resilience considerations into the agency's programs, guidance, and policies, consistent with existing transportation law,<sup>1</sup> the Secretary's 2011 [policy statement](#) on climate adaptation, and the President's [Executive Order 13653](#) on climate preparedness.

- FHWA issued a [memo in 2012](#) clarifying that climate adaptation activities are eligible for FHWA funding, including vulnerability assessments and design and construction of projects or features to protect assets from damage associated with climate change.
- FHWA updated the [Emergency Relief Manual](#) to reflect concerns tied to resilience.
- FHWA is developing a rule to implement the legislative requirement that state DOTs develop risk-based asset management plans. Climate change is one of multiple risks that impact asset management. The legislation also includes requirements to consider alternatives for facilities repeatedly needing repair or replacement using federal funding.<sup>2</sup>
- FHWA is updating multiple engineering circulars with climate resiliency considerations: Hydraulic Engineering Circular (HEC) 25 Highways in the Coastal Environment, HEC-17 Highways in the River Environment, and Hydraulic Design Series (HDS) 2 Highway Hydrology.

The actions outlined above assist FHWA and stakeholders in responsibly managing the risks posed by a changing climate. Managing these risks is critical to FHWA's core mission to improve highway system performance—particularly its safety, reliability, effectiveness, and sustainability.

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<sup>1</sup> Transportation law charges FHWA with extending the useful life of highways, promoting highway safety, and serving as a wise steward of Federal funds (see 23 U.S.C. 109, 116, and 134 among others).

<sup>2</sup> Moving Ahead for Progress in the 21<sup>st</sup> Century (MAP-21) Section 1315b



**Hydraulic Engineering Circular No. 25 (Volume 2)**  
**Highways in the Coastal Environment: Assessing Extreme Events**

**Authors:**

Scott L. Douglass, Bret M. Webb, and Roger Kilgore

**Targeted Publication Date:** November 2014

**Synopsis:**

This manual provides technical guidance and methods for assessing the vulnerability of coastal transportation facilities to extreme events and climate change. This is a standalone supplement, a “Volume 2,” to the existing, primary FHWA Hydraulic Engineering Circular (HEC) manual: “Highways in the Coastal Environment,” HEC-25 (2<sup>nd</sup> ed., FHWA 2008). The focus of this supplement is quantifying exposure to sea level rise, storm surge, and waves considering climate change. It is anticipated that there will be multiple uses for this guidance including risk and vulnerability assessments, planning activities, and design procedure development.

The critical coastal processes controlling the vulnerability of transportation assets to extreme events are identified by region along with some available methods for modeling them and the likely impacts of climate change. Global sea level rise, including projections of future sea levels, is emphasized because of its importance. A site-specific example of how to estimate future sea level rise based on USACE guidance ER 1100-2-8162, Incorporating Sea Level Change in Civil Works Programs, is given.

Tools for developing vulnerability assessments for coastal transportation infrastructure are described within the framework of engineering risk. Storm damage mechanisms, often exacerbated by sea level rise and climate change, are described. Adaptation approaches for coastal transportation infrastructure are also described.

Many of the adaptations required for climate change and sea level rise are the same adaptations required for improving infrastructure resilience to extreme events with today’s sea levels. Specific approaches for assessing exposure of coastal infrastructure to extreme events and climate change are presented in three different “levels of effort” ranging from use of available data to original numerical modeling. The inclusion of trained coastal scientists and engineers in the analysis team is suggested at all levels of effort. Three case studies from the existing literature on coastal vulnerability assessments to extreme events and climate change are described. Our coastal transportation infrastructure is highly exposed to extreme events today and that exposure is going to increase with sea level rise and climate change.

**Hydraulic Engineering Circular No. 25 (Volume 2)**  
**Highways in the Coastal Environment: Assessing Extreme Events**

**Draft Outline:**

**Chapter 1 – Introduction**

- 1.1 Background
- 1.2 Purpose
- 1.3 Target Audience
- 1.4 Organization
- 1.5 Units of this Document
- 1.6 Related Guidance

**Chapter 2 – Relevant Coastal Processes and Climate Change Impacts**

- 2.1 Description of Relevant Coastal Processes
- 2.2 Damaging Processes of Extreme Coastal Events
- 2.3 Climate Change Impacts on Damaging Coastal Processes
- 2.4 Numerical Models of Critical Coastal Processes

**Chapter 3 – Risk, Vulnerability and Adaptation**

- 3.1 Engineering Risk at the Coast
- 3.2 Coastal Vulnerability Assessments
- 3.3 Climate Change and Extreme Events: Damage Mechanisms
- 3.4 Adaptation/Countermeasure Strategies for Coastal Highway Infrastructure

**Chapter 4 – Analysis Methods for Assessing Extreme Events and Climate Change**

- 4.1 General Framework Chapter 4 – Analysis Methods for Assessing Extreme Events and
- 4.2 Gulf of Mexico and South Atlantic Coast
- 4.3 Mid-Atlantic and New England Coast
- 4.4 Great Lakes Coast
- 4.5 Pacific Coast – Storms
- 4.6 Pacific Coast – Tsunamis

**Chapter 5 – Case Studies of Exposure and Vulnerability Assessment**

- 5.1 The Gulf Coast 2 Study - Mobile County, Alabama
- 5.2 Adapting to Rising Tides - San Francisco Bay Inundation Mapping
- 5.3 Synthetic Storm Analysis Applied to the Florida Coast

**Chapter 6 – References**



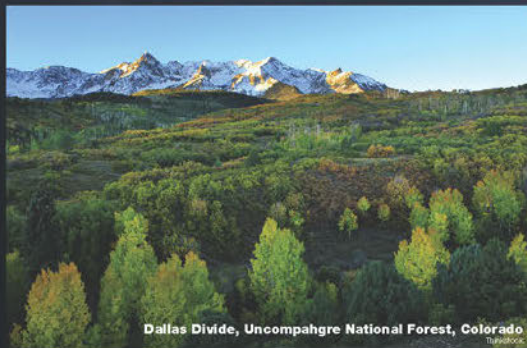
*"Climate change, once considered an issue for a distant future, has moved firmly into the present."*

– Third U.S. National Climate Assessment

Climate Change Preparedness and Resilience Exercise Series

# Colorado Climate Change Preparedness and Resilience Workshop

October 9, 2014



Dallas Divide, Uncompahgre National Forest, Colorado



FEMA

National Exercise Program  
The White House

Participant Handbook



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October 9, 2014

8:30 a.m.–5:00 p.m. Mountain Daylight Time (MDT)

## **WORKSHOP SCHEDULE**

**Welcome and Opening Remarks**

**Overview and Administration.**

**Video(s)**

**Panel Session #1:** Science—National and Regional Perspectives

**Panel Session #2:** Impacts—State and Local Perspective

**Panel Session #3:** Action—Challenges and Opportunities

**Tabletop Exercise:** Increased Risk of Drought, Wildfires, and Heat Waves in the Mid-Century

**Participant Feedback and Hotwash**

**Closing Remarks**

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## INTRODUCTION

The Colorado Climate Change Preparedness and Resilience Workshop is an element of the Climate Change Preparedness and Resilience Exercise Series sponsored by the White House National Security Council Staff, Council on Environmental Quality, and Office of Science and Technology Policy in collaboration with the Federal Emergency Management Agency (FEMA) National Exercise Division (NED). The Colorado Workshop is one of three jurisdictional workshops being conducted in October 2014—additional workshops are being held in Houston, Texas and Anchorage, Alaska—with the overarching goal of advancing the climate adaptation dialogue and identifying collaborative and sustainable approaches to community-based climate preparedness and resilience capabilities.

Hosted by the Colorado Recovery Office and the City of Fort Collins, the workshop is structured around three moderated and interactive panel sessions followed by a facilitated tabletop exercise. The morning panel sessions reflect a diverse group of panelists and disciplines with a focus on climate science (from national and regional perspectives), effects of climate change (from State and local perspectives), and associated challenges and opportunities (from a whole community perspective). These sessions set a foundation for the afternoon tabletop exercise discussions that will focus on planning, water, agriculture, health and social services, natural resources and ecosystems, infrastructure systems, and the economy within the State of Colorado. Ultimately, workshop participants will address the question of “what can be done now, as a whole community, to collaboratively and sustainably prepare, plan for, or help mitigate future projected climate impacts on Colorado.”

In support of the desired outcome to improve collaboration with and between whole community partners, workshop participants include local, State, Tribal, and Federal representatives as well as private sector, non-governmental, and academic partners who have roles, responsibilities, and expertise related to climate adaptation, hazard mitigation, and resiliency planning efforts.

This Participant Handbook provides goals and objectives for the workshop, a detailed scenario with focus areas, and facilitator questions for discussion during the exercise.

### Workshop Goal

The goal of the workshop is to provide a forum for Colorado planners and partners to identify and refine climate change preparedness and resilience requirements and initiatives in collaboration with numerous whole community stakeholders.

### Workshop Objectives

The workshop will have the following objectives:

1. Examine methods to better integrate existing and emerging information and requirements into current and future planning to manage and adapt to climate risks and vulnerabilities.
2. Identify collaborative and sustainable whole-community approaches to advance and sustain local climate preparedness and resilience programs, policies, and strategies.

3. Examine investment opportunities and the development of coalitions between local, State, Tribal, Federal, and private sector partners to support climate preparedness and resilience.

## Workshop Outcomes

The workshop will focus on the following outcomes:

1. Improved collaboration with and between whole community partners on climate preparedness and resilience strategies.
2. Identification of new research, information, and capabilities that will support local preparedness, adaptation, and mitigation planning.

## Workshop Output

Workshop outputs will include the following:

1. Workshop Summary Report that addresses key discussion points and identified climate preparedness and resilience information, innovations, and initiatives.
2. Potential climate preparedness and resilience requirements to support the Threat and Hazard Identification Risk Assessment (THIRA) process.

## Workshop Format

The workshop is a one-day facilitated event tailored for the specific requirements of the State of Colorado. The morning panel sessions are based on current scientific projections and climate preparedness and resilience efforts, while the afternoon is a facilitated scenario-driven tabletop exercise.

Scientific information describing observed climate trends and projected future climate conditions is derived primarily from the Third U.S. National Climate Assessment<sup>1</sup> and the Climate Change in Colorado<sup>2</sup> report developed for the Colorado Water Conservation Board.

The exercise scenario is tailored to examine specific jurisdictional impacts based on the existing Third U.S. National Climate Assessment regional scenarios and includes a specific scenario event—increased risk of drought, wildfires, and heat waves in the mid-21<sup>st</sup> century along the Colorado Front Range—to allow participants to focus their discussions.

## Workshop Participants

Workshop participants include local, State, Tribal, and Federal climate adaptation and mitigation planners, emergency managers, and subject matter experts (SMEs) as well as identified

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<sup>1</sup> Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

<sup>2</sup> Lukas, et. al. Western Water Assessment, Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder. A Report for the Colorado Water Conservation Board. Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation. Second Edition—August 2014.

stakeholders and partners from the private sector, non-governmental organizations, and academic institutions. Federal participants include both region-based Department and Agency representatives as well as select representatives from the National Capital Region (NCR).

**State of Colorado**

- Colorado Energy Office
- Department of Agriculture
- Department of Local Affairs
- Department of Public Health and Environment
- Department of Public Safety
- Department of Transportation

**Local Communities**

- Adams County
- Boulder County
- Denver County
- City of Boulder
- City of Denver
- City of Fort Collins
- Poudre Fire Authority
- Weld County

**Tribal Communities**

- Ute Mountain Ute Tribe

**Federal Departments and Agencies**

- National Aeronautics and Space Administration
- U.S. Army Corps of Engineers
- U.S. Department of Agriculture
  - U.S. Forest Service
- U.S. Department of Commerce

- National Oceanic and Atmospheric Administration
  - U.S. Economic Development Administration
- U.S. Department of Defense
  - U.S. Northern Command
- U.S. Department of Energy
- U.S. Department of Health and Human Services
- U.S. Department of Homeland Security
  - Federal Emergency Management Agency Region VIII
  - Office of Infrastructure Protection
- U.S. Department of the Interior
  - Bureau of Land Management
  - Bureau of Reclamation
  - Fish and Wildlife Service
  - National Park Service
  - U.S. Geological Survey / Climate Science Centers
- U.S. Department of Transportation
- U.S. Environmental Protection Agency
- U.S. Global Change Research Program
- U.S. Small Business Administration
- White House
  - Council on Environmental Quality
  - Office of Science and Technology Policy
  - National Security Council Staff

**Private Sector**

- Colorado Municipal League
- National Wildlife Federation

- Rocky Mountain Climate Organization
- Southwest Energy Efficiency Project
- Stratus Consulting
- The Nature Conservancy
- Urban Land Institute
- WaterJasmin Legal and Policy Consulting
- Went and Associates

### **Non-Governmental Organizations**

- AMEC
- National Center for Atmospheric Research

### **Academic Institutions**

- Colorado State University
- University of Colorado Boulder

## **Workshop Scope and Assumptions**

Exercises play a vital role in national preparedness by enabling whole community stakeholders to test and validate capabilities as well as identify potential capability shortfalls and planning requirements for improving preparedness. A well-designed exercise provides a low-risk environment to share understanding of requirements, familiarize personnel with roles and responsibilities, and foster meaningful interaction and communication across organizations. Exercises bring together and strengthen the whole community in its efforts to prevent, protect against, mitigate, respond to, and recover from all hazards. Overall, exercises are cost-effective and useful tools that help the nation practice and refine our collective capacity to build, sustain, and deliver the core capabilities needed to achieve climate preparedness and resilience.

Participants are encouraged to share their expertise, and the facilitator will ensure that participants have an opportunity to contribute. The scenario will integrate existing issues as identified through the planning process. Discussion questions aim to assist participants in achieving the objectives of the workshop.

Participants should consider the following exercise ground rules to ensure that objectives are met in a reasonable amount of time and that the workshop runs smoothly:

1. Keep exercise objectives in mind throughout the workshop.



2. Participate openly and focus discussions on appropriate topics. Asking questions, sharing thoughts, and offering forward-looking, problem-solving suggestions will enhance the exercise experience.
3. Focus comments and consider time constraints.

In any exercise, a number of assumptions may be necessary to complete play in the time allotted. During this exercise, the following assumptions apply:

1. The scenarios are plausible, and events occur as they are presented.
2. There is no “hidden agenda,” nor trick questions.
3. All players receive information at the same time.

### Workshop Evaluation

The evaluation process will align with requirements of the National Exercise Program (NEP) and will be consistent with Homeland Security Exercise and Evaluation Program (HSEEP) doctrine. Evaluation efforts will validate strengths and identify opportunities for improving climate resiliency among participating organizations by capturing key discussion points, identifying strengths and areas for improvement, and consolidating these discussion points within a Summary Report. This approach affords participating organizations an opportunity to revise, update, or modify current plans and strategies, as needed.

The Summary Report will capture key discussion points to include the following:

1. Recommendations on integration of climate preparedness and resilience requirements and initiatives into current and future planning to manage and adapt to climate risks and vulnerabilities.
2. Suggestions on maintaining collaborative partnerships and building new coalitions across the whole community.
3. Areas where additional information and research is needed.
4. Effects of climate change on Colorado-area missions, policies, and strategies, and resources required given the workshop scenario.

The NED will assign evaluators to capture participant discussions. The evaluation team will then produce the Summary Report and deliver it to the NED within two (2) weeks of the workshop’s conclusion. The exercise planning team and key participants will be invited to participate in a virtual After-Action Meeting in November 2014 to review the draft Summary Report and validate and revise the findings and observations in order to produce a final Summary Report.

### Core Capabilities

The National Preparedness Goal, released in September 2011, defines what it means for the whole community to be prepared for all types of disasters and emergencies. It identified five (5)

mission areas—Prevention, Protection, Mitigation, Response, and Recovery—which encompass 31 distinct critical elements (“core capabilities”) needed to achieve a secure and resilient Nation.

The workshop will focus on the Mitigation mission area, which is comprised of “the capabilities necessary to reduce the loss of life and property by lessening the impacts of disasters.”

Three (3) of the Mitigation core capabilities will be explored through the workshop:

1. Community Resilience
2. Long-Term Vulnerability Reduction
3. Risk and Disaster Resilience Assessment

Descriptions<sup>3</sup> for the core capabilities that will be examined during the workshop are as follows:

Core Capability	Description
Community Resilience	Lead the integrated effort to recognize, understand, communicate, plan, and address risks so that the community can develop a set of actions to accomplish mitigation and improve resilience.
Long-Term Vulnerability Reduction	Build and sustain resilient systems, communities, and critical infrastructure and key resources lifelines so as to reduce their vulnerability to natural, technological, and human-caused incidents by lessening the likelihood, severity, and duration of the adverse consequences related to these incidents.
Risk and Disaster Resilience Assessment	Assess risk and disaster resilience so that decision-makers, responders, and community members can take informed action to reduce their entity's risk and increase their resilience.

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<sup>3</sup> U.S. Department of Homeland Security. *National Preparedness Goal*. September 2011.

## SCENARIO BACKGROUND: *CLIMATE INFORMATION*

### Regional Changes in the Climate for the U.S. Southwest Region

According to the Third U.S. National Climate Assessment, the State of Colorado is part of the U.S. Southwest Region. The Southwest is the hottest and driest region in the United States. The availability of water has defined its landscapes, history of human settlement, and modern economy. Climate changes pose challenges for an already parched region that is expected to get hotter and, in its southern half, significantly drier. Increased heat and changes to rain and snowpack will send ripple effects throughout the region, affecting a population of 56 million people (which is expected to increase to 94 million by 2050) and its critical agriculture sector. Severe and sustained drought will stress water sources, already over-utilized in many areas, and force increased competition among farmers, energy producers, urban dwellers, and ecosystems for the region's most precious resource.<sup>4</sup> The Southwest regional findings of the Third U.S. National Climate Assessment include:

- **Key Message 1:** Snowpack and streamflow amounts are projected to decline in parts of the Southwest, decreasing surface water supply reliability for cities, agriculture, and ecosystems.
- **Key Message 2:** The Southwest produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat. Reduced yields from increasing temperatures and increasing competition for scarce water supplies will displace jobs in some rural communities.
- **Key Message 3:** Increased warming, drought, and insect outbreaks, all caused by or linked to climate change, have increased wildfires and impacts to people and ecosystems in the Southwest. Fire models project more wildfire and increased risks to communities across extensive areas of the region.
- **Key Message 4:** Projected regional temperature increases, combined with urban amplification of heat, will pose increased threats and costs to public health in southwestern cities, which are home to more than 90 percent of the region's population. Disruptions to urban electricity and water supplies will exacerbate these health problems.<sup>5</sup>

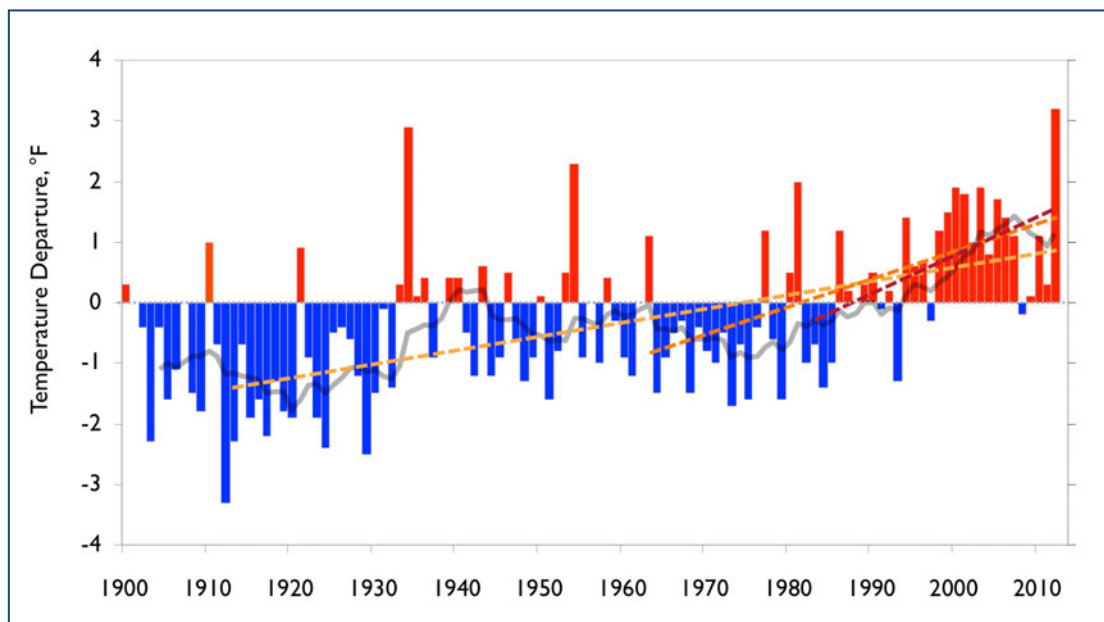
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<sup>4</sup> Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: *Highlights of Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program

<sup>5</sup> Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, R. Smyth, and R. Waskom, 2014: Ch. 20: Southwest. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program

Background Information for the State of Colorado<sup>6</sup>

Located far from the moderating impacts of humid maritime air, Colorado experiences frequent sunshine, low humidity, and rapid and large variations in temperatures. Colorado's complex topography—mountains, valleys, plateaus, and rolling plains—strongly influences temperature, air pressure, wind, and precipitation, which can vary dramatically over extremely short distances.



**Figure 1. Colorado statewide annually-averaged temperature ( degrees Fahrenheit), 1900–2012. Annual departures are shown relative to a 1971–2000 reference period. The light-orange, orange, and red lines are the 100-year, 50-year, and 30-year trends, respectively. All three warming trends are statistically significant. (Source: “Climate Change in Colorado, A Synthesis to Support Water Resources Management and Adaptation,” Second Edition, August 2014).**

Colorado serves as the headwaters for much of the western and central United States. Although most of Colorado is semi-arid and receives less than 20 inches of precipitation annually, Colorado's mountain ranges receive up to 60 inches of precipitation each year, mostly as snow. The spring and summer runoff from these deep snowpacks provides a large majority of annual streamflow in Colorado's major rivers. Water users in Colorado and 19 downstream states rely on this snowmelt-dominated hydrology. Colorado's tourism and recreation sectors likewise depends on the snowpack for skiing and other winter sports, and the runoff is the basis for rafting, fishing, and other river, lake, and reservoir activities.

<sup>6</sup> Except as indicated otherwise for specific paragraphs, adapted from “Climate Change in Colorado, A Synthesis to Support Water Resources Management and Adaptation”, Second Edition—August 2014, A Report for the Colorado Water Conservation Board, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder, Jeff Lukas, University of Colorado Boulder, CIRES, Joseph Barsugli, University of Colorado Boulder, CIRES, Nolan Doesken, Colorado State University, Colorado Climate Center, Imtiaz Rangwala, University of Colorado Boulder, CIRES, Klaus Wolter, University of Colorado Boulder, CIRES; pages 2-3.

Agriculture is the primary user of water in Colorado, supporting three (3) million acres of irrigated row crops, fruits, and vegetables. Dryland row crops and dryland grazing are also important elements of the state's agricultural sector.

Colorado's forests, woodlands, and rangelands experience periodic wildfires. With rapid development in the wildland-urban interface in recent decades, particularly on the Front Range, up to 300,000 homes statewide are thought to be at risk of damage from wildland fires.

Drought is a frequent occurrence in Colorado. Nearly every year, some part of the state has experienced a short-term drought, which impacts agriculture and can lead to increased wildfire occurrence. Persistent multi-year droughts, which tend to be more widespread, have occurred every 30-40 years. These have negative impacts on agriculture and recreational sectors and significantly stress water supplies. Wildfire-scarred areas are also more prone to flooding and debris flows, as they lack vegetation to hold soils in place. This can affect watershed health and water quality.

### Observed Climate Change Trends in the State of Colorado

**Temperatures have increased.** Statewide annual average temperatures have increased by 2.0 degrees Fahrenheit over the past 30 years and 2.5 degrees Fahrenheit over the past 50 years (see **Figure 1**). Warming trends have been observed over these periods in most parts of the state and in all seasons. Daytime high temperatures and nighttime low temperatures are both rising in Colorado. This could have negative impacts on crops and animal production. Heat waves have also become more frequent.

**Annual precipitation shows no trends.** No long-term trends in average annual precipitation have been detected across Colorado, even taking into account the relatively dry period since 2000. No long-term statewide trends in heavy precipitation events have been detected. The evidence suggests that there has been no statewide trend in the magnitude of flood events in Colorado.

**Snowpack has declined recently.** Although a definitive decline has not yet been established (based on 30- or 50-year trends), snowpack, as measured by April 1 snow-water equivalent, has been below-average since 2000 in all of Colorado's river basins. Over the past 30 years, the timing of snowmelt and peak runoff has shifted earlier in the spring by one (1) to four (4) weeks across Colorado's river basins due to the combination of lower snow-water equivalent since 2000, the warming trend in spring temperatures, and enhanced solar absorption from dust-on-snow.<sup>7</sup>

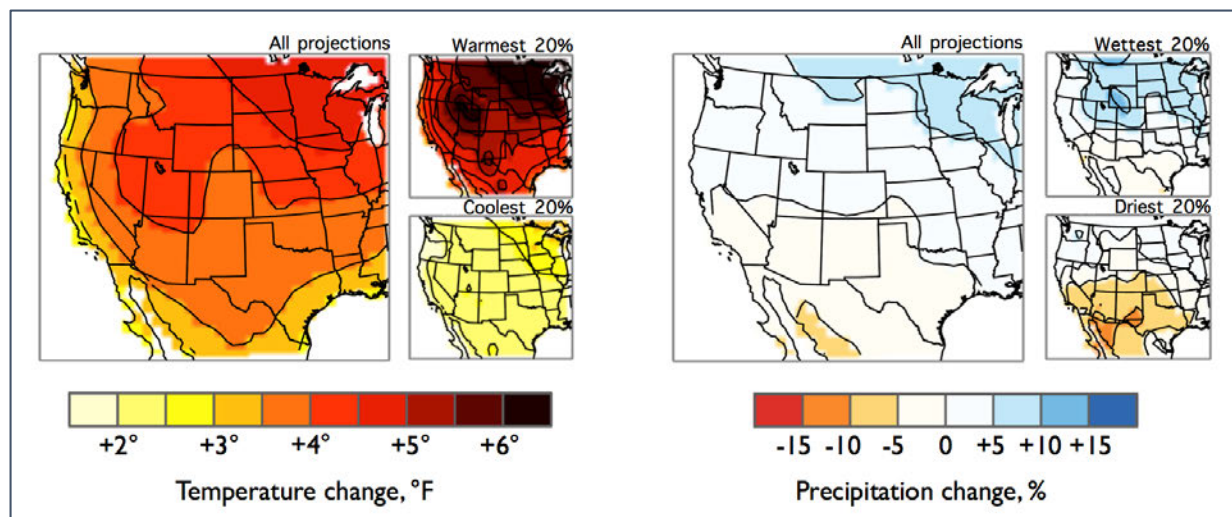
**Drought severity has increased.** The Palmer Drought Severity Index shows a trend of more severe soil-moisture drought conditions in Colorado over the past 30 years, reflecting the combination of below-average precipitation since 2000 and the warming trend (described above).

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<sup>7</sup> Dust-on-snow: Strong winds associated with springtime storms periodically strip the upper soil from the drylands of the Colorado Plateau region and deposit it as reddish dust on the snowpacks of Colorado's mountains. The dust darkens the snow surface so that it absorbs more of the sun's energy, causing snowmelt and runoff to occur earlier in the spring. This dust-on-snow effect appears to have worsened in the past few decades due to drier, warmer conditions and increased soil disturbance in the Colorado Plateau region.



Climate change may have increased the severity of recent drought conditions in the western United States due to the influence of warming on snowpack, streamflow, and soil moisture.



**Figure 2. Projected changes in annual average temperature and precipitation by 2050 (2035–2064) over the western United States from an ensemble of 37 climate models under Representative Concentration Pathway 4.5, a medium-low emissions scenario. The large maps show the average change for all of the models (n=37), and the small maps show the average changes for the highest and lowest 20 percent (n=8) of the models. For Colorado, all models show substantial warming, but there is less agreement about the direction of precipitation change. (Source: “Climate Change in Colorado, A Synthesis to Support Water Resources Management and Adaptation,” Second Edition, August 2014).**

### Projected Future Climate Conditions in the State of Colorado

**Much warmer annual and seasonal temperatures are projected.** As climate changes, temperatures in Colorado are projected to continue to increase (see **Figure 2**). If heat-trapping gas emissions continue on a high-emissions trajectory, temperatures in Colorado are projected to increase between 3.5 degrees Fahrenheit and 6.5 degrees Fahrenheit by 2050 and much more in the latter half of the century. Typical summer temperatures by 2050 are projected to be similar to the hottest summers that have occurred over the past 100 years.

**Precipitation changes are uncertain.** Climate model projections show less agreement regarding future precipitation changes for Colorado. Nearly all of the projections indicate increasing winter precipitation by 2050. There is weaker consensus among the projections regarding precipitation in the other seasons.

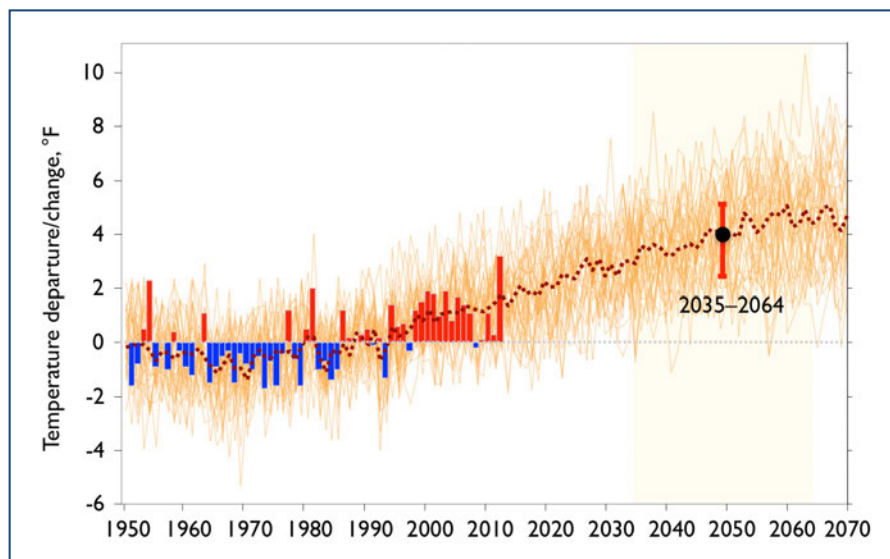
**Annual streamflow for Colorado's river basins are projected to decrease.** As a result of increased temperatures, projections for changes in annual streamflow indicate a tendency toward future decreases for Colorado's river basins. The peak of the spring runoff is projected to shift one (1) to three (3) weeks earlier by 2050 due to warming. Late-summer flows are projected to decrease as the peak shifts earlier. Changes in the timing of runoff are more certain than changes in the amount of runoff.

**Spring snowpack is expected to decline.**

Most projections of Colorado's spring snowpack (April 1 snow-water equivalent) show declines for 2050 due to projected warmer temperatures.

**Heat waves, droughts, and wildfires are expected to increase.**

Most climate projections indicate that heat waves, droughts, and wildfires will increase in frequency and severity in Colorado by 2050 due to projected warming.



**Figure 3. Projected Colorado Annual Temperature from 1950–2070.**

Modeled by 37 climate models under RCP 4.5 (yellow/orange lines) compared to the observed Colorado annual temperature anomalies, 1900–2012 (red/blue bars). All values are shown relative to the 1971–2000 baseline (gray dashed line). The models project a continuation of the recent warming trend through 2050, with typical temperatures matching or exceeding the warmest years of the 20<sup>th</sup> Century. (Source: *Climate Change in Colorado, A Synthesis to Support Water Resources Management and Adaptation*, Second Edition, August 2014).

## Climate Change Impacts for the State of Colorado

**Human health and well-being.** Exposure to excessive heat can threaten human health and well-being, especially for those who suffer from respiratory or heart disease. Higher temperatures can reduce air quality because atmospheric chemical reactions occur faster in warmer conditions. More frequent wildfires would also reduce air quality. Wildfire smoke exposure increases respiratory and cardiovascular hospitalizations; emergency department visits; and medication dispensations for asthma, bronchitis, chest pain, chronic obstructive pulmonary disease, respiratory infections, and lung diseases. Higher temperatures and longer warm seasons will also lead to shifts in the distribution of disease-transmitting mosquitoes.

**Essential infrastructure.** Warmer temperatures, drier conditions, and population increases can stress Colorado's energy infrastructure. Warmer temperatures will likely place higher demands on power production facilities in summer, as residents across the state increase air conditioner use. Warmer lakes and streams as well as earlier runoff could affect water use for cooling power plants and other industries.

**Economic activity.** The food, agriculture, tourism, and recreation sectors crucial to Colorado's economy face potential disruption in the face of possible future climate change. Changes in reservoir storage would affect recreation on-site and downstream. Earlier streamflow timing would affect rafting and fishing. Declining snowpacks would affect winter mountain recreation and tourism. Warming temperatures will lengthen the growing season and increase crop water use. The severity of future impacts will depend upon the complex interaction of water supply, crop pests, and changes in the seasonal timing of crop development.

**Water availability.** Earlier snowmelt and runoff, decreasing summer flows, and likely declines in average annual streamflow will create challenges for storage, delivery, and use of water supplies. The projected drying of arid lands southwest of Colorado may lead to more dust-on-snow events, which would hasten the shift toward earlier snowmelt and runoff caused by warming. Lower summer flows and warmer water temperatures could cause water quality to decline as well.

**Ecosystem services.** Higher temperatures enable more frequent and severe wildfires and make trees more vulnerable to insect infestation, such as bark beetles. Although bark beetles are native to Colorado's forests and have periodically erupted in epidemics every several decades, the epidemics in Colorado over the last 15 years are historically unprecedented in their scale. Since 2000, bark beetle epidemics have caused extensive tree mortality across four (4) million acres of forested watersheds in Colorado. The synchronous timing of these widespread outbreaks has been attributed to overall warmer and dryer conditions, which have promoted beetle overwintering survival and reproduction and reduced tree resistance to beetle attacks. Other impacts from higher temperatures have implications for water quality and watershed health. Warmer stream temperatures could have direct and indirect effects, including the spread of non-native species and diseases to higher elevations and aquatic ecosystems. Changes in streamflow timing could also affect river ecosystems.

## SCENARIO EVENT: INCREASED RISK OF DROUGHT, WILDFIRES, AND HEAT WAVES IN THE MID-CENTURY

### Summer 2044—Colorado Front Range

It is the year 2044, and the temperature model projections described earlier have occurred. Since 2008, average annual temperatures have increased by 3.5 degrees Fahrenheit. Over the last six years (2038-2044) of the drought, average annual temperatures statewide have been 6 degrees Fahrenheit warmer than the 1981-2010 normal temperatures, with the human-induced long-term warming trend of 3-4 degrees Fahrenheit exacerbated by dry, sunny weather. This summer, exceptionally dry soils have led to even greater heating, with statewide average temperatures 8 degrees Fahrenheit warmer than the 1981-2010 normal summer temperatures. In Denver, daily high temperatures have exceeded 105 degrees Fahrenheit—the all-time record as of 2014—for seven (7) straight days, with two (2) days over 110 degrees Fahrenheit. Overnight lows during this period have remained above 75 degrees Fahrenheit, allowing little relief from the heat. Colorado healthcare providers are stressed by an increase in the number of elderly patients, those with access/functional needs, and other populations of disproportionate impact due to the extreme heat and deteriorating air quality. Smoke pollution from numerous wildfires has

degraded air quality, affecting people with asthma and other respiratory conditions.<sup>8</sup> Additionally, outdoor workers are experiencing heatstroke and other heat injuries at much higher rates than normal (2.4 deaths per million workers compared to an average of 1.6 over the previous 50 years).

Over the last (6) six years, average annual precipitation in Colorado is 79 percent of the 1981-2010 normal levels, which is lower than the driest six (6) year periods of the 1930s and 1950s droughts. This persistent drought has occurred alongside a longer-term six (6) percent decline in annual precipitation, which has been attributed to human-induced climate change. Water supplies have been negatively affected, with well-below-average streamflows and steadily declining reservoir levels reported. Aquifers have also been depleted due to both reduced recharge and increased withdrawals. The winter and early spring of 2044 were the driest of the drought thus far, and the April 1 statewide Snow Water Equivalent of the snowpack was only 28 percent of the 1981-2010 average (lower than in 2002 or 2012). The drought has also seriously affected Colorado crops and cattle, which will likely necessitate the liquidation of 50 percent of the cattle stock. Colorado dry land crop production is down between 30 and 71 percent, depending on the specific crop.

The combination of very dry conditions and unusually hot temperatures has facilitated the ignition and spread of more than one dozen large wildfires along the Front Range, endangering several foothills and mountain communities, thousands of homes, hundreds of businesses, and manmade (power lines, cell tower, wooden bridges, etc.) and natural (forest habitats, parks and recreational sites, etc.) infrastructure. Warmer and drier temperatures are also expanding the range of non-native species, such as tamarisk shrubs<sup>9</sup> and disease carrying deer ticks, endangering the natural environment and human health.

Increased use of air conditioners throughout the state has strained an aging power grid. Electricity transmission lines, distribution lines, and substations have also been damaged by wildfires, further straining the power grid. Fossil fuel generating stations are experiencing problems due to the decreasing availability and increasing temperature of cooling water supplies. Hydroelectric generation has been negatively affected by low streamflows and reservoir levels as well. Infrequent but widespread brownouts and power outages have occurred due to a combination of each of the aforementioned factors.

Water distribution systems have been stressed due to increased water usage and water main malfunctions resulting from higher usage rates combined with aging infrastructure. Groundwater usage for agriculture has increased with the warmer temperatures, and changes in precipitation have affected ground water usage rates. In addition, a weather disturbance is forecasted to enter the area in three (3) days, with low potential for widespread beneficial rain but a high risk for brief and intense local downpours. Communities downstream of the burned areas are particularly concerned about flooding due to the decreased ability of the soil to absorb water. Area water quality may be affected by the amount of silt and debris in the runoff. Roadway washouts may affect critical supply chains, making it difficult for travel and the delivery of goods to some areas of the Front Range. They may also cut off some mountain communities, particularly if large debris flows occur.

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<sup>8</sup> Taken from <http://www.nrdc.org/health/climate/co.asp#airpollution>, accessed on 8/22/2014.

<sup>9</sup> Taken from <http://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1436.pdf>, accessed on 8/22/2014.



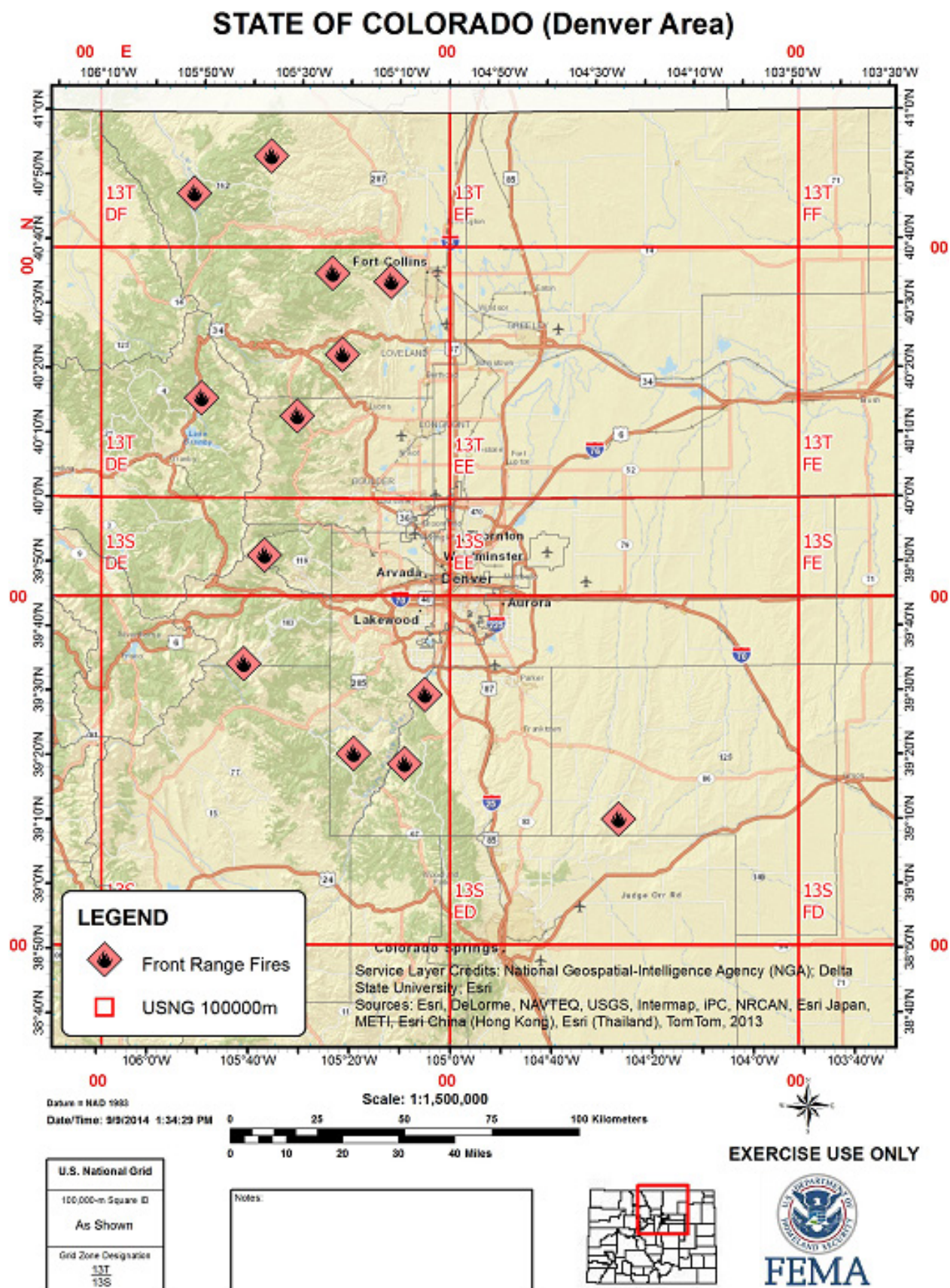


Figure 4. Wildfires along the Front Range.



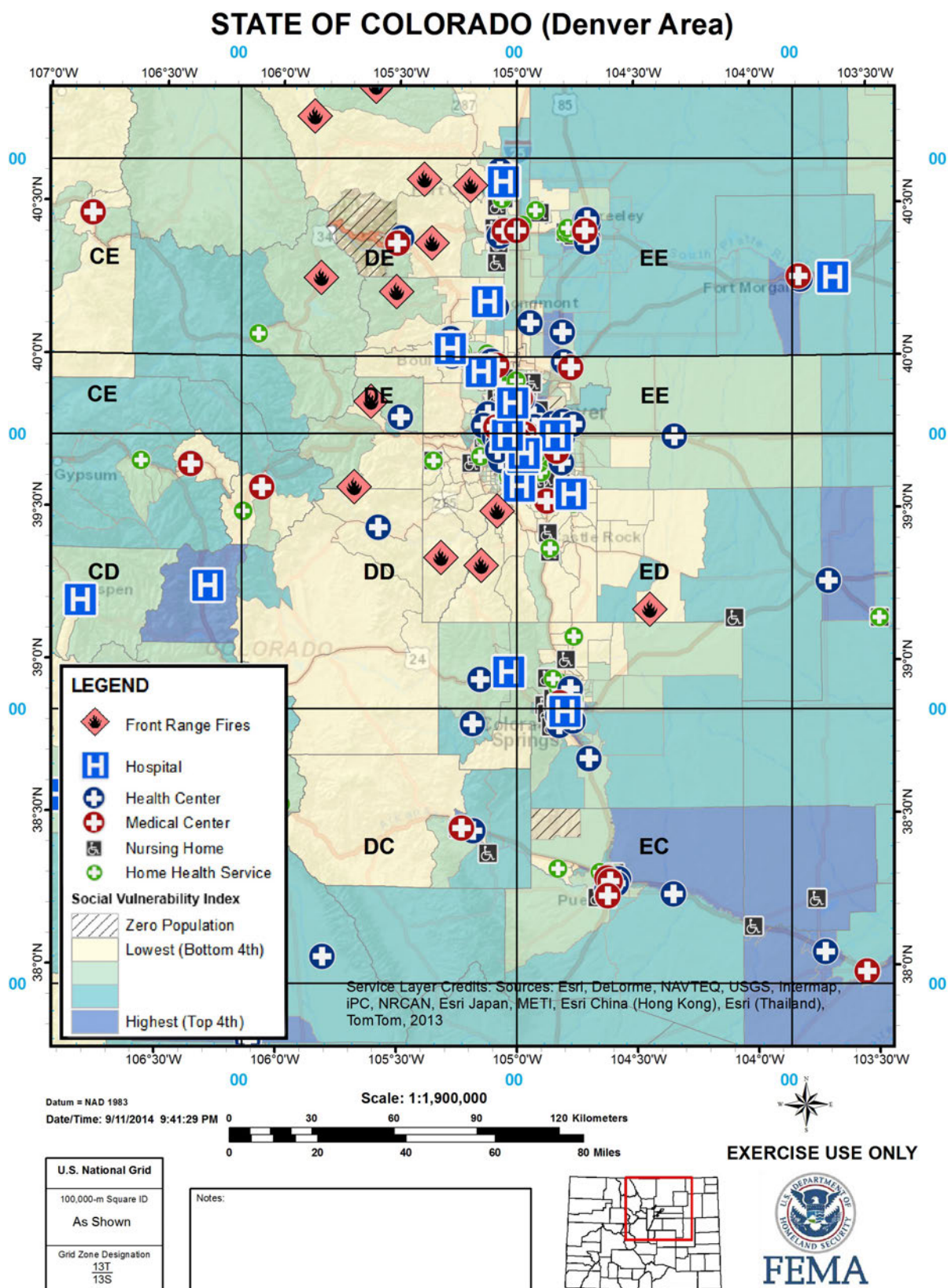


Figure 5. Vulnerable Populations and Medical Infrastructure near Colorado Wildfires.



## FACILITATOR DISCUSSION QUESTIONS

Given the observed climate trends and future climate conditions to the State of Colorado as well as the specific scenario event in the summer of 2044 along the Colorado Front Range, the following discussion questions will allow workshop participants to focus on the overarching question “what can be done now, as a whole community, to collaboratively and sustainably prepare, plan for, or help mitigate future projected climate impacts on Colorado?” Specific attention should be paid to planning, water, agriculture, health and social services, natural resources and ecosystems, infrastructure systems, the economy, and long term planning within the State of Colorado.

### Planning

1. What long-term planning efforts are underway in Colorado that would be affected by inclusion of the drought, the heat wave, or the wildfires?
  - a. Do these planning efforts take climate change—particularly, temperature increases, less but more intense precipitation, and more frequent flooding and wildfire events—into account?
  - b. What local, State, and Tribal agencies are involved in these planning efforts?
  - c. How can the Federal government and, particularly, regional Federal partners best support these efforts?
2. How can Federal Departments and Agencies and, particularly, regional Federal partners collaborate to enhance their assistance to local, State, and Tribal planning efforts?
3. What additional actions must be taken now or in the near-term to avert mission failure or mitigate these risks?
  - a. What changes need to be made to your organization’s plans and policies?
  - b. How can emerging information be continuously integrated into planning efforts?
  - c. How is Colorado integrating climate considerations into the Threat and Hazard Identification and Risk Assessment (THIRA) process (examining how climate change potentially exacerbates existing threats and hazards)?
4. Are there currently coalitions being organized between local, State, Tribal, Federal, and private sector partners to support adaptation planning for future drought conditions as described in the scenario?
  - a. What would make it easier to build these coalitions?
  - b. What governance structures are in place within Colorado to support collaborative climate adaptation planning efforts and coalitions across the whole community?

5. What obstacles have your Departments and Agencies encountered that affect adaptation planning?
  - a. Are there specific barriers that discourage investment?
  - b. Are there changes that need to be made to Federal, State, local, and Tribal legal, regulatory, and policy frameworks to support adaptation strategies?
  - c. What are other innovative approaches to overcoming these obstacles?
  - d. What actions are you taking as a jurisdiction to make climate adaptation a priority consideration for resource planning support?
6. What incentives should we pursue to enhance Federal, State, local, and Tribal preparedness and resilience in the face of climate change risks?
7. What public messaging/communications strategies are you developing or implementing to connect with the public on issues related to climate adaptation?
  - a. How can Federal Departments and Agencies best support local, State, and Tribal climate adaptation communications and outreach efforts?
  - b. What progress has been made in developing climate adaptation training and educational tools?
8. What is the National Oceanic and Atmospheric Administration (NOAA) doing to advance the understanding and prediction of weather and climate in Colorado?
9. What is NOAA doing to improve preparedness, response, and recovery from weather and water events in Colorado?
10. What is NOAA doing to strengthen the resiliency of communities and regions by delivering targeted services to build capacity in Colorado and to enable businesses to adapt and prosper by developing weather and climate-informed solutions?

## Water

1. What long-term water management infrastructure development, modification, or re-engineering efforts are underway in Colorado that would be affected by inclusion of either the drought or the heat wave?
  - a. Do these water management development/modification/re-engineering efforts take climate change—particularly, temperature increases, less but more intense precipitation, and more frequent flooding events—into account?
  - b. What local, State, and/or Tribal agencies are involved in these efforts?
  - c. What whole community partners are involved in these efforts?
  - d. How can the Federal government and, particularly, regional Federal partners best

support these efforts?

2. What long-term legislative efforts are underway in Colorado that would be affected by inclusion of either the drought or the heat wave?
  - a. Do these water management legislative efforts take climate change—particularly, temperature increases, less but more intense precipitation, and more frequent flooding events—into account?
  - b. What local, State, and/or Tribal agencies are involved in these efforts?
  - c. What whole community partners are involved in these efforts?
  - d. How can the Federal government and, particularly, regional Federal partners best support these efforts?
3. How can Federal Departments and Agencies and, particularly, regional Federal partners collaborate to enhance their assistance to local, State, and Tribal, water management infrastructure development/modification/re-engineering and/or legislative efforts?
  - a. At the Federal level, what regulatory and legislative changes are needed to effectively adapt to the changing water management environment in Colorado and the Southwest Region?
4. What are the anticipated effects of prolonged droughts and heat waves to Colorado ground water supplies in the mid-21<sup>st</sup> Century timeframe?
  - a. How do these anticipated affects shape public-private economic, demographic, and agricultural planning today?
5. What progress has been made in identifying best practices and innovative approaches for understanding the effects on the supply and demand for energy and water?
6. What scientific information is required to assess the vulnerability of water resources to climate change?
  - a. What data or modeling capabilities exist to support decision-making requirements or investment decisions related to water management?

## **Agriculture**

1. What long-term agricultural planning efforts are underway in Colorado that would be affected by inclusion of either the drought or the heat wave?
  - a. Do these planning efforts take climate change—particularly, temperature increases and drought with less but more intense precipitation—into account?
  - b. What local, State, and/or Tribal agencies are involved in these efforts?
  - c. How are the economic effects of climate change on Colorado's agricultural

industry incorporated into these planning considerations?

- d. How can the Federal government and, particularly, regional Federal partners best support these efforts?
2. What role, if any, do private sector and other whole community partners have in working with Colorado to address effects to agriculture?
3. What can be done today to mitigate the negative effects of drought on groundwater supplies?
4. What can be done today to mitigate the negative effects of drought and heat waves to Colorado's agricultural sector in the mid-21<sup>st</sup> Century timeframe?
  - a. What interagency coordination is required?
  - b. What are the barriers to this coordination?

### **Health and Social Services**

1. What can be done today to mitigate the negative effects of drought, heat waves, and wildfires to human health and, especially, to the health of populations of disproportionate impact (vulnerable populations) in the mid-21<sup>st</sup> Century timeframe?
  - a. What interagency coordination is required?
  - b. What are the barriers to this coordination?
2. What role do whole community partners have in addressing effects to human health and working with populations of disproportionate impact?
3. What data or modeling capabilities exist to support decision-making requirements or investment decisions related to the provision of health and social services?

### **Natural and Cultural Resources / Ecosystems**

1. What long-term natural and cultural resources development or re-development efforts are underway in Colorado that would be affected by inclusion of the drought, the heat wave, or the wildfires?
  - a. Do these natural and cultural resource development/re-development efforts take climate change—particularly, temperature increases, less but more intense precipitation, and more frequent flooding and wildfire events—into account?
  - b. What local and State agencies are involved in these efforts?
  - c. How can whole community partners best support these efforts?
2. How can Federal Departments and Agencies and, particularly, regional Federal partners collaborate to enhance their assistance to local, State, and Tribal natural and cultural

resource development/re-development efforts?

### Infrastructure Systems

1. What long-term, sustainable infrastructure development, modification, or re-engineering efforts are underway in Colorado, and in the Front Range in particular, that would be affected by inclusion of the drought, the heat wave, or the wildfires?
  - a. Do these infrastructure development/modification/re-engineering efforts take climate change—particularly, temperature increases, less but more intense precipitation, and more frequent flooding and wildfire events—into account?
  - b. What local, State, and/or Tribal agencies are involved in these efforts?
  - c. How can the Federal government and, particularly, regional Federal partners best support these efforts?
  - d. How can whole community and, particularly, private sector partners best support these efforts?
2. What progress has been made in identifying best practices and innovative approaches for understanding the effects on the supply and demand for energy?
3. How can Federal Departments and Agencies and, particularly, regional Federal partners collaborate to enhance their assistance to local, State, Tribal, and private sector infrastructure development/modification/re-engineering efforts?
4. What scientific information, data, or modeling capabilities exist to support decision-making requirements or investment decisions related to infrastructure systems?
5. What scientific information, data, or modeling capabilities are needed to support decision-making requirements or investment decisions related to infrastructure systems?

### Economy

1. What short-term and long-term investments must be made to build and sustain capabilities to support economic adaptation planning?
  - a. How can Federal, State, local, and Tribal investments be leveraged to support multi-agency requirements and vice versa?
  - b. How can public/private partnerships be leveraged to support multi-agency requirements?
2. Given past development patterns and future population density and development projections, what can local, State, Tribal, and Federal planners, in coordination with private sector partners, do today to mitigate the destructive effects of wildfires on Colorado communities (current and planned) in the mid-21<sup>st</sup> Century timeframe?
  - a. What interagency coordination is required?

- b. What are the barriers to this coordination?
- 3. What are some of the major anticipated effects on local, State, Tribal, regional, and national supply chains from widespread Front Range wildfires in the mid-21<sup>st</sup> Century timeframe?
- 4. What can local, State, Tribal, and Federal planners—from both the public and private sectors—do today to help mitigate the effects of Front Range wildfires to State, regional, and local supply chains?
- 5. What are some of the anticipated effects on the tourism and recreation industries?



## APPENDIX A: RESOURCES

### Useful Links:

#### **WHITE HOUSE RESOURCES**

- **Council on Environmental Quality:**  
<http://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience>
- **Office of Science and Technology Policy:**  
<http://www.whitehouse.gov/administration/eop/ostp>
- **National Security Council:** <http://www.whitehouse.gov/administration/eop/nsc>
- **White House Climate Data Initiative:** <http://www.data.gov/climate/>

#### **FEDERAL RESOURCES**

- **U.S. Global Change Research Program:** [www.globalchange.gov](http://www.globalchange.gov)
- **Third U.S. National Climate Assessment:** <http://nca2014.globalchange.gov/>
- **Third U.S. National Climate Assessment Download Materials:**  
<http://www.globalchange.gov/nca3-downloads-materials>
- **U.S. Global Change Research Program Adaptation Page:**  
<http://www.globalchange.gov/explore/adaptation>
- **U.S. Global Change Research Program Federal Adaptation Resources Library:**  
<http://www.globalchange.gov/browse/federal-adaptation-resources>
- **National Integrated Drought Information System (U.S. Drought Portal):**  
<http://www.drought.gov/drought/content/products/current-drought-and-monitoring>
- **Environmental Protection Agency Region 8:** <http://www2.epa.gov/aboutepa/epa-region-8-mountains-and-plains>
- **U.S. Agriculture Department's Northern Plains Regional Climate Hub:**  
[http://www.usda.gov/oce/climate\\_change/hubs/NorthernPlainsFactSheet.pdf](http://www.usda.gov/oce/climate_change/hubs/NorthernPlainsFactSheet.pdf)
- **U.S. Agriculture Department's Fire & Aviation Management:**  
<http://www.fs.fed.us/fire/>
- **U.S. Army Corps of Engineers Omaha District:** <http://www.nwo.usace.army.mil/>
- **U.S. Army Corps of Engineers Institute for Water Resources:**  
<http://www.iwr.usace.army.mil/>

- **U.S. Department of Commerce’s U.S. Economic Development Administration:** <http://www.eda.gov/>
- **U.S. Department of Defense U.S. Northern Command:** <http://www.northcom.mil/>
- **U.S. Department of Energy National Renewable Energy Laboratory:** <http://www.nrel.gov/>
- **U.S. Department of Health & Human Services Region 8:** <http://www.hhs.gov/iea/regional/region8/>
- **U.S. Department of the Interior National Park Service:** <http://www.nps.gov/index.htm>
- **U.S. Department of the Interior Bureau of Land Management, Colorado:** <http://www.blm.gov/co/st/en.html>
- **U.S. Department of the Interior Bureau of Reclamation:** <http://www.usbr.gov/main/regions.html>
- **U.S. Department of the Interior Bureau of Indian Affairs Ute Mtn. Ute Agency:** <http://www.bia.gov/WhoWeAre/RegionalOffices/Southwest/WeAre/UteMountainUte/index.htm>
- **U.S. Geological Survey Colorado Water Science Center:** <http://co.water.usgs.gov/>
- **Federal Emergency Management Agency Region VIII:** <http://www.fema.gov/region-viii-co-mt-nd-sd-ut-wy>
- **Federal Emergency Management Agency Community Planning and Capacity Building:** <http://www.fema.gov/community-planning-and-capacity-building>
- **National Oceanic and Atmospheric Administration Boulder Labs:** <http://www.boulder.noaa.gov/>
- **U.S. Small Business Administration Colorado District Office:** <http://www.sba.gov/offices/district/co/denver>
- **U.S. Army Corps of Engineers—Responses to Climate Change:** [corpsclimate.us](http://corpsclimate.us)
- **Interagency Climate Change and Water Working Group:** [ccawwg.us](http://ccawwg.us)

## **REGIONAL RESOURCES**

- **Central Region Regional Climate Science Director:** <http://www.regions.noaa.gov/central/?highlights=regional-climate-services-directors>
- **Colorado Municipal League:** <http://www.cml.org/>
- **Cooperative Institute for Environmental Sciences:** <http://cires.colorado.edu/index.html>

- **High Plains Regional Climate Center:** <http://www.hprcc.unl.edu/>
- **Landscape Conservation Cooperative Southern Rockies:**  
<http://southernrockieslcc.org/>
- **National Weather Service Central Region:**  
<http://www.nws.noaa.gov/om/csd/index.php?section=programs#central>
- **National Wildlife Federation Rocky Mountain Regional Center:**  
<http://www.nwf.org/rocky-mountain-region.aspx>
- **North Central Climate Science Center:**  
<http://www.interior.gov/csc/northcentral/index.cfm>
- **River Forecast Center Colorado Basin:** <http://www.cbrfc.noaa.gov/>
- **Rocky Mountain Climate Organization:** <http://www.rockymountainclimate.org/>
- **Southwest Energy Efficiency Project:** <http://www.swenergy.org/>
- **The Nature Conservancy Colorado:**  
<http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/colorado/>
- **Urban Land Institute Colorado:** <http://colorado.uli.org/>
- **Ute Mountain Ute Tribe:** <http://www.utemountainutetribe.com/>
- **Western Water Assessment:** <http://wwa.colorado.edu/>

## **STATE RESOURCES**

- **State of Colorado:** <http://www.colorado.gov/>
  - **Colorado Department of Agriculture:** <http://www.colorado.gov/ag>
  - **Colorado Division of Fire Prevention and Control:** <http://dfs.state.co.us/>
  - **Colorado Department of Local Affairs:**  
<http://www.colorado.gov/cs/Satellite/DOLA-Main/CBON/1251589672852>
  - **Colorado Department of Public Health and Environment:**  
<https://www.colorado.gov/cdphe>
  - **Colorado Department of Public Safety:** <http://cdpsweb.state.co.us/>
  - **Colorado Division of Homeland Security & Emergency Management:**  
<http://www.coemergency.com/>
  - **Colorado Department of Transportation:** <http://www.coloradodot.info/>

- **Colorado Energy Office:** <http://www.colorado.gov/energy/>
- **Colorado Water Conservation Board:**  
<http://cwcb.state.co.us/Pages/CWCBHome.aspx>
- **Colorado State Climatologist:** <http://climate.atmos.colostate.edu/>

## **LOCAL RESOURCES**

- **Adams County Planning & Development:**  
<http://www.co.adams.co.us/index.aspx?NID=283>
- **Boulder County Environment:** <http://www.bouldercounty.org/env/pages/default.aspx>
- **City of Boulder Community Planning and Sustainability:**  
<https://bouldercolorado.gov/planning>
- **City of Denver Office of Sustainability:**  
<http://www.denvergov.org/sustainability/OfficeofSustainability/tabid/445198/Default.aspx>
- **City of Fort Collins Climate Protection:** <http://www.fcgov.com/climateprotection/>
- **Denver Water:** <http://www.denverwater.org/>
- **Poudre Fire Authority:** <http://www.poudre-fire.org/>
- **Weld County Office of Emergency Management:**  
<http://www.co.weld.co.us/Departments/OEM/>

## **ACADEMIC RESOURCES**

- **Colorado State University:** <http://www.colostate.edu/>
  - **Colorado Climate Center:** <http://climate.atmos.colostate.edu/>
  - **Colorado Water Institute:** <http://www.cwi.colostate.edu/>
  - **North Central Climate Science Center:** <http://revampclimate.colostate.edu/>
- **University of Colorado Boulder:** <http://www.colorado.edu/>

## **OTHER RESOURCES**

- **National Center for Atmospheric Research:** <http://ncar.ucar.edu/>
- **Colorado Wheat:** <http://coloradowheat.org/>
- **Downscaled Climate and Hydrology Projections:**  
[http://gdo-dcp.ucllnl.org/downscaled\\_cmip\\_projections/dcpInterface.html#Welcome](http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html#Welcome)

**Attached Fact Sheets:**

1. U.S. Department of Agriculture Regional Hubs: Managing Your Risks in a Changing Climate. *Climate Risks in the Northern Plains*.
2. National Weather Service Drought Fact Sheet.



## USDA Regional Climate Hubs: Managing your risk in a changing climate.



# Climate Risks in the Northern Plains

## What type of agricultural production is in the Northern Plains?

The Northern Plains region (Mont., N.D., S.D., Wyo., Neb. and Colo.) has a high diversity of land uses including the largest remaining tracts of native rangeland in North America, substantial areas of both dryland and irrigated cropland and pasture, mosaics of cropland and grassland, and forested lands. Livestock production includes beef (cow-calf and yearling operations, feedlots), sheep, hogs, and dairy. Crop production is dominated by corn, soybeans, wheat, barley, alfalfa, and hay, but also includes a diversity of other crops such as potatoes, sugar beets, dry beans, sunflowers, millet, canola, and barley. Agroforestry includes windbreaks, silvopasture, riparian forest buffers, alley cropping and forest farms.

## How are climate change and weather variability affecting Northern Plains producers?

Land managers in the Northern Plains are experiencing changing climate and weather variability on the ground that is outside of the ranges they have dealt with in the past. These changes are impacting producers' day-to-day decisions, and some of these changes are expected to intensify. Examples include:

- **Extreme weather events:** Extreme events have dramatically influenced farmer and rancher livelihoods and enterprises in this region. The early October 2013 snowstorm (named "Atlas") resulted in tens of thousands of livestock deaths in western South Dakota and northwestern Nebraska with ripple economic effects to the businesses and local economies of these agricultural communities. Excessive rainfall in September 2013 in Colorado flooded crops and farmland, damaged houses and agricultural structures, and impaired water quality of rivers downstream in neighboring states.
- **Drought:** The extreme drought conditions of 2012 and 2013 had substantial negative economic results for land managers and local rural economies. Forage and hay production was less than half of average values resulting in low stocks of hay and much higher prices. Many livestock producers sold their herds, or markedly reduced their numbers, with the U.S. beef cow herd now at its lowest levels since 1952. Over 2,000 counties nationwide were designated as disaster areas due to drought.
- **Longer, hotter growing seasons:** Earlier arrival of spring is resulting in longer growing seasons and prolonged hot periods during the growing season, which affects the selection of crops and crop varieties. It is also enhancing the growth of non-native weeds (for example, cheatgrass, smooth brome, Kentucky bluegrass and Dalmatian toadflax) and increasing the risk of late-spring freeze damage to crops and forage production. Warmer and drier summers reduce forage production and crop yields, and are resulting in longer and more intense fire seasons that pose a risk by reducing forage available for livestock, altering critical wildlife habitat and impacting water quantity and quality from forest watersheds. The fire danger is especially acute for forested areas which had large diebacks of trees associated with the mountain pine beetle outbreak.



USDA has established the USDA Northern Plains Regional Climate Hub (NPRCH), located in Fort Collins, Colo. This multi-agency effort (Agricultural Research Service, Forest Service, Natural Resources Conservation Service) is being led by Justin Derner, Supervisory Research Leader and Rangeland Management Specialist with the Agricultural Research Service. The Hub will deliver science-based knowledge and practical information to farmers, ranchers, and forest landowners that will help them to adapt to climate change and weather variability by coordinating with local and regional partners in Federal and state agencies, universities, NGO's, private companies, and Tribes.

- Technical support for land managers to respond to drought, heat stress, floods, pests, and changes in growing season.
- Regional assessments and forecasts for hazard and adaptation planning.
- Outreach and education for land managers on ways to mitigate risks and thrive despite change.

**Water Supply Management:** The Natural Resources Conservation Service responded to concerns resulting from the recent drought with an Initiative for the Ogallala Aquifer, which supports 30 percent of American irrigated agriculture. This Initiative helped land managers improve water management and save money on irrigation through adjusting cropping systems, replacing inefficient irrigation systems and planting non-irrigated vegetation.

***Livestock and Weather Variability Research:*** The Agricultural Research Service used long-term (30-90 years) livestock weight gain data to determine effects of seasonal weather variability for ranchers. Wet winters and springs positively influence cattle production, whereas grazing season droughts can reduce cattle production by up to 60 percent. Cattle production is more sensitive to weather variability under heavy stocking rates. Land managers can use adaptive grazing management to reduce enterprise risk, and improve production capacity and production efficiency in the Northern Plains.

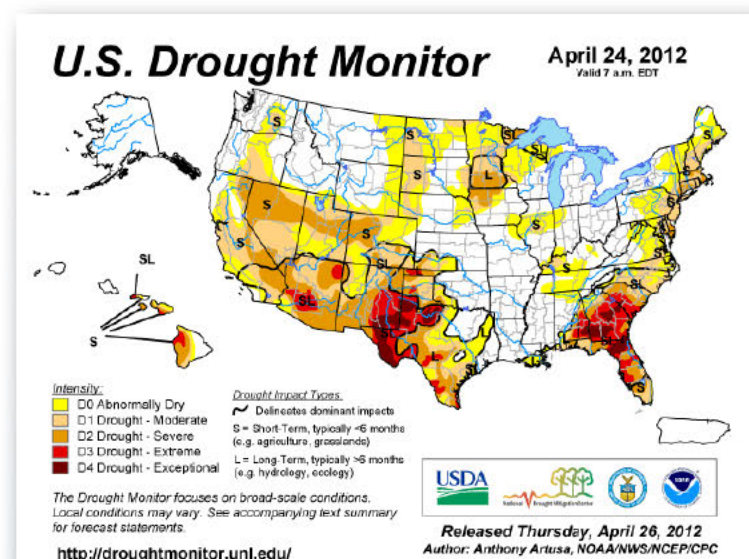
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October 2012

## WHAT IS DROUGHT?

Drought is a deficiency in precipitation over an extended period. It is a normal, recurrent feature of climate that occurs in virtually all climate zones. The duration of droughts varies widely. There are cases when drought develops relatively quickly and lasts a very short period of time, exacerbated by extreme heat and/or wind, and there are other cases when drought spans multiple years, or even decades. Studying the paleoclimate record is often helpful in identifying when long-lasting droughts have occurred.

## HOW IS DROUGHT MONITORED AND ASSESSED?



[www.drought.gov](http://www.drought.gov)

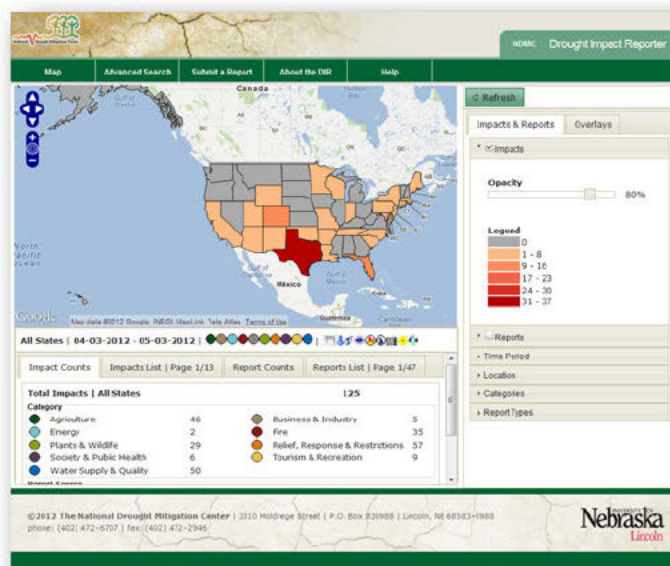
The U.S. Drought Monitor (USDM) is a weekly product that provides a general summary of current drought conditions. Multiple drought indicators, including various indices, outlooks, field reports, and news accounts are reviewed and synthesized. In addition, numerous experts from agencies and offices across the country are consulted. The result is the consensus assessment presented on the USDM map.

<http://droughtmonitor.unl.edu> <http://drought.unl.edu>

The USDM is an integral monitoring component in the National Integrated Drought Information System (NIDIS), which was established by Congressional Act in 2006 to implement an integrated drought monitoring and forecasting system at federal, state, and local levels. NIDIS includes drought monitoring, forecasting, response, research, and education components as part of its early warning system. These components are featured within the U.S. Drought Portal.



droughtreporter.unl.edu



**Drought Impact Reporter:** The goal of the National Drought Mitigation Center's Drought Impact Reporter is to collect, quantify, and map reported drought impacts for the United States and provide access to the reports through interactive search tools. Users can submit their own drought impact reports through the tool's easy web interface.

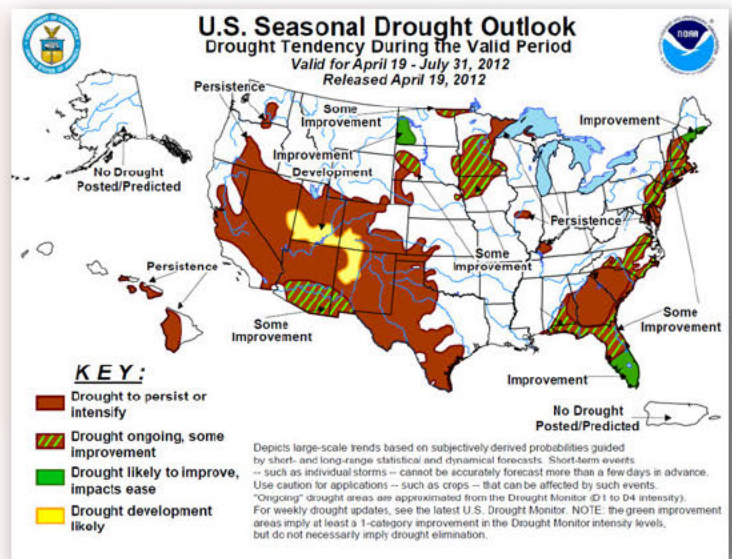
**FOR DROUGHT MONITORING, FORECASTING, AND INFORMATION GO TO:**

[www.drought.gov](http://www.drought.gov)



The U.S. Seasonal Drought Outlook shows predicted trends for areas experiencing drought depicted in the U.S. Drought Monitor, as well as indicating areas where new droughts may develop. The NOAA Climate Prediction Center issues this monthly product in conjunction with their long-lead temperature and precipitation outlooks on the first and third Thursday of each month and when weather events warrant an interim update. The general large-scale trends depicted are based on numerous indicators, including short and long-range forecasts. A discussion detailing the atmospheric, hydrologic, and climatic conditions affecting the drought trends is included.

*Human factors, such as water demand and water management, can exacerbate the impact that drought has on a region. Because of the interplay between a natural drought event and various human factors, drought means different things to different people. In practice, drought is defined in a number of ways that reflect various perspectives and interests.*



[www.cpc.ncep.noaa.gov/products/expert\\_assessment/seasonal\\_drought.html](http://www.cpc.ncep.noaa.gov/products/expert_assessment/seasonal_drought.html)

## COMMON TYPES OF DROUGHT

### Meteorological Drought

Meteorological Drought is based on the degree of dryness (rainfall deficit) and the length of the dry period.

### Agricultural Drought

Agricultural Drought is based on the impacts to agriculture by factors such as rainfall deficits, soil water deficits, reduced ground water, or reservoir levels needed for irrigation.

### Hydrological Drought

Hydrological Drought is based on the impact of rainfall deficits on the water supply such as stream flow, reservoir and lake levels, and ground water table decline.

### Socioeconomic Drought

Socioeconomic drought is based on the impact of drought conditions (meteorological, agricultural, or hydrological drought) on supply and demand of some economic goods. Socioeconomic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related deficit in water supply.

Additional information can be found at: [www.drought.unl.edu/DroughtBasics/TypesofDrought.aspx](http://www.drought.unl.edu/DroughtBasics/TypesofDrought.aspx)

## WHY IS DROUGHT IMPORTANT?

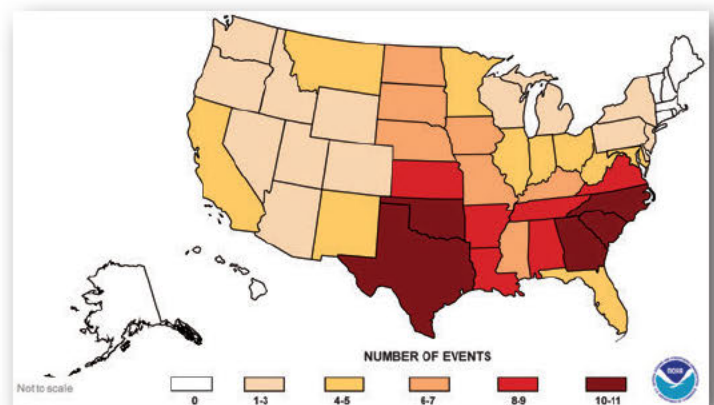
The United States is vulnerable to the social, economic, and environmental impacts of drought. More than 100 years of U.S. weather records indicate that there have been three or four major drought events during that period. Two of these, the 1930s Dust Bowl drought and the 1950s drought, each lasted five to seven years and covered large areas of the continental United States.

*Droughts are among the most costly weather related events.*

According to the National Climatic Data Center (NCDC), the United States has sustained 114 weather/climate disasters over the past 31+ years (up to 2011) in which overall damages/costs reached or exceeded \$1 billion. The total standardized losses for the 114 events exceed \$800 billion.

During this period, there have been 16 billion-dollar droughts, totaling \$195 billion in losses, which amounts to approximately \$12 billion for each billion-dollar drought event that has occurred.

Billion Dollar Drought and Heat Wave Disasters  
1980-2011



Source: National Climatic Data Center



Climate Change Preparedness and Resilience Exercise Series

# Alaska Climate Change Preparedness and Resilience Workshop

October 27, 2014



Wonder Lake, Denali National Park, Alaska



FEMA

National Exercise Program  
The White House

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## Alaska Climate Change Preparedness and Resilience Workshop



**Monday, October 27, 2014**

### SCHEDULE

**8:00 a.m.–4:45 p.m. Alaska Daylight Time**

Registration

Welcome and Opening Remarks

Overview and Administration

Observations, Patterns, and Trends

Session #1: Individual and Community Perspectives

Break

Session #2: State, Regional, and National Perspectives

Lunch

Session #3: Interdisciplinary Approaches to Climate Research

Tabletop Exercise

Participant Feedback and Hotwash

Closing Remarks

Adjournment



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## INTRODUCTION

The Alaska Climate Change Preparedness and Resilience Workshop is an element of the National Exercise Program Climate Change Preparedness and Resilience Exercise Series. The workshop is one of three jurisdictional workshops conducted in October 2014—additional workshops have been held in Houston, Texas, and Fort Collins, Colorado. These workshops are intended to advance climate adaptation dialogue and identify collaborative and sustainable approaches to build or enhance community-based planning and resilience capability and capacity.

Supported by the State of Alaska Division of Homeland Security and Emergency Management, the workshop is comprised of three interactive, moderated panel sessions and one facilitated tabletop exercise. The panelists reflect diverse disciplines that focus on consequences of long-term changes in the climate; local, state, regional, and tribal perspectives; and the effects of climate change and its associated challenges and opportunities.

These sessions provide a foundation for the tabletop exercise, with discussions on several key focus areas and concepts – environmental, social and cultural, economic, and security – that give context for examining climate change adaptation; the range of consequences that present both challenges and opportunities; overview of modeling and data needed to set priorities and define investments; and discussion of policy considerations. An overarching theme of increased human activities in the Arctic and the associated homeland security and national security challenges will be woven throughout the focus areas. The tabletop exercise will play out different challenges and opportunities faced by Alaskans in our time, our children’s time, and our grandchildren’s time.

To build upon and improve collaboration with and between whole community partners, workshop participants include local, state, tribal, and federal representatives, as well as private sector, non-governmental, and academic partners who have roles, responsibilities, and expertise as they relate to long-term climate adaptation, hazard mitigation, and resiliency planning efforts.

This Participant Handbook provides goals and objectives for the workshop, a detailed scenario with focus areas, and facilitator questions for discussion during the exercise and further consideration by participants during their follow-on climate adaptation efforts.

### Goal

The goal of the workshop is to provide a forum for a variety of stakeholders across the State of Alaska to identify and refine climate change preparedness and resilience needs and initiatives in collaboration with critical whole community partners.

### Objectives

Workshop objectives are:

1. Examine methods to better integrate and make actionable existing and emerging scientific information and other requirements into current and future planning to manage and adapt to climate risks and vulnerabilities.

2. Identify collaborative and sustainable whole community approaches to advance and sustain local climate preparedness and resilience programs, policies, and strategies.
3. Examine investment opportunities and the development of coalitions between local, state, federal, and private sector partners to support climate preparedness and resilience.

## Outcomes

The workshop will focus on the following outcomes:

1. Improved collaboration with and between whole-community partners on climate preparedness and resilience strategies.
2. Identification of new research, actionable information, and strategies or capabilities needed to support local preparedness, adaptation, and hazard mitigation planning.

## Output

Workshop outputs include the following:

1. Workshop Summary Report that addresses key discussion points and identified climate preparedness and resilience information, innovations, and initiatives.
2. Validation of potential climate change risks and vulnerabilities that should be considered in local, state, and regional Threat and Hazard Identification Risk Assessment (THIRA) processes.

## Format

The workshop is a one-day event tailored to the unique needs of the State of Alaska. Panel sessions are based on current scientific projections and climate preparedness and resilience efforts. Afternoon activities include a facilitated, scenarios-driven tabletop exercise.

The exercise scenario is tailored to examine specific jurisdictional climate effects and includes three climate change timeframes – our time (summer 2015), our children’s time (summer 2045), and our grandchildren’s time (summer 2085) – across key focus areas – environmental, social and cultural; economic; and security considerations – that allow participants to focus their discussions. Scientific information describing observed climate trends and projected future climate conditions is derived primarily from technical inputs that supported the development of the Third U.S. National Climate Assessment.<sup>1</sup>

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<sup>1</sup> Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.



## Participants

Workshop participants include local, state, tribal, and federal climate adaptation and hazard mitigation planners, emergency managers, and subject-matter experts (SMEs), as well as select stakeholders and partners from the private sector, non-governmental organizations, and academic institutions. Federal participants include region-based department and agency representatives as well as select representatives from the National Capital Region.

### State of Alaska

- Division of Homeland Security and Emergency Management
- Division of Community and Regional Affairs
- Department of Environmental Conservation
- Department of Health and Social Services
- Department of Transportation and Public Facilities
- Department of Commerce, Community, and Economic Development

### Local and Tribal Communities

- Unalakleet
- Nome
- Kotzebue
- Northwest Arctic Borough

### Federal Departments and Agencies

- U.S. Department of Agriculture
  - Natural Resource Conservation Service
- U.S. Department of Commerce
  - National Oceanic and Atmospheric Administration
  - U.S. Economic Development Administration
- U.S. Department of Defense
  - Alaskan Command / Joint Task Force Alaska
- U.S. Department of Health and Human Services
- U.S. Department of Homeland Security
  - Federal Emergency Management Agency, Region X
  - Office of Infrastructure Protection
  - United States Coast Guard, District 17
- U.S. Department of Housing and Urban Development
- U.S. Department of the Interior
  - Bureau of Land Management

- National Park Service
- U.S. Geological Survey
- U.S. Fish and Wildlife Service
- U.S. Department of State
- U.S. Department of Transportation
  - Federal Aviation Administration
  - Federal Highway Administration
  - Maritime Administration
- U.S. Environmental Protection Agency
- U.S. Global Change Research Program
- U.S. Small Business Administration
- White House
  - Council on Environmental Quality
  - National Security Council Staff

### **Non-Governmental Organizations**

- Alaska Native Tribal Health Consortium
- American Red Cross, Alaska Chapter

### **Academic Partners**

- University of Alaska, Anchorage
- University of Alaska, Fairbanks

## **Scope and Assumptions**

Exercises play a vital role in national preparedness by enabling whole community stakeholders to test and validate capabilities. They help communities identify potential capability shortfalls and planning needs for improving preparedness. Properly designed, exercises provide a low-risk environment to share understanding of requirements, familiarize personnel with roles and responsibilities, and foster interaction and communication across organizations. Exercises bring together and strengthen the whole community in its efforts to prevent, protect against, mitigate against, respond to, and recover from all hazards. Overall, exercises are cost-effective and useful tools that help the nation practice and refine its collective capacity to build, sustain, and deliver the core capabilities needed to achieve climate preparedness and resilience.

Participants are encouraged to share expertise, while the facilitator ensures participants have an opportunity to contribute to the discussion. The scenario will integrate existing issues as identified through the planning process. Discussion questions aim to assist participants in achieving objectives of the workshop.

Participants should follow these three exercise ground rules to ensure the workshop runs smoothly and that exercise objectives are met in a reasonable amount of time:

1. Keep exercise objectives in mind throughout the workshop.
2. Participate openly and focus discussions on appropriate topics. Asking questions, sharing thoughts, and offering forward-looking, problem-solving suggestions will enhance the exercise experience.
3. Focus comments and consider time constraints.

In any exercise, assumptions are often necessary to complete play in the time allotted. During this exercise, the following assumptions apply:

1. The scenarios are plausible, and events occur as they are presented.
2. There are no “hidden agendas” or trick questions.
3. All players receive information at the same time.

## Evaluation

The workshop evaluation process is consistent with Homeland Security Exercise and Evaluation Program (HSEEP) doctrine. Exercise evaluation serves to validate strengths and identify opportunities for improving climate preparedness and resiliency among participating organizations. Outcomes of exercise evaluation are captured in a Summary Report that summarizes key discussion points as well as identifies strengths and areas for improvement, to include the following:

1. Recommendations on integration of climate preparedness and resilience needs and innovations into current and future planning to manage and adapt to climate risks and vulnerabilities.
2. Suggestions on maintaining collaborative partnerships and building new coalitions across the whole community.
3. Areas where additional information and research are needed.
4. Effects of climate change on State of Alaska area missions, policies and strategies, and resources required given the workshop scenario.

The Summary Report provides organizations a tool that can support revising or modifying current climate adaptation and hazard mitigation plans and strategies, as needed. The National Exercise Division assigns an evaluation team to produce the draft Summary Report and deliver within two (2) weeks of the workshop’s conclusion. The exercise planning team and key participants will be invited to participate in a virtual After-Action Meeting in November 2014 to review the draft Summary Report and verify or revise findings and observations that will be captured in a final Summary Report.

## Core Capabilities

The National Preparedness Goal, released in September 2011, defines what it means for the whole community to be prepared for all types of disasters and emergencies. It identified five (5) Mission Areas—Prevention, Protection, Mitigation, Response, and Recovery—which encompass 31 distinct critical elements (“core capabilities”) needed to achieve a secure and resilient Nation.

The workshop will focus on the Mitigation Mission Area, which is comprised of “the capabilities necessary to reduce the loss of life and property by lessening the impacts of disasters.”

Five (5) of the Mitigation core capabilities will be explored through the workshop:

1. Community Resilience
2. Long-Term Vulnerability Reduction
3. Operational Coordination
4. Planning
5. Risk and Disaster Resilience Assessment

Descriptions<sup>2</sup> for the core capabilities that will be examined during the workshop are as follows:

Core Capability	Description
<b>Community Resilience</b>	Lead the integrated effort to recognize, understand, communicate, plan, and address risks so that the community can develop a set of actions to accomplish mitigation and improve resilience.
<b>Long-Term Vulnerability Reduction</b>	Build and sustain resilient systems, communities, and critical infrastructure and key resources lifelines so as to reduce their vulnerability to natural, technological, and human-caused incidents by lessening the likelihood, severity, and duration of the adverse consequences related to these incidents.
<b>Operational Coordination</b>	Establish and maintain a unified and coordinated operational structure and process that appropriately integrates all critical stakeholders and supports the execution of core capabilities.
<b>Planning</b>	Conduct a systematic process engaging the whole community as appropriate in the development of executable strategic, operational, and/or community-based approaches to meet defined objectives.
<b>Risk and Disaster Resilience Assessment</b>	Assess risk and disaster resilience so that decision-makers, responders, and community members can take informed action to reduce their entity's risk and increase their resilience.

<sup>2</sup> Department of Homeland Security. *National Preparedness Goal*. September 2011.

## THE SETTING: ABOUT ALASKA

Alaska is a vast wilderness of oceans, coastlines, tundra, boreal forest, mountains, rivers, and rainforests. Its people live in closeness with the land, the rivers, and the seas. Alaska is home to millions of migratory birds, hundreds of thousands of caribou, some of the world's largest salmon runs, and a significant proportion of the nation's marine mammals. Half of the nation's fish catch is harvested from Alaskan waters.

Energy production is the main driver of the Alaskan economy, generating a large portion of state government revenue and tens of thousands of jobs. Mining and fishing are the second- and third-largest industries in the state, with tourism steadily increasing in recent decades. Fisheries are managed for sustained yield but often vary in abundance and distribution possibly from extreme weather or emerging patterns of warmer waters and other variations in sea conditions. Tourism continues to adapt to shifting seasons with a dramatic increase in the "shoulder" weeks in late spring and early autumn. Ecotourism is emerging in the Arctic waters with more navigable passages across the Canadian North.

Alaska is home to 229 of the 566 federally recognized tribes in the United States. Long before statehood in 1959, tribal and rural communities have faced limited job opportunities, high costs of living, geographic remoteness, and rapid social change. These conditions exacerbate some of the potential consequences of a changing climate. Other consequences may lead to an improved quality of life from increased economic development and upgraded infrastructure.

The Arctic is an unforgiving environment, and for centuries all Alaskan communities have dealt with extreme weather and changing lands, rivers, and seas through their deep cultural reservoirs of flexibility and adaptability.<sup>3</sup>

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<sup>3</sup> Information in this section has been provided by the State of Alaska Division of Homeland Security and Emergency Management.



## SCENARIO TIMEFRAMES

The scenario provided in this section provides an overview of impacts to Alaska's air, sea, and land from a changing climate over three timeframes: our generation, our children's generation, and our grandchildren's generation. Included in each of the time frames are potential environmental, societal and cultural, economic, and security implications for the three generations should the effects of the observed and projected changes in the climate, outlined in Appendix A, come to fruition.

### OUR TIME: Summer 2015

#### OBSERVED AND PROJECTED FIRST-ORDER EFFECTS<sup>4</sup>

##### The Air

Due to its cold-adapted features and rapid warming, observed temperature-related climate change impacts on Alaska could include earlier spring snowmelt (which has implications for water supply), reduced sea ice, widespread glacier retreat, warmer permafrost, drier landscapes, and more extensive insect outbreaks and wildfire. The length of the growing season in interior Alaska has increased 45 percent over the last century.

##### The Sea

Arctic summer sea ice is receding faster than previously projected and is expected to virtually disappear before mid-century, resulting in challenges and opportunities such as altered marine ecosystems, more coastal erosion, greater ship access, and offshore development opportunities. Reductions in sea ice alter food availability for many species, make hunting less predictable and less safe for Alaska Native hunters, and create more accessibility for Arctic Ocean marine traffic, requiring greater Coast Guard activity.

##### The Land

The permafrost thawing trend is projected to continue, causing drier landscapes, increased possibility of more wildfires over time, altered wildlife habitat, increased infrastructure costs, and the release of heat-trapping gases that increase climate warming. The period during which oil and gas exploration is allowed on tundra has decreased by 50 percent since the 1970s as a result of permafrost vulnerability. Alaska currently spends an extra \$10 million per year repairing permafrost damage.

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<sup>4</sup> Chapin, F. S., III, S. F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A. D. McGuire, and M. Serreze, 2014: Ch. 22: Alaska. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 514-536. doi:10.7930/J00Z7150.

## POTENTIAL SECOND-ORDER EFFECTS<sup>5</sup>

### Environmental

Ocean acidification, rising ocean temperatures, declining sea ice, and other environmental changes may interact to affect the location and abundance of marine fish, including those that are commercially important, those used as food by other species, and those used for subsistence.

### Social and Cultural

Relocation away from traditional hunting, fishing, and gathering grounds – caused by permafrost thaw, erosion, sea ice retreat, and other phenomena – may affect Alaska Native traditions and educational opportunities, such as the preservation of native languages and histories. Relocation could also affect subsistence food availability and stimulate risk-taking behaviors such as hunting and fishing in unfamiliar and unsafe areas, which could pose public safety and health risks.

### Economic

The direct and indirect costs of community relocation – driven by potential coastal and river bank erosion and rising permafrost temperatures – strain individual, family, village, borough, state, tribal, and federal resources.

### Security

Sea level rise, flooding, and coastal erosion could put national and state defense facilities, transportation networks, and communications infrastructure and supporting infrastructure at risk.

## OUR CHILDREN'S TIME: Summer 2045

## POTENTIAL FIRST-ORDER EFFECTS<sup>6</sup>

### The Air

The annual area burned by wildfires in Alaska is projected to double by mid-century, fostering increased emissions of heat-trapping gases, higher annual temperatures, and increased fires. Smoke produced in years of extensive wildfire represents a human health risk.

### The Sea

Less seasonal sea ice cover and higher surface temperatures may open up new habitats for some important fish species. However, continued presence of cold bottom-water temperatures on the Alaskan continental shelf may limit northward migration into the northern Bering Sea and Chukchi Sea. Ice loss could result in population declines among polar bears, walruses, and many seal species.

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<sup>5</sup> Potential second-order effects are for discussion only, and not derived from the Third U.S. National Climate Assessment.

<sup>6</sup> Chapin, F. S., III, S. F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A. D. McGuire, and M. Serreze, 2014: Ch. 22: Alaska. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 514-536. doi:10.7930/J00Z7150.

## **The Land**

Uneven sinking of the ground caused by permafrost thaw is estimated to be an additional \$3.6 to \$6.1 billion (10 to 20 percent) to current costs of maintaining public infrastructure such as buildings, pipelines, roads, and airports over the next 20 years (2008 to 2030). In rural Alaska, permafrost thaw could disrupt community water supplies and sewage systems, with negative effects on human health.

## **POTENTIAL SECOND-ORDER EFFECTS<sup>7</sup>**

### **Environmental**

Ocean acidification, rising ocean temperatures, declining sea ice, and other environmental changes may alter the location and abundance of marine fish, creating challenges and opportunities for fisheries across the state. Non-native species could invade Alaskan waters more rapidly, primarily via more frequent ships bringing southerly species to Alaska, releasing ballast waters into warmer oceans. These species introductions have the potential to affect marine ecosystems, including the feeding relationships of fish important to commercial and subsistence fisheries.

### **Social and Cultural**

Greater economic opportunities related to fishing, energy exploration, and other industries may create an influx of non-local employees, altering the traditional ethnic and cultural balance of local communities, with both positive (increased diversity) and negative (increased crime, loss of local identity and traditions) consequences. Increased wildfires could negatively impact public health and safety, placing affected communities at risk. Changes in access to traditional foods could have significant impacts on public health in rural and tribal communities.

### **Economic**

Opportunities for increased exploitation of the area's natural resources may provide employment opportunities, boost local tax revenues, and stimulate construction of utility, transport, and communications infrastructure, creating jobs. However, infrastructure damage caused by permafrost thaw and sinking land could strain economic supply chains, complicate access to employment opportunities for isolated communities, and increase the need for local, state, and federal funding for infrastructure repairs.

### **Security**

Increased transit along Alaska's coastal areas may require increased abilities to protect the environment, conduct search and rescue operations, patrol economic zones, conduct immigration and customs operations, enforce maritime law, and protect the nation against external threats.

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<sup>7</sup> Potential second-order effects are for discussion only, and not derived from the Third U.S. National Climate Assessment.

**OUR GRANDCHILDREN'S TIME: Summer 2085****POTENTIAL FIRST-ORDER EFFECTS<sup>8</sup>****The Air**

Glacier retreat may increase river discharge and hydropower potential in south central and southeast Alaska, but over the longer term might reduce water input to reservoirs and destabilize hydropower resources.

**The Sea**

The Arctic Ocean could become more accessible to marine traffic, including trans-Arctic shipping, oil and gas exploration, and tourism. This may facilitate access to the substantial deposits of oil and natural gas under the seafloor in the Beaufort and Chukchi seas, while it may also heighten the risk to people and ecosystems from oil spills and other drilling and maritime-related accidents. A seasonally ice-free Arctic Ocean could also exacerbate maritime sovereignty and security concerns.

**The Land**

The effects of thawing permafrost, increased flooding, and increased coastal and riverbank erosion to roads, bridges, railways, and other infrastructure is likely to continue to be an area of concern for planners. The present value of additional public infrastructure costs due to climate change impacts was estimated at \$5.6 to \$7.6 billion through 2080, or 10 to 12 percent of total public infrastructure costs in Alaska.

**POTENTIAL SECOND-ORDER EFFECTS<sup>9</sup>****Environmental**

Ocean acidification, rising ocean temperatures, declining sea ice, and other environmental changes have the potential to transform the marine fishery population and species, creating challenges and opportunities for fisheries across the state.

**Social and Cultural**

Climate variability is likely to continue to affect Alaska Native traditions, threaten subsistence food availability, and stimulate risk-taking behaviors, such as hunting and fishing in unfamiliar and unsafe areas, which may pose public safety and health risks. Changes in access to traditional foods could have significant impacts on public health in rural and tribal communities.

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<sup>8</sup> Chapin, F. S., III, S. F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A. D. McGuire, and M. Serreze, 2014: Ch. 22: Alaska. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 514-536. doi:10.7930/J00Z7150.

<sup>9</sup> Potential second-order effects are for discussion only, and not derived from the Third U.S. National Climate Assessment.

**Economic**

The unpredictable arrival, departure, and extent of sea ice may create significant uncertainty, placing economic opportunities related to warmer waters and greater navigability at risk. The unpredictable thawing of permafrost and melting of lake ice affects infrastructure planning and development. Extreme weather events have the potential to affect human and animal activity.

**Security**

Variability and unpredictability of the climate may complicate efforts to protect the environment, conduct search and rescue operations, patrol economic zones, conduct immigration and customs operations, enforce maritime law, and protect the nation against external threats.



## FACILITATOR DISCUSSION QUESTIONS

Given the observed and projected trends and potential consequences of climate change, the following discussion questions allow workshop participants to focus on three overarching questions in the context of key areas – environmental; social and cultural; economic; and security.

“What can we do now as a whole community to collaboratively and sustainably prepare for and mitigate against the effects of climate and adapt to future projected climate changes in Alaska?”

“What opportunities are presented by our changing climate that we can build upon as a whole community?”

“What actionable information and policy considerations are needed to explore climate adaptation strategies, set priorities, and define investments to address challenges and opportunities encountered by climate change adaptation efforts?”

### OUR TIME: Summer 2015

#### ENVIRONMENTAL FOCUS AREA

- What key environmental climate change adaptation challenges does Alaska face in the near term (e.g., public health, food supply, fishing industry, community traditions)?
- What key climate change-related environmental adaptation opportunities can Alaskan communities use to prepare for climate change?
- What existing coalitions are being organized between local, state, tribal, federal, and private sector partners to support adaptation planning related to environmental issues?
- What obstacles have your departments and agencies encountered that affect joint environmental adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?

#### SOCIAL AND CULTURAL FOCUS AREA

- What key social and cultural climate change adaptation challenges does Alaska face in the near term (e.g., public health, housing, employment, food supply, community traditions)?
- What key climate change-related social and cultural adaptation opportunities can Alaskan communities use to prepare for climate change?
- What key investments need to be made in order to preserve the traditional way of life in Alaska (e.g., infrastructure, education, housing)?
- What existing coalitions are being organized between local, state, tribal, federal, and private sector partners to support adaptation planning related to social and cultural issues?
- What obstacles have your departments and agencies encountered that affect joint social and cultural adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?

**ECONOMIC FOCUS AREA**

- What key economic challenges related to climate change planning does Alaska face in the near term (e.g., infrastructure, industry, energy, housing, public health, security)?
- What economic opportunities are presented by climate change in the near term, and what adaptation strategies are being explored to seize these opportunities?
- What are the anticipated major climate change-related economic investments in Alaska in the near term (e.g., infrastructure, industry, energy, housing, public health, security)?
- What existing coalitions are being organized between local, state, tribal, federal, and private sector partners to support adaptation planning related to economic issues?
- What obstacles have your departments and agencies encountered that affect joint economic adaptation planning?
  - What strategies have been or could be implemented to remove those obstacles?

**SECURITY FOCUS AREA**

- What assets are most vulnerable to climate change in the near term (e.g., military facilities, naval installations, energy infrastructure, supply lines)?
- What critical investments need to be made to ensure Alaska's security in the near term?
- Are there currently coalitions being organized between local, state, tribal, federal, and private sector partners to support adaptation planning related to security issues?
- What obstacles have your departments and agencies encountered that affect joint security adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?

**OUR CHILDREN'S TIME: Summer 2045****ENVIRONMENTAL FOCUS AREA**

- What key environmental climate change adaptation challenges does Alaska face in the mid-term (e.g., public health, industry, employment, food supply, community traditions)?
- What key climate change-related environmental adaptation opportunities can Alaskan communities use to prepare for climate change in the mid-term?
- What existing coalitions are being organized between local, state, tribal, federal, and private sector partners to support adaptation planning related to environmental issues in the mid-term?
- What obstacles have your departments and agencies encountered that affect joint environmental adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?

**SOCIAL AND CULTURAL FOCUS AREA**

- What key social and cultural climate change adaptation challenges does Alaska face in the mid-term (e.g., public health, housing, employment, food supply, community traditions)?

- What adaptation planning areas (economic, industrial, educational, public health, environmental, or natural resources) should be explored today in order to preserve Alaska's communities and their traditional way of life in the 2045 timeframe?
- What can be done today to address the potential negative public health impacts of reduced access to traditional foods in Alaska's rural and tribal communities?
- What can be done today to mitigate the potential negative social and cultural impacts of wildfires, permafrost thaw, coastal and riverbank erosion, and other climate change-related natural phenomena on Alaskans in the 2045 timeframe?
- What obstacles could your departments and agencies encounter that might affect joint social and cultural adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?

### **ECONOMIC FOCUS AREA**

- What are some of the possible climate change-related economic opportunities and challenges in the 2045 timeframe (e.g., warmer fishing waters, increasingly navigable seas, expanded energy exploration opportunities, longer growing seasons, tourism, infrastructure)?
- How can Alaska work to transform its economy today in order to seize the opportunities and address the challenges of the 2045 timeframe?
- What planning can be done today to address the climate change-related infrastructure challenges (supply chains, farm-to-market access, access to jobs, telecommunications, workforce development, value engineering) associated with economic activity in the 2045 timeframe?
- Are there currently coalitions being organized between local, state, tribal, federal, and private sector partners to support adaptation planning related to economic issues?
- What obstacles have departments and agencies encountered that might affect joint economic adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?

### **SECURITY FOCUS AREA**

- What Alaska security assets are most likely to be vulnerable to climate change in the 2045 timeframe (e.g., military installations, transportation and energy infrastructure, naval facilities)?
- What maritime-related planning and investment (e.g., adaptation of port infrastructure, relocation and/or expansion of naval installations, expansion of naval capabilities to patrol increasingly navigable seas) is required to ensure Alaska's security in the 2045 timeframe?
- Are there currently coalitions organized between local, state, tribal, federal, and private sector partners to support adaptation planning related to security issues in the mid-21<sup>st</sup> century?
- What obstacles have departments and agencies encountered that might affect joint security adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?

**OUR GRANDCHILDREN'S TIME: Summer 2085****ENVIRONMENTAL FOCUS AREA**

- What key environmental climate change adaptation challenges does Alaska face in the long term (e.g., public health, industry, employment, food supply, community traditions)?
- What key climate change-related environmental adaptation opportunities can Alaskan communities use to prepare for climate change in the long-term?
- What existing coalitions are being organized between local, state, tribal, federal, and private sector partners to support adaptation planning related to environmental issues in the long-term?
- What obstacles have your departments and agencies encountered that affect joint long-term environmental adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?

**SOCIAL AND CULTURAL FOCUS AREA**

- What key social and cultural climate change adaptation challenges does Alaska face in the long term (e.g., public health, housing, employment, food supply, community traditions)?
- How can Alaska planners prepare today to utilize the possible economic benefits of climate change to preserve Alaska's communities and traditional ways of life in 2085?
- What can be done today to address the potential negative public health impacts of reduced access to traditional foods in Alaska's rural and tribal communities?
- How can Alaska facilitate the adaptation of Alaska Native communities to potential climate change-related developments in 2085? Education? Economic planning? Public health and safety campaigns? Housing policies? Infrastructure investments?
- What obstacles have departments and agencies encountered that might affect joint social and cultural adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?

**ECONOMIC FOCUS AREA**

- What are some of the possible climate change-related economic benefits and opportunities and challenges related to energy, fishing, mining, tourism, and other key Alaska industries in the 2085 timeframe?
- How can Alaska work to transform its economy today in order to best seize future opportunities and to address challenges in the 2085 timeframe?
- How can Alaska prepare today to address the economic and infrastructure challenges posed by permafrost thaw, sea ice retreat, coastal and riverbank erosion, extreme weather, and other potential climate change-related phenomena in 2085, and especially as they pertain to rural and Alaska Native communities?
- What obstacles have departments and agencies encountered that might affect joint long-term economic adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?

**SECURITY FOCUS AREA**

- What are some key security issues that Alaska is likely to face given 2085 climate change projections (e.g., greatly expanded ocean navigability, territorial challenges, maritime commercial disputes, naval infrastructure degradation, port transformation)?
- What investments and plans can be initiated today to address these future security issues and ensure Alaska's security at the end of the 21<sup>st</sup> century?
- Are there currently coalitions being organized between local, state, tribal, federal, and private sector partners to support adaptation planning related to security issues in the late 21<sup>st</sup> century?
- What obstacles have departments and agencies encountered that might affect joint long-term security adaptation planning support to local, state, tribal, and private sector partners?
  - What strategies have been or could be implemented to remove those obstacles?



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**APPENDIX A: OBSERVED AND PROJECTED CHANGES IN CLIMATE**

Information provided in this section was derived from technical inputs, scientific experts, and peer-reviewed information provided for the development of the Third U.S. National Climate Assessment's Alaska Chapter and other chapters that address relevant climate impacts to the State of Alaska. The Third U.S. National Climate Assessment is the result of a three-year analytical effort by a team of over 300 experts, overseen by a broadly constituted Federal Advisory Committee of 60 members. It was developed from information and analyses gathered in over 70 workshops and listening sessions held across the country. It was subjected to extensive review by the public and by scientific experts in and out of government, including a special panel of the National Research Council of the National Academy of Sciences. This process of unprecedented rigor and transparency was undertaken so that the findings of the National Climate Assessment would rest on the firmest possible base of expert judgment.

**OUR TIME: Summer 2015****OBSERVED CHANGES IN THE CLIMATE<sup>10</sup>****The Air**

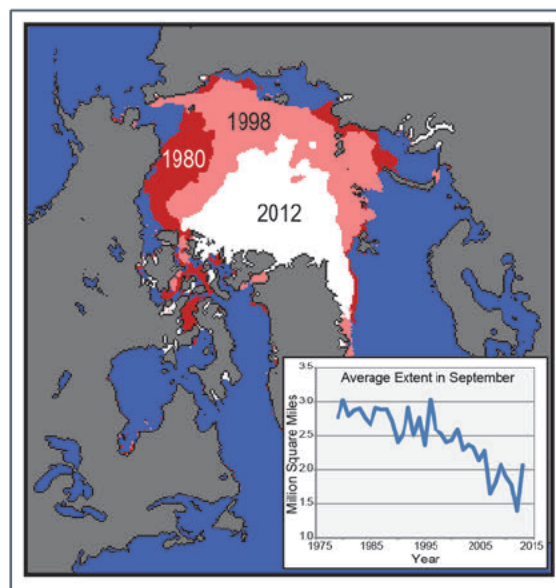
Over 60 years, Alaska has warmed more than twice as rapidly as the rest of the U.S., with average annual air temperature increasing by 3 degrees Fahrenheit and average winter temperature by 6 degrees Fahrenheit, with substantial year-to-year and regional variability.

**The Sea**

Since 1978, minimum Arctic sea ice extent (which occurs in early to mid-September) has decreased by more than 40 percent (See Figure 1). Ice thickness decreased by more than 50 percent from 1958 to 2008 and the percentage of the March ice cover made up of thicker ice (ice that has survived a summer melt season) decreased from 75% in the mid-1980s to 45% in 2011.

**The Land**

Permafrost near the Alaskan Arctic coast has warmed 4 to 5 degrees Fahrenheit at 65 foot depth since the late 1970s and 6 to 8 degrees Fahrenheit at 3.3 foot depth (near-surface) since the mid-1980s. Thaw is already occurring in interior Alaska and in northern Canada, where permafrost temperatures are near the thaw point.



**Figure 1. Average September extent of Arctic sea ice in 1980, 1998, and 2012 (Source: Third U.S. National Climate Assessment)**

<sup>10</sup> Chapin, F. S., III, S. F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A. D. McGuire, and M. Serreze, 2014: Ch. 22: Alaska. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 514-536. doi:10.7930/J00Z7150.

**OUR CHILDREN'S TIME: Summer 2045****PROJECTED CHANGES IN THE CLIMATE<sup>11</sup>****The Air**

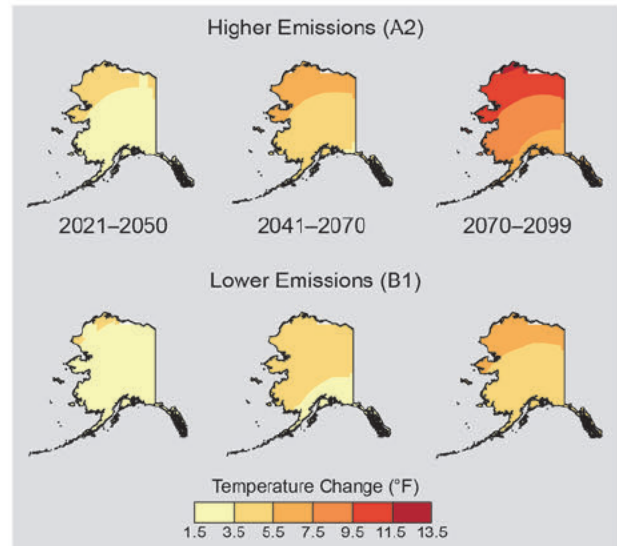
Average annual temperatures in Alaska are projected to rise by an additional 4 degrees Fahrenheit by 2050 (See Figure 2). Summer (June, July, and August) temperatures in Alaska are projected to be about 2.5 degrees Fahrenheit warmer, compared to the average during 1971-1999.

**The Sea**

The Arctic Ocean is expected to become essentially ice-free during the summer months. The Arctic is considered essentially ice-free when the real extent of ice is less than one million square kilometers. To put that in perspective, according to data collected by the National Snow and Ice Data Center, the 1981-2010 average summer minimum was 6.52 million square kilometers. The current record summer minimum of 3.41 square kilometers was recorded in September 2012.<sup>12</sup>

**The Land**

Models project that permafrost in Alaska will continue to thaw (See Figure 3).



**Figure 2.** Maps show changes in temperature, relative to 1971-1999, projected for Alaska in the early, middle, and late parts of this century, if heat-trapping gas emissions continue to increase (A2), or are substantially reduced (B1) (Source: *Third U.S. National Climate Assessment*)

**OUR GRANDCHILDREN'S TIME: Summer 2085****PROJECTED CHANGES IN THE CLIMATE<sup>13</sup>****The Air**

Global emissions are projected to continue to increase during this century, so temperatures may rise 8 degrees Fahrenheit in the north, 4 degrees Fahrenheit in the interior, and 6 degrees

<sup>11</sup> Chapin, F. S., III, S. F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A. D. McGuire, and M. Serreze, 2014: Ch. 22: Alaska. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 514-536. doi:10.7930/J00Z7150.

<sup>12</sup> <http://nsidc.org/arcticseaicenews/tag/arctic-sea-ice/>

<sup>13</sup> Chapin, F. S., III, S. F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A. D. McGuire, and M. Serreze, 2014: Ch. 22: Alaska. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 514-536. doi:10.7930/J00Z7150.

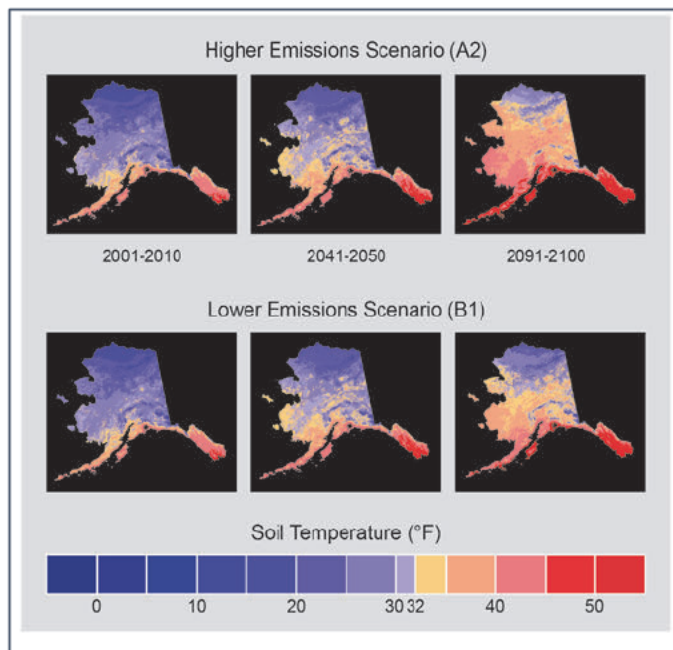
Fahrenheit in the rest of the state. Summer temperatures are projected to increase by 5.5 degrees Fahrenheit from the average during 1971-1999 (see Figure 2).

### The Sea

The Arctic Ocean is projected to be ice-free during the summer months.

### The Land

Near-surface permafrost is projected to be lost entirely from large parts of Alaska.



**Figure 3. The Big Thaw. Projected permafrost thaw in Alaska based on two emissions scenarios (Source: *Third U.S. National Climate Assessment*)**

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## APPENDIX B: RESOURCES

### Useful Links

#### White House Resources

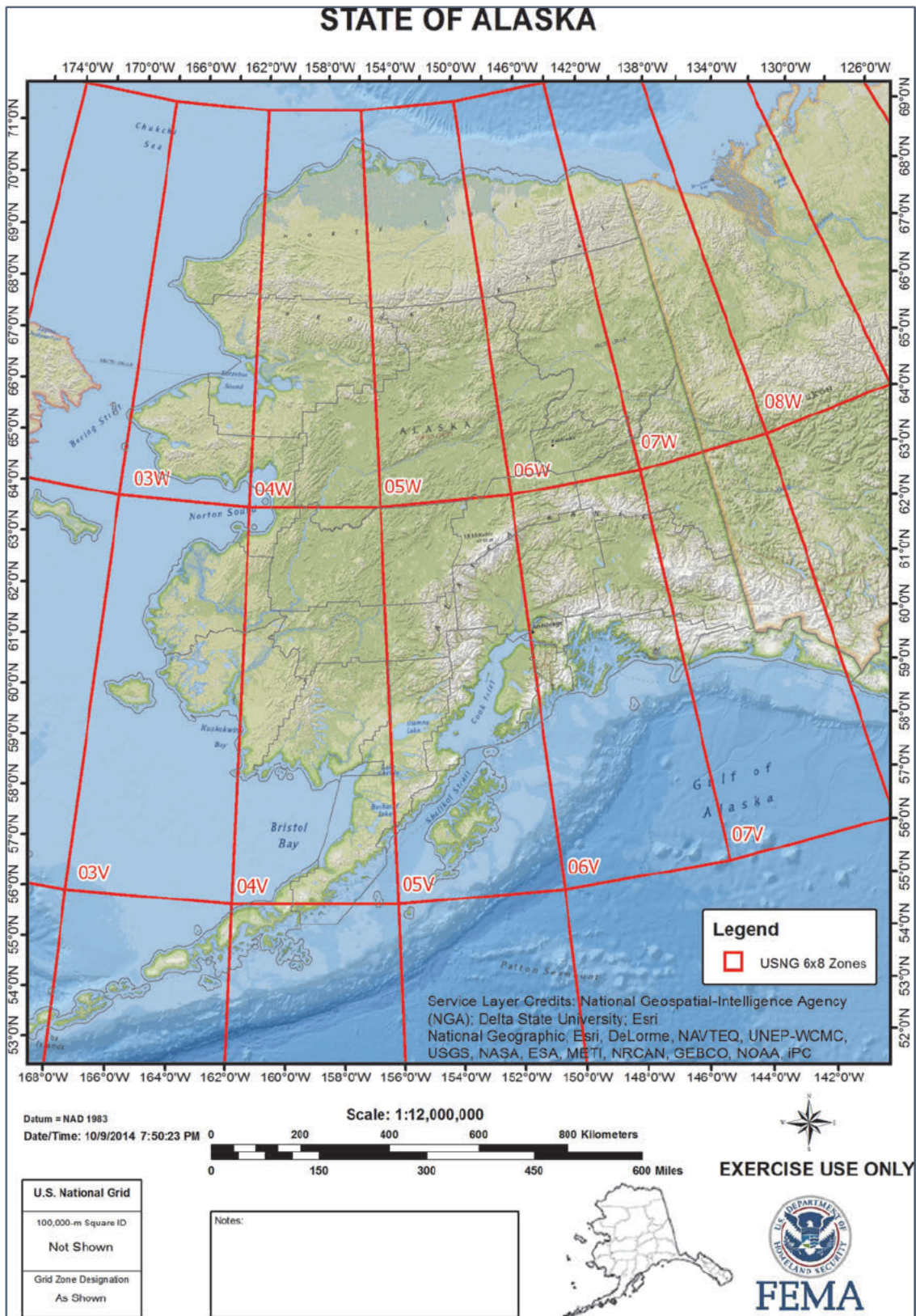
- The Council on Environmental Quality:  
<http://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience>
- The Office of Science and Technology Policy:  
<http://www.whitehouse.gov/administration/eop/ostp>
- White House Climate Data Initiative: <http://www.data.gov/climate/>

#### Federal Resources

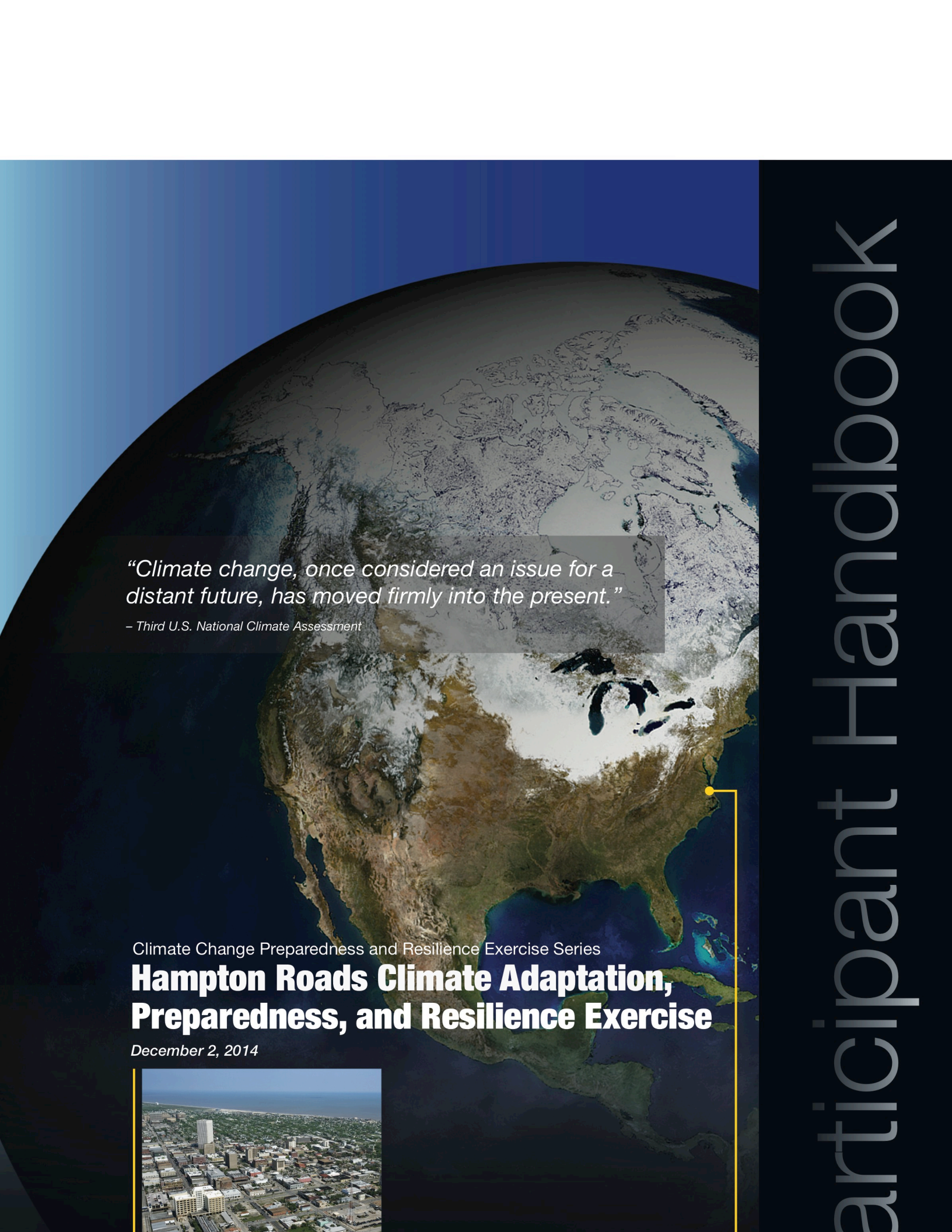
- The U.S. Global Change Research Program: [www.globalchange.gov](http://www.globalchange.gov)
- Third U.S. National Climate Assessment: <http://nca2014.globalchange.gov/>
- Third U.S. National Climate Assessment Download Materials:  
<http://www.globalchange.gov/nca3-downloads-materials>
- The U.S. Global Change Research Program Adaptation Page:  
<http://www.globalchange.gov/explore/adaptation>
- The U.S. Global Change Research Program Federal Adaptation Resources Library:  
<http://www.globalchange.gov/browse/federal-adaptation-resources>

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## APPENDIX C: MAP





A large satellite image of the Earth, centered on North America. The image shows the continents of North and South America, the Atlantic Ocean, and the Arctic region. A yellow line with a dot at the end points to the Hampton Roads area on the eastern coast of the United States.

*"Climate change, once considered an issue for a distant future, has moved firmly into the present."*

– Third U.S. National Climate Assessment

Climate Change Preparedness and Resilience Exercise Series

# **Hampton Roads Climate Adaptation, Preparedness, and Resilience Exercise**

December 2, 2014



Participant Handbook

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## INTRODUCTION

The Hampton Roads Climate Adaptation, Preparedness, and Resilience Exercise is an element of the National Exercise Program Climate Change Preparedness and Resilience Exercise Series sponsored by the White House National Security Council Staff, Council on Environmental Quality, and Office of Science and Technology Policy, in collaboration with the Federal Emergency Management Agency National Exercise Division. The Hampton Roads exercise is one of four jurisdictional events conducted in 2014—additional events were conducted in Houston, Texas; Fort Collins, Colorado; and Anchorage, Alaska. Each of these events were designed to advance the climate adaptation dialogue and identifying collaborative and sustainable approaches to community-based climate preparedness and resilience capabilities.

In support of the desired outcome to improve collaboration among whole community partners, exercise participants include local, state, and federal representatives as well as private sector, non-governmental, and academic partners who have roles, responsibilities, and expertise in climate adaptation, hazard mitigation, and resiliency planning efforts.

This Participant Handbook provides the goals and objectives for the exercise, a detailed scenario with focus areas, and facilitator questions for discussion during the exercise.

### Goal

This exercise is intended to provide a forum for stakeholders in the Hampton Roads, Virginia region to identify and refine climate adaptation, preparedness, and resilience requirements and initiatives in collaboration with critical whole community stakeholders. This event supports the strategic long-term planning priorities of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project initiated in June 2014.

### Objectives

Exercise objectives are:

1. Examine intergovernmental coordination of climate preparedness and resiliency assessment, planning, and vulnerability reduction initiatives to manage and adapt to risks and vulnerabilities associated with the hazards of sea level rise, storm surge, and flooding.
2. Identify collaborative and sustainable whole community approaches to advance local climate adaptation, preparedness, and resilience programs and policies, and to address the *Recommendations to The Secure Commonwealth Panel on the Issue of Sea Level Rise and Recurrent Flooding in Coastal Virginia* submitted to the Virginia Secure Commonwealth Panel in September 2014.
3. Examine coordination, planning, and investment opportunities between local, state, federal, and private sector partners to support climate adaptation, preparedness, and resilience.

## Outcomes

The exercise will focus on the following outcomes:

- Improved collaboration with and between whole community partners on climate preparedness and resilience strategies.
- Identification of new research, information, and capabilities that will support local preparedness, adaptation, and hazard mitigation planning.
- Encourage the development of a regional “whole of government” and “whole of community” approach to strategic sea level rise preparedness and resilience planning in Hampton Roads that also can be used as a template for other regions.

## Output

Exercise outputs include the following:

- Enhanced regional coordination and collaboration among Hampton Roads community planning efforts.
- Identify new research, information and regional capabilities to support Hampton Roads community-based preparedness, adaptation, and hazard mitigation planning.

## Format

The exercise is a one-day (8:30a.m.- 4:00p.m.) facilitated event tailored to the specific needs of the Hampton Roads, Virginia region.

Morning presentations and focused group/team discussions will be based on current scientific projections and associated consequences, climate preparedness, and resilience efforts. Participants will be asked to discuss necessary planning capabilities across the Hampton Roads community in order to consider and determine desired outcomes associated with short-term actions (60-90 days), near-term actions (6-12 months), and long-term actions (beyond 12 months).

The afternoon session, a facilitated tabletop exercise, will address storm events in two generational timeframes – our children’s time and our grandchildren’s time – using pre-identified participant-led breakout groups to consider hazard mitigation planning necessary to examine future projected effects and adaptation requirements.

The exercise scenario is tailored to look at jurisdictional effects based on the existing Third U.S. National Climate Assessment regional scenarios, and include specific scenario events –a Category 3 hurricane making landfall in Hampton Roads, Virginia in 2044 (our children’s time) and a nor’easter making landfall in 2084 (our grandchildren’s time) – to allow participants to focus their discussions.

The schedule for the event is as follows:

Registration	7:30 – 8:30 a.m.
Welcome and Opening Remarks	8:30 a.m.

Administration, Overview, and Introductions	9:00 a.m.
Climate Projected Regional Effects and Consequences	9:30 a.m.
Focus Group Table Discussions Table Discussion	10:00 a.m.
Break	11:15 a.m.
Focus Group/Table Discussion Brief-Outs	11:30 a.m.
Lunch	12:00 p.m.
Key-Note Speaker: Cascading Effects of Superstorm Sandy	12:30 – 12:45 p.m.
Hurricane Science and Consequences – sea level rise, storm surge, and flooding	1:00 -1:30 p.m.
Tabletop Exercise: Hurricane Effects and Consequences in Our Children’s Generation/Our Grandchildren’s Generation	1:30 -3:30 p.m.
Break	3:30 p.m.
Tabletop Exercise Brief-Outs	3:45 p.m.
Closing Remarks	4:15 p.m.
Adjournment	<b>4:30 p.m.</b>

## Exercise Participants

Exercise participants include local, state, and federal climate adaptation and hazard mitigation planners, emergency managers, and subject matter experts, as well as identified stakeholders and partners from the private sector, non-governmental organizations, and academic institutions. Federal participants include both region-based department and agency representatives, as well as select representatives from the National Capital Region.

### Commonwealth of Virginia

- Virginia Attorney General's Office
- Virginia Department of Conservation and Recreation
- Virginia Department of Emergency Management
- Virginia Department of Transportation
- Virginia National Guard
- Virginia Port Authority

### Hampton Roads Area

- City of Hampton
- City of Norfolk
- City of Virginia Beach
- Gloucester County



- Hampton Roads Alliance for Environmental Education
- Hampton Roads Center for Civic Engagement
- Hampton Roads Community Foundation
- Hampton Roads Planning District Commission
- Hampton Roads Sanitation District
- Hampton Roads Transportation Planning Organization
- Henrico County
- Urban Land Institute, Hampton Roads

**Federal Departments and Agencies**

- Environmental Protection Agency
- Federal Emergency Management Agency, Region III
- Joint Base Langley-Eustis
- National Aeronautics and Space Administration
- Naval Air Station Oceana
- Navy Judge Advocate General
- U. S. Air Force, Judge Advocate General
- U.S. Army Corps of Engineers
- U.S. Coast Guard
- U.S. Department of Commerce
- National Oceanic and Atmospheric Administration
- U.S. Economic Development Administration
- U.S. Department of Energy
- U.S. Department of Health and Human Services
- U.S. Department of the Interior
- U.S. Department of Transportation
- U.S. Fleet Forces Command
- U.S. Naval Facilities Engineering Command, Mid-Atlantic

**Non-Governmental Organizations**

- American Planning Association
- Chesapeake Bay Foundation
- Chesapeake Climate Action Network
- CIVIC Leadership program
- Elizabeth River Project
- League of Women Voters
- Lynnhaven River NOW
- Resilient Virginia
- Sierra Club
- Southeast CARE Coalition
- Virginia Association of Counties
- Virginia Association of Zoning Officials
- Virginia Coastal Coalition
- Virginia Floodplain Managers Association
- Virginia Municipal League

- Wetlands Watch
- World Resources Institute

### Private Sector

- 2rw Consultants, Inc.
- Building Constructive Solutions, LLC
- Coastal Observing Services Inc.
- Cox Communications
- Dominion Virginia Power
- Landmark Publishing
- Maersk Shipping
- Marstel-Day, LLC
- Norfolk Southern
- Saunders + Crouse Architects
- Sentara Health
- Solstice Environmental, LLC.
- Storm Center Communications
- The Terry Peterson Co.
- Verizon Communications
- Weston Solutions, Inc.
- Williams Mullen

### Academic Partners

- College of William & Mary
- Old Dominion University
- Virginia Institute of Marine Science

## Exercise Scope and Assumptions

Exercises play a vital role in national preparedness by enabling whole community stakeholders to test and validate capabilities, as well as identify potential capability shortfalls and planning requirements for improving preparedness. A well-designed exercise provides a low-risk environment to share understanding of requirements, familiarize personnel with roles and responsibilities, and foster meaningful interaction and communication across organizations. Exercises bring together and strengthen the whole community in its efforts to prevent, protect against, mitigate, respond to, and recover from all hazards. Overall, exercises are cost-effective and useful tools that help the nation practice and refine our collective capacity to build, sustain, and deliver the core capabilities needed to achieve climate preparedness and resilience.

Participants are encouraged to share expertise and experience, while the facilitator (s) will ensure that participants have an opportunity to contribute. The scenario will integrate existing issues as identified through the planning process. Discussion questions will aim to assist participants in achieving the exercise objectives.

Participants should consider the following exercise ground rules to ensure that objectives are met in a reasonable amount of time and that the exercise runs smoothly:

- Keep exercise objectives in mind throughout the exercise.
- Participate openly and focus discussions on appropriate topics—asking questions; sharing thoughts; and offering forward-looking, problem-solving suggestions, as these will enhance the exercise experience.
- Focus comments and consider time constraints.

In any exercise, a number of assumptions may be necessary to complete play in the time allotted. During this exercise, the following apply:

- The scenarios are plausible, and events occur as they are presented.
- There are no “hidden agendas” or trick questions.
- All players receive information at the same time.

### Exercise Evaluation

The exercise evaluation process aligns with requirements of the National Exercise Program and will be consistent with Homeland Security Exercise and Evaluation Program doctrine. Evaluation efforts validate strengths and identify opportunities for improving climate resiliency among participating organizations by capturing key discussion points, identifying strengths and areas for improvement, and consolidating these discussion points within a Summary Report. This approach affords participating organizations an opportunity to revise, update, or modify current climate change adaptation and hazard mitigation plans and strategies, as needed.

The Summary Report will capture key discussion points to include the following:

- Recommendations on integration of climate preparedness and resilience requirements and initiatives into current and future planning to manage and adapt to climate risks and vulnerabilities.
- Suggestions on maintaining collaborative partnerships and building new coalitions across the whole community.
- Areas where additional information and research is needed.
- Effects of climate change on Hampton Road regional missions, policies, and strategies, and resources required given the exercise scenario.

The National Exercise Division assigns evaluators to capture participant discussions. The evaluation team will then produce the Summary Report and deliver it to the National Exercise Division within two weeks of the exercise’s conclusion. The exercise planning team and key participants will be invited to participate in a virtual After-Action Meeting in December 2014, to review the draft Summary Report and validate and revise the findings and observations so that a final Summary Report may be produced.

### Core Capabilities

The National Preparedness Goal, released in September 2011, defines what it means for the whole community to be prepared for all types of disasters and emergencies. It also identified five mission areas – Prevention, Protection, Mitigation, Response, And Recovery – which encompass

31 distinct critical elements (“core capabilities”) needed to achieve the National Preparedness Goal of a secure and resilient Nation.

The Exercise will focus on the Mitigation Mission Area, which is comprised of, “the capabilities necessary to reduce the loss of life and property by lessening the impacts of disasters.”

Four of the Mitigation Mission Area core capabilities will be explored through the exercise:

1. Planning
2. Community Resilience
3. Long-term Vulnerability Reduction; and
4. Risk and Disaster Resilience Assessment

Descriptions<sup>1</sup> for the core capabilities that will be examined during the exercise are as follows:

Core Capability	Description
<b>Community Resilience</b>	Lead the integrated effort to recognize, understand, communicate, plan, and address risks so that the community can develop a set of actions to accomplish mitigation and improve resilience.
<b>Long-Term Vulnerability Reduction</b>	Build and sustain resilient systems, communities, and critical infrastructure and key resources lifelines so as to reduce their vulnerability to natural, technological, and human-caused incidents by lessening the likelihood, severity, and duration of the adverse consequences related to these incidents.
<b>Planning</b>	Conduct a systematic process engaging the whole community as appropriate in the development of executable strategic, operational, and/or community-based approaches to meet defined objectives.
<b>Risk and Disaster Resilience Assessment</b>	Assess risk and disaster resilience so that decision-makers, responders, and community members can take informed action to reduce their entity’s risk and increase their resilience.

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<sup>1</sup> Department of Homeland Security. *National Preparedness Goal*. September 2011.

## SCENARIO BACKGROUND: *CLIMATE INFORMATION*

### Regional Changes in the Climate in the Southeast and Along the Coast

The expected rise in sea level, as predicted in the Third U.S. National Climate Assessment, will result in the potential for greater damage from storm surge in the Hampton Roads area. The U.S. Southeast and Caribbean<sup>2</sup> regional findings include:

- **Key Message 1: Sea Level Rise Threats.** Sea level rise poses widespread and continuing threats to both natural and built environments and to the regional economy.
- **Key Message 2: Increasing Temperatures.** Increasing temperatures and the associated increase in frequency, intensity, and duration of extreme heat events will affect public health, natural and built environments, energy, agriculture, and forestry.
- **Key Message 3: Decreased Water Availability.** Decreased water availability, exacerbated by population growth and land-use change, will continue to increase competition for water and affect the region's economy and unique ecosystems.

The U.S. Coastal Zone Development and Ecosystems<sup>3</sup> regional findings of the Third U.S. National Climate Assessment include:

- **Key Message 1: Coastal Lifelines at Risk.** Coastal lifelines, such as water supply and energy infrastructure and evacuation routes, are increasingly vulnerable to higher sea levels and storm surges, inland flooding, erosion, and other climate-related changes.
- **Key Message 2: Economic Disruption.** Nationally important assets, such as ports, tourism, and fishing sites, in already-vulnerable coastal locations, are increasingly exposed to sea level rise and related hazards. This threatens to disrupt economic activity within coastal areas and the regions they serve and results in significant costs from protecting or moving these assets.
- **Key Message 3: Uneven Social Vulnerability.** Socioeconomic disparities create uneven exposures and sensitivities to growing coastal risks and limit adaptation options for some coastal communities, resulting in the displacement of the most vulnerable people from coastal areas.
- **Key Message 4: Vulnerable Ecosystems.** Coastal ecosystems are particularly vulnerable to climate change because many have already been dramatically altered by human

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<sup>2</sup> Carter, L. M., J. W. Jones, L. Berry, V. Burkett, J. F. Murley, J. Obeysekera, P. J. Schramm, and D. Wear, 2014: Ch. 17: *Southeast and the Caribbean. Climate Change Impacts in the United States: The Third U.S. National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 396-417. doi:10.7930/J0NP22CB.

<sup>3</sup> Moser, S. C., M. A. Davidson, P. Kirshen, P. Mulvaney, J. F. Murley, J. E. Neumann, L. Petes, and D. Reed, 2014: Ch. 25: *Coastal Zone Development and Ecosystems. Climate Change Impacts in the United States: The Third U.S. National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 579-618. doi:10.7930/J0MS3QNW..

stresses; climate change will result in further reduction or loss of the services that these ecosystems provide, including potentially irreversible impacts.

- **Key Message 5: The State of Coastal Adaptation.** Leaders and residents of coastal regions are increasingly aware of the high vulnerability of coasts to climate change and are developing plans to prepare for potential impacts on citizens, businesses, and environmental assets. Significant institutional, political, social, and economic obstacles to implementing adaptation actions remain.

### Local Background Information for the Hampton Roads Area

The second most populous region in the Commonwealth of Virginia (behind Northern Virginia), Hampton Roads is second only to New Orleans in its vulnerability to sea level rise. The area includes the cities of Chesapeake, Poquoson, Franklin, Portsmouth, Hampton, Suffolk, Newport News, Virginia Beach, Norfolk, and Williamsburg. Approximately 1.6 million people<sup>4</sup> live in the region, many in low-elevation neighborhoods prone to flooding.

The Hampton Roads region is a key economic center for Virginia. The Port of Virginia maintains four large facilities in the region: Norfolk International Terminals (NIT), Portsmouth Marine Terminal (PMT), Newport News Marine Terminal (NNMT), and Virginia International Gateway (VIG) at Portsmouth. Each year, millions of tourists visit Virginia Beach, Yorktown Battlefield, Jamestown Settlement, Colonial Williamsburg, and the numerous museums located in the area. Hampton Roads is also critical to national security. The U.S. Department of Defense maintains numerous military installations in the area, including Camp Peary, Joint Base Langley-Eustis, Naval Air Station Oceana, Joint Expeditionary Base Little Creek, and the world's largest naval base, Naval Station Norfolk. Flooding associated with sea level rise threatens these and other installations, and the readiness and effectiveness of the forces stationed there.

Like many urban centers, the Hampton Roads region depends on infrastructure—such as water and sewage systems, roads, bridges, and power plants—that is aging and in need of repair or replacement. Rising sea levels, storm surges, heat waves, and extreme weather events will compound these issues, stressing or even overwhelming these essential services.

Hampton Roads region residents are vulnerable to disruptions in essential infrastructure services from climate change, in part because many of these infrastructure systems are reliant on each other. For example, electricity is essential to multiple systems, and a failure in the electrical grid can affect water treatment, transportation services, and public health. These infrastructure systems will continue to be affected by various climate-related events and processes.

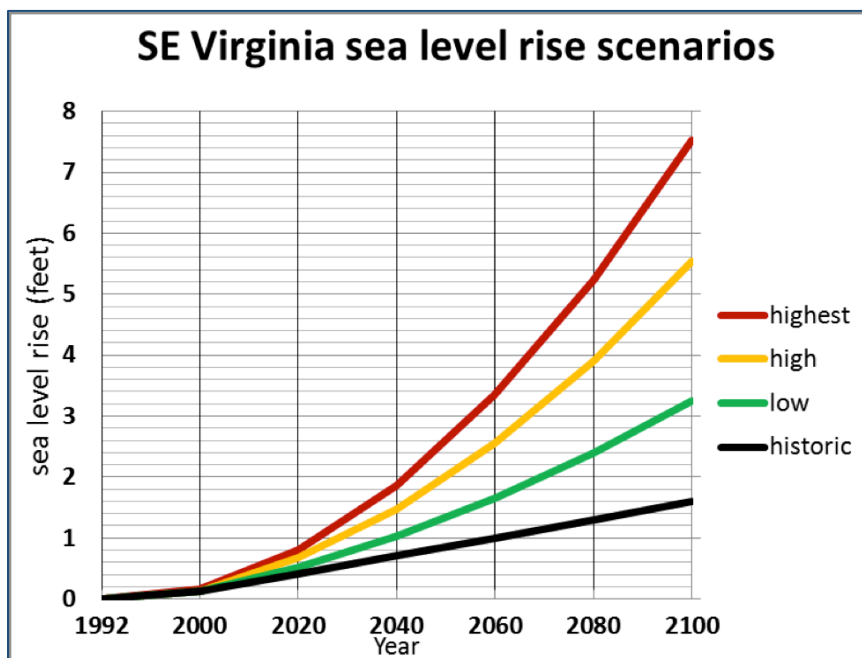
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<sup>4</sup> 2010 U.S. Census data.



**Projected Future Climate Conditions for the Hampton Roads Area****Projected Sea Level Rise.**

Relative sea level rise<sup>5</sup> is a major issue in Hampton Roads, driven primarily by increasing volumes of ocean water as a result of melting ice and warming ocean temperatures, and the area's pervasive land subsidence (sinking).<sup>6</sup> In the past 80 years, sea levels have risen over one foot in Hampton Roads.<sup>7</sup> Models indicate that sea levels could rise as much as 7.5 feet in Hampton Roads by 2100.<sup>8</sup> Sea level rise of this magnitude threatens to flood over 176,000 homes, affect approximately 500 miles of roadways, threaten thousands of businesses, and inundate over 100,000 acres of wetlands.<sup>9</sup>



**Figure 1.** Source: Recurrent Flooding Study for Tidewater Virginia, Virginia Institute for Marine Science, January 2013.

**Projected Increase in Average Annual Temperatures and Extreme High Temperatures.**

Currently, temperatures in the Hampton Roads area range from an average of 40 degrees Fahrenheit in January to 79 degrees Fahrenheit in July.<sup>10</sup> By 2100, average annual temperatures

<sup>5</sup> Relative sea level rise (RSLR) is the combined effect of the projected increase in the volume of the world's oceans (eustatic sea level change), which results from increases in temperature and melting of ice, and the projected changes in land surface elevation at a given location due to subsidence of the land surface.

<sup>6</sup> Land subsidence in Hampton Roads is driven by several factors: readjustment of the earth due to glacial retreat since the end of the last Ice Age, ongoing compaction of the land in the wake of the meteor strike that impacted the area 35 million years ago, and the large scale pumping of groundwater for residential and commercial use.

<sup>7</sup> Mitchell, M., C. Hershner, J. Herman, D. Schatt, E. Eggington and S. Stiles. 2013. *Recurrent Flooding Study for Tidewater Virginia*. Virginia Senate Document No. 3. Richmond, Virginia.

<sup>8</sup> Mitchell, M., C. Hershner, J. Herman, D. Schatt, E. Eggington and S. Stiles. 2013. *Recurrent Flooding Study for Tidewater Virginia*. Virginia Senate Document No. 3. Richmond, Virginia.

<sup>9</sup> McFarlane, Benjamin J. *Climate Change in Hampton Roads: Phase III: Sea Level Rise in Hampton Roads, Virginia*. Hampton Roads Planning Commission, July 2012.

<sup>10</sup> *Adapting Now to a Changing Climate: Langley Research Center*. National Aeronautics and Space Administration, Fall 2011.

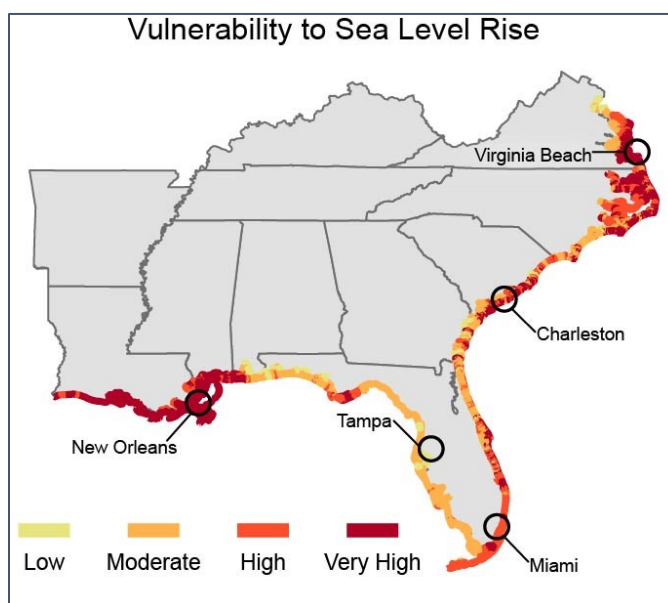
in Virginia could increase by 5.6 degrees Fahrenheit,<sup>11</sup> with over 80 days per year at or above 90 degrees Fahrenheit.<sup>12</sup>

**Projected Increase in Intensity of Extreme Weather Events.** The Hampton Roads area is subject to hurricanes and the associated high winds, storm surge, and flooding. Rising sea level and land subsidence will increase the risk of catastrophic storm surge impacts on regional infrastructure assets, human capital, and natural resources. According to some models, warming Atlantic Ocean temperatures may make hurricanes and other storm events more powerful.<sup>13</sup> Rising relative sea level will exacerbate exposure to storm surge and flooding. Extreme floods and storms associated with climate change will also lead to increased movement of sediment and buildup of sandy formations in port channels. Projected changes in the frequency of some extreme events like hot and cold days may also lead to large impacts.<sup>14</sup>

### Potential Climate Change Consequences for the Hampton Roads Area

#### Human Health and Well-Being.

As urban areas develop, changes occur in their landscape. Buildings, roads, and other infrastructure replace open land and vegetation. Surfaces that were once permeable and moist become impermeable and dry. These changes cause urban regions to become warmer than their rural surroundings, forming an "island" of higher temperatures in the landscape.<sup>15</sup> Urban heat islands, combined with an aging population and increased urbanization, are projected to increase the vulnerability of urban populations to



**Figure 2.** The map shows the relative risk that physical changes will occur as sea level rises. The Coastal Vulnerability Index used here is calculated based on tidal range, wave height, coastal slope, shoreline change, landform and processes, and historical rate of relative sea level rise. (Source: *Third U.S. National Climate Assessment*)

<sup>11</sup> McFarlane, Benjamin J., Eric J. Walberg. *Climate Change in Hampton Roads: Impacts and Stakeholder Involvement*. Hampton Roads Planning District Commission, February 2010.

<sup>12</sup> *Adapting Now to a Changing Climate: Langley Research Center*. National Aeronautics and Space Administration, Fall 2011.

<sup>13</sup> Bender, Morris A., Thomas R. Knutson, Robert E. Tuleya, Joseph J. Sirutis, Gabriel A. Vecchi, Stephen T. Garner, Isaac M. Held. *Modeled Impact of Anthropogenic Warming on the Frequency of Intense Atlantic Hurricanes*. *Science*, 22 January 2010: Vol. 327. no. 5964, pp. 454 - 458 DOI: 10.1126/science.1180568

<sup>14</sup> Carter, L. M., J. W. Jones, L. Berry, V. Burkett, J. F. Murley, J. Obeysekera, P. J. Schramm, and D. Wear, 2014: Ch. 17: Southeast and the Caribbean. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 396-417. doi:10.7930/JON- P22CB.

<sup>15</sup> U.S. Environmental Protection Agency. Basic Information – What is an Urban Heat Island? 2013. Online resource.

heat-related health impacts in the future. Additionally, sea level rise and increased storm surge can contribute to saltwater contamination of freshwater supplies, urban flooding, sewer overflows, and other public health risks in the Hampton Roads region. Homes and infrastructure in low areas are increasingly prone to flooding during hurricanes and tropical storms. As a result, insurance costs may increase or coverage may become unavailable, and people may move from vulnerable areas, stressing the social and infrastructural capacity of surrounding areas.<sup>16</sup>

**Essential Infrastructure and Economic Activity.** There is an imminent threat of increased inland flooding during heavy rain events in low-lying coastal areas such as Hampton Roads. The Department of Defense is responsible for over 46% of the region's economy; numerous Hampton Roads military installations are directly impacted by sea level rise, and their forced relocation away from Hampton Roads would have severe economic repercussions. Rising sea levels can affect residential areas, flooding neighborhoods and overwhelming drainage systems. Hundreds of miles of roadways and thousands of acres of land are threatened. Studies indicate that 3 feet of sea level rise could cost Hampton Roads over \$80 billion in infrastructure costs.<sup>17</sup> Hurricane Isabel, which made landfall at the Outer Banks of North Carolina in September 2003 as a Category 2 hurricane, cost Virginia approximately \$925 million in damages;<sup>18</sup> warming oceans and sea level rise are expected to make hurricanes more powerful, more destructive, and more costly in the 21<sup>st</sup> century. The Hampton Roads area maintains some of the busiest ports in the country; \$1.5 billion in agricultural exports alone flow through the ports annually, including over 70% of total U.S. tobacco exports. The economic impacts from a major disruption in traffic through these ports could be catastrophic, regionally and nationally.<sup>19</sup>

**Fresh Water Availability.** The continued development of urbanized areas will increase water demand, exacerbate saltwater intrusion into freshwater aquifers, and threaten environmentally sensitive wetlands bordering urban areas. Higher sea levels in the Hampton Roads area will accelerate saltwater intrusion into freshwater supplies from rivers, streams, and groundwater sources near the coast. The region's aquaculture industry also may be compromised by climate-related stresses on groundwater quality and quantity. Porous aquifers in some areas make them particularly vulnerable to saltwater intrusion. Increases in water demand by the energy, agricultural, and urban sectors will increase the competition for water, particularly in situations where environmental water needs conflict with other uses.<sup>20</sup>

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<sup>16</sup> Carter, L. M., J. W. Jones, L. Berry, V. Burkett, J. F. Murley, J. Obeysekera, P. J. Schramm, and D. Wear, 2014: Ch. 17: Southeast and the Caribbean. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 396-417. doi:10.7930/J0N- P22CB.

<sup>17</sup> Old Dominion University Center for Sea Level Rise.

<sup>18</sup> Post, Buckley, Schuh and Jernigan. *Hurricane Isabel Assessment*. Prepared for U.S. Army Corps of Engineers, Philadelphia and Wilmington Districts, and Federal Emergency Management Agency, Region III and IV, March 2005.

<sup>19</sup> 2013 export information provided by the U.S. Department of Agriculture, Foreign Agriculture Service, Global Policy Analysis Division.

<sup>20</sup> Carter, L. M., J. W. Jones, L. Berry, V. Burkett, J. F. Murley, J. Obeysekera, P. J. Schramm, and D. Wear, 2014: Ch. 17: Southeast and the Caribbean. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 396-417. doi:10.7930/J0N- P22CB.

**Ecosystem Services.** Wetlands protect Hampton Roads’ coastal communities from floods and storm surge, and filter out pollutants that may contaminate freshwater drinking supplies. Though wetlands have proven to be resilient in the face of rising seas, human responses to sea level rise—such as the construction of dams and sea walls—may hinder the wetlands’ ability to adapt, resulting in significant losses to these protective resources and natural habitats.<sup>21</sup> Wetland and marsh ecosystems are sensitive to changes in sediment deposition levels, plant growth, and saltwater-freshwater balances, all of which are expected to be affected by relative sea level rise in the Hampton Roads region.<sup>22</sup>

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<sup>21</sup> Minogue, Kristen. “Humans threaten wetlands’ ability to keep pace with sea-level rise.” Virginia Institute of Marine Science, December 4, 2013.

<sup>22</sup> Eggleston, Jack, and Pope, Jason, 2013, Land subsidence and relative sea-level rise in the southern Chesapeake Bay region: U.S. Geological Survey Circular 1392, 30 p., <http://dx.doi.org/10.3133/cir1392>.

## SCENARIO EVENTS

### Our Children's Time

It is August 2044. The population of Hampton Roads increases to nearly 2 million residents.<sup>23</sup> The area has experienced approximately 1.5 feet of sea level rise over the last five decades (since 1992).<sup>24</sup> So far, the area has recorded 59 days of temperatures at or above 90 degrees Fahrenheit.<sup>25</sup>

It is a busy tourist season. Hotels and holiday rental homes are at near capacity throughout Hampton Roads, as visitors enjoy the area's beaches, amusement parks, and historical attractions.

On August 15, 2044, Hurricane Elvis emerges as a tropical storm off the western coast of Africa, in the North Atlantic Ocean. By August 19, Hurricane Elvis is bearing northwest, towards the southeastern United States. A Category 4 hurricane, Elvis hits Puerto Rico, the Dominican Republic, and the Bahamas with 140 mph winds on August 21, resulting in damages totaling \$1.5 billion, with 50 reported deaths. The National Weather Service forecasts that Elvis will make landfall at Hampton Roads on August 23, 2044, as a Category 3 hurricane. Storm surges of 3 to 8 feet are projected throughout the Hampton Roads region, depending on landfall time and location, tide levels, and other factors.<sup>26</sup>

The Governor and local officials order the evacuation of tourists and people living in certain designated storm surge zones along the coast. Neighborhoods in Virginia Beach, Norfolk, Poquoson, and Hampton are believed to be the most at risk for flooding. Naval Station Norfolk, Norfolk Naval Air Station, JEB Little Creek, and Dam Neck Naval Station are believed to be at high risk for storm-related damage, as are some hospitals, including Norfolk's Bon Secours-DePaul Medical Center and Sentara General Hospital.

Communicating the danger of the storm to the public is critical to ensuring that individuals follow evacuation recommendations. Of particular concern are vulnerable populations, including the disabled, the elderly, the sick, and those with limited English proficiency. Studies indicate that the most vulnerable populations are often the least likely to evacuate, placing them at elevated risk for storm-related injury. The millions of tourists currently visiting the region further complicate evacuation efforts.

In the days leading up to the arrival of the storm, the region is inundated with heavy rain. The Interstates and other evacuation routes are clogged with extremely heavy traffic. It is estimated

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<sup>23</sup> Population projection extrapolated from *Virginia Community Profile: Hampton Roads*, Virginia Labor Market Information, Virginia Employment Commission, November 14, 2014.

<sup>24</sup> Mitchell, M., C. Hershner, J. Herman, D. Schatt, E. Eggington and S. Stiles. 2013. *Recurrent Flooding Study for Tidewater Virginia*. Virginia Senate Document No. 3. Richmond, Virginia.

<sup>25</sup> *Adapting Now to a Changing Climate: Langley Research Center*. National Aeronautics and Space Administration, Fall 2011.

<sup>26</sup> Estimates based on *Service Assessment: Hurricane Isabel, September 18-19, 2003*, National Oceanic and Atmospheric Administration, May 2004.

that 1.1 million people in the region will be asked to evacuate; however, only 860,000 are predicted to do so. Of those evacuating, approximately 80,000 will seek public shelter.

### Our Grandchildren's Time

It is November 2084 and the current population of Hampton Roads is more than 2.3 million people.<sup>27</sup> Sea level rise in the area is now measured at 4.5 feet since 1992.<sup>28</sup> Hampton Roads has experienced 75 days of temperatures over 90 degrees so far this year.<sup>29</sup>

On November 12, 2084, Hurricane Priscilla emerges as a tropical storm in the Caribbean Sea. By November 15, Hurricane Priscilla dissipates in the Gulf of Mexico after reaching Category 2 strength. However, the remnants of Priscilla's mid-level circulation result in the formation of a powerful nor'easter off the coast of Georgia, bearing north, up the east coast of the U.S. The National Weather Service forecasts that the nor'easter will impact Hampton Roads on November 17, 2084. Winds of up to 65 miles per hours are projected.<sup>30</sup> Storm surges of 3 to 8 feet are projected throughout the Hampton Roads region, depending on landfall time and location, tide levels, and other factors.<sup>31</sup> Water levels are expected to be elevated for several days, with persistent onshore flows.

The Governor and local officials order the evacuation of tourists and people living in certain designated storm surge zones along the coast. Neighborhoods in Virginia Beach, Norfolk, Poquoson, Chesapeake, and Hampton are believed to be the most at risk for flooding. Naval Station Norfolk, Fort Monroe, Langley Air Force Base, Norfolk Naval Air Station, Joint Expeditionary Base Little Creek, and Dam Neck Naval Station are believed to be at high risk for storm-related damage, as are some hospitals, including Norfolk's Bon Secours-Depaul Medical Center and Sentara General Hospital.

Communicating the danger of the storm to the public is critical to ensuring that individuals follow evacuation recommendations. Of particular concern are vulnerable populations, including the disabled, the elderly, the sick, and those with limited English proficiency. Studies indicate that the most vulnerable populations are often the least likely to evacuate, placing them at elevated risk for storm-related injury.

In the days leading up to the arrival of the storm, the region is inundated with heavy rain. The Interstates and other evacuation routes are clogged with extremely heavy traffic. It is estimated that 1.3 million people in the region will be asked to evacuate; however, only 990,000 are

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<sup>27</sup> Population projection extrapolated from *Virginia Community Profile: Hampton Roads*, Virginia Labor Market Information, Virginia Employment Commission, November 14, 2014.

<sup>28</sup> Mitchell, M., C. Hershner, J. Herman, D. Schatt, E. Eggington and S. Stiles. 2013. *Recurrent Flooding Study for Tidewater Virginia*. Virginia Senate Document No. 3. Richmond, Virginia.

<sup>29</sup> *Adapting Now to a Changing Climate: Langley Research Center*. National Aeronautics and Space Administration, Fall 2011.

<sup>30</sup> Projection developed by the Virginia Institute of Marine Science, based on average storm surge levels recorded throughout the Hampton Roads area during Hurricane Isabel.

<sup>31</sup> Estimates based on *Service Assessment: Hurricane Isabel, September 18-19, 2003*, National Oceanic and Atmospheric Administration, May 2004.



predicted to heed the warnings. Of those evacuating, approximately 92,000 will seek public shelter.

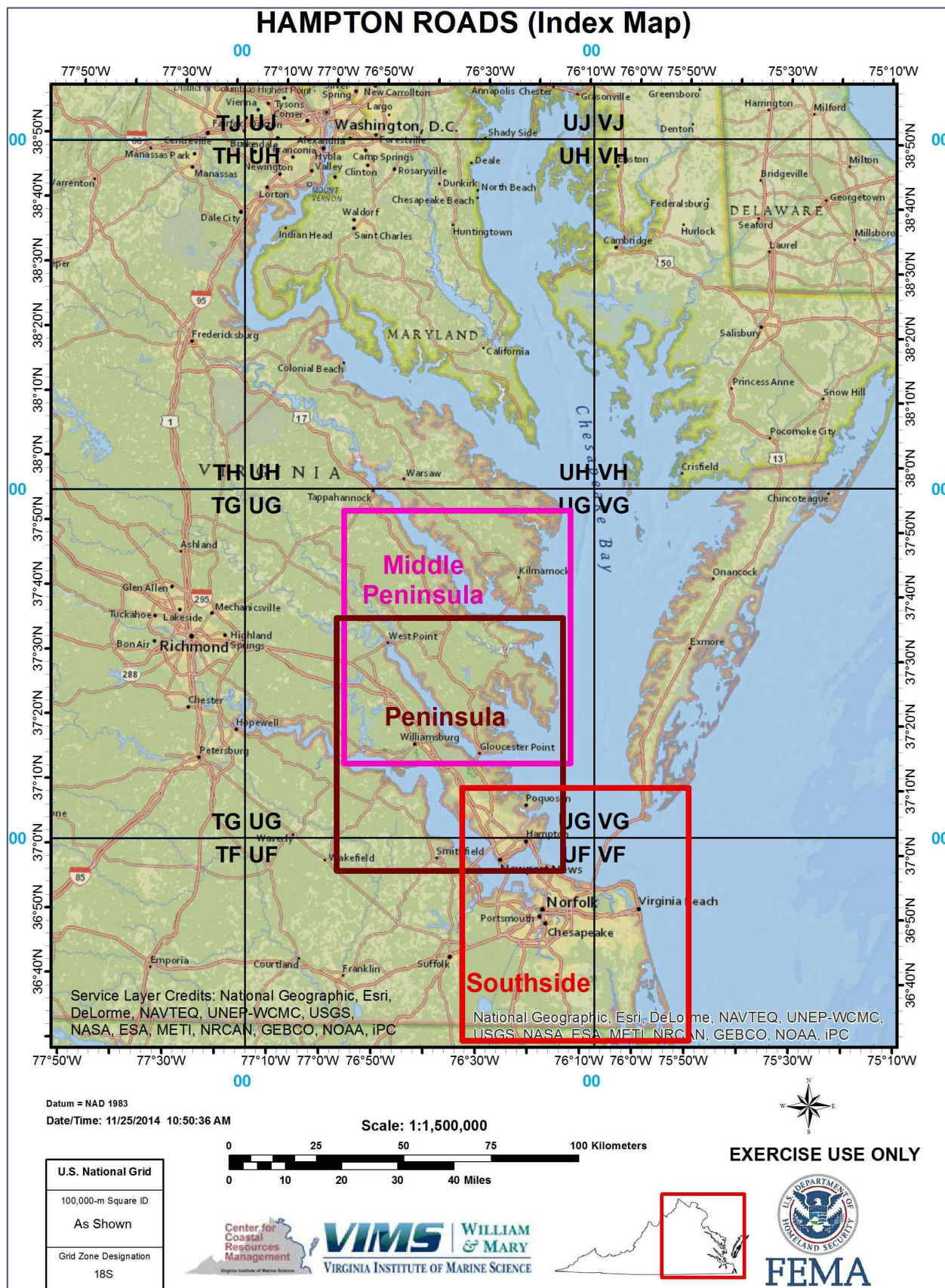
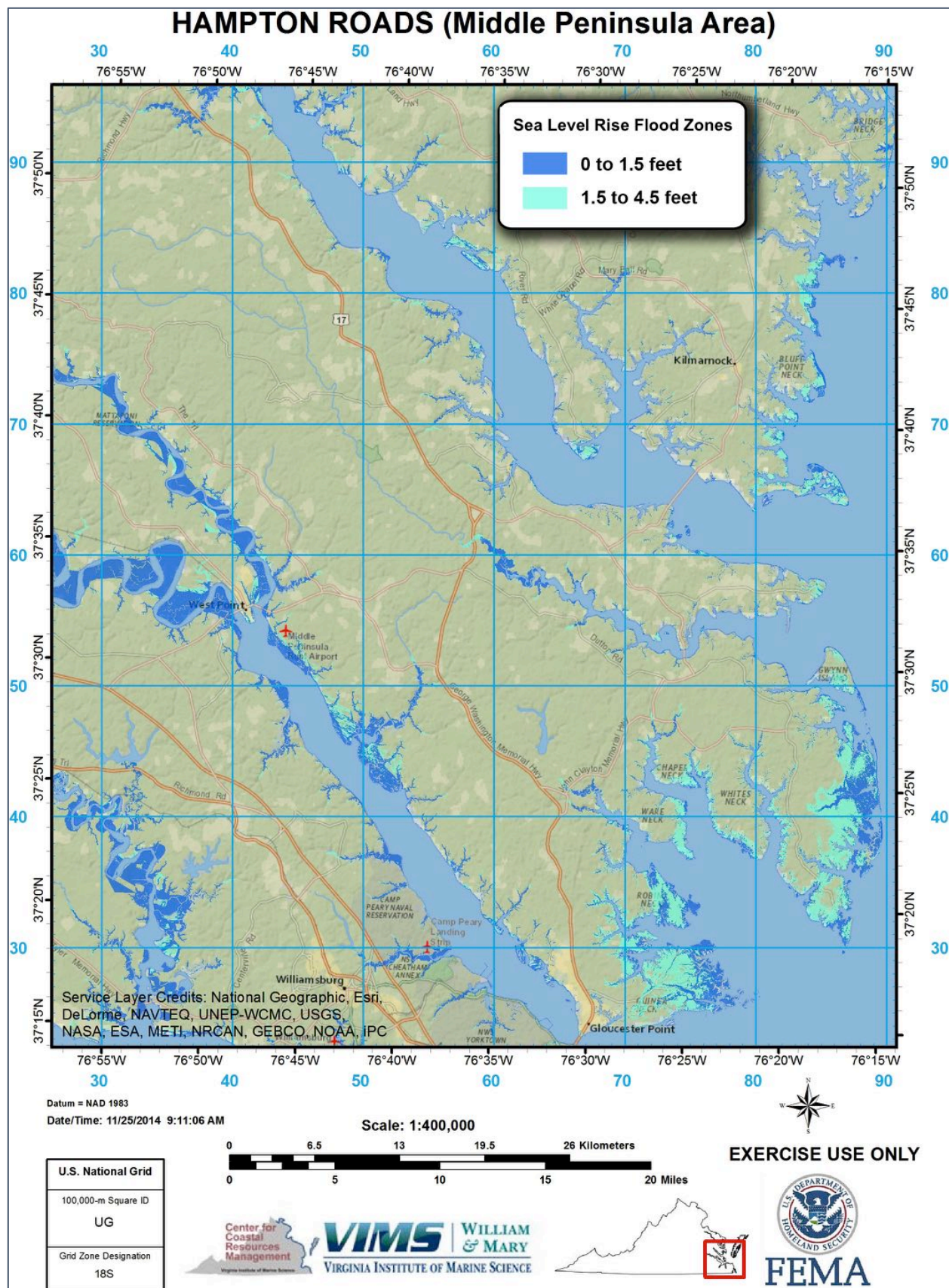


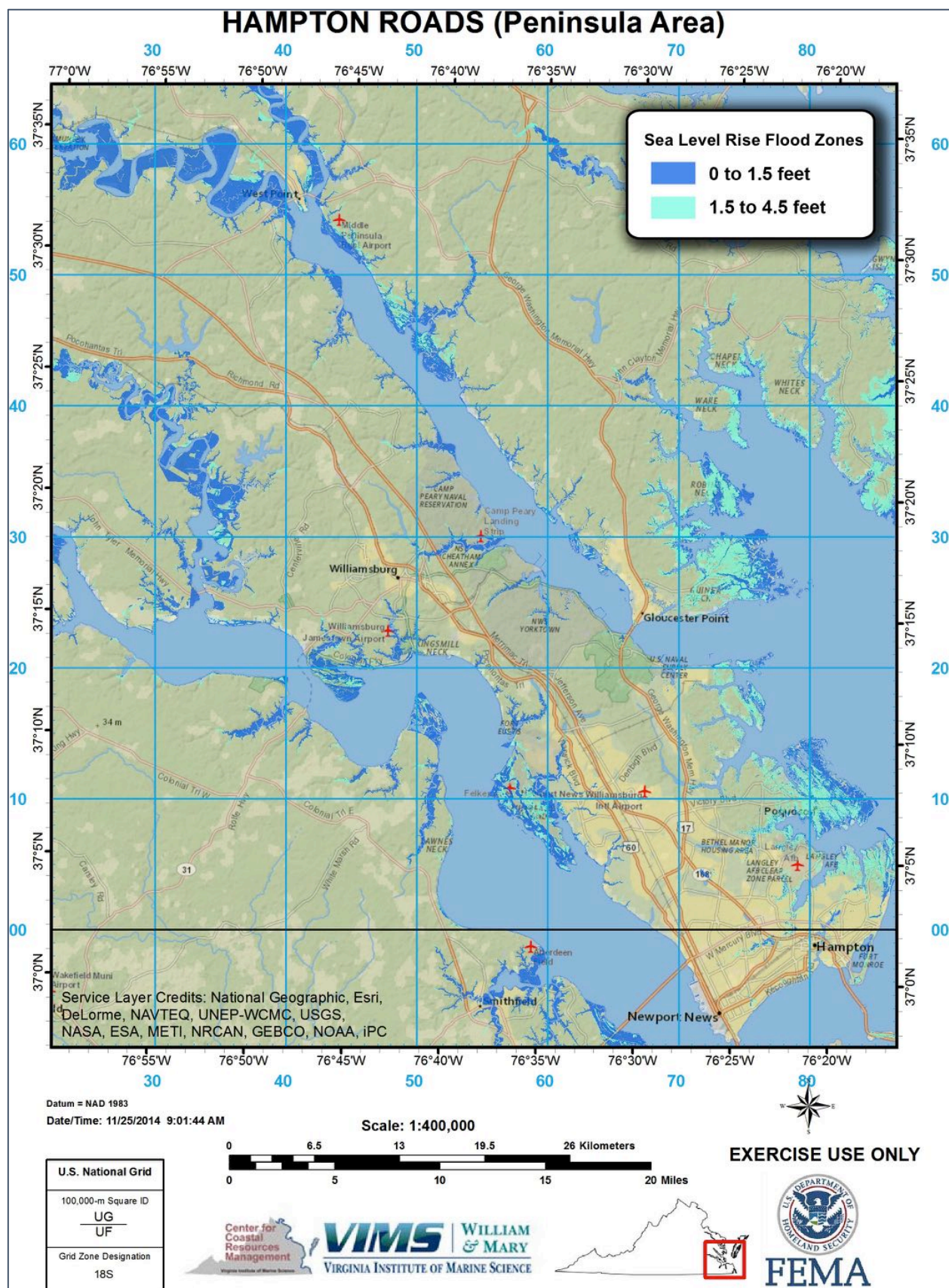
Figure 3. The Hampton Roads area.





**Figure 4.** Sea level rise of 1.5 and 4.5 feet in the Middle Peninsula area (Source: Virginia Institute of Marine Science)





**Figure 5.** Sea level rise of 1.5 and 4.5 feet in the Peninsula area (Source: Virginia Institute of Marine Science)



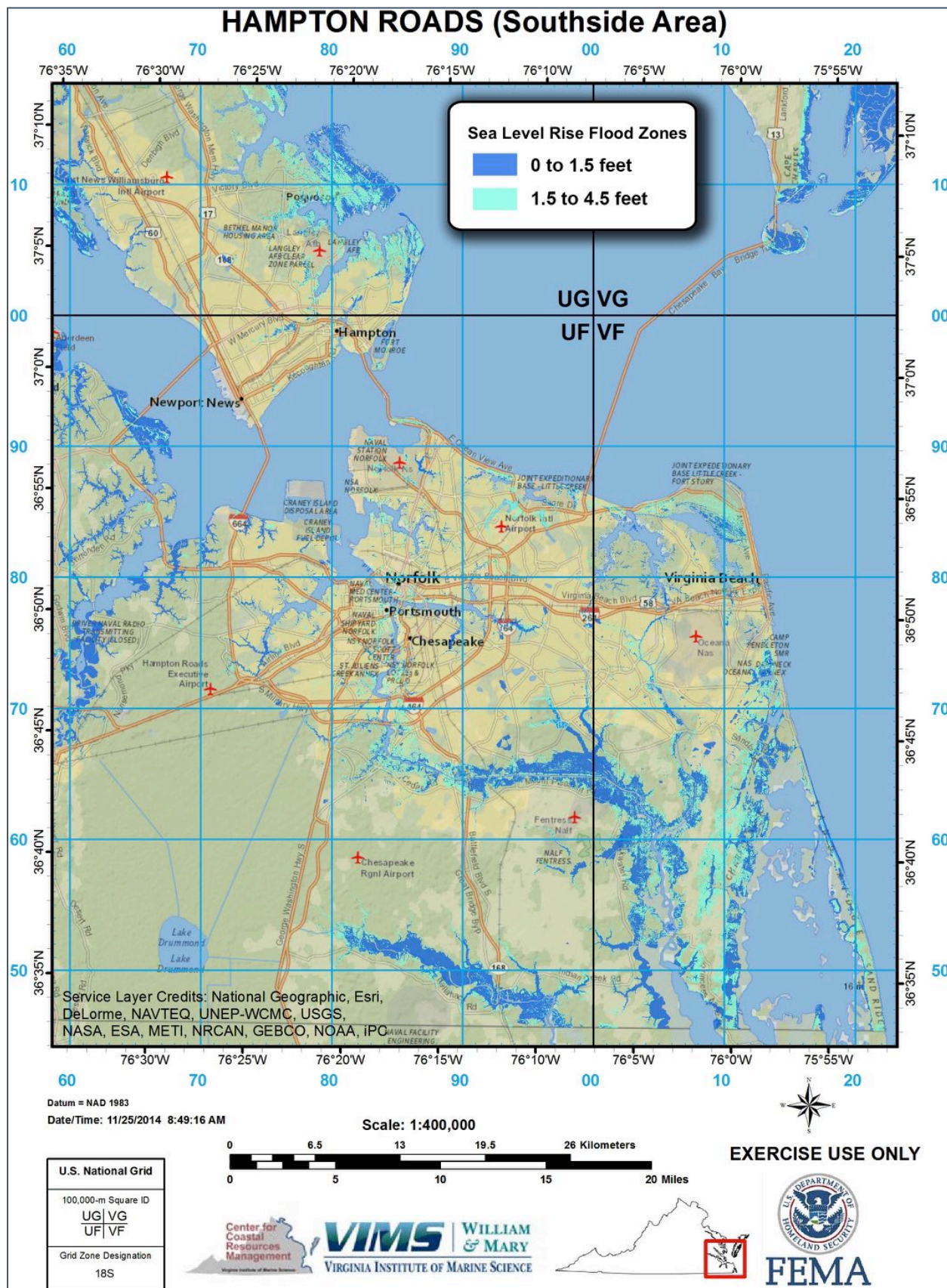
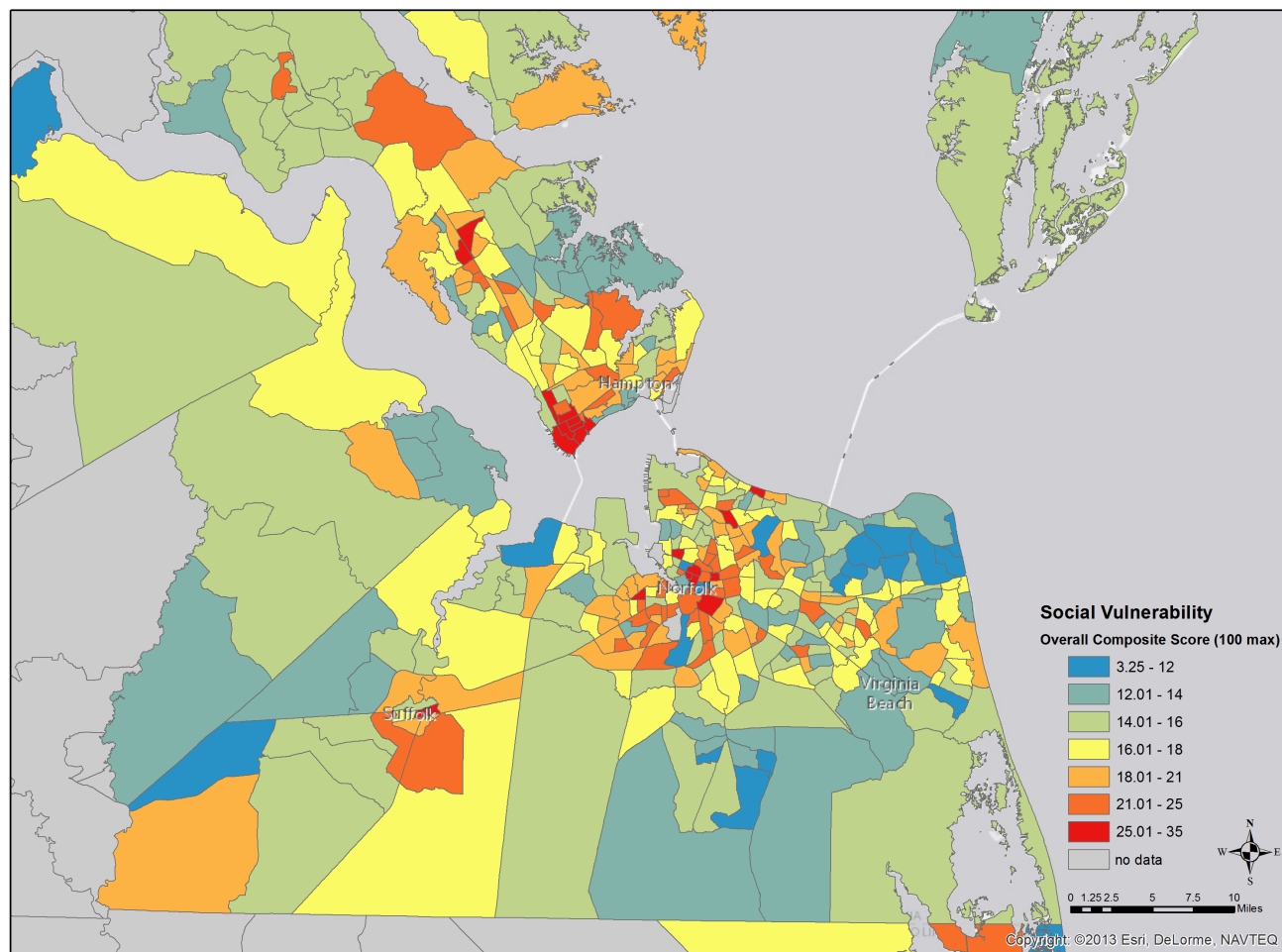


Figure 6. Sea level rise of 1.5 and 4.5 feet in the Southside area (Source: Virginia Institute of Marine Science)



**Figure 7.** Hampton Roads Composite Measure of Social and Community Vulnerability, Indicators of Sea Level Rise & Storm-related Population Vulnerability, derived from 7,068 household interviews of following severe storm Irene, August 2011. Research conducted by Dr. Joshua G. Behr and Dr. Rafael Diaz with the support of Old Dominion University and the Hampton Roads Regional Catastrophic Planning Team.



## APPENDIX A: FOCUS GROUP TABLE DISCUSSION QUESTIONS

The following questions are designed to guide the discussions concerning climate adaptation, preparedness, and resiliency planning in the Hampton Roads region, especially as it relates to sea level rise, storm surge, and recurrent flooding. They are provided to assist the exercise facilitators and participants. Participants should not feel obligated to answer all of the questions.

### Science Advisory Committee

1. What agencies (local, state, or federal), private sector partners, and non-governmental organizations are critical to providing local planners with scientific advice under this scenario? Are any not currently engaged in this committee that should be?
2. What are the priorities for the Hampton Roads scientific community in meeting the potential consequences of sea level rise, storm surge, and recurrent flooding?
3. What additional resources does the Science Advisory Committee require to forecast, map, and analyze the impacts from sea level rise, storm surge, and recurrent flooding?
4. What concrete steps does the Science Advisory Committee need to take in the short-term (1 month), in the near term (6 months+), and the long-term (18 months+) next to advance the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project goals?

### Economic Impacts Advisory Committee

1. How can the Economic Impacts Advisory Committee ensure that the agencies (local, state, federal, or tribal), private sector partners, and non-governmental organizations critical to economic impact planning in Hampton Roads are engaged in this planning effort?
2. What resources – economic, legislative, scientific, etc. – does the Economic Impacts Advisory Committee require to better mitigate the future consequences of sea level rise, storm surge, and recurrent flooding?
3. What concrete steps will the Economic Impacts Advisory Committee take in near-/long-term (6 to 18 months) to ensure that Hampton Roads industries are better integrated into resiliency planning?
4. What concrete steps does the Economic Impacts Advisory Committee need to take immediately (1 month), in the near term (6 months), and the long-term (18 months) to advance the goals of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?

### Municipal Planning Advisory Committee

1. What resources – economic, legislative, scientific, etc. – does the Municipal Planning Advisory Committee require to better realize the goals of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?
2. How can the Municipal Planning Advisory Committee best incorporate the U.S. Department of Housing and Urban Development's housing recovery best practices when

conducting response and recovery planning focusing on vulnerable populations in the Hampton Roads region?

3. What steps will the Municipal Planning Advisory Committee take in the next 6 to 18 months to develop and implement a Post-Incident Data Collection Plan, as discussed in the *Recommendations to The Secure Commonwealth Panel on the Issue of Sea Level Rise and Recurrent Flooding in Coastal Virginia* submitted to the Virginia Secure Commonwealth Panel in September 2014?
4. What concrete steps does the Municipal Planning Advisory Committee need to take immediately (1 month), in the near term (6 months), and the long-term (18 months) to advance the goals of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?

#### **Private Infrastructure Advisory Committee**

1. What are the priorities for the Private Infrastructure Advisory Committee in meeting the potential consequences of sea level rise, storm surge, and recurrent flooding?
2. What resources – economic, legislative, scientific, etc. – does the Private Infrastructure Advisory Committee require to better mitigate the future consequences of sea level rise, storm surge, and recurrent flooding?
3. How can the Private Infrastructure Advisory Committee work to identify and preserve critical infrastructure interdependencies affected by sea level rise, storm surge, and recurrent flooding in the Hampton Roads region?
4. What barriers exist to prevent effective climate change mitigation planning, and how can the Private Infrastructure Advisory Committee work to overcome those barriers?
5. What concrete steps does the Private Infrastructure Advisory Committee need to take immediately (1 month), in the near term (6 months), and the long-term (18 months) to advance the goals of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?

#### **Citizen Engagement Advisory Committee**

1. What should be the priorities for the Citizen Engagement Advisory Committee be in meeting the potential consequences of sea level rise, storm surge, and recurrent flooding?
2. What resources – economic, legislative, scientific, etc. – does the Citizen Engagement Advisory Committee require to better mitigate the future consequences of sea level rise, storm surge, and recurrent flooding?
3. What avenues for public communication about sea level rise, storm surge, and recurrent flooding currently exist? What future avenues should be explored?
4. How can emergency plans better address the warning, evacuating, and sheltering of vulnerable populations, including those with limited English proficiency?
5. What concrete steps does the Citizen Engagement Advisory Committee need to take immediately (1 month), in the near term (6 months), and the long-term (18 months) to advance the goals of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?

### **Senior Leadership Advisory Committee**

1. What are the priorities for the Senior Leadership Advisory Committee be in meeting the potential consequences of sea level rise, storm surge, and recurrent flooding?
2. What resources – economic, legislative, scientific, etc. – does the Senior Leadership Advisory Committee require to better mitigate the future consequences of sea level rise, storm surge, and recurrent flooding?
3. What should be done to increase local, regional, state, and federal engagement for climate adaptation, preparedness, and resilience in the Hampton Roads area?
4. How can the Senior Leadership Advisory Committee work to utilize the National Incident Management System, and more specifically, establish an Incident Command System structure-style management structure inclusive of all primary and support agencies, as detailed in the *Recommendations to The Secure Commonwealth Panel on the Issue of Sea Level Rise and Recurrent Flooding in Coastal Virginia* submitted to the Virginia Secure Commonwealth Panel in September 2014?
5. What concrete steps does the Senior Leadership Advisory Committee need to take immediately (1 month), in the near term (6 months), and the long-term (18 months) to advance the goals of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?

### **Legal Working Group**

1. What are the priorities for the Legal Working Group be in meeting the potential consequences of sea level rise, storm surge, and recurrent flooding?
2. What resources – economic, legislative, scientific, etc. – does the Legal Working Group require to better mitigate the future consequences of sea level rise, storm surge, and recurrent flooding?
3. What committees or working groups will need the most support from the Legal Working Group to effectively plan for the consequences of sea level rise, storm surge, and recurrent flooding?
4. How can the Legal Working Group seek to overcome possible legal barriers preventing all appropriate local, state, and federal stakeholders from acting as full acting members of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?
5. What concrete steps does the Legal Working Group need to take immediately (1 month), in the near term (6 months), and the long-term (18 months) to advance the goals of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?

### **Infrastructure Working Group**

1. What should be the priorities for the Infrastructure Working Group be in meeting the potential consequences of sea level rise, storm surge, and recurrent flooding?
2. What resources – economic, legislative, scientific, etc. – does the Infrastructure Working Group require to better mitigate the future consequences of sea level rise, storm surge, and recurrent flooding?

3. How can the Infrastructure Working Group identify local infrastructure plans that need to be updated to meet the consequences of future sea level rise, storm surge, and recurrent flooding, and assist in updating those plans?
4. What concrete steps does the Infrastructure Working Group need to take immediately (1 month), in the near term (6 months), and the long-term (18 months) to advance the goals of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?

### **Land Use Working Group**

1. What should be the priorities for the Land Use Working Group be in meeting the potential consequences of sea level rise, storm surge, and recurrent flooding?
2. What resources – economic, legislative, scientific, etc. – does the Land Use Working Group require to better mitigate the future consequences of sea level rise, storm surge, and recurrent flooding?
3. What type of land use mitigation measures could be used to prepare for the consequences associated with sea level rise, storm surge, and recurrent flooding? Are any of these measures in use or in development today?
4. How can this working group collaborate with the Municipal Planning Advisory Committee and the Private Infrastructure Advisory Committee to mitigate the consequences of sea level rise, storm surge, and recurrent flooding?
5. What concrete steps does the Land Use Working Group need to take immediately (1 month), in the near term (6 months), and the long-term (18 months) to advance the goals of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?

### **Outreach and Education Working Group**

1. What should be the priorities for the Outreach and Education Working Group be in meeting the potential consequences of sea level rise, storm surge, and recurrent flooding?
2. What resources – economic, legislative, scientific, etc. – does Outreach and Education Working Group require to better mitigate the future consequences of sea level rise, storm surge, and recurrent flooding?
3. What can Outreach and Education Working Group do to ensure the needs of the ‘Whole Community’ are addressed?
4. What avenues for public communication about sea level rise, storm surge, and recurrent flooding currently exist? What additional avenues should be explored, as discussed in the *Recommendations to The Secure Commonwealth Panel on the Issue of Sea Level Rise and Recurrent Flooding in Coastal Virginia* submitted to the Virginia Secure Commonwealth Panel in September 2014?
5. How can the Outreach and Education Working Group work to develop emergency plans that better address the warning, evacuating, and sheltering of vulnerable populations, including those with disabilities and / or limited English proficiency?
6. What concrete steps does the Outreach and Education Working Group need to take immediately (1 month), in the near term (6 months), and the long-term (18 months) to

advance the goals of the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Planning Pilot Project?



## APPENDIX B: TABLETOP EXERCISE FACILITATOR QUESTIONS

The following questions are designed to guide the discussions concerning climate adaptation, preparedness, and resiliency planning in the Hampton Roads region, especially as it relates to sea level rise, storm surge, and recurrent flooding. They are provided to assist the exercise facilitators and participants. Participants should not feel obligated to answer all of the questions.

### 2044 Scenario

1. What key climate change adaptation challenges related to sea level rise, storm surge, and recurrent flooding does Hampton Roads face in the 2044 time frame (e.g., public health, industry, employment, etc.)?
2. What specific challenges does the hurricane season pose to adaptation planning in the long-term?
3. How can Hampton Roads work today to transform its economy, its infrastructure, and its communities in order to best seize future opportunities and to address challenges posed by sea level rise, storm surge, and recurrent flooding in 2044?
4. What obstacles have your departments and agencies encountered that affect joint mid-term environmental adaptation planning? What strategies have been or could be implemented to remove those obstacles?
5. What incentives should we pursue to enhance local, state, tribal, and federal preparedness and resilience in the face of climate change risks in the mid-term?
6. What public messaging/communications strategy are you developing today to connect with the public on issues related to climate adaptation and hazard mitigation in the long term?
7. What mid-term energy and chemical infrastructure development, modification, or re-engineering efforts are underway in the Hampton Roads area to mitigate the threats from sea level rise, storm surge, and recurrent flooding? How can the whole community coordinate today to ensure that these efforts are successful in 2044?
8. What long-term natural resources development or re-development efforts are underway in the Hampton Roads area to ensure their viability in 2044?
9. How would health and social services in the Hampton Roads area be affected by severe storm-related flooding, given the expected rise in population and projected socio-economic conditions of the mid-21<sup>st</sup> century?

### 2084 scenario

1. What key climate change adaptation challenges related to sea level rise, storm surge, and recurrent flooding does Hampton Roads face in the 2084 time frame (e.g., public health, industry, employment, etc.)?
2. What specific challenges does the winter storm season pose to adaptation planning in the long-term?

3. How can Hampton Roads work today to transform its economy, its infrastructure, and its communities in order to best seize future opportunities and to address challenges posed by sea level rise, storm surge, and recurrent flooding in 2084?
4. What obstacles have your departments and agencies encountered that affect joint long-term environmental adaptation planning? What strategies have been or could be implemented to remove those obstacles?
5. What incentives should we pursue to enhance local, state, tribal, and federal preparedness and resilience in the face of climate change risks?
6. What public messaging/communications strategy are you developing today to connect with the public on issues related to climate adaptation and hazard mitigation in the long term?
7. What long-term energy and chemical infrastructure development, modification, or re-engineering efforts are underway in the Hampton Roads area to mitigate the long-term threats from sea level rise, storm surge, and recurrent flooding? How can the whole community coordinate today to ensure that these efforts are successful in 2084?
8. What long-term natural resources development or re-development efforts are underway in the Hampton Roads area to ensure their viability in 2084?
9. How would health and social services in the Hampton Roads area be affected by severe storm-related flooding, given the expected rise in population and projected socio-economic conditions of the late 21<sup>st</sup> century?

## APPENDIX E: ADDITIONAL RESOURCES

### WHITE HOUSE RESOURCES

- Council on Environmental Quality: <http://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience>
- Office of Science and Technology Policy: <http://www.whitehouse.gov/administration/eop/ostp>
- White House Climate Data Initiative: <http://www.data.gov/climate/>

### FEDERAL RESOURCES

- The U.S. Global Change Research Program: [www.globalchange.gov](http://www.globalchange.gov).
- Third U.S. National Climate Assessment: <http://nca2014.globalchange.gov/>
- Third U.S. National Climate Assessment Download Materials: <http://www.globalchange.gov/nca3-downloads-materials>
- The U.S. Global Change Research Program Adaptation Page: <http://www.globalchange.gov/explore/adaptation>
- The U.S. Global Change Research Program Federal Adaptation Resources Library: <http://www.globalchange.gov/browse/federal-adaptation-resources>

### REGIONAL RESOURCES

- Third U.S. National Climate Assessment: Southeast and the Caribbean: <http://nca2014.globalchange.gov/report/regions/southeast>

### LOCAL RESOURCES

- Recommendations To The Secure Commonwealth Panel On The Issue Of Sea Level Rise And Recurrent Flooding In Coastal Virginia: <http://www.norfolk.gov/DocumentCenter/View/17786>
- Recurrent Flooding Study for Tidewater Virginia: [http://ccrm.vims.edu/recurrent\\_flooding/Recurrent\\_Flooding\\_Study\\_web.pdf](http://ccrm.vims.edu/recurrent_flooding/Recurrent_Flooding_Study_web.pdf)
- The Center for Sea Level Rise, Old Dominion University: <http://www.centerforsealevelrise.org/>
- Old Dominion University Mitigation and Adaptation Research Institute: <http://mari.odu.edu/>

## New England Climate Adaptation, Preparedness, and Resilience Workshop - Overview

Sponsor	Federal Emergency Management Agency Region I
Goal	Support state, tribal, and federal coordination, integration, and prioritization of community climate adaptation, preparedness, and resilience initiatives, and identify new opportunities for whole community collaboration and investment to enhance regional resilience.
Objectives	<ol style="list-style-type: none"> <li>1. Examine methods to better <b>integrate existing and emerging actionable information</b> into current and pending federal regional planning in order to enhance management and/or adaptation of climate risks and vulnerabilities.</li> <li>2. Identify collaborative and <b>sustainable whole community approaches</b> to advance climate adaptation, preparedness, and resilience programs, policies, and strategies within Region I, consistent with seven recommendation themes from the State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience.</li> <li>3. Examine <b>community coalition research and investment opportunities</b> to support climate adaptation and resilience initiatives.</li> <li>4. <b>Capitalize on existing regional community climate adaptation champions and centers</b> and support broader engagement by whole community partners in their efforts and initiatives.</li> </ol>
Key Outcomes	<ol style="list-style-type: none"> <li>1. Enhanced understanding and integration of existing and proposed community initiatives with a focus on resiliency and mitigation strategies.</li> <li>2. Support state, tribal, and federal interagency climate adaptation information-sharing processes geared toward inter-agency and inter-disciplinary coordination throughout the entire region.</li> <li>3. Establish cohesive framework for continued dialogue among whole-community partners to build and sustain regional community activities.</li> </ol>
Format	<ul style="list-style-type: none"> <li>• Customized to goals and capabilities of New England states</li> <li>• One and a half day event (Day 1: 10:00am – 5:00pm, Day 2: 9:00am – 3:00pm)</li> <li>• Features interactive seminar presentations, facilitated discussions, and brainstorming sessions that identify actionable next steps for regional resiliency efforts</li> <li>• Presentation, case study, and focus areas include: research and investment opportunities; existing and proposed plans and coalitions; context for climate narrative based on effects to infrastructure (4 critical lifeline sectors), health and social vulnerabilities, and natural resources; regional challenges; and actionable next steps</li> </ul>
Scenario	Scenario is based on documented and projected climate-related threats and hazards to New England communities.
Intended Audience	Approximately 200 state, tribal, and federal interagency partners and other stakeholders.
Presenters	<ul style="list-style-type: none"> <li>• State, tribal, and federal subject matter experts</li> <li>• Spokesperson for each breakout group provides an out brief during plenary sessions addressing priorities, challenges, and solutions identified by their group for their assigned focus areas</li> </ul>
Special Guests	Identified by core planning team in conjunction with state and federal partners.



# Climate Adaptation, Preparedness, and Resilience Exercise Seminar

**Miami, Florida**

September 21-22, 2015



National Exercise Program  
2015-2016 Cycle

Participant Manual



# SEMINAR AGENDA

Topic	Time
<b>Day 1</b>	
<i>Registration Open</i>	7:00 a.m. – 8:00 a.m.
Welcome	8:00 a.m. – 8:30 a.m.
Interactive Polling Icebreaker	8:30 a.m. – 9:00 a.m.
Course Introduction	9:00 a.m. – 9:15 a.m.
Climate Leadership Training	9:15 a.m. – 10:00 a.m.
Break	10:00 a.m. – 10:15 a.m.
Climate Leadership Training (cont.)	10:15 a.m. – 11:00 a.m.
Introduction to Climate Resilience Exercises	11:00 a.m. – 12:00 p.m.
Lunch	12:00 p.m. – 1:00 p.m.
Adaptation and Resilience Planning	1:00 p.m. – 2:30 p.m.
Break	2:30 p.m. – 2:45 p.m.
Climate Tools Spotlight I	2:45 p.m. – 3:45 p.m.
Break/Move to 19 <sup>th</sup> Floor	3:45 p.m. – 4:00 p.m.
Climate and Infrastructure Presentations I	4:00 p.m. – 4:45 p.m.
Day 1 Closing Remarks	4:45 p.m. – 5:00 p.m.
<i>Networking Reception</i>	5:00 p.m. – 6:00 p.m.
<b>Day 2</b>	
Welcome	8:00 a.m. – 8:15 a.m.
Climate Tools Spotlight II	8:15 a.m. – 9:15 a.m.
Climate and Infrastructure Presentations II	9:15 a.m. – 9:30 a.m.
Exercise Design	9:30 a.m. – 10:15 a.m.
Break	10:15 a.m. – 10:30 a.m.
Exercise Design (cont.)	10:30 a.m. – 12:00 p.m.
Lunch	12:00 p.m. – 1:00 p.m.
Activity: Designing Discussion-based Climate Exercises	1:00 p.m. – 2:00 p.m.
Break	2:00 p.m. – 2:15 p.m.
Activity: Tabletop Exercise	2:15 p.m. – 3:45 p.m.
Way Forward – Beyond the Seminar	3:45 p.m. – 4:00 p.m.
Closing Remarks	4:00 p.m. – 4:30 p.m.

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# About the Participant Manual

The Exercise Seminar Participant Manual is a supplemental resource designed to accompany the Climate Adaptation, Preparedness, and Resilience Seminar. This document provides information and templates that support delivering whole community preparedness, adaptation, and resilience exercises with a focus on climate and extreme weather events.

This Participant Manual provides three primary categories of information:

- Guidance and basic principles for building community resilience against current and future hazards;
- Tools and guides for building mitigation exercises, including incorporating climate considerations into existing exercises; and
- Resources identifying climate-related programs, networks and training across all levels of government, non-profit organizations, private sector entities, and the academic community.

The complete document is available to Seminar participants and local stakeholders through an [online portal](#) via the National Exercise Division (NED).

*Note: This Participant Manual is a living document and subject to change as climate risks, research and technology, and legal frameworks continue to shift.*



# INTRODUCTION

## SEMINAR PURPOSE

The National Exercise Program *Climate Adaptation, Preparedness, and Resilience Exercise Seminar Series* empowers communities to undertake climate adaptation and vulnerability reduction efforts at the local, state, and tribal level. This two-day exercise seminar supports sustainable community-based climate adaptation, preparedness, and resilience planning by providing the knowledge and tools necessary for communities to address local climate issues.

Additionally, this Participant Manual provides resilience information resources, potential adaptation strategies, and sample templates and materials that provide a range of practical tools to aid in undertaking local climate adaptation, preparedness, and resilience programs and exercises within individual communities.

This Seminar builds and delivers sustainable community-based capability and capacity enhancement to develop and conduct seminars and exercises that will address climate-related risk, hazards, and consequences.

## SEMINAR GOALS AND OBJECTIVES

1. Provide communities with knowledge, tools, resources, and technical support to enable organic design and delivery of seminars and exercises that reduce long-term vulnerability at the community level
2. Encourage a collaborative, regional approach to climate adaptation, preparedness, and resilience seminars through strengthening existing or emerging regional governance structures and identifying regional resilience practitioners
3. Align strategies with the State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience recommendations to support advancing climate adaptation and resilience dialogue and identifying practical solutions that drive action
4. Strengthen the ability of communities to understand risks and estimate capability requirements related to climate preparedness and adaptation through alignment with the U.S. National Climate Assessment process

## SEMINAR OUTCOME

The Seminar will focus on the following outcomes:

1. Improved collaboration with and between whole community partners on climate adaptation, preparedness, and resilience strategies
2. Identification of new research, information, and capabilities that will support local preparedness, adaptation, and mitigation planning
3. Enhanced understanding of the application of climate-related hazards to community resilience-building seminars and exercises



## SEMINAR OUTPUT

The Seminar output will consist of an Exercise Seminar Summary Report that addresses key discussion points and identified climate adaptation, preparedness, and resilience information, innovations, and initiatives.

## SEMINAR FORMAT

This is a two-day facilitated event tailored for specific requirements of the region. Day One focuses on community adaptation and resilience planning, while the Day Two focuses on applying exercise methodology to adaptation and resilience planning.

The curriculum has been developed using instructional design and adult learning theory methodology. This design ensures the Seminar is as interactive as possible—this includes group activities, interactive polling, case studies, and exercises—minimizing lecture-style teaching and maximizing a peer-based approach.

Scientific information describing observed climate trends and projected future climate conditions throughout the Seminar is primarily derived from the *Third U.S. National Climate Assessment* and the United States Climate Resilience Toolkit. The exercise scenario is tailored to examine specific jurisdictional impacts based on information and tools from these resources.

## SEMINAR PARTICIPANTS

Participants include local and regional resilience, adaptation, and mitigation planners, emergency managers, and subject-matter experts (SMEs), as well as identified stakeholders and partners from the private sector, non-governmental organizations, and academic institutions.

## SEMINAR EVALUATION

Evaluation efforts will validate strengths and identify opportunities for improving Seminar materials and delivery.

Participants will have the opportunity to provide feedback regarding the effectiveness and relevancy of the following:

- Resource links and lists for future reference
- Conceptual explanations and materials
- Networking and interactive learning activities of Seminar

Participants will be able to provide feedback during Seminar discussions and through feedback forms. Following the event, evaluators will compile and summarize all findings, for National Exercise Division use in improving future iterations of the Seminar.

# MANUAL PURPOSE STATEMENT

Provide local, state, territory, tribal, federal and non-government/private sector exercise planners with foundational elements and guiding principles needed to deliver community adaptation, preparedness, and resilience exercises with a focus on risks associated with or exacerbated by climate and extreme weather events.

Using lessons-learned from the Climate Change Preparedness and Resilience Exercise Pilot Series (conducted in Houston, Colorado, Alaska, and Hampton Roads) in 2014, the Participant Manual provides communities with climate information, exercise strategies, templates, online resources, and technical guidance needed to enhance climate awareness, strengthen community-based resilience networks, and develop and deliver adaptation, preparedness, and resilience exercises.

This guide provides basic principles and templates to design mitigation-focused exercises, including incorporating climate risks into existing exercises, while strengthening partnerships and networks within the community.

Resilience exercises focus on mitigation – reducing the effects of a disaster – specifically the loss of life and potential damage to property. Effective mitigation requires all members of the community to understand local risks, address hard choices, and invest in long-term community well-being. It is pertinent that communities prepare for all hazards and threats to reduce human, economic, social, and environmental consequences.



FEMA / Steve Zumwalt



FEMA / Jocelyn Augustino

# NATIONAL PREPAREDNESS GOAL

The [National Preparedness Goal](#) defines what it means for the whole community to be prepared for all types of disasters and emergencies. The National Preparedness Goal identifies [five mission areas](#) encompassing [31 core capabilities](#), or the distinct critical elements needed to achieve the goal as a Nation or as a community. The five mission areas include Prevention, Protection, Mitigation, Response, and Recovery.

This Climate Adaptation, Preparedness, and Resilience Seminar Series focuses on the **Mitigation** mission area, particularly **the capabilities needed to reduce loss of life and property by lessening the effects of disasters**. This Manual is a tool to assist communities examining mitigation core capabilities and, ultimately, initiating and/or accelerating their resilience planning. Sound mitigation efforts coupled with resilience planning enable communities to minimize human, economic, social, and environmental risk. Consider mitigation and response but remember to tailor the capabilities according to your specific community-based focus areas and challenges.

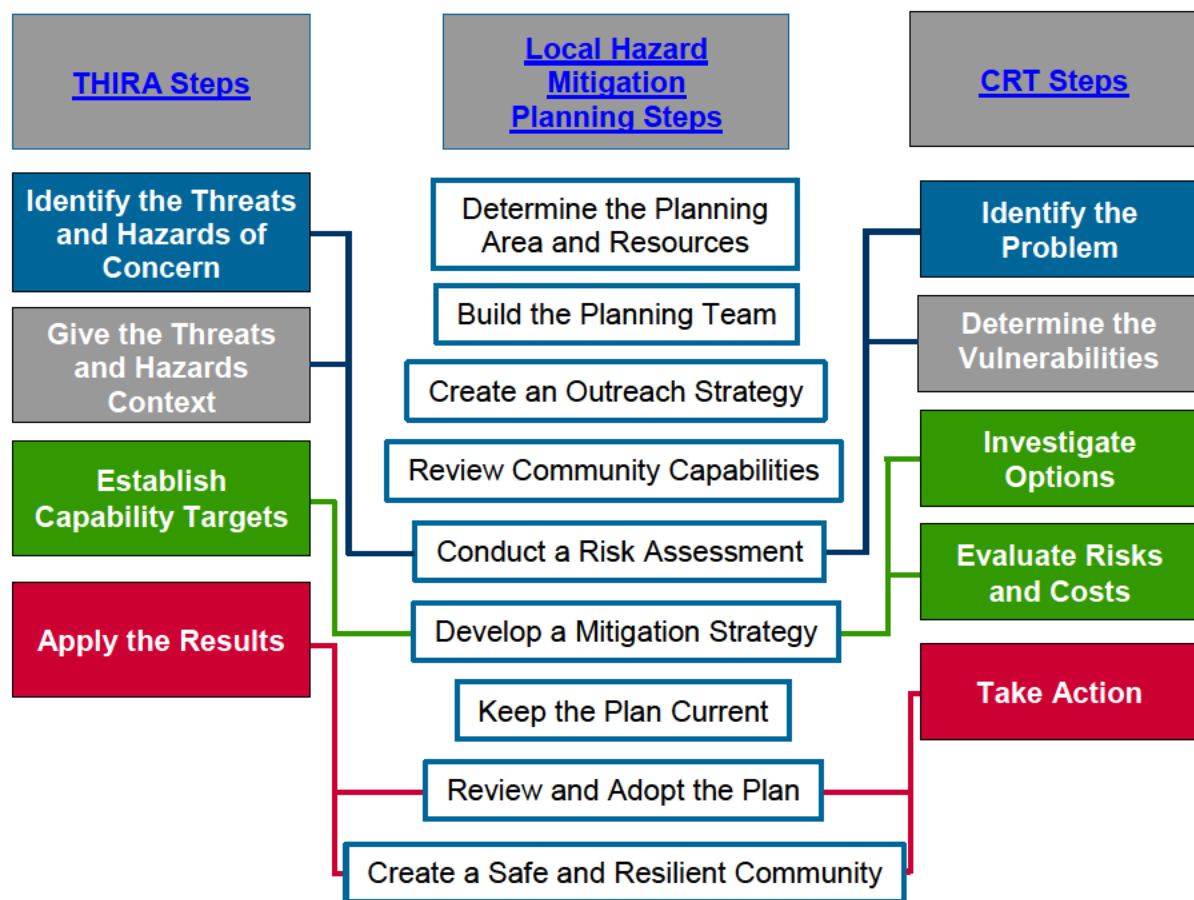
Preparedness Goal		
“A secure and resilient nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk.”		
Capabilities		
Mission Areas	Prevention	Capabilities necessary to avoid, prevent or stop a threatened or actual act of terrorism
	Protection	Capabilities necessary to secure the homeland against acts of terrorism and manmade or natural disasters
	Mitigation	Capabilities necessary to reduce the loss of life and property by lessening the impact of disasters
	Response	Capabilities necessary to save lives, protect property and the environment, and meet basic human needs after an incident has occurred
	Recovery	Capabilities necessary to assist communities affected by an incident to recover effectively

# THE IMPORTANCE OF MITIGATION

Mitigation reduces loss of life and potential damage to property by reducing the effects of disasters. Effective [mitigation](#) requires that all citizens understand local [risks](#) and [vulnerabilities](#), address hard choices, and invest in long-term community well-being. Part of that investment should include managing effective response strategies – critical elements for achieving community resilience. The U.S. Climate Resilience Toolkit (CRT) defines [resilience](#) as the capacity of a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption.

When examining vulnerabilities and opportunities in your community, it is helpful to view capabilities and plans within the context of existing threat, hazard, mitigation, and climate vulnerability assessment steps and processes. Examining commonalities among existing efforts in the community will allow you to strengthen partnerships with experts and stakeholders, focus limited resources, and identify crosscutting challenges, strengths, and opportunities for community resilience.

The [Threat and Hazard Identification and Risk Assessment \(THIRA\)](#) and the [CRT Steps to Resilience](#) will help to integrate the identified risks and vulnerabilities into a mitigation strategy for community resilience.



# BUILDING AN EXERCISE

## FUNDAMENTAL FIRST STEPS AND GUIDING QUESTIONS

### Let's get started!

The following questions encompass the initial steps for strengthening community resilience. It is important to remember that this is not a survey and each community may be in a different process phase. This Participant Manual allows flexible navigation within the preparedness cycle, depending on your goals, resources, and capabilities.

**Click on the links below to navigate the Participant Manual**

[Who are you?](#)

[Where are you in the community resilience process?](#)

[Have you completed a vulnerability assessment?](#)

[How can exercises assist you in enhancing community resilience?](#)

[What type of discussion-based exercise do you want to conduct?](#)

[Who are your community experts?](#)

[How can you build or expand your community network?](#)

[What are the benefits of a regional network?](#)

[How do you want to coordinate the design, development, and conduct of the exercise?](#)



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## WHO ARE YOU?

This Participant Manual provides generic templates for local, state, territory, tribal, federal, and non-government / private sector exercise planners and the tools they need to deliver community mitigation-focused exercises. Please take some time and familiarize yourself with [existing capabilities](#) and [networks](#) in your community.

As you move through the Manual, consider potential networks, not just at the community level but at the regional level as well. Looking at risks from a regional perspective allows you to consider the various community constructs and systems (physical, natural, social, and cultural) upon which your community depends.

- Does the data within the [National Climate Assessment \(NCA3\)](#) present any regional trends that would affect other communities near you?
- Are there benefits to coordinating exercises with other communities in your region?
  - Sharing of resources
  - Building adaptive capacity
  - Collaborative mitigation discussions
  - Identification / alignment of priorities
  - Coordination of regional investment opportunities

Local	<a href="#">Find your experts</a> <a href="#">Find your network</a>
State	<a href="#">Find your experts</a> <a href="#">Find your network</a>
Territory	<a href="#">Find your experts</a> <a href="#">Find your network</a>
Tribal	<a href="#">Find your experts</a> <a href="#">Find your network</a>
Federal	<a href="#">Find your experts</a> <a href="#">Find your network</a>
Private Sector/Non- Governmental	<a href="#">Find your experts</a> <a href="#">Find your network</a>

## WHERE ARE YOU IN THE COMMUNITY RESILIENCE PROCESS?

Taking action to build and strengthen community preparedness requires a thoughtful approach to planning for and building resilience. It is important to identify your community's vulnerabilities, explore options and solutions, and take appropriate action. Consider the following five steps adapted from the [CRT](#).

### Identify Stressors

#### STEP 1

- Identify [stressors](#) and events that might
  - Close businesses, disrupt communications, and/or result in infrastructure failure
- Find opportunities for mutual benefits
  - Resilience-building technologies, jobs, and upgraded infrastructure
- What are the cause and effect relationships?
  - Trace past impacts back to their causes
  - Identify natural processes, thresholds, and physical features involved with the problem or opportunity
- Work with your [network](#) to define and solve the problem
  - Identify and incorporate stakeholders into the process
  - Focus on common values, shared understandings and limitations, and set new goals

### Determine Vulnerabilities

#### STEP 2

- Focus first on known issues:
  - Identify places, people, and resources affected by previous climate-related events
- Identify current and future vulnerabilities and risks
  - [Use data, maps, tools, and experts](#) to help determine vulnerabilities
    - Risk Mapping, Assessment, and Planning Program ([Risk MAP](#))
  - Determine the adaptive capacity of your population?
  - What are the costs and benefits of taking action or not taking action to enhance resilience?
- Share and validate your list of vulnerabilities with your [network](#)

## WHERE ARE YOU IN THE COMMUNITY RESILIENCE PROCESS? (CONT.)

### Investigate Options and Potential Solutions

STEP 3

- Establish ground rules:
  - Limitations and important objectives (e.g., “do no harm,” “operate within budget constraints,” etc.)
- After establishing ground rules, brainstorm, research, invent, and innovate:
  - Consult your [experts](#) and [network](#) for help
  - Options should always reduce vulnerability or enhance resilience
  - Create an exhaustive list and compare with your network and surrounding networks’ experiences

### Evaluate Risks and Costs

STEP 4

- Determine the best option for your specific situation
- Use a consistent method when comparing options
  - Establish what is most important within your network and prioritize most-valued assets
  - Consider cost and benefits (financial or otherwise)
  - Identify a preferred solution and distinct phases of action

### Take Action

STEP 5

- Measure effectiveness of each step
- Seek input and feedback
- Revisit each step multiple times
- Share your story



[Source: FEMA Risk Mapping, Assessment and Planning \(MAP\)](#)

## HAVE YOU COMPLETED A VULNERABILITY ASSESSMENT?

Before you reach out to your experts and other stakeholders to start developing an exercise, it is helpful to identify the climate risks that could affect you or your community.

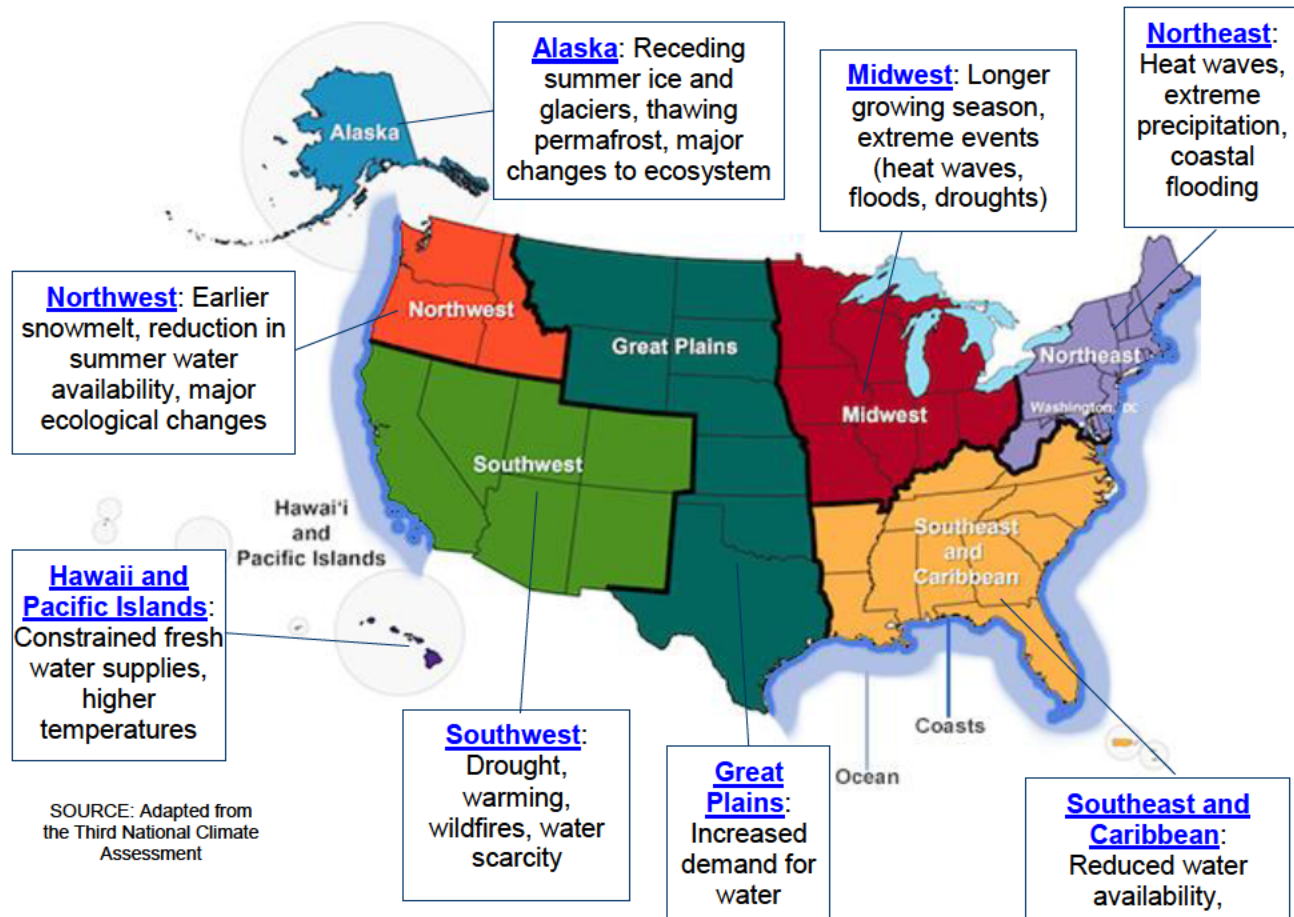
Consider the following questions:

- 1) What are some risks that your community may face in the future?
- 2) What are your risks related to a changing climate and extreme weather events?
- 3) How will gradual changes in the climate and extreme weather events exacerbate the risks you identified above?

Consider the [THIRA](#) steps and the [CRT](#) Steps to Resilience to identify common themes that will help you decide which vulnerability assessment(s) to complete and how to integrate the steps into your overall hazard mitigation planning [steps](#).

Evidence of a changing climate appears in every region and the effects are visible in every state. Click [here](#) to explore how climate is affecting your region. The map below provides examples of observed trends and future conditions, but is not an exhaustive list.

### Observed Trends and Future Conditions



## HOW CAN EXERCISES ASSIST YOU IN ENHANCING COMMUNITY RESILIENCE?

This Manual presents two ways to deliver exercises with a focus on climate and extreme weather events that can assist you in enhancing community resilience: creating a new exercise or incorporating climate risks into existing exercises. This Manual provides basic principles and templates that will allow you to proceed with either option while strengthening partnerships and networks within your community.

### INCORPORATE CLIMATE RISKS INTO AN EXISTING EXERCISE

As an exercise planner, incorporating climate preparedness, adaptation and resilience exercise objectives and discussion questions into an existing exercise can raise awareness of the effects of current and future climate risks on existing hazards within the community. Examples based on existing climate data (with projected effects) are below:

- Incorporate a mitigation-based climate module (higher temperatures, sea level change, more intense rainfall, drought, heatwaves, etc.) into a hurricane exercise to identify mitigation strategies and investment opportunities
  - Sea surface temperatures are rising and are expected to rise faster over the next few decades, with significant regional variation, and with the possibility for more intense hurricanes as oceans warm: [NCA3 – Coasts](#). That said, will the effects and consequences of your existing hurricane scenario change based on sea level rise projections?
  - What actions, investments, or decisions can you make now to mitigate the effects of this scenario in 30 years?
- Incorporate a mitigation-based climate module into a critical infrastructure/infrastructure systems exercise to identify mitigation strategies and/or investment opportunities
- Incorporate climate adaptation discussion questions into a public health exercise to examine how climate projections affect capabilities and/or compound existing public health, medical, and social services challenges

### CREATE A NEW EXERCISE

As an exercise planner, you may want to deliver a discussion-based exercise with the exercise scope and objectives (and their aligned core capabilities) exclusively focused on building community resilience. This option provides a direct opportunity to examine the capabilities and needs of the community as these kinds of exercises can address climate effects projected to exacerbate existing hazards.

Click [here](#) to view scenario examples provided within the Participant Manual.



## WHAT TYPE OF DISCUSSION-BASED EXERCISE DO YOU WANT TO CONDUCT?

Discussion-based exercises focus on strategic, policy-oriented issues. Facilitators and/or presenters usually lead the discussion, keeping participants on track to achieve exercise objectives.



### Seminar

**An optimal starting point to raise awareness of climate preparedness, adaptation, and resilience within your community**

- Introduce participants to the best available science, authorities, strategies, plans, policies, procedures, protocols, resources, concepts, and ideas
- Valuable for entities developing or making major changes to existing plans or procedures
- Helpful for assessment of interagency operations capabilities



### Workshop

**An effective exercise format to engage your community in the development of a resilience plan or to incorporate climate considerations into existing community-based plans**

- Includes a broad attendance from stakeholders to increase interaction and discussion
- Focus is on achieving or building a product such as new standard operating procedures, emergency operation plans, or mutual aid agreements



### Tabletop Exercise

**Once your community has a climate resilience plan/existing plans that incorporate climate considerations, deliver a tabletop exercise to validate plans**

- Intended to generate discussion of various issues regarding a hypothetical, simulated disaster or gradual change in the climate
- Helpful in enhancing general awareness, validating plans, rehearsing concepts, and assessing the types of systems needed to guide the prevention of, protection, from mitigation of, response to, and recovery from a defined event



### Games

**Create an interactive exercise environment that actively conveys climate risks and decision-making requirements, based on existing plans within your community**

- Simulation of operations that often involves multiple teams, in a competitive environment, using rules, data, and procedures depict a hypothetical situation
- Explore consequences of player decisions and actions
- Useful tool for validating plans and procedures or evaluating resource requirements

## WHO ARE YOUR COMMUNITY EXPERTS?

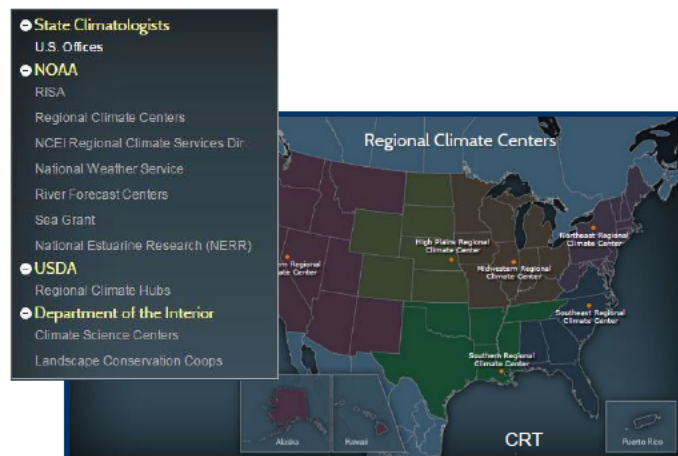
It is important to understand the existing capabilities and networks within your community in order to share resources and strengthen the climate dialogue. This Manual addresses how to [build a network](#). Prior to doing so, it is especially important to **identify local experts** who can help you work through the [five steps](#) to resilience as well as subsequent development of effective climate-focused exercises.

The following resources are a small sampling, not an exhaustive list. It is strongly encouraged that you explore other resources curated to your region, and review the additional resources found in [Appendix I](#).

The [American Association of State Climatologists](#) (AASC) strives to bring climatology experts together in a unified effort. Association members are comprised of designated state climatologists, Regional Climate Center directors, and other associates such as assistant climatologists and representatives of federal climate agencies. **Use [this resource](#) to contact state climatologists, identify regional programs, receive news updates, and register for local events.**

“State [climatologists](#) are individuals who have been identified by a state entity as the state’s climatologist and who are also recognized by the Director of the National Climate Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA) as the state climatologist of a particular state.” (AASC)

The [U.S. Climate Resilience Toolkit](#) provides a mapping tool for locating experts in your area. Regional and locally-focused centers across the nation are available to help you build resilience to climate-related changes in your community. **Browse [this map](#) to find experts, state climatologists, regional/local climate hubs, and research centers.**



Local universities, [climate champion universities](#), and other research institutions are also useful resources and often have notable experts.

Be sure to vary your resource pool and remember the importance of seeking assistance from and **establishing relationships with experts from local, state, and regional entities** in addition to any other sources you identify.

## HOW CAN YOU BUILD OR EXPAND YOUR COMMUNITY NETWORK?

Consider the following broad categories of positions, expertise, and organizations as a starting point for community outreach when establishing the planning team for your exercise, and subsequently, for identifying the individuals to participate in your exercise. Managing an effective climate-focused exercise starts with collaborating and learning from all community partners.

One of the desired strategic outcomes for this Seminar is **improved collaboration with and between whole community partners**. A diverse group of planners and participants strengthens partnerships and provides unique perspectives on climate risks and opportunities facing the entire community. Once exercise-specific objectives and key focus area are identified you can further refine the scope of your participants.

### Types of Individuals, Positions and Expertise:

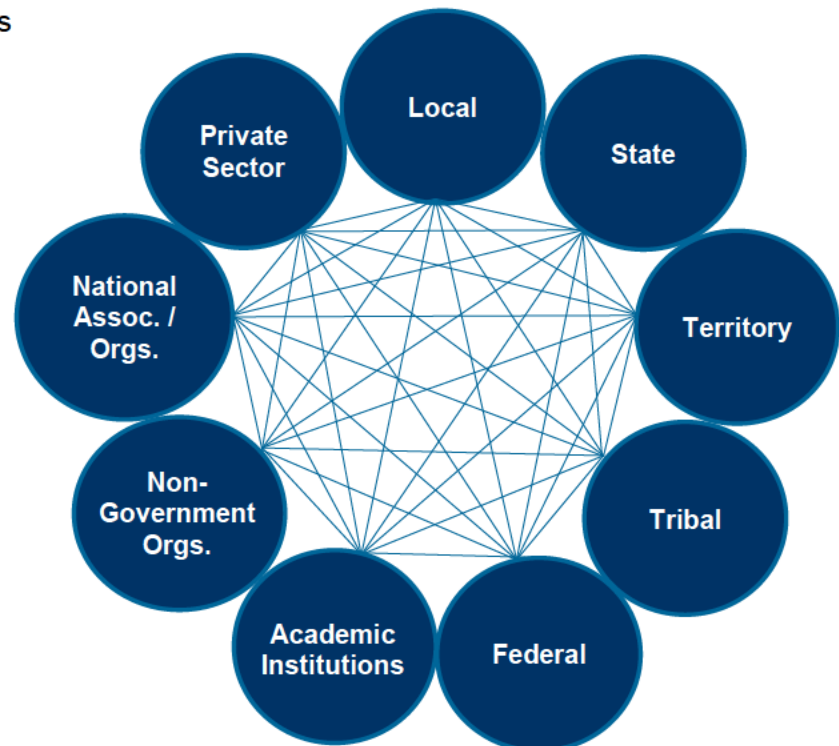
- Community Group Leaders
- Community / Jurisdiction Managers and Administrators
- Community / Jurisdiction Planners (Sustainability, Recovery, Mitigation, Land Use, Urban)
- Owners and Operators of community constructs and systems (e.g. critical infrastructure)
- Climate Scientists and Communicators
- Elected and Appointed Officials
- Emergency Managers
- Hospital and Health Network Representatives
- Insurance Industry Representatives
- Public Information Officers
- Environmental Engineers

[Click here to find various stakeholder engagement maps](#)

[Click here to find your local network and ongoing initiatives](#)

[Click here to find out how federal agency coordination works](#)

[Click here to find your regional resources and support](#)





## WHAT ARE THE BENEFITS OF A REGIONAL NETWORK?

Regional partners offer unique perspectives for managing climate challenges and play an important role in planning and conducting a successful exercise. Ample regionally- tailored resources exist to help communities achieve exercise goals and build resilience to all-hazards changes. Reach out to members in your [regional network](#) to gain insights on previous mitigation- or climate-focused exercises, existing mitigation discussions, regional investments, and resource-sharing, as well as best practices for identifying and aligning priorities.

Consider contacting your [Regional Exercise Officer](#) who may be aware of regional or state level exercises and training officers who can assist you in reaching your preparedness goals. You may also contact your Protective Security Advisor (PSA). [PSAs](#) serve as infrastructure liaisons and facilitate local field activities in coordination with other Department of Homeland Security offices. To find your local PSA, please send an e-mail to [PSCDOperations@hq.dhs.gov](mailto:PSCDOperations@hq.dhs.gov). To see a map of the PSA Locations, reference [Appendix I](#). Remember, your regional partners are excellent sources of information as you begin forming your core network.

Regional resources may also guide you to other resilience activities in your region. For example, NOAA's web-based mapping system highlights key [national-level resilience initiatives](#) in each region across the United States. The system also hosts maps depicting [Regional Climate Centers](#) and [Regional Climate Hubs](#).



## BUILDING YOUR EXERCISE

When creating a discussion-based, climate exercise or incorporating climate risks into an existing community-based exercise, remember that this initiative focuses on the mitigation mission area (per the [National Preparedness Goal](#)) and is designed to help communities examine National core capabilities, and, ultimately, initiate and/or accelerate community preparedness and resilience.

Click [here](#) for Exercise Objectives

Click [here](#) for Exercise Core Capabilities

Click [here](#) for Exercise Scenarios

Click [here](#) for Exercise Facilitator/Discussion Questions

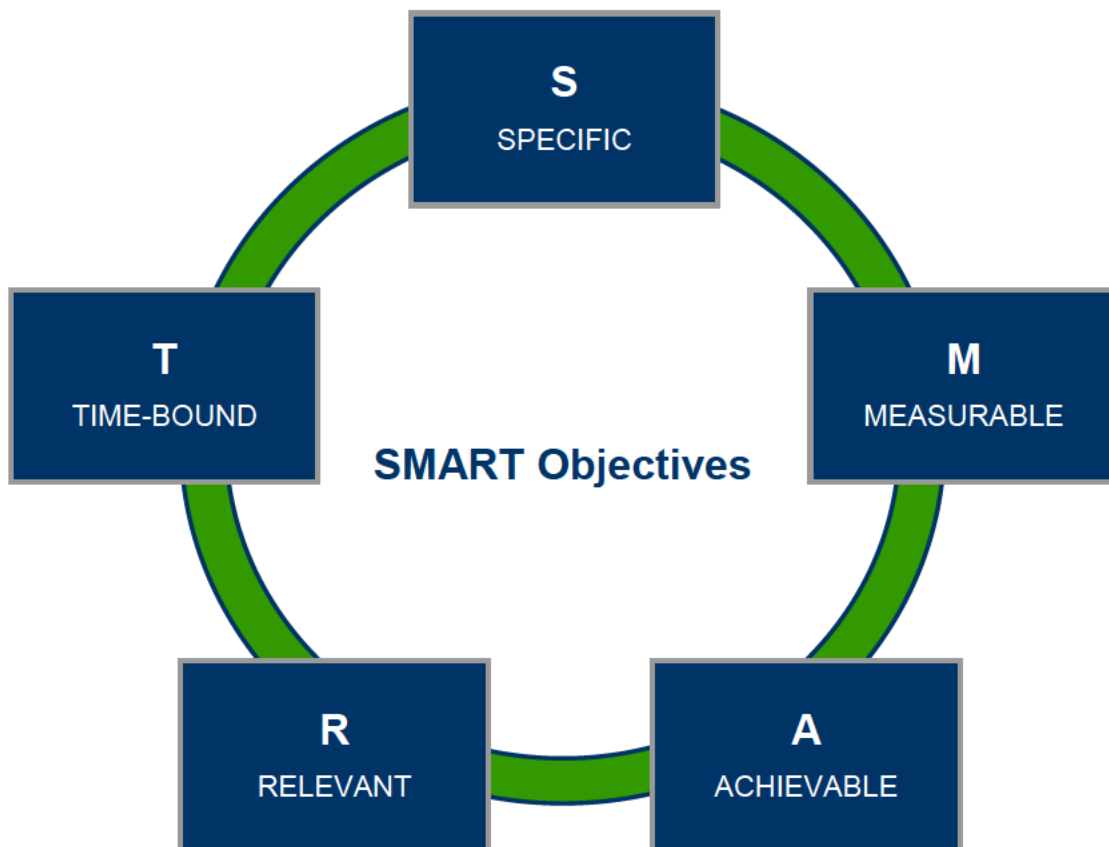


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## EXERCISE OBJECTIVES

Develop your exercise objectives according to the specific type of discussion-based exercise you are designing and consider the following strategic objectives:

- Examine methods to better integrate existing and emerging climate science, information, and requirements into current and future planning to manage and mitigate climate risks
- Identify collaborative, flexible, and sustainable whole-community approaches to advance and sustain community-based climate preparedness and resilience programs, policies, and strategies
- Examine investment opportunities and the development of coalitions between local, state, territory, tribal, federal, and non-government / private sector partners to support climate preparedness, adaptation, and resilience



## NATIONAL CORE CAPABILITIES

[National core capabilities](#) can help you shape the exercise scenario narrative and focus the discussion questions for your exercise. Align core capabilities with your exercise objectives – remember the fundamental premise of [mitigation](#) and [response](#), but tailor the capabilities according to your specific community-based focus areas and challenges.

In addition to the mitigation and response core capabilities, consider the following:

- What focus areas do you have for this exercise?
- Do you want to focus on infrastructure and therefore choose the infrastructure systems capability?
- Do you want to focus on economic effects and consequences and therefore align the economic recovery capability to the exercise?
- Other possibilities include health and social services, natural and cultural resources, and environmental response / health and safety

Core Capabilities				
Prevention	Protection	Mitigation	Response	Recovery
Planning	Planning	Planning	Planning	Planning
Public Information and Warning	Public Information and Warning	Public Information and Warning	Public Information and Warning	Public Information and Warning
Operational Coordination	Operational Coordination	Operational Coordination	Operational Coordination	Operational Coordination
Forensics and Attribution	Access Control and Identity Verification	Community Resilience	Critical Transportation	Economic Recovery
Intelligence and Information Sharing	Cybersecurity	Long-term Vulnerability Reduction	Environmental Response / Health and Safety	Health and Social Services
Interdiction and Disruption	Intelligence and Information Sharing	Risk and Disaster Resilience Assessment	Fatality Management Services	Housing
Screening, Search, and Detection	Interdiction and Disruption	Threats/Hazards Identification	Infrastructure Systems	Infrastructure Systems
	Physical Protective Measures		Mass Care Services	Natural and Cultural Resources
	Risk Management for Protection Programs\ Activities		Mass Search and Rescue Operations	
	Screening, Search and Detection		On-scene Security and Protection	
	Supply Chain Integrity\ Security		Operational Communications	
			Public and Private Services and Resources	
			Public Health and Medical Services	
			Situational Awareness	

## EXERCISE SCENARIO

The scenario is the storyline that drives the exercise and includes the general context or comprehensive story, technical details of the story's conditions and events, and conditions for assessing/demonstrating capabilities. Think broadly about the types of climate risks that might affect businesses, disrupt communications, or cause critical water, energy, or transportation infrastructure systems to fail. From a range of possible issues, identify the most important or immediate problems you are likely to face.

- **Scenarios should be:**
  - Threat-based and performance-based
  - Realistic
  - Challenging, but not so demanding that participants become overwhelmed
- **Scenarios should consist of three basic elements:**
  1. General context or comprehensive story
  2. Required conditions so that players have the opportunity to demonstrate proficiency and competency in conducting critical tasks, demonstrating core capabilities, and meeting exercise objectives
  3. Technical details necessary to accurately depict scenario conditions and events
- **Exercises are the continuation of a story begun with the scenario. Be sure to consider the following:**

<b>Hazard(s)</b>	▪ What were the results of your vulnerability assessment? Consider past events and the current or future hazards specific to your region
<b>Affected entity or entities</b>	▪ The jurisdiction, facility, or systems affected
<b>Timing</b>	▪ The date, time of day, and seasonality
<b>Consequence</b>	▪ Effects on human health, economic activity and the built environment, mission/function execution, behavior
<b>Objectives and Core Capabilities</b>	▪ Think about the goal of your exercise, what you want participants to consider, and what topics need to be discussed

The following are six tools will help you identify hazards in your area, potential effects in your community, and projected outcomes – all things you should consider when deciding on a scenario for your exercise:

1	<a href="#">Climate Explorer</a>	2	<a href="#">Economics: National Ocean Watch (ENOW) Explorer</a>
3	<a href="#">FIRMette Web</a>	4	<a href="#">National Integrated Drought Information System (NIDIS) / U.S. Drought Portal</a>
5	<a href="#">U.S. Energy Mapping System</a>	6	<a href="#">Surging Seas: Sea Level Rise Analysis</a>

You may also reference [Appendix I](#) for additional tools and resources that will help you identify climate risks in your region and potential outcomes effects to your community.

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## EXERCISE FACILITATOR / DISCUSSION QUESTIONS

When developing exercise facilitator / discussion questions, you should align your questions with the identified core capabilities and exercise objectives for your exercise. The links below provide just a handful of generic examples for various capabilities.

### [Environmental Themes](#)



### [Social and Cultural Themes](#)



### [Economic Themes](#)



### [Security Themes](#)



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## EXERCISE FACILITATOR / DISCUSSION QUESTIONS (CONT.)

### ENVIRONMENTAL THEMES

- What key climate risks will affect your community's environment in the (near / mid / long) term?
- What effect do these risks have on various sectors and community constructs and systems (e.g., public health, food supply, fishing industry, community traditions)?
- What key environmental opportunities can stakeholders in your community use to enhance your adaptive capacity and become resilient?
- Are there existing coalitions or collaborative efforts between local, state, territory, tribal, federal, and non-government / private sector partners to support resilience planning related to your community's environmental vulnerabilities? What are they?
- Have your departments and agencies encountered any obstacles that affect joint resilience or adaptation planning support to local, state, territory, tribal, federal, and non-government / private sector? If so, what are the obstacles?
  - What strategies can you implement to remove the obstacles?



### SOCIAL AND CULTURAL THEMES

- What key climate-related social and cultural challenges does your community face in the (near / mid / long) term (e.g., public health, housing, employment, food supply, community traditions)?
- What key climate-related social and cultural adaptation opportunities can your community use to become resilient?
- What key investments should occur in order to preserve the traditional way of life in your community (e.g., infrastructure, education, and housing)?
- Are there existing organized coalitions between local, state, territory, tribal, federal, and non-government / private sector partners to support resilience planning related to social and cultural issues? What are they?
- Have your departments and agencies encountered any obstacles that affect joint social and cultural adaptation planning support to local, state, territory, tribal, federal, and non-government / private sector partners? If so, what are the obstacles?
  - What strategies can you implement to remove the obstacles?



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## EXERCISE FACILITATOR / DISCUSSION QUESTIONS (CONT.)

### ECONOMIC THEMES

- What key economic challenges related to climate risks and planning for resilience does your community face in the (near / mid / long) term (e.g., infrastructure, industry, energy, housing, public health, security)?
- What economic opportunities are presented by climate risks in the (near / mid / long) term, and what adaptation strategies are being explored to seize these opportunities?
- What are the anticipated major climate-related economic investments in your community in the (near / mid / long) term (e.g., infrastructure, industry, energy, housing, public health, security)?
- Are there existing organized coalitions between local, state, territory, tribal, federal, and non-government / private sector partners to support resilience planning related to economic issues? What are they?
- Has your community encountered any obstacles that affect joint adaptation planning to reduce the economic impacts of a changing climate? If so, what are the obstacles?
  - What strategies can you implement to remove the obstacles?



### SECURITY THEMES

- What assets are most vulnerable to climate risks in the (near / mid / long) term (e.g., military facilities, energy infrastructure, supply lines)?
- What critical investments need to be made to ensure your community's security in the (near / mid / long) term?
- Are there existing organized coalitions between local, state, territory, tribal, federal, and non-government / private sector partners to support resilience planning related to security issues? What are they?
- Has your community encountered any obstacles that affect joint security resilience planning support to local, state, territory, tribal, federal, and non-government / private sector partners?
  - What strategies can you implement to remove the obstacles?

# TEMPLATES

## SITUATION MANUAL TEMPLATE AND SAMPLES

A Situation Manual (SitMan) is a core exercise document that provides the contextual background for the exercise, and stands as a primary reference document for those participating in seminars, workshops, tabletop exercises, and games.

In 2014, the National Exercise Program conducted four seminars as part of the Climate Change Preparedness and Resilience Exercise Pilot Series sponsored by White House National Security Council Staff, Council on Environmental Quality, and Office of Science and Technology Policy, and in collaboration with the National Exercise Division. The goal was to advance the climate adaptation dialogue and identify collaborative and sustainable approaches to community based climate preparedness and resilience capabilities.

Below are the outcomes of each seminar and link to the applicable SitMan.

### [Houston Climate Change Preparedness and Resilience Exercise Seminar](#)

The exercise discussions focused on the effects of climate change, the associated challenges and opportunities, and specific immediate actions to collaboratively and sustainably prepare, plan for, or help mitigate future projected climate challenges on the Houston-Galveston area.

Key highlights from the discussion include:

- Identification of opportunities to align natural and built systems
- Recognition of critical interdependent lifelines
- Need for strategic messaging
- Many partnerships exist, but a more coordinated approach is needed
- Agreement from all participants on the need for a unified regional resilience framework

### [Colorado Climate Change Preparedness and Resilience Exercise Seminar](#)

The exercise discussions focused on the effects of climate change in Colorado, the associated challenges and opportunities, and specific immediate actions to collaboratively and sustainably prepare, plan for, or help mitigate future projected climate challenges.

Key highlights from the discussion include:

- Colorado is forward leaning in identifying and understanding its vulnerabilities to climate change and taking action to create a more resilient Colorado
- Water is the resource most affected by future changes in Colorado's climate, and a resource that affects all other critical sectors
- Numerous opportunities exist to build public-private partnerships
- Many public partnerships already exist, but there are opportunities to broaden collaboration
- There is a need to integrate social and economic sciences into the climate change science and adaptation dialogue
- There is a need for science translation of and strategic messaging on climate change risks, opportunities, and potential solutions

### **Alaska Climate Change Preparedness and Resilience Exercise Seminar**

The exercise discussions focused on key focus areas and concepts: environmental, social and cultural, economic, and security. These areas gave context for examining effects of climate variability and change in Alaska, associated challenges and opportunities across two generational time horizons. Additionally, specific immediate actions and sustainable approaches to preparation, planning, or mitigation of future projected climate effects were examined.

Key highlights from the discussion include:

- Strong desire to re-invigorate the Governor's Subcabinet on Climate Change and the Immediate Action Working Group
- Challenges exist in preserving traditional way of life for Alaska Native communities and adapting to the effects of climate change
- Increased shipping in the Arctic presents opportunities and challenges
- Federal grants do not have flexibility to fund resilience projects

### **Hampton Roads, Virginia Climate Change Preparedness and Resilience Exercise Seminar**

The exercise discussions focused on the effects of climate change, the associated challenges and opportunities, and specific immediate actions to collaboratively and sustainably prepare, plan for, or help mitigate future projected climate challenges on the Hampton Roads area.

Key highlights for the discussion include:

- Attaining organizational cohesion and collaboration among the various Hampton Roads jurisdictions remains the most pressing challenge to meaningful climate change mitigation planning
- Transportation critical infrastructure was identified the most serious and economically important climate change vulnerability
- Transformation of the Hampton Roads economy is a climate adaptation imperative

# SUPPLEMENTAL TOOLS

## GRANTS AND FUNDING

Finding ways to fund the projects that will make you climate resilient is crucial to your success. Various government and private entities in the United States offer financial assistance or other resources to support various project needs.

Funding Options	
<a href="#"><u>Climate Funding Opportunities</u></a>	<a href="#"><u>Wildlife Conservation Society's Climate Adaptation Fund</u></a>
<a href="#"><u>Building Blocks for Sustainable Communities</u></a>	<a href="#"><u>Open Space Institute Resilient Landscape Initiative</u></a>
<a href="#"><u>Partnership for Sustainable Communities</u></a>	<a href="#"><u>United Nations Framework Convention on Climate Change</u></a>
<a href="#"><u>Federal Emergency Management Agency (FEMA) Preparedness (Non-Disaster) Grants</u></a>	<a href="#"><u>The World Bank Climate Finance Options</u></a>
<a href="#"><u>FEMA Hazard Mitigation Assistance</u></a>	<a href="#"><u>The World Bank—Financing and Risk Management Site</u></a>
<a href="#"><u>FEMA Disaster Survivor Assistance</u></a>	<a href="#"><u>Accessing Resources Under the Special Climate Change Fund</u></a>
<a href="#"><u>Drought Recovery Information</u></a>	<a href="#"><u>The Adaptation Fund</u></a>
<a href="#"><u>United States Department of Agriculture (USDA) Natural Resources Conservation Service</u></a>	<a href="#"><u>Terra Viva Grants Directory</u></a>
<a href="#"><u>Massachusetts' Storm-Smart Coasts Initiative</u></a>	<a href="#"><u>Rockefeller Foundation Climate Change Resilience Grants and Grantees</u></a>
<a href="#"><u>100 Resilient Cities Challenge</u></a>	<a href="#"><u>Financing for Climate</u></a>
<a href="#"><u>Kresge Environment Program</u></a>	<a href="#"><u>Climate Finance Tracking</u></a>
Click <a href="#"><u>here</u></a> for additional funding sources.	

## CASE STUDIES & REGIONAL CLIMATE SUMMARIES

When striving to become climate resilient, it is often very helpful to examine a broader network that includes examples of recent lessons learned and success stories from communities who are experiencing similar climate-related challenges. The following resources are just a few examples of various communities building resilience to climate risks.

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### CASE STUDIES - RESILIENCE IN ACTION

Communities and businesses are taking action to mitigate climate-related effects and build resilience to extreme weather events. The stories below illustrate the application of the process and tools featured in this Manual. Browse the stories by region in the list below.

- Click [here](#) for case studies based in the Northeast U.S.
- Click [here](#) for case studies based in the Southeast U.S.
- Click [here](#) for case studies based in the Midwest U.S.
- Click [here](#) for case studies based in the U.S. Great Plains
- Click [here](#) for case studies based in the Southwest U.S.
- Click [here](#) for case studies based in the Northwest U.S.
- Click [here](#) for case studies based in Alaska
- Click [here](#) for case studies based Internationally
- Click [here](#) for case studies based Nationally




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### REGIONAL CLIMATE TRENDS AND SCENARIOS: SUMMARIES


- Click [here](#) for the regional summary for the Climate of the Northeast U.S.
- Click [here](#) for the regional summary for the Climate of the Southeast U.S.
- Click [here](#) for the regional summary for the Climate of Midwest U.S.
- Click [here](#) for the regional summary for the Climate of the U.S. Great Plains
- Click [here](#) for the regional summary for the Climate of the Southwest U.S.
- Click [here](#) for the regional summary for the Climate of Northwest U.S.
- Click [here](#) for the regional summary for the Climate of Alaska
- Click [here](#) for the regional summary for the Climate of the Pacific Islands
- Click [here](#) for the regional summary for the Climate of the Contiguous U.S.



## LEARNING TOOLS AND TRAINING COURSES

Training	
<p><a href="#"><u>US Climate Resilience Toolkit Training Courses</u></a></p>  <p><b>U.S. Climate Resilience Toolkit</b></p>	<ul style="list-style-type: none"> <li>▪ Training courses can help you acquire the tools, skills, and knowledge you need to manage your climate-related risks and opportunities</li> <li>▪ Each training module is accompanied with a test to help you evaluate your knowledge</li> <li>▪ These courses feature scientific information adapted from authoritative sources, prepared by recognized subject-matter experts</li> </ul>
<p><a href="#"><u>USGCRP Training Courses</u></a></p>  <p>United States Global Change Research Program</p>	<ul style="list-style-type: none"> <li>▪ Climate change trainings (including the Environment Protection Agency (EPA) climate training 101)</li> <li>▪ A variety of methods and opportunities for training and communication to facilitate adaptation in the Federal Government and beyond</li> </ul>
<p><a href="#"><u>National Oceanic and Atmospheric Administration Office for Coastal Management</u></a></p>  <p><b>OFFICE FOR COASTAL MANAGEMENT</b> NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION</p>	<ul style="list-style-type: none"> <li>▪ <a href="#"><u>Climate Adaptation for Coastal Communities</u></a> <ul style="list-style-type: none"> <li>– Conveys information and practical skills for incorporating climate considerations into planning processes, and provides time in class to apply what is learned to individual issues</li> </ul> </li> <li>▪ <a href="#"><u>Coastal Community Planning and Development</u></a> <ul style="list-style-type: none"> <li>– Provides examples and strategies to implement alternative development principles in coastal communities</li> </ul> </li> <li>▪ <a href="#"><u>Coastal Inundation Mapping</u></a> <ul style="list-style-type: none"> <li>– Provides information on coastal inundation issues and teaches spatial techniques for mapping inundation</li> </ul> </li> <li>▪ <a href="#"><u>Introducing Green Infrastructure for Coastal Resilience</u></a> <ul style="list-style-type: none"> <li>– Teaches green infrastructure concepts that support coastal resilience</li> </ul> </li> <li>▪ <a href="#"><u>Roadmap for Adapting to Coastal Risk</u></a> <ul style="list-style-type: none"> <li>– Provides online instruction and mapping resources for engaging a community in assessment and planning that considers coastal risks and vulnerabilities</li> </ul> </li> </ul>

## LEARNING TOOLS AND TRAINING COURSES (CONT.)

Training	
<p><a href="#"><u>FEMA Emergency Management Institute (EMI) Independent Study Program (ISP) Courses</u></a></p> 	<ul style="list-style-type: none"><li>▪ IS-271.a - Anticipating Hazardous Weather &amp; Community Risk, 2<sup>nd</sup> Edition</li><li>▪ IS-319 - Tornado Mitigation Basics for Mitigation Staff</li><li>▪ IS-320 - Wildfire Mitigation Basics for Mitigation Staff</li><li>▪ IS-321- Hurricane Mitigation Basics for Mitigation Staff</li><li>▪ IS-322 - Flood Mitigation Basics for Mitigation Staff</li><li>▪ IS-323 - Earthquake Mitigation Basics for Mitigation Staff</li><li>▪ IS-324.a - Community Hurricane Preparedness</li><li>▪ IS-325 - Earthquake Basics: Science, Risk, and Mitigation</li><li>▪ IS-326 - Community Tsunami Preparedness</li></ul>

## EXECUTIVE ORDERS & OTHER GOVERNMENT DOCUMENTS

The following links provide reference for the legal frameworks surrounding climate adaptation in the United States.

- [Executive Order 13693 \(2015\)](#)
- [Executive Order 13653](#)
- [President's Climate Action Plan 2013](#)
- [Regulations, Guidance, and Policy](#)
- [Progress Report: Highlighting Federal Actions Addressing the Recommendations of the State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience \(2015\)](#)
- [Other executive orders and government documents](#)

# GLOSSARY OF TERMS

Terms are from the FEMA and NOAA's U.S. Climate Resilience Toolkit (CRT) where noted.

Term	Definition	Example (If Applicable)
Adaptive capacity	The ability of a person or system to adjust to a stressor, take advantage of new opportunities, or cope with change. (CRT)	Increasing the capacity of stormwater runoff channels enhances the adaptive capacity of places that face flooding from increasingly heavy rainfalls. (CRT)
After-Action Report (AAR)	The AAR summarizes key exercise-related evaluation information, including the exercise overview and analysis of objectives and Core Capabilities. The AAR is usually developed in conjunction with an Improvement Plan (IP). The lead evaluator and exercise planning team draft the AAR and submit it to meeting participants before the AAM. (FEMA)	
Capability	A capability may be delivered with any combination of properly planned, organized, equipped, trained, and exercised personnel to achieve an intended target. (FEMA)	An exercise to test a communities ability to responds to the 'planning' capability (FEMA)
Climate	The generally prevailing weather conditions of a region, throughout the year, averaged over a series of years. (CRT)	The average high temperature for today's date, for this region. (CRT)
Climate stressor	Events and trends related to weather, climate, and climate change that have an important, generally negative, effect on exposed systems.(CRT)	Increasing frequency and intensity of drought conditions can be a climate stressor for forests and crops. (CRT)
Exercise	An exercise is an instrument to train for, assess, practice, and improve performance in prevention, protection, mitigation, response, and recovery capabilities in a risk-free environment. Exercises can be used for testing and validating policies, plans, procedures, training, equipment, and interagency agreements; clarifying and training personnel in roles and responsibilities; improving interagency coordination and communications; improving individual performance; identifying	

	gaps in resources; and identifying opportunities for improvement. (FEMA)	
Final Planning Meeting (FPL)	The FPM is the final forum for reviewing exercise processes and procedures. An FPM should be conducted for all exercises to ensure that all elements of the exercise are ready for conduct. Prior to the FPM, the exercise planning team receives final drafts of all exercise materials. No major changes to exercise's design, scope, or supporting documentation should take place at or following the FPM. The FPM ensures that all logistical requirements have been met, outstanding issues have been identified and resolved, and exercise products are ready for printing. (FEMA)	
Game	A game is a simulation of operations that often involves two or more teams, usually in a competitive environment, using rules, data, and procedures designed to depict an actual or hypothetical situation. Games explore the consequences of player decisions and actions and are therefore excellent tools to use when validating or reinforcing plans and procedures or evaluating resource requirements. (FEMA)	
Hazard	<p>The potential occurrence of an event that may cause injury, illness, or death to humans, damage to assets or infrastructure, or adverse effects on ecosystems. (CRT)</p> <p>A potential incident resulting from acts of nature (Natural Hazard/FEMA)</p>	Extended periods of excessive heat are likely to be an increasingly common hazard in the coming decades (CRT)
Homeland Security Exercise and Evaluation Program (HSEEP)	HSEEP is a program that provides a set of guiding principles for exercise programs, as well as a common approach to exercise program management, design and development, conduct, evaluation, and improvement planning. (FEMA)	
Impact	Effects on natural and human systems due to extreme weather, climate events, and climate change. (CRT)	Wildfires in the West are starting earlier in the spring and lasting later into the fall, an impact of hotter and drier weather and earlier snowmelt. (CRT)

Improvement Plan (IP)	The IP identifies specific corrective actions, assigns them to responsible parties, and establishes target dates for their completion. The IP is developed in conjunction with the After-Action Report. (FEMA)	
Mission Areas	The National Preparedness Goal identified five mission areas, in which it groups the 31 core capabilities. (FEMA)	<p>Mission areas are</p> <ul style="list-style-type: none"> <li>▪ Prevention</li> <li>▪ Protection</li> <li>▪ Mitigation</li> <li>▪ Response</li> <li>▪ Recovery</li> </ul>
Mitigation	<p>Measures to reduce the amount and speed of future climate change. (CRT)</p> <p>The capabilities necessary to reduce loss of life and property by lessening the impact of disaster. (FEMA)</p>	<p>Reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere. (CTR)</p> <p>Mitigation capabilities include</p> <ul style="list-style-type: none"> <li>▪ Planning</li> <li>▪ Public Information and Warning</li> <li>▪ Operational Coordination</li> <li>▪ Community Resilience</li> <li>▪ Long-Term Vulnerability Reduction</li> <li>▪ Risk and Disaster Resilience Assessment</li> <li>▪ Threats and Hazard Identification (FEMA)</li> </ul>
National Exercise Division	Develops, coordinates, and manages the FEMA's National Exercise Program (FEMA)	
National Exercise Program Climate Change Preparedness and Resilience Exercise Series	In 2014, National Exercise Program (NEP) conducted four Climate Change Preparedness and Resilience Exercise Seminars sponsored by White House National Security Council Staff, Council on Environmental Quality, and Office of Science and Technology Policy, and in collaboration with the National Exercise Division. The goal was to advance the climate adaptation dialogue and identify collaborative and sustainable approaches to community based climate preparedness and resilience capabilities. (FEMA)	
National Oceanic and Atmospheric	An American scientific agency within the U.S. Department focused on the conditions of the oceans and the atmosphere. NOAA's scientists, use	



Administration (NOAA)	cutting-edge research, and high-tech instrumentation to provide citizens, planners, emergency managers and other decision makers with reliable information they need when they need it. (NOAA)	
National Exercise Program (NEP)	The NEP's mission is to serve as the principal exercise mechanism for examining the preparedness and measuring the readiness of the United States across the entire homeland security enterprise by designing, coordinating, conducting, and evaluating a progressive cycle of exercises that rigorously test the Nation's ability to perform missions or functions that prevent, protect against, respond to, recover from, and mitigate all-hazards. (FEMA)	
National Preparedness Goal (Goal)	The National Preparedness Goal defines the core capabilities necessary to prepare for the specific types of incidents that pose the greatest risk to the security of the Nation. The Goal emphasizes actions aimed at achieving an integrated, layered, and all-of-Nation preparedness approach that optimizes the use of available resources. Specifically, the Goal defines success as: A secure and resilient Nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk. (FEMA)	
Objectives	Objectives are the distinct outcomes an organization wishes to achieve during an individual exercise. Objectives should reflect the exercise sponsor's specific needs, environment, plans, and procedures, while providing a framework for scenario development and a basis for evaluation. Objectives can be based on outcomes from a THIRA, from Homeland Security Strategies, and other preparedness documents. Planners should create objectives that are specific, measurable, achievable, relevant, and time-bound (SMART) and should limit the number of exercise objectives to	

	enable timely exercise conduct, facilitate reasonable scenario design, and support successful evaluation. (FEMA)	
Preparedness	The actions taken to plan, organize, equip, train, and exercise to build and sustain the capabilities necessary to prevent, protect against, mitigate the effects of, respond to, and recover from those threats that pose the greatest risk to the security of the Nation. (FEMA)	
Participant	Participants are the overarching group that includes all players, controllers, evaluators, and staff members involved in conducting an exercise. (FEMA)	
Prevention	The capabilities necessary to avoid, prevent, or stop a threatened or actual act of terrorism (FEMA)	<p>Prevention capabilities include:</p> <ul style="list-style-type: none"> <li>▪ Planning</li> <li>▪ Public Information and Warning</li> <li>▪ Operational Coordination</li> <li>▪ Forensics and Attribution</li> <li>▪ Intelligence and Information Sharing</li> <li>▪ Interdiction and Disruption</li> </ul> <p>Screening, Search, and Detection (FEMA)</p>
Protection	The capabilities necessary to secure the homeland against acts of terrorism and manmade or natural disasters (FEMA)	<p>Protection capabilities include:</p> <ul style="list-style-type: none"> <li>▪ Planning</li> <li>▪ Public Information and Warning</li> <li>▪ Operational Coordination</li> <li>▪ Access Control and Identity Verification</li> <li>▪ Cybersecurity</li> <li>▪ Intelligence and Information Sharing</li> <li>▪ Interdiction and Disruption</li> <li>▪ Physical Protective Measures</li> <li>▪ Risk Management for Protection Programs and Activities</li> <li>▪ Screening, Search and Detection</li> </ul> <p>Supply Chain Integrity and Security (FEMA)</p>

Recovery	The capabilities necessary to assist communities affected by an incident to recover effectively (FEMA)	<p>Recovery capabilities include:</p> <ul style="list-style-type: none"> <li>▪ Planning</li> <li>▪ Public Information and Warning</li> <li>▪ Operational Coordination</li> <li>▪ Economic Recovery</li> <li>▪ Health and Social Services</li> <li>▪ Housing</li> <li>▪ Infrastructure Systems</li> </ul> <p>Natural and Cultural Resources (FEMA)</p>
Resilience	The capacity of a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption. (CRT)	Installation of backflow preventers in the stormwater systems of a coastal city increased their resilience to flooding from extreme high tide
Response	The capabilities necessary to save lives, protect property and the environment, and meet basic human needs after an incident has occurred (FEMA)	<p>Response capabilities include</p> <ul style="list-style-type: none"> <li>▪ Planning</li> <li>▪ Public Information and Warning</li> <li>▪ Operational Coordination</li> <li>▪ Critical Transportation</li> <li>▪ Environmental Response/Health and Safety</li> <li>▪ Fatality Management Services</li> <li>▪ Infrastructure Systems</li> <li>▪ Mass Care Services</li> <li>▪ Mass Search and Rescue Operations</li> <li>▪ On-Scene Security and Protection</li> <li>▪ Operational Communications</li> <li>▪ Public and Private Services and Resources</li> <li>▪ Public Health and Medical Services</li> <li>▪ Situational Assessment (FEMA)</li> </ul>
Risk	Threats to things of value (life, environment, etc.), evaluated by probability of hazardous event occurring multiplied by the effects event would have. (CRT)	Warehouses sited on a floodplain represent a higher risk for flooding when they are filled with products than when they are empty. (CRT)
Risk Mapping, Assessment, and Planning (MAP)	A tool designed to deliver precise and accurate data that increases public awareness and leads to action that reduces risk to life and property. (FEMA)	

Scenario	A scenario provides the storyline that drives an exercise to test objectives. The scenario selected for an exercise should be informed by the actual threats and hazards faced by the exercise stakeholders. The exercise scenario should realistically stress the delivery of core capabilities, providing a mechanism for testing objectives and assessing core capability levels and gaps. (FEMA)	
Scope	Scope is an indicator of extent of the exercise. The key elements in defining exercise scope include exercise type, participation level, exercise duration, exercise location, and exercise parameters. (FEMA)	
Seminar	Seminars generally orient participants to, or provide an overview of, authorities, strategies, plans, policies, procedures, protocols, resources, concepts, and ideas. As a discussion-based exercise, seminars can be valuable for entities that are developing or making major changes to existing plans or procedures. Seminars can be similarly helpful when attempting to gain awareness of, or assess, the capabilities of interagency or inter-jurisdictional operations. (FEMA)	
Sensitivity	The degree to which a system, population, or resource is affected by climate effects. (CRT)	The yield of crops with a high sensitivity may be reduced in response to a change in the mean, range, or variability of temperature. (CRT)
Situational Manual (SitMan)	A SitMan is provided for tabletop exercises and games as the core documentation that provides the textual background for a multimedia, facilitated exercise. The SitMan supports the scenario narrative and serves as the primary reference material for all participants during conduct. (FEMA)	
Stressor	Events and trends that affect human and/or natural systems. (CRT)	Increasing population raises demand for water and food and puts additional stress on the infrastructure required to deliver them. (CRT)

Third National Climate Assessment (NCA3)	The National Climate Assessment summarizes the impacts of climate change on the United States, now and in the future. A team of more than 300 experts guided by a 60-member Federal Advisory Committee produced the report, which was extensively reviewed by the public and experts, including federal agencies and a panel of the National Academy of Sciences. This is the third iteration of the report. (NCA3)	
Tabletop Exercise	A TTX is typically held in an informal setting intended to generate discussion of various issues regarding a hypothetical, simulated emergency. TTXs can be used to enhance general awareness, validate plans and procedures, rehearse concepts, and/or assess the types of systems needed to guide the prevention of, protection from, mitigation of, response to, and recovery from a defined incident. Generally, TTXs are aimed at facilitating conceptual understanding, identifying strengths and areas for improvement, and/or achieving changes in attitudes. (FEMA)	
United States Global Change Research Program (USGCRP)	Established in 1989 by Presidential Initiative, the program manages and coordinates a comprehensive and integrated United States research program to assist the National and world to understand, assess, predict, and respond to human-induced and natural processes of global change. (USGCRP)	
Vulnerability	The propensity or predisposition of human and other systems to be adversely affected by climate change. (CRT)	Despite the thick walls of the old lighthouse, its location on a barrier island made it vulnerable to shoreline erosion. (CRT)
Weather	The state of the atmosphere with respect to wind, temperature, cloudiness, moisture, pressure, etc. (CRT)	Today's high temperature in this region. (CRT)
Whole Community	A focus on enabling the participation in national preparedness activities of a wider range of stakeholders from the Federal, State, local, tribal, and	



	territorial government, the private and nonprofit sectors (including nongovernmental organizations), and the general public in order to foster better coordination and working relationships. Used interchangeably with “all-of-Nation.” (FEMA)	
Workshop	Although similar to seminars, workshops differ in two important aspects: participant interaction is increased, and the focus is placed on achieving or building a product. Effective workshops entail the broadest attendance by relevant stakeholders. Products produced from a workshop can include new standard operating procedures, emergency operations plans, continuity of operations plans, and mutual aid agreements. To be effective, workshops should focus on a specific issue, and the desired objective, product, or goal must be clearly defined. (FEMA)	

# ACRONYMS AND ABBREVIATIONS

Acronym	Term
AAR	After Action Report
AASC	American Association of State Climatologists
CRT	Climate Resilience Toolkit
EMI	Emergency Management Institute
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
HSEEP	Homeland Security Exercise and Evaluation Program
ISP	Independent Study Program
NCDC	National Climate Data Center
NCA3	Third National Climate Assessment
NOAA	National Oceanic and Atmospheric Administration
PSA	Protective Security Advisor
SitMan	Situational Manual
THIRA	Threat and Hazard Identification and Risk Assessment
USDA	United States Department of Agriculture
USGCRP	United States Global Change Research Program

# APPENDIX A: RESOURCES

*Appendix A: Resources* hosts a links listing of sources available online that can provide supplementary guidance for creating climate exercises. Resources include climate science information and mapping tools, federal reports or guidance for local, state, and tribal communities, existing research on adaptation, preparedness, and resilience, and information on existing initiatives or exercises.

# Climate Adaptation, Preparedness, and Resilience Exercise Seminar

**Miami, Florida**

September 21-22, 2015



RESOURCES




National Exercise Program  
2015-2016 Cycle



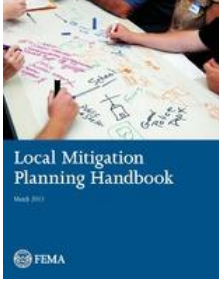




The Participant Manual provides participants with direct links to other climate-related programs, tools, and resources across all levels of government, non-profit organizations, and the academic community. Consider the following resources but this is not an exhaustive list.


Reports, Tools and Other Resources	
<p><a href="#"><u>American Association of State Climatologists</u></a></p> 	<ul style="list-style-type: none"> <li>Strives to bring climatology experts together to enhance their combined efforts</li> <li>Highlights designated state climatologists, Regional Climate Center directors, and other associates such as assistant climatologists and representatives of federal climate agencies</li> <li><a href="#"><u>Contact</u></a> state climatologists, identify regional programs, receive news updates, and register for local events</li> </ul>
<p><a href="#"><u>Center for Climate Adaptation Science and Solutions</u></a></p> 	<ul style="list-style-type: none"> <li>Provides guidance to local, state, federal employees, elected officials, tribes, businesses, and private citizens on how to connect scientific understanding of a changing climate with management practices in the U.S. and abroad</li> <li>Assists with <ul style="list-style-type: none"> <li>Adaptation planning</li> <li>Assessing adaptive capacity</li> <li>Designing strategies for reducing vulnerability of resources and populations to climate change</li> <li>Networking and academic/government partnerships</li> <li>User needs assessments</li> <li>Extensive partnerships/contacts</li> </ul> </li> </ul>
<p><a href="#"><u>Center for Climate Communications</u></a></p> 	<ul style="list-style-type: none"> <li>Conducts public engagement research and assists government agencies, non-profit organizations and companies implement research findings</li> <li>Hosts research reports, databases, PowerPoint presentations</li> </ul>
<p><a href="#"><u>Center for Research on Environmental Decisions</u></a></p> 	<ul style="list-style-type: none"> <li>Uses decision science to study individual and group decision-making under climate uncertainty and decision making in the face of environmental risk</li> <li>Conducts research in laboratories and field sites</li> <li>Conducts outreach using education, communication guides, advising to local, national and international organizations</li> <li>Develops decision support tools which facilitate use of scientific information about the environment</li> </ul>
<p><a href="#"><u>Climate Action Network International</u></a></p> 	<ul style="list-style-type: none"> <li>Global network of over 950 non-governmental organizations (NGOs) working to minimize climate adaptation</li> </ul>



	<ul style="list-style-type: none"> <li>▪ Member-based platform</li> <li>▪ Regional network hubs for coordinated efforts</li> </ul>
<p><a href="#"><u>Climate Communities</u></a></p> 	<ul style="list-style-type: none"> <li>▪ National coalition of cities and counties</li> <li>▪ Educates federal policymakers about the essential role of local governments in developing new approaches to create livable communities, reduce energy use and curb greenhouse gas emissions</li> <li>▪ Works with local governments to ensure that federal policies provide strong incentives and resources for local clean energy and sustainability actions</li> </ul>
<p><a href="#"><u>Climate Explorer</u></a></p>  <p>U.S. Climate Resilience Toolkit</p>	<ul style="list-style-type: none"> <li>▪ Data-based maps of climate stressors and their impacts and compare historical records of daily temperature and precipitation observations to long-term climate normals at thousands of weather stations in the United States.</li> </ul>
<p><a href="#"><u>Climate Science Centers</u></a></p> 	<ul style="list-style-type: none"> <li>▪ The regional Department of the Interior Climate Science Centers (CSCs) partner with natural &amp; cultural resource managers to provide science that helps fish, wildlife, ecosystems &amp; the communities they support adapt to climate change. The Climate Science Centers: <ul style="list-style-type: none"> <li>– Conduct <b>cutting-edge research projects</b> at local, regional and national scales; and produce products that include climate, water and ecosystem modeling, and geospatial, habitat, and species-level data.</li> <li>– Are built upon <b>federal-university partnerships</b>, and are dependent upon engagement with a community of <b>stakeholders</b> to define research priorities and initiatives.</li> <li>– Provide <b>educational opportunities</b> for students and early career scientists through fellowships, workshops, and trainings.</li> <li>– Work with <b>tribes and indigenous communities</b> to better understand their specific vulnerabilities to climate change and to help them adapt to these impacts. The CSCs were established within DOI by <a href="#"><u>Secretarial Order No. 3289</u></a>. National coordination and management for the CSCs is provided by the U.S. Geological Survey's <a href="#"><u>National Climate Change and Wildlife Science Center</u></a>.</li> </ul> </li> </ul>
<p><a href="#"><u>Department of Homeland Security</u></a></p> <p><a href="#"><u>Protective Security Advisors</u></a></p>	<ul style="list-style-type: none"> <li>▪ Regional Directors manage local Protective Security Advisors who facilitate local field activities in coordination with other Department of Homeland Security offices</li> </ul>




 <b>Homeland Security</b>	<ul style="list-style-type: none"> <li>Works with federal, state, local, tribal, and territorial government mission partners and members of the private sector stakeholder community to protect critical infrastructure</li> </ul>
<p><a href="#"><u>FEMA Flood Map Service Center</u></a></p>  <b>FEMA</b>	<ul style="list-style-type: none"> <li>Official public source for flood hazard information produced in support of the National Flood Insurance Program</li> <li>Provides official flood maps, access a range of other flood hazard products, and tools for better understanding flood risk</li> </ul>
<p><a href="#"><u>Federal Emergency Management Agency (FEMA) Local Mitigation Planning Handbook</u></a></p> 	<ul style="list-style-type: none"> <li>Official guide for local governments to develop, update and implement local mitigation plans</li> <li>Provides guidance to local governments on developing or updating hazard mitigation plans to meet the requirements under the Code of Federal Regulations (CFR) Title 44 – Emergency Management and Assistance §201.6, Local Mitigation Plans for FEMA approval and eligibility to apply for FEMA Hazard Mitigation Assistance grant programs</li> <li>Offers practical approaches, tools, worksheets and local mitigation planning examples for how communities can engage in effective planning to reduce long-term risk from natural hazards and disasters</li> </ul>
<p><a href="#"><u>FEMA Regional Exercise Officers</u></a></p>  <b>FEMA</b>	<ul style="list-style-type: none"> <li>Regionally-based exercise officers</li> <li>Provide knowledge on state and regional exercises</li> <li>May facilitate introductions with regional Training Officers</li> </ul>
<p><a href="#"><u>FEMA Tribal Affairs Resources</u></a></p>  <b>FEMA</b>	<ul style="list-style-type: none"> <li>Provides disaster assistance resources for tribal governments</li> <li>“Along with the need to ensure the safety of tribal communities and tribal lands in the face of disasters, FEMA shares the U.S. government’s unique government-to-government relationship with federally recognized tribes. FEMA acknowledges the sovereignty of federally recognized tribes and is committed to enhancing their working relationship with tribal governments to improve emergency and disaster responsiveness throughout Indian Country”</li> </ul>
<p><a href="#"><u>Georgetown Climate Center</u></a></p>	<ul style="list-style-type: none"> <li>Highlights the status of state adaptation efforts</li> <li>Provides users ability to view a state and its summary of its progress to date</li> </ul>






	<ul style="list-style-type: none"> <li>Profile pages include a detailed breakdown of each state's adaptation work and links to local adaptation plans and resources</li> </ul>
<p><b><u>ICLEI – Local Governments for Sustainability</u></b></p> 	<ul style="list-style-type: none"> <li>Hosts a variety of local program offerings including: Programs on Emissions Management, Climate Preparedness, Resources Efficiency &amp; Renewables, Climate Finance, Leadership campaigns, Internal Collaboration, City-Business collaboration, and Climate Equity</li> <li>Supports local governments and the private sector</li> </ul>
<p><b><u>Institute for Sustainable Communities</u></b></p> 	<ul style="list-style-type: none"> <li>Promotes community-driven projects through partnership with governments, foundations, and other non-profits organizations</li> <li>Resources include training, workshops, partnership and network development, multi-stakeholder engagement creation of resilience frameworks,</li> </ul>
<p><b><u>Institute for Social and Environmental Transition (ISET)-International</u></b></p> 	<ul style="list-style-type: none"> <li>Helps local partners build strategies to assist marginalized populations adapt to environmental change</li> <li>Provides research i.e., case studies, program reports, policy briefs, discussion papers, and others, training opportunities, and implementation activities</li> <li>Activities include: <ul style="list-style-type: none"> <li>Shared Learning</li> <li>Water Resource Management and Planning</li> <li>Resilience and Adaptation Planning</li> <li>Disaster Risk Management</li> <li>Climate Analysis and Interpretation Including Downscaling</li> <li>Vulnerability Analysis</li> <li>Communication</li> <li>Economic Analysis</li> <li>Knowledge and Methodology Development and Innovation</li> <li>Incubation Support</li> <li>Evidence-Based Advocacy</li> </ul> </li> </ul>
<p><b><u>Landscape Conservation Cooperatives</u></b></p>	<ul style="list-style-type: none"> <li>Protecting natural and cultural resources is essential to sustaining our health and quality of life. We, along with fish and wildlife, rely on clean water and the benefits of having healthy rivers, streams, wetlands, forests, grasslands, and coastal areas in order to thrive. Managing the landscapes that provide our</li> </ul>

	<p>natural and cultural resources has become increasingly challenging. With the signing of <a href="#">Secretarial Order No. 3289</a>, the Department of the Interior launched the Landscape Conservation Cooperatives (LCCs) to better integrate science and management to address climate change and other landscape scale issues. By building a network that is holistic, collaborative, adaptive, and grounded in science, LCCs are working to ensure the sustainability of our economy, land, water, wildlife, and cultural resources.</p> <ul style="list-style-type: none"> <li>▪ The 22 LCCs collectively form a network of resource managers and scientists who share a common need for scientific information and interest in conservation. Each LCC brings together federal, state, and local governments along with Tribes and First Nations, non-governmental organizations, universities, and interested public and private organizations. Our partners work collaboratively to identify best practices, connect efforts, identify science gaps, and avoid duplication through conservation planning and design.</li> </ul>
<p><a href="#"><u>Local Environmental Observer (LEO) Network</u></a></p> 	<ul style="list-style-type: none"> <li>▪ Tribal professionals who apply traditional knowledge, western science and technology to document unusual plants and wildlife, extreme weather, erosion, flooding, droughts, wildfire and other events that can threaten food security, water security and community health</li> </ul>
<p><a href="#"><u>National Oceanic and Atmospheric Administration Office for Coastal Management</u></a></p> 	<ul style="list-style-type: none"> <li>▪ Provides numerous data sets, tools and training courses for the coastal management community</li> <li>▪ Data registry includes more than 1,500 data sets and 99 collections</li> <li>▪ Hosts numerous tools categorized by data type, focus areas, function, platform and tool type</li> </ul>
<p><a href="#"><u>National Climate Assessment</u></a></p> 	<ul style="list-style-type: none"> <li>▪ Summarizes the consequences of climate change on the U.S., now and in the future</li> <li>▪ Created by a team of more than 300 experts guided by a 60-member Federal Advisory Committee which was extensively reviewed by the public and experts, including federal agencies and a panel of the National Academy of Sciences</li> <li>▪ <a href="#"><u>Report Highlights</u></a></li> </ul>

<p><b><u>National Disaster and Resilience Competition</u></b></p> 	<ul style="list-style-type: none"> <li>▪ Hosts a competition for 40 states and communities competing for nearly \$1 billion in funding in a National Disaster Resilience Competition</li> <li>▪ Finalists are invited to propose specific projects that advance their community's resilience plans</li> </ul>
<p><b><u>National Institute of Standards and Technology (NIST) Community Resilience Guide</u></b></p> 	<ul style="list-style-type: none"> <li>▪ Natural, technological, and human-caused hazards take a high toll on communities, but the costs in lives, livelihoods and quality of life can be reduced by better managing disaster risks. Planning and implementing prioritized measures can strengthen resilience and improve a community's abilities to continue or restore vital services in a more timely way, and to build back better. That makes them better prepared for future events and more attractive to businesses and residents alike.</li> <li>▪ The NIST Community Resilience Planning Guide for Buildings and Infrastructure Systems (Guide)* will provide a practical and flexible approach to help communities to better set priorities and allocate resources and reduce hazard risks by improving their resilience. Using the Guide, communities will be able to integrate resilience plans into their economic development, zoning, mitigation, and other local planning activities that impact buildings, public utilities and other infrastructure systems. Residents and businesses rely upon this “built environment” for important services.</li> </ul>
<p><b><u>National Preparedness Report</u></b></p> 	<ul style="list-style-type: none"> <li>▪ Fourth iteration of this annual report</li> <li>▪ Required annually by Presidential Policy Directive 8: National Preparedness</li> <li>▪ Summarizes progress in building, sustaining, and delivering the <a href="#">31 core capabilities</a></li> <li>▪ Assesses gains that whole community partners—including all levels of government, private and nonprofit sectors, faith-based organizations, communities, and individuals—have made in preparedness, and identifies where challenges remain</li> <li>▪ <a href="#">Report Summary</a></li> </ul>



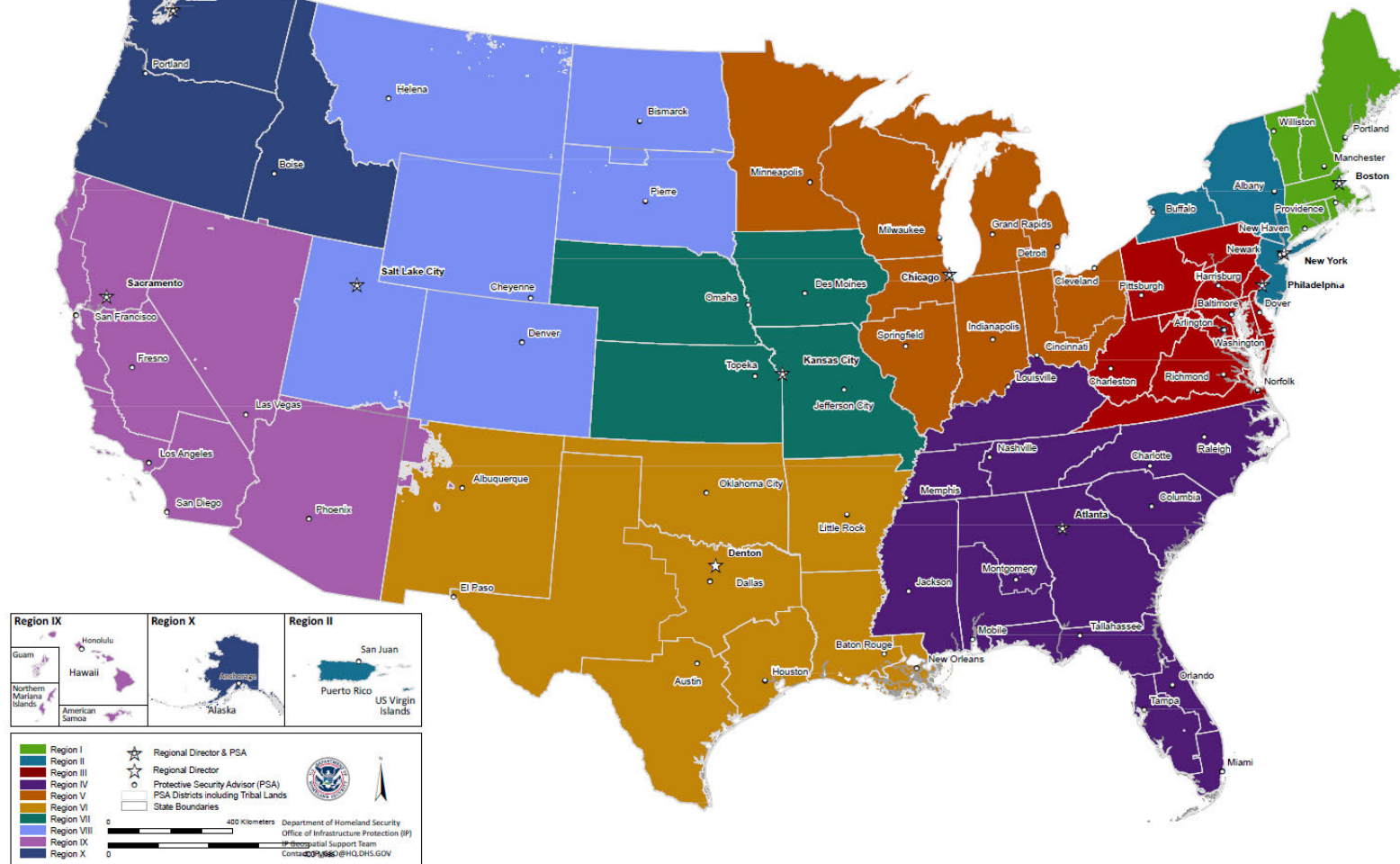
<p><a href="#"><u>Northern Arizona University Climate Change Resources</u></a></p>  <p><b>NORTHERN ARIZONA UNIVERSITY</b></p>	<ul style="list-style-type: none"> <li>▪ Institute for Tribal Environmental Professionals (ITEP) at Northern Arizona University strengthens tribal capacity and sovereignty in environmental and natural resource management</li> <li>▪ Created to support Native American natural resources in conjunction with local, state, and tribal governments and the private sector and NAU research/technical resources</li> <li>▪ <a href="#"><u>Hosts resources</u></a> for tribes working to address the changing climate or for those seeking to understand the effects of changing climate on tribal communities <ul style="list-style-type: none"> <li>– Searchable database developed by ITEP</li> <li>– Adaptation Planning Tool Kit</li> <li>– Fact Sheets developed by the ITEP</li> <li>– Links to news items, technical resources, announcements about upcoming events</li> </ul> </li> <li>▪ Funding opportunities</li> </ul>
<p><a href="#"><u>Peninsular Florida Landscape Conservation Cooperative</u></a></p> 	<ul style="list-style-type: none"> <li>▪ The Peninsular Florida Landscape Conservation Cooperative (PFLCC) is part of a national network of <a href="#"><u>Landscape Conservation Cooperatives(LCCs)</u></a>. LCCs are applied conservation science partnerships among federal agencies, regional organizations, states, tribes, NGOs, private stakeholders, universities and other entities within a geographic area. They are designed to inform resource management decisions in an integrated fashion across landscapes at a broader scale than any individual partner's responsibility.</li> <li>▪ The partnership considers landscape-scale stressors, including climate change, habitat fragmentation, invasive species, and water scarcity as it attempts to provide a vision for a landscape capable of sustaining healthy populations of fish, wildlife, plants and cultural resources.</li> </ul>
<p><a href="#"><u>Second Nature</u></a></p>  <p><b>SECOND NATURE</b> Education for Sustainability</p>	<ul style="list-style-type: none"> <li>▪ Works closely to support senior leaders in higher education to adopt values of sustainability</li> <li>▪ Advances Education for Sustainability (EFS) networks at the state, regional, and national levels</li> <li>▪ Extensive array of capacity building initiatives</li> <li>▪ Provides publications and climate science resources such as maps, fact sheets, scenarios, and reports and external links to additional resources</li> <li>▪ Hosts webinars, workshops, and events, and leadership summits</li> </ul>
<p><a href="#"><u>State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience</u></a></p>	<ul style="list-style-type: none"> <li>▪ Part of the President Climate Action Plan</li> </ul>

	<ul style="list-style-type: none"> <li>▪ Established to advise the Administration on how the Federal Government can respond to the needs of communities nationwide that are dealing with the challenges associated with climate change</li> <li>▪ Task Force members include governors, mayors, county officials, and Tribal leaders from across the U.S.</li> <li>▪ Highlights first-hand experiences in building climate preparedness and resilience in their communities to inform their recommendations to the Administration</li> <li>▪ Click <a href="#">here</a> to see the task force recommendations</li> </ul>
<p><a href="#"><u><b>Southeast Climate Science Center</b></u></a></p> 	<ul style="list-style-type: none"> <li>▪ The Department of the Interior Southeast Climate Science Center (SE CSC) provides scientific information, tools and techniques that land, water, wildlife and cultural resource managers and other interested parties can apply to anticipate, monitor and adapt to climate and ecologically-driven responses at regional-to-local scales.</li> </ul>
<p><a href="#"><u><b>Southeast Florida Regional Compact Climate Change</b></u></a></p> 	<ul style="list-style-type: none"> <li>▪ Established to coordinate mitigation and adaptation activities across county lines</li> <li>▪ Highlights examples on how regions across the U.S. can establish local climate governance entities to build relationships, share goals and resources, and become climate resilient together</li> </ul>
<p><a href="#"><u><b>United Nations Private Sector Initiative</b></u></a></p> 	<ul style="list-style-type: none"> <li>▪ Online database hosts case studies outlining best practices and climate adaptation activities taken by private sector companies and non-government organizations</li> </ul>
<p><a href="#"><u><b>U.S. Climate Resilience Toolkit (CRT)</b></u></a></p> 	<ul style="list-style-type: none"> <li>▪ Created in response to the President's Climate Action Plan and Executive Order to help the nation prepare for climate-related changes</li> <li>▪ Created by U.S. federal government agencies, led by the Office of Science and Technology Policy and the Council on Environmental Quality</li> <li>▪ Provides scientific tools, information, and expertise to help people manage their climate-related risks and opportunities, and improve their resilience to extreme events</li> </ul>

<p><b><u><a href="#">U.S. Climate Resilience Toolkit State Climatologists Map</a></u></b></p> 	<ul style="list-style-type: none"> <li>▪ Mapping tool assists with locating state climatologists and other experts in your area</li> <li>▪ Regional and locally-focuses centers across the nation are available to help you build resilience to climate-related changes in your community</li> </ul>
<p><b><u><a href="#">U.S. Climate Resilience Toolkit Tribal Nations</a></u></b></p>  <p>U.S. Climate Resilience Toolkit</p>	<ul style="list-style-type: none"> <li>▪ Component of CRT providing key information for climate risk assessment for Tribal Nations</li> </ul>
<p><b><u><a href="#">U.S. Energy Mapping System</a></u></b></p>	<ul style="list-style-type: none"> <li>▪ Explore maps of various energy resources, infrastructure, and transportation networks, or access profiles summarizing energy production, consumption, and expenditures for states and territories</li> </ul>
<p><b><u><a href="#">U.S. Global Change Research Program</a></u></b></p>  <p>United States Global Change Research Program</p>	<ul style="list-style-type: none"> <li>▪ Mandated by Congress in the Global Change Research Act of 1990</li> <li>▪ Comprehensive and integrated U.S. research program developed to assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change</li> <li>▪ Resources include: <ul style="list-style-type: none"> <li>- <a href="#">Information on climate change and built infrastructure</a></li> <li>- <a href="#">Information on climate and human health</a></li> <li>- <a href="#">Regional Climate Change Preparedness &amp; Resilience Exercise Series and other regional information, tools, and partnerships (from the NCA, from the agencies)</a></li> </ul> </li> </ul>
<p><b><u><a href="#">U.S. Resilience Initiatives</a></u></b></p> 	<ul style="list-style-type: none"> <li>▪ Web-based mapping application highlights the participation of U.S. municipalities within selected national-level resilience initiatives and programs</li> <li>▪ Map options include displaying National-level Summary municipalities symbolized based on the number of resilience initiatives and programs they participate in, Federal Resilience Initiatives and Programs, and NGO and Philanthropic Resilience Initiatives and Programs</li> </ul>

## PSA LOCATIONS

Protective Security Advisor (PSA) Locations - August 27, 2015



## ACRONYMS AND ABBREVIATIONS

Acronym	Term
CRT	Climate Resilience Toolkit
CFR	Code of Federal Regulations
EFS	Education for Sustainability
FEMA	Federal Emergency Management Agency
ISSET	Institute for Social and Environmental Transition
ITEP	Institute for Tribal Environmental Professionals
LEO	Local Environmental Observer
NGO	Non-governmental Organization



# Climate Adaptation, Preparedness, and Resilience Exercise Seminar

**Miami, Florida**

September 21-22, 2015



National Exercise Program  
2015-2016 Cycle

Templates



# Climate Adaptation, Preparedness, and Resilience Exercise Seminar

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National Exercise Program  
2015-2016 Cycle

**Situation Manual**

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## HANDLING INSTRUCTIONS

1. The title of this document is *The Climate Adaptation, Preparedness, and Resilience Tabletop Exercise Situation Manual*.
2. The information gathered in this SitMan is For Trusted Agents Only and should be handled as sensitive information not to be disclosed. This document should be safeguarded, handled, transmitted, and stored in accordance with appropriate security directives. Reproduction of this document, in whole or in part, without prior approval from the National Exercise Division, is prohibited.
3. This exercise is an unclassified exercise. The control of information is based more on public sensitivity regarding the nature of the exercise than on the actual exercise content. Some exercise material is intended for the exclusive use of exercise planners, facilitators, and evaluators, but players may view other materials deemed necessary for performance. All exercise participants should use appropriate guidelines to ensure the proper control of information within their areas of expertise and protect this material in accordance with current jurisdictional directives. Public release of exercise materials to third parties is at the discretion of the National Exercise Division.
4. Please contact [REDACTED], National Exercise Division, at [REDACTED] for information or questions regarding the exercise.

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## EXERCISE OVERVIEW

<b>Exercise Name</b>	Climate Adaptation, Preparedness, and Resilience Tabletop Exercise
<b>Exercise Dates</b>	September 22, 2015
<b>Scope</b>	This exercise is a tabletop planned for one half-day at Florida International University, in Miami, Florida. Exercise play is limited to participants of the National Exercise Program Climate Adaptation, Preparedness, and Resilience Exercise Seminar
<b>Mission Area(s)</b>	Mitigation
<b>Core Capabilities</b>	Planning, Community Resilience, Long-Term Vulnerability Reduction
<b>Objectives</b>	<ul style="list-style-type: none"> <li>▪ Discuss opportunities to better integrate existing and emerging climate science, information, and requirements into current and future planning to manage and adapt to climate stressors</li> <li>▪ Identify collaborative and sustainable whole community approaches to advance and sustain community-based climate preparedness and resilience programs, policies, and strategies</li> <li>▪ Identify opportunities for regional partnership and collaboration</li> </ul>
<b>Threat or Hazard</b>	Stressors associated with a changing climate
<b>Scenario</b>	The exercise scenario will address sea level rise threats, increasing temperatures, decreased water availability, coastal lifelines at risk, economic disruption, and uneven social vulnerability
<b>Sponsor</b>	Federal Emergency Management Agency, National Exercise Division
<b>Participating Organizations</b>	Participants in this exercise were selected in coordination with Florida International University and drawn from member jurisdictions of the Southeast Florida Climate Change Compact
<b>Point of Contact</b>	<div></div> <div></div> <div></div>

## **GENERAL INFORMATION**

### **Background**

Climate-related impacts such as sea level change, increasing temperatures, and severe weather events are already affecting infrastructure systems across the Nation. The past 30 years have seen a dramatic increase in costly weather and climate-related natural disasters.

From 1980 to 2014, the U.S. has sustained 178 weather and climate disasters, 38 of which occurred in Florida, where overall damage/costs reached or exceeded \$1 billion (including Consumer Price Index adjustment to 2014). The total cost of these 178 events exceeds \$1 trillion. In 2014, there were eight (8) weather and climate disaster events with losses exceeding \$1 billion each across the United States. These events included a drought event, a flooding event, five (5) severe storm events, and a winter storm event. Overall, these events resulted in the deaths of 53 people and had significant economic effects on the affected areas.

There is a growing concern among scientists and policymakers that weather events may grow in frequency, duration, and/or intensity. Infrastructure systems are already subject to a wide variety of natural disasters and these shifts in climate patterns increase the range of potential risks they face. Because of this, it is becoming increasingly important that whole communities consider incorporating climate-related threats and hazards into resilience planning and exercises.

In 2014 the White House National Security Council Staff, the White House Council on Environmental Quality, and the White House Office of Science and Technology Policy, in collaboration with the National Exercise Division, launched a pilot Climate Adaptation, Preparedness, and Resilience Exercise Series. This inaugural campaign was comprised of five events—a federal interagency workshop in May 2014; regional workshops in Houston (TX), Fort Collins (CO), and Anchorage (AK) in October 2014; and a regional exercise in Hampton Roads (VA) in December 2014.

Building upon these initial events, a more holistic, scalable, and sustainable approach has been designed to enable climate adaptation, preparedness, and resilience and community-driven vulnerability reduction among local, state, territory and tribal communities. The development of a two-day climate seminar, participant manual, and associated tabletop (TTX) exercise will help to strengthen, enhance, and institutionalize the Nation's climate adaption capabilities in support of a more secure and resilient nation.

### **Purpose**

The purpose of this scenario-based TTX is to provide officials and key personnel an opportunity to consider sea level rise, rising temperatures, decreased water availability, and analyze consequential effects on coastal lifelines, economic disruption, and uneven social vulnerability. Participants will conduct team evaluations on policies, plans, procedures, and mitigation efforts related to building whole community resilience. This exercise is designed to bring together local, state, federal, private sector and non-profit stakeholders in the South Florida region to develop strategies, build stakeholder planning processes, and coordinate stakeholder planning efforts to address climate-related impacts to critical infrastructure.

## Scope

This half-day TTX is designed to enhance understanding and awareness of the roles and responsibilities of local, state, territory, tribal, federal, private sector and non-profit stakeholders in preparation for potential changes in weather and climate-related hazards in the South Florida region. There will be an emphasis on processes and decision-making, stakeholder coordination, integration of capabilities, and long-term resilience planning.

## Exercise Objectives and Core Capabilities

The following exercise objectives in Table 1 describe the expected outcomes for the exercise. The objectives are linked to core capabilities, which are distinct critical elements necessary to achieve the specific mission area. The objectives and aligned core capabilities are guided by federal interagency partners and were selected by the Exercise Planning Team.

**Table 1: Exercise Objectives**

Exercise Objective	Core Capabilities
Discuss opportunities to better integrate existing and emerging climate science, information, and requirements into current and future planning to manage and adapt to climate stressors	Planning, Long-term Vulnerability Reduction
Identify collaborative and sustainable whole-community approaches to advance and sustain community-based climate preparedness and resilience programs, policies, and strategies	Planning, Long-term Vulnerability Reduction
Identify opportunities for regional partnership and collaboration	Community Resilience

**Table 2: Core Capabilities**

Core Capability	Description
<b>Community Resilience</b>	Lead the integrated effort to recognize, understand, communicate, plan, and address risks so that the community can develop a set of actions to accomplish mitigation and improve resilience
<b>Long-Term Vulnerability Reduction</b>	Build and sustain resilient systems, communities, and critical infrastructure and key resources lifelines so as to reduce their vulnerability to natural, technological, and human-caused incidents by lessening the likelihood, severity, and duration of the adverse consequences related to these incidents
<b>Planning</b>	Conduct a systematic process engaging the whole community as appropriate in the development of executable strategic, operational, and/or community-based approaches to meet defined objectives

## Participant Roles and Responsibilities

The term *participant* encompasses many groups of people, not just exercise players. Exercise participants and their respective roles and responsibilities, are as follows:

- **Players:** Players are personnel who have an active role in discussing or performing their regular roles and responsibilities during the exercise. Players discuss or initiate actions in response to the simulated emergency
- **Observers:** Observers do not directly participate in the exercise. However, they may support the development of situational player responses during the discussion by, asking relevant questions or providing subject-matter expertise
- **Facilitators:** Facilitators provide situation updates and moderate discussions. They also provide additional information or resolve questions as required. Key members of the Exercise Planning Team may also assist with facilitation as subject-matter experts (SMEs) during the exercise

## Exercise Structure

This exercise will be a facilitated, discussion-based exercise. Players will participate in the following two scenarios:

- Scenario 1: 2025 - Sea Level Rise Threats, Increasing Temperatures, and Population Growth
- Scenario 2: 2045 - Sea Level Rise Threats, Increasing Temperatures, Population Growth, and a Category 3 Hurricane

## Exercise Guidelines

- This exercise will be held in an open, low-stress, no-fault environment
- Respond to the scenario using your knowledge of current plans and capabilities (i.e., you may use only existing assets) and insights derived from your training
- Decisions are not precedent-setting and may not reflect an organization's final position on a given issue. This exercise is an opportunity to discuss and present multiple options and possible solutions
- Suggestions and recommended actions that could improve adaptation, preparedness and resilience efforts are more valuable than issue identification. Focus efforts on problem solving

## **Exercise Assumptions and Artificialities**

In any exercise, assumptions and artificialities may be necessary to complete play in the allotted time and/or account for logistical limitations. Exercise participants should accept that assumptions and artificialities are inherent in any exercise, and should not allow these considerations to negatively impact their participation. During this exercise, the following apply:

- The exercise will be conducted in a no-fault learning environment where systems and processes, not individuals, will be evaluated
- All players will receive information at the same time
- The scenario is plausible, and events occur as they are presented
- Time jumps may be used to discuss different aspects of climate adaptation, preparedness, and resilience measures



## SCENARIO 1: 2025

### September 22, 2025

The expected rise in sea level, as predicted in the Third U.S. National Climate Assessment, will result in the potential for greater damage from flooding in the southeast portion of the state. Global sea levels have increased over the past ten years by approximately one (1) foot. Southeast Florida has also seen an increase in population over the past ten years to nearly 6.4 million residents. As a result 6% of existing (current year) road infrastructure, 11% of public safety facilities, and 15% of protected lands are now at risk due to sea level rise.

County	Population
Broward	1,850,000
Miami-Dade	2,900,000
Monroe	70,000
Palm Beach	1,550,000
<b>Total</b>	<b>6,370,000</b>

### Key Issues

- Rise in sea level poses widespread and continuing threats to the regional economy and both natural and built environments
- Increasing temperatures and the associated increase in frequency, intensity, and duration of extreme heat events will affect public health, natural and built environments, energy, agriculture, and forestry
- Decreased water availability, exacerbated by population growth and land-use change, will continue to increase competition for water and affect regional economy and unique ecosystems

### Discussion Questions

Based on the information provided, participate in a discussion regarding the issues raised in Scenario 1. Identify any critical issues, decisions, requirements, or questions to be addressed at this time.

The following questions are provided as suggested subjects that may be addressed during the discussion. These questions do not constitute a definitive list of concerns to be addressed, nor is there a requirement to address every question.

- How would this increase in sea level rise affect planning for the following areas:
  - Critical facilities
  - Transportation infrastructure
  - Land use
- What opportunities at the community level are present for further collaboration?
- What opportunities at the local and regional government level are present for further collaboration?
- What opportunities within the private and non-profit sectors are present for further collaboration?
- How would this scenario impact the local and regional economy?
- What industries would be most affected?
- What can be done today (present day) to mitigate the effects of this scenario on the local and regional economy?
- Based on today's discussion, what type of investments can and should be made today (present day)?

## SCENARIO 2: 2045

### September 22, 2025

The expected rise in sea level, as predicted in the Third U.S. National Climate Assessment, will result in the potential for greater damage from flooding in the southeast portion of the state. Global sea levels have increased over the past ten years by approximately three (3) feet. Southeast Florida has also seen an increase in population over the past ten years to over seven (7) million residents.

County	Population
Broward	2,000,000
Miami-Dade	3,200,000
Monroe	70,000
Palm Beach	1,750,000
<b>Total</b>	<b>7,020,000</b>

On September 22, 2045, Hurricane Maria emerges as a tropical storm off the western coast of Africa. By September 25, Hurricane Maria is bearing northwest, towards the southeastern United States. A Category 4 hurricane, Maria hits Puerto Rico and the Dominican Republic with 140 mph winds on September 27, resulting in damages totaling \$1.5 billion, with 50 reported deaths.

The National Weather Service forecasts that Maria will make landfall near Miami on September 29, 2045, as a Category 3 hurricane. Storm surges of eight (8) to ten (10) feet are projected throughout the southeast Florida region.

### Key Issues

- Coastal lifelines, such as water supply and energy infrastructure and evacuation routes, are increasingly vulnerable to higher sea levels and storm surges, inland flooding, erosion, and other climate-related changes
- The threat of storm surge is exacerbated by the projected sea level rise
- Socioeconomic disparities create uneven exposures and sensitivities to growing coastal risks and limit adaptation options for some coastal communities, resulting in the displacement of the most vulnerable populations from coastal areas

## **Discussion Questions**

Based on the information provided, participate in a discussion regarding the issues raised in Scenario 2. Identify any critical issues, decisions, requirements, or questions to be addressed at this time.

The following questions are provided as suggested subjects that may be addressed during the discussion. These questions do not constitute a definitive list of concerns to be addressed, nor is there a requirement to address every question.

- How does a changing climate affect the way planners prepare for a hurricane?
- How does the scenario presented affect evacuation planning?
- What adaptation measures or resilience strategies can be taken today (present day)?
- Who are the people most at risk under this scenario?
- What is the effect on socially vulnerable populations in southeast Florida?
- What is the public health risk in this scenario and how is it different from the current risk?
- What type of adaptation and resilience projects should local and regional communities undertake to address the hazards presented by this scenario?
- What more can be done on the community level to promote action?

## **APPENDIX A: SCENARIO DATA SOURCES**

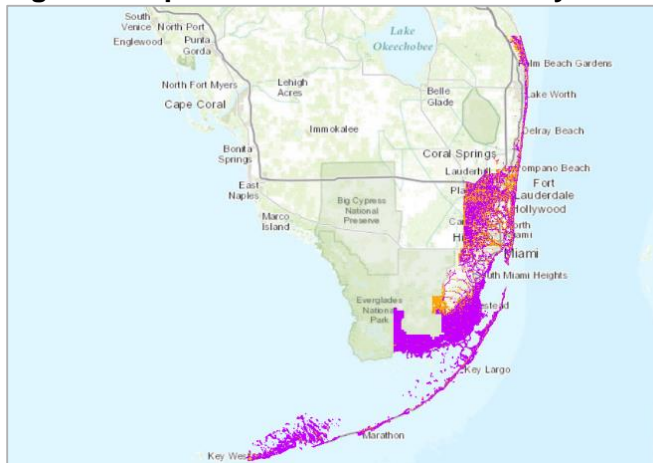
During the development of the hazard analysis for South Florida, the following data sources were used:

- Hazard information specific to rising sea levels and storm surges was informed by the Third U.S. National Climate Assessment, the United States Climate Resilience Toolkit, Surging Seas – Sea Level Rise Analysis View tool, and the Southeast Climate Compact
- Population projections and maps were derived from CoastalResilience.org
- The National Integrated Drought Information System (NIDIS) provided information about the risk and impact of droughts in the context of past droughts compared to current conditions, as well as information on decreased water availability exacerbated by population growth and land-use change
- Economic data characterizing the size and makeup of the ocean economy was derived from the Economics: National Ocean Watch (ENOW) Explorer
- Flood hazard information in support of the National Flood Insurance Program (NFIP) was gleaned from the Federal Emergency Management Agency’s FIRMette Web tool
- The U.S. Energy Mapping System provided visual representations of energy resources, infrastructure, and transportation networks

Data sources and applicable tools can be found below.

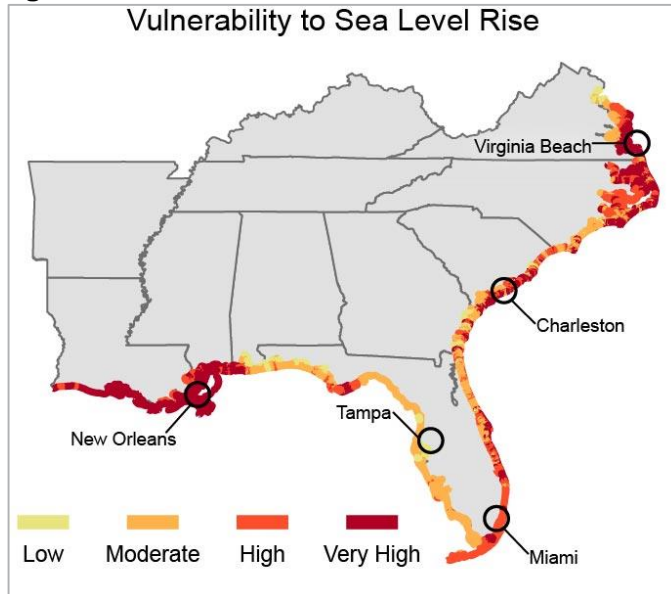


**Figure 1 Population and Sea Level Analysis**



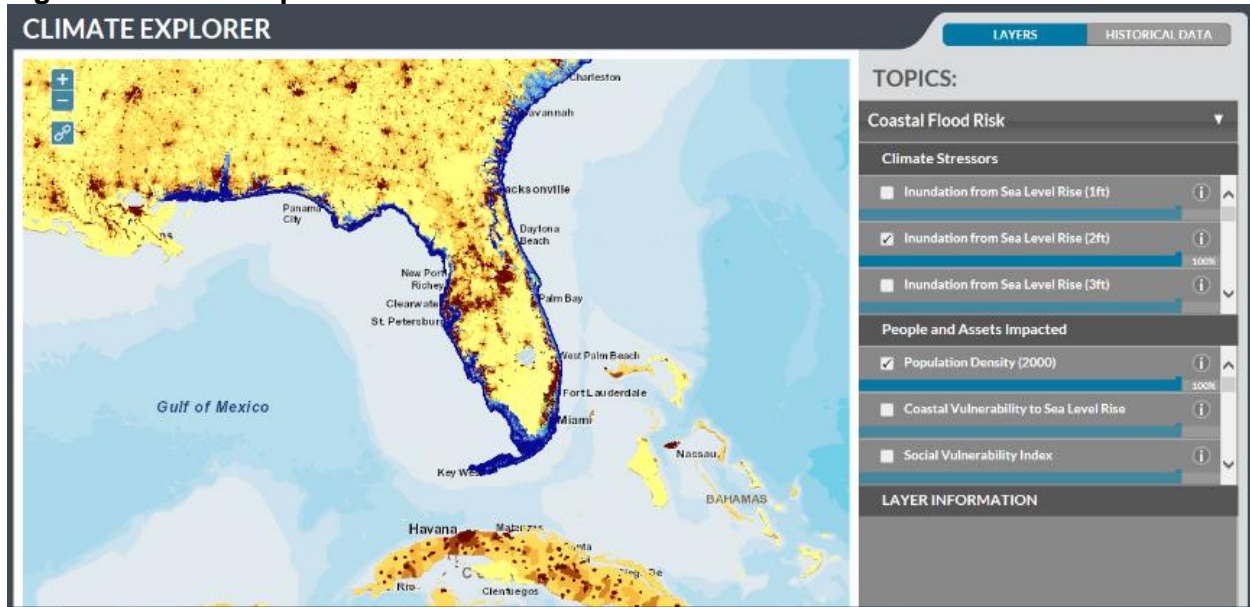
<http://coastalresilience.org/>

**Figure 2 Third U.S. National Climate Assessment  
Vulnerability to Sea Level Rise**



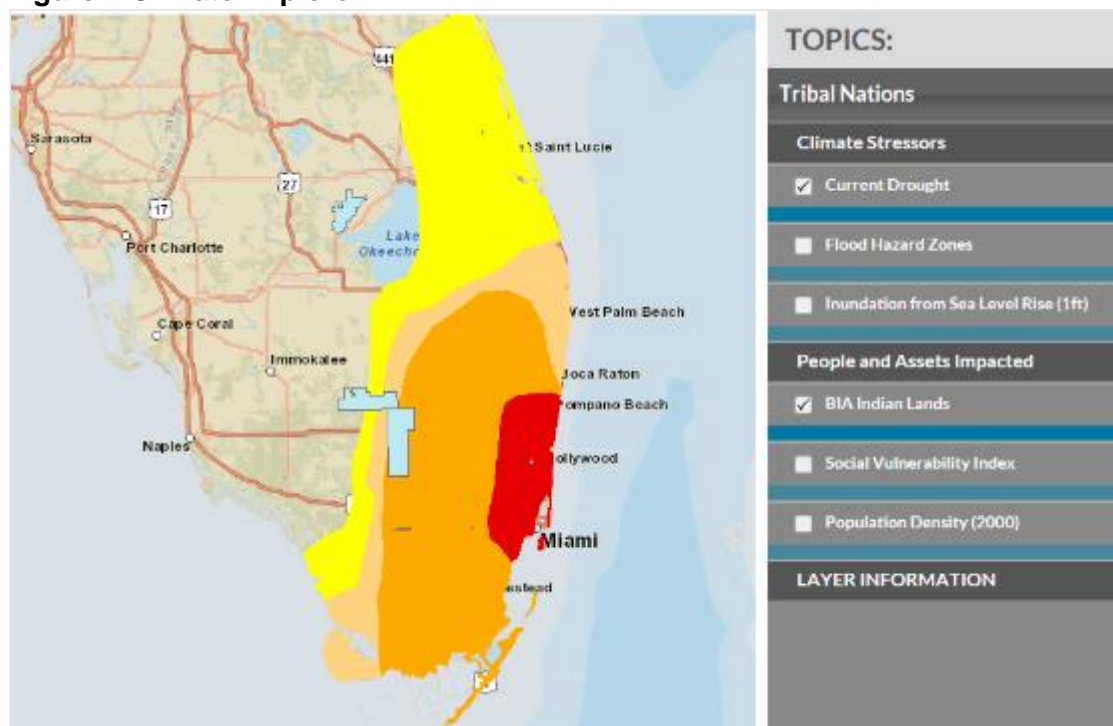
<http://nca2014.globalchange.gov/highlights/regions/southeast>

Figure 3 Climate Explorer



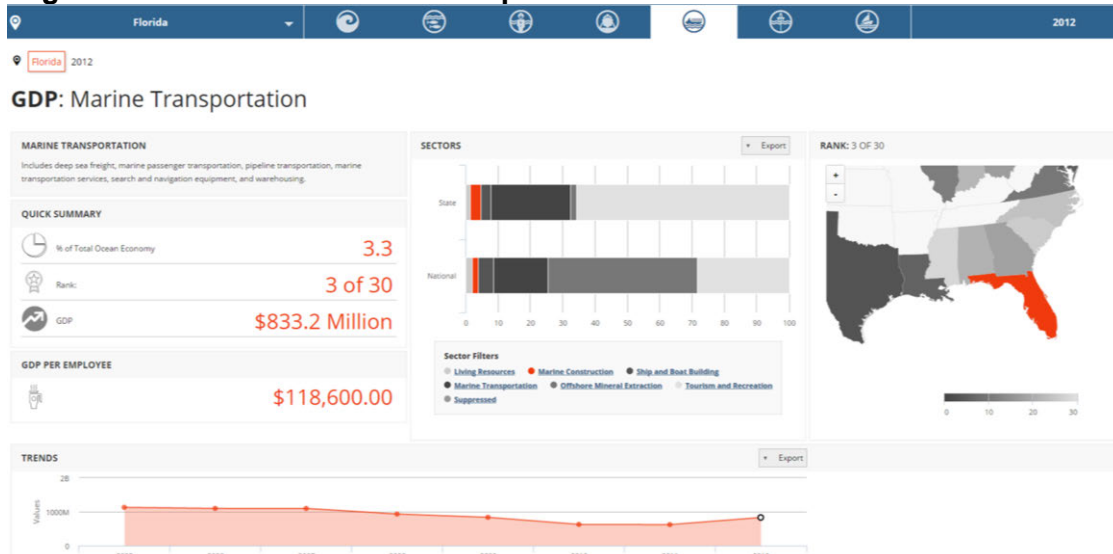
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Figure 4 Climate Explorer



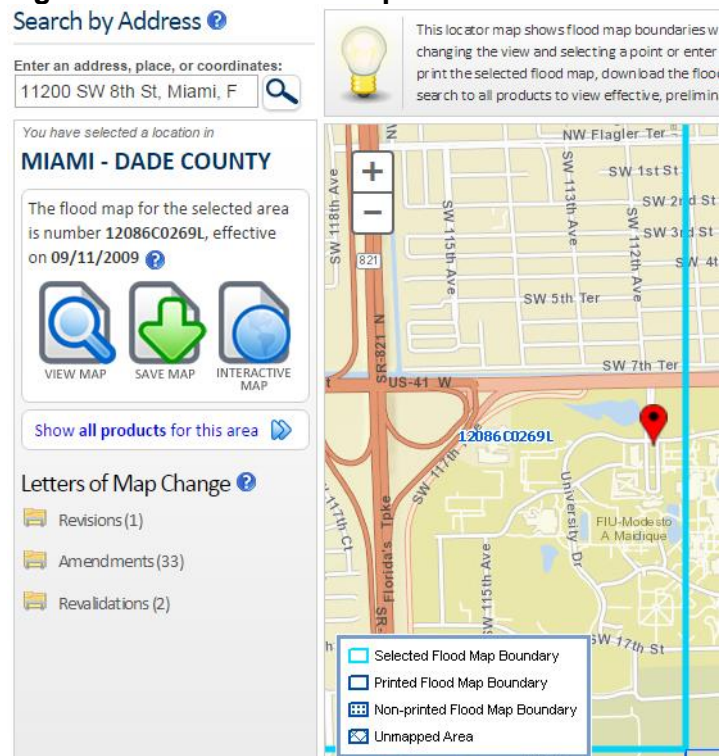
[http://toolkit.climate.gov/climate-explorer/?tp=g\\_a](http://toolkit.climate.gov/climate-explorer/?tp=g_a)

Figure 5: National Ocean Watch Explorer



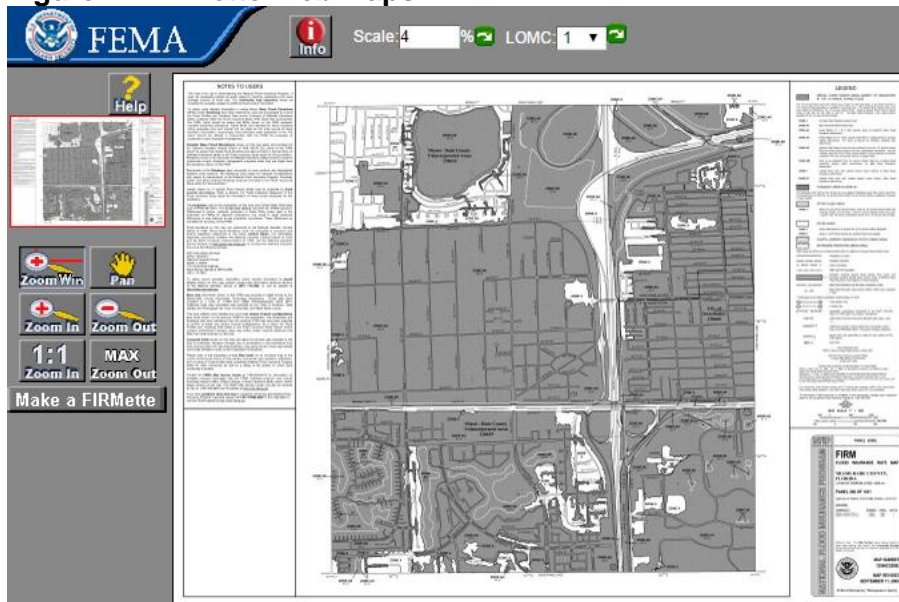
<http://coast.noaa.gov/enowexplorer/>

Figure 6: FIRMetra Web Maps



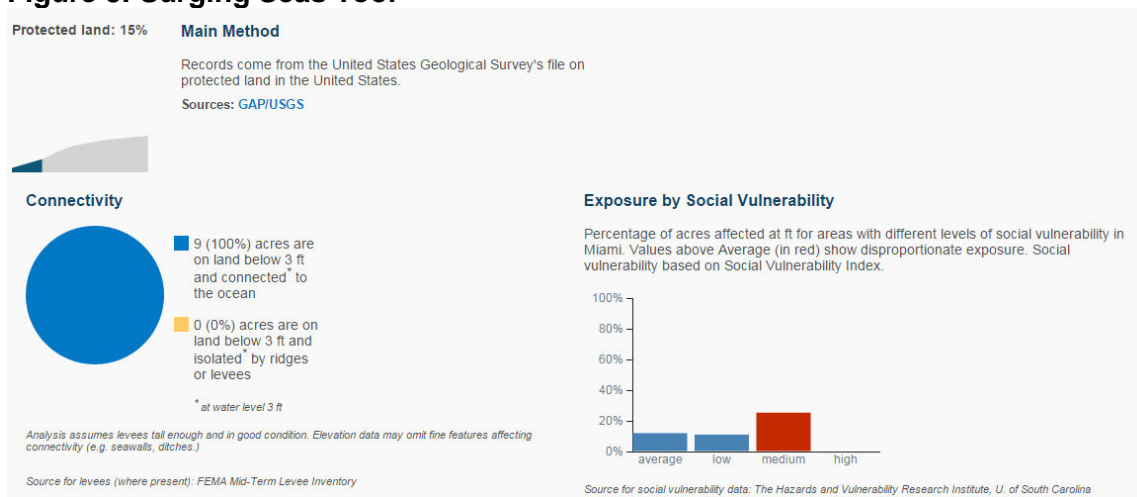
<http://msc.fema.gov/portal>

Figure 7: FIRMette Web Maps



<http://msc.fema.gov/portal>

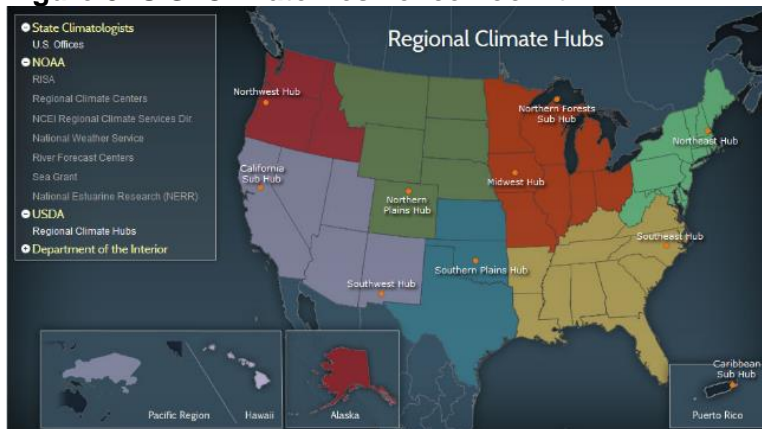
Figure 8: Surging Seas Tool



<http://sealevel.climatecentral.org/ssrf/florida>

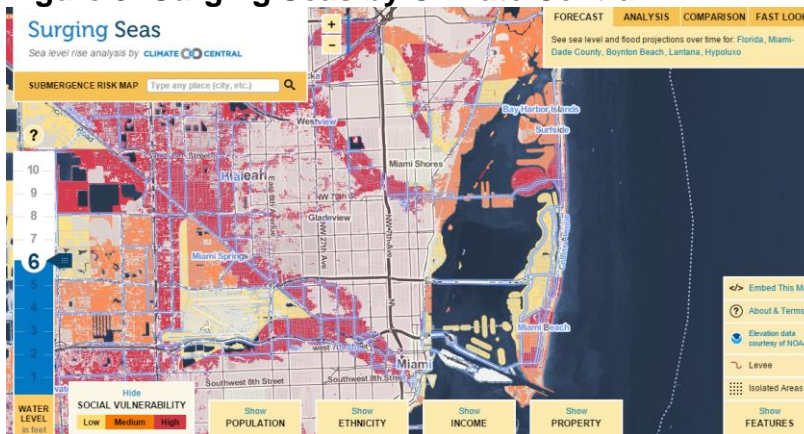


Figure 8: U.S. Climate Resilience Toolkit



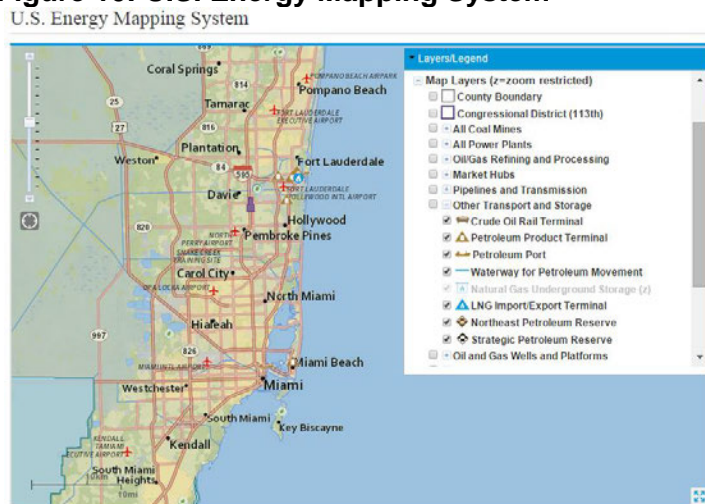
<https://toolkit.climate.gov/>

Figure 9: Surging Seas by Climate Central



<http://sealevel.climatecentral.org/>

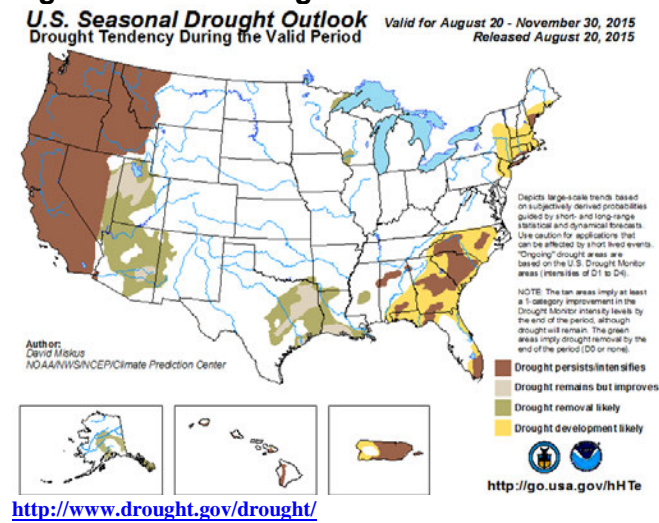
Figure 10: U.S. Energy Mapping System



<http://www.eia.gov/state/maps.cfm?src=home-f3>



Figure 11: U.S. Drought Portal



## APPENDIX B: EXERCISE SCHEDULE

**Note:** This exercise is part of a larger two-day seminar. The schedule below only reflects the exercise portion of the Seminar.

Time	Activity
Tuesday September 22, 2015	
2:15 pm	Welcome and Opening Remarks
2:30 pm	Scenario 1
3:00 pm	Scenario 2
3:30 pm	Hot Wash
3:45 pm	Closing Comments

## APPENDIX C: ACRONYMS

Acronym	Term
CRT	Climate Resilience Toolkit
ENOW	Economics: National Ocean Watch
FEMA	Federal Emergency Management Agency
FIRMette	Flood Insurance Rate Maps
NFIP	National Flood Insurance Program
NIDIS	National Integrated Drought Information System
SitMan	Situation Manual
SME	Subject-Matter Expert
TTX	Tabletop Exercise